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Vol. 68, Parts 1-4 **1970** **Pages 1-429**

CONTENTS

PAGES

CHAKRABORTY, S.—On a collection of mammals from Bhutan . . 1

ADAM SHAFEE, S.—A new family of Chalcidoidea (Insecta : Hymenoptera) 21

PATEL, B.H. and PATEL, H.K.—On some new species of Spiders of family Gnaphosidae (Araneae : Arachnida) from Gujarat, India 33

BHANOTAR, R.K., GUHA-ROY, S. and MUKHERJEE, G.D.—Population dynamics and morphometry of the 1956 and 1957 Desert Locust populations in India in relation to eye-stripe composition and sex-ratios . 41

BHANOTAR, R.K.—Eye-stripe composition, sex-ratios and morphometry of the 1949–61 Desert Locust populations in India in relation to phase transformation 79

CHHOTANI, O.B.—Revision of the genus *Glyptotermes* Froggatt (Kalotermitidae, Isoptera, Insecta) from the Indian Region 109

ANANTHASUBRAMANIAN, K.S. and ANANTHAKRISHNAN, T.N.—Taxonomic, Biological and Ecological studies of some Indian Membracids (Insecta : Homoptera). Part I 161

KHERA, S.—On some nematodes belonging to the orders Chromadorida and Enoplida from India 273

KHERA, S., and CHATURVEDI, Y.—On some Tylenchid Nematodes from Orissa 287

RAMAKRISHNA, G.—Results of fifty years of faunistic survey of Indian Isopods 297

PAGES

ANANTHASUBRAMANIAN, K.S., and ANANTHAKRISHNAN, T.N.—Taxonomic, Biological and Ecological studies of some Indian Membracids. Part II 305

MANDAL, A.K.—Fifty years' progress in the Taxonomy of Coccidia (Protozoa : Sporozoa) from India 341

CHATTOPADHYAY, S.K.—Studies on fresh water fishes of Beliaghata Bheries, Calcutta 355

LAHIRI, A.R.—Report on the faunistic Survey (Odonata) of the South Andaman Islands 365

GHOSH, R.K., and CHAUHAN, B.S.—Fifty years of faunistic Survey in India. Helminthological studies and Zoological Survey of India 367

GUPTA, P.D.—Fifty years (1920–1969) of faunistic surveys of Rajasthan (India) 383

SHUJA-UDDIN—Two new species of Aphidiidae (Hymenoptera) from India 415

DURVE. V.S.—Commerical marine molluscs of India and the need for their survey 421

Rec. zool. Surv. India, **68**: 1–20, 1975

ON A COLLECTION OF MAMMALS FROM BHUTAN

By

S. CHAKRABORTY

Zoological Survey of India

(One Text-figure)

INTRODUCTION

The Kingdom of Bhutan is situated in the heart of the Himalaya in its eastern part. The country spreads over an area of about 20,000 square kilometers lying between latitudes 26°45′ and 28°20′ N. and longitudes 89°10′ and 92°15′ E. Nevertheless, within this limited space one may travel from the tropical foothills in the south to the perpetual snows at about 8,000 metres high peak of Kula Kangri in the north, from the zone of tropical rain forest to alpine vegetation through the temperate coniferous forests. Adverse physical features, such as the rugged mountains, heavy rainfall and dense vegetation combined with the earlier policy of isolation, constituted a formidable barrier to modern exploration of Bhutan. In 1960, however, the King and the Prime Minister of Bhutan decided to abandon the country's policy of isolation. During the years 1966 (March-May), 1967 (November-December), 1969 (January-March), Dr. B. Biswas of this department and his party conducted faunistic surveys of the tropical rain forest and temperate coniferous forest areas of eastern, central and western Bhutan. They collected a large number of different groups of animals from the region they surveyed. The present paper deals with the mammalian collection which consists of 104 specimens comprising 20 species, together with those seen in the field but not collected. Except for some stray reports of Pemberton (1839), Blyth (1842), Gray (1842), Blanford (1888, 1891), Pocock (1939, 1941), Ellerman (1963), Moore and Tate (1965) and Holmes (1970), the available information on the mammalian fauna of Bhutan is negligible. The results of these surveys are, therefore, of much biological interest. This paper aims at giving a list of mammalian species found in Bhutan, along with notes on their distribution, variations, taxonomic status and field observations. However, the list is only provisional and it is in no way complete, as the northern, high altitude areas are yet to be surveyed.

All measurements are given in millimetres and mean values are given in parenthesis. Measurements of Insectivora, Chiroptera and Rodentia are taken after Roonwal (1949), Khajuria (1952) and Ellerman (1963), respectively, while those of other groups are taken after Pocock (1939, 1941). External measurements and weights were taken by the collector in the field within a few hours after the animal was killed.

The colours given with initial capital letters in the text have been recognised according to Ridgway's (1886) nomenclature.

The following abbreviations have been used in the measurements.—

External: e. = Ear; f. = Forearm; H. & B. = Head and body length; H.F.= Hind foot; p.= Pollex; Tl.= Tail length; t. = Tibia.

Cranial: apf.= Anterior palatine foramina; bul.= Bullae; cb.= Condylobasal; cw.= Cranial width; c′—c′.= Shortest distance between the outer surfaces of the roots of canines; dia.= Diastema; fr.= Frontal; io.= Interorbital; mw.= Maxillary width; m^3–m^3.= Distance between the outer surfaces of the third upper molars; m.= Molar; nas.= Nasal; on.= Occipitonasal; or.= Orbit; pal.= Palatal; po.= Postorbital; pm. = Premolar; Tl.= Total length; TR.= Upper tooth row; zw.= Zygomatic width.

Systematic account

Order INSECTIVORA

Family Soricidae

Suncus murinus soccatus (Hodgson)

1845. *Sorex soccatus* Hodgson, *Ann. Mag. nat. Hist.*, **15** : 270.
1855. *Sorex heterodon* Blyth, *J. Asiat. Soc. Beng.*, **24** : 31.
1929. *Suncus soccatus*, Lindsay, *J. Bombay nat. Hist. Soc.*, **33** : 332.
1951. *Suncus murinus soccatus*, Ellerman and Morrison-Scott, *Checklist of Palaearctic and Indian Mammals:*, 66.

Material.—1♂, 1♀: Gaylegphug, *c.* 153 m., C. Bhutan; 10 Nov., 1967. 1♀: Rongtong, Manas Valley, *c.* 1740 m., E. Bhutan, 5 Apr., 1966.

Measurements:

External.— 1♂: H. & B. 141; Tl. 71; H.F. 21; e. 13.
2♀♀: H. & B. 110, 134; Tl. 66, 74; HF. 18, 20; e. 8, 12.
Cranial.— 1♂: Tl. 38.8; pal. 16; TR. 15.5; cw. 13.2.
1♀: Tl. 29.8; pal. 14; TR. 13.8; cw. 12.
Weights.— 1♂: 51 g.
2♀♀: 40 g., 40 g.
Mammae.—Three pairs, all inguinal.

Seasonal variation in the nature of fur is well marked. The fur is short and close in the April specimen while very long and soft with a slight silvery sheen in those of November.

This is the first record of the genus *Suncus* Ehrenberg from Bhutan.

Order CHIROPTERA

Family Pteropidae

Rousettus leschenaulti leschenaulti (Desmarest)

1820. *Pteropus leschenaulti* Desmarest, *Encycl. Meth. Mamm.*, **1** : 110.
1835. *Pteropus pyrivorus* Hodgson, *J. Asiat. Soc. Beng.*, **4** : 700.
1843. *Cynopterus marginatus* Gray, *List. Mamm. Brit. Mus.*, 38.
1870. *Xantharpyia seminuda* Gray, *Cat. Monkeys, Lemurs and Fruiteating Bats*, 115.
1870. *Eleutherura fuliginosa* Gray, *Cat. Monkeys, Lemurs and Fruiteating Bats*, 118.
1912. *Rousettus leschenaulti*, Andersen, *Catalogue of the Chiroptera in the collection of the Brit. Mus.*, 1. *Megachiroptera*, 35.

Material.—3 ♀♀, 1 subad. ♀: Panjurmane, *c.* 1525 m., C. Bhutan, 11 and 12 Dec., 1967.

Measurements:

External.— 3 ♀♀: H. & B. 109, 121, 124; Tl. 12, 12, 15; f. 76, 79, 80; H.F. 18, 20, 20; t. 32, 34.3, 38; e. 18, 19, 19; p. 23, 23.5, 24.2.

Cranial.— 2♀♀: cb. 40.8, 41; pal. 20.2, 20.4; zw. 22.3, 23; c′–c′ 6.8, 7; m^3–m^3. 11, 11.5; cw. 15.4, 16; io. 8, 8.1; TR. 13.4, 14.

Weights.— 3♀♀: 55 g., 77 g., 80 g.

The dorsum of my specimens fits in well with the description given by Andersen (1912), but the venter is Smoke Gray instead of Drab or Isabella colour. Also, numerous white spots are present on the wings of two adult female specimens.

This is the first record of this species from Bhutan.

Sphaerias blanfordi (Thomas)

(Blanford's Fruit Bat)

1891. *Cynopterus blanfordi* Thomas, *Ann. Mus. Stor. nat. Genova*, **2** : 10

1912. *Sphaerias blanfordi*, Andersen, *Catalogue of the Chiroptera in the collection of the Brit. Musg.* **1**, *Megachiroptera:* 674.

Material.—2 ♂♂ : Ganglakha, *c.* 1860 m., W. Bhutan, 27 Jan., 1969.

Measurements:

External.— 2 ♂♂: H. & B. 84, 84; f. 52, 54; H.F. 12, 12; e. 18, 19; t. –, 19.3; p. 17, 18.

Cranial.— 1♂ : cb. 26.2; pal. 13.8; zw. 18; c′–c′ 6.4; m^3–m^3. 8.2; cw. 12.8; io. 5.4; TR. 8.

Body is covered with very long, close, soft fur, but wings are naked. Base of ear white but edges are brownish and not white as stated by Andersen (1912). Two Buff spots are present on the chin, which were not mentioned in earlier description.

According to Ellerman and Morrison-Scott (1951), this species is known to occur in Karin Hills, Burma, and in Siam. The present specimens constitute the first record of this species from Bhutan. Moreover, in the collection of the Zoological Survey of India, there is a subadult female specimen of *S. blanfordi* from Darjeeling, West Bengal, and recently Bhat (1968) has reported it from Western Himalaya in the Uttar Pradesh. The range of this species, therefore, appears much more extensive than hitherto known.

Order PRIMATES

Family CERCOPITHECIDAE

Presbytis geei Khajuria

(The Golden Langur)

1956. *Presbytis geei* Khajuria, *Ann. Mag. nat. Hist.*, (12) **9** : 86-88.

Material—1 ♂: Panjurmane, *c* 1525 m., C. Bhutan, 11 Dec., 1967. 1♂: Gaylegphu *c.* 153 m., C. Bhutan, 9 Nov., 1967.

Measurements:

External.— 1♂: H. & B. 530, Tl. 890; H.F. 195; e. 36. 1♀: H. & B. 505; Tl. 727; H.F. 166; e. 32.

Cranial.— 1♂: Tl. 98; cb. 81; zw. 77; or. 69; mw. 30. 1♀: Tl. 94; cb. 74; zw. 77; or. 63; mw. 25.

Compared with the male, in the female specimen the golden tinge is more conspicuous, particularly on the sides and hinder part of the body. The same difference is also exhibited by specimens of the type-series present in the Zoological Survey of India. It is evident, therefore, that there is sexual dimorphism in regard to the depth of the golden tinge in this species.

The male specimen is somewhat abnormal. The fingers of the right hand are without nails and are dwarfed. The first right upper premolar is absent, there being no place for it in the jaw. This animal was found on a terminal branch of the tree, and it was somewhat isolated from the troop.

The nipples of the female specimen were very prominent and it was found to be pregnant. On dissection a foetus was obtained. The foetus is entirely hairless and cream-coloured; its hands, feet and tail are well developed; trace of the fold of the lower eyelid and of external pinna are indicated. It measures, vortex-coccyx 50; tail 60.

Our knowledge of the distribution and behaviour of the Golden Langur has so far been due to Gee (1961) and Wayre (1968). According to them it occurs from the east of Sankosh river to the west of Manas river in Assam and in the Manas Wild Life Sanctuary of Bhutan just across Assam border. The Zoological Survey of India party observed *P. geei* in different parts of central Bhutan and collected specimens from far north of the known range. It will, therefore, be of interest to add a few lines from the collector's note as follows:

Gaylegphug: Hardly a kilometre north of the township of Gaylegphug a troop of the Golden Langur was seen on a Peepul (*Ficus religiosa*) tree, about 40 m. high by the side of the main road towards Tongsa. The troop consisted of about 18 individuals comprising of adult males, females, adolescents and youngs. Youngs were not clinging to their mothers. All were busy feeding on the berries and tender twigs of the tree and often leaping from branch to branch. As soon as they noticed the collector they began to move north-west, when a female was shot down. Immediately the troop began to flee but a large male (probably troop leader) jumped near the dead animal and howled loudly. A few hesitating adolescent animals were driven away by him while he himself occasionally moving near the dead animal and howled continuously. As the body was recovered by the Zoological Survey of India party, he went away and joined the troop.

Local people reported that the 'Sugrib' (the local name of the Golden Langur) is a permanent resident of Gaylegphug forests, often roaming from forest to forest usually along the banks of the Ai river.

Batase: No Golden Langur was seen here, but local people reported that there were many in the areas of Cardamon (*Amomum aromaticum*) plantation on the slope across the Rong river, which is surrounded by thick forests. There they are said to cause considerable damage to the cultivation.

Tama: On the slope of Tama Khola the Golden Langurs are in plenty. A troop of more than 20 individuals was seen, but owing to

the inaccessibility of the area, they could not be approached close enough. In this troop youngs were very few.

Panjurmane: Two troops were noticed, one in the evening roosting on a large tree (unidentified) and other on the road in an afternoon. Both the troops were made up of 15 to 20 individuals of all ages.

It is interesting to note that so far no Golden Langur has been seen, nor reported from the west of Sankosh river, and this agrees with the observation of Gee (1961) in Assam that the Golden Langur is restricted to the east of Sankosh river.

Regarding the correct authorship of this species, Biswas (1966) may be referred.

Order CARNIVORA

Family VIVERRIDAE

Herpestes sp.

Material.—1 subad. ♂ : Gaylegphug, *c* 158 m., C. Bhutan, 9 Nov., 1967.
Measurements:

External.— H. & B. 257; Tl. 228; H.F. 50; e. 17.

Cranial.— Tl. 57; cb. 57; zw. 26.5; io. 10.3; po. 13.2; mw. 9.9; pm^4. 6×4.4; m_1. 5×3.1.

The present specimen is very peculiar as it shares the characters of both *H. auropunctatus* (Hodgson) and *H. palustris* Ghose. General tint is dark brown, with minute nearly Ochraceous speckling. The contour hairs are short. This agrees with the description of new summer coat of *H. auropunctatus* given by Pocock (1941). The number of bands on the individual contour hairs is five, but a few hairs at the tail tip are entirely black. Muzzle is black like that of *H. palustris.*

Skull without any sagittal crest. The postorbital width is greater than that of interorbital width. This characteristic is found in the subadult specimens of both *H. auropunctatus* and *H. palustris.*

Based on the collection present in the Zoological Survey of India, the present specimen may be compared with *H. auropunctatus* (2 ♀♀ : Golaghat, Assam; 1♀: Goalpara, Assam; 1♂: Howrah, West Bengal), and *H. palustris* (15♂♂; 4 ♀♀ : topotypes) as follows:

Characters	Present specimen	*H. auropunctatus*	*H. palustris*
Muzzle:	Black	Brown	Black
Grizzling of pelage:	Fine	Fine	Coarse
Coat:	Smooth and silky	Smooth and silky	Rough
Tail tip:	Black	Concolorous with tail base.	In 11 concolorous with tail base but in eight black tipped.

In view of the fact that I have only a single subadult specimen from Bhutan and that I do not have sufficient comparative material of *H. auropunctatus*, the specific identification of the present specimen is withheld.

Family FELIDAE

Felis bengalensis horsfieldi (Gray)

(The Leopard Cat)

1842. *Leopardus horsfieldi* Gray, *Ann. Mag. nat. Hist.*, **10** : 260.
1844. *Felis pardochrous* Hodgson, *Calcutta J. nat. Hist.*, **4** : 260.
1939. *Prionailurus bengalensis horsfieldi*, Pocock, *Fauna of Brit. India including Ceylon and Burma*, **1** : 271.
1951. *Felis bengalensis horsfieldi:* Ellerman and Morrison-Scott, *Checklist of Palaearctic and Indian Mammals:* 313.

Material.—1♂: Honka, W. Bhutan; 20 Jan., 1969.

Measurements:

External.— H. & B. 519; Tl. 280; H.F. 110; e. 45.

Cranial.— Tl. 90; cb. 88; zw. 63.1; io. 15; po. 25; mw. 12.5.

External features agree with the description given by Pocock (1939).

The type skin of *F. b. horsfieldi* was designated by Gray (1842) as from Bhutan, but Pocock (1939) believed that it came from upper Assam. However, the present specimen constitutes an authentic record of the occurrence of *F. b. horsfieldi* in Bhutan.

Order ARTIODACTYLA

Family CERVIDAE

Muntiacus muntjak vaginalis (Boddaert)

(The Barking Deer)

1785. *Cervus vaginalis* Boddaert, *Elench. Anim*, **1** : 136.
1833. *Cervus ratwa* Hodgson, *Asiatick Res.* **18** (2) : 139.
1845. *Cervus styloceros* Schinz, *Synop. Mamm.* **2** : 549.
1852. *Stylocerus muntjacus* Kelaart, *Prod. Faun. Zeylan:* 85.
1951. *Muntiacus muntjak vaginalis*, Ellerman and Morrison-Scott, *Checklist of Palaearctic and Indian Mammals:* 356.

Material.—1 subad. ♀: Tama, *c* 1130 m., C. Bhutan; 26 Nov., 1967.

Measurements:

External.— H. & B. 1160; Tl. 180; H.F. 280 (to the tip of hoof).

Cranial.—Tl. 183.

Facial region Bistre instead of usual brown. Body is uniform brown in colour without any white spotting.

On the basis of the skull of this specimen and the adult skulls present in the Zoological Survey of India, interesting variations are noticed between the deciduous and permanent set of teeth. In the permanent set pm^1, pm^2, pm^3 and pm_3 are single lobed, while in the deciduous set pm^1, pm^2 and pm^3 have two lobes and pm_3 has three lobes.

The present specimen constitutes the first record of the occurrence of the Barking Deer in Bhutan.

Order RODENTIA

Family SCIURIDAE

Petaurista magnificus (Hodgson)
(Hodgson's Flying Squirrel)

1836. *Sciuropterus magnificus* Hodgson, *J. Asiat. Soc. Beng.*, **5** : 231. Nepal
1842. *Sciuropterus nobilis* Gray, *Ann. Mag. nat. Hist.*, **10** : 263. Darjeeling
1844. *Sciuropterus chrysotrix* Hodgson, *J. Asiat. Soc. Beng.*, **13** : 67. Nepal
1947. *Petaurista magnificus*, Ellerman, *J. Mammal.*, **28** : 254.

Material.—1♂, 1♀: Paro, *c* 2440 m., W. Bhutan; 14 Feb., 1969. 1♂: Gomchu, *c* 2500 m., E. Bhutan; 28 Mar. 1966. 1♀: Mithangar, *c* 1525 m., E. Bhutan; 7 May 1966.

Measurements:

External.— 2♂♂: H. & B. 390, 415; Tl. 495, 510; H.F. 80, 81; e. 48, 51.
2♀♀: H. & B. 414, 487; Tl. 464, 522; H.F. 79, 85; e. 45, 50.

Cranial.— 1♂: on. 72; pal. 38.1; nas. 22.1; fr. 16.1; or. 26.1; TR. 17.8. 1♀: on. 75.5; pal. 39.8; nas. 22.4; fr. 17; or. 28; TR. 18.

Mammae.—1—2 = 6.

Forehead is yellowish buff in colour. A dark maroon saddle is present on the back, which bifurcates in the region of the neck and extends along the sides of the head up to the nose. A few yellowish buff hairs are also present on the mid region of dark maroon saddle. Sides of the body and parachute are yellowish orange and sharply marked off from the back. Margin of parachute is rose red in colour. Hands and feet are Maroon. Tail is tricolored; more than half of its proximal part yellowish buff, followed by rose red and terminally black. Ventral fur soft, woolly and light orange in colour. The greatest lengths of the head and body, occipitonasal, palatal and orbit differ somewhat from the recorded measurements in published works; these are 487, 75.5, 39.8 and 28 respectively in the present material as against 420, 72.9, 36.5, 27.2 recorded in literature.

Blanford (1891) regarded *P. nobilis* and *P. chrysotrix* as synonyms of *P. magnificus*, in which dorsal colour changes seasonally. He believed (p. 364), *P. nobilis* and *P. chrysotrix* "to be the summer garb, the body, neck and head are deep maroon, generally with a more or less well-marked yellow median line, commencing with a broad spot on the forehead" and *P. magnificus* as the winter garb with no median dorsal line, "the body and head are chestnut above, more or less grizzled by some of the longer hairs being whitish near the tip". Wroughton (1911) retained only *P. nobilis* believing *P. magnificus* to be a synonym of *P. albiventer* Gray. Robinson and Kloss (1918) reverted to Blanford's nomenclature and so also did Ellerman (1940, 1947, 1963) and Ellerman and Morrison-Scott (1951). In the specimens from Bhutan collected in both summer and winter no seasonal change can be marked, and all of them fit in well with the description of the summer garb of *P. magnificus* given by Blanford (*op. cit.*) and with the paratype of *P. magnificus*

present in the Zoological Survey of India collection. A re-examination of the further material present in the Zoological Survey of India (1♀: no locality, August; 1 ad. and 1 subad.: Sikkim, unsexed and without date; 1 adult: no history) reveals that all of them are very similar to the paratype of *P. magnificus*. Moreover, the original descriptions of *P. nobilis* and *P. chrysotrix* are applicable to the paratype of *P. magnificus* as well. It may therefore, be concluded that *P. magnificus* is a distinct species with a constant pelage colour, and that *P. nobilis* and *P. chrysotrix* are nothing but its synonyms. *Petaurista magnificus* differs from all other species of the genus *Petaurista* Link by having a constant dark maroon saddle on the back even in the subadult stage, which may sometimes partly or fully be divided down the spine by a yellowish buff line.

Callosciurus erythraeus bhutanensis (Bonhote)

1901. *Sciurus erythraeus bhutanensis* Bonhote, *Ann. Mag. nat. Hist.*, (7) **7** : 161. Bhutan
1961 (1963). *Callosciurus erythraeus bhutanensis*, Ellerman, *Fauna of India including Pakistan, Burma and Ceylon, Mammalia*, **3** [*Rodentia*]: 125.

Material.—1♂: Putlibir, *c* 2103 m., W. Bhutan, 5 Mar., 1969. 1♀: Phuntsholing, *c* 610 m., W. Bhutan; 20 Jan., 1969. 2♀♀: Gaylegphug, *c* 153 m., C. Bhutan, 11 Nov. 1967. 2♀♀: Mithangar, *c* 1525 m., E. Bhutan; 3 and 4 May 1966.

Measurements:

External	1♂	5♀♀
H. & B.	212	213, 217, 218, 230, 233
Tl.	208	182, 193, 209, 211, 222
H.F.	49	46, 49, 49, 51, 55
e.	22	19, 19, 20, 22, 22

Cranial.— 4♀♀: on. 52.5, 53.1, 54.4, 55; pal. 26, 27, 27, 27.2; nas. 15.4, 15.6, 17, 18; fr. 192, 19.4, 19.8, 20; or. 16.3, 17, 17, 18; TR. 10, 10, 10, 10.2.
Weights.— 1♂: 345 g. 4♀♀: 355 g., 365 g., 375 g., 400 g.
Mammae.—1 —1 = 4.

Dorsal hairs are basally slate gray, apically with three or four Rufous annulations alternating with black. Ventral pelage varies seasonally. In two specimens (1♂, 1♀) of March and January, the venter is concolorous with the dorsum. In specimens of May (1♀) and November (2♀♀) sides of the venter Ochraceous Rufous with a median longitudinal stripe which is made up of furs similar to those of the back. The other May specimen (1♀) appears to be moulting. Its venter is poorly haired and entirely Rufous. Tail tip black but in the two specimens from Gaylegphug there are also a few white hairs mixed with the black ones. Muzzle and inner border of ear distinctly Rufous in all the specimens.

Baculum consists of two parts, a slightly bend rod-like shaft or capsulus of about 21.5 mm. long and a sharp blade or lamina about 8.8 mm. long, attached to the shaft only at the distal part (Text-fig. 1a).

A May specimen from Mithangar was pregnant; its uterus contains two embryos at very early stage of development.

Bonnhote (1901) described *bhutanensis* with the forehead Rufous and similar in coloration to the underparts. Robinson and Kloss (1918), and Ellerman (1963) without having sufficient material regarded it as a doubtful subspecies. They were not sure whether reddish face was a good character or individual or seasonal variation. Moore and Tate (1965) regarded the type of *bhutanensis* as an intergrade between *C. e. erythrogaster* (Blyth) and *C. crumpi* Wroughton, and placed *C. crumpi* as a synonym of *bhutanensis*. From the present material it is obvious that Rufous face is a constant and, therefore, sufficiently good character to accept *bhutanensis* as a distinct subspecies. From an examination of one specimen of *C. crumpi* present in the Zoological Survey of India and from the description given by Ellerman (1963), it becomes obvious that *C. crumpi* differs from *bhutanensis* by having brownish dorsal pelage, lighter tail tip, dark belly, slightly smaller frontal (18.7–19.1 *vs.* 19.8–20) and orbit (16–16.3 *vs.* 16.8–18). In all the above-mentioned external features *C. crumpi* comes closer to *C. caniceps* (Gray). I would, therefore agree with Ellerman (1963) in treating *C. crumpi* separate from *bhutanensis* and considering it as a subspecies of *C. caniceps*.

This squirrel is very common in the forest floor and prefers shelter behind the bushes.

Collosciurus pygerythrus lokroides (Hodgson)
(The Hoary bellied Himalayan Squirrel)

1836. *Sciurus lokroides* Hodgson, *J. Asiat. Soc. Beng.*, **5** : 232.
1867. *Macrozus similis* Gray, *Ann. Mag. nat. Hist.*, **20** : 281.
1947. *Callosciurus pygerythrus lokroides*, Ellerman, *J. Mammal.*, **28** : 266.

Material.—2♂♂: Gaylegphug *c* 153, m., *C.* Bhutan; 13 Nov., 1967.

Measurements:

External.— 2♂♂: H. & B. 162, 172; Tl. 148, 174; H.F. 39, 41; e. 18, 19.

Cranial.— 2♂♂: on. 43.5, 46.3; pal. 21.3, 22.9; nas. 12.3, 13; fr. 15, 15; or. —, 15; TR. —, 8.9.

Weights.— 2♂♂: 117 g., 188 g.

Hip patches which are usually met with in this subspecies, are not visible in the present specimens from the dorsal side, but ventrally two distinct reddish areas can easily be marked. General coloration is similar to the description given by Moore and Tate (1965) with the following variations:

Hands, feet and forehead are darker than back; a light brownish streak extending from the throat to the hindermost part of the belly, is present in the venter of one specimen.

This is the most common arboreal as well as ground squirrel of Bhutan.

Tamiops macclellandi macclellandi (Horsfield)
(The Himalayan Striped Squirrel)

1839. *Sciurus macclellandi* Horsfield, *Proc. zool. Soc. Lond.*: 152.
1842. *Sciurus pembertonii* Blyth, *J. Asiat. Soc. Bengal.*, **11** : 887.
1900. *Sciurus macclellandi manipurensis* Bonhote, *Ann. Mag. nat. Hist.*, **5** : 51.
1965. *Tamiops macclellandi macclellandi:* Moore and Tate, *Fieldiana, Zool.*, **48** : 237.

Material.—2♂♂: Susuna, Ha Road, *c* 2350 m., W. Bhutan, 10 Feb., 1969. 1♀ : 18 km. N.E. of Simtokha, *c* 3200 m., W. Bhutan; 23 Feb., 1969. 1♂, 1♀: Shamgong, *c* 1960 m., C. Bhutan; 3 and 4 Dec., 1967. 1♂: Bulfai, *c* 2800 m. E. Bhutan; 30 Mar. 1966. 1♂: Gomchu, *c* 2500 m. E. Bhutan; 7 Apr., 1966. 1♀: Kaling *c* 2200 m. E. Bhutan; 11 Apr. 1966.

Measurements:

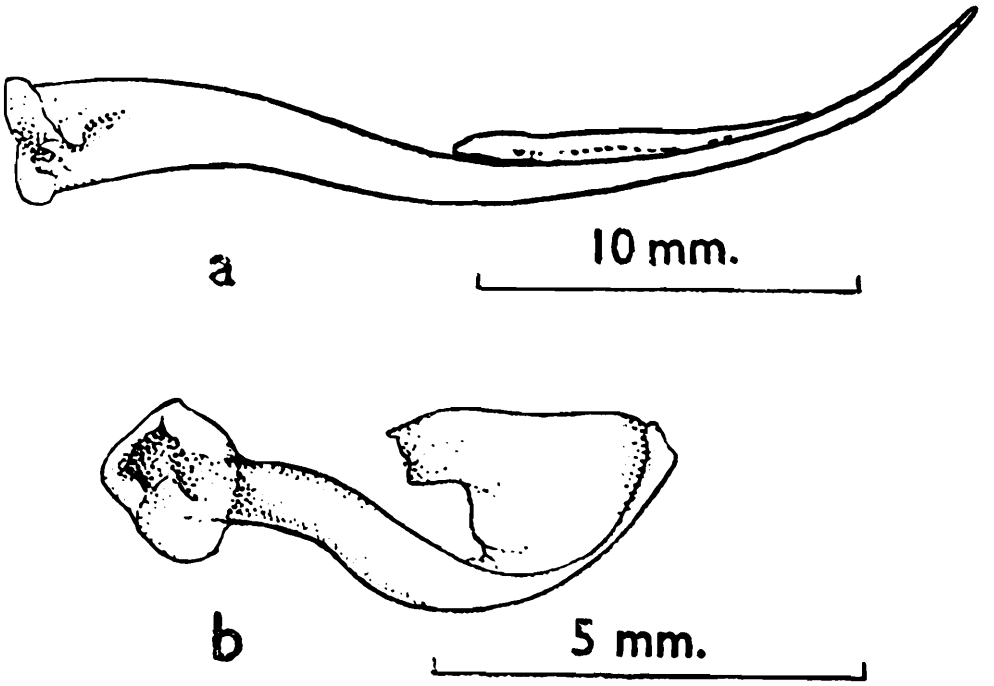
External.—	5♂♂	3♀♀
H. & B.	116, 117, 120, 120, 120	103.5, 111, 125
Tl.	91, 95, 98, 103, 104	93, 102, 110
H.F.	18(?), 24, 27, 27, 28	26.5, 27.5, 27.5
e.	12, 12.5, 13, 14, 14	11.5, 13, 13.

Cranial.—	3♂♂	1♀
on.	32.2, 32.9, 33.1	34
pal.	15.5, 15.5, 16	15.4
nas.	9, 9.1, 9.2	9
fr.	11.9, 12, 12.2	12.3
or.	8.8, 9.6, 10	10.2
TR.	5.2, 5.2, 6	6

Weights.— 4♂♂: 52 g., 54 g., 54 g., 59 g. 1♀: 64 g.

External features fit in well with the description given by Ellerman (1963).

Baculum is a curved hook like structure, made up of a bend shaft, at the distal end of which a thin triangular blade is attached. The shaft is slightly swollen at the base (Fig. 1b).



TEXT-FIG. 1(*a*). Baculum of *Callosciurus erythraeus bhutanensis*
(*b*). Baculum of *Tamiops macclellandi macclellandi*.

It may not be out of place to discuss the status of the genus *Tamiops* Allen. It was treated as a subgenus of *Funambulus* Lesson by Zahn quoted by Moore and Tate (1965) and of *Callosciurus* Gray by Osgood

(1932), Ellerman (1940) and Simpson (1945). The question was recently re-examined by Moore and Tate (1965), and they have shown that *Tamiops* have enough distinguishing characters from allied genera to be honoured with a generic rank. The present study reveals that the structure of baculum is also very different from that of both *Funambulus* and *Callosciurus*. I have, therefore, no hesitation in concurring with Moore and Tate (1965).

Dremomys lokriah bhotia Wroughton

(The Orange-bellied Himalayan Squirrel)

1916. *Dremomys lokriah bhotia* Wroughton, *J. Bombay nat. Hist. Soc.*, **24** : 425. Sedonchen, Sikkim.

Material.—1♂: *c* 36 km. from Simtokha on Wangdu Phodrang Road, Menchuna Valley, *c* 2377 m., W. Bhutan; 26 Feb., 1969. 1♀: Chasilakha, *c* 1860 m., W. Bhutan; 1 Feb., 1969. 1♀: Susuna, Ha Road, *c* 2350 m., W. Bhutan; 11 Feb., 1969. 1♂: Panjurmane, *c* 1525 m., C. Bhutan; 12 Dec., 1967. 3♀♀: Gomchu, *c* 2500 m., E. Bhutan; 8 and 12 Apr., 1966.

Measurements:

External.—	2♂♂	5♀♀
H. & B.	177, 189	160, 173, 175, 175, 205.
Tl.	134, 142	114, 115, 120, 130, —.
H.F.	41, 46	38, 40, 40, 46, —.
e.	20, 22	18, 19, 19, 20, 23.
Cranial.—	1♂	4♀♀
on.	51	47, 47.6, 48.5, 51.5
pal.	24.3	23, 23.4, 23.8, 26.
nas.	15.6	14.1, 14.2, 14.5, 17.
fr.	14.8	14.5, 14.5, 14.5, 16.5
or.	15	14, 14.5, 14.6, 14.8.
TR.	8.4	8.2, 8.2, 8.3, 8.8.

Weights: 1♂: 200 g. 5♀♀: 139 g., 148. g., 150 g., 172 g., 260 g.
Mammae: 1—1—1 = 6.

General colour of back is dark olive. Individual hair is slate black at base, and apically having three or four olivaceous annulations alternating with black. A few entirely white hairs are not uncommon. Feet blackish.

The palate of the female specimen from Chasilakha is more than half of the occipitonasal length, which is very unusual for this species.

Wroughton's (1916) *D. l. bhotia* from eastern Sikkim, was synonymized with *D. l. lokriah* (Hodgson) by Ellerman (1947), and this treatment was supported by Moore and Tate (1965). The present specimens as well as two from Bhuntang, Sikkim when compared with five specimens of Central Nepal present in the Zoological Survey of India, are found to be distinctly darker and olivaceous against the browner pelage of the specimens of Nepal. Moreover, the colour of foot is brownish in *D. l. lokriah* but blackish in *D. l. bhotia*. I would, therefore, accept *bhotia* as a distinct subspecies. Here it will be worthwhile to mention that, Palmajua, Darjeeling, West Bengal, though geographically nearer to Sikkim, five specimens (3♂♂, 2♀♀) of June and July from that

area present in the Zoological Survey of India, collection are similar to the specimens of *D. l. lokriah* from Central Nepal.

The genus *Dremomys* Heude is generally separated from *Callosciurus* Gray by the length of its nasal being greater than that of frontal. Ellerman (1963) stated that the length of nasal in *Dremomys* is often subequal to frontal, and in two out of 24 measurable skulls it is actually shorter. In the present series from Bhutan also two specimens out of five have nasal shorter than frontal. This character should not therefore, be given much importance.

This species is often met with on the floor of mixed, wet forest. Its individuals congregate at dusk and then break up into groups of seven or eight. Its call sounded somewhat like 'Chikwik. .Kwik. Chikwik' A female taken in February from Chasilakha was lactating.

Ratufa bicolor gigantea (McClelland)

(The Large Malay Squirrel)

1839. *Sciurus giganteus* McClelland, *Proc. zool. Soc. Lond.,*: 150.
1849. *Sciurus macruroides* Hodgson, *J. Asiat. Soc. Beng.*, **18** : 775.
1923. *Ratufa gigantea stigmosa* Thomas, *J. Bombay nat. Hist. Soc.*, **29** : 86.
1947. *Ratufa bicolor gigantea*, Ellerman, *J. Mammal.*, **28** : 260.

Material.—1♂: Chasilakha, *c* 1860 m., W. Bhutan; 5 Feb., 1969. 1♂: Panjurmane, *c* 1525 m., C. Bhutan; 8 Dec., 1967. 1♀: Shamgong, *c* 1960 m., C. Bhutan; 3 Nov., 1967. 1♀: Batase, *c* 1433 m., C. Bhutan; 17 Nov. 1967. 1♀: Langsaran, *c* 1250 m., E. Bhutan; 3 May 1966.

Measurements:

External.— 2♂♂: H. & B. 371, 379; Tl. 482, 501; H.F. 74, 78; e. 33, 35. 3♀♀: H. & B. 362, 390, 405; Tl. 422, 440, 481; H.F. 77, 80, 87; e. 27, 34, 37.

Cranial.— 2♂♂: on. 73.5, 76.1; pal. 31.8, 34; nas. 22.1, 22.1; fr. 29.2, 30; or. 25, 26.4; TR. 14, 14.3. 2♀♀: on. 76, 78; pal. 33.1, 33.8; nas. 23, 24; fr. 31, 31.5; or. 26.8, 27; TR. 14.4, 15.

Mammae: 2—1 = 6.

Tail tip brown with a little admixture of white. The fleshy part of the tail tip of the specimen from Langsaran was abnormally swollen, presumably an after-effect of some earlier injury.

Family Muridae

Rattus rattus brunneusculus (Hodgson)

1845. *Mus brunneusculus* Hodgson, *Ann. Mag. nat. Hist.*, **15** : 267.
1919. *Rattus rattus sikkimensis* Hinton, *J. Bombay nat. Hist. Soc.*, **26** : 394.
1947. *Rattus rattus brunneusculus*, Ellerman, *J. Mammal.*, **28** : 380.

Material.—2♀♀: Wangdu Phodrang, Punakha Valley, *c* 1372 m., W. Bhutan; 23 and 24 Feb., 1969. 1 subad. ♂: Gaylegphug, *c* 153 m., C. Bhutan; 9 Nov. 1967.

Measurements:

External.— 1 subad. ♂: H. & B. 129; Tl. 131; H.F. 29; e. 19. 2♀♀: H. & B. 166, 180; Tl. 178, 192; H.F. 32, 32; e. 22, 23.

Cranial.— 1 subad. ♂: on. 34.4; pal. 18.4; apf. 6.8; nas. 11.9; TR. 6.4; bul. 6; dia. 9. 2♀♀: on. 40, 41.5; pal. 22.4, 24.5; apf. 7, 7.9; nas. 14, 15.9; TR. 6.9, 6.9; bul. 6.8, 6.8; dia. 10.6, 11.5.

Weights.— 1 subad. ♂: 45 g. 2♀♀: 110 g., 140 g.

Tail though always longer than head and body, is somewhat shorter than that of the specimens present in the Zoological Survey of India. Compared with the measurements given by Ellerman (1963), too, my specimens have shorter tail.

In a specimen from Wangdu Phodrang the molars are worn out to such an extent that only the remnants of the first lamina of the left m^1, and the first and third laminae of the right m^1 are present.

This is the first record of *brunneusculus* from Bhutan.

Rattus rattus tistae Hinton.

1918. *Rattus rattus tistae* Hinton, *J. Bombay nat. Hist. Soc.*, **26** : 68.

Material.—3♂♂, 2 subad. ♂♂, 2 ♀♀: Wangdu Phodrang, Punakha valley, *c* 1372 m., W. Bhutan; 23 Feb. to 9 Mar., 1969. 3♂♂, 1♀: Putlibir, *c* 2103 m., W. Bhutan; 9 and 10 Mar. 1969. 1♀: Simtokha, Thimpu Valley, *c* 2408 m. W. Bhutan; 21 Feb. 1969. 1♂, 1♀, 3 subad. ♀♀ : Batase, *c* 1433 m. C. Bhutan; 18 to 20 Nov., 1967. 1♂: Tama *c* 1130 m., C. Bhutan; 26 Nov. 1967. 6♂♂, 5 subad. ♂♂, 9 ♀♀, 5 subad. : ♀♀. Shamgong, *c* 1960 m., C. Bhutan; Nov. and 1 Dec. 1967.

Measurements:

External.—	12♂♂	10♀♀
H. & B.	146, 147, 148, 150, 157, 160, 162, 162, 170, 175, 184, 190.	146, 155, 157, 173, 173, 175, 175, 178, 180, 185.
Tl.	130, 149, 151, 151, 151, 156, 166, 170, 175, 186, 194, —,	144, 145, 155, 169, 169, 175, 178, 178, 180, —.
H.F.	31, 33, 33, 34, 34, 34, 34, 34, 35, 35, 38, —.	32, 32, 33, 33, 34, 34, 35, 35, 35, 35.
e.	21, 21.5, 22, 22, 22, 22, 22, 22, 22, 23, 25, —.	21, 22, 22, 22, 22, 22, 22, 22.5, 23, 23.

Cranial.—	9♂♂	4♀♀
on.	30, 35.8, 36.1, 36.5, 37.2, 38.6, 39.5, 40.1, 44.6.	41, 43, 43, 43.3.
pla.	18.5, 19, 19.2, 19.8, 20.7, 20.8, 21.2, 22.3, 23.9.	22.4, 23.6, 23.8, 24.2.
apf.	5.2, 6, 6.1, 6.2, 6.8, 6.8, 6.8, 7.9, 8.1.	7.1, 7.6, 8, 8.

nas.	12.5, 12.8, 12.9, 13.9, 14, 14.3, 14.3, 16.2, 16.5.	15.6, 16, 18, 18.3,
TR.	6.2, 6.3, 6.3, 6.5, 6.5, 6.8, 6.8, 6.9, 7.	6.6, 6.8, 6.8, 7.
bul.	5.9, 6, 6, 6, 6, 6, 6, 6.1, 6.8.	6.2, 6.5, 6.5, 6.5.
dia.	8.4, 8.8, 9.2, 10, 10.3, 10.5, 10.8, 11.4, 12.9.	11, 11.9, 12, 12.

Weights	9 ♂♂	6 ♀♀
	30 g., 57 g., 82 g., 87 g., 100 g., 110 g., 135 g., 155 g., 210 g.	50 g., 56 g., 90 g., 140 g., 179 g., 186 g.

Mammae: 3—1—2 = 12.

This is the commonest house rat of Bhutan. In comparison with material of *tistae* in the Zoological Survey of India, fur in the present specimens is long and soft. The length of tail varies from 85.5% to 105% of the head and body length, agreeing with Ellerman's (1963) measurements but differing from those of Hinton (1918) who gave the tail length as 122% to 124%. Tail is dark and unicolored except in three specimens in which it is tipped with white. The greatest lengths of the hindfoot, occipitonasal, palatal and diastema differ somewhat from the recorded measurements in published works; these are 38, 44.6, 24.2, 12.9 respectively in my material as against 35, 42, 22.7 and 11.2 recorded in literature.

The specimens from Wangdu Phodrang and Putlibir appear to be pathological cases inasmuch as their fingers, toes, distal part of tail, and facial region are decayed much like in advanced cases of leprosy in man. In two specimens, even the nasal bones and teeth are affected.

Teats are not prominent in the females taken in November. A female taken in March from Wangdu Phodrang was pregnant.

This is the first record of *tistae* from Bhutan.

Rattus rattus tistae Hinton⇌**Rattus rattus brunneusculus** (Hodgson)

Material.—1 ♀: Batase, *c* 1438 m., C. Bhutan; 19 Nov. 1967.

Measurements:

External.— H. &. B. 182; Tl. 181; H.F. 33; e. 23.

Cranial.— on, 43; pal. 23.6; apf. 7.6; nas. 18; TR. 6.8; bul. 6.5; dia. 12.

The dark-bellied *tistae* occurs extensively with the white-bellied *brunneusculus*, so that Ellerman (1963) regarded the former as a commensal type. The present specimen is of much interest as its undersurface is dark for the greater part but with a distinct white streak along the midventral region extending from throat to anus. From the nature of the coloration of the belly it appears to be an intergrade between *tistae* and *brunneusculus*. This led me to examine 93 adult specimens of *tistae* and *brunneusculus* from Darbhanga (Bihar), Nepal, Darjeeling

(West Bengal), Sikkim, and Assam present in the Zoological Survey of India collection, in addition to those of Bhutan with a view to studying the nature of the coloration of the belly. The study reveals that considerable intergradation takes place between these two subspecies at least in the region of Nepal, Darjeeling, Bhutan and Assam (Table I).

TABLE 1.—Showing the percentage of intergrades between *Rattus rattus tistae* and *Rattus rattus brunneusculus*.

Locality	No. of specimens	White-bellied	Dark-bellied	Inter-grades	Percentage of intergrades
Darbhanga	3	0	3	0	0%
Nepal	14	10	2	2	14%
Darjeeling	46	14	27	5	11%
Sikkim	5	4	1	0	0%
Bhutan	31	2	28	1	3%
Assam	25	10	12	3	12%

Out of the 11 intergrades, the one from Bhutan has already been described. In five other specimens the undersurface is white but in the region of the chest it is dark. In two a dark stripe extends from the throat to belly. In the other three undersurface is dark but with a white streak about 70 mm. long, on the belly.

Rattus rattus brevicaudus n. subsp.

Material.—Holotype: Adult ♀; Tashigong, Manas Valley, *c.* 1800 m., E. Bhutan; 4 April, 1966; coll. B. Biswas. Skin and skull deposited in the Zoological Survey of India.

Paratypes: 3 adult ♂♂, 2 subad. ♂♂, 1 adult ♀; Tashigong, Manas Valley, *c* 1800 m., E. Bhutan; 4 Apr., 1966; coll. B. Biswas; deposited in the Zoological Survey of India.

Diagnosis.—Differs from all other known subspecies of the species by the possession of the following combination of characters: (1) Fur on the dorsal surface very long, soft, basally slate in colour, with a subterminal or terminal Orange-Ochraceous band, when subterminal there is a very narrow black terminal band. (2) Belly perfectly white. (3) Tail always shorter than head and body length (Table 2). (4) Hind-foot relatively smaller, being only 15 to 17% of the head and body length. (Table 2). (5) Mammae 8 or 10. (6) Skull moderately large, occipitonasal length more than 40 mm. (7) Bullae well developed and longer than upper tooth row (Table 2).

Rattus r. brevicaudus is allied to *R. r. brunneusculus* (Hodgson), *R. r. tistae* Hinton, *R. r. bullocki* Roonwal, *R. r. tikos* Hinton, but differs from them as follows: From *brunneusculus* by (*i*) tail being always shorter than head and body, (*ii*) length of bulla being greater than upper tooth row; from *tistae* by (*i*) the colour of the dorsal fur being Orange-Ochraceous occasionally with terminal black band, (*ii*) white belly, (*iii*) tail always shorter than head and body, (*iv*) having smaller hindfoot; from *bullocki* by (*i*) tail being always shorter than head and body, (*ii*) having smaller hindfoot; from *tikos* by (*i*) having tail always shorter than head and body, (*ii*) and shorter hindfoot.

TABLE 2.—External and Cranial measurements of five subspecies of *Rattus rattus* (Linnaeus).

Measurements	*brunneusculus*	*tistae*	*tikos*	*bullocki*	*brevicaudus*
Head and body length	14♂♂ 140—203(164) 15♀♀ 151—203(173)	17♂♂ 142—198(162) 12♀♀ 148—175(161)	9♂♂ 161—210(181) 7♀♀ 156—195(171)	40♂♂ 150—191(174) 41♀♀ 148—193(170)	3♂♂ 193—212(199) 2♀♀ 173, 183(178)
Tail length	14♂♂ 188—230(208) 15♀♀ 167—238(209)	17♂♂ 136—196(172) 12♀♀ 158—208(168)	9♂♂ 161—200(181) 7♀♀ 168—188(179)	40♂♂ 133—216(173) 41♀♀ 131—216(172)	3♂♂ 164—167(165.5) 2♀♀ 165, 168(166.5)
Percentage of tail length in relation to head and body length	14♂♂ 112—134%(121%) 15♀♀ 108—119%(116%)	17♂♂ 84—120%(106%) 12♀♀ 96—127%(108%)	9♂♂ 82—115%(102%) 7♀♀ 89—103%(105%)	40♂♂ 72—127%(100.4%) 41♀♀ 73—127%(100.5%)	3♂♂ 80—84%(82%) 2♀♀ 91%,93%(92%)
Hindfoot	14♂♂ 31—37(35.5) 15♀♀ 31—36(32.5)	17♂♂ 29—36(32) 12♀♀ 30—35(32)	9♂♂ 32—38(35.4) 7♀♀ 32—34(33)	40♂♂ 28—36(32) 41♀♀ 29—36(32)	3♂♂ 30—33(31) 2♀♀ 27.5, 31(29)
Percentage of hindfoot in relation to head and body length	14♂♂ 18—22%(19%) 15♀♀ 17—21.5%(19.2%)	17♂♂ 15—23%(19%) 12♀♀ 18—21.5%(20%)	9♂♂ 19—21%(19.5%) 7♀♀ 17—21%(19%)	40♂♂ 12—22%(19%) 41♀♀ 13—22%(18.2%)	3♂♂ 15—16%(15%) 2♀♀ 15%, 17%(16%)
Occipitonasal length	9♂♂ 38.5—43.7(42) 11♀♀ 38.5—43.5(40)	13♂♂ 36.1—44.6(39.8) 9♀♀ 38—43.3(40.5)	6♂♂ 39.6—44.3(41.7) 3♀♀ 40—41.3(40.8)	13♂♂ 37—43.5(40.3) 12♀♀ 36—43(40.1)	3♂♂ 41—41.8(41.3) 2♀♀ 40.3, 42(41.1)
Upper tooth row	9♂♂ 6.8—7.4(7.3) 11♀♀ 6.7—7.4(7)	13♂♂ 6.2—7.3(6.5) 9♀♀ 6.2—7(6.7)	6♂♂ 6.6—7.2(6.9) 3♀♀ 6.4—7(6.6)	13♂♂ 6.2—7.5(6.9) 12♀♀ 6.1—7.5(6.9)	3♂♂ 6.8—7(6.9) 2♀♀ 6.9, 6.9(6.9)
Bullae	9♂♂ 6.4—7.1(6.8) 11♀♀ 6.5—7.2(6.8)	13♂♂ 6—7.3(6.6) 9♀♀ 6.2—7.4(6.9)	6♂♂ 6.9—8(7.3) 3♀♀ 7.2—8(7.5)	13♂♂ 6.6—8.5(7.4) 12♀♀ 6.6—7.7(7.2)	3♂♂ 6.9—7.4(7.2) 2♀♀ 6.9, 7.3(7.1)

Measurements of holotype:

External.— H. & B. 183; Tl. 168; H.F. 31; e. 24.
Cranial.— on. 42; pal. 22.5; apf. 6.1; nas. 16.6; TR. 6.9;bul. 7.3; dia. 11.

Rattus niviventer ? niviventer (Hodgson)
(The White-bellied Rat)

Material.—1♂: Susuna, Ha Road, *c* 2350 m., W. Bhutan; 11 Feb. 1969.

Measurements:

External.— H. & B. 139; Tl. 182; H.F. 25; e. 26.
Cranial.— on. 37; pal. 17.6; apf. 6; nas. 13.8; TR. 6.1; bul. 5; dia. 9.

Colour of the back cold gray with a certain admixture of brown, and not black as mentioned by Ellerman (1963). The specimen is somewhat large for this subspecies, and in both external and cranial measurements appears closer to *R. n. mentosus* Thomas. However, it has provisionally been placed under *niviventer* on geographical consideration.

The present specimen constitutes the first record of *R. niviventer* from Bhutan.

Rattus nitidus nitidus (Hodgson)
(The Himalayan Rat)

1845. *Mus nitidus* Hodgson, *Ann. Mag. nat. Hist.*, **15** : 267.
1845. *Mus pyctoris* Hodgson, *Ann. Mag. nat. Hist.*, **15** : 267.
1845. *Mus horeites* Hodgson, *Ann. Mag. nat. Hist.*, **15** : 268.
1849. *Mus aequicaudalus* Hodgson, *Ann. Mag. nat. Hist.*, **3** : 203.
1947. *Rattus nitidus nitidus:* Ellerman, *J. Mammal.*, **28** : 378.

Material.—1 subad. ♂, 1♀: Mithangar, *c* 1525 m., E. Bhutan, 3 May 1966.

Measurements:

External.— 1♀: H. & B. 175; Tl. —, H.F. 33; E. 22.
Cranial.— 1♀: on. 44; pal. 24; apf. 7.5; nas. 17; TR. 6.2.
Weights.— 1♂: 55 g. 1♀: 148 g.
Mammae: 1—2—1—2 = 12.

The subadult specimen is darker than the adult and the coloration of its sides are not well marked from the ventral surface.

This is the first record of *R. nitidus* from Bhutan.

Mus pahari jacksoniae (Thomas)
(The Sikkim Mouse)

1921. *Leggada jacksoniae* Thomas, *J. Bombay nat. Hist. Soc.*, **27** : 596.
1947. *Mus pahari jacksoniae:* Ellerman, *J. Mammal.*, **28** : 382.

Material.—1♂: Putlibir, *c* 2103 m., W. Bhutan; 9 Mar. 1969.

Measurements:

External.— H. & B. 83; Tl. 82; H.F. 19; E. 16.5.
Cranial.— on. 23.6; pal. 11.6; apf. 4; nas. 8.5; TR. 3.5; bul. 3.4; dia. 6.1.

Ellerman (1963) stated that the fur in this species is bristly and spiny, but in the present specimen the fur is long and soft.

Diastema long, more than one-fourth of the occipitonasal length.

This is the first record of this species from Bhutan.

Observations on other species

The Assamese Macaque (*Macaca assamensis* McClelland): A troop comprising of about 20 adults with a few young ones clinging to their mothers was noticed in the forest near Shamgong.

The Asiatic Black Bear (*Selanarctos thibetanus* (G. Cuvier)): Footprints and faecal matters were seen at Shamgong. Its call was heard in the evening at Shamgong, Panjurmane and Ganglakha.

The Leopard (*Panthera pardus* (Linnaeus)): Its pug-marks were noticed in the dry bed of Ai river at Gaylegphug.

The Yellow-throated Marten (*Martes flavigula* (Boddaert)): A pair was seen at the base of an Oak tree near Susuna. At the sight of the party they jumped away inside the thick forest.

The Sambar (*Cervus unicolor* Kerr): Footprints were seen almost everywhere.

The Bharal (*Pseudois nayaur* (Hodgson)): A single animal was seen at dusk in a hill slope near Shamgong.

The Indian Elephant (*Elephas maximus* Linnaeus): Footprints and faecal matters were seen in the forests in Gaylegphug and Ganglakha.

Summary

An account of the mammalian fauna of Bhutan based mainly on the collections from western, central and eastern Bhutan made by the Zoological Survey of India parties during 1966, 1967, 1969 is given. The present account includes report on 104 specimens comprising of 20 species and subspecies, together with those seen in the field but not collected.

Taxonomic status of three species and subspecies, *Petaurista magnificus* (Hodgson), *Callosciurus erythraeus bhutanensis* (Bonhote), *Dremomys lokriah bhotia* Wroughton, and of the genus *Tamiops* Allen have been discussed.

A new subspecies of *Rattus rattus* (Linnaeus) has been described, which can be differentiated from all its nearest allies by its tail being always shorter than head and body, and by several other features.

Intergradation between *Rattus rattus tistae* Hinton and *Rattus rattus brunneusculus* (Hodgson) has been reported.

Structure of bacula of *Callosciurus erythraeus bhutanensis* (Bonhote) and *Tamiops macclellandi macclellandi* (Horsfield) have been described. Variations in coloration, size, etc., have been reported in a number of forms.

Field observations on several species of mammals have been included.

Altogether 11 species are recorded for the first time from Bhutan.

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My sincere thanks are due to Dr. A. P. Kapur, the Director, Zoological Survey of India, for providing me facilities for this work, and to Dr. B. Biswas for valuable suggestions and going through the manuscript. I am also indebted to Dr. K. K. Tiwari, Dr. V C. Agrawal, Dr. A. K. Mandal, Shri S. S. Saha and Shri M. Sengupta for many valuable suggestions.

REFERENCES

ANDERSEN, K. 1912. *Catalogue of the Chiroptera in the Collection of the British Museum*, I, Megachiroptera. Brit. Mus., London.

BHAT, H. R. 1968. *Sphaerias blanfordi* (Thomas, 1891) from Himalayan region of Uttar Pradesh: An addition to the Chiroptean fauna of India.—*J. Bombay nat. Hist. Soc.*, **65** (2): 471–473.

BISWAS B. 1966. Authorship of the name *Presbytis geei* (Mammalia : Primates). *J. Bombay nat. Hist. Soc.*, **63**(2) : 429-431.

BLANFORD, W. T 1888-1891. *The fauna of British India*, Mammalia. Taylor and Francis, London.

BLYTH, E. 1842. Report of the Curator, Museum of the Asiatic Society of Bengal.—*J. Asiat. Soc. Beng.*, **11** : 880–891.

BONHOTE, J. L. 1901. On the squirrels of the *Sciurus erythraeus* group.—*Ann. Mag. nat. Hist.*, (7) **7** : 160–167.

ELLERMAN, J. R. 1940. *The families and genera of living rodents*. **1.** Brit. Mus., London.

ELLERMAN, J. R. 1947. A key to the Rodentia inhabiting India, Ceylon, and Burma, based on the collections in the British Museum.—*J. Mammal.*, **28** (3-4): 249–278 & 357–386.

ELLERMAN, J. R. 1961 1963. *The fauna of India including Pakistan, Burma and Ceylon*. Mammalia, **3** [Rodentia]. Govt of India, Delhi.

ELLERMAN, J. R. and MORRISON-SCOTT, T C. S. 1951. *Checklist of Palaearctic and Indian mammals*. Brit. Mus., London.

GEE, E. P. 1961. The distribution and feeding habits of the Golden Langur, *Presbytis geei* Gee (Khajuria, 1956).—*J. Bombay nat. Hist. Soc.*, **58** (1): 1–12.

GRAY, J. E. 1842. Descriptions of some new genera and fifty unrecorded species of Mammalia.—*Ann. Mag. nat. Hist.*, **10** : 255–267.

HINTON, M. A. C. 1918. Scientific results from the Mammal Survey, No. 18. Report of the House Rats of India, Burma and Ceylon.—*J. Bombay nat. Hist. Soc.*, **26** (1): 59–88.

HOLMES, J. R. S. 1970. Himalayan Tanr, *Hemitragus jemlahicus* (H. Smith, 1826) in Bhutan.—*J. Bombay nat. Hist. Soc.*, **67** (1): 106.

KHAJURIA, H. 1952. Taxonomic studies on some Indian Chiroptera.—*Rec. Indian Mus.*, **50** : 113–128.

KHAJURIA, H. 1956. A new Langur (Primates: Colobidae) from Goalpara district Assam.—*Ann. Mag. nat. Hist.*, (12) **9** : 86–88.

MOORE, J. C. and TATE, G. H. H. 1965. A study of the diurnal squirrels, Sciurinae, of the Indian and Indochinese subregions.—*Fieldiana, Zool.*, **48** : 1–351.

OSGOOD, W. H. 1932. Mammals of the Kelley—Roosevelts and Delacour Asiatic expeditions.—*Field, Mus. Pub. Chicago Zool.*, **18** : 193–339.

PEMBERTON, R. B. 1839. *Report on Bootan.* Bengal Military Orphan Press, Calcutta. (Reprinted 1961).

POCOCK, R. I. 1939. *The fauna of British India*, Mammalia, 1. Taylor and Francis, London.

POCOCK, R. I. 1941. The fauna of British India, Mammalia, 2. Taylor and Francis, London.

RIDGWAY, R. 1886. *Nomenclature of colors.* Little Brown & Co., Boston.

ROBINSON, H. C. and KLOSS, C. B. 1918. A nominal list of the Sciuridae of the Oriental region with a list of specimens in the collection of the Zoological Survey of India.—*Rec. Indian Mus.*, **15** : 171–254.

ROONWAL, M. L. 1949. Contributions to the fauna of Manipur State, Assam. Part 3. Mammals with special reference to the family Muridae (Order Rodentia).—*Rec. Indian Mus.*, **47** : 1–64.

SIMPSON, G. G. 1945. The principles of classification and a classification of Mammals. *Bull. Am. Mus. nat. Hist.*, **85** : 1–350.

WAYRE, P. 1968. Some observations on the Golden Langur *Presbytis geei* (Ms. Khajuria) Gee.—*J. Bombay nat. Hist. Soc.*, **65** (2): 473–477.

WROUGHTON, R. C. 1911. Oriental Flying Squirrels of the "*Pteromys*" group.—*J. Bombay nat. Hist. Soc.*, **20** (4): 1012–1023.

WROUGHTON, R. C. 1916. Scientific results from the Mammal Survey. No. 13G. New Rodents from Sikkim.—*J. Bombay nat. Hist. Soc.*, **24** (3): 424–430.

Rec. zool. Surv. India, **68**: 21-31, 1975

A NEW FAMILY OF CHALCIDOIDEA (INSECTA: HYMENOPTERA)

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(with 4 text-figures)

EURYISCHIDAE fam.n.

The present author proposes a new family Euryischidae based on the genus *Euryischia* Riley. This genus was erected by Riley (1889) and retained in the subfamily Elasminae of the family Chalcididae. Ashmead (1900) erected the genus *Myiocnema* and placed it in the subfamily Aphelininae. The same author (1904) placed *Euryischia* in the family Elasmidae.

Howard (1907), Mercet (1912) and Girault (1915) accepted Ashmead (1900) by retaining the genus *Myiocnema* in Aphelininae.

Girault (1912) considers doubtful the inclusion of the genus *Euryischia* in the family Elasmidae. Nevertheless, he accepted Ashmead's placing of this genus in Elasmidae and said "neither the insect nor its original description is accessible to me" He (1913) considers *Euryischia* to be undoubtedly an Encyrtid and credited the genus to Howard instead of Riley. The same author (1914) erected the genus *Euryischomyia* and placed it in Elasmidae.

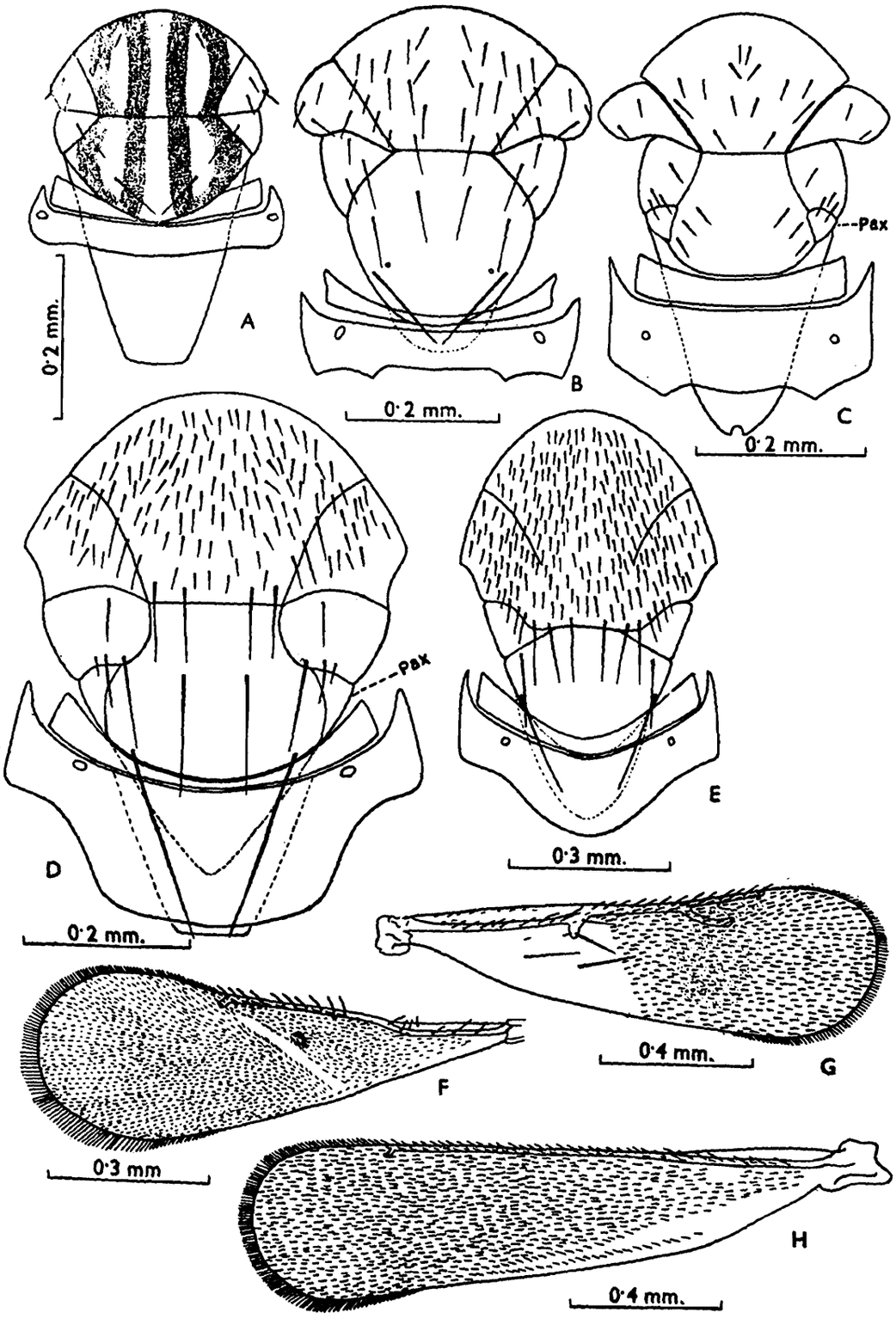
Girault (1916) after examination of the typegenus of *Myiocnema* declared it to be a synonym of *Euryischia*. He credited the genus *Euryischia* to Koebele.

Smith and Compere (1928) published a letter written by A. B. Gahan, in which Gahan said "*Euryischia*, however, is surely elasmid and *Myiocnema* is just as surely closely related to *Euryischia*, although the latter apparently forms a connecting link between the Elasmidae and the aphelinines"

Compere (1947) suggested that "*Myiocnema*, as well as *Euryischia* Riley, are out of place in the ELASMIDAE, since both of these genera resemble *Aphelinus* Dalman much more closely than they do with *Elasmus* Westwood"

Ghesquière (1955) placed *Euryischia* Riley, *Myiocnema* Ashmead, *Eriaporus* Waterston and *Eunotiscus* Compere in his newly proposed subfamily Eriaporinae of Aphelinidae. Ferrière (1965), Burks (1965) and Riek (1966) accepted Compere (1947) and Ghesquière (1955) in retaining these genera in the family Aphelinidae.

Keeping in view the diagnostic keys to the families of Chalcidoidea proposed by Mani (1938), Nikol'skaya (1952), Brues et al (1954) and Peck et al (1964), the genus *Euryischia* runs near the family Elasmidae. However, it differs from this family in having (*i*) 5-jointed tarsi, (*ii*) Post axilla, (*iii*) Complete parapsidal furrows, (*iv*) Fore wings with well



Text-fig. 1.—(A-E) Thoracic dorsum of (A) *Syediella* Shafee; (B) *Eriaporus* Waterston; (C) *Euryischomyia* Girault; (D) *Euryischia* Riley; (E) *Elasmus* Westwood; (F-H) Fore wings of (F) *Syediella* Shafee; (G) *Euryischia* Riley (H) *Elasmus* Westwood *Pax, Post axilla.*

developed costal cell, submarginal, marginal, postmarginal and stigmal veins, (*v*) Fore tibiae with curved spur, (*vi*) Tridentate mandibles and (*vii*) Male antennae unbranched.

In Vierek's (1916) and Essig's (1954) keys to the families of Chalcidoidea, the genus *Euryischia* runs near the family Aphelinidae. However, it differs from this family having (*i*) Post axilla, (*ii*) hind coxae much compressed and disc-like, (*iii*) hind tibiae with two long and thick spurs at apex and with a row of thick setae on the outer margin, (*iv*) fore wings with well developed costal cell, submarginal, marginal, postmarginal and stigmal veins and (*v*) much broad propodeum.

In the Comstock's (1954), Imms (1957) and Borror et al (1963) keys to the families of Chalcidoidea, the genus *Euryischia* neither falls in the family Elasmidae nor in Aphelinidae owing to some special characters for which a new family Euryischidae is proposed and placed between the families Aphelinidae and Elasmidae.

The genera *Myiocnema* Ashmead and *Euryischomyia* Girault are placed in the new family Euryischidae for having (*i*) Coarse setae on the body, (*ii*) complete parapsidal furrows, (*iii*) Post axilla, (*iv*) broad propodeum, (*v*) fore wings with well developed costal cell, submarginal, marginal, postmarginal and stigmal veins, (*vi*) hind coxae and femora enlarged, (*vii*) hind tibiae with thick setae on outer margin and (*viii*) antennae 8-segmented, excluding the ring segments.

The new family Euryischidae is characterised as follows :

Body black and covered with coarse setae; mandibles (Text-figs. 3B & 4C) tridentate; antennae (Text-figs. 3D & 4E) 8-segmented, excluding the ring segments; thorax with complete parapsidal furrows; post axilla (Text-figs. 1C, *Pax* & 1D, *Pax*) present; propodeum broad; fore wings (Text-fig. 1G & 4A) with well developed costal cell, submarginal, marginal, postmarginal and stigmal veins; fore tibiae with curved spur; middle tibiae (Text-fig. 3H) with long spur; hind coxae enlarged or much compressed and disc-like; hind femora and tibiae usually compressed; hind tibiae usually with two long spurs and with a row of thick setae on outer margin (Text-figs. 2C & 2D); all tarsi 5-jointed; abdomen longer than thorax, flat above and keeled below; ovipositor slightly exserted.

Type-genus, *Euryischia* Riley

Key to subfamilies and genera of EURYISCHIDAE fam. n. *based on females.*

1. Hind coxae normal, not compressed and disc-like; hind femora and tibiae normal; propodeum uniformly broad ; hind tibiae with 1-2 short and weak spurs. .. .. .MYIOCNEMINAE sub fam. n.

—Hind coxae much compressed and disc-like; hind femora and tibiae compressed; propodeum much dilated in middle; hind tibiae with two long and thick spurs. EURYISCHINAE subfam. n.. .. ..*Euryischia* Riley, 1889

—Mandibles with two teeth and a truncation; maxillary and labial palps 3 and 2-segmented respectively; antennae with three ring segments; club shorter than funicle; fore wings with a large discoidal infuscated patch beneath the marginal vein; apex of submarginal vein much dilated bearing two long setae; a long seta beneath the submarginal vein; hind tibiae with two spurs. ... .*Myiocnema* Ashmead, 1900

—Mandibles with one tooth and a truncation; maxillary and labial palps each 2-segmented; antennae with two ring segments; club longer than funicle; fore wings with a broad transverse infuscated band beneath the marginal and postmarginal veins; apex of submarginal vein not much dilated, bearing two short setae; hind tibiae with one spur. .*Euryischomyia* Girault, 1914

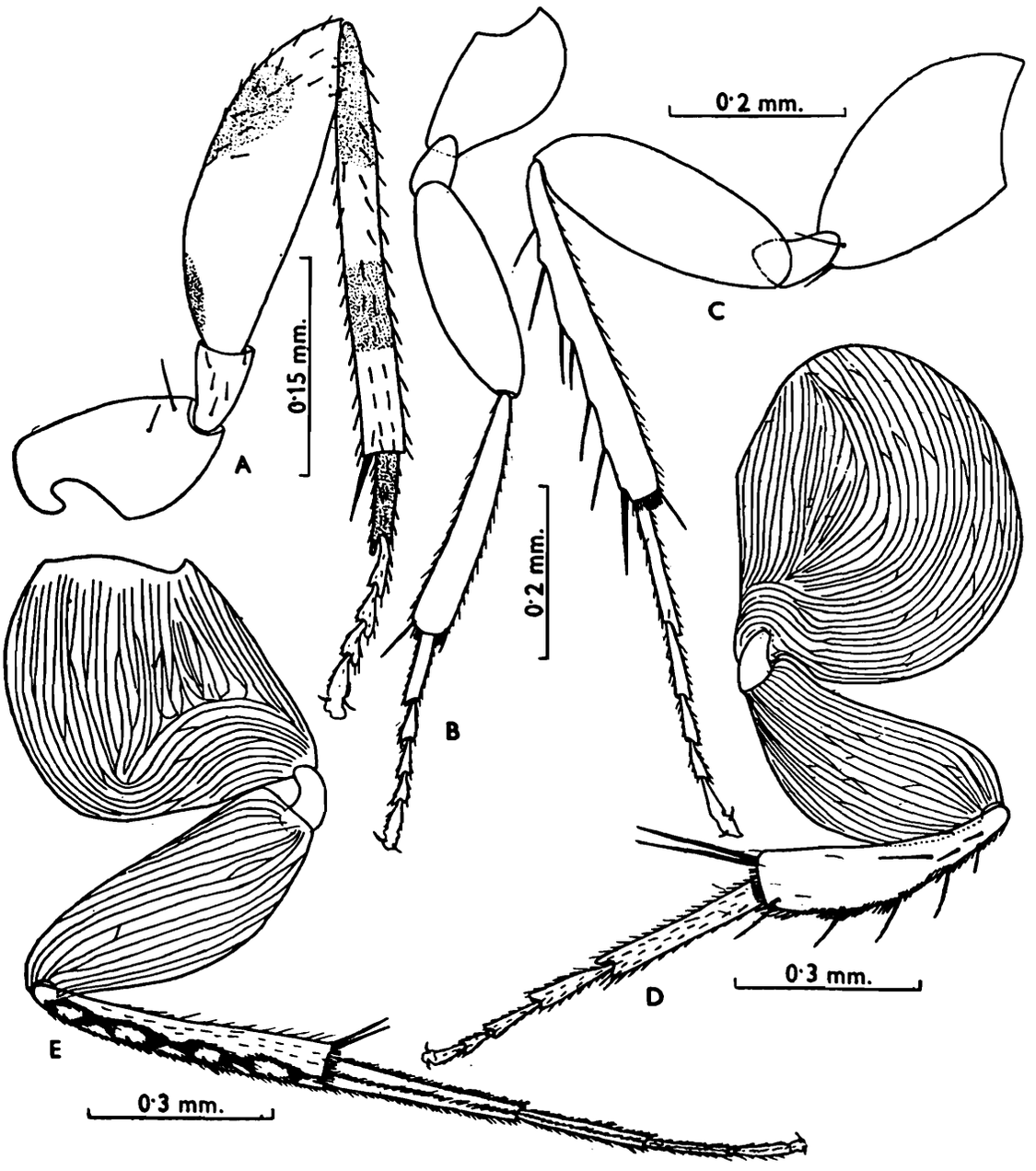
EURYISCHINAE subfam.n.

Type-genus, *Euryischia* Riley, 1889

The genus *Euryischia* is characterised as follows:

Female

Body black, covered with coarse setae; head (Text-fig. 3A) wider than long in facial view; mandibles (Text-fig. 3B) with two teeth and a truncation; maxillary and labial palps (Text-fig. 3C) 3 and 2-segmented respectively; antennae (Text-fig. 3D) 8-segmented, excluding the ring segment; pronotum (Text-fig. 3E) with posterior margin straight; mesoscutum with well developed parapsidal furrows; axillae widely separated; post axillae (Text-fig. 1D, *Pax*) present; scutellum with four long setae; postscutellum well developed; propodeum much dilated in middle; fore wings (Text-fig. 1G) with well developed costal cell, submarginal, marginal, postmarginal and stigmal veins; fore tibiae with curved spur; middle tibial spur (Text-fig. 3H) about as long



Text-fig. 2(A-E).—Hind legs of (A) *Syediella* Shafee; (B) *Eriaporus* Waterston; (C) *Euryischomyia* Girault; (D) *Euryischia* Riley; (E) *Elasmus* Westwood.

as basitarsus; hind coxae much compressed and disc-like; hind femora and tibiae compressed; hind tibiae with two long and thick spurs and also with a row of thick setae on outer margin (Text-fig. 2D); all tarsi 5-jointed; abdomen slightly longer than thorax, flat above and keeled below; ovipositor slightly exserted; middle of anterior margin of subgenital plate (Text-fig. 3I) cone-like and connected with the central notch of posterior margin by a narrow longitudinal groove; third valvulae (Text-fig. 3J) distinct.

Euryischia indica Mani and Kurian

(Text-figs. 1D, G; 2D; 3A-K)

Female

Head (Text-fig. 3A).—Black, with coarse setae, wider than long in facial view; frontovertex wider than long; ocelli arranged in obtuse angled triangle, basal ocellus removed by slightly more than its diameter from eye rim and less than its diameter from occipital margin; malar space longer than transverse diameter of eyes; antennae inserted below lower level of eyes; mandibles (Text-fig. 3B) with two teeth and a truncation; maxillary and labial palps (Text-fig. 3C) 3 and 2-segmented respectively.

Antennae (Text-fig. 3D).—Brownish; scape about three times longer than wide (0.12:0.04 mm); pedicel one and a half times longer than wide (0.06:0.04mm); a distinct ring segment present; first funicle segment slightly longer than wide; second and third funicle segments slightly wider than long; club about two times as long as wide, distinctly shorter than funicle.

Thorax (Text-fig. 1D).—Black, with coarse setae; pronotum (Text-fig. 3E) with posterior margin straight, bearing 13 pairs of setae; scutum and parapside profusely setose; scutellum with two pairs of long setae; postscutellum well developed.

Fore wings (Text-fig. 1G).—Hyaline, except a small infuscated patch below the junction of marginal, postmarginal and stigmal veins; basal one third of wing naked, except two long setae; costal cell broad; apex of submarginal vein dilated and bears two long setae; marginal vein shorter than submarginal and longer than postmarginal and stigmal veins separately; postmarginal vein distinctly longer than stigmal vein (Text-fig. 3F); marginal fringe short.

Hind wings.—Hyaline, about four and a half times longer than wide; length of marginal fringe equal to one-sixth of wing width.

Fore legs (Text-fig. 3G).—Brownish-black except tibial spur and basal three tarsal segments which are yellowish brown; tibial spur slightly curved.

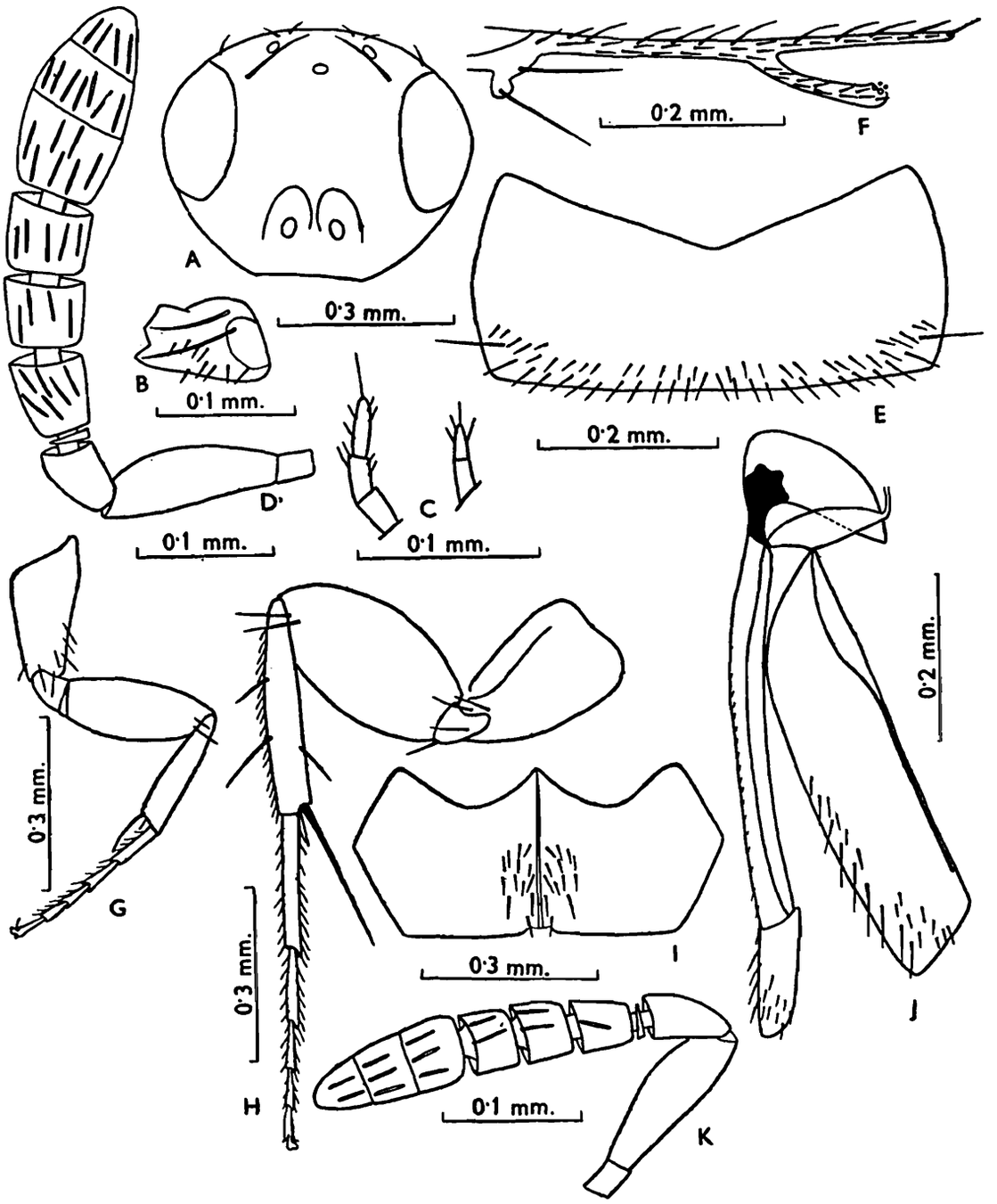
Middle legs (Text-fig. 3H).—Brownish, except tibial spur which is white; tibial spur about as long as basitarsus.

Hind legs (Text-fig. 2D).—Brownish black, except tibial spurs which are white; coxae much compressed and disc-like; femora and tibiae compressed; tibiae with two long and thick spurs and also with a row of thick setae on outer margin; basitarsus as long as following three tarsal segments combined.

Abdomen.—Black, shining, slightly longer than thorax, flat above and keeled below; ovipositor slightly exserted.

Female length: 1.77 mm.

Male. Resembles female.



Text-fig. 3(A-K).—*Euryischia indica* Mani & Kurian (A) Head facial view; (B) Mandible; (C) Maxillary and labial palps; (D) Antenna; (E) Pronotum; (F) Fore wing venation; (G) Fore leg; (H) Middle leg; (I) Subgenital plate; (J) Genitalia; (K) Male antenna.

Material examined.—20 ♀, 10 ♂, INDIA: Bihar, Darbhanga, Pusa, ex *Icerya pilosa* Green on *Saccharum officinarum* Linn., 8-11-1969 (S. Adam Shafee); 20 ♀, 5 ♂, INDIA: Andhra, Kurnool, Giddalur, ex *Icerya seychellarum* (Westwood) on *Cassia* sp., 20-2-1971 (S. Adam Shafee). Material in Zoological Museum, Aligarh Muslim University, Aligarh, India.

MYIOCNEMINAE subfam. n.

Type-genus, *Myiocnema* Ashmead
Ashmead, 1900, *Canad. Ent.* **32:** 349.
Smith & Compere, 1928, *Univ. Calif. Publ. Ent.* **4:** 301.

Euryischomyia Girault

The genus is characterised as follows:

Female (Text-fig. 4A)

Body black, covered with coarse setae; head (Text-fig. 4B) wider than long in facial view; mandibles (Text-fig. 4C) with one acute tooth and a truncation; maxillary and labial palps (Text-fig. 4D) each 2-segmented; antennae (Text-fig. 4E) 8-segmented, excluding two ring segments; pronotum (Text-fig. 4F) with posterior margin straight; mesoscutum with well developed parapsidal furrows; axillae widely separated; post axillae (Text-fig. 1C, *Pax*) present; propodeum uniformly broad; fore wings with basal one-third naked and with a broad transverse infuscated band beneath the marginal and postmarginal veins; submarginal vein long, slightly dilated at apex; marginal, postmarginal and stigmal veins well developed; fore tibial spur curved; hind coxae and femora enlarged; hind tibiae with single spur and also with a row of thick setae on outer margin (Text-fig. 2C); abdomen about as long as head and thorax combined; ovipositor slightly exserted: subgenital plate (Text-fig. 4G) with broadly rounded posterior margin; third valvulae (Text-fig. 4H) distinct, movably articulated with second valvifers. The genus is recorded for the first time from India.

Euryischomyia alami* sp.n.

(Text-figs. 4A-H)

This species is closely related to *E. washingtoni* Girault, from which it can be separated in having first funicle segment much short and distinctly wider than long; basal one-third of fore wing naked; legs except tibiae and tarsi brownish-black.

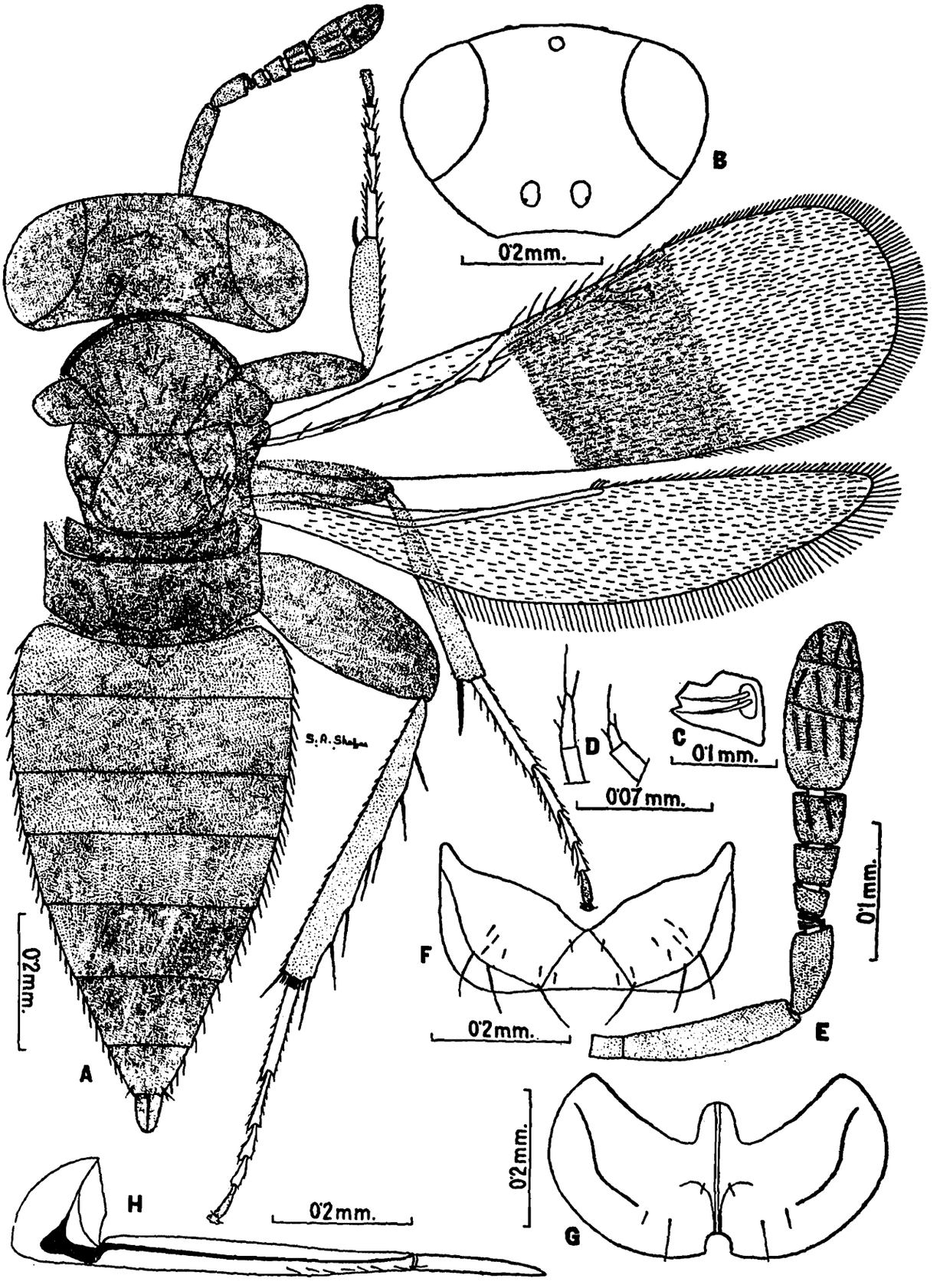
Female (Text-fig. 4A)

Head (Text-fig. 4B).—Black, with coarse setae, wider than long in facial view; frontovertex slightly wider than long; ocelli arranged in obtuse angled triangle, basal ocellus removed 2 times its diameter from eye rim, still more removed from occipital margin; mandibles (Text-fig. 4C) with one acute tooth and a broad truncation; maxillary and labial palps (Text-fig. 4D) each 2-segmented.

Antennae (Text-fig. 4E).—Dark-brown; scape cylindrical about four a half times longer than wide; pedicel slightly more than two times and longer than, as long as ring and following two funicle segments combined; two ring segments present; first funicle segment much

* Named after Prof. S. Mashhood Alam.

short and distinctly wider than long (0.025:0.019 mm); second and third funicle segments about as long as wide; club slightly more than two times longer than wide, distinctly longer than funicle.



Text-fig. 4(A-H).—*Euryischomyia alami* sp.n. (A) Entire female; (B) Head facial view; (C) Mandible; (D) Maxillary and labial palps; (E) Antenna; (F) Pronotum; (G) Subgenital plate; (H) Genitalia.

Thorax.—Black; pronotum (Text-fig. 4F) with posterior margin straight, bearing 6 long setae; mesoscutum with 7 pairs of setae; each axilla and parapside with 4 and 2 setae respectively; post axilla naked; scutellum with 3 pairs of setae; propodeum uniformly much broad.

Fore wings.—Slightly less than three times longer than wide; basal one-third naked; broad transverse infuscated band present beneath the marginal and postmarginal veins; costal cell broad; submarginal vein long and slightly dilated at apex; marginal vein slightly less than half of submarginal and distinctly longer than postmarginal and stigmal veins separately; marginal fringe spaced by a distance equal to one-sixth their length.

Hind wings.—Hyaline, about five times longer than wide; length of marginal fringe equal to one-third of wing width and are spaced by a distance equal to one-fifth their length.

Legs.—Coxae, trochanters, femur and pretarsus dark-brown; tibiae and basal four tarsal segments yellowish-brown; hind coxae and femora enlarged; hind tibiae with single spur and also with a row of thick setae on outer margin.

Abdomen.—Black with slight metallic reflections and about as long as head and thorax combined; ovipositor slightly exserted.

Female length: 1.48 mm.

Holotype ♀, 1 ♀ paratype, INDIA: Mysore, Bangalore, Channapatna, ex *Nipaecoccus vastator* (Maskell) on *Mangifera indica* Linn., 2-7-1968 (*S. Adam Shafee*). Material in Zoological Museum, Aligarh Muslim University, Aligarh, India.

POST AXILLA

Smith and Compere (1928) have shown the presence of a triangular sclerite lying posterior to and contiguous with the axilla in the genus *Myiocnema* Ashmead. They did not propose any name for this sclerite. The present writer has observed a similar sclerite in the genera *Euryischia* Riley (Text-fig. 1D, *Pax*) and *Euryischomyia* Girault (Text-fig. 1C, *Pax*), for which the name *Post axilla* is proposed.

SUMMARY

A new family Euryischidae is proposed, based on the genus *Euryischia* Riley. The systematic position of the genera *Myiocnema* Ashmead and *Euryischomyia* Girault is discussed. Two new subfamilies, Euryischinae based on the genus *Euryischia* and Myiocneminae based on the genus *Myiocnema* under Euryischidae have been proposed. A key to subfamilies and genera of Euryischidae fam.n. is given. *Euryischia indica* Mani & Kurian in the subfamily Euryischinae and *Euryischomyia alami* sp.n. in the subfamily Myiocneminae are described in detail. The name *Post axilla* is given to a sclerite lying posterior to and contiguous with the axilla in the genera *Euryischia*, *Myiocnema* and *Euryischomyia*.

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REFERENCES

ASHMEAD, W. H. 1900. Description of a new genus in the Aphelininae. *Canad. Ent.*, **32:** 349.

BORROR, D. J. and DELONG, D. M., 1963. An introduction to the study of insects. Revised edn. N.Y 819 pp.

BRUES, C. T., MELANDER, A. L. and CARPENTER, F. M. 1954. Classification of insects. *Bull. Mus. Comp. Zool.*, **108:** 917 pp.

BURKS, B. D. 1965. The North American species of *Elasmus* Westwood (Hymenoptera, Eulophidae). *Proc. Biol. Soc. Wash.*, **78:** 201-208.

COMPERE, H. 1947. A new genus and species, *Eurymyiocnema aphelinoides* (Hymenoptera, Aphelinidae), and a history of the genera *Euryischia* Riley and *Myiocnema* Ashmead. *Bull. ent. Res.*, **38:** 381-388.

COMSTOCK, J. H. 1954. An introduction to Entomology, Revised edn. Ithaca, N.Y 1064 pp.

ESSIG, E. O. 1954. Insects and Mites of Western North America. Revised edn. Macmillan Co. N.Y 1050 pp.

FERRIÈRE, C. 1965. Hymenoptera Aphelinidae d'Europe et du Bassin Mèditerranéen. *Faune. Eur. Bass. mèdit.*, **1:** 1-208.

GHESQUIÈRE, J. 1955. Contribution à I'étude du genre *Eriaporus* Waterston et genres affins (Hym. Chalcidoidea Aphelinidae). *Mem. Soc. R. Ent. Belg.*, **27:** 217-238.

GIRAULT, A. A. 1912. Australian Hymenoptera Chalcidoidea 3. The family Elasmidae, with descriptions of new species. *Mem. Qd. Mus.*, **1:** 176-189.

GIRAULT, A. A. 1913. Australian Hymenoptera Chalcidoidea 3. Supplement. *Mem. Qd. Mus.*, **2:** 130-139.

GIRAULT, A. A. 1914. *Canad. Ent.*, **46:** 285.

GIRAULT, A. A. 1916. Australian Hymenoptera Chalcidoidea. General. supplement. *Mem. Qd. Mus.* **5:** 205-230.

HOWARD, L. O. 1907. New genera and species of Aphelininae, with a revised table of genera. *U.S. Dep. Agr. Tech. Ser.*, **12:** 69-88.

IMMS, A. D. 1957. A general text book of Entomology. 9th edn. revised. London., 886 pp.

MANI, M. S. 1938. Catalogue of Indian insects Chalcidoidea. I.C.A.R. 11, **23**: 1-174.

MANI, M. S. and KURIAN, C. 1953. Descriptions and records of Chalcids (Parasitic Hymenoptera) from India, *Ind. J. Ent.* **15**: 1-22.

MERCET, R. G. 1912. Los Afelininos. *Trab. Mus. Cienc. Nat. Madr.* **10**: 1-306.

NIKOL'SKAYA, M. N. 1952. The Chalcid fauna of the U.S.S.R. (Chalcidoidea). *Acad. Sci. U.S.S.R.* No., **44**: 1-575.

PECK, O., BOUCEK, Z. and HOFFER, A. 1964. Keys to the Chalcidoidea of Czechoslovakia (Insecta: Hymenoptera). *Mem. ent. Soc. Canada*, No. **34**: 1-120.

RIEK, E. F. 1967. Australian Hymenoptera Chalcidoidea family Eulophidae, subfamily Elasminae. *Aust. J. Zool.*, **15**: 145-199.

SHAFEE, S. A. 1970. New genus of Aphelinidae recorded from Ootacamund (India) (Hymenoptera). *Mushi*, **43**: 143-147.

SMITH, H. S. and COMPERE, H. 1928. A preliminary report on the insect parasites of the Black Scale, *Saissetia oleae* (Bernard). *Univ. Calif. Publ. Ent.*, **4**: 231-334.

VIEREK, H. L., et al. 1916. The Hymenoptera, or Wasp-like insects, of Connecticut. *Bull. Conn. State geol. nat. Hist. Surv.*, **22**: 824 pp.

Rec. zool. Surv. India, **68**: 33—39, 1975.

ON SOME NEW SPECIES OF SPIDERS OF FAMILY GNAPHOSIDAE (ARANEAE : ARACHNIDA) FROM GUJARAT, INDIA

By

B. H. PATEL[1] AND H. K. PATEL[2]

(With 3 text-figures)

INTRODUCTION

Although the spiders are extremely abundant throughout our country, the representative works of Pocock (1900) and Thorell (1895) contain no references to the family Gnaphosidae. Very recently Tikader (1959, 1961) described several new species of spiders belonging to different families including Gnaphosidae.

In course of the taxonomic studies of spiders, one of the authors (BHP) collected spiders from various parts of Gujarat State during the last four years. While examining the interesting collections one of the authors (BHP) came across several new and remarkable forms of spiders. The present paper contains the descriptions of three new species of gnaphosid spiders.

The spiders of this family are of typical appearance and for the most part, dull coloured or black or brown-black. They live under stones, amongst leaves or in the roots of grasses or heather. *Scotophaeus* is normally found in the houses and out-houses. Most species are nocturnal in habit excepting *Micaria*. Some of them build silken retreats but no regular web for the capture of prey.

All the type specimens will in due course be deposited in the National Zoological Collections of Zoological Survey of India, Calcutta.

1. **Drassodes gujaratensis** sp. n.

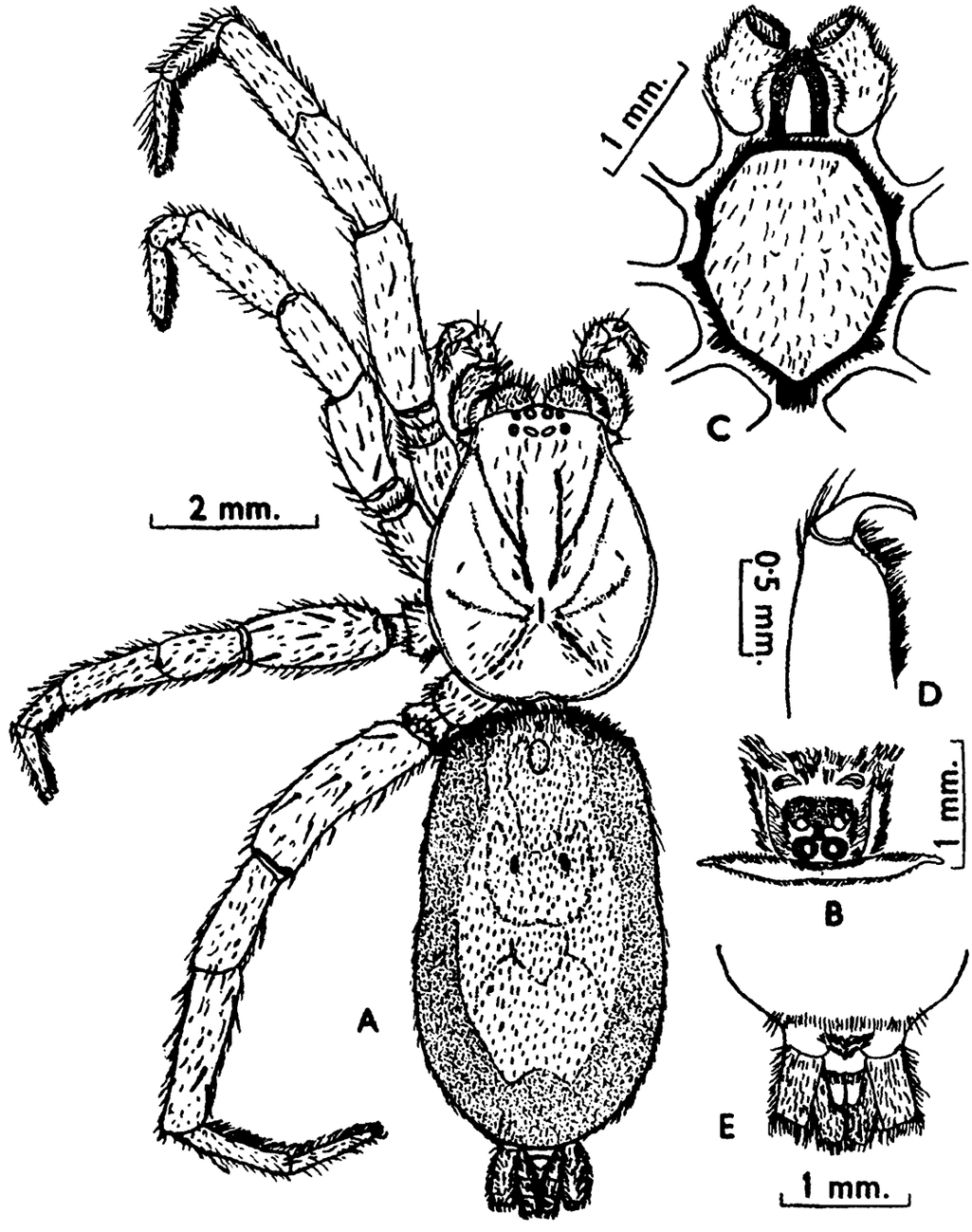
(Text-fig. 1, a–e)

General.—Cephalothorax and legs dark-brown, abdomen brown. Total length 8.70 mm. Carapace 3.44 mm. long, 2.73 mm. wide; abdomen 5.25 mm. long, 3.00 mm. wide.

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Cephalothorax. Slightly broader anteriorly, longer than broad, covered with few black hairs, with a fovea on the thorax and radial furrows. Eyes of anterior row straight, posterior row slightly longer and procurved, anterior medians dark in colour, rest white; anterior medians smaller than the laterals and a little closer to the laterals than to each other, posterior medians oblong, slightly larger and close to each other than to the laterals. Ocular quad longer than broad. Sternum oblong, truncate anteriorly and pointed behind, with a dark-brown margin, covered with hairs. Labium ovate reaching beyond the mid-point of maxilla as in Text-fig. 1, c. Chelicerae brown, vertical, strong, with two promarginal and three retromarginal teeth as in



Text-fig. 1. *Drassodes gujaratensis* sp. n.

(*a*) Dorsal view of female, legs on one side omitted; (*b*) Epigyne; (*c*) Sternum, labium and maxilla; (*d*) Right chelicera; (*e*) Spinners seen from ventral side.

Text-fig. 1, d. Legs long, stout, brown, covered with hairs and few spines. Only two dorsal spines on femora I and II; two ventral spines on metatarsus I and three on metatarsus II; spines on all segments except tarsi of III and IV Scopulae extended nearly upto the base of metatarsi and tarsi of I and II and upto the base of tarsi III and IV Two pectinate tarsal claws with claw tufts present.

Abdomen.—Brown, oblong, covered with fine pubescence. Dorsally pale yellowish patches marked by faint yellow lines and a pair of dark oval spots just near the anterior half. Ventrally inbetween the posterior half and the spinners, light colour chevrons present. Epigyne as in Text-fig. 1, b.

Holotype.—Female in spirit.

Type-locality.—Vallabh Vidyanagar *ca.* 6 kilometers West of Anand, Dist. Kaira; 9.x.1967; *B. H. Patel* Coll.

Distribution.—Known from the type-locality only.

This species resembles to *Drassodes malodes* Tikader, but differs as follows: (*i*) Anterior row of eyes straight but in *D. malodes* anterior row of eyes slightly procurved. (*ii*) Anterolateral corner of abdomen not angular but in *D. malodes* anterolateral corner of abdomen slightly angular. (*iii*) Dorsally and ventrally colour patches on abdomen but in *D. malodes* no such colour patches. (*iv*) Epigynal structure also differs.

2. **Scotophaeus chohanius** sp. n.

(Text-fig. 2, a–e)

General.—Cephalothorax and legs brown, abdomen dark-brown to black. Total length 5.66 mm. Carapace 2.21 mm long, 1.81 mm. wide; abdomen 3.45 mm. long, 2.18 mm. wide.

Cephalothorax.—Longer than wide, clothed with fine pubescence. Cephalic region high with depression and radial furrows, a fovea on the thorax. Eyes of both rows procurved; anterior medians round and dark and slightly smaller than the laterals, posterior medians irregular-oblong; eyes pearly white except anterior medians which are dark. Ocular quad as long as wide. Clypeus low. Sternum heart-shaped, tapering and pointed behind, brown, clothed with hairs. Labium and maxilla as in Text-fig. 2, c; labium reaching beyond the mid-point of maxilla. Chelicerae vertical, brown and robust on anterior surface as in Text-fig. 2, d. Legs brown, long, clothed with hairs and few black spines. Two dorsal and one epical prolateral spines on femora I. Two unpaired dorsal spines on femora II. Scopulae on metatarsi and tarsi of all legs; tarsi with two pectinate claws.

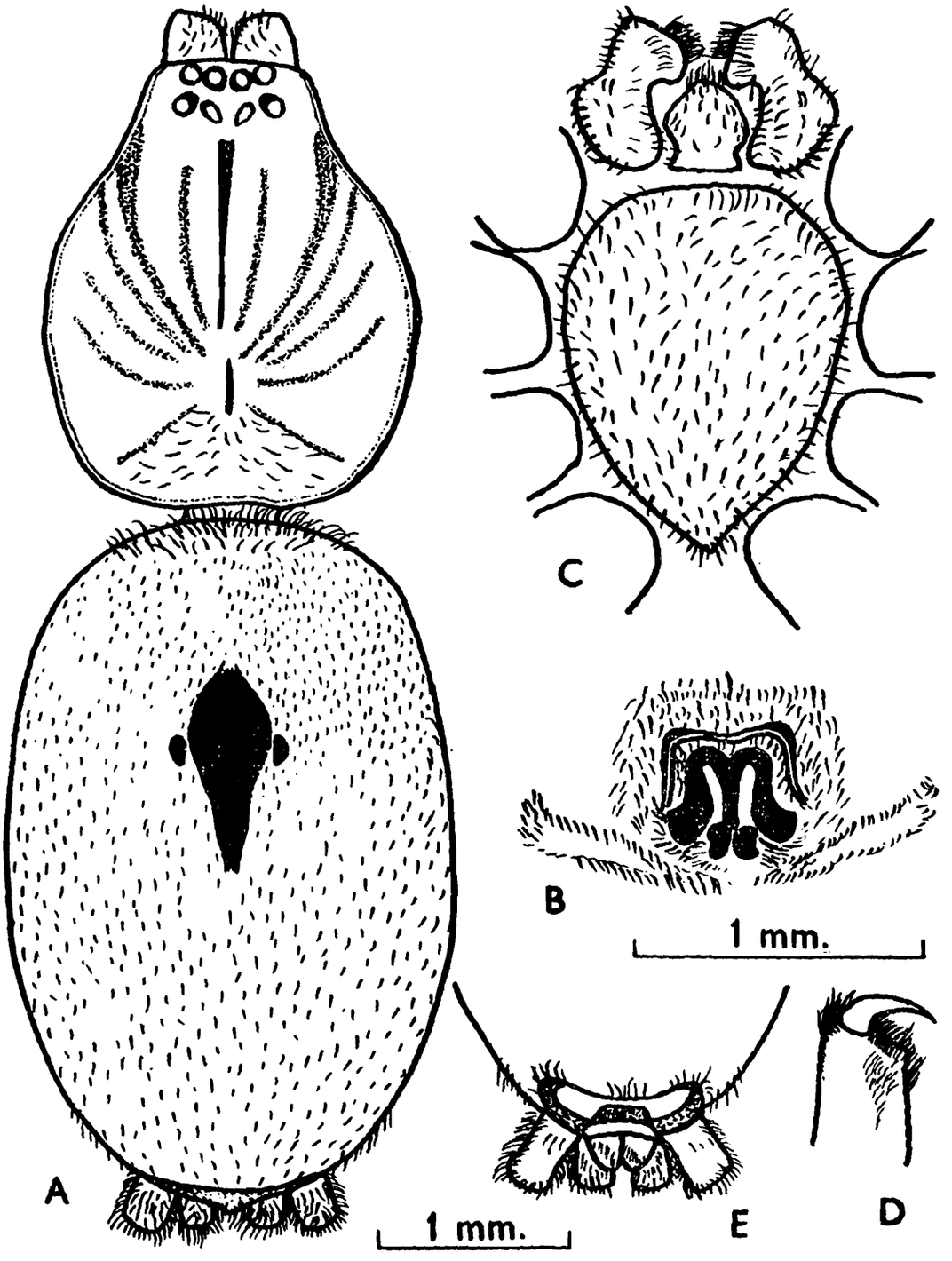
Abdomen.—Oblong, longer than broad, dark-brown to black, clothed with fine pubescence. A mid-dorsal black patch with two lateral oblong brown spots present. Ventral side lighter in colour with two black lines extending from epigastric fold upto posterior one-fourth length of abdomen. Epigyne as in Text-fig. 2, b.

Holotype.—Female, *paratype* one female in spirit.

Type-locality.—Vallabh Vidyanagar *ca.* 6 kilometer West of Anand,

Dist. Kaira; 3.viii.1970; *B. H. Patel* Coll.

Distribution.—Known from the type-locality only.



Text-fig. 2. *Scotophaeus chohanius* sp. n.

(*a*) Dorsal view of female, legs omitted; (*b*) Epigyne; (*c*) Sternum, labium and maxilla; (*d*) Right chelicera; (*e*) Spinners seen from ventral side.

This species closely resembles to *Scotophaeus domesticus* Tikader, but differs as follows: (*i*) Cephalothorax with radial furrows but in *S. domesticus* no radial furrows. (*ii*) Anterior median eyes slightly smaller than the laterals but in *S. domesticus* anterior medians larger than the laterals,

(*iii*) Shape and arrangement of eyes of posterior row quite differ. (*iv*) Femur I with two dorsal and one epical prolateral spines and femur II with two unpaired dorsal spines and no spines on tibia and metatarsi but in *S. domesticus* legs with black spines on tibiae and femora; tibiae I and II with three unpaired ventral spines, metatarsi I and II with one pair of ventral spines near the base. (*v*) A dorsal patch on mid-dorsal side of abdomen but in *S. domesticus* no such patch on abdomen. (*vi*) Structure of labium, maxilla and epigyne also differs.

3. **Phaeocedus haribhaiius** sp. n.

(Text-fig. 3, a–e)

General.—Cephalothorax, abdomen and legs light-brown. Total length 8.57 mm. Carapace 3.33 mm. long, 2.28 mm. wide; abdomen 5.24 mm. long, 3.15 mm. wide.

Cephalothorax.—Longer than wide, clothed with fine pubescence, convex with a fovea on the thorax. Cephalic region high. Eyes of anterior row straight to slightly procurved, dark in colour; anterior medians larger than the laterals; eyes of posterior row procurved, pearly white, posterior medians oblong and larger than the laterals. Ocular quad longer than wide. Sternum brown, oblong, narrowed behind, reaching inbetween the posterior coxae; broad and truncate anteriorly, covered with hairs. Labium and maxilla as in Text-fig. 3, c. Labium truncate in front, reaching beyond the mid-point of maxilla. Chelicerae brown, strong, with three promarginal and two retromarginal teeth, fang strong as in Text-fig. 3, d. Legs long, stout, covered with hairs and few spines. Two ventral spines on metatarsi I and II and on tibia I; one ventral and one prolateral spines on tibia II. Scopulae reaching nearly upto the base of metatarsi and tarsi of I and II and upto the base of tarsi of III and IV

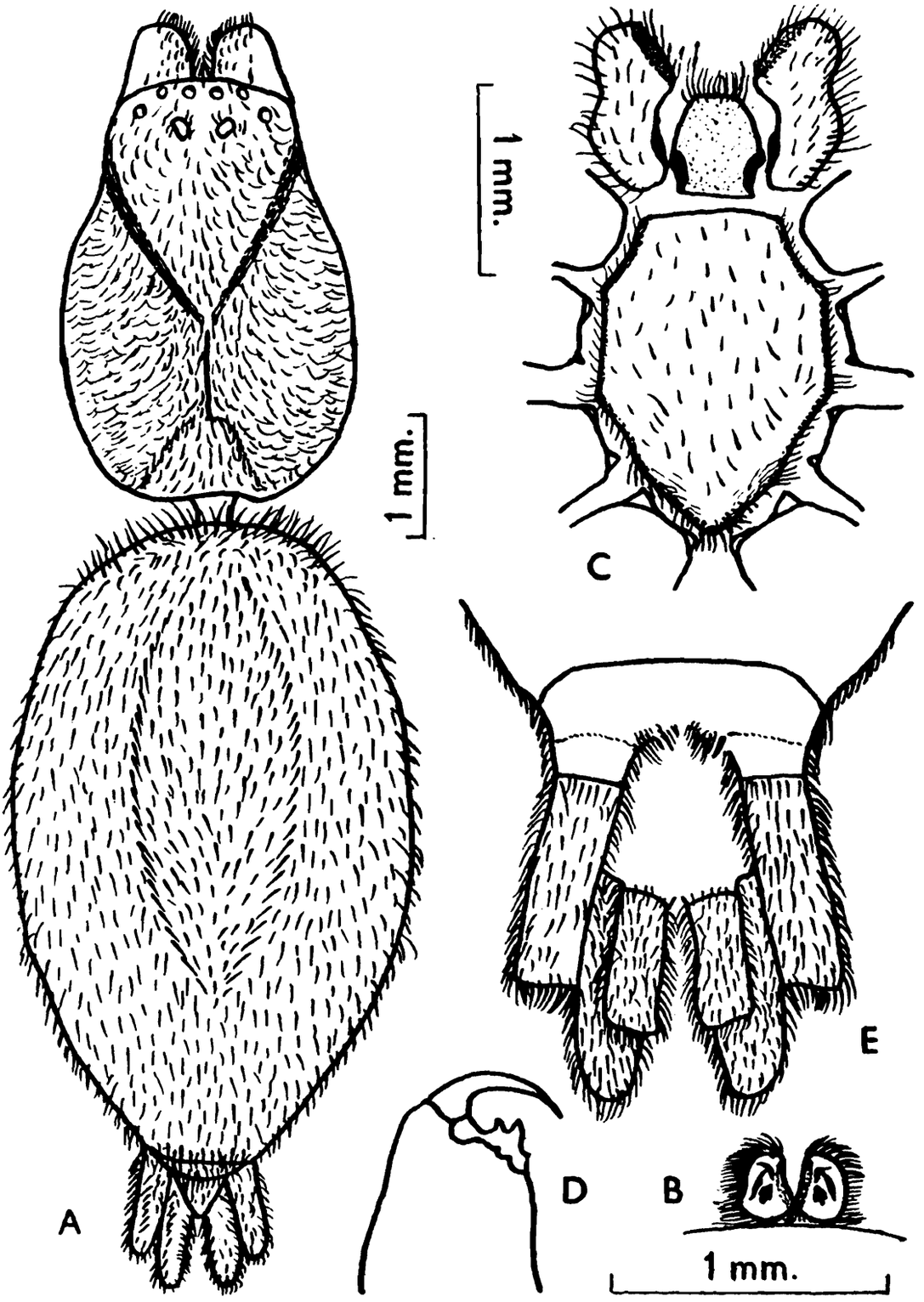
Abdomen.—Pale-brown, oval, clothed with fine pubescence, longer than broad, tapering posteriorly, with a yellowish-brown colour on anterior mid-dorsal portion. Epigyne simple as in Text-fig. 3, b.

Holotype.—Female in spirit.

Type-locality.—Vallabh Vidyanagar *ca.* 6 kilometers West of Anand, Dist. Kaira; 3.viii.1970; *B. H. Patel* Coll.

Distribution.—Known from the type-locality only.

This species resembles to *Phaeocedus mosambaensis* Tikader, but differs as follows: (*i*) Eyes of anterior row unequal but in *P. mosambaensis* eyes of anterior row equal. (*ii*) Abdomen pale brown, oblong, tapering posteriorly with an anterior mid-dorsal yellowish-brown colour but in *P. mosambaensis* abdomen dark-brown, posterior half of dorsal surface with deep-brown chevrons. (*iii*) Sternum oblong narrowed behind, reaching inbetween the posterior coxae, broad and truncate anteriorly, covered with few hairs but in *P. mosambaensis* sternum oval and narrowed behind. (*iv*) Structure of labium, maxilla and epigyne also differs.



Text-fig. 3. *Phaeocedus haribhaiius* sp. n.

(*a*) Dorsal view of female, legs omitted; (*b*) Epigyne; (*c*) Sternum, labium and maxilla; (*d*) Right chelicera; (*e*) Spinners seen from the ventral side.

Summary

Three species of spiders are described in this paper. All the species were collected from Vallabh Vidyanagar, Dist. Kaira, Gujarat. The new species belong to three different genera contained in the family Gnaphosidae.

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REFERENCES

COMSTOCK, J. H. 1940. *The Spider Book.* Comstock Publishing Associates, New York, (Revised and edited by W. J. Gertsch): 321–336.

DYAL, S. 1935. Spiders of Lahore. *Bull. Dep. Zool. Punjab Univ.*, **1** : 119–252.

LOCKET, G. H. and MILLIDGE, A. F. 1951. *British Spiders.* I. Ray Society, London: 59–119.

POCOCK, R. I. 1900. *Fauna of British India.* Arachnida. Taylor and Francis, London: 153–279.

SIMON, E. 1892. *Historite Naturelle des Araignees.* I. Paris: 359–370.

THORELL, T 1895. *Descriptive catalogue of the spiders of Burma,* British Museum, London: 1–460.

TIKADER, B. K. 1959. On two new species of spiders of the genera *Scotophaeus* and *Drassodes* (family Gnaphosidae) from West Bengal. *Proc. Ist All India Congress of Zoology,* Part 2: 570–573.

TIKADER, B. K. 1961. Zoological results of the Indian Cho-Oyu Expedition (1958) in Nepal. Part 8. Arachnida. *Rec. Indian Mus.*, **59**(3) : 257–267.

TIKADER, B. K. 1961. On a collection of spiders (Araneae) from the desert areas of Rajasthan (India). *Rec. Indian Mus.*, **59**(4): 435–443.

Rec. zool. Surv. India, **68** : 41–78, 1975.

POPULATION DYNAMICS AND MORPHOMETRY OF THE 1956 AND 1957 DESERT LOCUST POPULATIONS IN INDIA IN RELATION TO EYE-STRIPE COMPOSITION AND SEX-RATIOS

By

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Zoological Survey of India, Calcutta-12

(With 10 Tables and 15 Text-figures)

CONTENTS

	PAGE
I—INTRODUCTION	42
1. General ..	42
2. History of the 1956-57 population	42
3. Abbreviation used	42
4. Acknowledgements	43
II—MATERIAL AND METHODS	43
1. General	43
2. Statistical procedure	44
3. Characteristics of the 1956-57 population	44
III—EYE-STRIPE COMPOSITION AND SEX-RATIOS	45
1. General	45
2. Eye-stripes	45
3. Sex-ratios	45
4. Discussion	45
IV—MORPHOMETRIC CHARACTERS (SIZE OF BODY-PARTS)	46
1. General . .	46
2. Width of head at the ocular level (O)	51
3. Width of head at the genal level (C)	52
4. Length of pronotum at the keel (P)	54
5. Height of pronotum at the prozona (H) .	55
6. Width of pronotum at the constriction (M)	57
7. Length of elytron (E) ..	58
8. Restricted width of elytron (W_1)	60
9. Length of hind-femur (F) ..	61
10. General conclusions regarding size of body-parts	63
V—MORPHOMETRIC RATIOS	63
1. General	63
2. Ratio P/C	64
3. Ratio M/C	65
4. Ratio H/C	67
5. Ratio E/W_1	68
6. Ratio E/F	69
7. Ratio E/C	71
8. Ratio F/C	73
9. General conclusions regarding ratios	74
VI—DISCUSSION AND CONCLUSIONS	74
VII—SUMMARY	75
VIII—REFERENCES	76

I—Introduction

1. *General*

The ninth (recorded) cycle of the Desert Locust *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) in India started in the year 1949 and ended in 1955. The study of the population immediately succeeding this swarming cycle of 1949–1955 is of considerable biological interest, and may throw light on the processes of phase transformation. This is attempted here for the non-swarming population for the years 1956 and 1957 in India which are for convenience and because of small sample—size ($n = 93$) treated here together (also *vide infra* under Material and Methods).

It has been shown by Roonwal and Bhanotar (1966) that the population of the last period (Group III) of the 1955-population was "dissocians" in nature. The 1956-57 population is compared with immediately preceding population (1955-Gr. III), and with other known populations in various degrees of phase-transformation, in order to ascertain its correct phase status.

The 1956-57 population is analysed in regard to size of body-parts, morphometric ratios, sex-ratios and eye-stripe composition.

2. *History of the 1956-57 population*

The specimens for the 1956-57 population were collected either singly from scattered populations or from thin concentrations. The populations remained fluctuating throughout the year. The maximum population density during the early period (January–April) in each year was 960 individuals per square mile. During the second period (May–August), the maximum population density was 5,040 per square mile, except for a few localities where the population became "countless" During the last or third period (November and December), no locusts were found, and the population was zero.

3. *Abbreviation used*

Except where otherwise stated, the following abbreviations have been used throughout:—

O, Width of head at ocular level.
C, Width of head at genal level.
P, Length of pronotum.
H, Height of pronotum.
M, Width of pronotum at the constriction.
E, Length of elytron.
W_1, Restricted width of elytron.
F, Length of hind-femur.

S.E., Standard error.

S.D., Standard deviation.

S.D.P., Sexual dimorphism percentage.

6-*gregaria* or 6-*greg.* or *greg.*, or *greg.* (6), typical 6-striped phase *gregaria* individuals.

6-7—*solitaria*, 6-*sol.*, or *sol.* (6) or *sol.* (7), Typical 6- or 7-striped phase *solitaria* individuals.

6-7—striped, 6- or 7- eye-striped.

5-8—striped, 5- or 8- eye-striped.

Group I Gr. I, 1954 Group I populations.

Group II Gr. II, 1954 Group II populations.

Group III Gr. III, 1954 Group III populations.

1955-Gr. I, 1955 group I populations.

Gr.I(6) or Gr.I(7), 6- or 7- striped individuals of Group I.

Gr.II(6) or Gr.II(7), 6- or 7- striped individuals of Group II.

Gr.III(6) or Gr.III(7), 6- or 7- striped individuals of Group III.

Kakko pop., *Kakko Conc.* or *K* or *Inl. Conc.*, Initial concentration of locusts Kakko village (Rajasthan) in 1949 (Misra, 1952).

Ajmer Sw., or *Ajm.sw.* or *Ajm.*(6), Ajmer Swarm population of 1950 (Roonwal & Misra, 1952).

K (6) or K (7), 6- or 7- striped individuals of initial or *Kakko Concentration* (1949)

N S, not significant.

n, number of examples.

*, Significant at 5% level.

**, Significant at 1% level.

***, Significant at 0.1% level.

4. *Acknowledgements*

The locust specimens studied here were received from the Plant Protection Advisor to the Government of India, New Delhi, and his assistance is gratefully acknowledged. Thanks are due to Director, Zoological Survey of India for giving us necessary laboratory facilities. We are deeply indebted to Dr. M. L. Roonwal, Vice-Chancellor, Jodhpur University, Jodhpur, for his valuable suggestions and guidance.

II—MATERIAL AND METHODS

1. *General*

The material for the 1956-57 population was obtained mostly from contiguous localities in Rajasthan, Western, India. A total of 93 specimens were obtained (69 for the year 1956 and 24 for the year 1957).

The 93 individuals were collected from eight Districts of Rajasthan as follows:—

	District	*Number of samples*
1.	Jaisalmer	22
2.	Bikaner	41
3.	Jodhpur	16
4.	Churu	1
5.	Barmer	6
6.	Ganganagar	4
7.	Suratgarh	2
8.	Sikar	1

Measurements: Morphometric measurements of eight body parts were made and were taken according to method laid down in Third International Locust Conference, London (1934); and as taken earlier by Roonwal *et. al.*, (1945, 1947, 1949, 1952 and 1966).

2. *Statistical procedure*

Technique: For comparison with "typical phases" and other previously studied populations, statistical comparison was made in respect of a number of morphometric characters and ratios. The common mean and dispersions (standard deviation), along with their standard errors, were computed as usual. The difference in mean values was tested for significance by expressing it as a ratio to the standard error of difference and referring the same to Normal Distribution table, if the sample size was fairly large. Where the sample-size was small and the hypotheses of equality of variances true as judged by Variance-Ratio Test, Student's *t* distribution was employed. In case of samples size being small but variances unequal, a more exact test procedure was adopted by finding a weighted average of level of significance for the two samples, the weights being the squares of standard errors of respective mean values. The level of significance was chosen at the 5% point of probability, but the significance of difference was examined at 1% and 0.1% points also.

The populations were also compared by the graphical method.

3. *Characteristics of 1956-57 population*

The adult samples were randomly collected from a non-swarming periods of a short duration of two consecutive years. This period of two years have not been separately dealt with for two reasons: (i) They both belong to a similar populations; and (ii) To increase the precision of statistical tests by including all the specimens in one sample. Classification of population of any year into seasonal groups, as was done in previous studies, was not made due to the non-availability of sufficient number of specimens in all the months. It is justifiably assumed that the data are homogeneous and truly represent the field population.

III—EYE-STRIPE COMPOSITION AND SEX-RATIOS

(Table 1)

TABLE 1.—*Schistocerca gregaria.* Number and distribution of samples, regarding sex-ratios and eye-stripes in the 1956-57 population in India.

Abbreviations: As in text.

Eye-stripe category	Number of individuals			Sex-ratio (%) ± S.E.		Proportion (%) of eye-stripes ± S.E.		
	Males	Females	Total	Males	Females	Males	Females	Total
6-striped	42	14	56	75±6	25±6	75±6	38±8	60±5
6-striped	14	23	37	38±8	62±8	25±6	62±8	40±5
Total	56	37	93	60±5	40±5	—	—	—

1. *General*

The sample size being small, the lumped population for the entire 1956-57 period was analysed, and the results are given below:—

2. *Eye-stripes* (Table 1)

Only two types of specimens, the 6- and 7- eye-striped, were observed; the proportion of the two varying as follows:—

Number of eye-stripes	*Number (and %) of individuals*		
	Males	*Females*	*Total*
6-	42 (75±6%)	14 (38±8%)	56 (60±5%)
7-	14 (25±6%)	23 (62±8%)	37 (40±5%)

3. *Sex-ratios* (Table 1)

The sex-ratios among the 93 individuals were: Males 56 (60.2%), females 37 (39.8%).

The percentage of sex-ratios in relation to the eye-stripe categories varied thus:—

Eye-stripes	*Males*	*Females*
6- eye-striped	75±6%	25±6%
7- eye-striped	38±8%	62±8%

4. *Discussion*

The eye-stripe composition and sex-ratio may now be discussed in relation to population and phases in the light of Roonwal's hypotheses (1945).

The 6- eye-striped individuals constitute less than 80% of the population (60±5%) and indicate *solitaria* affinities. In the 6- striped category, the high proportion of males (75±6%), instead of 50% which is characteristic of phase *gregaria*, indicates *solitaria* affinities. In the 7- striped category, the predominance of females over males (♀♀ 62±8%: ♂♂38±8%) further confirms the *solitaria* nature of the population.

IV—Morphometric characters (size of body-parts)

(Tables 2, 3, 7 and 8; and Text-figs. 1–8)

Table 2.—*Schistocerca gregaria*. Range, mean±S.E. and S.D.±S.E. for various morphometric characters O, C, P and H in the 1956-57 population in India.

Abbreviations: As in text.

Sex (and eye-stripes)	Statistical measures	Morphometric characters (symbols)			
		O	C	P	H
♂ (6)	Range (mm.)	5.7—6.6	5.9—7.1	8.4—10.8	7.0—8.3
	(*n*)	(42)	(42)	(42)	(42)
	Mean±S.E. (mm.)	6.13±0.032	6.40±0.043	9.82±0.078	7.86±0.047
	S.D.±S.E. (mm.)	0.211±0.023	0.280±0.030	0.503±0.05	0.304±0.033
♂ (7)	Range (mm.)	6.1—6.9	6.4—7.0	9.4—11.1	7.5—8.8
	(*n*)	(14)	(14)	(13)	(14)
	Mean±S.E. (mm.)	6.421±0.059	6.75±0.064	10.24±0.149	8.25±0.086
	S.D.±S.E. (mm.)	0.219±0.041	0.238±0.045	0.538±0.106	0.323±0.061
♀ (6)	Range (mm.)	6.3—7.2	7.0—7.9	10.7—12.7	8.5—10.1
	(*n*)	(14)	(14)	(13)	(14)
	Mean±S.E. (mm.)	6.72±0.076	7.39±0.088	11.46±0.176	9.13±0.142
	S.D.±S.E. (mm.)	0.286±0.054	0.328±0.062	0.633±0.124	9.530±0.100
♀ (7)	Range (mm.)	6.4—7.5	6.8—8.5	10.7—13.0	8.4—10.4
	(*n*)	(23)	(23)	(22)	(23)
	Mean±S.E. (mm.)	7.04±0.003	7.74±0.090	12.10±0.129	9.57±0.116
	S.D.±S.E. (mm.)	0.302±0.044	0.433±0.604	0.604±0.091	0.558±0.082

1. *General*

Only the more sensitive morphometric characters were studied, namely:

1. Width of head at the ocular level (O).
2. Width of head at the genal level (C).
3. Length of pronotum at the keel (P).
4. Height of pronotum at the prozona (H).
5. Width of pronotum at the constriction (M).
6. Length of elytron (E).
7. Restricted width of elytron (W_1).
8. Length of hind-femur (F).

TABLE 3.—*Schistocerca gregaria*. Range, mean±S.E. and S.D.±S.E. for various morphometric characters M, E, W_1 and F in the 1956-57 populations in India.

Abbreviations: As in text.

Sex (and eye-stripes)	Statistical measures	Morphometric characters (symbols)			
		M	E	W_1	F
♂ (6)	Range (mm.)	4.9—6.0	45.3—55.4	5.5—7.7	23.2—27.2
	(*n*)	(42)	(42)	(42)	(40)
	Mean±S.E. (mm.)	5.54±0.038	50.85±0.365	6.47±0.066	25.56±0.152
	S.D.±S.E. (mm.)	0.247±0.027	2.364±0.258	0.425±0.046	0.960±0.107
♂ (7)	Range (mm.)	5.4—6.6	50.2—56.8	6.1—7.3	25.7—28.4
	(*n*)	(14)	(14)	(14)	(14)
	Mean±S.E. (mm.)	5.89±0.080	53.25±0.578	6.76±0.093	27.09±0.253
	S.E.±S.E. (mm.)	0.297±0.056	2.164±0.409	0.348±0.066	0.947±0.179
♀ (6)	Range (mm.)	6.2—7.1	55.1—64.3	7.0—8.3	27.9—32.4
	(*n*)	(14)	(13)	(14)	(14)
	Mean±S.E. (mm.)	6.55±0.069	59.62±0.823	7.52±0.100	29.92±0.389
	S.D.±S.E. (mm.)	0.259±0.051	2.968±0.582	0.372±0.070	1.455±0.400
♀ (7)	Range (mm.)	6.3—7.5	56.4—68.1	7.3—8.4	29.0—34.2
	(*n*)	(23)	(23)	(23)	(22)
	Mean±S.E. (mm.)	6.85±0.066	62.94±0.584	7.94±0.065	31.73±0.288
	S.D.±S.E. (mm.)	0.316±0.047	2.801±0.413	0.311±0.046	1.351±0.204

TABLE 4.—*Schistocerca gregaria*. Range, mean±S.E. and S.D.±S.E. for the morphometric ratios P/C, M/C, H/C and E/W_1 in the 1956-57 population in India.

Abbreviations: As in text.

Sex (and eye-stripes)	Statistical measures	Morphometric ratios			
		P/C	M/C	H/C	E/W_1
♂ (6)	Range	1.40—1.68	0.80—0.93	1.14—1.32	7.19—8.92
	(*n*)	(42)	(42)	(42)	(42)
	Mean±S.E.	1.54±0.010	0.87±0.005	1.23±0.006	7.87±0.063
	S.E.±S.E.	0.066±0.007	0.031±0.003	0.040±0.004	0.407±0.044
♂ (7)	Range	1.40—1.66	0.80—0.98	1.16—1.28	7.30—8.27
	(*n*)	(13)	(14)	(14)	(14)
	Mean±S.E.	1.52±0.020	0.87±0.013	1.22±0.010	7.89±0.076
	S.E.±S.E.	0.071±0.014	0.048±0.009	0.036±0.007	0.286±0.054
♀ (6)	Range	1.48—1.70	0.80—0.92	1.18—1.28	7.61—8.58
	(*n*)	(13)	(14)	(14)	(13)
	Mean±S.E.	1.56±0.019	0.89±0.009	1.24±0.009	7.96±0.067
	S.D.±S.E.	0.069±0.014	0.032±0.006	0.033±0.006	0.242±0.048
♀ (7)	Range	1.46—1.71	0.84±0.94	1.13±1.29	7.52±8.47
	(*n*)	(22)	(23)	(23)	(23)
	Mean±S.E.	1.57±0.014	0.89±0.007	1.24±0.009	7.93±0.048
	S.D.±S.E.	0.064±0.010	0.032±0.005	0.041±0.006	0.228±0.034

TABLE 5.—*Schistocerca gregaria.* Range, mean±S.E. and S.D.±S.E. for the morphometric ratios E/F, E/C and F/C in the 1956-57 population in India.

Abbreviations: As in text.

Sex (and eye-stripes)	Statistical measures	Morphometric ratios		
		E/F	E/C	F/C
♂ (6)	Range	1.92—2.06	7.39—8.59	3.70—4.25
	(*n*)	(40)	(42)	(40)
	Mean±S.E.	2.00±0.005	7.95±0.041	3.98±0.021
	S.E.±S.E.	0.032±0.004	0.266±0.029	0.131±0.015
♂ (7)	Range	1.88—2.05	7.30—8.27	3.76—4.27
	(*n*)	(14)	(14)	(14)
	Mean±S.E.	1.97±0.012	7.89±0.067	4.02±0.038
	S.D.±S.E.	0.045±0.008	0.250±0.047	0.143±0.027
♀ (6)	Range	1.86—2.04	7.76—8.49	3.93—4.25
	(*n*)	(13)	(13)	(14)
	Mean±S.E.	2.00±0.013	8.07±0.050	4.05±0.024
	S.D.±S.E.	0.047±0.009	0.179±0.035	0.089±0.017
♀ (7)	Range	1.92±2.10	7.56±8.83	3.91±4.55
	(*n*)	(22)	(23)	(22)
	Mean±S.E.	1.99±0.008	8.14±0.058	4.11±0.033
	S.D.±S.E.	0.039±0.006	0.281±0.041	0.157±0.024

TABLE 6.—*Schistocerca gregaria.* Intra-population comparison of various morphometric characters and ratios (within same sex and eye-stripe category) in the 1956-57 population in India.

Abbreviations: As in text.

Characters and ratios	Significance of difference between sexes		Significance of difference in eye-stripes (6 & 7)	
	6-striped	7-striped		
O	***	***	***	**
C	***	***	***	**
P	***	***	*	**
H	***	***	***	*
M	***	***	***	**
E	***	***	***	**
W_1	***	***	*	***
F	***	***	***	***
P/C	NS	*	NS	NS
M/C	NS	NS	NS	NS
H/C	NS	NS	NS	NS
E/W_1	NS	NS	NS	NS
E/F	NS	NS	*	NS
E/C	NS	**	NS	NS
F/C	*	NS	NS	NS

TABLE 7.—*Schistocerca gregaria.* Inter-population comparison of mean±S.E., for the morphometric characters O, C, P and H between the 1956-57 population and other known populations.

Abbreviations: As in text.

Populations with eye-stripes (6- or 7-)	Significance of difference from the 1956-57 population in mean values for characters							
	O		C		P		H	
	(6)	(7)	(6)	(7)	(6)	(7)	(6)	(7)
				Males				
greg. (6)	–	–	***	***	NS	*	***	NS
Cal.Sw.(6) 1961	–	–	***	***	*	NS	–	–
Ajm.Sw.(6) 1950	–	–	***	***	NS	NS	–	–
Sol.(6)	–	–	–	–	–	–	–	–
sol.(7)	–	–	–	–	–	–	–	–
Gr.III(6) 1955	*	**	*	**	NS	*	***	NS
Gr.III(7) 1955	***	NS	***	NS	**	NS	***	NS
Kakko Conc.(6) 1949	–	–	***	*	NS	**	–	–
				Females				
greg. (6)	–	–	***	NS	***	***	NS	***
Cal.Sw.(6) 1961	–	–	***	*	***	***	–	–
Ajm.Sw.(6) 1950	–	–	NS	NS	NS	***	–	–
sol.(6)	–	–	–	–	–	–	–	–
sol.(7)	–	–	–	–	–	–	–	–
Gr.III(6) 1955	NS	*	NS	NS	*	***	NS	NS
Gr.III(7) 1955	***	NS	*	NS	*	NS	***	**
Kakko Conc.(6) 1949	–	–	NS	NS	**	***	–	–
Kakko Conc.(7) 1949	–	–	–	–	–	–	–	–

TABLE 8.—*Schistocerca gregaria.* Inter-population comparison of mean±S.E., for various morphometric characters M, E, W_1 and F between the 1956-57 population and other known populations.

Abbreviations: As in text.

Populations with eye-stripes (6- or 7-)	Significance of difference from 1956-57 population in mean values for characters							
	M		E		W_1		F	
	(6)	(7)	(6)	(7)	(6)	(7)	(6)	(7)
				Males				
greg.(6)	***	NS	**	NS	–	–	***	***
Cal.Sw.(6) 1961	–	–	***	NS	–	–	**	***
Ajm.Sw.(6) 1950	–	–	***	NS	–	–	***	***
sol.(6)	–	–	**	NS	–	–	NS	***
sol.(7)	–	–	**	NS	–	–	*	**
Gr.III(6) 1955	***	NS	*	NS	*	NS	NS	***
Gr.III(7) 1955	***	NS	**	NS	*	NS	NS	**
Kakko Conc.(6) 1949	–	–	NS	**	–	–	**	***
				Females				
greg.(6)	NS	***	NS	***	–	–	***	***
Cal.Sw.(6) 1961	–	–	NS	***	–	–	***	***
Ajm.Sw.(6) 1950	–	–	NS	NS	–	–	***	***
sol.(6)	–	–	*	*	–	–	NS	***
sol.(7)	–	–	***	NS	–	–	*	*
Gr.III(6) 1955	NS	NS	NS	**	NS	***	*	***
Gr.III(7) 1955	***	**	***	NS	**	NS	**	NS
Kakko Conc.(6) 1949	–	–	NS	***	–	–	***	***
Kakko Conc.(7) 1949	–	–	NS	NS	–	–	NS	NS

TABLE 9.—*Schistocerca gregaria.* Inter-population comparison of mean±S.E., for the morphometric ratios P/C, M/C and H/C between the 1956-57 population and other known populations.

Abbreviations: As in text.

Population with eye-stripes (6 & 7)	Significance of difference from 1956-57 population in mean values for ratios					
	P/C		M/C		H/C	
	(6)	(7)	(6)	(7)	(6)	(7)
			Males			
greg.(6)	***	***	***	***	***	***
Cal.Sw.(6) 1961	***	***	–	–	–	–
Ajm.Sw.(6) 1950	***	***	–	–	–	–
sol.(6)	–	–	–	–	–	–
sol.(7)	–	–	–	–	–	–
Gr.III(6) 1955	*	NS	***	NS	*	*
Gr.III(7) 1955	NS	NS	***	NS	*	*
Kakko Conc.(6) 1949	***	NS	–	–	–	–
			Females			
greg.(6)	***	***	***	***	***	***
Cal.Sw. (6) 1961	***	***	–	–	–	–
Ajm.Sw.(6) 1950	***	***	–	–	–	–
sol.(6)	–	–	–	–	–	–
sol.(7)	–	–	–	–	–	–
Gr.III(6) 1955	*	**	NS	NS	NS	NS
Gr.III(7) 1955	NS	NS	***	***	***	***
Kakko Conc.(6) 1949	***	***	–	–	–	–
Kakko Conc.(7) 1949	–	–	–	–	–	–

TABLE 10.—*Schistocerca gregaria.* Inter-population comparison of mean=±.E. for the morphometric ratios E/W_1, E/F, E/C and F/C between the 1956-57 population and other known populations.

Abbreviations: As in text.

Populations with eye-stripes (6 & 7)	Significance of difference from 1956-57 population in mean values for ratios							
	E/W_1		E/F		E/C		F/C	
	(6)	(7)	(6)	(7)	(6)	(7)	(6)	(7)
				Males				
greg.(6)	–	–	***	***	–	–	***	***
Cal.Sw.(6) 1961	–	–	**	***	–	–	***	***
Ajm.Sw.(6) 1950	–	–	***	***	–	–	***	***
sol.(6)	–	–	***	***	–	–	–	–
sol.(7)	–	–	NS	*	–	–	–	–
Gr.III(6) 1955	NS	NS	***	**	NS	NS	***	**
Gr.III(7) 1955	NS	NS	NS	**	NS	NS	NS	*
Kakko Conc.(6) 1949	–	–	***	***	–	–	***	***
				Females				
greg(6)	–	–	***	***	–	–	***	***
Cal.Sw.(6) 1961	–	–	**	**	–	–	***	***
Ajm.Sw.(6) 1950	–	–	***	***	–	–	***	***
sol.(6)	–	–	***	***	–	–	–	–
sol.(7)	–	–	*	***	–	–	–	–
Gr.III(6) 1955	NS	NS	**	***	NS	NS	*	**
Gr.III(7) 1955	*	**	**	***	**	NS	NS	NS
Kakko Conc.(6) 1949	–	–	***	***	–	–	***	***
Kakko Conc.(7) 1949	–	–	**	***	–	–	–	–

The data were compared among the sexes and the eye-stripe categories, and also with the conditions obtaining in the following known populations for which data are available:—

(i) 6- and 7- eye-striped individuals of "typical" phase *solitaria* and phase *gregaria* (Roonwal, 1949; Roonwal and Nag, 1951).

(ii) 6- eye-striped (males and females) and 7- eye-striped (females only) individuals of the Initial or Kakko Concentration of 1949, *i.e.*, the first year population of the 1949–55 Swarming cycle (Misra, 1952).

(iii) 6- eye-striped individuals of the Ajmer Swarm of 1950 *i.e.*, the second year of the 1949-55 swarming cycle (Roonwal and Misra, 1952).

(iv) 6- eye-striped individuals of the Calcutta Swarm of 1961, *i.e.*, the third year population of the 1959–63 swarming cycle (Roonwal and Bhanotar 1962, and in Press).

(v) 6- and 7- eye-striped individuals of the 1955-Gr.III population (the last year of the 1949–55 cycle) (Roonwal and Bhanotar, 1966).

2. *Width of head at the ocular level* (O)

(Tables 2, 6 and 7; and Text-fig. 1)

(*a*) *Mean width* (mm.) (Table 2): This varies as follows:—

Sex (and eye-stripes)	*Mean width (mm.)* $\pm$ *S.E.*
Males (6)	6.13 ± 0.032
Males (7)	6.42 ± 0.059
Females (6)	6.72 ± 0.076
Females (7)	7.04 ± 0.063

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- striped categories, the value is significantly higher (at all levels) in females than in the corresponding males.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms in significantly lower than in 7- stripes ones at all levels.

(*d*) *Inter-population comparison* (Table 7): Comparison was made with the 1955-Gr.III population (data given below); no comparison could be made with other population for want of data.

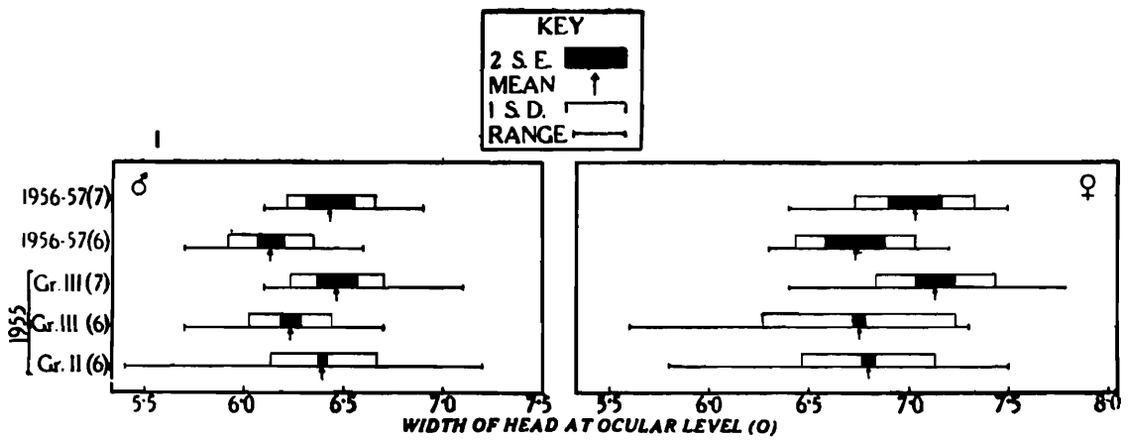
1955-*population* (*and eye-stripes*)	*Mean width (mm.)* $\pm$ *S.E.* *Males*	*Females*
Gr.III (6)	6.24 ± 0.025	6.75 ± 0.013
Gr.III (7)	6.46 ± 0.05	7.14 ± 0.05

In 6-striped males, the mean value is significantly lower than in 1955-Gr.III at the 5% level only. In all other cases (*i.e.*, 6-striped females and 7-striped males and females), the values in the 1956-57 population do not differ significantly from the 1955-Gr.III,

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 *population*	*S.D.P.*	1955-*population* (*and eye-stripes*)	*S.D.P.*
6- eye-striped	9.62±1.38	1955-Gr.I (6)	6.51±1.36
7- eye-striped	9.66±1.40	1955-Gr.II (6)	6.09±0.31
		1955-Gr.III (6)	8.17±2.19
		1955-Gr.III (7)	10.53±1.10

In the 6- eye-striped category, the value is not significantly different from those in the 1955-Grs.I and III, but is higher than in the 1955-Gr.II at the 5% level. No significant difference is noticed in the 7-striped categories.



Text-fig. 1.—*Schistocerca gregaria.* Dicegram to show variance of range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding width of head at ocular level (O). (For explanations *see* text.)

3. *Width of head at the genal level* (C)
(Tables 2, 6 and 7; and Text-fig. 2)

(*a*) *Mean width* (*mm.*) (Table 2): This varies as follows:—

Sex (*and eye-stripes*)	*Mean width* (*mm.*)±*S.E.*
Males (6)	6.40±0.043
Males (7)	6.75±0.064
Females (6)	7.39±0.088
Females (7)	7.74±0.090

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms is significantly lower than in 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 7): The 1956-57 population is compared with other known populations (data given below), as follows:—

Other populations (*and eye-stripes*)	*Mean* (*mm.*) ± *S.E.* *Males*	*Females*
6-*greg.*	7.55±0.045	7.89±0.074
Ajm. Sw.(6)	7.53±0.082	7.90±0.248
Cal.Sw.(6)	7.43±0.040	8.00±0.050
Kakko (*Inl.*)*Conc.*(6)	7.60±0.033	7.41±0.041
1955-Gr.III(6)	6.55±0.04	7.42±0.16
1955-Gr.III(7)	6.67±0.05	7.70±0.05

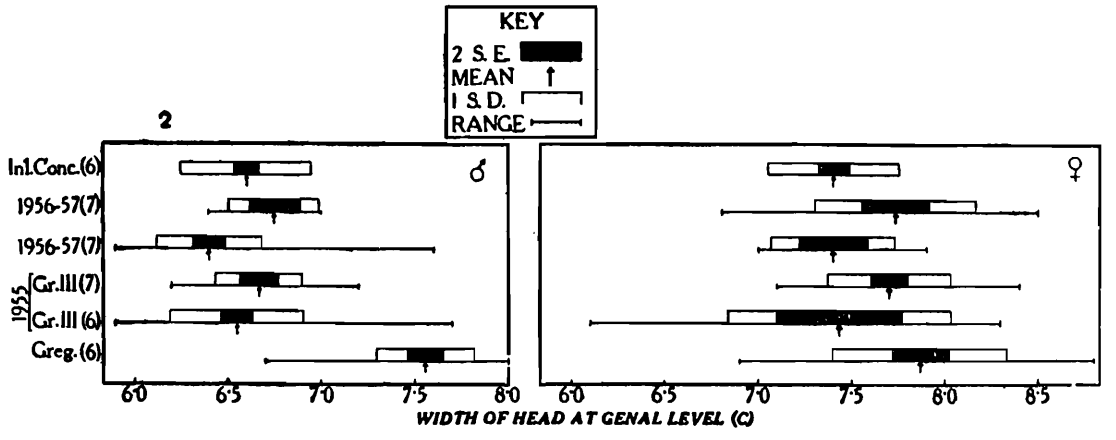
6-*striped males*:—The value in the 1956-57 population is significantly lower than in the 6-*greg.*, the *Ajm.Sw.*, the *Kakko Conc.* and the *Cal.Sw.*, at all levels, and the 1955-Gr.III at the 5% level only.

6-*striped females:* The value is significantly lower than in 6-*greg.* and *Cal.Sw.* at all levels, but is not different from those in the *Ajm.Sw.*, the *Kakko Conc.* and the 1955-Gr.III.

7-*striped males and females:* The values are not significantly different from those in the corresponding sex of 1955-Gr.III at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 *population*	*S.D.P.*	*Other populations* (*and eye-stripes*)	*S.D.P.*
6-eye-striped	15.47±1.58	1955-Gr.I(6)	7.11±1.46
7-eye-striped	15.67±1.72	1955-Gr.II(6)	9.44±0.40
		1955-Gr.III(6)	13.28±2.62
		1955-Gr.III(7)	15.44±1.18
		6-*greg.*	4.50±1.50
		Ajm.Sw.(6)	4.91
		Kakko Conc.(6)	12.27±0.8



Text-fig. 2.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding width of head at genal level (C).
(For explanations *see* text.)

In the 6- eye-striped category, the value in the 1956-57 population is significantly higher than in the 6-*gerg.* and the 1955-Grs.I and II, at all levels, but is not different from those in the 1955-Gr.III and the *Kakko Conc.* No significant difference is noticed in the 7- eye-striped category.

4. *Length of pronotum at the keel* (P)

(Tables 2, 6 and 7; and Text-fig. 3)

(*a*) *Mean length* (*mm.*) (Table 2): This varies as follows:—

Sex (*and eye-stripes*)	*Mean length* (*mm.*) $\pm$ *S.E.*
Males (6)	9.82$\pm$0.078
Males (7)	10.24$\pm$0.149
Females (6)	11.46$\pm$0.176
Females (7)	12.10$\pm$0.129

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in corresponding males, at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms is significantly lower than in 7-striped ones, at all levels.

(*d*) *Inter-population comparison* (Table 7): The 1956-57 population compare with other populations (data given below), as follows:—

Other populations (*and eye-stripes*)	*Mean length* (*mm.*) $\pm$ *S.E.* *Males*	*Females*
6-*greg.*	9.87$\pm$0.079	10.49$\pm$0.133
Cal.Sw.(6)	10.07$\pm$0.090	10.79$\pm$0.090
Ajm.Sw.(6)	10.01$\pm$0.108	10.78$\pm$0.343
Kakko Conc.(6)	9.76$\pm$0.054	10.94$\pm$0.088
1955-Gr.III(6)	9.86$\pm$0.06	10.76$\pm$0.29
1955-Gr.III(7)	10.20$\pm$0.08	11.90$\pm$0.10

6-*striped males:* The value in the 1956-57 population is not significantly different from those in 6-*greg.*, the *Ajm. Sw.*, the *Kakko Conc.* and the 1955-Gr.III, at all levels, but is significantly lower than in the *Cal.Sw.* at the 50% level only.

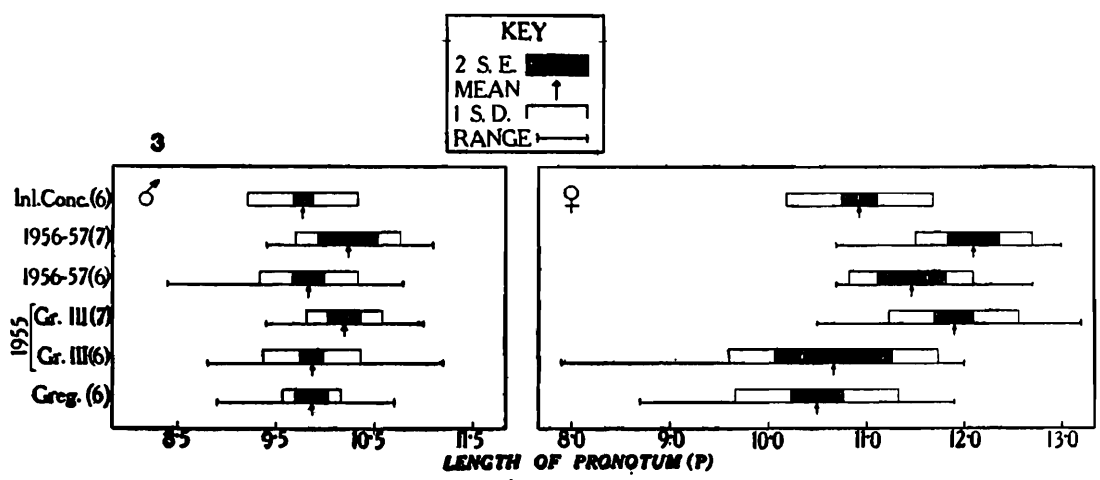
6-*striped females:* The value is significantly higher than in 6-*greg.* and the *Cal.Sw.* at all levels, the 1955-Gr.III at the 5% level, and the *Kakko Conc.* at the 1% level, but is not significantly different from that in the *Ajm.Sw.* at all levels.

7-*striped males and females:* For each sex the values are not significantly different from those in the 1955-Gr.III at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	16.70±2.01	1955-Gr.I(6)	8.38±1.74
7- eye-striped	18.16±2.13	1955-Gr.II(6)	9.26±0.44
		1955-Gr.III(6)	9.13±3.06
		1955-Gr.III(7)	15.67±1.38
		6-*greg.*	6.28±1.60
		Ajm.Sw.(6)	7.69
		Kakko Conc.(6)	12.09±1.09

In the 6- eye-striped category, the value in 1956-57 population is significantly higher than in 6-*greg.*, and the 1955-Gr.II at all levels, and 1955-Gr.I at the 1% level, and the 1955-Gr.III and the *Kakko Conc.* at the 5% level. No significant difference is seen in the 7-striped category.



Text-fig. 3.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding length of pronotum (P).
(For explanations *see* text.)

5. *Height of pronotum at the prozona* (H)

(Tables 2, 6 and 7; and Text-fig. 4)

(*a*) *Mean height* (*mm.*) (Table 2): This varies as follows:—

Sex (and eye-stripes)	*Mean height (mm.)±S.E*
Males (6)	7.86±0.047
Males (7)	8.25±0.086
Females (6)	9.13±0.142
Females (7)	9.57±0.116

(*b*) *Inter-sex comparison:* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms is significantly lower than in 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 7): The 1956-57 population compare with other known populations (data given below) as follows:—

Other populations (and eye-stripes)	*Mean height (mm.)* ± *S.E.*	
	Males	*Females*
6-*greg.*	8.39±0.05	8.92±0.10
1955-Gr.III(6)	8.20±0.04	9.10±0.27
1955-Gr.III(7)	8.40±0.09	9.90±0.07

6-*striped males:* The value is significantly lower than in 6-*greg.* and the 1955-Gr.III at all levels.

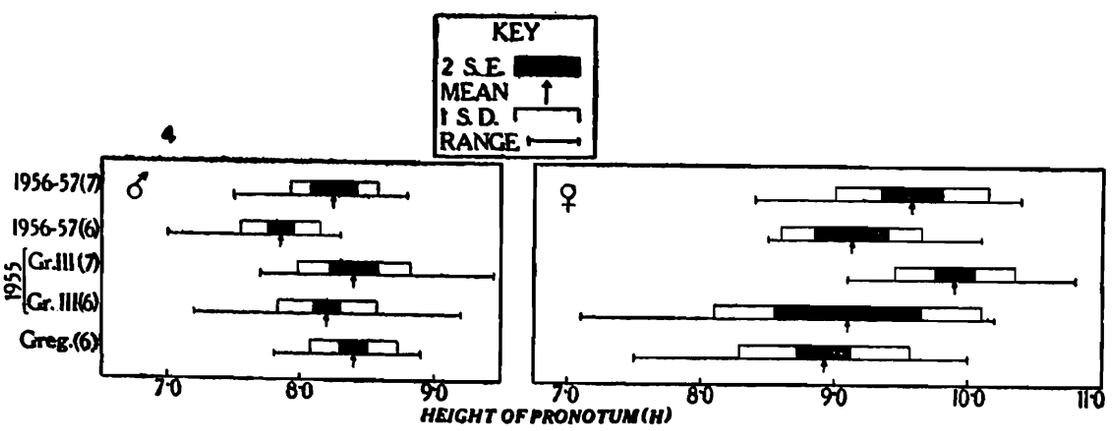
6-*striped females:* The value is not significantly different from that in 6-*greg.* and the 1955-Gr.III at all levels.

7-*striped males and females:* For each sex the values are not significantly different from those in the 1955-Gr.III at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P. ± S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	16.16±1.93	1955-Gr.I(6)	8.34±1.74
7- eye-striped	16.00±1.86	1955-Gr.II(6)	10.32±0.43
		1955-Gr.III(6)	10.98±3.37
		1965-Gr.III(7)	17.86±1.58

In the 6- eye-striped category, the value in the 1956-57 population is significantly higher than in the 1955-Grs.I and II at all levels, but is not significantly different from that in the 1955-Gr.III. No significant difference is seen in the 7-striped categories.



Text-fig. 4.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding height of pronotum (H).
(For explanations *see* text.)

6. *Width of pronotum at the constriction* (M)

(Tables 3, 6 and 8; and Text-fig. 5)

(*a*) *Mean width* (Table 3): This varies as follows:—

Sex (and eye-stripes)	*Mean width (mm.)* $\pm$ *S.E.*
Males (6)	5.54$\pm$0.038
Males (7)	5.89$\pm$0.080
Females (6)	6.55$\pm$0.069
Females (7)	6.85$\pm$0.066

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms is significantly lower than in 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 8): The 1956-57 population compare with other populations (data given below), as follows:.—

Other populations (and eye-stripes)	*Mean width (mm.)* $\pm$ *S.E.* *Males*	*Females*
6-*greg.*	5.86$\pm$0.04	6.36$\pm$0.08
1955-Gr.III(6)	5.84$\pm$0.03	6.67$\pm$0.15
1955-Gr.III(7)	5.98$\pm$0.05	7.09$\pm$0.04

6-*striped males:* The value is significantly lower than in 6-*greg.* and the 1955-Gr.III at all levels.

6-*striped females:* The value is not significantly different from those in 6-*greg.* and the 1955-Gr.III at all levels.

7-*striped males:* The value is not significantly different from that in the 1955-Gr.III at all levels.

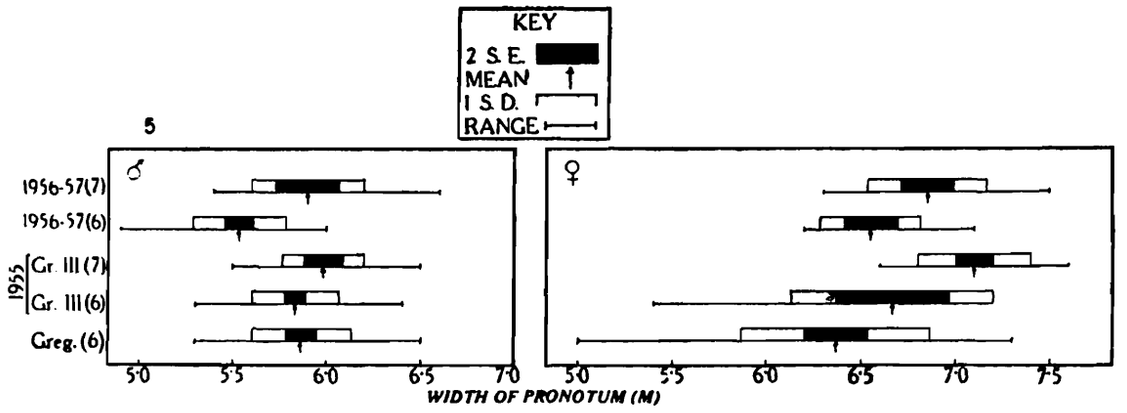
7-*striped females:* The value in 1956-57 population is significantly lower than in the 1955-Gr.III at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P. $\pm$ S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	18.23$\pm$1.50	1955-Gr.I(6)	12.41$\pm$1.56
7- eye-striped	16.30$\pm$1.92	1955-Gr.II(6)	12.18$\pm$0.40
		1955-Gr.III(6)	14.21$\pm$2.58
		1955-Gr.III(7)	18.56$\pm$1.21

In the 6- eye-striped category, the value in the 1956-57 population is significantly higher than in 1955-Gr.I (at 1% level) and 1955-Gr.II

(at all levels), but is not significantly different from that in 1955-Gr.III at all levels. No significant difference is seen in the 7-striped categories.



Text-fig. 5.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviations (S.D.) in various populations regarding width of pronotum (M).
(For explanations *see* text.)

7. *Length of elytron* (E)

(Tables 3, 6 and 8; Text-fig. 6)

(*a*) *Mean length* (Table 3): This varies as follows:—

Sex (and eye-stripes)	*Mean length (mm.)* $\pm$ *S.E*
Males (6)	50.85 $\pm$ 0.365
Males (7)	53.25 $\pm$ 0.578
Females (6)	59.62 $\pm$ 0.823
Females (7)	62.94 $\pm$ 0.584

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in the corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in the 6- striped forms is significantly lower than in 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 8): The 1956-57 population compare with other known populations (data given below), as follows:—

Other populations (and eye-stripes)	*Mean length (mm.)* $\pm$ *S.E.* *Males*	*Females*
6-*greg.*	52.85 $\pm$ 0.52	58.01 $\pm$ 0.81
Cal.Sw.(6)	53.82 $\pm$ 0.45	59.36 $\pm$ 0.82
Ajm.Sw.(6)	54.16 $\pm$ 0.70	59.70 $\pm$ 1.68
6-*sol.*	52.15 $\pm$ 0.24	61.56 $\pm$ 0.31
7-*sol.*	52.38 $\pm$ 0.42	62.90 $\pm$ 0.26
Kakko Conc.(6)	51.46 $\pm$ 0.29	59.73 $\pm$ 0.42
Kakko Conc.(7)	—	61.83 $\pm$ 1.41
1955-Gr.III(6)	52.07 $\pm$ 0.31	59.74 $\pm$ 0.91
1955-Gr.III(7)	52.58 $\pm$ 0.43	63.39 $\pm$ 0.48

6-*striped males:* The value in the 1956-57 population is significantly lower than in 6-*greg.* and the *Ajm.Sw.* at 1% level, the *Cal.Sw.* at the 0.1% level, and the 6-*sol.* and the 1955-Gr.III at the 5% level; it is not significantly different from that in the *Kakko Conc.* at all levels.

6-*striped females:* The value is not significantly different from those in 6-*greg.*, the *Cal.Sw.*, the *Ajm.Sw.*, the 1955-Gr.III and the *Kakko Conc.*, at all levels, but is significantly lower than in 6-*sol.* at the 5% level.

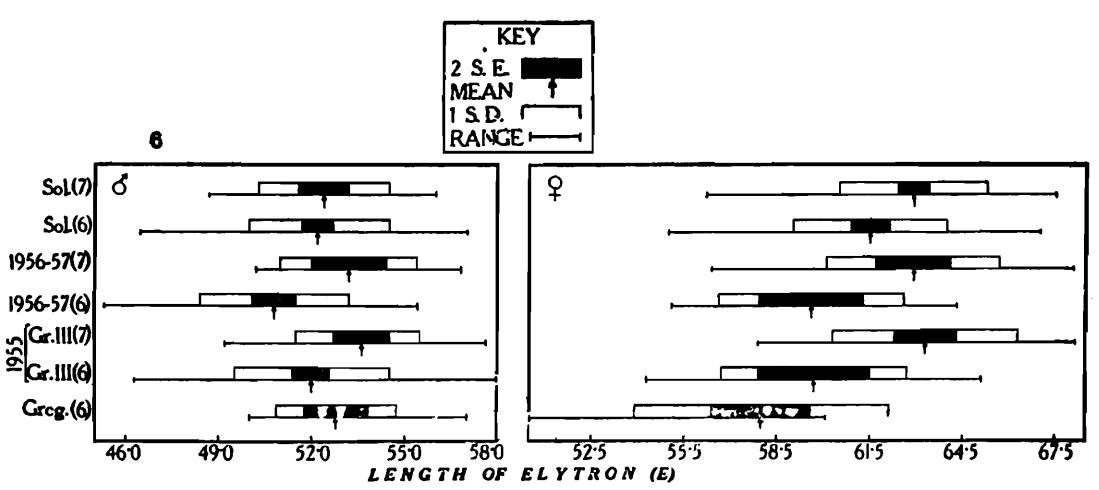
7-*striped males:* The value is not significantly different from those in 7-*sol.* and the 1955-Gr.III at all levels.

7-*striped females:* The value is not significantly different from those in 7-*sol.*, the 1955-Gr.III and the *Kakko Conc.* at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.$\pm$S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	17.25$\pm$1.84	1955-Gr.I(6)	11.92$\pm$1.78
7- eye-striped	18.20$\pm$1.74	1955-Gr.II(6)	12.00$\pm$0.39
		1955-Gr.III(6)	14.73$\pm$1.87
		1955-Gr.III(7)	20.66$\pm$1.33
		6-*greg.*	9.76$\pm$1.88
		Ajm.Sw.(6)	10.23
		Kakko Conc.(6)	16.07$\pm$1.04
		6-*sol.*	18.04$\pm$0.80
		7-*sol.*	20.08$\pm$1.08

In the 6-striped category, the value in the 1956-57 population is significantly higher than in 6-*greg.* and the 1955-population (Grs.I and II) at the 1% and 5% levels respectively, but is not significantly different from those in the 1955-Gr.III, 6-*sol.* and the *Kakko Conc.*, at all levels. No significant difference is seen in the 7-striped categories.



Text-fig. 6.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding length of elytron (E).
(For explanations *see* text.)

8. *Restricted width of elytron* (W_1)

(Tables 3, 6 and 8; and Text-fig. 7)

(*a*) *Mean width* (Table 3): This varies as follows:—

Sex (and eye-stripes)	*Mean width (mm.)* $\pm$ *S.E.*
Males (6)	6.47$\pm$0.066
Males (7)	6.76$\pm$0.093
Females (6)	7.52$\pm$0.100
Females (7)	7.94$\pm$0.065

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the value in females is significantly higher than in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In males and females, the value in 6-striped forms is significantly lower than in 7-stripes ones at the 5% and 0.1% levels respectively.

(*d*) *Inter-population comparison* (Table 8): The 1956-57 population compare with other populations (data given below), as follows:—

Other populations (and eye-stripes)	*Mean width (mm.)* $\pm$ *S.E.* *Males*	*Females*
1955-Gr.III(6)	6.66$\pm$0.05	7.36$\pm$0.16
1955-Gr.III(7)	6.71$\pm$0.07	7.84$\pm$0.06

6-*striped males:* The value in the 1956-57 population is significantly lower than in the 1955-Gr.III at the 5% level.

6-*striped females:* The value is not significantly different from that in the 1955-Gr.III at all levels.

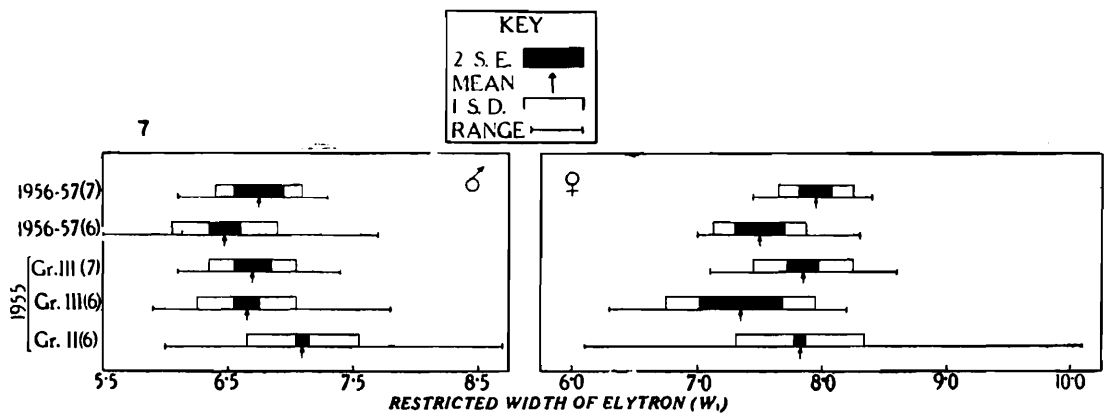
7-*striped males and females:* In the corresponding sex the value is not significantly different from that in the 1955-Gr.III at all levels.

(*d*) *Sexual dimorphism percentage:* The S.D.P.$\pm$S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	16.23$\pm$1.94	1955-Gr.I(6)	11.18$\pm$1.44
7- eye-striped	17.46$\pm$1.88	1955-Gr.II(6)	10.14$\pm$0.47
		1955-Gr.III(6)	10.51$\pm$2.60
		1955-Gr.III(7)	16.84$\pm$1.61

In the 6-striped category, the value in the 1956-57 population is significantly higher than in the 1955-Grs.I and II at the 5% and 1%

levels, but is not significantly different from that in the 1955-Gr.III. No significant difference is seen in the 7-striped category.



Text-fig. 7.—*Schistocerca gregaria*. Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviations (S.D.) in various populations regarding restricted width of elytron (W_1). (For explanations *see* text.)

9. *Length of hind-femur* (F)

(Tables 3, 6 and 8; and Text-fig. 8)

(*a*) *Mean length* (Table 3): This varies as follows:—

Sex (and eye-stripes)	*Mean length (mm.) ± S.E.*
Males (6)	25.56 ± 0.152
Males (7)	27.09 ± 0.253
Females (6)	29.92 ± 0.389
Females (7)	31.73 ± 0.288

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7- eye-striped categories, the values in females are significantly higher than in the corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both males and females, the value in 6-striped forms is significantly lower than in the 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 8): The 1956-57 population compare with other populations (data given below), as follows:—

Other populations (and eye-stripes)	*Mean length (mm.) ± S.E.* *Males*	*Females*
6-*greg.*	24.32 ± 0.20	26.44 ± 0.37
Cal.Sw.(6)	24.82 ± 0.23	27.32 ± 0.33
Ajm.Sw.(6)	24.37 ± 0.29	27.28 ± 0.61
6-*sol.*	25.40 ± 0.12	29.37 ± 0.18
7-*sol.*	26.13 ± 0.21	30.92 ± 0.13
Kakko Conc.(6)	24.92 ± 0.16	28.35 ± 0.25
Kakko Conc.(7)	—	29.94 ± 0.92
1955-Gr.III(6)	25.24 ± 0.16	27.97 ± 0.90
1955-Gr.III(7)	24.92 ± 0.16	31.21 ± 0.22

6-*striped males:* The value is significantly higher than in 6-*greg.* and the *Ajm.Sw.* at the 0.1% level, and the *Cal.Sw.* and the *Kakko Conc.* at the 1% level, but is not significantly different from that in 6-*sol.* and the 1955-Gr.III.

6-*striped females:* The value is significantly higher than in 6-*greg.*, the *Cal.Sw.*, the *Ajm.Sw.*, and the 1955-Gr.III at the 0.1% level, but is not significantly different from that in 6-*sol.* and the *Kakko Conc.*

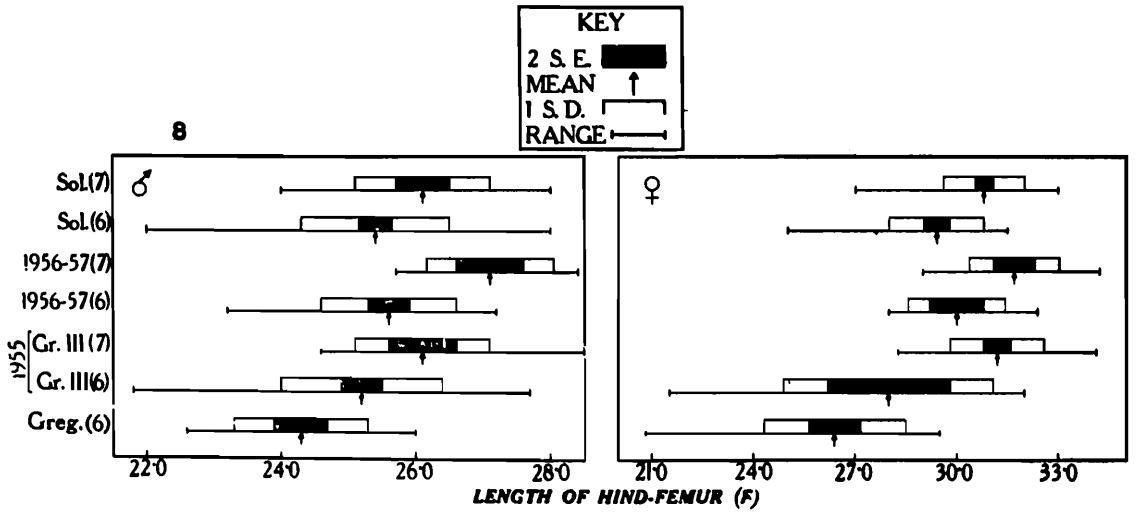
7-*striped males:* The value is significantly higher in 7-*sol.* and the 1955-Gr.III at 1% level.

7-*striped females:* The value is significantly higher than in 7-*sol.* at the 5% level only, but is not significantly different from those in the 1955-Gr.III and the *Kakko Conc.*

(*e*) *Sexual dimorphism percentage:* The S.D.P.$\pm$S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	17.06$\pm$1.66	1955-Gr.I(6)	10.43$\pm$1.94
7- eye-striped	17.13$\pm$1.54	1955-Gr.II(6)	10.14$\pm$0.43
		1955-Gr.III(6)	10.82$\pm$3.66
		1955-Gr.III(7)	19.49$\pm$1.35
		6-*greg.*	8.72$\pm$1.76
		Ajm.Sw.	11.94
		Kakko Conc.(6)	13.76$\pm$1.24
		6-*sol.*	15.63$\pm$0.89
		7-*sol.*	18.33$\pm$1.07

In the 6-striped category, the value is significantly higher than in 6-*greg.*, the 1955-Grs.I and II, at the 0.1%, 1% and 0.1% levels respectively, but is not significantly different from those in 6-*sol.*, the *Kakko Cong.*, and the 1955-Gr.III. No significant difference is seen in the 7-striped categories.



Text-fig. 8.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviations (S.D.) in various populations regarding length of hind-femur (F).
(For explanations *see* text.)

10. *General conclusions regarding size of body-parts*

All the morphometric characters in the 1956-57 population demonstrate uniformly high degrees of differences between the sexes and the eye-stripe groups.

The four characters, namely, O, H, M, and W_1 (the data for which were not available for "typical" *solitaria* population) were compared with the 1955-Group III, which is considered here as a close approximation to *solitaria* (Roonwal and Bhanotar, 1966).

For the 1955-Gr.III, the 6-striped males (in all the above characters *i.e.*, O, H, M and W_1) and the 7-striped females (in H and M only), show divergence, *i.e.*, the mean values are significantly higher from the corresponding eye-stripe and sex-groups of the 1956-57 population. It may be pointed out that though both the populations are of the *solitaria* facies, one (1955-Gr.III) is heading towards it and the other (1956-57) has possibly attained that phase so that some difference between the two is to be expected. The values in the 1956-57 population are nearer the typical *solitaria* than those of the 1955-Gr.III population.

Four other characters (C, P, E and F) were two utilized. Thus, for C, in the 6-striped males of the 1956-57 population, the value is significantly lower from *gregaria* population (*viz.*, the "typical" *gregaria*, the *Ajmer Swarm* and the *Calcutta Swarm*) and from the 1955-Gr.III (*solitaria facies*) and the *Kakko Conc.* (1949). A significantly higher value in the 1956-57 population is noticed in P for females from those in *gregaria* populations, where as for males no significant difference is seen in this respect, except for the *Calcutta Swarm* (of 1961), where the value is significantly lower at the 5% level. In respect of E, the value in 6-striped males in the 1956-57 population is significantly lower than in both *gregaria* (at all levels) and *solitaria* (at 5% level) populations, except for the *Kakko Conc.* (of 1949). For 6-striped females, E in the 1956-57 population is not significantly different from *gregaria* populations, but is significantly higher from phase *solitaria* at the 5% level.

Regarding F, the 6-striped categories in both sexes have significantly higher values than the *gregaria* populations and the *Kakko Conc.*, but are not significantly different from the "typical" *solitaria* and other *solitaria* facies populations (1955-Gr.III). In 7-striped females, the 1956-57 population retains its affinity to phase *solitaria* by not being different from the 1955-Gr.III(7) and the *Kakko Conc.*(7). However, in males, the value is significantly higher than in phase *solitaria*(7) and the 1955-Gr.III(7).

V—MORPHOMETRIC RATIOS

1. *General*

The following seven of the more sensitive ratios were studied for the 1956-57 population:—

1. Pronotum—Head Ratio (P/C)
2. Pronotum—Head Ratio (M/C)
3. Pronotum—Head Ratio (H/C)

4. Elytron Ratio (E/W_1)
5. Elytron—Femur Ratio (E/F)
6. Elytron—Head Ratio (E/C)
7. Femur—Head Ratio (F/C)

The mean values of these ratios were calculated separately for each individual and then a single mean was derived collectively.

2. *Ratio P/C*

(Tables 4, 6 and 9; and Text-fig. 9)

(*a*) *Mean ratio* (Table 4): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio*$\pm$*S.E.*
Males (6)	1.54$\pm$0.010
Males (7)	1.52$\pm$0.020
Females (6)	1.56$\pm$0.019
Females (7)	1.57$\pm$0.014

(*b*) *Inter-sex comparison* (Table 6): 6-*striped:* The value in females is not significantly different from that in males at all levels. 7-*striped:* The value in females is significantly higher than in males at the 5% level only.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both sexes the value in the 6-striped category is not significantly different from that in the corresponding 7-striped one at all levels.

(*d*) *Inter-population comparison* (Table 9): The 1956-57 population compare with the other populations (data given below) as follows:—

Other populations (and eye-stripes)	*Mean ratio*$\pm$*S.E.* *Males*	*Females*
6-*greg.*	1.305$\pm$0.011	1.324$\pm$0.009
Cal.Sw.(6)	1.35 $\pm$0.007	1.35 $\pm$0.008
Ajm.Sw.(6)	1.330$\pm$0.011	1.363$\pm$0.018
Kakko Conc.(6)	1.483$\pm$0.007	1.477$\pm$0.008
1955-Gr.III(6)	1.51 $\pm$0.007	1.47 $\pm$0.025
1955-Gr.III(7)	1.52 $\pm$0.011	1.54 $\pm$0.009

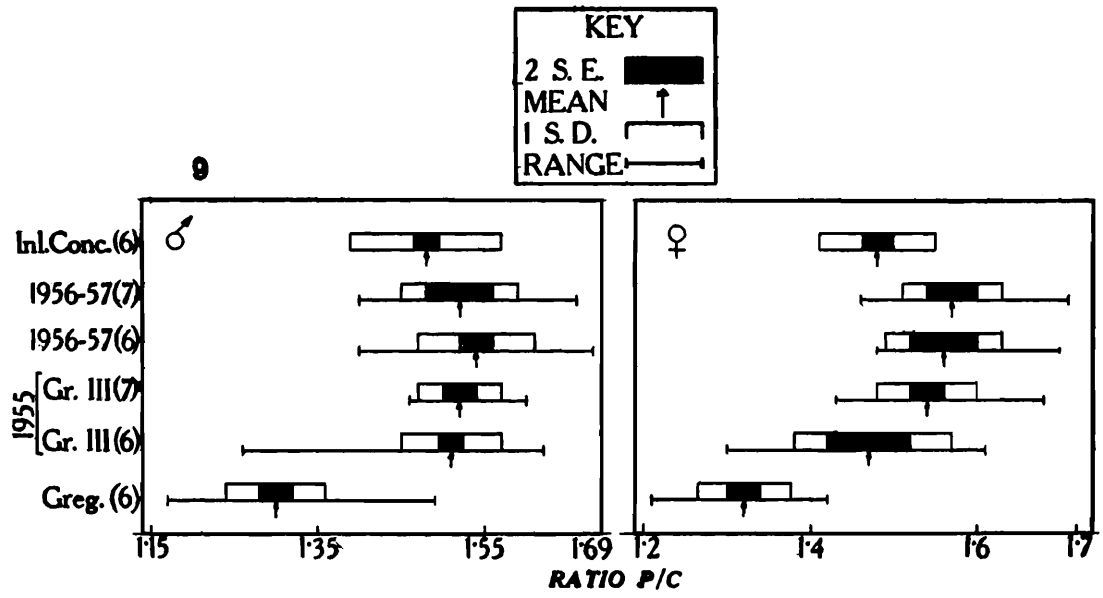
6-*striped males and females:* The values are significantly higher than in 6-*greg.*, the *Cal.Sw.*, the *Ajm.Sw.*, and the *Kakko Conc.* at all levels, and in the 1955-Gr.III at the 5% level only.

7-*striped males and females:* The values are not significantly different from those in the 1955-Gr.III population at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	1.30±1.40	1955-Gr.I(6)	1.52±1.27
7- eye-striped	3.29±1.60	1955-Gr.III(6)	−2.65±1.73
		1955-Gr.III(7)	1.32±0.96
		6-*greg.*	1.46±1.10
		Ajm.Sw.(6)	2.48
		Kakko Conc.(6)	−0.40±0.72

In the 6- and 7- eye-striped categories, the values in the 1956-57 population are not significantly different from those in the other known populations.



Text-fig. 9.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio P/C (Length of pronotum/width of head at genal level).

(For explanations *see* text.)

3. *Ratio M/C*

(Tables 4, 6 and 9; and Text-fig. 10)

(*a*) *Mean ratio* (Table 4): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio±S.E.*
Males (6)	0.87±0.005
Males (7)	0.87±0.013
Females (6)	0.89±0.009
Females (7)	0.89±0.007

(*b*) *Inter-sex comparison* (Table 6): In both 6- and 7-striped categories, the values in females are not significantly different from those in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): Within each sex-group, the value in the 6- eye-striped category is not significantly different from that in the 7-striped one all levels.

(*d*) *Inter-population comparison* (Table 9): The 1956-57 population compare with other populations (date given below) as follows:—

Other populations (and eye-stripes)	*Mean ratios±S.E.* *Males*	*Females*
6-*greg.*	0.779±0.008	0.805±0.005
1955-Gr.III(6)	0.89 ±0.003	0.90 ±0.012
1955-Gr.III(7)	0.90 ±0.006	0.92 ±0.004

6-*striped males:* The value is significantly higher than in 6-*greg.* and lower than in the 1955-Gr.III at all levels.

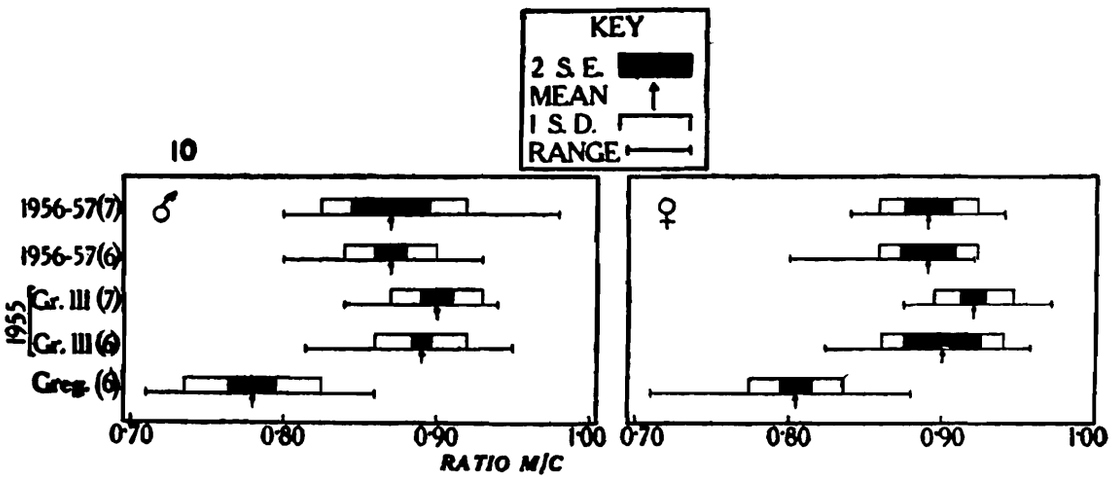
6-*striped females:* The value is significantly higher than in 6-*greg.* at all levels, but is not significantly different from that in the 1955-Gr.III.

7-*striped males:* The value is not significantly different than in the 1955-Gr.III at all levels.

7-*striped females:* The value is significantly lower than in the 1955-Gr.III at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E., varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	1.15±1.11	1955-Gr.I(6)	5.06±1.22
7- eye-striped	1.64±1.06	1955-Gr.II(6)	2.68±0.23
		1955-Gr.III(6)	0.90±1.36
		1955-Gr.III(7)	2.11±0.82



Text-fig. 10.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio M/C (width of pronotum/width of head at genal level).
(For explanations *see* text.)

In the 6- and 7- eye-striped categories, the value is significantly lower than in the 1955-Gr.I(6) and the 1955-Gr. III(7), but is not significantly different from other populations.

4. *Ratio H/C*

(Tables 4, 6 and 9; and Text-fig. 11)

(*a*) *Mean ratio* (Table 4): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio*$\pm$*S.E.*
Males (6)	1.23$\pm$0.006
Males (7)	1.22$\pm$0.010
Females (6)	1.24$\pm$0.009
Females (7)	1.24$\pm$0.009

(*b*) *Inter-sex comparison* (Table 6): In both 6- and 7- eye-striped categories, the value in females is not significantly different from that in the corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In either sex, the value in 6-striped individuals is not significantly different from that in the corresponding 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 9): The 1956-57 population compare with other populations (data given below) as follows:—

Other populations (and eye-stripes)	*Mean ratio*$\pm$*S.E.* *Males*	*Females*
6-*greg.*	1.112$\pm$0.008	1.126$\pm$0.007
1955-Gr.III(6)	1.25 $\pm$0.006	1.24 $\pm$0.016
1955-Gr.III(7)	1.25 $\pm$0.008	1.29 $\pm$0.002

6-*striped males:* The value is significantly higher than in 6-*greg.* at all levels, but lower than in the 1955-Gr.III at the 5% level.

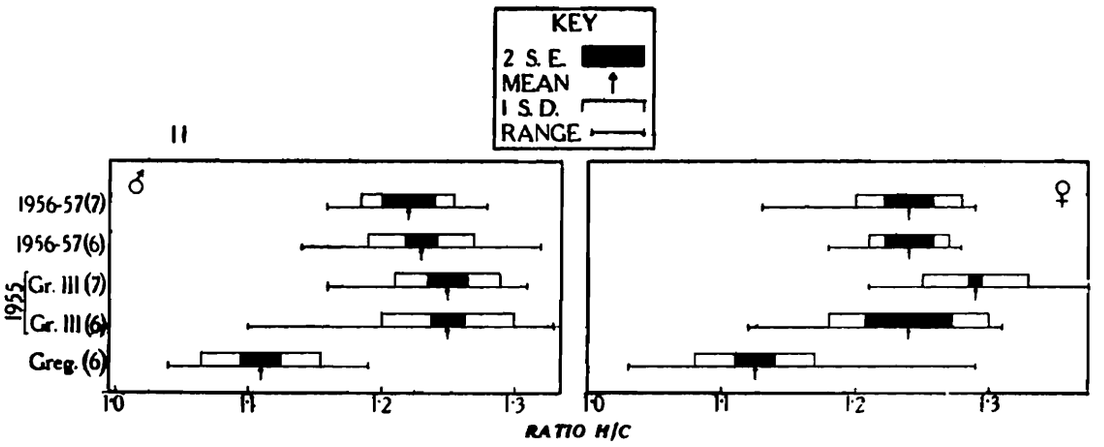
6-*striped females:* The value is significantly higher than in 6-*greg.* at all levels, but is not significantly different from that in the 1955-Gr.III.

7-*striped males and females:* The value is significantly lower than in the 1955-Gr.III at the 5% level in males and at all levels in females.

(*e*) *Sexual dimorphism percentage:* The S.D.P.$\pm$S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	0.81$\pm$0.88	1955-Gr.I(6)	1.82$\pm$1.10
7- eye-striped	1.64$\pm$1.06	1955-Gr.II(6)	0.88$\pm$0.22
		1955-Gr.III(6)	0.80$\pm$1.35
		1955-Gr.III(7)	3.20$\pm$0.86

In the 6- and 7- eye-striped categories the values in the 1956-57 population are not significantly different from other populations in the corresponding categories.



Text-fig. 11.—*Schistocerca gregaria*. Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio H/C (Height of pronotum/Width of head at genal level).
(For explanations *see* text.)

5. *Ratio* E/W_1

(Tables 4, 6 and 10; and Text-fig. 12)

(*a*) *Mean ratio* (Table 4): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio* $\pm$ *S.E.*
Males (6)	7.87 ± 0.063
Males (7)	7.89 ± 0.076
Females (6)	7.96 ± 0.067
Females (7)	7.93 ± 0.048

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7-striped categories, the value in females is not significantly different from those in corresponding males at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both sexes, within each sex-group, the values in the 6-striped categories are not significantly different from those in the corresponding 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 10): The 1956-57 population compare with other populations (data given below) as follows:—

Other populations	*Mean ratio* $\pm$ *S.E.*	
(and eye-stripes)	*Males*	*Females*
1955-Gr.III(6)	7.88 ± 0.038	8.10 ± 0.123
1955-Gr.III(7)	7.84 ± 0.068	8.12 ± 0.045

6-*striped males and females:* In both sexes, the value is not significantly different from that in the 1955-Gr.III in the corresponding sex, at all levels.

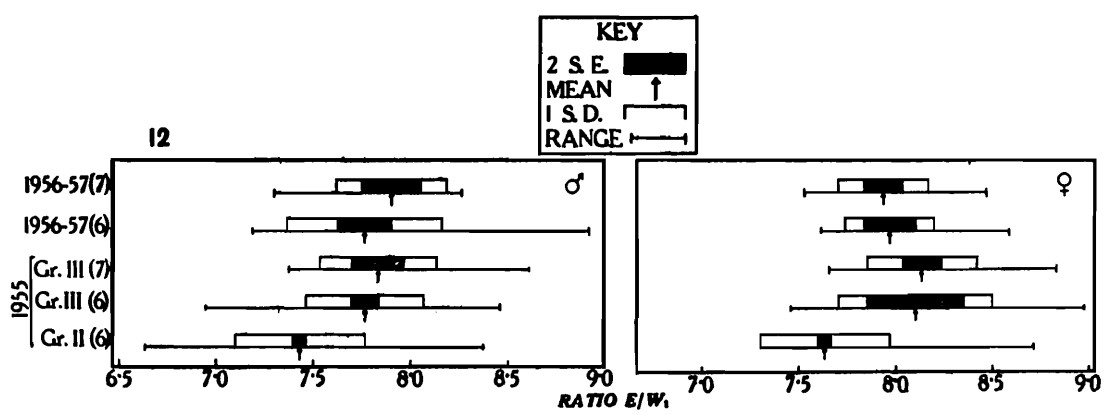
7-*striped males:* The value is not significantly different from that in the 1955-Gr.III population.

7-*striped females:* The value in the 1956-57 population is significantly lower than in the 1955-Gr.III at the 1% level.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 *population*	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	1.14±1.18	1955-Gr.I(6)	0.54±1.43
7- eye-striped	0.51±1.14	1955-Gr.II(6)	2.02±0.30
		1955-Gr.III(6)	2.79±1.63
		1955-Gr.III(7)	3.57±1.07

In the 6- and 7- eye-striped categories, the values in the 1956-57 population are not significantly different from other populations in the corresponding eye-stripe groups.



Text-fig. 12.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio E/W_1 (Length of elytron/Restricted width of elytron).

(For explanations *see* text.)

6. *Ratio E/F*

(Tables 5, 6 and 10; and Text-fig. 13)

(*a*) *Mean ratio* (Table 5): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio±S.E.*
Males (6)	2.00±0.005
Males (7)	1.97±0.012
Females (6)	2.00±0.013
Females (7)	1.99±0.008

(*b*) *Inter-sex comparison* (Table 6): In both the 6- and 7-striped categories, the values in females are not significantly different from that in corresponding males at all levels.

(*c*) *Inter-eye-stripes comparison* (Table 6): The value in 6-striped individuals is significantly higher than in 7-striped ones (at the 5% level only) in males, but is not significantly different in females.

(*d*) *Inter-population comparison:* The 1956-57 population compare with other populations (data given below) as follows:—

Other populations (*and eye-stripes*)	*Mean ratio*±*S.E.*	
	Males	*Females*
6-*greg.*	2.17±0.024	2.25±0.017
Cal. Sw.(6)	2.18±0.010	2.21±0.070
Ajm. Sw.(6)	2.22±0.023	2.19±0.035
6-*sol.*	2.05±0.012	2.09±0.008
7-*sol.*	2.00±0.006	2.03±0.007
Kakko Conc.(6)	2.06±0.010	2.12±0.011
Kakko. Conc.(7)	—	2.07±0.022
1955-Gr.III(6)	2.07±0.010	2.11±0.031
1955-Gr.III(7)	2.01±0.009	2.04±0.008

6-*striped males and females:* In both sexes, the values are significantly lower than those in corresponding sex in the 6-*greg.*, the *Cal.Sw.*, the *Ajm.Sw.*, the *Kakko Conc.*, the 6-*sol.* and the 1955-Gr.III at all levels.

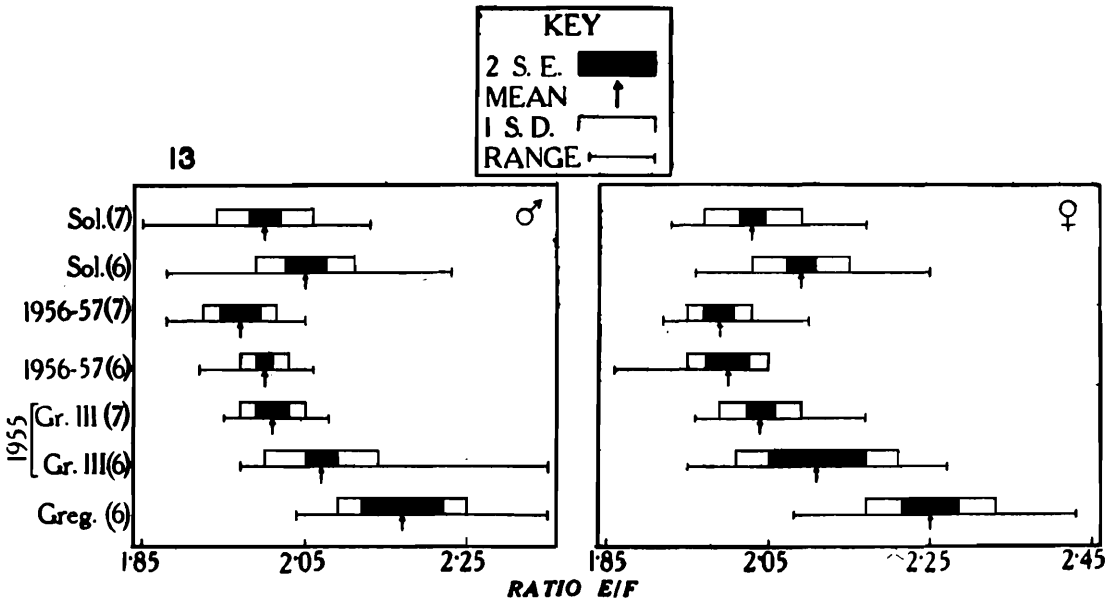
7-*striped males:* The value is significantly lower than in 7-*sol.* and the 1955-Gr.III at the 1% level.

7-*striped females:* The value is significantly lower than in 7-*sol.*, the 1955-Gr.III and the *Kakko Conc.* at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. in the 1956-57 population and other populations varies as follows:—

1956-57 *population*	*S.D.P.*	*Other populations* (*and eye-stripes*)	*S.D.P.*
6- eye-striped	0.00±0.70	1955-Gr.I(6)	1.36±1.10
7- eye-striped	1.02±0.74	1955-Gr.II(6)	2.29±0.23
		1955-Gr.III(6)	1.93±1.57
		1955-Gr.III(7)	1.49±0.63
		6-*greg.*	3.69±1.40
		Ajm.Sw.(6)	−1.35
		Kakko Conc.(6)	2.91±0.73
		6-*sol.*	1.95±0.49
		7-*sol.*	1.50±0.62

In the 6- eye-striped category, the value in the 1956-57 population is not significantly different from those in 1955-Gr.I(6) and 1955-Gr.III (6) at all levels, but is significantly lower than in 1955-Gr.II(6), 6-*greg.*, *Kakko Conc.*(6), 6-*sol.* at all levels. No comparison could be made with *Ajm.Sw.*(6), firstly S.D.P. being negative in *Ajm.Sw.* and secondly the data of S.E. is lacking. No significant difference is noticed in the 7-eye-striped category.



Text-fig. 13.—*Schistocerca gregaria.* Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio E/F (Length of elytron/Length of hind-femur).

(For explanations *see* text.)

7. *Ratio E/C*

(Tables 5, 6 and 10; and Text-fig. 14)

(*a*) *Mean ratio* (Table 5): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio* $\pm$ *S.E.*
Males (6)	7.95 ± 0.041
Males (7)	7.89 ± 0.067
Females (6)	8.07 ± 0.050
Females (7)	8.14 ± 0.058

(*b*) *Inter-sex comparison* (Table 6): The value in females is not significantly different from that in the corresponding males in the 6-striped category, but is significantly higher in the 7-striped category at the 1% level.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both sexes, the value in the 6-striped category is not significantly different from that in the corresponding 7-striped one at all levels.

(*d*) *Inter-population comparison* (Table 10): The 1956-57 population compare with the 1955-Gr.III population (data given below) as follows (the data for other populations are not available):—

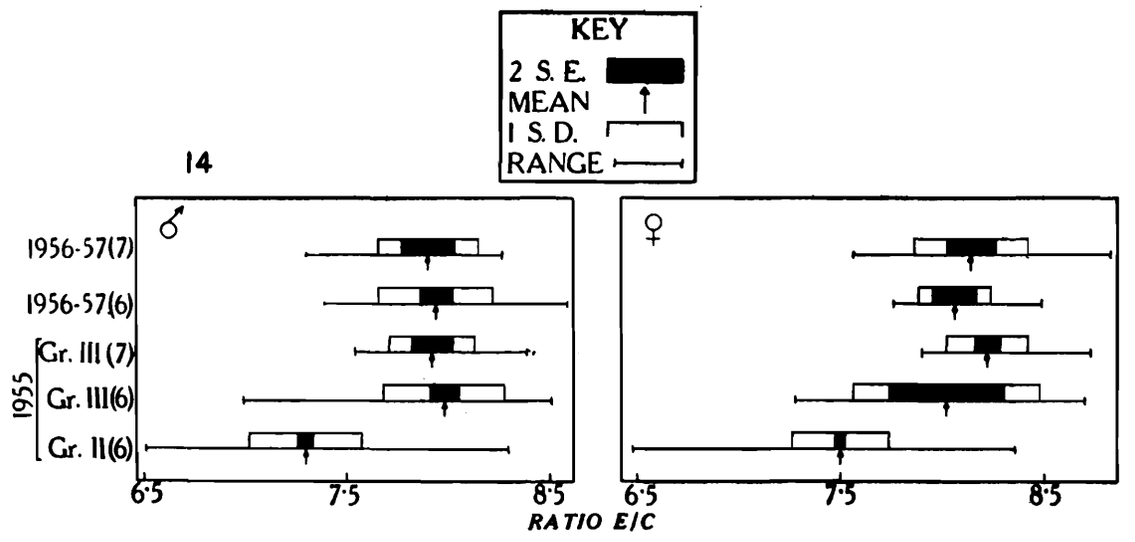
Other populations (*and eye-stripes*)	*Mean ratio*±*S.E.* *Males*	*Females*
1955-Gr.III(6)	7.98±0.04	8.03±0.14
1955-Gr.III(7)	7.92±0.05	8.23±0.03

In both sexes, and in both 6- and 7-striped forms, the value in the 1956-57 population is not significantly different from that in the corresponding 1955-Gr.III population at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P.±S.E. varies as follows:—

1956-57 population	*S.D.P.*	*Other populations* (*and eye-stripes*)	*S.D.P.*
6- eye-striped	1.51±0.82	1955-Gr.I(6)	4.44±1.12
7- eye-striped	3.17±1.15	1955-Gr.II(6)	2.74±0.25
		1955-Gr.III(6)	0.63±1.79
		1955-Gr.III(7)	3.91±0.75

In the 6- eye-striped category, the value in the 1956-57 population is significantly lower than in the 1955-5Gr.I one at the 5% level, but is not significantly difference from other populations. No significant difference is seen among the 7-striped categories.



Text-fig. 14.—*Schistocerca gregaria*. Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio E/C (Length of elytron/Width of head at genal level).

(For explanations *see* text.)

8. *Ratio F/C*

(Tables 5, 6 and 10; and Text-fig. 15)

(*a*) *Mean ratio* (Table 5): This varies as follows:—

Sex (and eye-stripes)	*Mean ratio* $\pm$ *S.E.*
Males (6)	3.98 $\pm$ 0.021
Males (7)	4.02 $\pm$ 0.038
Females (6)	4.05 $\pm$ 0.024
Females (7)	4.11 $\pm$ 0.033

(*b*) *Inter-sex comparison* (Table 6): In 6-striped forms the value in females is significantly higher than in males at the 5% level only, but in 7-striped ones there is not significant difference between the sexes at all levels.

(*c*) *Inter-eye-stripe comparison* (Table 6): In both sexes, the value in 6-striped individuals is not significantly different from that in the corresponding 7-striped ones at all levels.

(*d*) *Inter-population comparison* (Table 10): The 1956-57 population compare with other populations (data given below) as follows:—

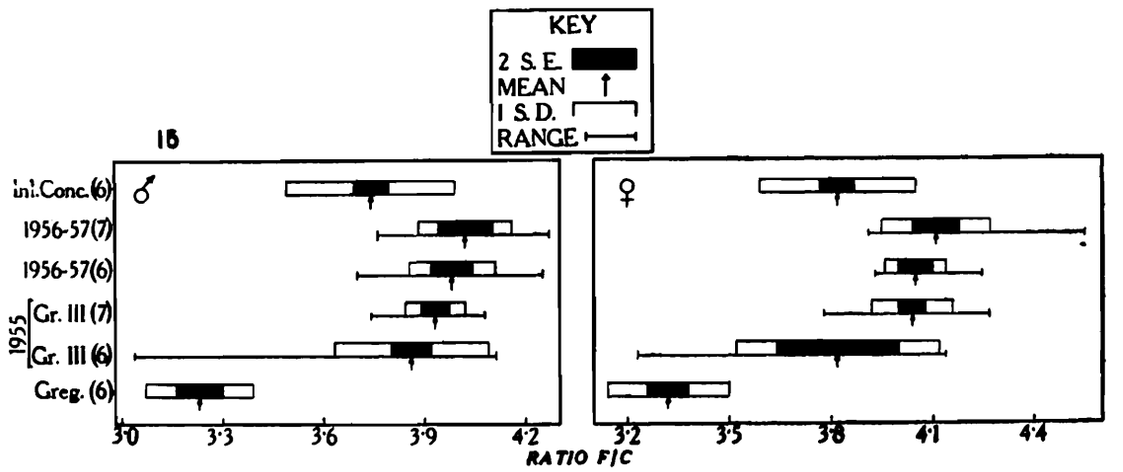
Other populations (and eye-stripes)	*Mean ratio* $\pm$ *S.E.* *Males*	*Females*
6-*greg.*	3.223 $\pm$ 0.032	3.320 $\pm$ 0.032
Cal.Sw.(6)	3.35 $\pm$ 0.010	3.41 $\pm$ 0.020
Ajm.Sw.(6)	3.237 $\pm$ 0.036	3.458 $\pm$ 0.079
Kakko Conc.(6)	3.790 $\pm$ 0.024	3.824 $\pm$ 0.027
1955-Gr.III(6)	3.86 $\pm$ 0.03	3.82 $\pm$ 0.09
1955-Gr.III(7)	3.93 $\pm$ 0.02	4.04 $\pm$ 0.02

Within the 6-striped category in both sexes, the value in the 1956-57 population is significantly higher than the individuals of the corresponding sex in 6-*greg.*, the *Cal.Sw.*, the *Ajm.Sw.*, the *Kakko Conc.* and the 1955-Gr.III at all levels. In 7-striped males the value in the 1956-57 population is significantly higher than in the 1955-Gr.III at the 5% level only, but in females there is no significant difference at all levels.

(*e*) *Sexual dimorphism percentage:* The S.D.P. $\pm$ S.E. in the 1956-57 population and other populations varies as follows:—

1956-57 population	*S.D.P.*	*Other populations (and eye-stripes)*	*S.D.P.*
6- eye-striped	1.76 $\pm$ 0.79	1955-Gr.I(6)	2.52 $\pm$ 1.71
7- eye-striped	2.24 $\pm$ 1.28	1955-Gr.II(6)	0.30 $\pm$ 0.33
		1955-Gr.III(6)	$-$1.04 $\pm$ 2.40
		1955-Gr.III(7)	2.80 $\pm$ 0.72
		6-*greg.*	2.69 $\pm$ 1.42
		Ajm.Sw.(6)	6.83
		Kakko Conc.(6)	0.90 $\pm$ 0.90

In both the 6- and 7- eye-striped categories, the value in the 1956-57 population is not significantly different from other populations in the respective eye-stripe groups.



Text-fig. 15.—*Schistocerca gregaria*. Dicegram to show variance in range, mean and its confidence limits (2 S.E.) and standard deviation (S.D.) in various populations regarding the ratio F/C (Length of hind-femur/Width of head at genal level).

(For explanations *see* text.)

9. *General conclusions regarding ratios*

Within the 1956-57 population, with the exception of a few ratios, the sexual and eye-stripe differences remain invariant.

In respect of the ratio P/C, the 6-striped males and females in the 1956-57 population have significantly higher ratios than those in populations of the typical *gregaria* facies, the 1955-Gr.III(6) and the *Kakko Conc.* (1949) (the latter two populations tending towards phase *solitaria* but not quite attaining the stage). Regarding the ratios M/C and H/C, significantly higher values are recorded in the 1956-57 population than in typical *gregaria* for both sexes, but the difference from the 1955-Gr.III(6) population is not so marked, particularly in females.

The ratio E/W_1 does not show any appreciable difference from the 1955-Gr.III(6) population. It is interesting to note that the ratio E/F shows significantly lower values in the 1956-57 population than in both the "typical" phases *gregaria* and *solitaria*. Since it has attained values even lower than in phase *solitaria*, the *solitaria* nature of this ratio may not be doubted. Values for the ratio E/C are available only for the 1965-Gr.III and a comparison of the 1956-57 population with it does not reveal any difference of note.

Regarding the ratio F/C, considered now as the most sensitive ratio, the 1956-57 population differs from the typical *gregaria* population to a great extent and is almost identical with the typical *solitaria* populations.

VI—Discussion and conclusions

We may now summarise some general conclusions regarding the phase status of the 1956-57 population.

With respect to the composition of eye-stripes and sex-ratios, the 1956-57 population reveals, in general, its similarity with the "typical" phase *solitaria* and other *solitariform* populations.

The nearly equal percentages of the sex-ratios (♂50: ♀ 50) in the 6- eye-striped individuals, which is a condition usually associated with *gregaria* populations (Roonwal's Hypotheses, 1945), is here completely disturbed. Sex-ratio in 6-striped individuals is ♂75±6: 25±6. In the 7-striped category, females predominate (♂38±8%: ♀ 62±8%), thereby further indicating the *solitaria* nature of the population. The same nature is shown by the eye-stripes proportions; a shrinking in the number of 6-eye-striped individuals to under 80%, and a relative abundunce of the 7-striped individuals, characters which show the *solitaria* nature of the population.

In 6-striped males, the characters P, E and F show their closeness to the *solitaria* condition. The character O, C and W_1 though differing from *solitaria* values, do so to a small extent only. Only characters H and M differ considerably from the *solitaria* values. In 6-striped females, the characters O, C, H, M, E, W_1 and F have values close to typical *solitaria* ones; but character P shows significant difference at the 5% level. In the 7-striped category, in both males and females, all the characters, except F in males, show their close affinity with the *solitaria* condition.

With respect to ratios, in 6-striped males, E/W_1 and E/C show no difference from the *solitaria* condition, but ratios P/C and H/C differ to a small extent. The ratio E/F is smaller than the typical values for both phases. F/C has values closer to *solitaria*. Only the ratio M/C does not indicate any definite affinity to either of the phases. In 6-striped females, the ratios M/C, H/C, E/W_1 and E/C have values similar to those in the typical *solitaria* populations. In the ratios P/C and F/C, the difference is less pronounced from the typical *solitaria* than from the typical *gregaria*. The ratio E/F differs from the typical values in both the phases, but is closer to the *solitaria*.

In 7-striped males, P/C, M/C, E/W_1 and E/C do not show any difference from the *solitaria* values, but the other ratios have values which are either significantly lower (H/C and E/F for both sexes) or higher (F/C for males only) from those in typical *solitaria* populations. In 7-striped females, P/C, E/W_1, E/C and F/C have values as in phase *solitaria*. The remaining ratios do not indicate any definite affinity to either of the phases.

Thus we may say that while generally, the 1956-57 population shows affinity to the *solitaria* phase, in some respect it behaves in a peculiar way. Females have been found to be more phase sensitive than males, the latter, in many characters, retaining a *gregaria* or a near *gregaria* characteristic.

VII—SUMMARY

1. A random sample of 93 individuals of a Desert Locust population in Rajasthan, western India, obtanied during the non-swarming

period 1956-57, was analysed for morphometrically and for eye-stripes and sex-ratios for ascertaining its phase status.

2. The sex-ratio in the 6-eye-striped individuals (♂75%: ♀25%) reveals a phase *solitaria* nature.

3. The eye-stripe proportions (6-striped population 75% *i.e.*, under 80%; and 7-striped one abundant, 62±8% also suggests the *solitaria* nature of population.

4. From inter-sex and inter-eye-stripe comparisons, it is seen that a high degree of sexual and eye-striped differences are demonstrated in the 1956-57 population for morphometric characters (size of body-parts) but such differences are not marked in the ratios.

5. The values of the morphometric characters P, E and F in males and O, C, H, M, E, W_1 and F in females, show affinity with *solitaria* phase values. The ratios E/W_1, E/C, E/F and F/C in males and E/F, M/C, H/C, E/W_1 and E/C in females also show affinity with the *solitaria* phase values.

6. Taken as a whole, the 1956-57 population has phase *solitaria* character.

VIII—References

Dirsh, V M. 1953. Morphometric studies on phase of the Desert Locust (*Schistocerca gregaria* Forskål).—*Anti-Locust Bull.*, No. 16, 4+34 pp. [International Locust Conference, Cairo], 1936. *Proceedings*. ix+96+51 appendices.—Cairo.

Misra, S. D. 1952. Studies of eye-stripe characteristics and the biometrical ratios of the body-parts in a concentration of Desert Locust individuals met with in July 1949 in the Rajasthan Desert, and thus started a new locust cycle in India. (In Misra, S. D., Nair, K. R. and Roonwal, M. L., 1952).—*Indian J. Ent.*, **14** (2): 100–112.

Misra, S. D. 1953. Confirmation of Roonwal's Hypotheses for prediction of swarming of Desert Locust from data collected in 1949.—*Saugar Univ. J.*, **1** (2): 233–238.

Misra, S. D., Nair, K. R. and Roonwal, M. L. 1951. Dynamics of eye-stripe composition, biometrical ratios and certain other characters during phase transformation in the Desert Locust.—*Curr. Sci.*, **20** (6): 164–165.

Misra, S. D., Nair, K. R. and Roonwal, M. L. 1952. Studies in intraspecific variation. Part VI. Dynamics of variability in respect of eye-stripe characters, sex-ratios and body-size of Desert Locust populations during the initial years (1949–1950) of a new swarming cycle in India, together with a statistical note on Roonwal's Hypotheses on prediction of swarming.—*Indian J. Ent.*, **14** (2): 95–152.

NAIR, K. R. 1952. Use of measurements of more than one biometric character regarding size of body-parts for discriminating between phases in the case of six eye-striped specimens of the Desert Locust. (In Misra, S. D., Nair, K. R. and Roonwal, M. L. 1952).—*Indian J. Ent.*, **14** (2): 126–136.

NAIR, K. R. 1952. A statistical note on Dr. Roonwal's Hypotheses for prediction of the swarming of the Desert Locust (*In* Misra, S. D., Nair, K. R. and Roonwal, M. L., 1952).—*Indian J. Ent.*, **14** (2): 136–147.

RAO, Y. RAMACHANDRA, 1942. Some results of studies on the Desert Locust (*Schistocerca gregaria* Forsk.) in India.—*Bull. ent. Res.*, London, **33** (4): 241–265.

RAO, Y RAMACHANDRA, 1960. *The Desert Locust in India*, xix+721 pp., 25 text-figs., 59 pls.—New Delhi (Indian Counc. Agric., Monogr. No. 21).

ROONWAL, M. L. 1936. On the existence of two different types of striped eyes among solitary type specimens on the Desert Locust, *Schistocerca gregaria* Forsk.—*Curr. Sci.*, **5** (1): 24.

ROONWAL, M. L. 1945. New hypotheses for the prediction of the swarming of the Desert Locust.—*Bull. ent. Res.*, London, **35** (4): 391–393.

ROONWAL, M. L. 1947. Variation and structure of the eyes in the Desert Locust, *Schistocerca gregaria* (Forskal) [Orthoptera, Acrididae].—*Proc. R. Soc.*, London, (B) **134** : 245–272, 3 pls.

ROONWAL, M. L. 1949*a*. Studies in intraspecific variation. III. Body-size and biometrical ratios in various types of individuals of the Desert Locust, *Schistocerca gregaria* (Forskål) [Orthoptera, Acrididae].—*Rec. Indian Mus.*, **45** (2-3): 149–165.

ROONWAL, M. L. 1949*b*. Studies in intraspecific variation. IV The role of some variation, *e.g.*, eye-stripes, etc., as "population indicators" in the Desert Locust, and their practical importance.—*Rec. Indian Mus.*, **45** (2-3): 167–180.

ROONWAL, M. L. 1954. On a new evolutionary phenomenon; The sharp increase of intraspecific variation in minimum population, as evidenced by the Desert Locust.—*Rec. Indian Mus.*, **51** (4): 481–525, 4 pls.

ROONWAL, M. L. 1955. Studies in the intraspecific variation. VII. Sex-ratios and eye-stripes in a July-1954 swarm (phase *gregaria*) of the Desert Locust, and a possible hint as to the decline of the current cycle.—*Indian J. Ent.*, **17** (1): 6–10.

ROONWAL, M. L. 1958. The Tata Medal Lecture. Recent researches on population dynamics and evolutionary problems in the Desert Locust, together with a new theory of the visual maintenance of gregarization in locusts.—*J. zool. Soc. India*, **9** (1): 72–96, 1 pl.

ROONWAL, M. L. 1961. Bibliographia Acrididiorum. A bibliography of the Orthopterous insects of the family Acrididae (comprising the short-horned grasshoppers and locusts) from the earliest times to the end of 1954 (with some additions for 1955-57).—*Rec. Indian Mus.*, **56** (1–4), [1958]: i-ix+1–611*a*, 1 pl.

ROONWAL, M. L. 1962. Phase and non-phase polymorphism in the Desert Locust.—*Colloq. int. Centre National Rech. Sci.*, No. 114 (Physiol., Comport. et Ecol. des. Acridiens en Rapport avec la phase), Paris, preprint: 1–6.

ROONWAL, M. L. and BHANOTAR, R. K. 1962. Studies in intraspecific variation. Part 12. Population dynamics and morphometry of the Desert Locust in the Calcutta Swarm of January 1961.—*Abstracts of papers 2nd All-India Congr. Zool.* (*Varanasi, Oct.* 1962), Cuttack, pp. 49–50.

ROONWAL, M. L. and BHANOTAR, R. K. 1966. Studies in intraspecific variation. Part X. Variation of metasternal interspace in relation to phase, sex and eye-stripes in the Desert Locust.—*J. zool. Soc. India, Calcutta*, **15** (1-2) [1963]: 32–46, 6 Tables, in 1 Fig.

ROONWAL, M. L. and BHANOTAR, R. K. 1966. Studies in intraspecific variation. Part XI. Morphometric characters, sex-ratios and eye-stripes in the 1955-population of the Desert Locust, in India.—*Rec. Indian Mus.*, **60** (1-2) [1962]: 1–80, 7 pls.

ROONWAL, M. L. and BHANOTAR, R. K. 1966. Studies in intraspecific variation. Part XII. Population dynamics and morphometry of the Desert Locust in the Calcutta Swarm of January 1961.—*Proc. 2nd All-India Congr. Zool.* (*Varanasi*, 1962), pt. 2 (Sci. Papers), Oct., 1966, Calcutta, pp. 287–296.

ROONWAL, M. L. and MISRA, S. D. 1952. Variability in a sample of Desert Locust population taken from a swarm in the Rajputana Desert, India, in 1950, the second year of a swarming cycle, together with discussion of the dynamics of phase transformation. (In Misra, S. D., Nair, K. R. and Roonwal, M. L. 1952).—*Indian J. Ent.*, **14** (2): 112–126.

ROONWAL, M. L. and NAG, M. K. 1951. Studies in intraspecific variation. Part V Statistical supplement to the analysis of biometrical data on body-size, etc. of various types of individuals of the Desert Locust, presented in Part III.—*Rec. Indian Mus.*, **47** (3-4): [1949]: 265–275.

STOWER, W. J., DAVIES, D. E. and JONES, I. B. 1960. Morphometric studies of the Desert Locust, *Schistocerca gregaria* (Forsk.).—*J. anim. Ecol.*, **29** : 309–339.

"STUDENT" [GOSSET, W. S.] 1908. On the probable error of a mean.—*Biometrika*, **6** : 1–25.

UVAROV, B. P. 1928. *Locusts and Grasshoppers. A Handbook for their study and Control.* xiii+352, 9 pls.—London (Imp. Inst. Ent.).

UVAROV, B. P. 1966. *Grasshoppers and Locusts. A Handbook of General Acridology. Vol. 1. Anatomy, Physiology, Development, phase polymorphism, Introduction to Taxonomy.* xi+481 pp., 1 frontpiece (col.). —Cambridge (Univ. Press).

WALOFF, Z. 1966. The upsurge and recessions of the Desert Locust plague: An historical survey.—*Anti-Locust Mem.*, No. 8: 1–111, 4 flagged maps.

Rec. zool. Surv. India, **68** : 79–107, 1975.

EYE-STRIPE COMPOSITION, SEX-RATIOS AND MORPHOMETRY OF THE 1949-61 DESERT LOCUST POPULATIONS IN INDIA IN RELATION TO PHASE TRANSFORMATION

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(With 7 Text-figures)

CONTENTS

	PAGE
I—INTRODUCTION	80
1. General	80
2. Abbreviations used	80
3. Acknowledgement	81
II—EYE-STRIPES AND SEX-RATIOS	81
1. Eye-stripes	81
2. Sex-ratios	84
III—MORPHOMETRIC CHARACTERS	84
1. General	84
2. Width of head at ocular level (O)	85
3. Width of head at genal level (C)	86
4. Length of pronotum (P)	87
5. Height of pronotum (H)	88
6. Width of pronotum at the constriction (M)	89
7. Length of elytron (E)	90
8. Restricted width of elytron (W_1)	91
9. Length of hind-femur (F)	92
IV—MORPHOMETRIC RATIOS	93
1. General	93
2. Ratio P/C	94
3. Ratio M/C	95
4. Ratio H/C	96
5. Ratio E/W_1	96
6. Ratio E/F	97
7. Ratio E/C	98
8. Ratio F/C	99
V—DISCUSSION	100
VI—SUMMARY	104
VII—REFERENCES	104

I—Introduction

1. *General*

The Ninth (recorded) Swarming Cycle of the Desert Locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae) in India (1949–55) started with a sudden increase in locust population density in 1949, a small sample of which, taken from the village Kakko (Bikaner, District, Rajasthan) had a population density of about 18,000 locusts per square mile. This initial or *Kakko Concentration* was analysed morphometrically by Misra (1952). Roonwal (1952) studied the second year of the swarming cycle from a small sample obtained from the *Ajmer Swarm* of 1950. Bhanotar *et al.* (in press) studied the 1954-population. A small sample from a swarm in July 1954 was also studied by Roonwal (1955). Roonwal and Bhanotar (1966) studied the 1955-population which formed last year of this Ninth Cycle. Bhanotar *et al.* (in press) studied samples from populations of the first and second years (1956 and 1957) of the non-swarming period which immediately followed the 1949–55 swarming Cycle and lasted upto 1958. Finally, Roonwal and Bhanotar (1962 and 1966) studied a sample obtained from a *Calcutta Swarm* of 1961 which represented the third year of the Tenth Swarming Cycle in India (1959–63).

Thus, we have now available considerable data on several biologically interesting populations representing various degrees of phase-transformation in the Desert Locust in India. For the 1949–55 cycle we have the *Kakko Concentration* of 1949 which started the initial phase-transformation from *solitaria* to *gregaria* populations; the 1955-population (particularly the last one-third or Group III) during which transformation from *gregaria* to *solitaria* population took place; and the intervening populations of the years 1950, 1954 and the earlier two-thirds of 1955 (Groups I and II); then were studied the representative of the years 1956-57 (of the non-swarming period 1956-58); and finally, another *gregaria* representative (a 1961 swarm) of the swarming period 1959–63.

The phase status of all these populations have now been studied. We may now be able to know the behaviour of the morphometric characters and the ratios in phase-transformation. Similarly, we are in a position to study the behaviour of the eye-stripes (5-8-striped individuals) and the sex-ratios. We may further be able to know which are the more sensitive phase-characters and how they behave in the critical periods of phase-transformation.

2. *Abbreviations used*

Except where otherwise stated, the following abbreviations have been used throughout:—

O, Width of head at ocular level.
C, Width of head at genal level.
P, Length of pronotum.
H, Height of pronotum.

M, Width of pronotum at the constriction.
E, Length of elytron.
W_1, Restricted width of elytron.
F, Length of hind-femur.
S.E., Standard error.

6-*greg.*, *greg.* or *Greg.*, typical 6- striped phase *gregaria* individuals.
6-*sol.*, 7-*sol.*, ph. *sol.*, typical 6- or 7- striped phase *solitaria* individuals.
6-, 7-, (6) or (7)- striped, 6- or 7- eye-striped.
5- 8- striped, 5- or 8- eye-striped.

1954 (Dehra Dun swarm), 6- or 7- striped individuals of 1954-Dehra Dun swarm (Roonwal, 1955).
1954-Gr.I, 1954 Group I populations.
1954-Gr.II, 1954, Group II populations.
1954-Gr.III, 1954 Group III populations.
1955-Gr.I, 1955 Group I populations.
1955-Gr.II, 1955 Group II populations.
1955-Gr.III, 1955 Group III populations.
1956-57 6- or 7- striped individuals of 1956 and 1957 years populations.
1961 (*Calcutta swarm*) or 1961 (*Cal.sw.*) or *Cal.sw.*(6), 6- or 7- striped individuals of 1961 Calcutta swarm.
Gr.I(6) or Gr.I(7), 6- or 7- striped individuals of Group I.
Gr.II(6) or Gr.II(7), 6- or 7- striped individuals of Group II.
Gr.III(6) or Gr.III(7), 6- or 7- striped individuals of Group III.
1949-*Kakko Conc.* or *Inl. Conc.*, Initial concentration of locusts Kakko village (Rajasthan, India) in 1949 (Misra, 1952).
1950-*Ajm. sw.*, or *Ajm.*(6), Ajmer Swarm population of 1950 (Roonwal and Misra, 1952).

3. *Acknowledgement*

I am grateful to Dr. M. L. Roonwal, Vice-Chancellor, University of Jodhpur, Jodhpur, Rajasthan and formerly, Director, Zoological Survey of India, Calcutta, for his valuable suggestions and guidance. Thanks are due to Director, Zoological Survey of India, for giving all laboratory facilities.

II—EYE-STRIPES AND SEX-RATIOS

1. *Eye-stripes*

(*a*) *Eye-stripes composition* (*1949–61*).—The number of eye-stripes varies from 5–8, and the composition (percentage) of such individuals in

various populations is as given below:—

Years	*% of individual in each type±S.E.*			
	5-striped	*6-striped*	*7-striped*	*8-striped.*
1949	0.4 (1 ex.)	94.0 ±1.4	5.6 ±1.4	0
1950	0	93.00	7.00	0
1954 (Dehra Dun swarm)	0	99.9	0.1	0
1954-Gr.I	0	85.14±4.13	14.86±4.14	0
1954-Gr.II	0	99.77±0.13	0.23±0.14	0
1954-Gr.III	0	97.84±0.69	2.16±0.69	0
1955-Gr.I	0	93.0 ±4	7.0 ±4	0
1955-Gr.II	0.20±0.3 (2 exs.)	98.6 ±0.3	1.2 ±0.3	0
1955-Gr.III	0	56.0 ±4	42.7 ±4	1.3±4 (2 exs.)
1956-57	0	60.0 ±5	40.0 ±5	0
1961 (Calcutta swarm)	0	100.00	0	0

(*b*) *Discussion.*—No eye-stripe data is available for the non-swarming period 1947-48. However, Roonwal (1954, p. 507) mentioned the common occurrence of 7-striped forms; but no 8-striped forms were reported. During the ninth swarming cycle in India (1949–55), all the four types (*viz.*, 5- to 8-striped) forms occured. The 5- and 8-striped forms are of a rare occurrence in nature. We may now discuss the position regarding each type of eye.

(*i*) 5-*eye-stripes:* Roonwal (1954) placed the 5-striped forms with solitaria population, but left its position open.

In the 1949–55 Cycle, Misra (1952) found a single 5-striped form in the initial *Kakko Concentration* of 1949, a period when phase-transformation took place. Later on, from the last year of this cycle (1955), particularly Group II, Roonwal and Bhanotar (1966) found two 5-striped forms, and correlated its appearance with the most critical period of the Desert Locust plague, when the equilibrium in the morphometric characters and ratios appears to be most disturbed. Still, its basic origin and phase-status remain problematic. For the present we may associate the occurrence of 5-striped forms with the critical period when the phase is being transformed (*vide*, discussion in Roonwal, in press).

(*ii*) 6-*eye-stripes:* As viewed against Roonwal's First Hypothesis (1945), the populations of the years 1949–55 (swarming cycle), behaved in a set pattern. Right from the initial *Kakko concentration* of 1949, the "above 80 percent rule for 6-striped forms was strictly maintained by the populations (indicating a swarming or *gregaria* tendency) upto August, 1955 (ranges of means 85.14 ± 4.13 to 99.9%). In the 1954-gr.I population, the proportion of 6-striped forms (85.14 ± 4.13%) came down somewhat, but still remained above 80%. In the critical

1955-Gr.III population (September-December), a sudden transformation to *solitaria* phase took place. The proportion of 6-striped forms fell far below 80%, coming down to 56.0 ± 4% along with a corresponding increase in the proportion of 7-striped forms (44.0 ± 4%). This declined ratio was maintained by the succeeding population of the years 1956 and 1957 (6-striped, 60.0 ± 5%). In the *Calcutta Swarm* of 1961, representing the third year of the tenth swarming cycle (1959–63), the percentage of 6-striped forms arose to 100% and 7-striped forms were completely absent.

(*iii*) *7-eye-stripes:* The presence of 7-striped forms in all the studied populations of the Ninth Swarming Cycle (1949–55), may indicate the mildness of this Cycle. But the sudden abundance of 7-striped forms (44.0 ± 4%) in the 1955-Gr.III population (September-December) show an abrupt disturbance in the hitherto stable condition of the eye-stripe composition. This eye-stripe shift in the last generation of the 1955-population corresponds to the complete break down of the Cycle, as seen from the study of the immediately succeeding populations of the years 1956 and 1957.

(*iv*) *8-eye-stripes:* The earlier record of the occurrence of 8-striped forms was reported in India during the non-swarming period 1932–39, particularly in the years 1936–38. Roonwal (1954, p. 504) associated this form with the "extreme development of the *solitaria* period" In the 1949–55 Swarming Cycle, 8-striped forms were reported only in the last part of 1955 (Gr.III) population when two such individuals were found.

(*v*) *Asymmetry in eye-stripes:* Usually the number of eye-stripes in an individual are symmetrical *i.e.*, both eyes has the same number of stripes. But in the middle period of 1955 (Gr.II), an asymmetrical individual occurred (Bhanotar, 1959). While the right eye had 8-stripes the left eye only 7. The phase significance of this asymmetry is problematic—probably it has none.

Thus, the important and significant role of eye-stripes composition in determining the phase nature of a population is established, and the data give further support to Roonwal's (1945) First Hypothesis.

(*b*) *Discussion.*—Except for three 5-striped individuals (1♂, 2♀♀) and two 8-striped ones (both females), the sexes in the remaining individuals of the 1949–55 cycle were associated with 6- and 7-striped forms only.

As viewed against Roonwal's (1945) Second hypothesis, during the swarming period, in all the population—groups from July 1949 to August, 1955, in the 6- eye-striped category, the proportion of sexes remained almost equal (range 45–56%), indicating a *gregaria* characteristic of the desert locust population, where the sex-ratio is typically 50: 50. However, this stability of the sex-ratio was found to be disturbed in the 1955-Gr.III population (September-December 1955). Where the sex-ratio in the 6-striped category was ♂84±4: ♀16±4. This predominance of males over females showed a *solitaria* facies of the population. In the 7-striped category of the same population, the proportion of females was higher (♂33±5: ♀67±5), thereby further indicating the *solitaria* characteristic of the population.

The trend of the sex-ratio as found in the 1955-Gr. III population was maintained by the immediately succeeding population of the years 1956 and 1957, where the ratio in 6-striped category was ♂75±6: ♀25±6 and in the 7-striped category ♂38±8: ♀62±8.

In the 1961-population (*Calcutta swarm*) the sex-ratio was almost equal (♂49.23±6.20: ♀50.77±6.20), indicating the *gregaria* nature of this population.

2. *Sex-ratios*

(*a*) *Sex-ratios* (*1949-61*).—The sex-ratios in the various populations of the period 1949–61 are as given below:—

Years	Sex-ratio (%)			
	6- eye-striped		7- eye-striped	
	Male	Female	Male	Female
1949	54±3	46±3	20±10	80±10
1950	71.43	25.87	(1 ex.)	—
1954 (Dehra Dun Swarm)	48.8	51.2	—	(1 ex.)
1954-Gr.I	50.79±6.30	49.21±6.30	27.27±13.45	72.73±13.43
1954-Gr.II	54.54±1.39	45.46±1.39	0	0
1954-Gr.III	50.66±2.35	49.34±2.35	70.00±14.49	30.00±14.49
1955Gr.I	56±7	44±7	100	0
1955-Gr.I	47.52±2	52.5±2	9±9	91±9
1955-Gr.III	84±4	16±4	33±5	67±5
1956-57	75±6	25±6	38±8	62±8
1961 (*Cal.Sw.*)	49.23±6.20	50.77±6.20	0	0
Typical ph. gregaria (Roonwal's Hypotheses)	50	50	0	0
Typical ph.solitaria (Roonwal's Hypotheses)	60	40	35	65

III—Morphometric characters

(Text-figs. 1–4)

1. *General*

For comparisons among the various populations, only the following morphometric characters are taken into account. For the others, (namely, the length of eye (A), width of eye (B), and maximum (K) and minimum (L) width of mesosternal interspace, the data is either lacking or meagre.

1. Width of head at ocular level (O).
2. Width of head at genal level (C).
3. Length of pronotum (P).
4. Height of pronotum (H).
5. Width of pronotum at the constriction (M).
6. Length of elytron (E).
7. Restricted width of elytron (W_1).
8. Length of hind-femur (F).

These characters are discussed below with respect to their phase-association in relation to sex- and eye-stripe categories, to determine their trend in the swarming and non-swarming populations.

2. *Width of head at ocular level (O)*

(*a*) *Mean values.*—The mean values (mm.) of O in the available populations for swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean width (mm.) S. ± E.* *Males*	*Females*
1954-Gr.I(6)	6.40±0.07	6.81±0.13
1954-Gr.II(6)	6.44±0.01	6.76±0.01
1954-Gr.III(6)	6.41±0.02	6.68±0.02
1954-Gr.I(7)	6.60±0.50	7.00±0.06
1954-Gr.II(7)	—	7.00±0.22
1954-G.III(7)	6.33±0.12	7.05±0.07
1955-Gr.I(6)	6.30±0.05	6.71±0.07
1955-Gr.II(6)	6.40±0.01	6.79±0.01
1955-Gr.III(6)	6.24±0.025	6.75±0.013
1955-Gr.I(7)	6.27±0.09	—
1955-Gr.II(7)	6.10	6.94±0.10
Ph. sol. Gr.III(7)	6.46±0.05	7.14±0.05
Ph. sol. 1956-57 (6)	6.13±0.032	6.72±0.076
Ph. sol. 1956-57 (7)	6.42±0.059	7.04±0.063

(*b*) *Discussion.*—Data for only four years (1954–57) are available. Of these, the populations of the periods 1954-Grs. I–III and 1955-Grs. I and II are *gregaria* in nature and the 1955-Gr. III and 1956-57 populations are *solitaria.*

For each eye-stripe and sex-group, the mean values are significantly higher in phase *gregaria* populations than in *solitaria* ones, and this is particularly evident in males, females are less phase-sensitive.

Generally, in each eye-stripe and phase-group, the values in females are significantly higher than in males and 6-striped individuals are significantly smaller than 7-striped ones.

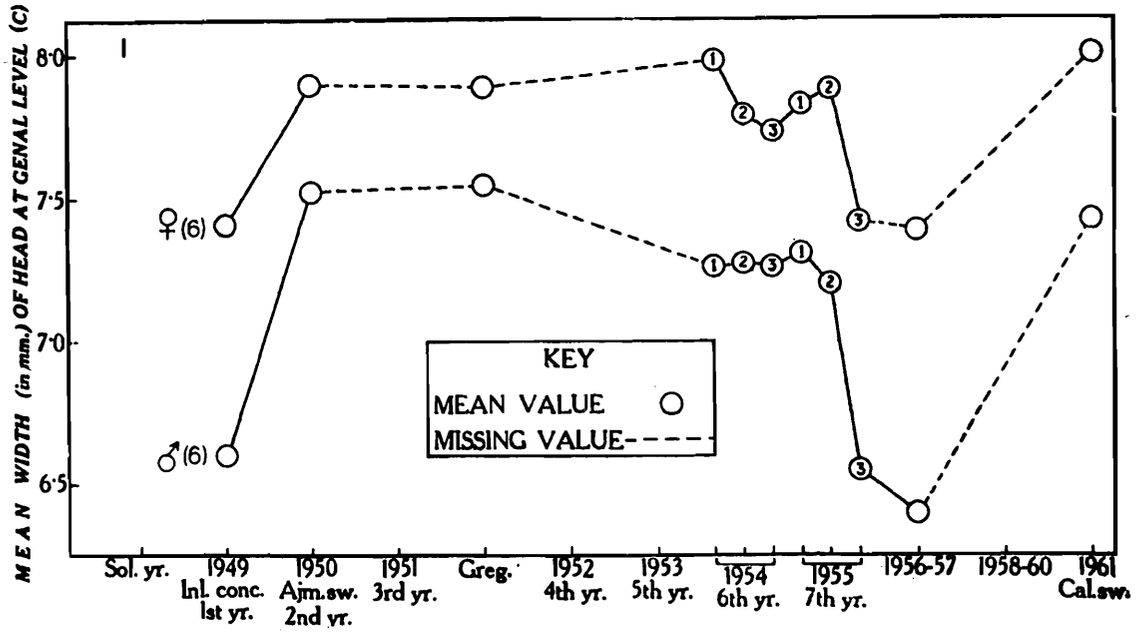
Thus, the width of head at the ocular level is correlated with the degree of gregariazation and solitariness of the population. It tends to increase from a lower *solitaria* level to a higher *gregaria* level, particularly in males. This phase-transformation apparently takes place in one generation, *i.e.*, very quickly.

3. *Width of head at genal level (C)*

(Text-fig. 1)

(*a*) *Mean values.*—The mean values (mm.) of C in the available populations for swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean width (mm.) ± S.E.* *Males*	*Females*
6-*greg.*	7.55±0.04	7.89±0.07
1949-*Kakko Conc.*(6)	7.60±0.033	7.41±0.041
1950-*Ajm.Sw.*(6)	7.53±0.082	7.90±0.248
1954-Gr.I(6)	7.26±0.10	7.98±0.07
1954-Gr.II(6)	7.27±0.01	7.79±0.02
1954-Gr.III(6)	7.26±0.02	7.73±0.03
1954-Gr.I(7)	6.97±0.32	7.65±0.09
1954-Gr.II(7)	—	7.70±0.22
1954-Gr.III(7)	6.50±0.14	7.67±0.16
1955-Gr.I(6)	7.31±0.07	7.83±0.07
1955-Gr.II(6)	7.20±0.02	7.88±0.02
1955-Gr.III(6)	6.55±0.04	7.42±0.16
1955-Gr.I(7)	6.63±0.14	—
1955-Gr.II(7)	6.30	7.63±0.15
Ph. sol. 1955-Gr.III(7)	6.67±0.05	7.70±0.05
Ph. sol. 1956-57 (6)	6.40±0.043	7.39±0.088
Ph. sol. 1956-57 (7)	6.75±0.064	7.74∓0.090
1961-*Cal.Sw.*(6)	7.43±0.040	—



Text.-fig 1.—*Schistocerca gregaria.* Graph showing the trend of variability in the width of head at genal level (C) in various populations, *viz.*, swarming populations (1949–55 and '61), non-swarming populations (1956-57), and "typical" phases *solitaria* and *gregaria*. The missing values are shown in broken lines. Numerals in the circles indicate the population—Groups (1–3) of a particular year.

For other explanations *see* text.

(*b*) *Discussion.*—Data for the population of seven years (1949, '50, '54, '55, '56, '57 and '61) are available. Of these populations of 1950, 1954 (Grs. I–III), 1955 (Grs. I and II) and 1961 represent the *gregaria* facies and those of 1949, 1955 (Gr. III) and 1956-57 the *solitaria* facies.

This character, C, is the most sensitive phase-differentiating character. The mean value is significantly lower in *solitaria* population than in *gregaria*. Further, the 6- eye-striped individuals are significantly smaller than 7-striped ones in both sexes, and females are significantly larger than males.

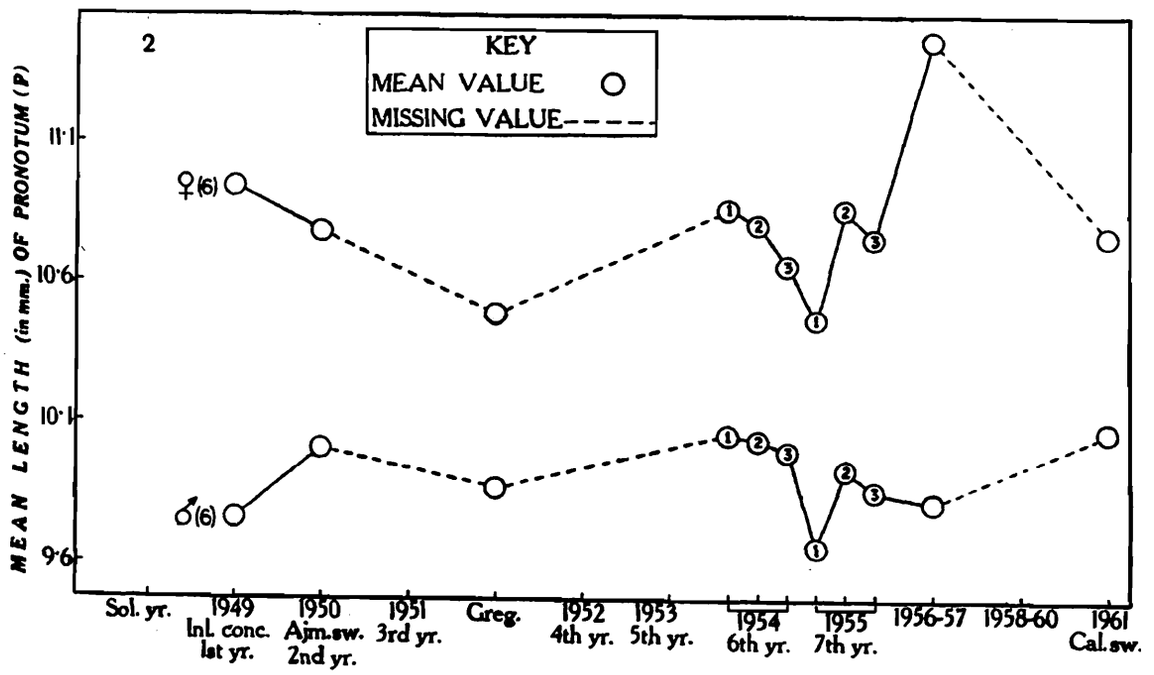
Thus, the width of the head at genal level is narrower in typical *solitaria* than in *gregaria* populations. In the latter it is wider and the value acquires a certain stability. The character is distinctly correlated with phase, and phase-transformation takes place in one generation, *i.e.*, very quickly.

4. *Length of pronotum* (*P*)

(Text-fig. 2)

(*a*) *Mean values.*—The mean length (mm.) of P in the available populations for swarming and non-swarming periods (1949–61) are as follows:—

Populations (*and eye-stripes*)	*Mean length* (*mm.*) ± *S.E.* *Males*	*Females*
6-greg.	7.55±0.04	7.89±0.07
1949-*Kakko Conc.*(6)	9.76±0.054	10.94±0.088
1950-*Ajm.Sw.*(6)	10.01±0.108	10.78±0.343
1954-Gr.I(6)	10.06±0.12	10.86±0.10
1954-Gr.II(6)	10.04±0.03	10.81±0.03
1954-Gr.III(6)	10.00±0.04	10.66±0.04
1954-Gr.I(7)	10.30±0.78	11.22±0.20
1954-Fr.II(7)	—	11.60±0.36
1954-Gr.III(7)	9.90±0.28	11.77±0.34
1955-Gr.I(6)	9.66±0.11	10.47±0.11
1955-Gr.II(6)	9.94±0.02	10.86±0.03
1955-Gr.III(6)	9.86±0.06	10.76±0.29
1955-Gr.I(7)	9.67±0.44	—
1955-Gr.II(7)	10.00	11.50±0.29
Ph. sol. 1955-Gr.III(7)	10.20±0.08	11.90±0.10
Ph. sol. 1956-57 (6)	9.82±0.078	11.46±0.176
Ph. sol. 1956-57 (7)	10.24±0.149	12.10±0.129
1961-*Cal.Sw.*(6)	10.07±0.090	10.79±0.090



Text-fig. 2.—*Schistocerca gregaria.* Graph showing the trend of variabiltiy in the length of pronotum (P) in various populations as in Text-fig. 1. For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the populations of six years, along with those of "typical" *gregaria*, are available. Of these, those of the years 1950, 1954 (Grs. I–III), 1955 (Grs. I and II) and 1961 represent the *gregaria* facies, and those of 1949, 1955 (Gr.III) and 1956-57 the *solitaria* facies.

The mean value in the *solitaria* facies population is significantly higher than in the *gregaria* for females, the difference in males being less pronounced. Within each phase—and eye-stripe group, females are significantly larger than males; and 6-striped individuals are smaller than 7-striped ones in both sexes.

In females, the length of the pronotum value increases as the populations moves from the *gregaria* to the *solitaria* facies. This tendency is reversed in males and the values tend, though at a slower rate, to decrease as the populations approach the *solitaria* condition.

Phase-transformation takes place in one generation *i.e.*, quickly and the change is more pronounced in males than in females.

5. *Height of pronotum (H)*

(*a*) *Mean values.*—The mean value (mm.) of H in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean height (mm.) ± S.E.* *Males*	*Females*
1954-Gr.I(6)	8.16±0.10	8.93±0.07
1954-Gr.II(6)	7.99±0.02	8.69±0.03
1954-Gr.III(6)	7.90±0.03	8.49±0.03
1954-Gr.I(7)	8.50±0.40	9.39±0.10
1954-Gr.II(7)	—	9.30±0.20

Populations (and eye-stripes)	*Mean height (mm.)±S.E.* *Males*	*Females*
1954-Gr.III(7)	7.83±0.16	9.07±0.12
1955-Gr.I(6)	8.03±0.08	8.70±0.11
1955-Gr.II(6)	8.14±0.02	8.98±0.03
1955-Gr.III(6)	8.20±0.04	9.10±0.27
1955-Gr.I(7)	8.13±0.26	—
1955-Gr.II(7)	7.70	9.37±0.21
Ph. sol. 1955-Gr.III(7)	8.40±0.09	9.90±0.07
Ph. sol. 1956-57 (6)	7.86±0.047	9.13±0.142
Ph. sol. 1956-57 (7)	8.25±0.086	9.57±0.116

(*b*) *Discussion.*—Data for the populations of only four years (1954–57) are available. Of these, the populations of 1954 (Grs. I–III) and 1955 (Grs. I and II) represent *gregaria* facies and of 1955 (Gr.III) and 1956-57 the *solitaria* facies. The mean value is significantly higher in males than in females in *gregaria* populations. The character P is moderately phase—sensitive.

Within the same phase- and eye-stripe—group, females are significantly larger than males and 6-striped individuals are significantly smaller than 7-striped ones in both sexes. Thus, the height of pronotum decreases with the increase of gregarization, particularly in females. For males, however, this tendency is reversed. Phase transformation takes place, in one generation, *i.e.*, quickly.

6. *Width of pronotum at the constriction (M)*

(*a*) *Mean values.*—The mean values of M in the available populations for the swarming and non-swarming periods (1949–61) are as follows :—

Populations (and eye-stripes)	*Mean width (mm.)±S.E.* *Males*	*Females*
6-greg.	5.86±0.04	6.36±0.08
1954-Gr.I(6)	5.95±0.08	6.71±0.07
1954-Gr.II(6)	5.73±0.01	6.38±0.02
1954-Gr.III(6)	5.64±0.02	6.23±0.03
1954-Gr.I(7)	6.27±0.33	6.85±0.06
1954-Gr.II(7)	—	6.70±0.27
1954-Gr.III(7)	5.59±0.12	6.67±0.15
1955-Gr.I(6)	5.80±0.05	6.52±0.07
1955-Gr.II(6)	5.91±0.01	6.63±0.02
1955-Gr.III(6)	5.84±0.03	6.67±0.15
1955-Gr.I(7)	5.80±0.15	—
1955-Gr.II(7)	5.70	6.78±0.12
Ph. sol. 1955-Gr.III(7)	5.98±0.05	7.09±0.04
Ph. sol. 1956-57 (6)	5.54±0.038	6.55±0.069
Ph. sol. 1956-57 (7)	5.89±0.080	6.85±0.066

(*b*) *Discussion.*—Data for the populations of only four years (1954-57) along with those of "typical" *gregaria* are available. Of these, the populations of the year 1954 (Grs. I–III) and 1955 (Grs. I and II) represent the *gregaria* facies and of 1955-Gr.III and 1956-57 the *solitaria* facies. In males, the pronotum is significantly wider in *gregaria* populations than in *solitaria* ones, but females are less sensitive. The character M shows moderate phase-sensitivity in differentiating populations. Within each phase- and eye-stripe group, females have wider pronotum than males.

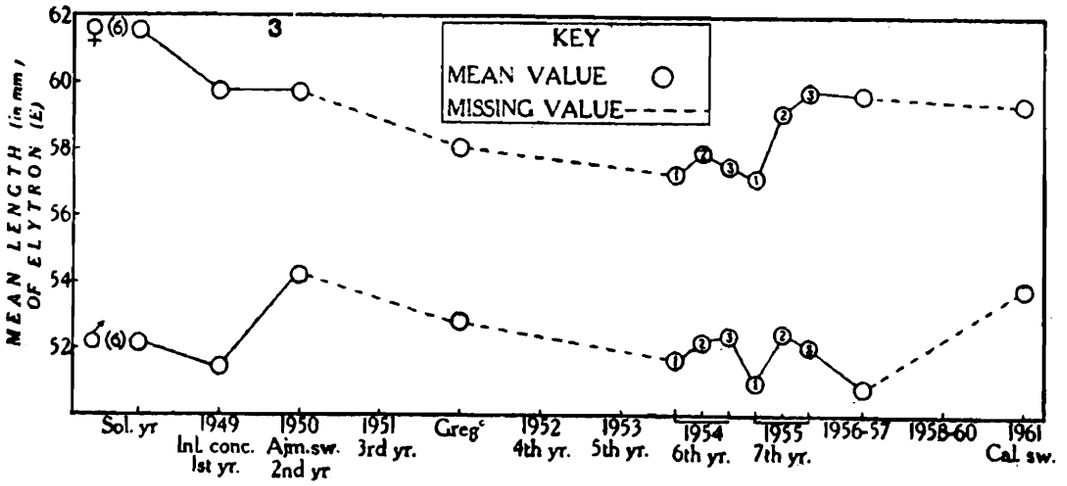
Thus, the width of pronotum increases with the increase of gregarization particularly in males; females are less sensitive. Phase-transformation takes place quickly, in one generation, and the change is reflected more in males than in females.

7. *Length of elytron* (*E*)

(Text-fig. 3)

(*a*) *Mean values.*—The mean values of E in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (*and eye-stripes*)	*Mean length* (*mm.*)±*S.E.* *Males*	*Females*
6-sol.	52.15±0.24	61.56±0.31
7-sol.	52.38±0.42	62.90±0.26
6-greg.	52.85±0.52	58.01±0.81
1949-*Kakko Conc.*(6)	51.46±0.29	59.73±0.42
1949-*Kakko Conc.*(7)	—	61.38±1.41
1950-*Ajm.Sw.*(6)	54.16±0.70	59.70±1.68
1954-Gr.I(6)	51.71±0.97	57.24±1.27
1954-Gr.II(6)	52.25±0.13	57.90±0.18
1954-Gr.III(6)	52.41±0.21	57.51±0.25
1954-Gr.I(7)	51.83±2.32	—
1954-Gr.II(7)	—	61.90±4.65
1954-Gr.III(7)	51.77±1.32	64.10±0.80
1955-Gr.I(6)	51.01±0.49	57.09±0.72
1955-Gr.II(6)	52.48±0.13	59.09±0.14
1955-Gr.III(6)	52.07±0.31	59.74±0.91
1955-Gr.I(7)	50.23±1.51	—
1955-Gr.II(7)	50.20	60.22±0.90
Ph. sol. 1955-Gr.III(7)	52.58±0.43	63.39±0.48
Ph. sol. 1956-57 (6)	52.07±0.31	59.62±0.823
Ph. sol. 1956-57 (7)	53.25±0.578	62.94±0.584
1961-*Cal.Sw.*(6)	53.82±0.45	59.36±0.82



Text-fig. 3.—*Schistocerca gregaria.* Graph showing the trend of variability in the length of elytron (E) in various populations as in Text-fig. 1.
For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the population of seven years, along with the "typical" values for phases *gregaria* and *solitaria*, are thus available. Of these, the populations for the periods 1950, 1954 (Grs. I–III), 1955 (Grs. I and II) and 1961 represent the *gregaria* facies and those for 1949, 1955 (Gr. III) and 1956-57 the *solitaria* or near-*solitaria* facies.

The length of elytron in the *gregaria* populations is significantly longer than in the *solitaria* ones in males and smaller in females. Within the same phase—and eye-stripe-group, females have significantly longer elytra than males; and 6- eye-striped individuals have smaller elytra than 7-striped ones.

The trend thus is that in males E increases as the population tends towards phase *gregaria;* and in females the reverse occurs. On the whole, the length of elytron is not a very phase-sensitive character.

8. *Restricted width of elytron* (W_1)

(*a*) *Mean values.*—The mean values of W_1 in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean width (mm.) ± S.E.* *Males*	*Females*
1954-Gr.I(6)	7.05±0.10	7.67±0.08
1954-Gr.II(6)	7.13±0.02	7.76±0.02
1954-Gr.III(6)	7.02±0.03	7.60±0.03
1954-Gr.I(7)	6.57±0.29	7.52±0.07
1954-Gr.II(7)	—	7.90±0.24
1954-Gr.III(7)	6.54±0.21	8.03±0.29
1954-Gr.III(7)	—	—
1955-Gr.I(6)	6.89±0.07	7.66±0.07
1955-Gr.II(6)	7.10±0.02	7.82±0.02
1955-Gr.III(6)	6.66±0.05	7.36±0.16
1955-Gr.I(7)	6.57±0.43	—

Populations (and eye-stripes)	*Mean width (mm.)±S.E.* *Males*	*Females*
1955-Gr.II(7)	6.20	7.67±0.14
Ph. sol. 1955-Gr.III(7)	6.71±0.07	7.84±0.06
Ph. sol. 1956-57 (6)	6.47±0.066	7.52±0.100
Ph. sol. 1956-57 (7)	6.76±0.093	7.94±0.065

(*b*) *Discussion.*—Data for the population of four years (1954–57) are available. Of these, the populations for 1954 (Grs. I–III) and 1955 (Grs. I and II) represent the *gregaria* facies, and for 1955 (Gr.III) and 1956-57 the *solitaria* facies.

The 'restricted' width of elytron is significantly greater in *gregaria* populations than in *solitaria* ones. Within the same phase—and eye-stripe group, females have significantly wider elytron than males; 6-striped individuals have significantly narrower elytra than 7-striped ones in both sexes.

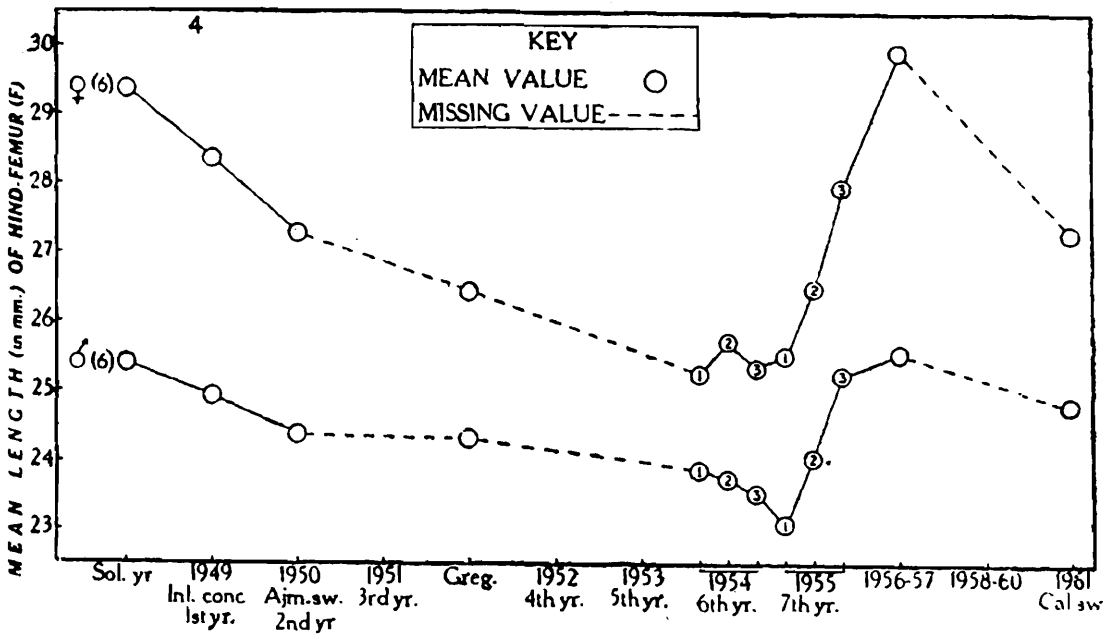
The character W_1 is among the very sensitive characters for differentiating the phases. Phase transformation takes place quickly, in one generation. In both sexes the 'restricted' width of elytron tends to increase from a lower *solitaria* level to a higher *gregaria* level, particularly in 6- eye-striped individuals.

9. *Length of hind-femur (F)*

(Text-fig. 4)

(*a*) *Mean values.*—The mean values of F in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean length (mm.)±S.E.* *Males*	*Females*
6-sol.	25.40±0.12	29.37±0.18
7-sol.	26.13±0.21	30.92±0.13
6-greg.	24.32±0.20	26.44±0.37
1949-*Kakko Conc.*(6)	24.92±0.16	28.35±0.25
1949-*Kakko Conc.*(7)	—	29.94±0.92
1950-*Ajm.Sw.*(6)	24.37±0.29	27.28±0.61
1954-Gr.I(6)	23.88±0.33	25.25±0.39
1954-Gr.II(6)	23.76±0.07	25.71±0.10
1954-Gr.III(6)	23.54±0.11	25.36±0.14
1954-Gr.I(7)	—	29.50±1.00
1954-Gr.II(7)	—	29.90±1.45
1954-Gr.III(7)	25.73±0.71	—
1955-Gr.I(6)	23.11±0.26	25.52±0.34
1955-Gr.II(6)	24.06±0.07	26.50±0.07
1955-Gr.III(6)	25.24±0.16	27.97±0.90
1955-Gr.I(7)	25.30±0.64	—
1955-Gr.II(7)	25.10	28.63±0.55
Ph. sol. 1955-Gr.III(7)	26.12±0.23	31.21±0.22
Ph. sol. 1956-57 (6)	25.56±0.152	29.92±0.389
Ph. sol. 1956-57 (7)	27.09±0.253	31.73±0.288
1961-*Cal.Sw.*(6)	24.82±0.23	27.32±0.33



Text-fig. 4.—*Schistocerca gregaria.* Graph showing the trend of variability in the length of hind-femur (F) in various populations as in Text-fig. 1.

For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the populations of seven years (1949, '50, '54, '57 and '61), along with "typical" values for phases *gregaria* and *solitaria*, are available. Of these years, the populations of 1950, 1954 (Grs. I–III), 1955 (Grs. I and II) and 1961 represent the *gregaria* facies, and those of 1949, 1955 (Gr.III) and 1956-57 the *solitaria* facies.

In both sexes, the hind-femur is significantly longer in *solitaria* than in *gregaria* populations. Within the same phase- and eye-stripe-group, females have significantly longer hind-femora than males; and 6-striped individuals have smaller hind-femora than 7-striped ones. This is one of the more sensitive character for differentiating the phase. In both sexes, the length of hind-femur is negatively correlated with the intensity of gregarization, the length increasing as the population approach to the *solitaria* facies.

IV—Morphometric ratios

1. *General*

The following seven morphometrical ratios, for which adequate data are available in literature, are discussed below; for others the data are either meagre or absent :—

1. P/C
2. M/C
3. H/C
4. E/W_1
5. E/F
6. E/C
7. F/C

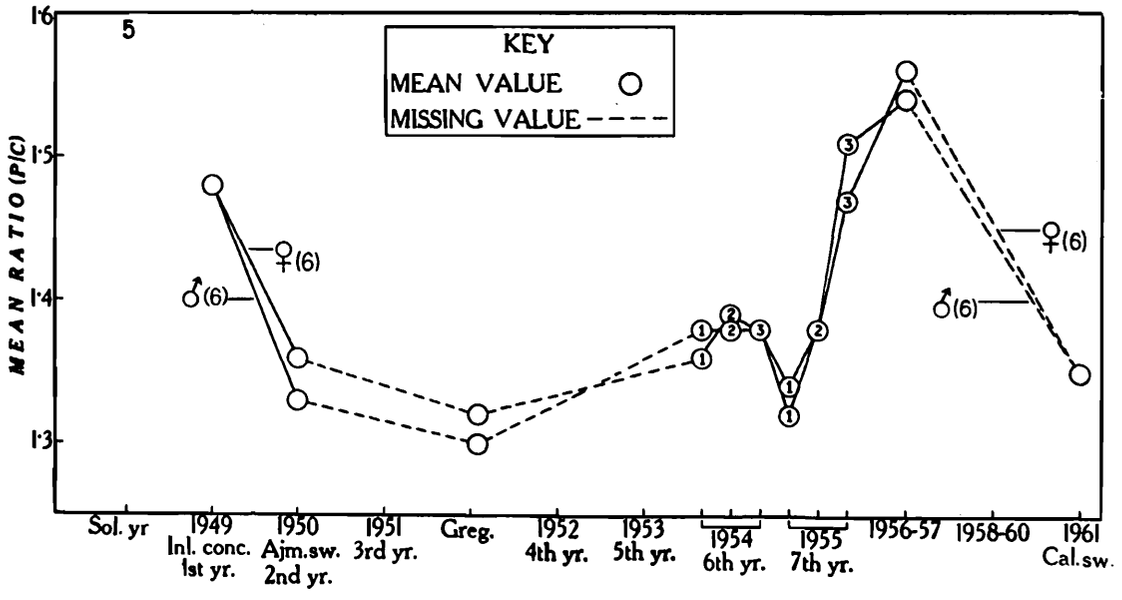
The ratios are discussed with respect to their phase-significance in relation to sex and eye-stripes, along with their trend in various populations.

2. *Ratio P/C*

(Text-fig. 5)

(*a*) *Mean values.*—The mean values of the ratio P/C in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (*and eye-stripes*)	*Mean ratio* ± *S.E.* *Males*	*Females*
6-greg.	1.305±0.011	1.324±0.009
1949-*Kakko Conc.*(6)	1.483±0.007	1.477±0.008
1950-*Ajm.Sw.*(6)	1.330±0.011	1.363±0.018
1954-Gr.I(6)	1.38 ±0.02	1.36 ±0.01
1954-Gr.II(6)	1.38 ±0.002	1.39 ±0.002
1954-Gr.III(6)	1.38 ±0.004	1.38 ±0.003
1954-Gr.I(7)	1.47 ±0.05	1.47 ±0.02
1954-Gr.II(7)	—	1.48 ±0.08
1954-Gr.III(7)	1.52 ±0.02	1.54 ±0.03
1955-Gr.I(6)	1.32 ±0.012	1.34 ±0.011
1955-Gr.II(6)	1.38 ±0.003	1.38 ±0.002
1955-Gr.III(6)	1.51 ±0.007	1.47 ±0.025
1955-Gr.I(7)	1.46 ±0.033	—
1955-Gr.II(7)	1.59	1.50 ±0.027
Ph. sol. 1955-Gr.III(7)	1.52 ±0.011	1.54 ±0.009
Ph. sol. 1956-57 (6)	1.54 ±0.010	1.56 ±0.019
Ph. sol. 1956-57 (7)	1.52 ±0.020	1.57 ±0.014
1961-*Cal.Sw.*(6)	1.35 ±0.007	1.35 ±0.008



Text-fig. 5.—*Schistocerca gregaria.* Graph showing the trend of variability in the ratio P/C in various populations as in Text-fig. 1.

For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the population of seven years are available. Of these, the populations of 1950, 1954 (Grs. I–III) 1955 (Grs. I and II)

and 1961 represent *gregaria* facies and those for 1949, 1955 (Gr. III) and 1956-57 the *solitaria* facies.

The mean value of P/C in *solitaria* populations is significantly higher than in *gregaria* ones in both sexes. Except in 7-striped forms, no significant sexual difference is seen. The ratio P/C is highly phase-sensitive. It bears an inverse relationship with the intensity of gregarization, the values rising as the population tends towards the *solitaria* phase.

3. *Ratio M/C*

(*a*) *Mean values.*—The mean values of M/C, in the available populations for swarming or non-swarming periods (1949–61), are as follows:—

Populations (and eye-stripes)	*Mean ratio ± S.E.* *Males*	*Females*
6-greg.	0.779±0.008	0.805±0.005
1954-Gr.I(6)	0.82 ±0.01	0.84 ±0.01
1954-Gr.II(6)	0.79 ±0.001	0.82 ±0.001
1954-Gr.III(6)	0.78 ±0.002	0.80 ±0.002
1954-Gr.I(7)	0.90 ±0.01	0.90 ±0.01
1954-Gr.II(7)	—	0.85 ±0.01
1954-Gr.III(7)	0.86 ±0.01	0.87 ±0.02
1955-Gr.I(6)	0.79 ±0.005	0.83 ±0.008
1955-Gr.II(6)	0.82 ±0.002	0.84 ±0.001
1955-Gr.III(6)	0.89 ±0.003	0.90 ±0.012
1955-Gr.I(7)	0.87 ±0.032	—
1955-Gr.II(7)	0.91	0.88 ±0.012
Ph. sol. 1955-Gr.III(7)	0.90 ±0.006	0.92 ±0.004
Ph. sol. 1956-57 (6)	0.87 ±0.005	0.89 ±0.009
Ph. sol. 1956-57 (7)	0.87 ±0.013	0.89 ±0.007

(*b*) *Discussion.*—Data for the populations of four years (1954–57), along with the "typical" value for phase *gregaria*, are available. Of these, the populations for 1954 (Grs. I–III) and 1955 (Grs. I and II) represent the *gregaria* facies and those for 1955 (Gr.III) and 1956-57 the *solitaria* facies.

The ratio M/C is significantly higher in *solitaria* phase in both sexes, but no sexual and eye-stripe differences are noticed. It is very sensitive ratio for differentiating the phases. In both sexes, ratio M/C is negatively correlated with the degree of gregarization, the value decreasing with the increase of gregarization.

4. *Ratio H/C*

(*a*) *Mean values.*—The mean values of H/C in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean ratio±S.E.* *Males*	*Females*
6-greg.	1.112±0.008	1.126±0.007
1954-Gr.I(6)	1.13 ±0.01	1.12 ±0.01
1954-Gr.II(6)	1.10 ±0.002	1.12 ±0.002
1954-Gr.III(6)	1.09 ±0.003	1.10 ±0.002
1954-Gr.I(7)	1.22 ±0.004	1.23 ±0.009
1954-Gr.II(7)	—	1.19 ±0.03
1954-Gr.III(7)	1.20 ±0.01	1.18 ±0.02
1955-Gr.I(6)	1.10 ±0.008	1.12 ±0.009
1955-Gr.II(6)	1.13 ±0.002	1.14 ±0.002
1955-Gr.III(6)	1.25 ±0.006	1.24 ±0.016
1955-Gr.I(7)	1.23 ±0.014	—
1955-Gr.II(7)	1.22	1.23 ±0.016
Ph. sol. 1955-Gr.III(7)	1.25 ±0.008	1.29 ±0.002
Ph. sol. 1956-57 (6)	1.23 ±0.006	1.24 ±0.009
Ph. sol. 1956-57 (7)	1.22 ±0.010	1.24 ±0.009

(*b*) *Discussion.*—Data for the populations of four years (1954–57), along with the "typical" value for phase *gregaria*, are available. Of these, the populations for 1954 (Grs. I–III) and 1955 (Grs. I and II) represent the *gregaria* phase and those for 1955 (Gr.III) and 1956-57 the *solitaria* phase. The ratio is significantly higher in the *solitaria* phase than in the *gregaria;* no sexual and eye-stripes differences are seen. The ratio is a sensitive phase-discriminant character. It increases with the decrease in intensity in gregarization.

5. *Ratio E/W_1*

(*a*) *Mean values.*—The mean values of the ratio E/W_1 in the available populations for the swarming and non-swarming periods (1949–61) are as follows :—

Populations (and eye-stripes)	*Mean ratio±S.E.* *Males*	*Females*
1954-Gr.I(6)	7.49±0.08	7.58±0.06
1954-Gr.II(6)	7.32±0.01	7.49±0.01
1954-Gr.III(6)	7.47±0.02	7.55±0.02
1954-Gr.I(7)	7.90±0.10	—
1954-Gr.II(7)	—	—
1954-Gr.III(7)	7.82±0.14	7.78±0.23
1955-Gr.I(6)	7.41±0.068	7.45±0.081
1955-Gr.II(6)	7.42±0.016	7.57±0.015

Populations (*and eye-stripes*)	*Mean ratio*±*S.E.* *Males*	*Females*
1955-Gr.III(6)	7.88±0.038	8.10±0.123
1955-Gr.I(7)	7.69±0.285	—
1955-Gr.II(7)	8.10	7.92±0.132
Ph. 1955-Gr.III(7)	7.84±0.068	8.12±0.045
Ph. 1956-57 (6)	7.87±0.063	7.96±0.067
sol. 1956-57 (7)	7.89±0.076	7.93±0.048

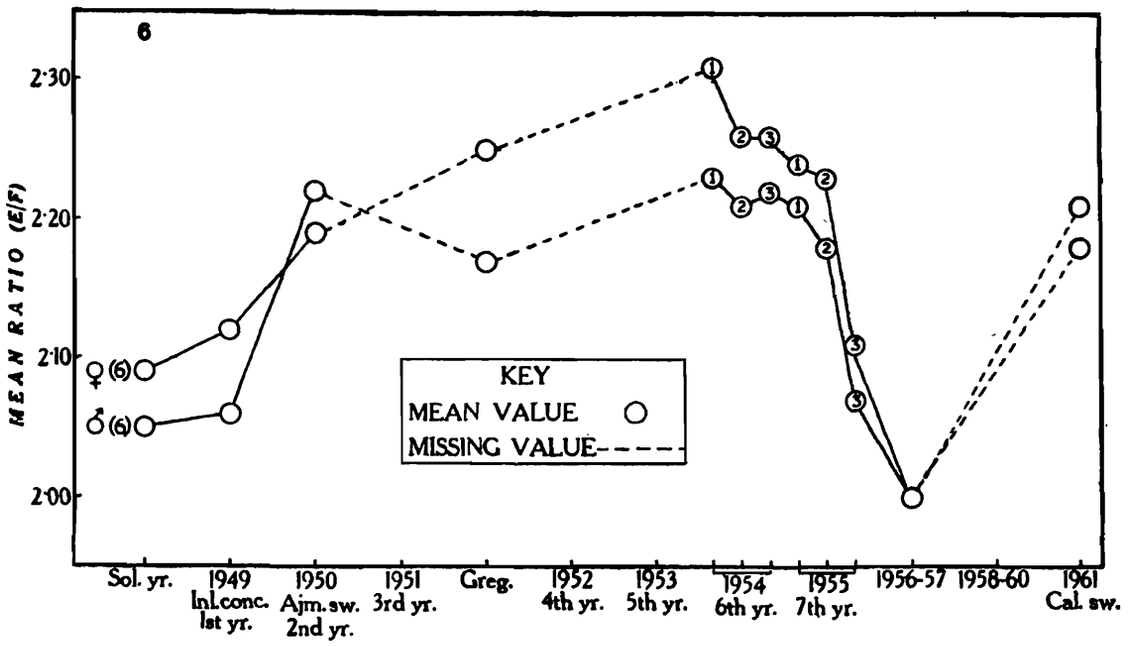
(*b*) *Discussion.*—Data for the populations of four years (1954–57) are available. Of these, the populations for 1954 (Grs. I–III) and 1955- (Grs. I and II) are of the *gregaria* phase and those for 1955 (Gr. III) and 1956-57 of the *solitaria* phase. The ratio is significantly lower in *gregaria* than in *solitaria* phase. No sexual and eye-stripes differences, are seen. Since the values of the ratio in the two phases are far apart, it may be considered as a useful ratio for discriminating the phases. The ratio bears an inverse relationship with the intensity of gregarization, the values increasing as the populations move towards the *solitaria* phase.

6. *Ratio E/F*

(Text-fig. 6)

(*a*) *Mean values.*—The mean values of the ratio E/F in the available populations for the swarming and non-swarming periods (1949–61) are as follows :—

Populations (*and eye-stripes*)	*Mean ratio*±*S.E.* *Males*	*Females*
6-sol.	2.05±0.012	2.09±0.008
7-sol.	2.00±0.006	2.03±0.007
6-greg.	2.17±0.024	2.25±0.017
1949-*Kakko Conc.*(6)	2.06±0.010	2.12±0.011
1949-*Kakko Conc.*(7)	—	2.07±0.022
1950-*Ajm.Sw.*(6)	2.22±0.023	2.19±0.035
1954-Gr.I(6)	2.23±0.03	2.31±0.03
1954-Gr.II(6)	2.21±0.004	2.26±0.004
1954-Gr.III(6)	2.22±0.007	2.26±0.02
1954-Gr.I(7)	—	—
1954-Gr.II(7)	—	—
1954-Gr.III(7)	2.00±0.03	—
1955-Gr.I(6)	2.21±0.018	2.24±0.016
1955-Gr.II(6)	2.18±0.004	2.23±0.004
1955-Gr.III(6)	2.07±0.010	2.11±0.031
1955-Gr.I(7)	1.99±0.013	—
1955-Gr.II(7)	2.00	2.10±0.021
Ph. 1955-Gr.III(7)	2.01±0.009	2.04±0.008
Ph. 1956-57 (6)	2.00±0.005	2.00±0.013
sol. 1956-57 (7)	1.97±0.012	1.99±0.008
1961-*Cal.Sw.*(6)	2.18±0.010	2.21±0.070



Text-fig. 6.—*Schistocerca gregaria*. Graph showing the trend of variability in the ratio E/F in various populations as in Text-fig. 1.

For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the populations of seven years, along with "typical" values for phases *gregaria* and *solitaria* are available. Of these, the populations for 1950, 1954 (Grs. I–III), 1955 (Grs. I and II) and 1961 are of the *gregaria* phase and those for 1949, 1955 (Gr.III) and 1956-57 of the *solitaria* phase.

Unlike other ratios, E/F is significantly larger in *gregaria* populations than in *solitaria* ones. No sexual difference is seen. But eye-stripe differences are noticeable and 7-striped males have significantly larger ratios than 6-striped ones. The ratio is highly phase-sensitive. It increases with the increase in the intensity of gregarization.

7. *Ratio E/C*

(*a*) *Mean values.*—The mean values of E/C in the available populations for the swarming and non-swarming periods for four years (1954–57) are as follows :—

Populations (and eye-stripes)	*Mean ratio ± S.E.*	
	Males	*Females*
1954-Gr.I(6)	7.31±0.08	7.30±0.09
1954-Gr.II(6)	7.20±0.01	7.45±0.01
1954-Gr.III(6)	7.21±0.02	7.43±0.02
1954-Gr.I(7)	7.44±0.13	—
1954-Gr.II(7)	—	—
1954-Gr.III(7)	7.86±0.09	8.22±0.32
1955-Gr.I(6)	6.98±0.05	7.29±0.06
1955-Gr.II(6)	7.30±0.01	7.50±0.01
1955-Gr.III(6)	7.98±0.04	8.03±0.14
1955-Gr.I(7)	7.57±0.07	—

Populations (and eye-stripes)	*Mean ratio±S.E.* *Males*	*Females*
1955-Gr.II(7)	7.97	7.96±0.11
Ph. sol. 1955-Gr.III(7)	7.92±0.05	8.23±0.03
Ph. sol. 1956-57 (6)	7.95±0.041	8.07±0.050
Ph. sol. 1956-57 (7)	7.89±0.067	8.14±0.058

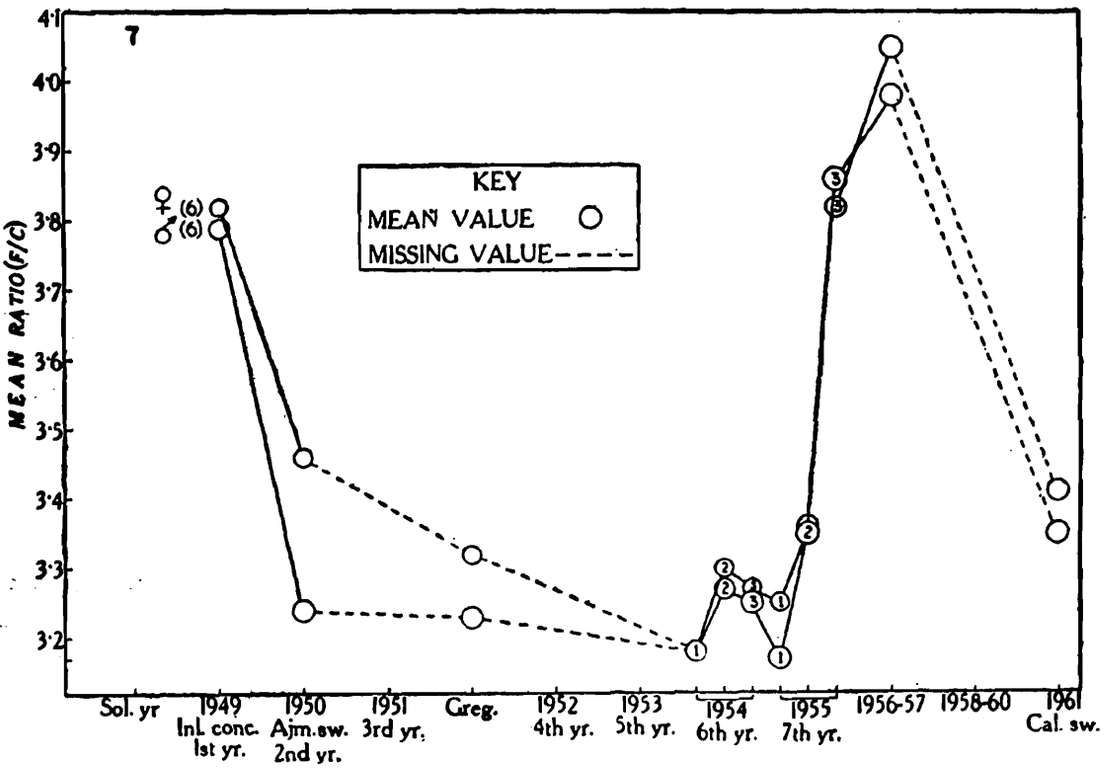
(*b*) *Discussion.*—The populations for 1954 (Grs. I–III) and 1955 (Grs. I and II) represent the *gregaria* phase and those for 1955 (Gr.III) and 1956-57 the *solitaria* phase. The ratio is significantly smaller in *gregaria* populations than in *solitaria* ones. Only in the 7- eye-striped category, females are significantly larger than males, there being no other differences in the various eye-stripes categories. Like other ratios involving C (width of head at the genal level), E/C is a highly phase sensitive ratio. It bears an inverse relationship with the intensity of gregarization, the value falling as the populations tend towards *gregaria* phase.

8. *Ratio F/C*

(Text-fig. 7)

(*a*) *Mean values.*—The mean values of F/C in the available populations for the swarming and non-swarming periods (1949–61) are as follows:—

Populations (and eye-stripes)	*Mean ratio±S.E.* *Males*	*Females*
6-greg.	3.233±0.032	3.320±0.032
1949-*Kakko Conc.*(6)	3.790±0.024	3.824±0.027
1950-*Ajm.Sw.*(6)	3.237±0.036	3.458±0.079
1954-Gr.I(6)	3.18 ±0.02	3.18 ±0.04
1954-Gr.II(6)	3.27 ±0.01	3.30 ±0.01
1954-Gr.III(6)	3.25 ±0.01	3.27 ±0.01
1954-Gr.I(7)	—	3.86 ±0.007
1954-Gr.II(7)	—	3.70 ±0.007
1954-Gr.III(7)	3.92 ±0.04	—
1955-Gr.I(6)	3.17 ±0.04	3.25 ±0.04
1955-Gr.II(6)	3.35 ±0.01	3.36 ±0.01
1955-Gr.III(6)	3.86 ±0.03	3.82 ±0.09
1955-Gr.I(7)	3.81 ±0.02	—
1955-Gr.II(7)	3.98	3.79 ±0.08
Ph. sol. 1955-Gr.III(7)	3.93 ±0.02	4.04 ±0.02
Ph. sol. 1956-57 (6)	3.98 ±0.021	4.05 ±0.024
Ph. sol. 1956-57 (7)	4.02 ±0.038	4.11 ±0.038
1961-*Cal.Sw.*(6)	3.35 ±0.010	3.41 ±0.020



Text-fig. 7.—*Schistocerca gregaria*. Graph showing the trend of variability in the ratio F/C in various populations as in Text-fig. 1.

For explanations *see* Text-fig. 1 and the text.

(*b*) *Discussion.*—Data for the population of seven years along with the "typical" values for phase *gregaria*, are available. Of these, the populations for 1950, 1954 (Grs. I–III), 1955 (Grs. I and III) and 1961 represent the *gregaria* phase and those for 1949, 1955 (Gr.III) and 1956-57 the *solitaria* phase.

The ratio in *solitaria* phase populations is significantly higher than in *gregaria* phase in both sexes. Only in the 6- eye-striped category, females are significantly larger than males, their being no other difference in the eye-stripes categories. The ratio F/C is found to be one of the most sensitive characters for discriminating the phases. It varies inversely with the intensity of gregarization, and falls as the populations tend towards the *gregaria* phase.

V—Discussion

1. *General*

The study of population dynamics in the Desert Locust is approached here with the aid of such "population-indicators" as the morphometric characters (size of body-parts and their ratios).

2. *Eye-stripes and sex-ratios*

The eye-stripe (5-, 8-striped) composition and sex-ratio being associated with phase transformation, their study in relation to these chains of populations (1949–61) is most desirable. The population of the initial year (1949-*Kakko concentration*) of the Ninth Cycle in India, is characterized by the high proportion (94%) of 6-striped individuals,

and the male: female ratio is 54: 46. A 5-striped form is recorded for the first time in this population. Its appearance in a population heading towards *gregaria* will serve as a clue for associating it with either of the phases.

In the *Ajmer swarm* (1950), the sample-size is not sufficiently large ($n' = 15$) to enable us to place too much reliance on the observed sex-ratio (♂71 : ♀29%). The presence of 7-striped individuals, although in exceedingly small proportions, in this swarming population is an important phenomenon and its occurrence may be attributed to the initial stage of the cycle.

The proportion of 6-striped individuals in the swarming 1954-population is 99% and the sex-ratio ♂53 : ♀47.

In the 1955-population also, the 6-striped individuals predominate (93%). The sex-ratio is ♂51 : ♀49, thus closely approaching the 50: 50 ratio. A few 8- eye-striped form appear in the last quarter of this year, thus indicating the advent of the *solitaria* period (Roonwal, 1954). A few 5- eye-striped individuals were also observed during the mid-year period.

In the 1956-57 population the eye-stripe composition 6: 7 striped as 60: 40 is at variance with that of the previous years as is seen from the decline of the proportion of 6-striped individuals. The proportion of males (60%), on the other hand, goes up.

The swarming population of 1961 (*Calcutta swarm*) is free from 5-, 7- and 8- eye-striped individuals and only 6-striped ones occurring. The sex-ratio is ♂55 : ♀45. This slight deviation from the 50: 50 ratio in swarms may be ascribed to sampling fluctuations.

3. *Morphometric characters and ratios*

The dynamics of morphometric variation in the desert locust populations for a complete swarming non-swarming cycle is compared here for the first time. This will help in the understanding of the variation-intensity of a locust plague and finding out characters which are variation—stable (*vide*, Roonwal, 1954). Each of the populations has been compared with other known populations and with the "typical" values for the phases in order to assess the extent of disparity. For the initial year (*Kakko concentration*, 1949) of the ninth (1949–55), swarming cycle, the variation was studied by utilizing five characters (C, P, E, W and F) and four ratios (P/C, E/W_1, E/F and F/C). A high degree of sexual difference is recorded with regard to all characters and the ratio E/F. There is generally no difference between 6- and 7- eye-striped individuals. Compared with "typical" values for the phases, this population is seen to be of non-swarming or *solitaria* facies, even though the population is rather high (over 18,000 per square mile). Though occupying an intermediate position, it tends towards the *solitaria* phase. The greater dispersion of values in this initial concentration as compared to the extreme phases is an indicator of its heterogeneity.

In the *Ajmer Swarm* (1950), belonging to the second year of 1949–55 swarming cycle, the same set of characters and ratios as in the previous year as mentioned above, was used. Comparison with "typical" *gregaria* and the initial *Kakko Concentration* (1949) shows some resemblance of the swarm with the previous years population. The difference between the two populations is due to the increase of gregarization in the second year, and males are more variable than females. (As stated earlier, the populations of the years 1951–53 were nct considered; they belong to heavy swarms and may therefore, be presumed to be of *gregaria* nature).

Populations of the years 1954 and 1955 are of considerable interest as belonging to the last facet of the 1949–55 Swarming Cycle. For finding any seasonal influence on the morphometry and for convenience of study, the population of each of these years was divided into three natural Groups (I–III) each comprising of four consecutive months. Eight characters (O, C, P, H, M, E, W_1 and F) and seven ratios (P/C, M/C, H/C, E/W_1, E/F, E/C and F/C) were used. Several important results were derived. Thus, plasticity here is more pronounced in females than in males, and there is a high degree of sexual dimorphism in Groups II and III for 1954-population. The eye-stripe composition (6- and 7-striped) differ to a great extent, particularly in Group III (September-December population). The group-difference is well exhibited by the character M and the ratio M/C, F/C and H/C.

A decided difference is found between Groups II (May-August) and III (September-December). Irrespective of the Groups, the 1954-population as a whole differs from the "typical" *solitaria* phase populations in respect of the characters E, F and the ratio E/F. Generally speaking, the values in the penultimate year's population have greater leanings towards the typical *gregaria* phase and the *Ajmer Swarm* (1950) than towards the *solitaria* phase and the *Kakko Concentration* (1949). The length of the hind-femur (F) has proved to be a sensitive character in this respect.

Two new characters (A and B)* and one ratio (K/L) were also utilized in the 1955-population which belongs to the last year of the 1949–55 Cycle.

The values of morphometric characters in the 1955-population suddenly change in the last four months to resemble that of the *solitaria* phase. The first two Groups (I and II), however, are similar to the Groups of the 1954-population which are of the *gregaria* type. The sex difference is also very high, females having higher values than males in almost all cases (the ratio K/L being an exception). Notwithstanding the difference between the Groups I and II, their morphological similarity is not greatly disturbed. Compared to the "typical" values for the phases, the 1955-Groups I–II are found to closely approach the typical *gregaria* and Group III the typical *solitaria* values. This finding is further confirmed when the groups are compared with the *Ajmer Swarm* (1950) and the *Kakko Concentration* (1949). The characters

* A, length of eye; B, maximum width of eye; K, greatest; and L, narrowest, width of metasternal interspace.

C, W_1, F and the ratios involving C are highly sensitive under different degrees of population densities.

For the 1956-57 population, the same set of characters and ratios as in 1954 was studied. This is a population from two non-swarming years, just following the 1949–55 Swarming Cycle in India. Samples being taken from scattered population of low densities, the distribution over the whole year is not uniform so that "Groupings", as in the years 1954 and 1955, were not done. A point of interest is that high sexual and eye-stripes (6- and 7-striped) differences are recorded with regard to all the morphometric characters, where as such differences are lacking in respect of most of the ratios. Another characteristic of this population is the lack of consistency in its affinity to the "typical" phases. For some characters and ratios it is closer to *gregaria* phase and for the others to the *solitaria* phase. This may be due to the instability of the population which is not yet completely freed from the influence of gregarization. Inspite of this, the population has a greater affinity to phase *solitaria*, as is obvious from the general consideration of the several morphometric characters.

In 1961, a typical swarm sample from Calcutta was studied in respect of four characters (C, P, E and F) and three ratios P/C, E/F and F/C). Like *Ajmer Swarm* of 1950, this also represents the population of the second year of a Swarming Cycle (the Tenth) in India, though the samples were collected in the early period of the third year. The comparative study of their characteristics has a special significance. A point of difference between the two years 1950 and 1961, lies in the smaller dispersion of values of the 1961-swarm than in the 1950 one, and in the "typical" *gregaria* phase values. Except for F/C in males, the two swarms do not differ appreciably. The correlation between F and C varies in degrees in the two swarms. In other pairs of characters, *viz.*, (E, F), (E, C), (E, P), (F, P) and (C, P), the association, though generally higher in the 1961 swarm, is not significantly different. Generally speaking a few points of dissimilarity that are noted indicate the greater homogeneity and fuller gregarization of the *Calcutta Swarm* as compared to *Ajmer Swarm.*

The morphometric superiority of females over males has been judged by the Sexual Dimorphism Percentage (S.D.P.) (Roonwal, 1949). This measure was used to substantiate the inter-sex comparison of mean sizes. Though not very efficient as a phase discriminant, the S.D.P. values help to some extent in identifying populations of *gregaria* facies from those of *solitaria* ones. It has been noticed that gregarization in a population is corrleated with S.D.P.—inversely for morphometric characters (size of the body-parts) and directly for their ratios.

From these population studies an assessment can be made of the efficacy of the different morphometric characters and ratios for introducing a considerable "distance" between two populations or phases. It has been observed that the performance of many characters do not remain the same in different types of population-comparison. Among the very few characters which retain their sensitivity uniformly, the width of head at the genal level (C) is the most outstanding. The

other important characters to be utilized along with C are M, E, W_1 and F. The ratios which involve the use of C are all sensitive. The ratio E/F is, however, a sophisticated ratio for phase-discrimination, and is less uniformly sensitive than the others.

VI—Summary

1. Morphometric data obtained from the present thesis and published elsewhere in the literature is used for studying the population dynamics of the Desert Locust during the period 1949 to 1961 (representing the Ninth and earlier part of the Tenth Locust Cycle in India).

2. Ten morphometric characters (size of body-parts) and eight ratios along with eye-stripe composition and sex-ratios are considered.

3. The important role of eye-stripe and sex-ratios as "indicators" in the study of phase biology and population dynamics of the Desert Locust is discussed.

4. The morphometric character 'C' (width of head at genal level) emerged as the most phase sensitive character. The other sensitive characters are M (width of pronotum at the constriction), E (length of elytron), W_1 (restricted width of elytron) and F (length of hind-femur).

5. Among the ratios, which involve the use of C (width of head at genal level) were found to be most sensitive.

6. The sensitive role of certain body-size and ratios, along with behaviour of the sexes in varying population densities, and the intra-specific divergence in different population groups are discussed.

7. The trend and performances of sensitive characters and ratio indicates the existence of more or less set pattern in the phase-biology of the Desert Locust.

VII—References

Albrecht, F. O. 1953. The reliability of the E/F ratio, a measure of phase status, in fresh and in dried locusts (Orthoptera).—*Proc. R. ent. Soc. Lond.*, (B), **21** (11-12): 167–169.

Bhanotar, R. K. 1959. Asymmetry in the striped eyes of the Desert Locust *Schistocera gregaria* (Forskål).—*J. zool. Soc. India*, **10** (2): 148–149.

Bhanotar, R. K., Guharoy, S. and Harjai, S. C. Population dynamics and morphometry of the 1954—Desert Locust population in India in relation to eye-stripes and sex-ratios.—(In press).

Bhanotar, R. K., Guharoy, S. and Mukherjee, G. D. Population dynamics and morphometry of the 1956 and 1957 Desert Locust populations in India in relation to eye-stripes composition and sex-ratios.—(In press).

DIRSH, V M. 1953. Morphometric studies on phases of the Desert Locust (*Schistocerca gregaria* Forskål).—*Anti-Locust Bull.*, No. 16, 4+34 pp.

FISHER, R. A. 1925. *Statistical Methods for Research Workers.*—London (Oliver & Boyd).

FISHER, R. A. 1941. The asymptotic approach to Behren's integral with further tables for the *d* test of significance.—*Ann. Eugenics*, London, **11** : 141–172.

MISRA, S. D. 1952. Studies of eye-stripe characteristics and the biometrical ratios of the body-parts in a concentration of Desert Locust individuals met with in July 1949 in the Rajputana Desert, that brought about incipient swarming and thus started a new locust cycle in India. (In Misra, Nair & Roonwal, *vide infra*).—*Indian J. Ent.*, **14** (2): 100–112.

MISRA, S. D. 1953. Confirmation of Roonwal's hypotheses for prediction of swarming of Desert Locust from data collected in 1949.—*Saugar. Univ. J.*, **1** (2): 233–238.

MISRA, S. D., NAIR, K. R. and ROONWAL, M. L. 1951. Dynamics of eye-stripe composition, biometrical ratios and certain other characters during phase transformation in the Desert Locust.—*Curr. Sci.*, **20** (6): 164–165.

MISRA, S. D., NAIR, K. R. and ROONWAL, M. L. 1952. Studies in intraspecific variation. Part VI. Dynamics of variability in respect of eye-stripes characters, sex-ratios and body-size of Desert Locust populations during the initial years (1949–1950) of a new swarming cycle in India, together with a statistical note on Roonwal's hypotheses on prediction of swarming.—*Indian J. Ent.*, **14** (2): 95–152.

NAIR, K. R. 1952*a*. Use of measurements of more than one biometric character regarding size of body-parts for discriminating between phases in the case of six-eye-striped specimens of the Desert Locust. pp. 126–136. (*In* S. D. Misra, K. R. Nair and M. L. Roonwal.)—*Indian J. Ent.*, **14** (2): 126–136.

NAIR, K. R. 1952*b*. A statistical note on Dr. Roonwal's hypotheses for prediction of the swarming of the Desert Locust. (In S. D. Misra K. R. Nair and M. L. Roonwal.)—*Indian J. Ent.*, **14** (2): 136–147.

RAO, Y RAMACHANDRA 1942. Some results of studies on the Desert Locust (*Schistocerca gregaria* Forsk.) in India.—*Bull. ent. Res.*, **33** (4): 241–265.

RAO, Y RAMACHANDRA 1960. *The Desert Locust in India.* xix+721 pp., 25 text-figs., 59 pls.—New Delhi (Indian Counc. Agric. Res., Monogr. No. 21).

ROONWAL, M. L. 1936. On the existence of two different types of striped eyes among solitary specimens of the Desert Locust, *Schistocerca gregaria* Forsk.—*Curr. Sci.*, **5** : 24.

ROONWAL, M. L. 1945. New hypotheses for the prediction of the swarming of the Desert Locust.—*Bull. ent. Res.*, **35** (4): 391–393.

ROONWAL, M. L. 1946. On a new phase character, the metasternal interspace, in the Desert Locust, *Schistocerca gregaria* (Forskal) [Orthoptera, Acrididae].—*Proc. R. ent. Soc. Lond.*, (A) **21** (1–3): 13–15.

ROONWAL, M. L. 1947. Variation and structure of the eyes in the Desert Locust, *Schistocerca gregaria* (Forskål).—*Proc. R. Soc., London*, (B), **134** (No. 875): 245–272, 3 pls. (*Errata, Ibid*, No. 877, p. 545.)

ROONWAL, M. L. 1949*a*. Studies in intraspecific variation. III. Body-size and biometrical ratios in various types of individuals of the Desert Locust, *Schistocerca gregaria* (Forskål) [Orthoptera, Acrididae.]—*Rec. Indian Mus.*, Delhi, **45** (2-3): [1947): 149–165.

ROONWAL, M. L. 1949*b*. Studies in intraspecific variation. IV The role of some variation *e.g.*, eye-stripes, etc., as "population indicators" in the Desert Locust, and their practical importance.—*Rec. Indian Mus.*, **45** (2-3): 167–180.

ROONWAL, M. L. 1954. On a new evolutionary phenomenon: The sharp increase of intraspecific variation in minimum populations, as evidenced by the Desert Locust.—*Rec. Indian Mus.*, Delhi, **51** (4), [Dec. 1953], pp. 481–526+6; 4 pls. (1 cols.).

ROONWAL, M. L. 1955. Studies in intraspecific variation. VII. Sex-ratio and eye-stripes in July–1954 swarm (phase *gregaria*) of the Desert Locust, and a possible hint as to the decline of the current cycle.—*Indian J. Ent.*, **17** (1): 6–10.

ROONWAL, M. L. 1958. The Tata Medal Lecture. Recent researches on population dynamics and evolutionary problems in the Desert Locust, together with a new theory of the visual maintenance of gregarization in locusts.—*J. zool. Soc. India*, **9** (1): 72–96, 1 pl.

ROONWAL, M. L. 1961. Bibliographia Acrididiorum. A bibliography of the Orthopterous insects of the family Acrididae (comprising the short-horned grasshoppers and locusts) from the earliest times to the end of 1954 (with some additions for 1955–1957).—*Rec. Indian Mus.*, Delhi, **45** (1-4) [1958], pp. i–ix+1–611*a*, 1 pl.

ROONWAL, M. L. 1962. Phase and non-phase polymorphism in the Desert Locust.—*Colloq. int. Centre National Rech. Sci.*, No. 114 (Physiol., Comport. et Ecol. des. Acridiens en Rapport auec la phase), Paris, reprint, pp. 1–6.

ROONWAL, M. L. Some aspect of population dynamics in Desert Locust. —*Proc. int. Symp. Arid. Zone* (*Jodhpur*, 1964), (In press).

ROONWAL, M. L. and BHANOTAR, R. K. 1962. Studies in intraspecific variation. Part 12. Population dynamics and morphometry of the Desert Locust in the Calcutta-swarm of January 1961.—*Abstracts 2nd All-India Congr. Zool.* (Varanasi, 1962), Cuttack, pp. 49–50.

ROONWAL, M. L. and BHANOTAR, R. K. 1966*a*. Studies in intraspecific variation. Part X. Variation of metasternal interspace in relation to phase, sex, and eye-stripes in the Desert Locust.—*J. zool. Soc. India*, **15** (1 & 2) [1963]: 32–46, 6 tables.

ROONWAL, M. L. and BHANOTAR, R. K. 1966*b*. Studies in intraspecific variation. Part XI. Morphometric characters, sex-ratios and eye-stripes in the 1955-population of the Desert Locust in India.—*Rec. Indian Mus.*, **60** (1) [1962]: 1–80, 7 pls.

ROONWAL, M. L. and BHANOTAR, R. K. 1966. Studies in intraspecific variation. Part XII. Population dynamics and morphometry of the Desert Locust in the Calcutta swarm of January 1961.—*Proc. 2nd. All-India Congr. Zool.* (Varanasi, 1962), pt. 2 (*Sci. Papers*), Calcutta, pp. 287–296.

ROONWAL, M. L. and MISRA, S. D. 1952. Variability in a sample of Desert Locust population taken from a swarm on the Rajputana Desert, India, in 1950, the second year of a swarming cycle, together with a discussion on the dynamics of phase-transformation. (*in* Misra, Nair & Roonwal, *vide supra.*)—*Indian J. Ent.*, **14** (2): 112–126.

ROONWAL, M. L. and NAG, M. K. 1951. Studies in intraspecific variation. Part V Statistical supplement to the analysis of biometrical data on body-size, etc. of various types of individuals of the Desert Locust presented in Part III.—*Rec. Indian Mus.*, **47** (3-4) [1949] 265–275.

STOWER, W. J., DAVIS, D. E. and JONES, I. B. 1960. Morphometric studies of the Desert Locust, *Schistocerca gregaria* (Forsk.).—*J. anim. Ecol.*, **29** : 309–339.

"STUDENT" [GOSSET, W. S.] 1908. On the probable error of a mean.—*Biometrika*, **6** : 1–25.

UVAROV, B. P. 1928. Locusts and Grasshoppers. *A Handbook for their Study and Control.* xiii+352 pp., 9 pls.—London (Imp. Inst. Ent.).

UVAROV, B. P. 1966. *Grasshoppers and Locusts. A Handbook of General Acridology. Vol.* 1. *Anatomy, physiology, Development, Phase Polymorphism, Introduction to Taxonomy.* xi+481 pp., 1 front piece (Col.).—Cambridge (Univ. Press).

WALOFF, S. 1966. The upsurge and recessions of the Desert Locust plague: An historical survey.—*Anti-Locust Mem.*, No. 8: 1–111, 4 flagged maps.

Rec. zool. Surv. India, **68**: 109–159, 1975

REVISION OF THE GENUS *GLYPTOTERMES* FROGGATT (KALOTERMITIDAE, ISOPTERA, INSECTA) FROM THE INDIAN REGION

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(With 14 Text-figures and 7 Tables)

CONTENTS

	PAGE
I—INTRODUCTION	110
(a) General	110
(b) Acknowledgements	110
(c) Abbreviations used	110
II—INDIAN *Glyptotermes*: SYSTEMATIC REVISION, ZOOGEOGRAPHY AND PHYLOGENY :	111
1. General Remarks, Zoogeography, etc.	111
(a) General remarks	111
(b) Zoogeography and distribution	111
(c) Phylogenetic position	113
(d) Taxonomic work on Indian *Glyptotermes*	113
(e) Distribution of *Glyptotermes* species in the Indian Region	113
(f) Note on *Lobitermes nigrifrons* Tsai & Chen	115
2. Systematic Account of *Glyptotermes*	115
(a) Characters of genus *Glyptotermes* Froggatt	116
(b) Keys for identification of Indian species of genus *Glyptotermes*	117
(i) Key to imagos	117
(ii) Key to soldiers	117
3. Descriptions of species of *Glyptotermes*	118
1. *Glyptotermes almorensis* Gardner	118
2. *Glyptotermes ceylonicus* Holmgren	128
3. *Glyptotermes coorgensis* Holmgren & Holmgren	134
4. *Glyptotermes dilatatus* (Bugnion and Popoff)	142
5. *Glyptotermes minutus* Kemner	150
6. *Glyptotermes nigrifrons* Mathur and Sen-Sarma	155
III—SUMMARY	157
IV—REFERENCES	157

I—Introduction

(a) *General*

Species of the genus *Glyptotermes* are wood termites and some of them are serious pests of rubber and tea plantations. Thus, they are of considerable economic importance.

A taxonomic revision of the oriental species of the genera *Kalotermes* and *Neotermes* has been done by Roonwal and Sen-Sarma (1960) and of that of the genus *Cryptotermes* by Chhotani (1970). Here in this paper, a taxonomic revision of the species of *Glyptotermes*, known from the Indian subregion, is undertaken and all the species so far recorded from this subregion are redescribed in detail and illustrated adequately. The imago of *G. coorgensis* Holmgren and Holmgren, so far not known, is described here for the first time. The following 6 species are dealt with:—*almorensis* Gardner, *ceylonicus* Holmgren, *coorgensis* Holmgren and Holmgren, *dilatatus* (Bugnion and Popoff), *minutus* Kemner and *nigrifrons* Mathur and Sen-Sarma. The zoogeographical distribution and the phylogenetic position of the genus have been discussed.

(b) *Acknowledgements*

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(v) Dr. P. N. Chatterjee, Forest Entomologist, Forest Research Institute, Dehra Dun (India).

(c) *Abbreviations used*

A.M.N.H.,	American Museum of Natural History, New York.
B.M.,	British Museum (Natural History), London.
coll.,	collected by.
det.,	determined by.
ex.,	from or out of.
F.R.I.,	Forest Research Institute, Dehra Dun.
Im.,	imago.
Ny.,	nymph.
Pw.,	pseudoworker.
S.,	soldier.
Sta. No.,	Collecting Station Number.
Z.S.I.,	Zoological Survey of India, Calcutta.

II—INDIAN *Glyptotermes*: SYSTEMATIC REVISION, ZOOGEOGRAPHY AND PHYLOGENY

1. GENERAL REMARKS, ZOOGEOGRAPHY, ETC.

(*a*) *General remarks*

Froggatt (1896) erected the genus *Glyptotermes* to include his species *tuberculatus*, *iridipennis*, *brevicornis* and *eucalypti* in his subfamily Glyptotermitinae. He also included his genus *Heterotermes* in the subfamily Glyptotermitinae (p. 518) but later on, in the same publication (p. 550) he relegated that genus and the species *H. platycephalus* to the subfamily Heterotermitinae. As in case of genus *Cryptotermes*, some authorities regard *Glyptotermes* also as a subgenus of *Kalotermes* (*Calotermes* of some authors) along with some other genera of the family Kalotermitidae (Holmgren 1910, '11*a*, '13; Emerson, 1925, '28; Hare, 1937; Hill, 1942; Rattan Lal and Menon, 1953; etc.). At present it is recognised as a full genus of the family Kalotermitidae.

The soldiers of some species of *Glyptotermes* show great diversity of characters and were thus from time to time referred to different genera, *e.g.*, *G. asperatus* Snyder to subgenus *Calcaritermes* of genus *Kalotermes* by Snyder (1926) when he described the species; *G. contracticornis* Snyder to subgenus *Neotermes* by Hare (1937); *G. posticus* Hagen to subgenus *Cryptotermes* by Holmgren (1911*a*) with some doubt; and so on. Holmgren (1911*a*) created the subgenus *Lobitermes* to accommodate *Calotermes lobicephalus* Silvestri (= *canellae* Müller) and *Calotermes pinangae* Haviland, both of which are now regarded as belonging to *Glyptotermes* (Snyder, 1949; Krishna, 1961).

Grasse (1949) recognised the validity of subgenus *Lobitermes* and raised it to full genus. Tsai and Chen (1963) have described a new species, *Lobitermes nigrifrons**. But Snyder (1949), Roonwal and Sen-Sarma (1960) and Krishna (1961) do not give generic status to *Lobitermes*, and I agree with the latter view.

(*b*) *Zoogeography and distribution* (Table 1)

Snyder (1949) recognised 45 living and one fossil species of *Glyptotermes* from the world. Krishna (1961) listed all the species included by Snyder (1949) except *Calotermes latifrons* Silvestri which he referred to genus *Proneotermes*. He also included six out of ten species of *Glyptotermes* described after Snyder (1949), thus making a total of 51 known species including a fossil one. Out of the other four, he refers *Glyptotermes longiceps* Cachan and ? *G. sordwanae* Coaton, along with several other species, to his new genus *Postelectrotermes;* and ? *G. umtatae* Coaton to genus *Kalotermes*. He does not include *G. alaotranus* Cachan in any of the Kalotermitid genera.

Mathur and Sen-Sarma (1960), Tsai and Chen (1963) and Ahmad (1965) have recently described *G. nigrifrons* from southern India, *G. chinpingensis* from southern China and *G. kachongensis* from Thailand,

* See discussion below, on *Lobitermes nigrifrons*.

respectively. Krishna and Emerson (1962) have added another 20 species from the Neotropical (8), Ethiopian (5), Papuan (5) and Indo-Malayan (2) regions. The total number of species thus known at

TABLE 1.—Distribution of species of *Glyptotermes* in various zoogeographical regions.

Region	Number of species			Present Account	
	Snyder (1949)	Emerson (1955)	Krishna (1961)	No. of described species	Percentage
Australian	5	5	5	5	6.8
Ethiopian	2	10	12 (including 6 new species)	11	15.1
Indo-Malayan	16	19	21 (including 3 new species)	23	31.5
Malagasy	1	2	2 (including 1 new species)	1	1.4
Neotropical	18	27	25 (including 8 new species)	25	34.2
Papuan	3	8	8 (including 5 new species)	8	11.0
Unknown Region	—	1	1	—	—
Total:	45	72 (including 25 new species)	74 (including 23 new species)	73	—

present from all over the world is 73 living and one fossil. The living forms are distributed in various zoogeographical regions as follows:— Australian (5 species or 6.8%); Papuan (8 or 11.0%); Indo-Malayan (23 or 31.5%); Ethiopian (11 or 15.1%); Malagasy (1 or 1.4%); and Neotropical (25 or 34.2%).

As the species of *Glyptotermes* are apparently not easily transportable by artificial means, their distribution is rather restricted. This restricted distribution and their abundance in the Neotropical (34.2%) and Indo-Malayan (31.5%) regions, provide some reasons to believe that, as suggested by Emerson (1952, 1955), the genus had its origin in either of these regions, and thence got dispersed in the late Jurassic or early Cretaceous through the Bering land bridge having a tropical climate during the Mesozoic times and to the Australian and Papuan Regions, through the former Papuan connections with the Indo-Malayan Region. An alternative is that the genus had the origin in the southern land mass, when these land masses were contiguous and thence got dispersed before they started drifting apart according to Wegener's hypothesis (Wegener 1922, van der Gracht 1928).

(*c*) *Phylogenetic position*

Glyptotermes falls in the group with other Kalotermitid genera which have the anterior margin of the 2nd marginal tooth of the left imago mandible, equal to the posterior margin of the 1st marginal (*i.e.*, the *Proelectrotermes-Calcaritermes* complex of Krishna, 1961). The median vein in all the genera of this complex is generally strongly chitinised except in case of the fossil genera *Proelectrotermes* and *Electrotermes* and the living genus *Kalotermes*. These fossil genera are definitely more primitive as indicated by the presence of spines on the middle tibia, a character which is in common with the probably more primitive termites of the families Mastotermitidae and some Hodotermitidae. *Glyptotermes* can be grouped with *Calcaritermes* because of the absence of the radial sector branches and in having a more compact costal area in the wings, features common to both the genera. The soldier of some of the species, however, has a phragmotic head which is comparable to the soldier head of the genera *Cryptotermes*, *Eucryptotermes*, *Calcaritermes* etc., a case of convergent evolution as suggested by Krishna (1961).

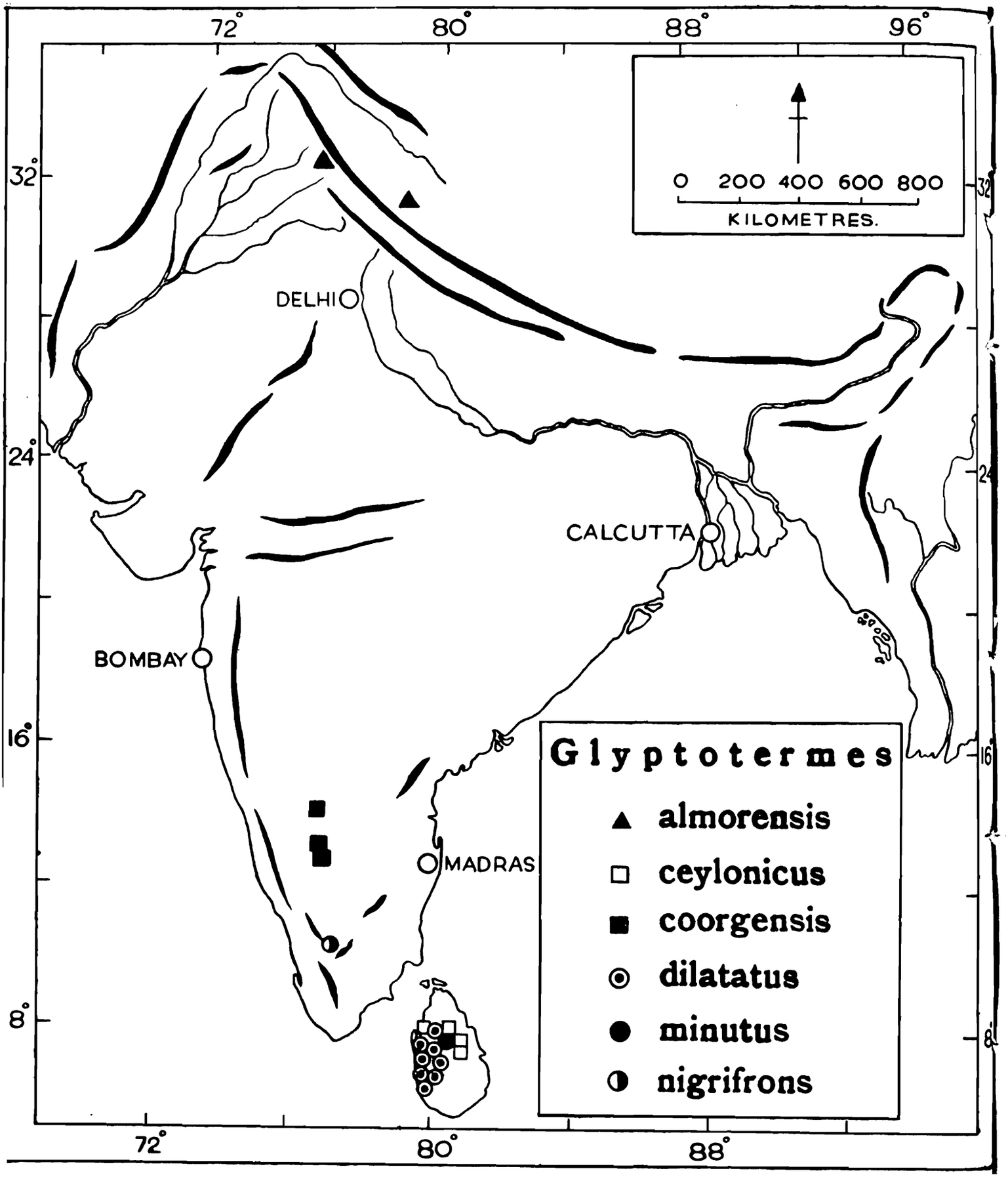
(*d*) *Taxonomic work on Indian Glyptotermes*

Bugnion and Popoff (1910) were the first to describe a species of *Glyptotermes* (*G. dilatatus*—their *Calotermes dilatatus*) from the Indian Region (Ambalangoda, Ceylon). Holmgren (1911*b*) described another species (*G. ceylonicus*) from Peradeniya, Ceylon, and later on (1913) revised the oriental species including these two known from Ceylon. Holmgren and Holmgren (1917) recorded the genus from the Indian mainland and described a species, *G. coorgensis*, from South India. Kemner (1932) described yet another species *G. minutus*, from Ceylon and Gardner (1944) described *G. almorensis* from Almora (Western Himalayas, India). Snyder (1949) included the Indian *Glyptotermes* in his world catalogue, and Rattan Lal and Menon (1953) have catalogued the Indian forms. Recently, Mathur and Sen-Sarma (1960) have described another species, *G. nigrifrons*, from southern India. Thus, so far only 6 species are known from the Indian region.

A considerable amount of work has been done on the biology and control of *G. dilatatus* which is a serious pest of tea in Ceylon and on *G. ceylonicus* (Holmgren). The more important works on biology, etc. which need reference here are those by Jepson (1930) and Pinto (1941).

(*e*) *Distribution of Glyptotermes species in the Indian region* (Text-fig. 1)

Out of the 73 wo ld and 23 Indo-Malayan species of *Glyptotermes*, only six are known from the Indian Region (India, Ceylon, Burma, Pakistan). From the Indian mainland 3 species (*almorensis*, *coorgensis* and *nigrifrons*) are known whereas the other 3 species (*ceylonicus*, *dilatatus* and *minutus*) are known from Ceylon. There are no records of any *Glyptotermes* from either Burma or Pakistan. The species have somewhat restricted distribution. *G. ceylonicus*, *G. dilatatus* and *G. minutus* are confined to Ceylon. The single record of *G. dilatatus* from Madras, India (Rattan Lal and Menon, 1953) is based on a paper by Rau, S. A. 1936 (*Rep. Tea Dep. U.P.A.S.I.*, 1935-36, Madras), but Rau refers to an undescribed species near *G. dilatatus*, *G. almorensis* is known from



Text-fig. 1.—Map of the Indian Region showing distribution of the Indian species of genus *Glyptotermes*.

the Western Himalayas (Almora and Garhwal, Uttar Pradesh) and *coorgensis* and *nigrifrons* are from southern India.

(*f*) *Note on Lobitermes nigrifrons* Tsai and Chen

The genus or subgenus *Lobitermes* is now generally recognised as a synonym (in part) of genus *Glyptotermes*, and in part that of the genera *Cryptotermes* and *Calcaritermes*. Recently, Tsai and Chen (1963) described a new species, *Lobitermes nigrifrons*, from South China which they placed near *Calotermes* (*Lobitermes*) *pinangae* Haviland. The latter species has now been referred to the genus *Glyptotermes* (Snyder, 1949; Krishna, 1961). I have not been able to examine specimens of *L. nigrifrons* Tsai and Chen and am, therefore, unable to give an opinion on its status. But if it is a *Glyptotermes*, which most likely is, it requires a new name as *Glyptotermes nigrifrons* Mathur and Sen-Sarma (1960) has priority.

2. SYSTEMATIC ACCOUNT OF GLYPTOTERMES

Genus **Glyptotermes** Froggatt

(i) Genus *Calotermes* (in part)

1858. H. A Hagen, *Linn. Ent.*, Berlin, **12** : 31–38.
1858. H. A. Hagen, *Catal. Specimens Neuropterous Insect Coll. Brit. Mus.*, London, Part 1: 1.
1898. G. D. Haviland, *J. Linn. Soc. Lond.*, London, **26** : 371, 373.
1904. J. Desneux, *Genera Insect.*, Brussels, Fasc. 25, *Termitidae:* 20–24.

(ii) Genus *Glyptotermes*

1896. W. W. Froggatt, *Proc. Linn. Soc. N.S.W.*, Sydney, **21** (4): 518, 543. (Type. by subsequent designation.) *Type of genus: Glyptotermes tuberculatus* Froggatt.
*1905. W. W. Froggatt, *Agr. Gaz. N.S.W.*, Sydney, **16** : 17, 23, 24.
*1915. W. W. Froggatt, *Bull. Dep. Agric. N.S.W.*, Sydney, No. 60: 25.
1924. T. E. Snyder, *Porc. U.S. nation. Mus.*, Washington, **64** (Art. 6):–109.
1926. Y. Sjöstedt, *K. Sv. Vet. Akad. Handl.*, Stockholm, (3)**3** (1): 22, 23, 42. [In part]
1930. S. F. Light, *Philipp. J. Sci.*, Manila, **42** (1): 15, 16, 18.
1934. N. A. Kemner, *K. Sv. Vet. Akad. Handl.*, Stockholm, **13** (4): 30, 38.
1941. M. P. D. Pinto, *Indian J. Ent.*, New Delhi, **3** (1): 85.
1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 45, 359.
1949. P. Cachan, *Mem. Inst. Sci. Madagascar*, Tenanarive, (A) **3** (2): 180, 185, 190, 208, [In part].
1949. P. P. Grassé, *Traite de Zoologie*, Paris, **9** : 531.
1950. M. Ahmad, *Bull. Amer. Mus. nat. Hist.*, New York, **95** (Art. 2): 44, 50.
1952. A. E. Emerson, *Bull. Amer. Mus. nat. Hist.*, New York, **99** (Art. 3): 218–219.
1955. H. Weidner, In: Schmidt's *Die Termiten:* 46, 48, 68.
1955. A. E. Emerson, *Fieldiana* (*Zool.*), Chicago, **37** : 468, 473, 476–478, 492, 507, 508.
1958. M. Ahmad, *Biologia*, Lahore, **4** (1-2): 35, 36.
1960. M. L. Roonwal and P. K. Sen-Sarma, *Contrib. Syst. Orient. Termites*, New Delhi : 97, 98.
1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122** (Art. 4): 343–348.
1961. W. V. Harris, *Termites: Their Recogn. & Cont.*, London, p. 47.

* Not seen in original.

(iii) Subgenus *Glyptotermes*

1910*a*. N. Holmgren, *Zool. Anz.*, Leipzig, **35** : 285. [Mentions *G. borneensis* as the type-species].
1910*b*. N. Holmgren, *Trans. Linn. Soc. Lond.* (*Zool.*), London, (2) **14** (8), Pt. 1: 140.
1911. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **46** (6): 53, 55, 56, 58–61. [Mentions *G. borneensis* Havil. as type-species].
1913. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **50** (2): 37, 49
1925. T. E. Snyder, *J. Washington Acad. Sci.*, Washington, **15** (7): 152, 157–158.
1925. A. E. Emerson, *Zoologica*, New York, **6** (4): 313, 331.
1928. A. E. Emerson, *Bull. Amer. Mus. nat. Hist.*, New York, **57** (Art. 7): 405, 412, 418.
1933. T. E. Snyder, *Proc. ent. Soc. Wash.*, Washington, **35** (5): 67.
1934. T. E. Snyder, *Indian For. Rec.* (*Ent.*), Delhi, **20** (11): 24, 27.
1937. L. Hare, *Ann. ent. Soc. Amer.*, Colombus (Ohio), **37** (3): 461, 474, 475.
1942. G. F. Hill, *Termites* (*Isop.*) *Austr. Region:* 7, 85.
1963. Rattan Lal and Menon, R. D., *Catalog. Indian Insects*, Part 27, *Isoptera*, Delhi: 8, 11–12.

(iv) Genus/subgenus *Lobitermes* Holmgren

1911. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **46** (6): 53, 56, 59–61.
1913. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **50** (2): 37, 59.
1924. T. E. Snyder, *Proc. U.S. nation. Mus.*, Washington, **24** (Art. 6): 9–10.
1925. T. E. Snyder, *J. Wash. Acad. Sci.*, Washington, **15** (7): 152, 158.
1925. A. E. Emerson, *Zoological*, New York, **6** (4): 337.
1928. A. E. Emerson, *Bull. Amer. Mus. nat. Hist.*, New York, **57** (Art. 7): 406.
1933. S. F. Light, *Calif. Univ. Publ.* (*Ent.*), Berkeley, **6** (5): 82, 101.
1933. T. E. Snyder, *Proc. ent. Soc. Wash.*, Washington, **35** (5): 67.
1949. P. P. Grassé, *Traite de Zoologie*, Paris, **9** : 531.

(*a*) *Characters of genus Glyptotermes* Froggatt

IMAGO: Head-capsule quadrate or subcircular, sides without eyes weakly convex or somewhat straight; posterior margin round; epicranial sutures present. Fontanelle absent. Eyes broadly oval and moderately large. Ocelli oval, either touching, or away from the eyes. Antennae with 11–17 segments. Clypeus flat, trapezoidal not very distinctly separated into an ante- and a postclypeus. Labrum broadly tongue-shaped; broader than long. Mandibles each with an apical and 2 marginal teeth; apical finger-like; anterior margin of 2nd marginal tooth of left mandible equal to posterior margin of 1st marginal; posterior margin of 2nd marginal of right mandible only slightly longer than molar plate. Pronotum narrower than, or as wide as, head with eyes. Legs with 3 apical spurs on each tibia. Tarsi 4-jointed; an arolium always present. Wings smoky brown, strongly punctate; all veins, except median in hindwing, arising independently from scale. Costa, subcosta, radius and median strongly, and cubitus weakly, chitinised. Costa bordering the anterior margin; subcosta in forewing short and fusing with costa just outside scale, and absent in hindwing; radius short fusing with costa a little away from scale; radial sector running parallel with costa upto the distal tip of wing-membrane; median running parallel with and close to radial sector, and arising independently from scale in forewing but from radial sector in hindwing; cubitus running medially, with branches to posterior margin. Abdomen long. Cerci 2-jointed and short.

SOLDIER: Head-capsule generally subrectangular, cylindrical; sometimes phragmotic, with frons sloping infront almost vertically as in *Cryptotermes* and cancave in some species, either weakly or distinctly

bilobed in front, with a U- or V-shaped depression in between; epicranial sutures present. Fontanelle absent. Eyes present, one on either side, unpigmented. Ocelli minute, translucent, dot-like, present near the extremity of lateral sutures of head, one on either side; sometimes not distinct. Antennae with 10–15 segments. Clypeus divided into an ante- and a postclypeus; postclypeus distinctly or weakly separated from frons. Labrum tongue-shaped. Mandibles prominently dentate, basally either humped or plain on outer margin; generally thick and stout. Postmentum long, club-shaped. Pronotum either narrower than or, as wide as or slightly wider than, head-capsule. Legs with 3 apical tibial spurs on each tibia. Tarsi 4-jointed. Abdomen elongate. Cerci 2-jointed, short.

PSEUDOWORKER: Head-capsule subcircular, broader than its length to base of mandibles; eyes rudimentary, unpigmented; ocelli absent. Antennae with 9–12 segments. Mandibles as in imago. Pronotum either narrower than, or as wide as, or wider than, head-capsule. Legs short, apical tipical spurs 3: 3: 3; tarsi 4-jointed. Abdomen elongate; cerci 2-jointed and short.

(b) *Keys for identification of Indian species of genus Glyptotermes*

(*i*) *Key to imagos*

Out of six species of *Glyptotermes* occuring in the Indian Region, imagos of only five are known, and are keyed below:—

1(4). Larger species: Head-width with eyes over 1 mm. (*c.* 1.03–1.30 mm.).
2(3). Darker species, head-capsule yellowish brown to brown; Y-suture distinct.
.. 1. *G. ceylonicus* Holmgren
3(2). Paler species, head-capsule brownish yellow; Y-suture indistinct.
. 2. *G. dilatatus* (Bugnion & Popoff)
4(1). Smaller species: Head-width with eyes under 1 mm. (*c.* 0.85–0.97 mm.).
5(6). Ocelli small and directed vertically when viewed laterally, diameter: (maximum 0.07, minimum 0.05 mm.).
.. 3. *G. coorgensis* Holmg. & Holmg.
6(5). Ocelli large and directed antero-laterally, diameter: (maximum 0.09, minimum 0.07–0.09 mm.).
7(8). Head-width with eyes 0.85 mm.; eyes separated from basal margin of head-capsule by a distance of *c.* 0.13 mm.
4. *G. minutus* Kemner.
8(7). Head-width with eyes 0.90–0.97 mm.; eyes separated from basal margin of head-capsule by a distance of *c.* 0.17 mm.
5. *G. almorensis* Gardner

(*ii*) *Key to soldiers*

1(4). Larger species: Head-length to lateral base of mandibles 2.0–3.01 mm.; maximum head-width 1.27–1.67 mm.
2(3). Mandibles short, thick and stout; left mandible with 2 thick marginal teeth; Mandible-Head Index (Left mandible length/Head-length to base of mandibles) smaller, *c.* 0.34–0.36. Head longer and wider (head-length to base of mandibles 2.62–3.01; maximum head-width 1.50–1.67 mm.).
1. *G. ceylonicus* Holmgren
3(2). Mandibles long and thin; left mandible with 4 prominent marginal teeth; Mandible-Head Index (Left mandible length/Head-length to base of mandibles) larger, *c.* 0.47–0.50. Head smaller and narrower (head-length to base of mandibles 2.0–2.23; maximum head-width 1.27–1.35 mm.).
2. *G. dilatatus* (Bugnion & Popoff)

4(1). Smaller species: Head-length to lateral base of mandibles 1.29–1.73 mm.; maximum head-width 0.90–1.20 mm.

5(6). Antero-lateral corners of head-capsule sharply pointed infront.
3. *G. coorgensis* Holmg. & Holmg.
.. 4. *G. nigrifrons* Mathur & Sen-Sarma

6(5). Antero-lateral corners of head-capsule rounded infront.

7(8). Head-capsule narrower (maximum width 0.90 mm.). Y-suture distinct.
... 5. *G. minutus* Kemner

8(7). Head-capsule wider (maximum width 1.06–1.13 mm.). Y-suture faint, lateral arms indistinct.
6. *G. almorensis* Gardner

3. DESCRIPTIONS OF SPECIES OF GLYPTOTERMES

1. **Glyptotermes almorensis** Gardner

(Text-figs. 2—5; and Tables 2–4)

(i) *Kalotermes* (*Glyptotermes*) *almorensis* Gardner

1944. J. C. M. Gardner, *Indian J. Ent.*, New Delhi, **6** : 104–105. *Im.* and *S.* Fig. 1 (*S.* mandibles). *Type-locality:* Bajwar (Almora District, Uttar Pradesh, India). Types examined.

1953. Rattan Lal and Menon, R. D. *Cal. Indian Insects*, Part 27, *Isoptera*, p. 12, India: Bajwara (= Bajwar), Almora Dist., U.P.

(ii) *Glyptotermes almorensis* Gardner

1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 45, India.

1953. M. L. Roonwal and G. D. Pant, *Indian For. Leafl.* (*Ent.*), Delhi, No. 121 (3): 44. *India:* Uttar Pradesh: Bajwar; Paithani-Jakh (Garhwal).

1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122** (Art. 4): 347.

1962. R. N. Mathur and R. S. Thapa, *Indian For. Leafl.* (*Ent.*), Delhi, No. 167: 9. *India:* Uttar Pradesh: Bajwar; Paithani-Jakh (Garhwal).

(*a*) *Material Examined*

(*A*) *Present in F.R.I., Dehra Dun:* (i) A vial (F.R.I. Nos. M.C. 17357/1, t. 3365, j. 115), with a soldier, an imago (alate) and several pseudoworkers, *cotypes*, Bajwar, Almora Dist. (Uttar Pradesh, India), coll. *J.C.M.* Gardner, June 1937, ex "dead *Rhododendron*"

(*B*) *Present in Z.S.I., Calcutta:* (ii) A vial (Z.S.I. No. 3729/H8), with 4 imagos (alates), 2 soldiers and 2 pseudoworkers, Jakh Kandar Syun, Paithani (Garhwal, U.P., India), coll. *B. Singh*, June 1941, ex "dead and hard stump of *Rhododendron arboreum*"

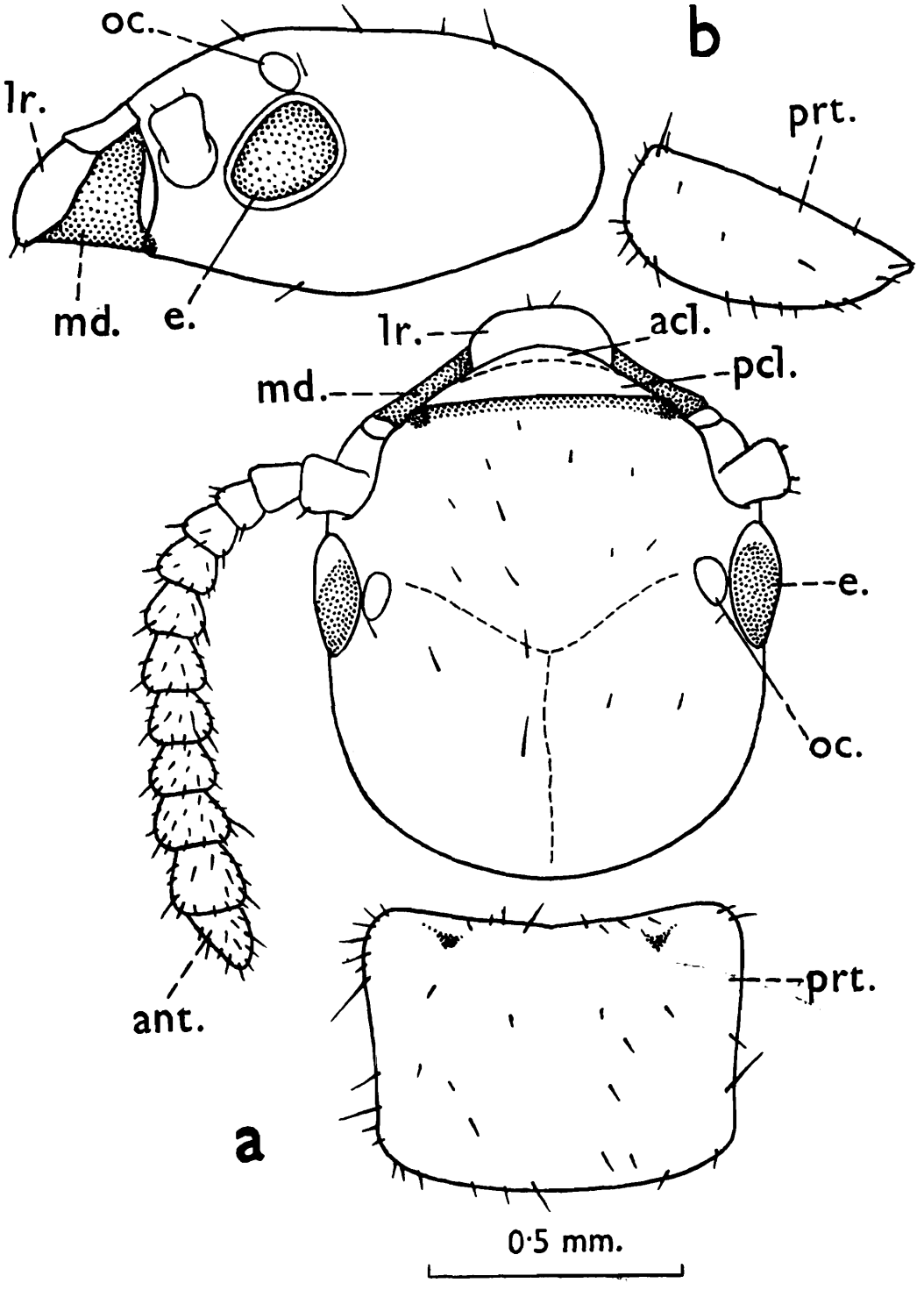
(*b*) *Description*

Types examined:

1. IMAGO (Text-figs. 2 & 3; Table 2).—

General: Head-capsule, pronotum and abdominal tergites castaneous brown; first 4 or 5 abdominal tergites darker; sternites paler; coxae and femora dark brown; labrum antennae, tibiae and tarsi pale brown;

mandibles brown with dark brown teeth; wings dark brown. The imago in the type collection has become paler, probably due to age.



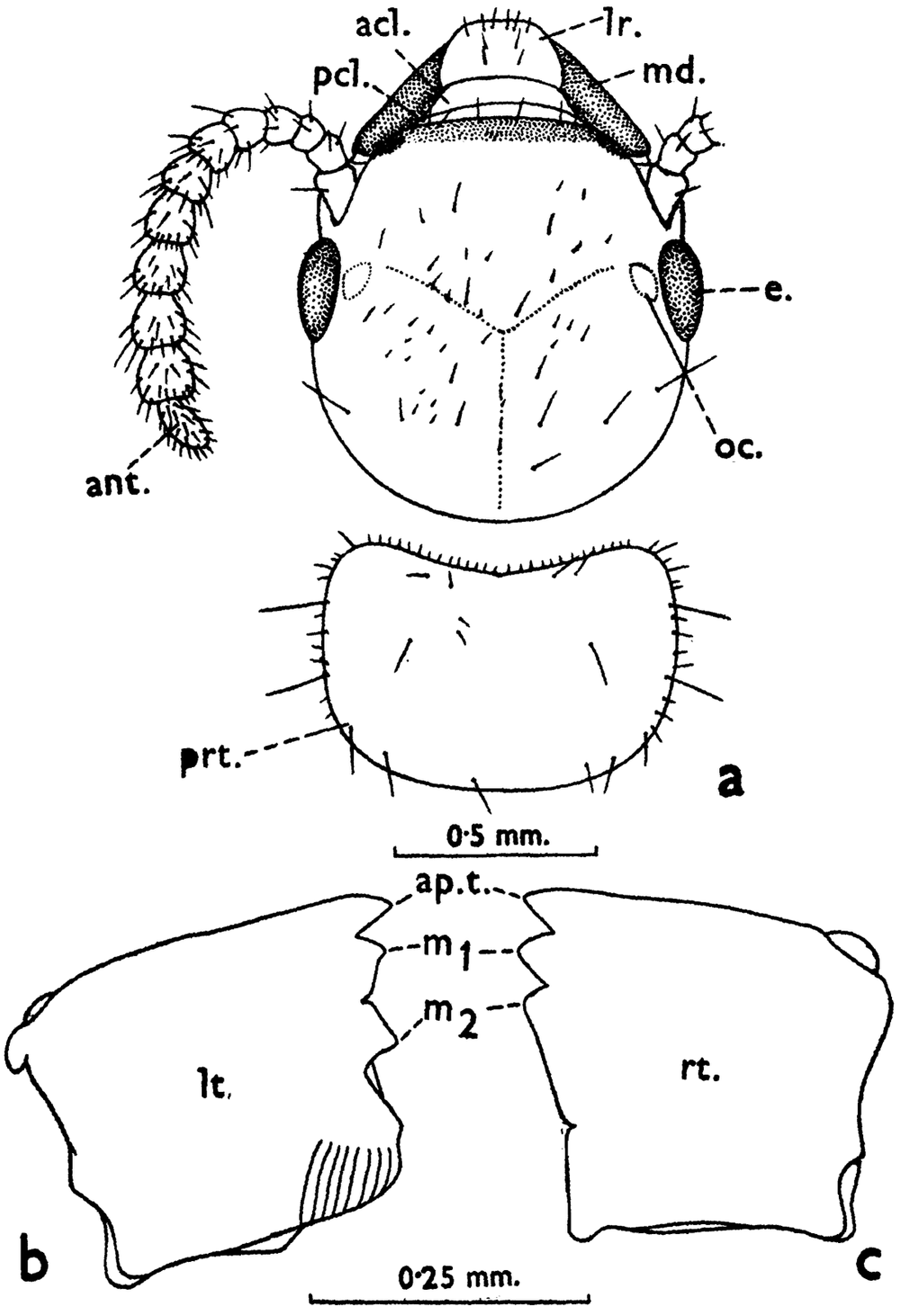
Text-fig. 2.—*Glyptotermes almorensis* Gardner. Imago. Paralectotype, from Bajwar (U.P., India).

(*a*) Head and pronotum, in dorsal view (sides of pronotum pressed down).
(*b*) Ditto, in side view.

acl., anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum.

Head and body sparsely hairy. Total body-length with wings *c.* 7.2–8.1, without wings *c.* 4.2–5.4 mm.

Head: Length of head-capsule generally equal to width (with eyes) sometimes a little less (length to base of mandibles 0.90–0.97;



Text-fig. 3.—*Glyptotermes almorensis* Gardner. Imago. Paithani (U.P., India).

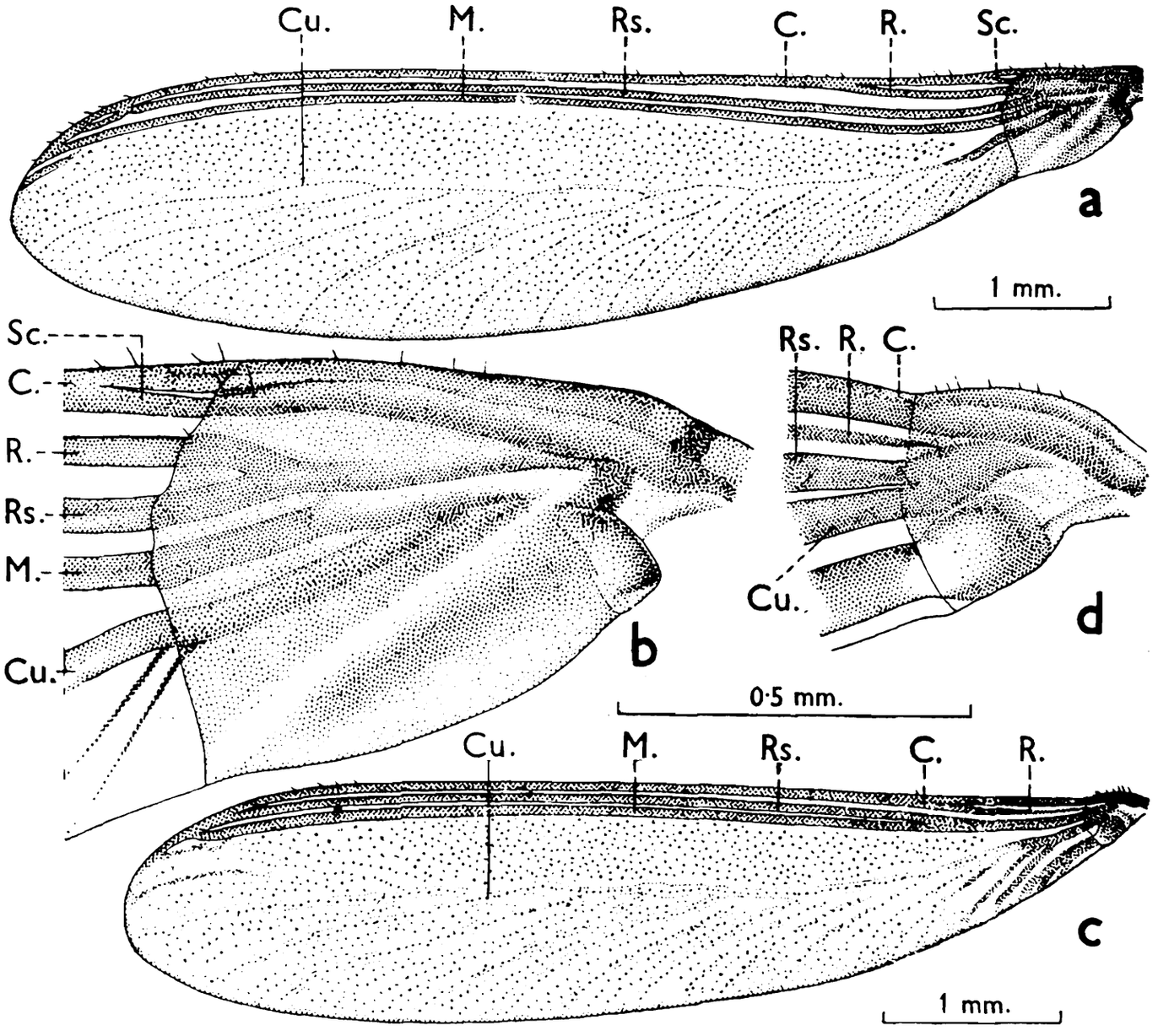
(*a*) Head and pronotum, in dorsal view (pronotum in actual shape, *in situ*). (*b*) Left mandible, in dorsal view. (*c*) Ditto, right mandible. *acl.*, anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandibles; *e.*, eye; *lr.*, labrum; *lt.*, left; m_1, m_2; 1st and 2nd marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

TABLE 2.—Measurements (in mm.) of *Glyptotermes almorensis* Gardner and *G. coorgensis* Holmgren & Holmgren. Imago.
ex., examples.

Body-parts	*G. almorensis* Range (5 ex.)	*G. coorgensis* Range (2 ex.)
1. Total body-length *with* wings (excluding antennae), *c.*	7.2 —8.1	—
2. Total body-length *without* wings, (excluding antennae), *c.*	4.4 —5.4	4.2 —4.6
3. Length of head to tip of labrum	1.13—1.30	1.07
4. Length of head to lateral base of mandibles	0.90—0.97	0.87—0.90
5. Maximum width of head (with eyes)	0.90—0.97	0.87—0.93
6. Maximum height of head	0.50—0.53	0.53
7. Maximum length of labrum	0.17—0.25	0.23
8. Maximum width of labrum	0.30—0.33	0.33
9. Maximum diameter of compound eye (with ocular sclerite)	0.23—0.25	0.25
10. Maximum diameter of lateral ocellus	0.09	0.07
11. Minimum diameter of lateral ocellus	0.09	0.05
12. Minimum ocellus-antennal distance	0.15—0.17	0.15
13. Minimum eye-ocellus distance	0.015 (in one ex. only)	—
14. Minimum eye-antennal distance	0.03—0.04	0.03
15. Minimum distance of eye from lateral base of head	0.17	0.15
16. Maximum length of pronotum	0.53—0.60	0.57
17. Maximum width of pronotum	0.77—0.83	0.80—0.83
18. Length of forewing with scale	5.70—6.30	—
19. Length of forewing scale	0.67—0.80	0.77—0.86
20. Length of hindwing with scale	5.40—5.80	—
21. Length of hindwing scale	0.30—0.33	0.33

width with eyes also 0.90–0.97 mm.); sides without eyes substraight; posterior margin round. *Frontanelle:* Absent. *Eyes:* Two lateral, small, suboval, black, facetted eyes, one on either side; maximum diameter with ocular sclerite 0.23–0.25; minimum diameter 0.20–0.21 mm.; situated at a distance of 0.17 mm. from the lateral base of head-capsule. *Ocelli:* Two medium-sized, oval, translucent ocelli, one on either side, somewhat directed in front; generally touching the eye of its side, sometimes slightly separated; separated from the antennae by a distance of *c.* 0.15–0.17 mm. *Antennae:* With 12 segments; basally sparsely and distally fairly pilose; segment 1 cylindrical; 2 longer than half of 1 and slightly longer than 3; 4 to the penultimate segments gradually increasing in length, large and broadly pyriform; last ovate, pointed apically and narrower than the penultimate one. *Clypeus:* Subtrapezoidal; anterior margin weakly convex to round, sides weakly incurved; indistinctly divided into an ante- and a post-clypeus. *Labrum:* Broader than long; anterior margin round; with a few hairs near anterior margin.

Mandibles: Subsquarish. Left mandible with an apical and two marginal teeth; apical finger-like; 1st marginal shorter but thicker than apical; 2nd marginal subequal to 1st and with anterior margin equal to the posterior margin of 1st. Right mandible also with an apical and two marginal teeth; apical finger-like, a little stronger than the corresponding one in left mandible; 1st marginal subtriangular, subequal to but stronger than apical; 2nd marginal short, with the posterior margin a little longer than molar plate.



Text-fig. 4.—*Glyptotermes almorensis* Gardner. Wings. From a specimen from Paithani (U.P., India).

(*a*) Forewing, in dorsal view. (*b*) Ditto, proximal portion enlarged. (*c*) Hindwing, in dorsal view. (*d*) Ditto, proximal portion, enlarged.

C., costa; *Cu.*, cubitus; *M.*, median; *R.*, radius; *Rs.*, radial sector; *Sc.*, subcosta.

Thorax: Pronotum: Subrectangular; narrower than headcapsule and broader than long; maximum length 0.53–0.60; maximum width 0.77–0.83 mm.; with short and long bristles on all margins and a few on body; anterior margin weakly concave; sides round (in the lectomorphotype, (Text-fig. 2*a*), the sides appear substraight in dorsal view due to the dehydration and pressing down of sides); posterior margin substraight; both antero-lateral and postero-lateral corners rounded, anterior ones narrower. *Legs:* Short and hairy; apical tibial spurs 3: 3: 3. Tarsi 4-jointed; arolium present.

Wings (Text-fig. 4): Dark brown; membrane covered with prominent granules. *Forewing:* A little longer than hindwing; scale also longer and covering the hindwing scale. All veins arising independently from scale. Costa, subcosta, radius, radial sector and median strongly chitinised and thick, cubitus generally weak somewhat prominent near the scale. Costa bordering the anterior margin and running upto distal end. Subcosta minute, fusing with costa just outside the scale. Radius short, arising separately and joining the costa at about one-sixth the length of wing-membrane from scale. Radial sector arising separately from scale (but from a common stalk, with radius inside the scale); curving up a little and then running parallel with costa upto the distal tip; without any branches to costal border. Median also curving up and running close to and parallel with radial sector. Cubitus running medially and with 11–14 branches to posterior margin; cross-veins between cubitus and median sometimes present. *Hindwing:* Costa, radius and radial sector as in forewing. Subcosta lacking. Median arising from the radial sector at about one-fourth to one-sixth of wing-membrane from the scale, and running close to, and parallel with the radial sector upto the distal end. Cubitus as in forewing, with 12–13 branches to posterior margin; cross-veins between cubitus and median sometimes present.

Abdomen: Oblong; hairy. Cerci 2-jointed, 0.10 mm. long. Styli (in males) single-jointed, 0.07 mm. long.

2. SOLDIER (Text-fig. 5; Tables 3).—

General: Head-capsule reddish brown, paler posteriorly and dark reddish brown anteriorly; antennae, labrum, legs and abdomen pale yellowish brown; the last tergite darker (testaceous, *vide* Gardner 1944); mandibles black. Head and body sparsely pilose with longish bristles. In the soldier in the type collection (now selected as Lectotype) the head is generally paler and the hairs haven fallen off probably due to faulty preservation. Total body-length *c.* 4.8–5.7 mm.

Head: Head-capsule subrectangular, flat; longer than broad, length about one-and-a half times the width (length to lateral base of mandibles 1.43–1.73; maximum width 1.06–1.13 mm.); frons sloping in front and weakly depressed medially; lateral protuberences on frons absent or weakly developed; sides substraight; posterior margin round; Y-suture faintly marked, median arm weak, lateral arms indistinct; genae round not sharply projected infront. *Fontanelle:* Absent. *Eyes:* Two lateral, oval, unpigmented eyes, one on either side; flush with head surface; situated at a distance of their short diameter from the

TABLE 3.—Measurements in mm.) etc., of *Glyptotermes almorensis* Gardner; *G. ceylonicus* Holmgren and *G. corogensis* Holmgren & Holmgren. Soldier.

ex., examples.

Body-parts	*G. almorensis*		*G. ceylonicus*	*G. coorgensis*
	Range (5 ex.)	Lectotype	Range (5 ex.)	Range (9 ex.)
1. Total body-length (excluding antennae) *c.*	4.8 –5.7	5.7	6.5 –10.4	4.8 –5.8
2. Length of head to lateral base of mandibles	1.43–1.73	1.73	2.67–3.00	1.33–1.70
3. Maximum width of head	1.07–1.13	1.13	1.50–1.67	1.00–1.20
4. Maximum height of head	0.87–0.93	0.90	1.37–1.40	0.80–1.00
5. Head Index I (Width/ Length)	0.65–0.75	0.65	0.56–0.60	0.65–0.75
6. Head Index II (Height/ Width)	0.80–0.87	0.80	0.84–0.91	0.79–0.87
7. Head Index III (Height/ Length)	0.52–0.60	0.52	0.47–0.51	0.53–0.61
8. Maximum length of labrum	0.20–0.25	0.23	0.32–0.47	0.13–0.23
9. Maximum width of labrum	0.27–0.30	0.30	0.33–0.43	0.27–0.30
10. Length of mandibles (from upper base of condyle to tip):				
(a) Left mandible	0.67–0.77	0.77	0.90–1.00	0.63–0.77
(b) Right mandible	0.70–0.77 (2 ex.)	0.77	0.90–1.00	0.63–0.77
11. Head-mandible length Index (Left mandible-length/ Head-length to base of mandibles)	0.45–0.47	0.45	0.33–0.36	0.43–0.48
12. Minimum median length of postmentum	0.90–1.10	1.10	1.90–2.33	0.83–1.17
13. Maximum width of postmentum	0.40–0.43	0.40	0.50–0.60	0.35–0.44
14. Width of postmentum at anterior end	0.27–0.30	0.27	0.33–0.40	0.21–0.30
15. Width of postmentum at waist	0.20–0.21	0.23	0.23	0.19–0.27
16. Postmentum-contraction Index (*i.e.*, Width at waist/ Maximum width)	0.47–0.57	0.57	0.38–0.46	0.48–0.62
17. Maximum length of pronotum	0.60–0.63	0.63	0.73–0.97	0.50–0.60
18. Maximum width of pronotum	1.03–1.07	1.07	1.33–1.67	0.87–1.03
19. Pronotum-head Index (Pronotum-width/Head-width)	0.94–0.96	0.94	0.87–1.00	0.86–1.00
20. Pronotum Index (Length/ Width)	0.58	0.58	0.55–0.60	0.55–0.61
21. Maximum width of mesonotum	0.80–0.93	0.93	1.33–1.60	0.80–0.97
22. Maximum width of metanotum	0.83–0.90 (2 ex.)	—	1.33–1.67	0.87–0.97

antennal socket. *Ocelli:* Indistinct. *Antennae:* With 11–12 segments; segments 1 and 2 sparsely and the remainder fairly, pilose; segment 1 longest, cylindrical; 2 cylindrical, about one-half of 1; 3 shorter than 2, subequal to or slightly longer than 4; sometimes subdivided; 4 to the penultimate one broadly pyriform and subequal; the last ovate and narrower than the penultimate one. *Clypeus:* Subtrapezoidal; divided into an ante- and a postclypeus. Anteclypeus a thin, pale, apilose strip. Postclypeus pilose; demarcated from frons by a thin, weak groove. *Labrum:* Broadly tongue-shaped and slightly wider than long; anterior margin rounded. *Mandibles:* Short, stout and strongly hooked apically; length a little less than half of head-capsule. Left mandible with 3 marginal teeth; marginals 1 and 2 close together and situated in distal third of mandible; marginal 3 larger and situated in middle-third. Right mandible with 2 marginal teeth in middle-third of mandible. *Postmentum:* Long, club-shaped; widest at about anterior one-third; sides gradually narrowing behind into a narrow waist at posterior one-third and widening again posteriorly; in front of widest point, sides weakly narrowed; anterior margin substraight; posterior margin concave, bulged medially.

Thorax: Pronotum: Subrectangular; slightly narrower than head-capsule (as wide as head, according to Gardner 1944); much broader than long (maximum length 0.60–0.63; maximum width 1.03–1.07 mm.); anterior margin weakly concave and slightly notched in middle; sides substraight and narrowed posteriorly; posterior margin nearly straight; antero-lateral corners narrower than postero-lateral corners. *Mesonotum:* Narrower than pronotum; posterior margin straight. *Metanotum:* As wide as, or a little wider than, mesonotum; posterior margin straight. *Legs:* Short and hairy; apical tibial spurs 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong, hairy; the last tergite somewhat darker than, the rest. Cerci 2-jointed.

3. PSEUDOWORKER (Table 4).—

General: Head-capsule pale brown; antennae, labrum and body paler than head. Mandibles pale brown with dark brown toothed margins. Head and body sparsely pilose. Total body-length *c.* 4.5–5.0 mm.

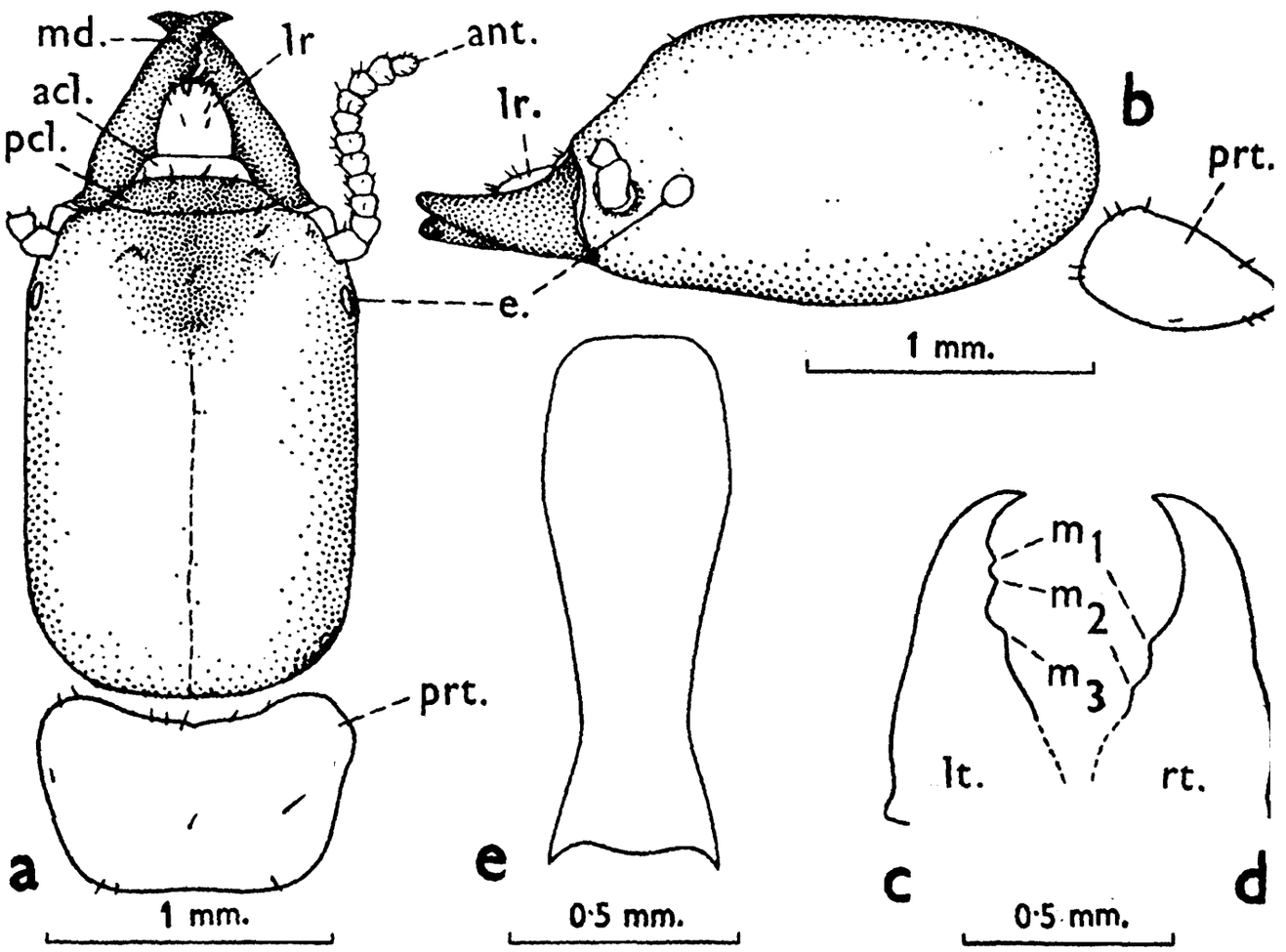
Head: Head-capsule subcircular; almost as wide as length to lateral base of mandibles (length to lateral base of mandibles 1.00; maximum width 0.93–1.03 mm.). *Fontanelle and ocelli:* Absent. *Eyes:* Two lateral unpigmented eyes, one on either side; flush with head-surface. *Antennae:* With 10–11 segments; segment 1 long, cylindrical; 2 a little longer than half of 1, cylindrical; 3 short; 4 to the penultimate one broadly pyriform and gradually increasing in length; the last ovate, narrower and shorter than the penultimate one. *Clypeus, labrum and mandibles:* As in imago.

Thorax: Pronotum: Almost as wide as, or slightly narrower than, head-capsule; broader than long (maximum length 0.57; maximum

width 0.90–1.00 mm.); anterior margin concave; posterior margin substraight. *Legs:* As in soldier.

Abdomen: Oblong, sparsely pilose. Cerci 2-segmented, 0.07 mm. long (broken in most of the specimens examined). Styli also broken in the specimens examined.

(*c*) *Type-specimens:*—Gardner (1944) neither selected the holotype nor gave any repository of the types. Out of the cotypes present in



Text-fig. 5.—*Glyptotermes almorensis* Gardner. Soldier. Lectotype, from Bajwar (U.P., India).

(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Left mandible, in dorsal view. (*d*) Ditto, right mandible. (*e*) Postmentum, in ventral view.

acl., anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum, *lt.*, left; m_1–m_3, 1st to 3rd marginal teeth of mandibles; *md.*, mandible; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

TABLE 4.—Measurements (in mm.) of *Glyptotermes almorensis* Gardner, *G. ceylonicus* Holmgren and *G. coorgensis* Holmgren & Holmgren. Pseudoworker.

ex., examples.

Body-parts	*G. almorensis*	*G. ceylonicus*	*G. coorgensis*
	Range (5 ex.)	(1 ex.)	Range (10 ex.)
1. Total body-length (excluding antennae) *c.*	4.5 —5.0	8.60	4.9 —6.2
2. Length of head to tip of labrum	1.17—1.37	1.83	1.17—1.33
3. Length of head to lateral base of mandibles	1.00	1.40	0.90—1.07
4. Maximum width of head	0.93—1.03	1.50	0.93—1.10
5. Maximum height of head	0.50—0.60	0.97	0.57—0.67
6. Maximum length of labrum	0.20—0.30	0.47	0.20—0.33
7. Maximum width of labrum	0.33—0.40	0.43	0.33—0.40
8 Maximum length of pronotum	0.57	0.90	0.53—0.70
9. Maximum width of pronotum	0.90—1.00	1.60	0.83—1.00

the F.R.I., Dehra Dun, *vide* "Material (i)" above, I have selected the lectotype and paralectotypes as follows:—

Lectotype: A soldier, in a vial.

Paralectotypes: An imago and several pseudoworkers, in a vial.

Cotypes are also present in B.M., London and with Prof. Emerson (now in A.M.N.H., New York) *vide* Roonwal and Pant (1953, p. 44).

(*d*) *Type-locality:*—Bajwar, Almora District (Uttar Pradesh, India), *c.* 31° 30′ N., 75° 55′ E.

(*e*) *Distribution:* India: *Uttar Pradesh:* Bajwar (type-locality), Almora District; and Paithani, 30° 05′ N., 78° 55′ E., Garhwal District.

(*f*) *Comparison.—Glyptotermes almorensis* is close to *G. coorgensis* Holmg. & Holmg. and *G. minutus* Kemner, and is separable from them as follows:—

1. From *G. coorgensis:*

Imago: (i) Slightly paler species. (ii) Head-capsule somewhat larger (length to base of mandibles 0.90–0.97 *vs.* 0.87–0.90 mm.; maximum width 0.90–0.97 *vs.* 0.87–0.93). (iii) Ocelli larger and directed anteriorly in lateral view *vs.* smaller and directed vertically (maximum diameter 0.09 *vs.* 0.07 mm.).

Soldier: (i) Antero-lateral corners of head-capsule at base of mandibles, rounded (*vs.* sharply projected). (*ii*) Head sutures indistinct (*vs.* distinct). (iii) Inner margin of left mandible between marginal

teeth 2 and 3 roundly concave (*vs.* incurved with a deep notch). (iv) Mandibles without a basal hump on outer margin (*vs.* with a weak to prominent hump).

2. From *G. minutus:*

Imago: (i) Generally larger (length to tip of labrum 1.13–1.30 *vs.* 0.99; length to base of mandibles 0.90–0.97 *vs.* 0.85; pronotum length 0.53–0.60 *vs.* 0.49; and pronotum width 0.77–0.83 *vs.* 0.76 mm.). (ii) Head-sutures distinct *vs.* indistinct. (iii) Eyes separated from antennae by a distance of 0.03–0.04 mm. *vs.* 0.015 mm.; and from basal margin of head by 0.17 *vs.* 0.13 mm.

Soldier: (i) Head-capsule wider (maximum width 1.06–1.13 *vs.* 0.90 mm. (index Width/Length 0.65–0.75 *vs.* 0.60). (ii) Head-sutures indistinct *vs.* distinct. (iii) Postmentum waist short and broad *vs.* long and narrow (Postmentum-Contraction Index *i.e.*, Width at waist/ Maximum width 0.47–0.57 *vs.* 0.46).

2. **Glyptotermes ceylonicus** Holmgren

(Text-figs. 6 & 7; Tables 3 & 4)

(i) *Calotermes* (*Glyptotermes*) *ceylonicus* Holmgren

1911*a*. N. Holmgren, In: Escherich's *Termitenleben auf Ceylon*,: 187, 189, *Im. Type-locality:* Peradeniya (Ceylon).
1911*b*. N. Holmgren, *Zool. Anz.*, Leipzig, **37** (26): 551. [= *C. dilatatus*].
1913*a*. N. Holmgren, *Spol. Zeylan.*, Colombo, **8** (32): 277, 279–280. *Im.* and *S.* Ceylon: Peradeniya.
1913*b*. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **50** (2): 49, 50, 55–56, fig. 10 (*S. mandibles*), pl. 1, fig. 12 (*S.*), *Im.* and *S.* Ceylon.
1913. E. E. Green, *Spol. Zeylan.*, Colombo, **9** (33): 8. Ceylon: Peradeniya.
1925. O. John, *Treubia*, Batavia, **6** (3-4): 380. Ceylon: Peradeniya.
1930. F. P. Jepson, *Trop. Agric.*, Peradeniya, **75** (3 & 4): 149, 151, 155, 1 pl. Ceylon: Elpitiya; Hewaheta; Peradeniya.
1931. F. P. Jepson, *Adm. Rep. Dir. Agric. Ceylon*, Colombo, 1930: 72, 73. Ceylon: Hewaheta Dist.; Chilaw; Peradeniya.
1934. V. Margabandhu, *J. Bombay nat. Hist. Soc.*, Bombay, **37** (3): 702. Ceylon: Peradeniya.

(ii) *Calotermes ceylonicus* Holmgren

1922. E. Hegh, *Les Termites*, Brussels, p. 48. Ceylon.

(iii) *Glyptotermes ceylonicus* Holmgren

1941. M. P. D. Pinto, *Indian J. Ent.*, New Delhi, **3** (1): 86. Ceylon: Hewaheta; Passara; Peradeniya.
1941. C. F. C. Beeson, *Ecology & Control Forest Insects, etc.*: 541.
1942. H. Kirby, *Univ. Calif. Publ.* (*Zool.*), Berkeley, **45** (2): 116. Protozoa.
1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 47. Ceylon.
1953. M. L. Roonwal and G. D. Pant, *Indian For. Leafl.* (*Ent.*), Delhi, No. 121 (3): 44. Ceylon: Kurunegala.
1958. M. Ahmad, *Biologia*, Lahore, **4** (1-2): 47, 50. Keys.
1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122**, (Art. 4): 347.
1962. R. N. Mathur and R. S. Thapa, *Indian For. Leafl.* (*Ent.*), Delhi, No. 167: 9. Ceylon: Kurunegala; Peradeniya.

(iv) *Kalotermes* (*Glyptotermes*) *ceylonicus* Holmgren

1953. Rattan Lal and Menon, R. D., *Catalogue Indian Insects*, Part 27—*Isoptera*: 12–13. Ceylon. Also see for other references on biology of this species.

(v) *Glyptotermes ceylonicus* var. *cylindricus* Kemner (MS name).

1941. M. P. D. Pinto, *Indian J. Ent.*, New Delhi, **3** (1): 87. Ceylon: Elpitiya.

1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 346. Ceylon: Elpitiya.

1962. R. N. Mathur and R. S. Thapa, *Indian For. Leafl.* (*Ent.*), Delhi, No. 167: 9. Ceylon: Elpitiya; Talgaswella.

(*a*) *Material Examined*

(*A*) *Present in Z.S.I., Calcutta:* (i) A vial with 2 soldiers, Kurunegala, Ceylon, *F.R.I.* coll., 24.xii.1934, ex "*Cutocarpus integrifolia*"

(*B*) *Present in Zoologiska Institute, Lund University, Lund:* (ii) A vial with 2 soldiers, 2 nymphs and 1 pseudoworker, Talgaswella, Elpitiya, Ceylon, coll. *F.P. Jepson* (No. 6489), 20.viii.1925, ex "dead *Heavea*" *Det.* N. Kemner "*Calotermes* (*Glyptotermes*) *ceylonicus* var. *cylindricus*" (MS name). (iii) A vial with 1 soldier, Ceylon, coll. *F.P. Jepson*, 20.viii.1925, ex "Kemner's Coll."

(*b*) *Description*

1. IMAGO.—

Imagos were not available to me. I, therefore, give below the English translation of the original description:

"IMAGO[1]) Head pale brown, paler in front [Yellowish brown to brown, *vide* Holmgren 1913]. Pronotum paler than head. Abdomen brownish above, paler below, legs rust yellow. Wings iridescent, with brownish anterior veins.

"Pilosity of head and thorax very thin.

"Head thick, almost quadrately oval. Facetted eyes and ocelli small, the latter separated from the eyes by their diameter or a little more [touching the eyes *vide* Holmgren 1913]. Clypeus short. Antenna 14-segmented (?) [13-segmented *vide* Holmgren 1913], distinctly thickened distally. Segment 2 almost as long as 3.

"Pronotum as wide as head posteriorly [narrower than head *vide* Holmgren 1913], anterior corners rectangular [acutely rounded *vide* Holmgren 1913], posterior corners strongly rounded, posterior margin hardly sinuate. Pronotum somewhat longer than half the width. Wings moderately long, narrow, marked, weakly iridescent. Subcosta not visible. Radius joined with anterior margin before the middle of wing. Radial sector single. Median outside running near the radial sector. Transverse branches absent. Cubitus only basally strongly marked, with generally 13 [10–12 *vide* Holmgren 1913] branches which stand thick basally."

"1) Description from a dried example."

The following measurements of imago are from Holmgren 1911*b* (original description), Holmgren (1913, *Spolia Zeyl.*, **8** (32), p. 279; and 1913, *K. Sv. Vet. Akad. Handl.*, **50** (2), p. 55):—

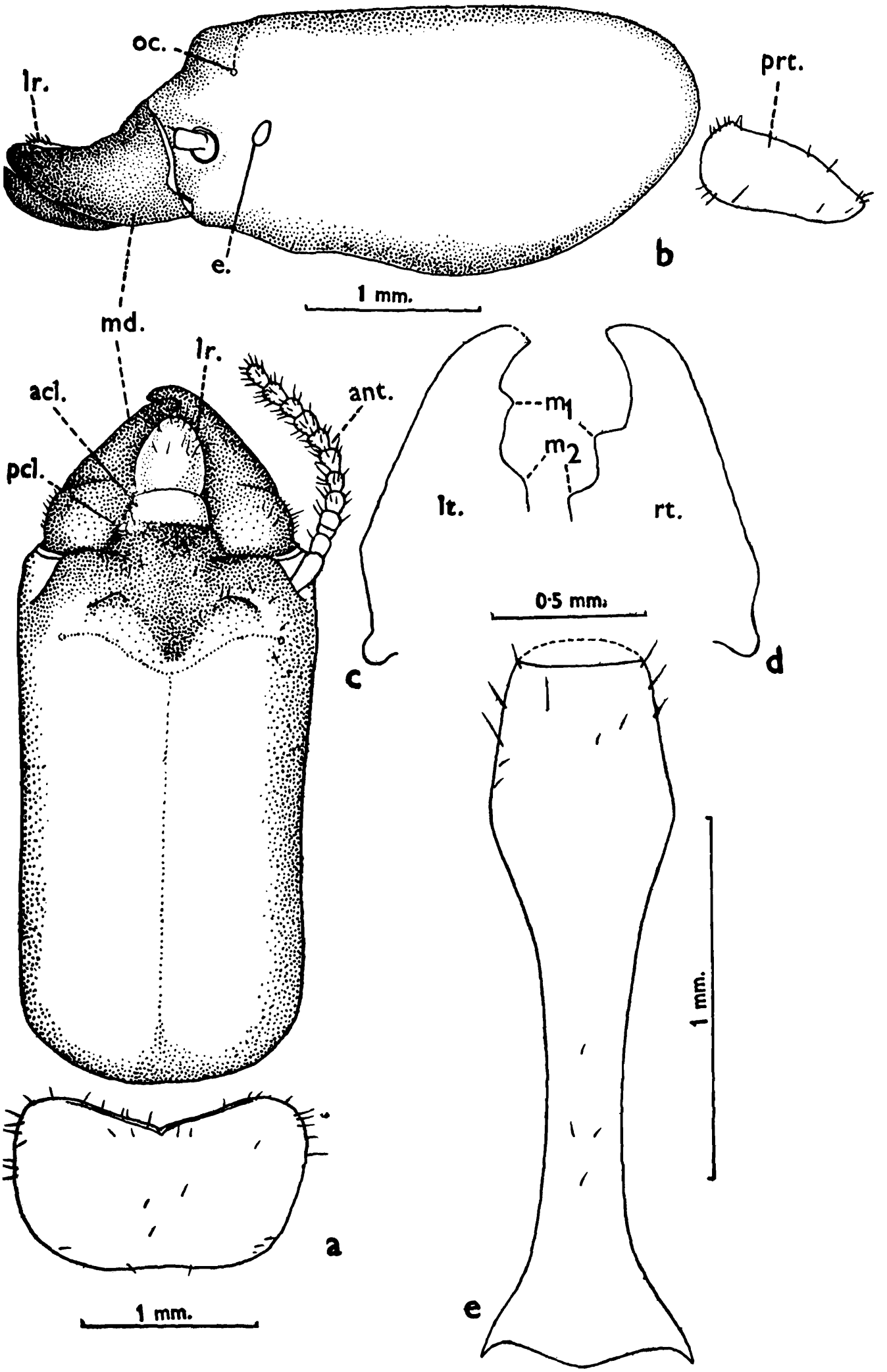
1.	Length with wings	8.5 –11.0	mm.
2.	Length without wings	4.7 – 6.0	,,
3.	Length of head	1.33– 1.52	,,
4.	Width of head	1.15– 1.30	,,
5.	Length of pronotum	0.52– 0.72	,,
6.	Width of pronotum	0.96– 1.22	,,
7.	Length of forewing	7.3	,,

2. SOLDIER (Text-fig. 6; Table 3).—

General: Head-capsule pale brownish yellow, frons reddish brown; mandibles black, reddish brown at base; labrum and antennae pale yellow to pale reddish yellow; body and legs straw yellow. Head sparsely and body moderately hairy. Total body-length *c.* 6.5–10.4 mm.

Head: Head-capsule subrectangular; frons sloping in front; dorso-lateral protuberances of frons quite prominent; much longer than broad (length to base of mandibles 2.62–3.01; maximum width 1.50–1.67 mm.); sides subparallel; posterior margin round; Y-suture present. *Fontanelle:* Absent. *Eyes:* Two lateral, translucent, suboval eyes; situated a little behind the antennae. *Ocelli:* Two lateral, dot-like, translucent ocelli, one on either side, at the end of the lateral arms of Y-suture. *Antennae:* With 12 segments; moderately pilose; segment 1 longest and cylindrical; 2 about half of 1 or a little longer, and cylindrical; 3 shortest; 4–11 pear-shaped; the last shorter and narrower than the penultimate one. *Clypeus:* Divided into an ante- and a post-clypeus. Anteclypeus apilose; either a thin or moderately long, rectangular, translucent strip. Postcylypeus pilose, demarcated from frons only at lateral corners. *Labrum:* Broadly tongue-shaped; anterior margin broad; slightly longer than broad and extending beyond the middle of mandibles. *Mandibles:* Thick and stout, distally broadly narrowed. Left mandible with 2 large, broad marginal teeth; 1st marginal a little above one-fourth of mandible (in one example very near the distal tip); 2nd marginal broader and larger than 1st and located in middle of mandible length. [In the figure given by Holmgren 1913, fig. 10, the 2nd marginal is shown just below the 1st. Dentition of left mandible is apparently very variable.] Right mandible with 2 marginal teeth in the middle of mandible-length. *Postmentum:* Long and club-shaped; with a few hairs anteriorly and in middle of waist; widest at about anterior one-fourth; anteriorly the sides weakly narrowed; posteriorly the sides strongly narrowing into a long waist and again widening out abruptly near posterior margin; anterior margin substraight or weakly convex; posterior margin medially projected.

Thorax: Pronotum: Flat, subrectangular, either narrower, or as wide as head (maximum length 0.65–0.97; maximum width 1.33–1.67 mm.); anterior margin concave and with a minute, median notch; sides round and faintly narrowed posteriorly; posterior margin convex, either



Text-fig. 6.—*Glyptotermes ceylonicus* Holmgren. Soldier. Elpitiya (Ceylon). (*a*) Head and pronotum, in dorsal view; (*b*) Ditto, in side view; (*c*) Left mandible, in dorsal view; (*d*) Ditto, right mandible: (*e*) Postmentum, in ventral view. *acl.*, anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum; *lt.*, left; m_1, m_2, 1st and 2nd marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

notched or incurved medially; antero-lateral corners narrower than postero-lateral corners. *Mesonotum:* Narrower than pronotum and weakly incurved at posterior margin. *Metanotum:* As wide as, or narrower than, pronotum and weakly incurved at posterior margin. *Legs:* Short and stout; apical tibial spurs 3 on each leg. Tarsi 4-jointed.

Abdomen: Oblong; moderately pilose. Cerci 2-jointed, 0.17–0.20 mm. long. Styli single-jointed, 0.10 mm. long.

3. PSEUDOWORKER (Text-fig. 7; Table 4).—

General: Head-capsule pale yellow; antennae, labrum, body and legs pale straw yellow; mandibles yellowish brown with dark brown toothed margins. Head and body moderately hairy. Total body-length *c.* 8.6 mm.

Head: Head-capsule subcircular, a little broader than long (maximum width 1.50; length to base of mandibles 1.40 mm.); head sutures not clear. *Fontanelle:* Absent. *Eyes:* Two lateral, compound, colourless eye-spots present, one on either side. *Ocelli:* Absent. *Antennae:* Broken in the specimen examined; only 8 segments present; segment 1 longest, cylindrical; 2 a little shorter than 1 and cylindrical; 3 shortest; 4–8 gradually increasing in length and broadly pyriform. *Clypeus:* Flat; trapezoidal; not clearly divided into an ante- and a postclypeus; with a few hairs near posterior margin. *Labrum:* Broadly tongue-shaped; longer than broad; with a few hairs near anterior margin and on body; anterior margin truncate. *Mandibles:* Of typically *Glyptotermes*-type.

Thorax: Pronotum: Flat, subrectangular; wider than head-capsule; much wider than long (maximum length 0.90; maximum width 1.60 mm.); anterior margin concave with a faint median notch; sides round; posterior margin with a broad median notch. *Legs:* Short and stout; apical tibial spurs 3 on each leg. Tarsi 4-jointed.

Abdomen: Oblong, moderately hairy. Cerci 2-jointed, 0.17 mm. long. Styli single-jointed, 0.10 mm. long.

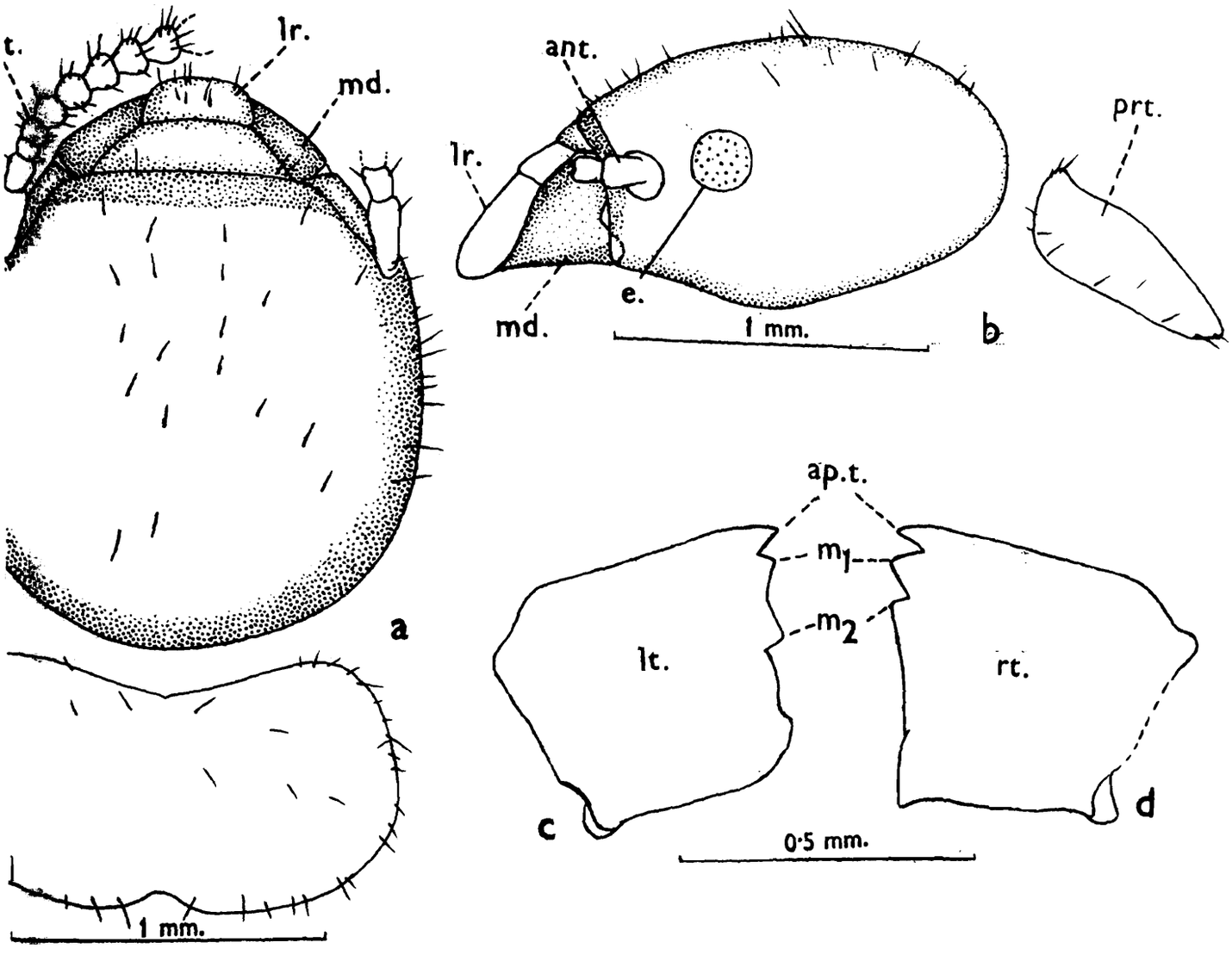
(*c*) *Type-specimens.*—The species was described by Holmgren (1911*b*) from a single dry imago which thus becomes the holotype; it is stated to be present in Vienna Museum.

(*d*) *Type-Locality.*—Peradeniya (Ceylon).

(*e*) *Distribution.*—The species is confined to Ceylon and has been recorded as follows:—

Chilaw, 7°34′ N., 79°48′ E.; Hewaheta; Elpitiya, 6°16′ N., 80°09′ E.; Kurunegala, 7°28′ N., 80°23′ E.; Passara, 6°57′ N., 81°09′ E.: Peradeniya, 7°16′ N., 80°37′ E.

(*f*) *Comparison—Glyptotermes ceylonicus* Holmgren along with *G. dilatatus* (Bugn. & Popoff) can be separated from all the other Indian species by their larger size. *G. ceylonicus* is close to *G. dilatatus* (Bugn. & Popoff),



Text-fig. 7.—*Glyptotermes ceylonicus* Holmgren. Pseudoworker. Elpitiya (Ceylon).

(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Left mandible, in dorsal view. (*d*) Ditto, right mandible.

ant., antenna; ***ap.t.***, apical tooth of mandibles; ***e.***, eye; ***lr.***, labrum; ***lt.***, left; m_1, m_2, 1st and 2nd marginal teeth of mandibles; ***md.***, mandible; notum; ***rt.***, right.

G. borneensis (Haviland) and *G. buttelreepeni* Holmg. but can be separated from them as follows:—

From G. dilatatus

Imago: (i) Darker (*vs.* paler). (ii) Sagittal-sutures distinct (*vs.* indistinct). (iii) Antero-lateral corners of pronotum narrowly round (*vs.* broadly rounded).

Soldier: (i) Head-capsule thicker, stouter and larger (length to lateral base of mandibles 2.62–3.01 *vs.* 2.00–2.33 mm.; maximum width 1.50–1.67 *vs.* 1.27–1.35 mm.). (ii) Mandibles thicker and shorter (length 0.90–1.00 *vs.* 1.03–1.13 mm.) (iii) Left mandible with two marginal teeth (*vs.* with four teeth). (iv) Labrum extending beyond the middle of mandibles (*vs.* not beyond middle). (v) Anteriorly, the genae with round and flat anterior margins (*vs.* projected in front). (vi) Anterior broad portion of postmentum simple (*vs.* bilobed). (vii) Anterior margin of pronotum angularly concave (*vs.* roundly concave).

2 *From G. borneensis*

Imago: (i) Antenna with 13 segments, segment 3 subequal to 2 (*vs.* with 11–12 segments, segment 3 shorter than 2). (ii) Pronotum narrower than head (*vs.* broader).

Soldier: (i) Head-capsule thicker and larger (length to lateral base of mandibles 2.62–3.01 *vs.* 2.32–2.47 mm.). (ii) Manidibles shorter and thicker, with 2 marginal teeth (*vs.* longer and thinner, with 4 marginal teeth).

3. *From G. buttel-reepeni*

Imago: (i) Paler and smaller (head width 1.15–1.30 *vs.* 1.44–1.47 mm; pronotum width 0.96–1.22 *vs.* 1.37 mm.). (ii) Antenna with 13 segments (*vs.* 11–12 segments). (iii) Wings shorter (forewing length 7.3 *vs.* 9.5 mm.).

Soldier: (i) Head-capsule longer and narrower (length to base of mandibles 2.62–3.01 *vs.* 2.66 mm.; maximum width 1.50–1.67 *vs.* 1.75 mm.); index Width/Length 0.56–0.60 *vs.* 0.66. (ii) Mandibles shorter and thicker (*vs.* comparatively longer and thinner).

3. **Glyptotermes coorgensis** Holmgren & Holmgren

(Text-figs. 8–10; Tables 2–4)

(i) *Calotermes* (*Glyptotermes*) *coorgensis* H. & H.

1917. K. Holmgren and N. Holmgren, *Mem. Dep. Agric. India*, Calcutta, **5** (3). 139–140, 1 fig. (*S.* mandibles). *S. Type-locality:* Sidapur, Coorg (Mysore State, India)

1934 V. Margabandhu, *J. Bombay nat. Hist. Soc.*, Bombay, **37** (3): 702. *India*. Sidapur (Coorg, Mysore State)

(ii) *Glyptotermes coorgensis* H. & H

1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112**: 49 India.

1958. G. D. Bhasin, M. L. Roonwal and S. Singh, *Indian For. Bull. (Ent.)*, (N.S.) Delhi, No. 171 (2): 99.

1958. M. Ahmad, *Biologia*, Lahore, **4** (1 & 2): 52. Keys.

1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122**, (Art. 4): 347

1962. R. N. Mathur and R. S. Thapa, *Indian For. Leafl. (Ent.)*, Delhi, No. 167 10. *India:* Sidapur (Coorg, Mysore State)

(iii) *Kalotermes* (*Glyptotermes*) *coorgensis* H. & H

1953. Rattan Lal and Menon, R. D., *Cat. Indian Insects*, Part 27, *Isoptera*, p. 13 India: Sidapur (Coorg, Mysore State)

(*a*) *Material Examined*

Present in Z.S.I., Calcutta. (i) A vial with 2 imagos (dealate), 3 soldiers and several pseudoworkers, Anekad Forest Range, Coorg (Mysore State, India), coll. *O. B. Chhotani*, 21.xi.1962, ex "dead portion of a *Ficus religiosa* Linn. tree"

(ii) A vial with 5 soldiers, and several pseudoworkers and nymphs, ex "dead log of an unknown wood lying on ground"; other data as in (i) above.

(iii) A vial with a soldier and several pseudoworkers, Z.S.I. Coll Sta. No. 13, Janserigoda, Bababudin Hills (Chickmagalur District, Mysore State, India), coll. *O. B. Chhotani*, 12.xi.1962, ex "a dead silver oak tree"

(*b*) *Description*

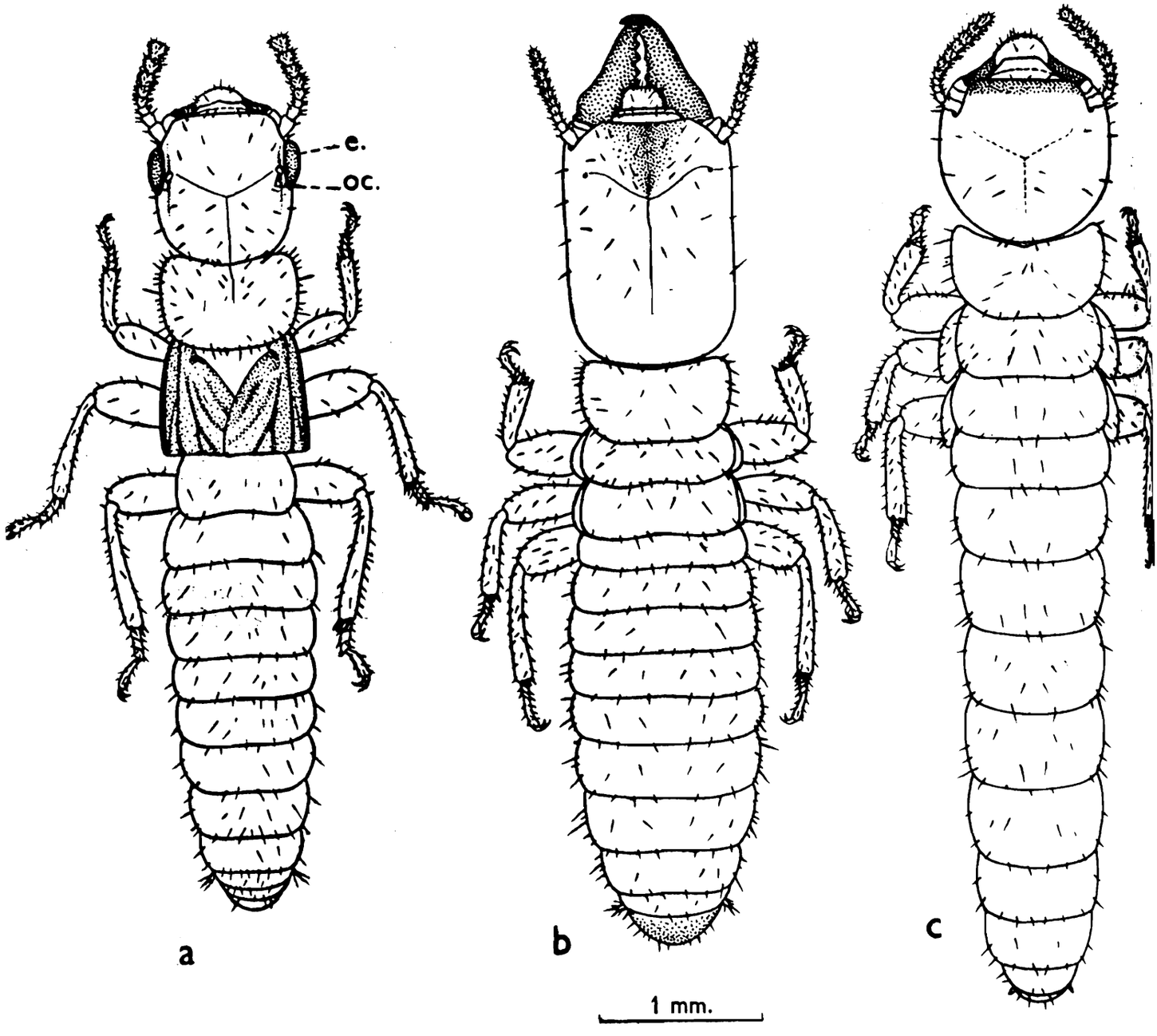
IMAGO (Text-figs. 8 & 9; Table 2).

The hitherto unknown imago caste of this species is described here for the first time.

General: Head-capsule dark castaneous brown; thorax, wing-scales and abdomen a little paler; abdominal sternites paler than targites, basal 4 sternites yellowish medially; labrum and legs brownish; antennae a little darker than labrum and legs; antennal segments paler distally; mandibles brownish, with dark brown toothed margins. Head and body fairly pilose with short and long hairs. Total body-length without wings *c.* 4.2–4.6 mm.

Head: Head-capsule subsquarish; as wide as or slightly wider than length to base of mandibles; maximum width with eyes 0.87–0.93; length to base of mandibles 0.87–0.90 mm.; sides substraight; posterior margin round; Y-suture present *Fontanelle*· Absent. *Eyes:* Two

lateral, oval, black, facetted eyes, one on either side; maximum diameter 0.25; minimum diameter 0.20–0.21 mm.; separated from the lower margin of head-capsule by a distance of 0.15 mm. *Ocelli:* Two small, oval, translucent ocelli one on either side, and touching the eye of its side; directed vertically when viewed laterally. Diameter: maximum 0.07, minimum 0.05 mm. *Antennae:* Incomplete in both



Text-fig. 8.—*Glyptotermes coorgensis* Holmgren and Holmgren.

Specimens from Anekad Forest Range, Coorg (Mysore State, India).

(*a*) Imago (dealate), in dorsal view. (*b*) Soldier, in dorsal view. (*c*) Pseudoworker, in dorsal view.

e., eye; *oc.*, ocellus.

examples (maximum 9 segments present); segments 1 and 2 sparsely, and the remainder fairly, pilose; segment 1 longest, cylindrical; 2 about half of 1 in length and cylindrical; 3 slightly shorter than 2; 4 onwards gradually increasing in size and pyriform. *Clypeus:* Subtrapezoidal; indistinctly divided into an ante- and a postclypeus. Anteclypeus apilose; anterior margin weakly projected in front medially. Postclypeus with a few hairs near posterior margin; anterior margin weakly convex. *Labrum.* Broader than long; with a few hairs near anterior margin and on body. *Mandibles:* Of typically *Glyptotermes*-type. Left mandible with an apical and two marginal teeth; apical finger-like; 1st marginal shorter than apical; 2nd subequal to 1st; posterior margin of 1st and anterior margin of 2nd subequal. Right mandible also with an apical and 2 marginal teeth; apical as in left mandible; 1st marginal short and triangular; 2nd shorter than 1st and with a long posterior margin.

Thorax: Pronotum: Subrectangular; anterior region paler; narrower than head with eyes; much broader than long (maximum length 0.57; maximum width 0.80–0.83 mm.); antero-lateral corners narrower than postero-lateral ones; anterior margin weakly concave; margin of sides weakly convex; posterior margin substraight. *Mesonotum and metanotum:* Weakly incurved at posterior margin. *Legs:* Short, hairy; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed; an arolium present between claws. *Wing-scales:* Forewing scale large, shield-like, 0.77–0.80 mm. long. Hindwing scales short, triangular, and completely covered by forewing scales; 0.33 mm. long.

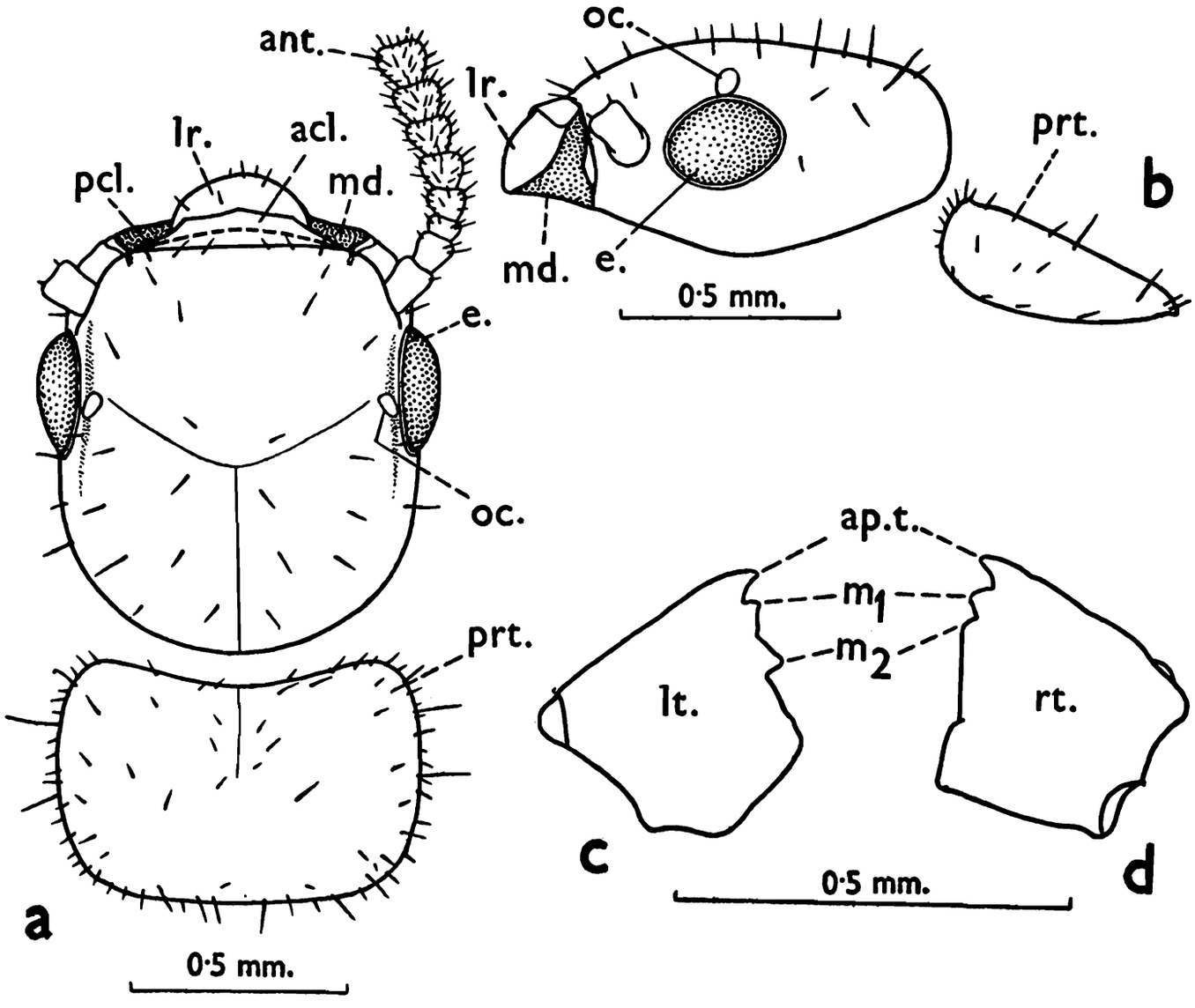
Abdomen: Oblong; hairy, with a few long and many short hairs near posterior margin of each tergum, and a few long hairs anteriorly. Cerci 2-jointed, *c.* 0.10 mm. long, hairy. Styli present in male, minute, one-jointed, 0.07 mm. long.

2. SOLDIER (Text-figs. 8 & 10; Table 3).—

General: Head-capsule reddish yellow; anteriorly reddish brown, posteriorly somewhat paler; mandibles blackish brown; antennae yellow to pale brown; labrum pale brown; thorax and abdomen creamish yellow to pale brown or pale reddish yellow, pronotum somewhat darker; legs yellow; last abdominal tergite weakly to strongly more chitinised than the preceeding ones. Head and body sparsely pilose. Total body-length *c.* 4.2–6.0 mm.

Head: Head-capsule subrectangular; longer than broad; length to lateral base of mandibles 1.29–1.70; maximum width 0.99–1.20 mm. frons bilobed, sloping in front at an angle of *c.* 45° and depressed medially; sides substraight; posterior margin round; Y-sutures present, distinct; antero-lateral corners of head-capsule sharply projected in front near the base of mandibles. *Fontanelle:* Absent. *Eyes:* Two lateral, oval, unpigmented eye-spots present, *c.* 0.08–0.13 mm. long. *Ocelli:* Two

lateral, minute, dot-like ocelli present, one on either side at the end of lateral arms of Y-suture. *Antennae:* With 9–11 segments; segments 1 and 2 sparsely, and the remainder fairly, pilose; segment 1 longest, cylindrical; 2 about half of 1 and cylindrical; 3 variable, either shortest or subequal to or longer than 2, sometimes subdivided into two; 4 to the penultimate one gradually increasing in size and pyriform; the last ovate, shorter and narrower than the penultimate one. *Clypeus:* Subtrapezoidal; divided into an ante- and a postclypeus. Anteclypeus pale brown, apilose, strip-like; either very short or as long as postclypeus. Postclypeus of same colour as frons, and pilose; separated

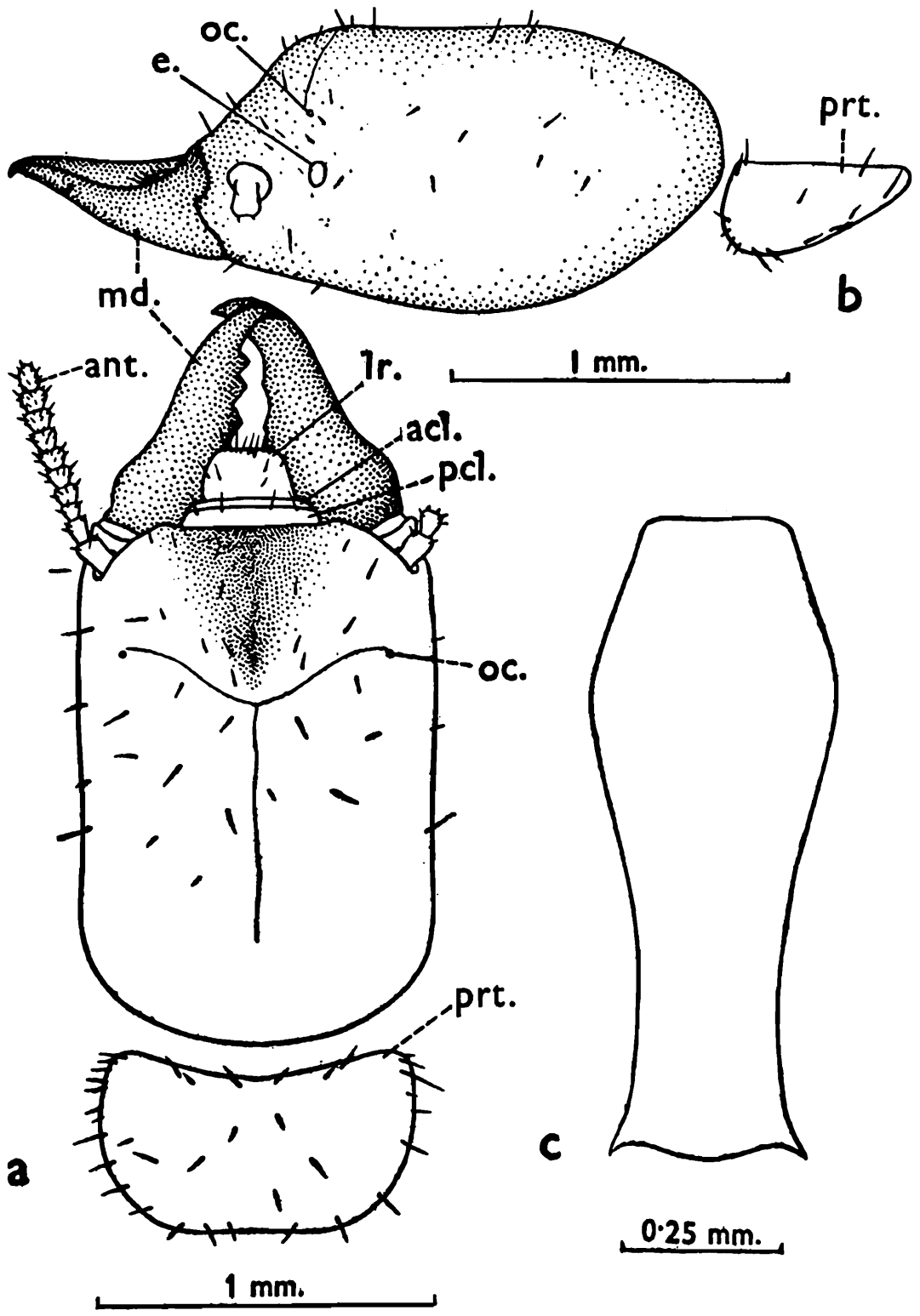


Text-fig. 9.—*Glyptotermes coorgensis* Holmgren and Holmgren. Imago. Anekad Forest Range, Coorg (Mysore State, India).

(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Left mandible, in dorsal view. (*d*) Ditto, right mandible.

acl., anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandibles; *e.*, eye; *lr.*, labrum; *lt.*, left; m_1, m_2, 1st and 2nd marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

from frons by a thin groove. *Labrum:* Broadly tongue-shaped; wider than long; anterior margin truncated or weakly rounded; with several hairs near tip and a few on body. *Mandibles:* Thick and short; shorter



Text-fig. 10.—*Glyptotermes coorgensis* Holmgren and Holmgren.
Soldier. Anekad Forest Range, Coorg (Mysore State, India).
(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Postmentum, in ventral view.
acl., anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum.

than half the length of head to base of mandibles; outer margin concave in basal third and with a weak to prominent hump further down. Left mandible with 3 marginal teeth; 1st and 2nd marginals close together; 3rd widely separated and larger; margin between the 2nd and 3rd incurved and notched. Right mandible with two small marginal teeth in middle third. *Postmentum:* Long, club-shaped; maximum width at about distal one-third; waist long; anterior margin substraight to weakly convex; posterior margin concave, medially convexly projected.

Thorax: Pronotum: Transversely subrectangular; narrower than head-capsule; much wider than long; maximum length 0.46–0.60; maximum width 0.87–1.06 mm.; anterior margin concave; sides weakly convex and narrowing posteriorly; posterior margin weakly convex, sometime slightly incurved medially; antero-lateral corners narrower than postero-lateral corners. *Mesonotum:* Slightly narrower than pronotum; posterior margin weakly incurved medially. *Metanotum:* As wide as pronotum; posterior margin weakly invaginated. Epimerson of meso- and metanota swollen. *Legs:* Short, hairy; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong ; hairy; 10th tergite slightly to somewhat strongly, sclerotised. Cerci short, 2-segmented; 0.08–0.10 mm. long. Styli single-segmented, short, finger-like; 0.07 mm. long; sometimes abesent.

3. PSEUDOWORKER (Text-fig. 8; Table 4).—

General: Head-capsule pale yellow to pale reddish yellow; antennae and legs paler than head; labrum pale brown; mandibles brownish yellow with dark brown toothed margins; thorax creamish white to pale brown, pronotum slightly more chitinised; abdomen creamish white but appearing pale pink to pale grey because of intestinal contents showing through the partly transparent tergites and sternites. Head and body fairly pilose. Total body-length *c.* 4.9–6.2 mm.

Head: Head-capsule subcircular; either as wide as or slightly wider than its length to base of mandibles (length upto base of mandibles 0.90–1.07; maximum width of head 0.93–1.10 mm.). *Fontanelle and Ocelli:* Absent. *Eyes:* Two lateral, unpigmented eyes present; sometimes not discernible. *Antennae:* With 10–11 segments; segments 1 and 2 as in soldier; 3 in 10 segmented antennae subequal to 2 and sometimes subdivided, in 11 segmented antennae shortest; 4- to the penultimate one gradually increasing in size and broadly pyriform; the last ovate, narrower and shorter than the penultimate one. *Clypeus, labrum and mandibles:* As in imago.

Thorax: Pronotum: Subrectangular; broader than long (maximum length 0.53–0.70; maximum width 0.83–1.00 mm.); narrower than head; anterior margin concave; sides weakly convex and narrowed posteriorly; hind margin weakly convex and slightly incurved medially. *Legs:* As in soldier.

Abdomen: Oblong, fairly pilose. Cerci 2-jointed, 0.10–0.13 mm. long. Styli single-jointed, short and finger-like; *c.* 0.07–0.10 mm. long.

(*c*) *Type-specimens.*—No holotype was selected by Holmgren and Holmgren (1917). The cotypes are present as follows:

(i) One soldier and several nymphs in Emerson Collection, now at A.M.N.H., New York. (ii) One pseudoworker, in F.R.I., Dehra Dun.

No cotypes apparently are present in the Holmgren Collection at the Naturhistoriska Riksmuseet, Stockholm (*vide* information received dated the 28th April, 1965 from that Museum, but they may still be found if the Holmgren Collection, which was poorly labelled by Holmgren, is examined in detail.

(*d*) *Type-locality.*—Sidapur, Coorg (Mysore State, India).

(*e*) *Distribution.*—INDIA: *Mysore State:* Anekad Forest Range, Coorg, *c.* 12°20′ N., 75°50′ E.; Janserigoda (Bababudin Hills, Chickmagalur Dist.), 13°30′ N., 75°45′ E. and Sidapur (type-locality), 12°15′ N., 75°50′ E.

(*f*) *Comparison.*—*Glyptotermes coorgensis* is close to *G. almorensis* Gardner, *G. brevicaudatus* (Haviland) and *G. minutus* Kemner, and is separable from these species as follows:—

1. *From G. almorensis:*

See under that species.

2. *From G. brevicaudatus:*

Imago: (i) Smaller in size and darker in colour *vs.* larger and paler (head-width 0.87–0.93 *vs.* 1.0–1.03 mm.; length to tip of labrum 1.07 *vs.* 1.22–1.29 mm.; pronotal width 0.80–0.83 *vs.* 0.91 mm.). (ii) Ocelli smaller, diameter: maximum 0.07 *vs.* 0.10 mm.; minimum 0.05 *vs.* 0.07 mm.).

Soldier: Soldier of one size-category (*vs.* of two categories, *e.g.* major and minor); *G. coorgensis* is close to the minor soldier of *brevicaudatus* but differs from it as follows:—(i) Left mandible with 3 prominent teeth (*vs.* with weak dentition). (ii) Margin between teeth of left mandible notched (*vs.* roundly concave). (iii) Right mandible with 2 teeth (*vs.* one tooth).

3. *From G. minutus:*

Imago: Somewhat larger (head-width with eyes 0.87–0.93 *vs.* 0.85; head-length to tip of labrum 1.07 *vs.* 0.99; length to base of mandibles 0.87–0.90 *vs.* 0.80; pronotal width 0.80–0.83 *vs.* 0.73 mm.). (ii) Sides of head-capsule without eyes substraight (*vs.* weakly convex and narrowed behind). (iii) Ocelli smaller and vertically directed when viewed laterally (*vs.* larger and directed antero-laterally (diameter: maximum 0.07 *vs.* 0.09, minimum 0.05 *vs.* 0.07 mm.).

Soldier: (i) Antero-lateral corners of head-capsule pointed in front (*vs.* rounded). (ii) Head-capsule wider absolutely and in comparison to length to base of mandibles (maximum width 0.99–1.20 *vs.* 0.90 mm.; index Width/Length to base of mandibles 0.65–0.75 *vs.* 0.60). (iii) Mandibles thicker apically and with different dentition. (iv) Postmentum behind the region of maximum width gradually narrowing *vs.* sharply narrowing and less contracted at waist (Contraction Index, Width at waist/Maximum width, 0.48–0.62 *vs.* 0.46).

4. **Glyptotermes dilatatus** (Bugnion & Popoff)

(Text-figs. 11 & 12; Tables 5–7)

(i) *Calotermes dilatatus* Bugnion & Popoff

1910. E. Bugnion and N. Popoff, *Mem. Soc. Zool. Fr.*, Paris, **23** : 137–143, text-fig. 13 (*S.*), pl. 4, *S.*, *Ny.* and *Larva. Type-locality:* Ambalangoda (Ceylon).
1911. N. Holmgren, *Zool. Anz.*, Leipzig, **37** (26): 551.
1922. E. Hegh, *Les Termites*, Brussels: 46, 48. Ceylon.
1926. N. A. Kemner, *Bull. ent. Res.*, London, **16** : 383–384. *Im.* and S. Ceylon: Ambalangoda; Elpitiya; Ingiriya; and Ratnapura.
1926. F. P. Jepson, *Trop. Agric.*, Peradeniya, **67** : 73, 77, 78, 2 pls.
1929. F. P. Jepson, *Trop. Agric.*, Peradeniya, **72** : 308–310.

(ii) *Calotermes* (*Glyptotermes*) *dilatatus* (Bugnion & Popoff)

1911. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **46** (6): 56, pl. 4, fig. 22 (*S.*).
1913*a*. N. Holmgren, *Spolia Zeylan.*, Colombo, **8** (32): 278. *Im.* Ceylon : Peradeniya.
1913*b*. N. Holmgren, *K. Sv. Vet. Akad. Handl.*, Stockholm, **50** (2): 56–57, fig. 11 (S. mandibles), pl. 1, fig. 10 (*S.*). *Im.* (dealate), *S.* and *Pw.* Ceylon.
1913. E. E. Green, *Spolia Zeylin.*, Colombo, **9** (33): 8. Ceylon: Ambalangoda; Avisawella; Kegalla; Ratanapura; and Udugama.
1914. N. Holmgren, *Zool. Jb.* (*Syst.*), Jena, **36** (2-3): 234–235. *Im.* and S. Ceylon: Peradeniya.
1914. E. Bugnion, *Bull. Hist. nat. Paris*, Paris, **20** (4): 176–177, pl. 4, figs. 1–4. Ceylon: Ambalangoda.
1925. O. John, *Treubia*, Batavia, **6** (3-4): 380. Ceylon.
1930*a*. F. P. Jepson, *Trop. Agric.*, Peradeniya, **75** (3 & 4), pp. 144–147, 155, 3 pls. Ceylon: Ambalangoda; Avissawella; Balangoda, Chilaw; Deniyaya; Elpitiya; Galaha; Galle; Gampola; Horana; Ingiriya; Kadugannawa; Katugastota; Kegalle; Kiriella; Matugama; Opanake; Pelmadulla; Peradeniya; Ratnapura; Udugama; Yatiyantota.
1930*b*. F. P. Jepson, *Trop. Agric.*, Peradeniya, **75** (3 & 4): 191–195. Ceylon: Kandy District, but mainly in low country districts.
1934. V. Margabandhu, *J. Bombay nat. Hist. Soc.*, Bombay, **37** (3): 702.

(iii) *Glyptotermes dilatatus* (Bugnion & Popoff)

1932. J. C. Hutson, *Adm. Rep. Dir. Agric. Ceylon*, Colombo, 1931 : 114–115. *Ceylon:* Galle and Yatiyantota Districts.
1937. S. F. Light, *Pan-Pacific. Ent.*, San Francisco, **13** (1 & 2): 15, 16–17. Peradeniya (Ceylon).
1941. H. Kirby, *Univ. Calif. Publ.* (*Zool.*), Berkeley, **45** (1): 33, 66. Ceylon. Protozoa.
1941. M. P. D. Pinto, *Indian J. Ent.*, New Delhi, **3** (1): 87. Ceylon: Ambalangoda; Kelani Valley.
1942. H. Kirby, *Univ. Calif. Publ.* (*Zool.*), Berkeley, **45** (3): 182, 191. Ceylon. Protozoa.

1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 47. Ceylon.

1953. M. L. Roonwal and G. D. Pant, *Indian For. Leafl.* (*Ent.*), Delhi, No. 121 (3): 44. Ceylon.

1958. M. Ahmad, *Biologia*, Lahore, **4** (1-2): 49, 51. Keys.

1958. G. D. Bhasin, M. L. Roonwal and B. Singh, *Indian For. Bull.* (*Ent.*), Delhi, (*N.S.*), No. 171 (2): 63, 95, 99.

1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122**, (Art. 4): 347.

1962. R. N. Mathur and R. S. Thapa, *Indian For. Leafl.* (*Ent.*), Delhi, No. 167: 10. Ceylon: Peradeniya.

(iv) *Kalotermes* (*Glyptotermes*) *dilatatus* (Bugnion & Popoff)

1953. Rattan Lal and Menon, R. D., *Cat. Indian Insects*, Part 27, *Isoptera:* 13–14. Ceylon. India: Madras.* [Authorship wrongly assigned to Bugnion. Also see this for more references on biology of the species].

(*a*) *Material Examined*

(*A*) *Present in Z.S.I., Calcutta*: (i) A vial (Z.S.I. Reg. No. 3741/19) with a soldier and a few nymphs and pseudoworkers, Ambalangoda (Ceylon), donor *E. E. Green.* (ii) A vial, Z.S.I. Reg. No. 4130/19 with a pseudoworker, Ambalangoda, Ceylon.

(*B*) *Present in F.R.I., Dehra Dun:* (iii) A vial (F.R.I. Nos. M.C. 17444/2, T 3431, J. 115) with 3 imagos, 3 soldiers and a few nymphs and pseudoworkers, Ceylon. (iv) A slide with wings, from the above material.

(*b*) *Description*

1. IMAGO (Text-fig. 11; Table 5).—

General: Head-capsule brownish yellow; antennae, labrum, legs and body paler; mandibles brown with dark brown toothed margins. Head and body sparsely pilose. Total body-length with wings *c.* 10.0–10.5 mm., without wings *c.* 4.3–6.0 mm.

Head: Head-capsule subcircular; broader than its length to base of mandibles (maximum width with eyes 1.03–1.32; length to base of mandibles 1.0–1.17 mm.); sides without eyes weakly convex, strongly rounded at postero-lateral corners; posterior margin round. *Fontanelle:* Absent. *Eyes:* Two lateral, subcircular, medium-sized, compound eyes, one on either side; diameter: maximum 0.30–0.40, minimum 0.24–0.37 mm., separated from lower margin of head by about half its short diameter (two-thirds its short diameter according to Light, 1937). *Ocelli:* Two lateral, oval, translucent ocelli, one on either side, only slightly separated from or touching the eye of its side; diameter: maxi-

* Recorded from Madras on the basis of a paper by Rau, S. A. 1936. (*Rep. Tea Dep. U.P.A.S.I.*, 1935-36, Madras, pp. 35–45), but Rau refers, in this paper, to an undescribed species near *G. dilatatus*.

mum 0.13–0.15, minimum 0.10 mm., minimum eye-ocellus distance (when separated) 0.03 mm. *Antennae:* With 13–15 segments; sparsely pilose; segment 1 longest, cylindrical; 2 short, cylindrical; 3 longer than or equal to either 2 or 4 (in an incomplete antenna 3 shorter than 2 or 4); 4 to the penultimate one pyriform and gradually increasing in size; the last ovate, shorter than the penultimate one. *Clypeus:* Subtrapezoidal. Anteclypeus hyaline, strip-like, apilose; anterior margin straight. Postclypeus pale yellow with 1 or 2 hairs near posterior

TABLE 5.—Measurements (in mm.) of *Glyptotermes dilatatus* (Bugnion & Popoff) and *G. minutus* Kemner. Imago.

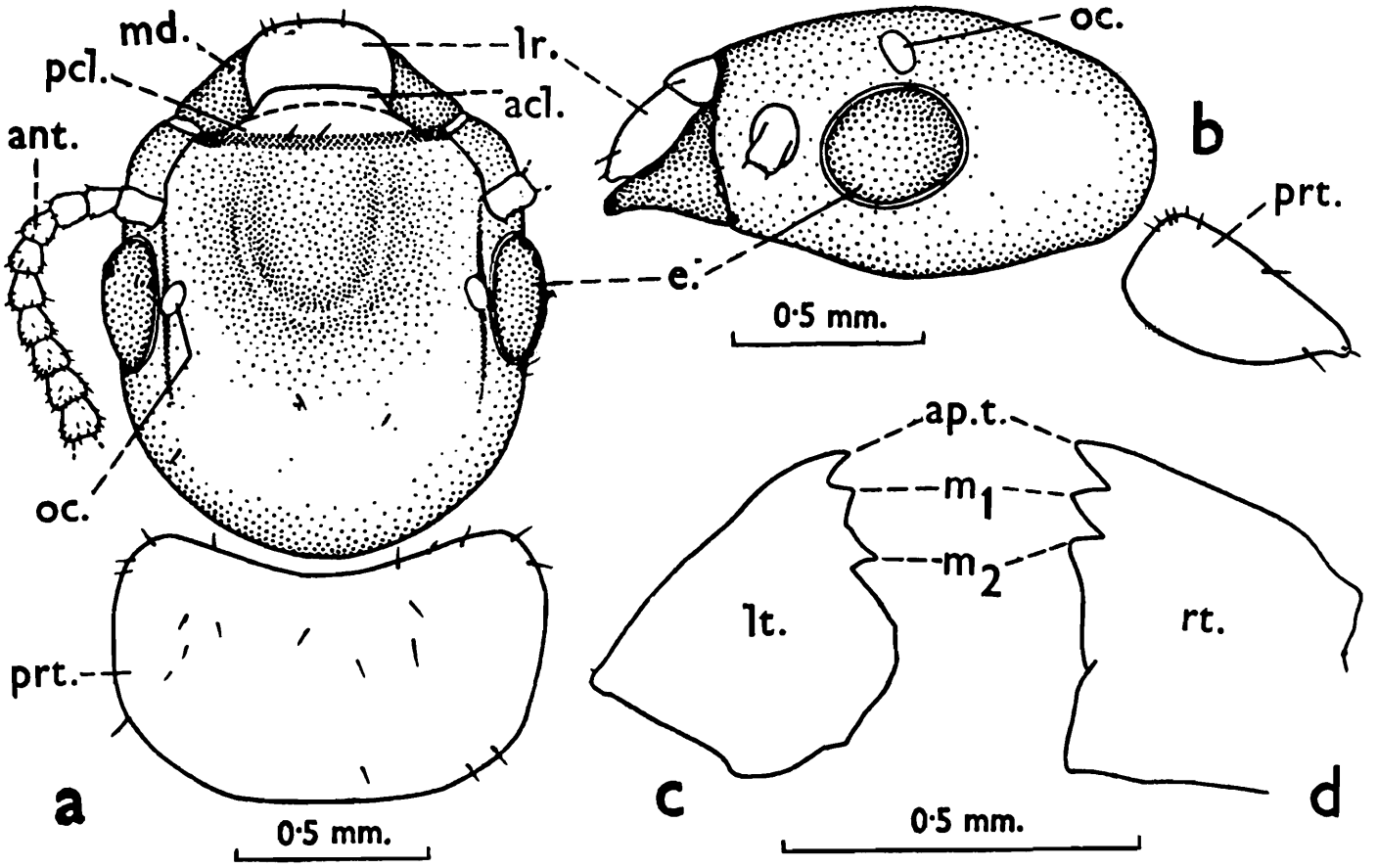
ex., examples.

Body-parts	*G. dilatatus* Range (2 ex.)	*G. minutus* (flex., Lecto-morphotype)
1. Total body-length *without* wings, (excluding antennae), *c.*	4.3 —4.7	—
2. Length of head to tip of labrum	1.23—1.40	0.99
3. Length of head to lateral base of mandibles	1.00—1.17	0.80
4. Maximum width of head (with eyes)	1.03—1.20	0.85
5. Maximum height of head	0.67—0.77	0.47
6. Maximum length of labrum	0.30	0.20
7. Maximum width of labrum	0.37—0.43	0.29
8. Maximum diameter of compound eye (with ocular sclerite)	0.37—0.40	0.25
9. Maximum diameter of lateral ocellus	0.13 (1 ex.)	0.09
10. Minimum diameter of lateral ocellus	0.10	0.07
11. Minimum ocellus-anternal distance	0.20—0.23	0.15
12. Minimum eye-ocellus distance	0.02	touching
13. Minimum eye-antennal distance	0.03 (1 ex.)	0.015
14. Minimum distance of eye from lateral base of head	0.13—0.17	0.13
15. Maximum length of pronotum	0.70	0.49
16. Maximum width of pronotum	1.00—1.13	0.73
17. Length of forewing scale	0.80 (1 ex.)	0.66
18. Length of hindwing scale	0.33	0.27

margin; anterior margin weakly convex. *Labrum:* Broader than long; anterior margin round; with a few hairs anteriorly. *Mandibles:* Subsquarish. Left mandible with an apical and 2 marginal teeth; apical finger-like; 1st marginal shorter than apical; posterior margin of 1st marginal subequal to anterior margin of 2nd marginal; 2nd equal to 1st. Right mandible also with an apical and 2 marginal teeth; apical finger-like; 1st marginal triangular and only slightly shorter than apical; 2nd marginal short, posterior margin a little longer than molar plate.

Thorax: Pronotum: Narrower than or as wide as head with eyes; much broader than long (maximum length 0.59–0.70, maximum width 1.0–1.32 mm.); anterior margin concave, without a median notch; sides weakly convex; posterior margin also weakly convex and without a median emargination or incurving. *Mesonotum and metanotum:* With weakly convex to substraight posterior margin. *Legs:* Short, thick and pilose; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed. Arolium present.

Wings: Costa, subcosta, radius, radial sector and median prominent and strongly chitinised; cubitus weakly chitinised and faint, proximally somewhat more chitinised and distinct. *Forewing:* All veins arising independently from the scale. Costa running along anterior margin upto distal end and with a row of hairs along the



Text-fig. 11.—*Glyptotermes dilatatus* (Bugnion & Popoff).

Imago. From Ceylon. (*a*) Head and pronotum, in dorsal view; (*b*) Ditto, in side view; (*c*) Left mandible, in dorsal view; (*d*) Ditto, right mandible.

acl., anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandibles; *e.*, eye; *lr.*, labrum; *lt.*, left; m_1, m_2, 1st and 2nd marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

margin. Subcosta short and fusing with costa just outside the scale. Radius also short and meeting the costa between one-fifth to one-third of wing-membrane. Radial sector running all along upto distal tip and parallel with costa; without any branches to latter. Median arising separately, slightly curving up anteriorly and running parallel to and close to radial sector. Cubitus running medially; with only 3–4 proximal branches prominent, others not clear in the material examined by me (according to Kemner (1926), with numerous but rather vague branches); and with a few faint cross-veins between median and cubitus in distal half of wing-membrane. *Hindwing:* Costa and radial sector as in forewing; subcosta absent. Radius as in forewing but fusing with costa at about one-seventh of wing-membrane. Median arising from radial sector near the point of fusion of radius and costa (in basal one-eighth, according to Light, 1937) and running parallel with and close to radial sector upto the distal tip. Cubitus as in forewing.

Abdomen: Oblong, sparsely pilose. Cerci 2-jointed, 0.10 mm. long. Styli (in male) short, single-jointed, 0.10 mm. long.

2. SOLDIER (Text-fig. 12; Table 6).—

General: Head-capsule yellowish brown to brownish red, anteriorly somewhat darker; labrum, thorax and body straw yellow to yellowish brown; mandibles black, basally dark brown. Head and body sparsely pilose. Total body-length 5.9–8.0 mm.

Head: Head-capsule cylindrical, much longer than broad (length to lateral base of mandibles 2.0–2.33; maximum width 1.27–1.37 mm.); frons sloping in front, bilobed and depressed medially; with 2 prominent protuberances, one on either side situated at base of the sloping frons; sides substraight; posterior margin round; Y-sutures present. *Eyes:* Two small, oval, unpigmented eyes, one on either side; flush with head-surface and faint; situated a little behind the antennal sockets; maximum diameter 0.13 mm. *Ocelli:* Two small, point-like, one on either side, near the end of lateral sutures. *Antennae:* With 11–13 segments; sparsely pilose; segment 1 longest, cylindrical and strongly chitinised; 2 shorter and cylindrical; 3 slightly longer or shorter than 2; 4 to the penultimate one pyriform and gradually increasing in length; the last ovate, shorter than the penultimate one. *Clypeus:* Divided into an ante- and a postclypeus. Anteclypeus thin, strip-like, apilose. Postclypeus of same colour as frons and not clearly differentiated from it, weakly pilose. *Labrum:* Broadly tongue-shaped to dome-shaped; either longer or shorter than wide. *Mandibles:* Long and strong. Left mandible with 4 marginal teeth of variable size. Right mandible with 2 large, medial marginal teeth. *Postmentum:* Long and club-shaped; club weakly bilobed; broadest at about anterior one-fifth; sides gradually narrowing behind into a long narrow waist and again widening out a little near posterior margin; posterior margin medially bulged.

Thorax: Pronotum: Flat, narrower to wider than head-capsule and much wider than long (maximum width 1.10–1.41; maximum length

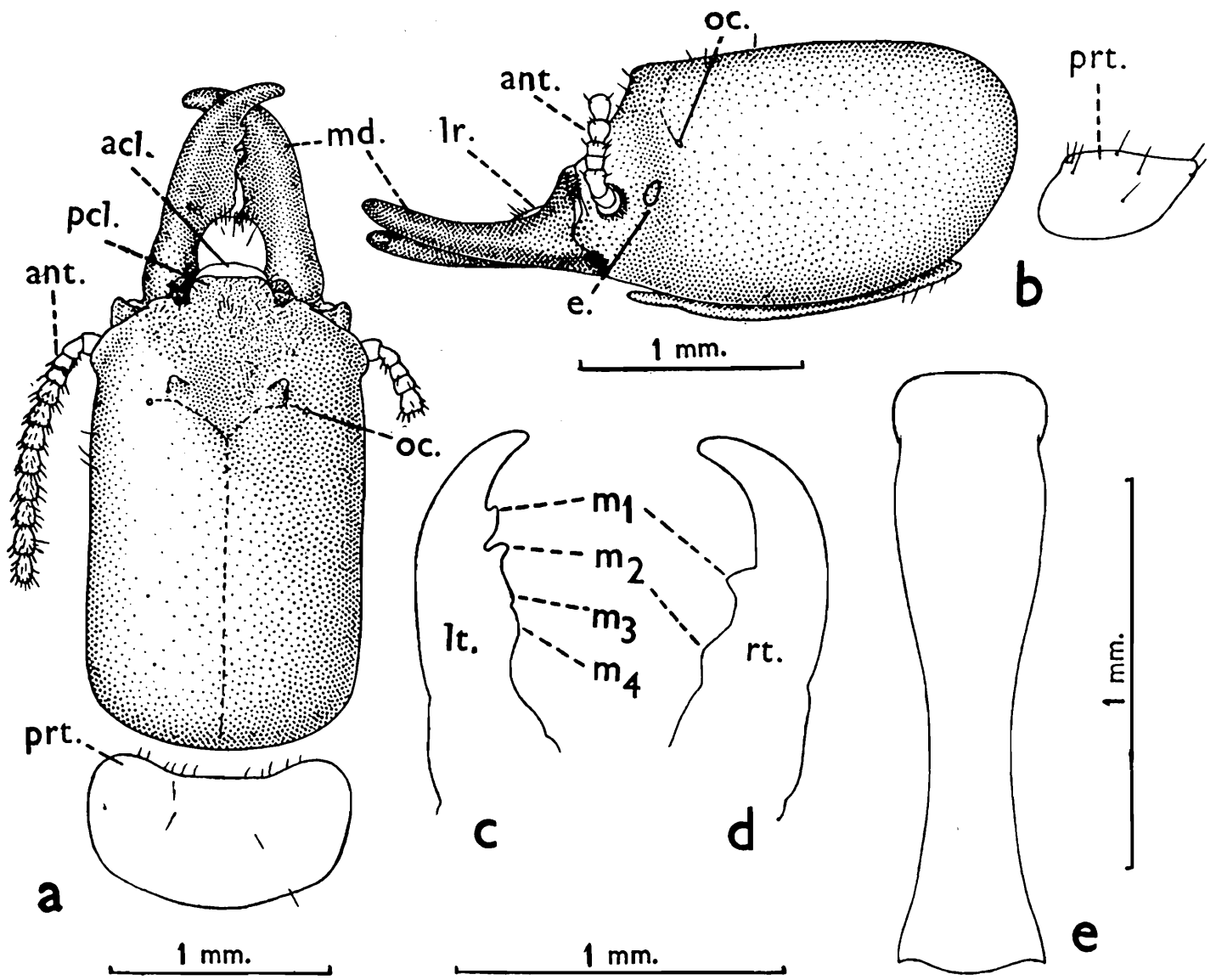
TABLE 6.—Measurements (in mm.) etc., of *Glyptotermes dilatatus* (Bugnion & Popoff); *G. minutus* Kemner and *G. nigrifrons* Mathur and Sen-Sarma. Soldier.

ex., examples.

Body-parts	*G. dilatatus* Range (4 ex.)	*G. minutus* Lectotype	*G. nigrifronns* Range (2 ex., paratype)
1. Total body-length (excluding antennea) *c.*	6.7 (1 ex.)	5.07	4.7 —6.6
2. Length of head to lateral base of mandibles	2.03—2.33	1.50	1.43—1.50
3. Maximum width of head	1.30—1.37	0.90	1.00—1.03
4. Maximum height of head	1.10—1.20	0.83	0.80—0.87
5. Head Index I (width/length)	0.59—0.64	0.60	0.69—0.70
6. Head Index II (height/width)	0.83—0.90	0.92	0.80—0.84
7. Head Index III (height/length)	0.50— 0.57	0.55	0.56—0.58
8. Maximum length of labrum	0.20—0.37	0.17	0.21—0.25
9. Maximum width of labrum	0.33—0.37	0.23	0.27—0.30
10. Length of mandibles (from upper base of condyle to tip):			
(a) Left mandible	1.03—1.13	0.63	0.70
(b) Right mandible	1.07—1.13	0.58	0.70
11. Head-mandibular length Index (Left mandible-length/Head-length to base of mandibles)	0.47—0.50	0.42	0.47—0.49
12. Minimum median length of postmentum	1.50—1.60	1.07	0.90—1.07
13. Maximum width of postmentum	0.40—0.50	0.37	0.37—0.40
14. Width of postmentum at anterior end	0.30—0.37	0.23	0.27
15. Width of postmentum at waist	0.20—0.23	0.17	0.20
16. Postmentum-contraction Index (*i.e.*, Width at base/Maximum width)	0.46—0.50	0.46	0.50—0.54
17. Maximum length of pronotum	0.73—0.77 (3 ex.)	0.60	0.50—0.57
18. Maximum width of pronotum	1.17—1.23 (3 ex.)	0.93	0.87—1.00
19. Pronotum-head Index (pronotum-width/Head-width)	0.85—0.94 (3 ex.)	1.03	0.87—0.97
20. Pronotum Index (length/width)	0.61—0.62 (3 ex.)	0.64	0.57
21. Maximum width of mesonotum	1.10—1.13 (2 ex.)	0.87	0.77—0.83
22. Maximum width of metanotum	1.03—1.13 (2 ex.)	0.93	0.80—0.87

0.65–0.77 mm.); anterior margin concave, without a median notch; sides rounded and a little narrowed behind; posterior margin convex, without a notch. *Mesonotum and metanotum:* Narrower than pronotum and without median emargination at posterior margin. *Legs:* Short, pilose; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong, sparsely pilose. Cerci 2-jointed, 0.13 mm. long. Styli 1-jointed, 0.10 mm. long.



Text-fig. 12.—*Glyptotermes dilatatus* (Bugnion & Popoff).

Soldier. Ambalangoda, Ceylon.

(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Left mandible, in dorsal view. (*d*) Ditto, right mandible. (*e*) Postmentum, in ventral view.

acl., anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum; *lt.*, left; m_1-m_4, 1st to 4th marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum; *rt.*, right.

3. PSEUDOWORKER (Table 7).—

General: Head-capsule straw yellow; antennae, thorax, legs and abdomen paler; mandibles yellowish with dark brown toothed margins. Head and body sparsely pilose. Total body-length 4.0–5.8 mm.

TABLE 7.—Measurements (in mm.) of Pseudoworker of *Glyptotermes dilatatus* (Bugnion & Popoff) and nymph of *G. minutus* Kemner.

ex., examples.

Body-parts	*G. dilatatus* Range (4 ex.)	*G. minutus* (1 ex.)
1. Total body-length (excluding antennae) *c.*	5.2 —5.8 (3 ex.)	4.0
2. Length of head to tip of labrum	1.40—1.50	0.93
3. Length of head to lateral base of mandibles	1.03—1.17	0.73
4. Maximum width of head	1.10—1.23	0.77
5. Maximum height of head	0.70—0.77	—
6. Maximum length of labrum	0.30—0.40	0.20
7. Maximum width of labrum	0.40—0.50	0.23
8. Maximum length of pronotum	0.60—0.70	0.43
9. Maximum width of pronotum	1.23—1.40	0.67

Head: Head-capsule subcircular; wider than its length to base of mandibles (maximum width 1.10–1.23 (0.65 *vide* Holmgren 1913), length to lateral base of mandibles 1.03—1.17 mm.); side convex and posterior margin rounded. *Fontanelle and Ocelli* : Absent. *Eyes :* Two lateral, oval to round eyes ; flush with head-surface and of almost the same colour as head. *Antennae* : With 11-12 segments ; sparsely pilose ; segment 1 longest cylindrical; 2 short, cylindrical; 3 in 11-segmented antenna slightly longer than 2, in 12-segmented one, short; 4 to the penultimate one gradually increasing in length and pyriform; the last ovate, shorter and narrower than the penultimate one. *Clypeus, labrum and mandibles:* As in imago.

Thorax: Pronotum: Flat; wider than head-capsule; much broader than long (maximum width 1.23–1.44; maximum length 0.60–0.70 mm.); anterior margin concave; posterior margin weakly convex. *Legs:* As in soldier.

Abdomen: Oblong, sparsely pilose; cerci 2-jointed, 0.15 mm. long. Styli single-jointed, finger-like, 0.13 mm. long.

(*c*) *Type-specimens.*—The repository of types not known.

(*d*) *Type-locality.*—Ambalangoda (Ceylon).

(*e*) *Distribution.—Ceylon:* Ambalangoda, 6°14′ N., 80°03′ E. (type locality); Avissawella, 6°57′ N., 80°13′ E.; Balangoda, 6°38′ N., 80°41′ E.; Chilaw, 7°34′ N., 79°48′ E.; Deniyaya, 6°20′ N., 80°34′ E.;

Elpitiya, 6°16′ N., 80°09′ E.; Galaha, 7°12′ N., 80°40′ E., Galle, 6°01′ N., 80°13′ E.; Gampola, 7°10′ N., 80°34′ E.; Horana, 6°42′ N., 80°04′ E.; Ingiriya, 6°45′ N., 80°10′ E.; Kadduganawa, 7°15′ N., 80°32′ E.; Kandy District; Katugastota; Kegalla, 7°14′ N., 80°12′ E.; Kelani Valley; Kiriella; Matugama, 6°32* N., 80°06′ E.; Opanake, 6°37′ N., 80°38′ E.; Pelmadulla, 6°37′ N., 80°33′ E.; Peradeniya, 7°16′ N., 80°37′ E.; Ratnapura, 6°41′ N., 80°25′ E.; Udugama, 6°13′ N., 80°20′ E.; and Yatiyantota, 7°03′ N., 80°18′ E.

(*f*) *Comparison.—Glyptotermes dilatatus* is closest to *G. ceylonicus* Holmgren. For differences see under the latter species, supra.

From the other Indian forms it is separable by its larger size and by the presence of the two prominent protuberances lying at base of the sloping frons.

5. **Glyptotermes minutus** Kemner

(Text-figs. 13 & 14; Tables 5 & 6)

(i) *Calotermes* (*Glyptotermes*) *minutus* Kemner (MS name).

1930. F. P. Jepson, *Tech. Rep. Dep. Agric. Ceylon*, 1929: 6.

(ii) *Glyptotermes minutus* Kemner

1932. N. A. Kemner, *Ent. Tidskr.*, Stockholm, **53** : 149–150. *Im.* and *S. Type-locality:* Ceylon. (Also see remarks under "Type-locality" below). Types examined.

1941. M. P. D. Pinto, *Indian J. Ent.*, New Delhi, **3** (1): 87–88. Peradeniya (Ceylon).

1941. H. Kirby, *Univ. Calif. Publ.* (*Zool.*), Berkeley, **45** (1): 52. Ceylon. [Protozoa.]

1942. H. Kirby, *Univ. Calif. Publ. Zool.*, Berkeley, **45** (2): 121. Ceylon. [Protozoa].

1949. T. E. Snyder, *Smiths. misc. Coll.*, Washington, **112** : 49. Ceylon.

1961. K. Krishna, *Bull. Amer. Mus. nat. Hist.*, New York, **122** (Art. 4): 347.

(iii) *Kalotermes* (*Glyptotermes*) *minutus* Kemner

1953. Rattan Lal and R. D. Menon, *Cat. Indian Insects*, Pt. 27, *Isoptera*, Delhi: 15. Ceylon.

(*a*) *Material Examined*

Present in Zoologiska Instituet, Lund University, Lund: One vial in spirit, with a lectotype soldier, a lectomorphotype imago ♀ (dealate, broken into 2 pieces) and a pseudoworker, Peradeniya (Ceylon), coll. *M.P.D. Pinto* (No. 7059), 22.vi.1928, *det.* N. A. Kemner.

(*b*) *Description*

Types examined.

1. IMAGO ♀ (Text-fig. 13; Table 5).—

General: Head-capsule, mandibles, thorax (including wing-scales) and abdomen dark brown; labrum and antennae brownish yellow; clypeus yellow; eyes black. Head and body sparsely hairy.

Head: Oval, longer than width with eyes; head-capsule subcircular; width with eyes more than length to base of mandibles (width 0.85; length 0.80 mm.); sides weakly convex and slightly narrowed posteriorly; posterior margin round. *Fontanelle:* Absent. *Eyes:* Two lateral, black, facetted, oval eyes, one on either side (diameter: maximum 0.25, minimum 0.20 mm.). *Ocelli:* Two lateral, oval ocelli, one on either side, 0.09 mm. long and 0.07 mm. wide; touching the eyes. *Antennae:* Incomplete (right antenna with 3 and left with 7 segments); segments 1 and 2 sparsely, the remainder fairly, pilose; segment 1 long; cylindrical; 2 longer than half of 1 and cylindrical; 3 subequal to 2; 4–7 subequal, broadly pyriform, longer than 3. *Clypeus:* Subtrapezoidal; indistinctly separated into an ante- and a postclypeus. Anteclypeus white, apilose, with a straight anterior margin. Postclypeus scantily pilose; anterior margin weakly convex. *Labrum:* Subsquarish, broader than long; sides weakly convex; anterior margin round, slightly incurved in middle; with 5 pairs of hairs on anterior margin and a pair on body. *Mandibles:* Not examined in the single specimen available for study.

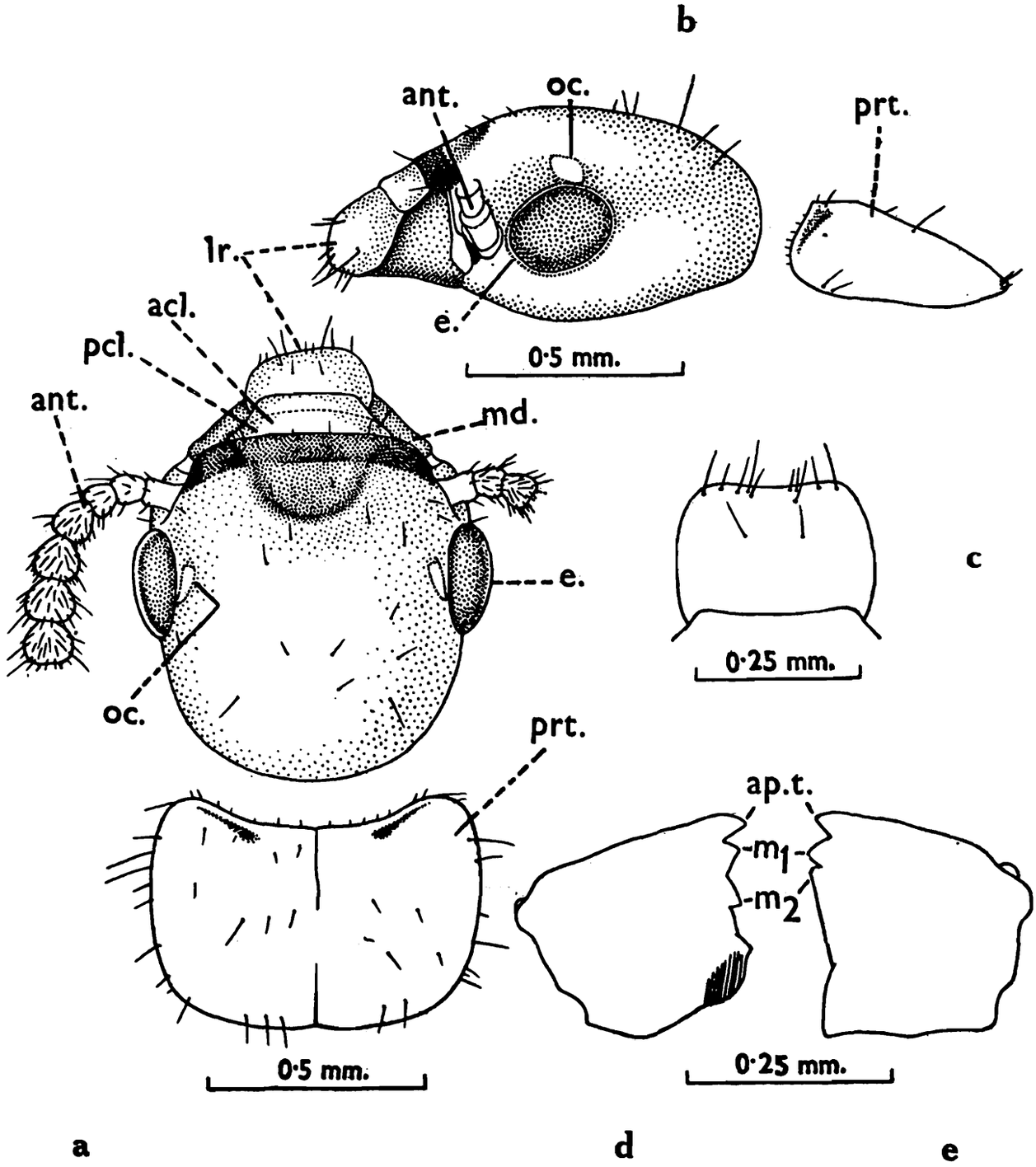
Thorax: Pronotum: Subrectangular; much broader than long (maximum width 0.73 (0.76 *vide* Kemner, 1932); maximum length 0.49 mm.); antero-lateral corners narrower than postero-lateral corners; anterior margin concave, weakly incised medially; sides weakly convex and narrowing behind; posterior margin convex; with a weak median notch. *Mesonotum and metanotum:* Weakly incurved medially at posterior margin. *Legs:* Broken. *Wings:* Only wingscales present. Forewing-scales large, shield-like, covering more than half of hindwing scales. Hindwing-scales short, triangular.

Abdomen: Oblong, hairy. Cerci 2-jointed, short, 0.05 mm. long and partly covered by 9th tergite. Styli absent.

2. SOLDIER (Text-fig. 14; Table 6).—

General: Head-capsule yellowish brown, reddish brown anteriorly; antennae, labrum and legs a little paler than head-capsule; mandibles black; pronotum yellowish brown, a little darker than posterior part of head, and with a darker anterior margin; body pale yellowish brown. Head and body moderately pilose. Total body-length *c.* 4.1–5.1 mm.

Head: Head-capsule rectangularly cylindrical and flat; length to base of mandibles 1.50 mm. (1.16–1.38 without mandibles *vide* Kemner, 1932); head-width 0.90 mm. (0.74–0.92 mm. *vide* Kemner, 1932) without any protuberances at the dorso-lateral corners of frons; frons sloping in front and somewhat depressed medially; rest of head uniformly high; sides parallel; posterior margin round; antero-lateral corners of head-capsule at base of mandibles round; Y-suture present. *Fontanelle:* Absent. *Eyes:* Two, small, oval eye-spots, one on either side, present; maximum diameter 0.07 mm. *Ocelli:* Minute, hardly discernible. *Antennae:* Only left antenna of the specimen complete, with 11-segments; segments 1–3 sparsely, and the remainder fairly, pilose; segment 1 longest, cylindrical; 2 about half of 1 and cylindrical; 3 shortest; 4 longer and broader than 3; 5 to the penultimate one subequal and pyriform; the last ovate and narrower than the penultimate one. [Kemner (1932, p. 150) described the antennae as follows:—Antennae short and thick,



Text-fig. 13.—*Glyptotermes minutus* Kemner.

Imago and Nymph. From types, Peradeniya, Ceylon. Figs. (*a*)–(*c*) Lectomorphotype imago; (*d*) and (*e*) nymph.

(*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Labrum, in dorsal view. (*d*) Left mandible of nymph, in dorsal view. (*e*) Ditto, right mandible.

acl., anteclypeus; *ant.*, antenna; *ap.t.*, apical tooth of mandibles; *e.*, eye; *lr.*, labrum; m_1, m_2, 1st and 2nd marginal teeth of mandibles; *md.*, mandible; *oc.*, ocellus; *pcl.*, postclypeus; *prt.*, pronotum.

not quite reaching the tip of the mandibles; 9–10 segmented. In 9-segmented antenna, segments 2, 3 and 4 subequal, but 4 is thicker. In 10-segmented antenna, segment 3 is smaller than 2 and much smaller and narrower than the very large segment 4.] *Clypeus:* Subtrapezoidal, divided into an ante- and a postclypeus. Ante-clypeus thin, narrow, apilose, strip-like. Postclypeus pilose, of same colour as frons and separated from latter by a thin groove. *Labrum:* Broader than long (Kemner, 1932, p. 150, mentioned this as, much longer than broad); weakly converging in front into a broadly rounded anterior margin; with a few hairs near anterior margin. *Mandibles:* Short and thick; strongly incurved at apex; and with weak basal humps. Left mandible with 3 (2 according to Kemner, 1932) marginal teeth. Right mandible with 2 marginal teeth of equal size. *Postmentum:* Long, club-shaped; maximum width is at anterior one-fourth, whence the sides narrowing posteriorly into a long narrow waist and weakly narrowing in front; near the posterior margin sides again widening out abruptly; anterior margin straight; posterior margin concave and bulged medially.

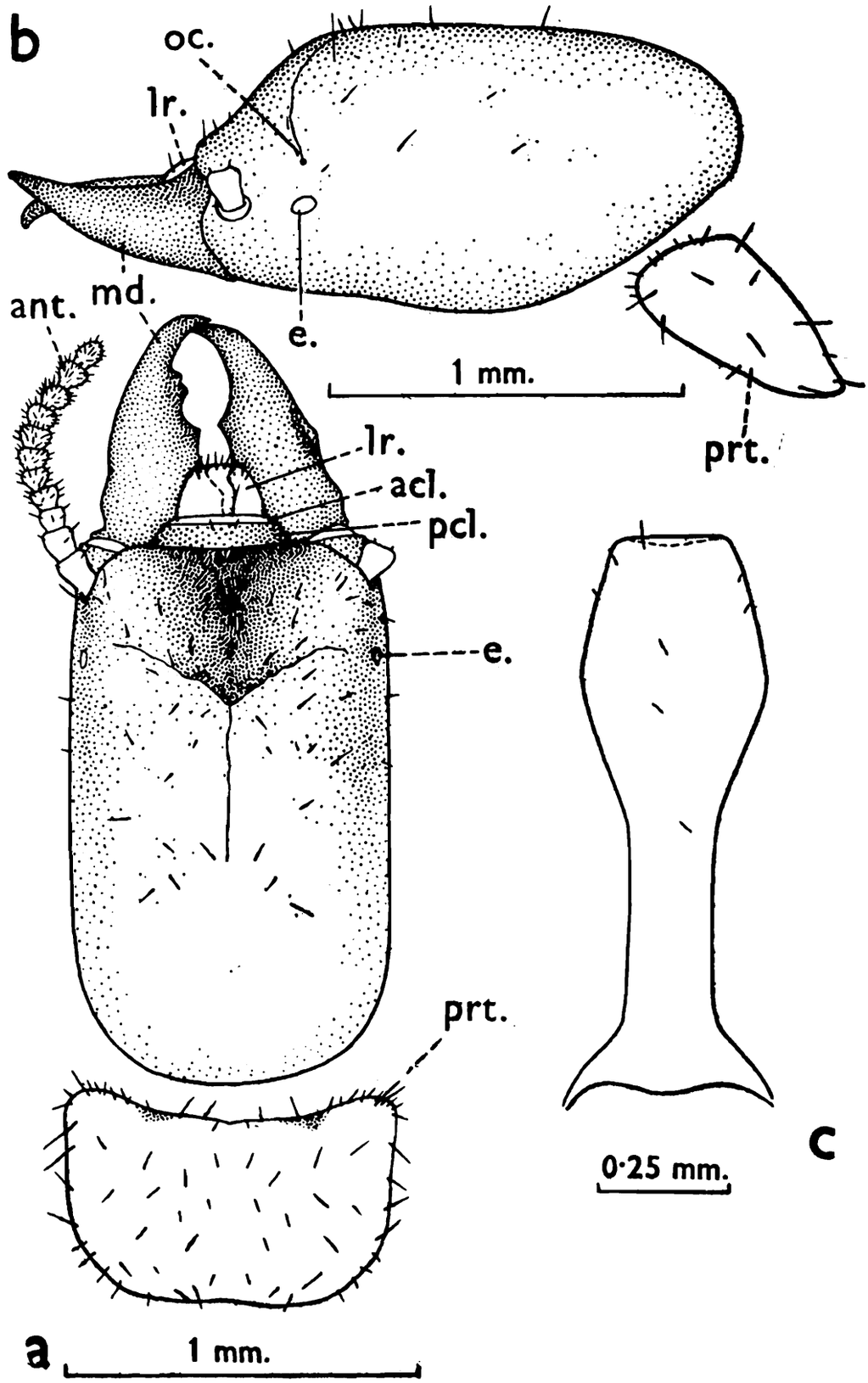
Thorax: Pronotum: Subrectangular; broader than long and slightly broader than head-capsule (Kemner, 1932, p. 150, says: as broad as or a little narrower than head); length 0.60 mm. (0.42–0.44 *vide* Kemner, 1932), width 0.93 mm. (0.70–0.81 *vide* Kemner, 1932); anterior margin broadly concave, with a weak median notch; sides substraight and weakly narrowing behind; posterior margin weakly convex and slightly incurved medially. *Mesonotum* narrower, and *metanotum* as wides as, pronotum; hind margin of both convex and somewhat incurved medially. *Legs:* Only the fore- and the left middle-legs present in the specimen, the others broken; legs short and thick; tibia of existing legs with 3 apical spurs. [According to Kemner (1932), legs short and stout, tibia with three spurs]. Tibial spur formula, thus, 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong, hairy; last tergite more strongly chitinised than the preceeding ones. Cerci 2-jointed, 0.09 mm. long. Styli single-jointed, 0.07 mm. long.

3. PSEUDOWORKER (Table 7).—

General: Head pale yellowish brown, somewhat paler anteriorly; antennae, legs and body somewhat paler; mandibles yellowish brown, with dark brown toothed margins. Head and body moderately hairy. Total body-length *c.* 4.0 mm.

Head: Oval, head-capsule subcircular, a little broader than long (length to base of mandibles 0.73, maximum width 0.77 mm.); posterior margin round. *Fontanelle and ocelli:* Absent. *Eyes:* Two hardly discernible, lateral eye-spots present; diameter 0.1 mm. *Antennae:* With 9 segments; segment 1 longest and cylindrical; 2 more than half of 1 and cylindrical; 3 shorter than, or subequal to, 2, and subdivided; 4–8 gradually increasing in length and becoming pyriform; the last ovate, narrower than and subequal to the penultimate one. *Clypeus:* Subtrapezoidal; anterior margin subconvex. Anteclypeus hyaline, apilose. Postclypeus pilose, convex anteriorly. *Labrum:* Subsquarish; sides weakly convex; anterior margin weakly incurved medially. *Mandibles:* Of typically *Glyptotermes*-type; subsquarish. Left mandible



Text-fig. 14.—*Glyptotermes minutus* Kemner.

Soldier. Lectotype, from Peradeniya, Ceylon. (*a*) Head and pronotum, in dorsal view. (*b*) Ditto, in side view. (*c*) Postmentum, in ventral view.

acl., anteclypeus; *ant.*, antenna; *e.*, eye; *lr.*, labrum; *md.*, mandible; *pcl.*, postclypeus; *prt.*, pronotum.

with an apical and 2 marginal teeth; apical finger-like and longer than the marginals; 1st marginal triangular, with anterior margin shorter than posterior; 2nd triangular and subequal to 1st, with anterior margin longer than posterior and subequal to posterior margin of 1st. Right mandible also with an apical and 2 marginal teeth; apical finger-like; 1st marginal thick, triangular; 2nd shorter than 1st, with posterior margin only a little longer than molar plate.

Thorax: Pronotum: Subrectangular, flat; with a pair of median, brownish markings a little behind the anterior margin; maximum width 0.67, maximum length 0.43 mm.; anterior margin concave, with a weak median notch; anterior angles projecting in front; sides substraight and weakly narrowing posteriorly; posterior margin convex, with a weak median notch. *Legs:* Short and thick; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong, hairy. Cerci 2-jointed, 0.07 mm. long. Styli absent in the specimen.

(*c*) *Type-specimens.*—No holotype was selected by Kemner. The lectotype* soldier and a lectomorphotype* imago (dealate) (selected A. E. Emerson, 1957) are present in the Zoologiska Instituet, Lund University, Lund (Sweden) and were examined (*vide* 'Material' above.)

(*d*) *Type-locality and Distribution.*—No exact locality in Ceylon was mentioned by Kemner, but the label with the type-specimens states 'Peradeniya' [Ceylon, *c.* 7°16′ N., 80°37′ E.] which thus becomes the type-locality.

Known only from type-locality.

(*e*) *Comparison.*—*Glyptotermes minutus* Kemner is close to *G. almorensis* Gardner and *G. coorgensis* Holmg. & Holmg. For differences see under those species, *supra.*

6. **Glyptotermes nigrifrons**† Mathur & Sen-Sarma
(Table 6)

(i) *Glyptotermes nigrifrons* M. & S.

1960 (Apr.). R. N. Mathur and P. K. Sen Sarma, *Entomologist*, London, 1960: 79-85 figs. 1 and 2 (*s.*), fig. 3. (Ny. mandibles). *S.* and *Ny. Type locality* : Top Slip, near Pollachi (Madras State, India).

1962. R. N. Mathur and R. S. Thapa, *Indian For. Leaft.* (*Ent.*), Delhi, No. 167: 11. *India*: Top slip (Madras State),

(*a*) *Material Examined*

A vial, Z.S.I. Reg. No. 3128/H8, with 2 soldiers (paratypes), Top Slip, near Pollachi, Coimbatore S. Div., (Madras State, India), coll. *R. N. Mathur* (No. 33), 6.i.1958, ex "rotton wood"

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* Professor Emerson selected the lectotype and lectomorphotype of this species in the year 1957; this being the first record of same since these designations have not been published by him so far.

† See "Remarks" on this species below.

(*b*) *Description*

As the species has been recently described in detail, I give here only a brief description.

1. IMAGO.—

Unknown.

2. SOLDIER (Table 16).—

General: Head-capsule yellowish brown (dark brown in region of frons), abdomen whitish, 10th tergite strongly chitinised and brown.

Head: Head-capsule subrectangular; antero-lateral corners sharply projected in front; Y-suture present. *Eyes:* Two lateral, oval, unpigmented eyes present. *Ocelli:* Two lateral, dot-like ocelli present; lying at the end of lateral arms of Y-suture. *Antennae:* With 10–12 segments. *Mandibles:* Short, about half of head-length to base of mandibles; left mandible with 3, and the right with 2 marginal teeth.

Thorax: Pronotum: Subrectangular, broader than long; anterior margin concave; posterior margin weakly convex, without median emargination. *Legs:* Short; apical tibial spur formula 3: 3: 3. Tarsi 4-jointed.

Abdomen: Oblong; 10th tergite greatly chitinised and brown. Cerci and styli present.

3. NYMPH.—

Not available to me for study. The tibial spurs of legs *i.e.*, 3: 2: 2 as given by Mathur and Sen-Sarma (1960) is apparently an error as the tibial spurs in the family Kalotermitidae are always 3: 3: 3.

(*c*) *Type Specimens.—Holotype and morphotype:* A holotype soldier and a morphotype nymph of alate, in Entomological collection at the F.R.I., Dehra Dun.

Paratypes and paramorphotypes: (i) 7 paratype soldiers and 10 paramorphotype nymphs of adults, in F.R.I., Dehra Dun. (ii) Two paratype soldiers, in Z.S.I., Calcutta. (iii) One paratype soldier and 1 paramorphotype nymph in Emerson collections (now in A.M.N.H., New York).

(*d*) *Type-locality and Distribution.—Type-locality:* Top Slip, near Pollachi, Coimbatore S. Division, Tamil Nadu, India (10°39′ N., 77°03′ E.). Known only from the type-locality.

(*e*) *Remarks.*—Mathur and Sen-Sarma (1960) separated *Glyptotermes nigrifrons* from all the other Indian species of *Glyptotermes* on the basis of the strongly sclerotised 10th abdominal tergite, in the soldier. It may be added, however, that *G. almorensis* Gardner, *G. coorgensis* Holmg. & Holmg. and *G. minutus* Kemner also have a strongly sclerotised 10th tergite.

This species is hardly differentiated from *G. coorgensis* Holmg. & Holmg. and I did not find any character to separate it from the specimens

of *G. coorgensis* which I studied, except that the soldier mandibles have weaker basal humps at outer margins. Krishna (personal communication dated 4th November, 1965, informs that he found this character variable in a collection of *G. coorgensis* with a long series of soldiers from Periyar Lake, Thekaday (S. India). He has also compared the paratype soldier of *nigrifrons* with the cotype soldier of *coorgensis* present in the A.M.N.H., New York and says that these species are not separable. I, in this study, am keeping this species separate as I personally have not examined the cotypes of *coorgensis*.

III—SUMMARY

1. Like the other members of the family Kalotermitidae, the species of the genus *Glyptotermes* are wood termites. Some of the species are serious pests of tea and rubber plantations, thus, they are of considerable economic importance.

2. The present studies deal with the zoogeography and distribution, the phylogenetic position of the genus and the taxonomic revision of the Indian species.

3. In the Indian subregion the genus is confined to India and Ceylon and only six species are known.

4. The generic characters and keys for separation of the six Indian species, based on imago and soldier characters, are given.

5. The following species are redescribed in some detail and illustrated adequately:—*Glyptotermes almorensis* Gardner, *G. ceylonicus* Holmgren, *G. coorgensis* Holmgren and Holmgren, *G. dilatatus* (Bugnion and Popoff), *G. minutus* Kemner and *G. nigrifrons* Mathur and Sen-Sarma. The so far unknown imago caste of *G. coorgensis* Holmgren and Holmgren is described.

6. The types of *Glyptotermes almorensis* Gardner and *G. minutus* Kemner were examined and the lectotypes of *almorensis* Gardner designated.

IV—REFERENCES

AHMAD, M. 1950. The phylogeny of termite genera based on imago-worker mandibles.—*Bull. Amer. Mus. nat. Hist.*, New York, **95** (Art. 2): 37–86.

AHMAD, M. 1958. Key to the Indo malayan termites.—*Biologia*, Lahore, **4** (1 & 2): 33–198.

AHMAD, M. 1965. Termites (Isoptera) of Thailand.—*Bull. Amer. Mus. nat. Hist.*, New York, **131** (Art. 1): 1–114.

BUGNION, E. and POPOFF, N. 1910. Le *Calotermes* de Ceylan.—*Mém. Soc. Zool. Fr.*, Paris, **23**(9): 124–143, 3 pls.

CHHOTANI, O. B. 1970. Taxonomy, Zoogeography and phylogeny of the genus *Cryptotermes* (Isoptera : Kalotermitidae) from the Oriental Region.—*Mem. zool. Surv. India*, Delhi, **15** (1): 1-81.

EMERSON, A. E. 1925. The termites of Kartabo, Bartica District, British Guiana.—*Zoologica*, New York, **6**(4): 291–459.

EMERSON, A. E. 1928. Termites of the Belgian Congo and the Cameroon.—*Bull. Amer. Mus. nat. Hist.*, New York, **57** (Art. 7): 401–574, 19 pls.

EMERSON, A. E. 1952. The biogeography of termites.—*Bull. Amer. Mus. nat. Hist.*, New York, **99** (Art. 3): 217–225.

EMERSON, A. E. 1955. Geographical origins and dispersions of termite genera.—*Fieldiana* (*Zool.*), Chicago, **37**: 465–521.

FROGGATT, W. W. 1896. Australian Termitidae. Part II.—*Proc. Linn. Soc. N.S.W.*, Sydney, **21** : 510–552, 2 pls.

GARDNER, J. C. M. 1944. New Termitidae from India and Burma (Isoptera).—*Indian J. Ent.*, New Delhi, **6** (1 & 2): 103–110.

GRASSÉ, P. P. 1949. Ordre des Isopteres on Termites, (Isoptera Brulle, 1832).—*Traite de Zoologie*, **9** : 408–544.—Paris (Masson & Co.).

HARE, L. 1937. Termite phylogeny as evidenced by soldier mandible development.—*Ann. ent. Soc. Amer.*, **30**(3): 459–486, 13 pls.

HILL, G. F. 1942. *Termites (Isoptera) from The Australian Region*, 479 pp., 24 pls.—Melbourne (Counc. Sci. Industr. Res. Org.).

HOLMGREN, K. and HOLMGREN, N. 1917. Report on a collection of termites from India.—*Mem. Dept. Agric. India* (*Ent.*), **5**(3): 137–171.

HOLMGREN, N. 1910. Das System der Termiten.—*Zool. Anz.*, **35** (9-10): 284–286.

HOLMGREN, N. 1911*a*. Termitenstudien. 2. Systematik der Termiten. Die Familien Mastotermitidae, Protermitidae, und Mesotermitidae.—*K. Sv. Vet. Akad. Handl.*, **46**(6): 1–86, 6 pls.

HOLMGREN, N. 1911*b*. Ceylon—Termiten, gesammelt von Prof. K. Escherich, nebst einer synoptischen Übersicht über alle bis jetzt von Ceylon und dem angrenzenden Festland bekannten Termitenarten.—In: Escherich's *Termitenleben auf Ceylon:* 183–212, 2 pls. Jena (Gustav Fischer).

HOLMGREN, N. 1913. Termitenstudien. IV Versuch einer systematischen Monographie der Termiten der orientalischen Region.—*K. Sv. Vet. Akad. Handl.*, **50**(2): 1–276, 8 pls.

JEPSON, F. P. 1930. Termites attacking *Hevea brasiliensis* in Ceylon.—*Trop. Agric.*, **75** (3 & 4): 143–156, 5 pls.

KEMNER, N. A. 1926. Some termites from Ceylon.—*Bull. ent. Res.*, London, **16** : 379–392.

KEMNER, N. A. 1932. Neue Termiten aus der orientalischen Region. I–II.—*Ent. Tidskr.*: **53** (2-3): 133–155.

KRISHNA, K. 1961. A generic revision and phylogenetic study of the family Kalotermitidae (Isoptera).—*Bull. Amer. Mus. nat. Hist.*, New York, **122,** (Art. 4): 303-408.

KRISHNA, K. and EMERSON, A. E. 1962. New species of the genus *Glyptotermes* Froggatt from the Papuan, Oriental, Ethiopian and Neoteopical regions (Isoptera: Kalotermitidae).—*Amer. Mus. Novit.*, New York, No. 2089: 1–65.

LIGHT, S. F. 1937. A collection of termites from Ceylon and Java.—*Pan-Pacific. Ent.*, San Francisco, **13** (1 & 2): 15–24.

MATHUR, R. N. and SEN-SARMA, P. K. 1960. *Glyptotermes nigrifrons* sp.n. from South India (Insecta: Isoptera: Kalotermitidae).—*Entomologist.*, London, **1960** (April): 79–85.

PINTO, M. P. D. 1941. Some observations on the biology of the Ceylonese Calotermitidae. *Indian J. Ent.*, **3** (1): 73-105.

RATTANLAL and MENON, R. D. 1953. *Catalogue of Indian Insects.* Part 27. *Isoptera*, 4+94 pp.—Delhi (Govt. India Publ.).

ROONWAL, M. L. and PANT, G. D. 1953. A systematic catalogue of the Main Identified Entomological Collection at the Forest Research Institute, Dehra Dun. Part 9. Order Isoptera.—*Indian For. Leafl.* (*Ent.*), No. 121(3): 40–60.

ROONWAL, M. L. and SEN-SARMA, P. K. 1960. *Contributions to the Systematics of Oriental Termites*, xiv+407 pp., 65 pls.—Delhi (Govt. India Publ.).

SNYDER, T. E. 1926. New termites from Guatemala, Costa Rica and Colombia.—*J. Wash. Acad. Sci.*, **16**(1): 18–28.

SNYDER, T. E. 1949. Catalog of the termites (Isoptera) of the world.—*Smiths. misc. Coll.*, **112** : 1–490.

TSAI, P. H. and CHEN, N. S. 1963. New termites from South China (In Chinese).—*Acta entom. Sinica*, **12**(2): 167—198.

VAN DER GRACHT, W. A. J. M. (ed.) 1928. Theory of Continental Drift. x+240 pp.—Tulsa (U.S.A.) (Amer. Assoc. Petrol. Geol.).

WEGENER, A. 1922. *Die Entstehung der kontinente und Ozeane* (3rd ed.) viii+144 pp.—Braunschweig.

Rec. zool. Surv. India, **68**: 161—272, 1975.

TAXONOMIC, BIOLOGICAL AND ECOLOGICAL STUDIES OF SOME INDIAN MEMBRACIDS (INSECTA : HOMOPTERA) PART I.

By

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INTRODUCTION

The family Membracidae has received little attention in India ever since the pioneering work of Distant in the early part of this century (1908, 1916). Besides very meagre descriptions, no mention was made by Distant of the host plants and of the sex of the insect described as the Type, and many species were left unfigured. In the wake of the modern concept of membracid taxonomy, it has become imperative to collect long series of male and female specimens belonging to the same population or reared from a single pair, in order to assess the range of individual variations and to reach a definite decision regarding the determination of species. With this point in view, an attempt is made to study the South Indian membracids from their taxonomic and biological angles. This paper deals with only the taxonomy of the family. and the biological and ecological studies of the group will be published under Part II of this work.

MATERIAL AND METHODS

The material discussed in this work was collected from all over South India during the years 1964-'68. Many species were also reared in their natural habitat by covering egg masses and nymphs with a fine netting to compare the results of laboratory experiments. Nymphs were reared in the laboratory on small pot plants enclosed in insect rearing cages. Thus long series of adults of both sexes could be obtained from laboratory cultures for systematic studies. Adults and the last nymphal instars were preserved by mounting on pins or by gumming on cards.

Two subfamilies of Membracidae occur in South India, the *Oxyrhachinae* and the *Centrotinae*. The Oxyrhachinae is separated from the Centrotinae by the presence of a rudimentary scutellum concealed by the pronotum, and by the development of propleural and mesopleural processes. In the Centrotinae the scutellum is always clearly visible, and the propleural and mesopleural processes are absent.

In the description of the species the important taxonomical characters, as illustrated for the common species, *Oxyrhachis tarandus* (Text fig. 2) to which continual reference will be made, are as follows :—

The position of *head*, whether directed obliquely downward or inclined backward; the proportion of length to width of head; the shape

of *fronto*-cl *clypeus* and the nature of its lobes whether fused or distinct; the position of *ocelli* in relation to eyes and to the *centro-ocular line* (c-o-l) which is an imaginary line drawn through the centre of the anterior margin of the base of the eyes when the head in a horizontal position is viewed from directly above; the nature of *metopidium* which is the declivous part of the pronotum from the base of head to the front of dorsum; the *humeral angles* which are lateral protuberances one on either side of pronotum above the eyes; the *supraocular callosities* which are irregular areas located on the metopidium above the eyes; the *suprahumeral horns*, also referred to as *suprahumerals* or *horns*; the *posterior* process which is by far the most important of all taxonomic characters: the posterior process may present a strong *gibba* in many species of Oxyrhachinae located above the metathorax or slightly behind it; the ridges or *carinae* usually conspicuous on the horns and on the posterior process; the nature of the tegmina whether presenting a *pterostigma* or not, the shape and size of the *apical cells*, the proportion of length to width of *first apical cell*; the number of *discoidal cells*, the colour patterns and the nature of apical limbus; the number of apical cells in the hind wings; the *scutellum* whether well developed or aborted, and the proportion of length to width of this structure.

The legs, as a rule, are not generally considered as important in the taxonomy but nevertheless prove indispensable in the diagnosis of the genus *Tricentrus* where the hind *trochanters* bear well developed teeth.

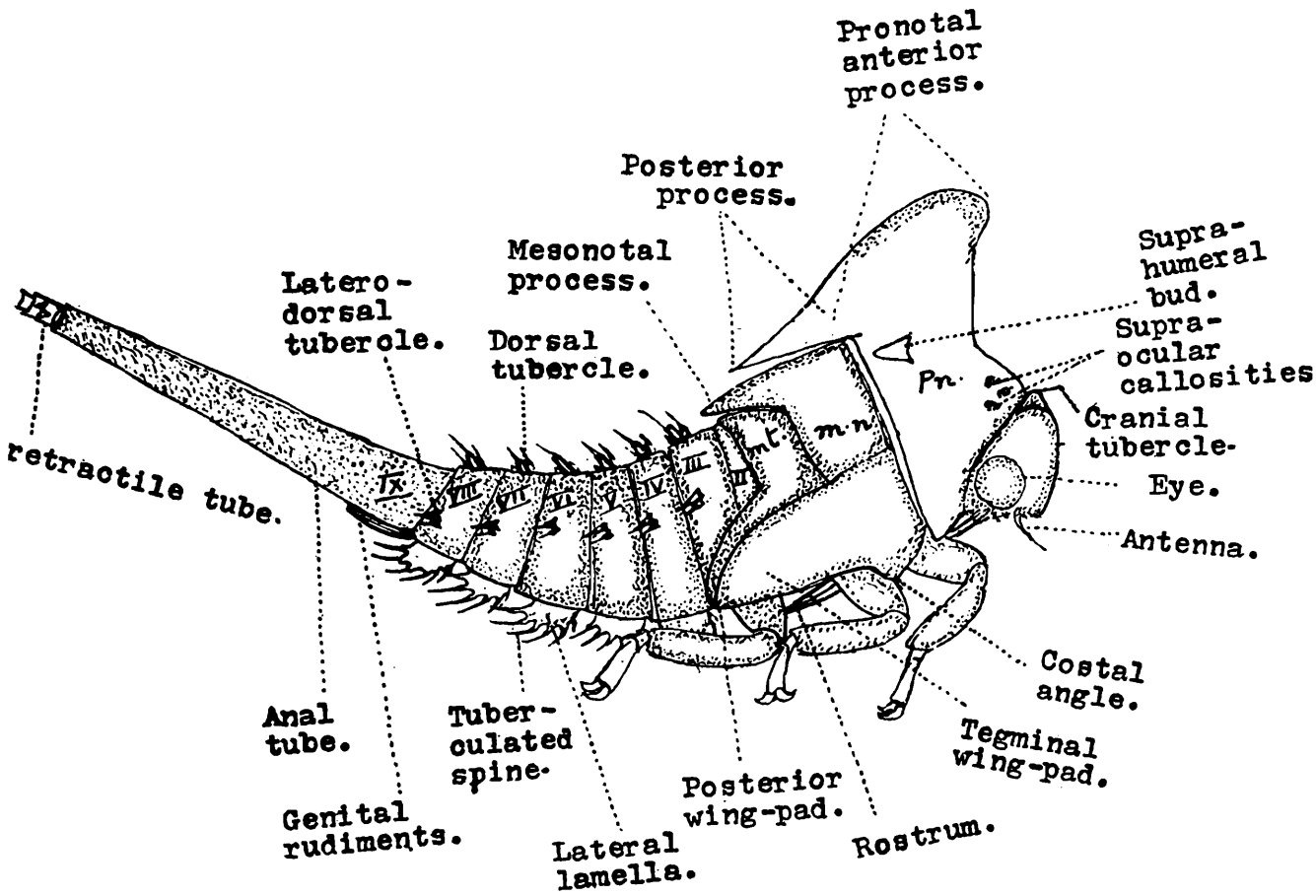
The *male genital structures*, namely, the *sternal plate* of the ninth abdominal segment, *lateral valves*, *parameres* and *aedeagus*, are of value at least as subsidiary characters.

It is not out of place to emphasise the fact that the adult membracids exhibit only a limited number of characters of taxonomic importance. On the contrary, a careful study of the nymphs, particularly in their last or fifth nymphal stage, has brought to light several characters which are used in description and based on which an attempt has been made to construct keys for genera and species; these characters to which continual references will be made are mentioned below and illustrated in Fig. 1.

Head : Cranial tubercules which are a pair of thorn-like or conical processes of vertex located above ocelli, rudimentary or obsolete in some, very prominent in others. The centro-ocular line (already stated) is of importance when ocelli are visible; the *subocular expansions* which are short acute tooth-like or flattened processes one on either side of vertex below eye, well developed in the Oxyrhachinae; the *foliate lobes*, one on either side of fronto-clypeus partially concealing it or fused with it.

Thorax.—The nature of metopidium whether convex in front, vertical or sloping backwards; the *pronotal crest*, which is a prominent ridge on the dorsum produced in some as an anterior process and a posterior process; the relative lengths of anterior and posterior processes when both are present (Text fig. 1a); the *suprahumeral buds* which are the rudiments of suprahumeral horns, present in some in the fifth instar as a

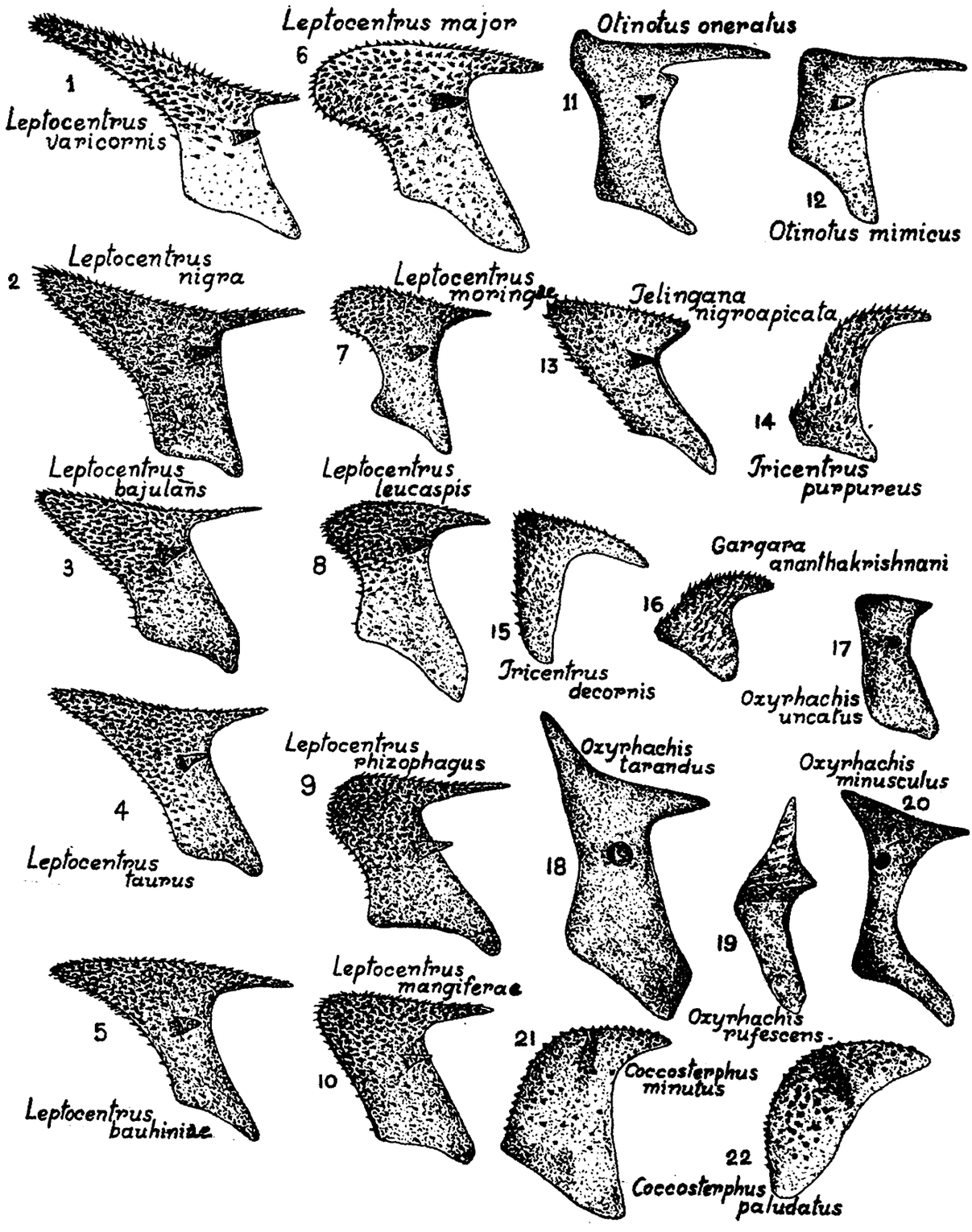
pair of small nodules or pointed conical processes; the wing-pads appearing in the third instar normally and assuming prominence in the last nymphal stage, extending backwards to a variable degree; the costal angles of tegminal wing pads, distinctly demarcated in some and inconspicuous in others.



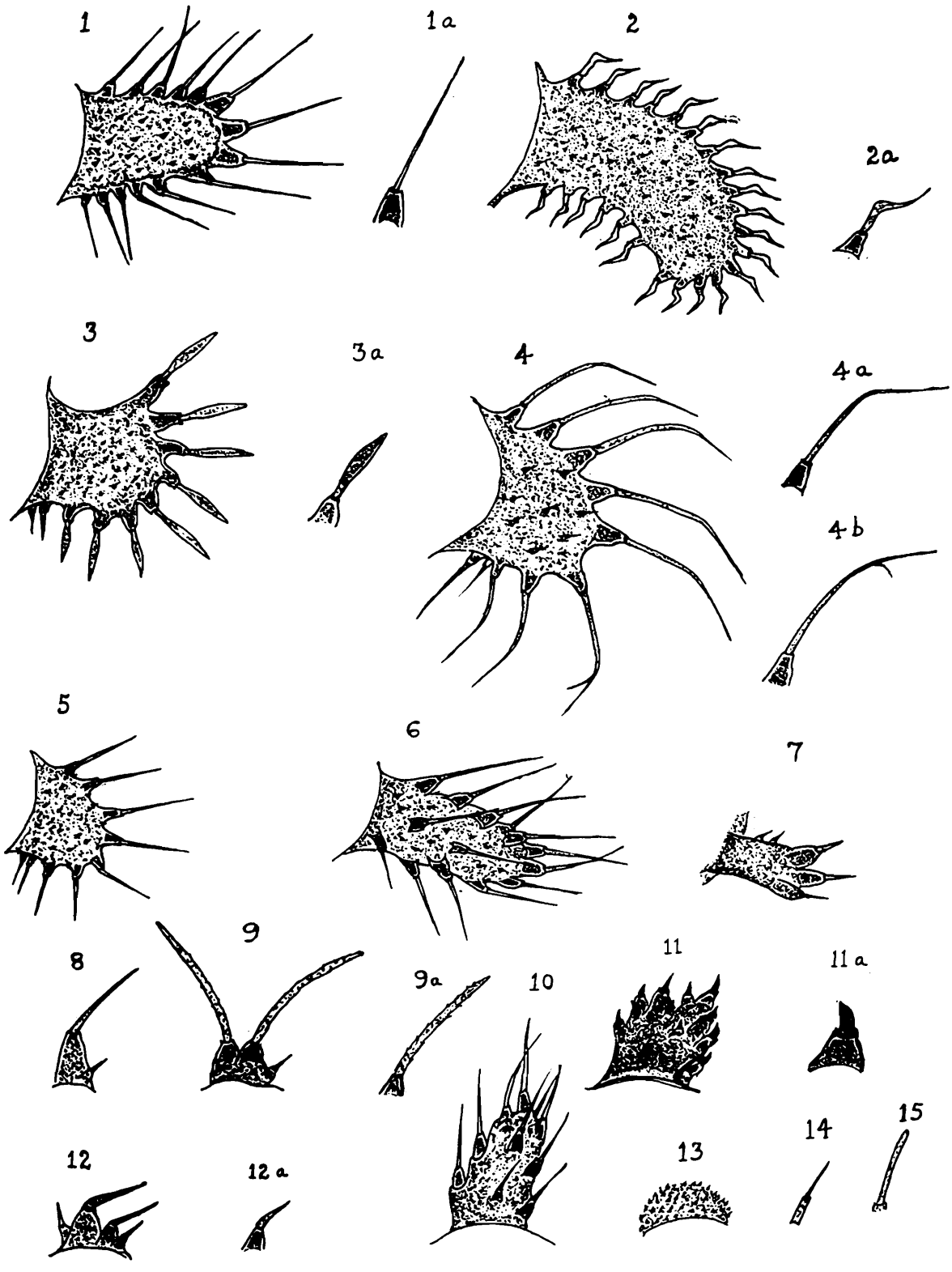
Text-fig. 1. *A Generalised Fifth Instar.*

Pn, Pronotum ; mn, Mesonotum; mt, Metanotum ; IX, Ninth segment forming the anal tube ; X, Tenth segment forming the eversible tube.

Abdomen.—The abdomen of membracid nymphs, according to Funkhouser (1917) is composed of eleven segments of which the first segment is obsolete, the second one narrow, the third to the eighth inclusive more or less identical, the ninth forming the *anal tube*, the tenth and the eleventh rudimentary, telescoped and often eversible. Capener (1962) considers the anal tube as the eighth segment. Since the first abdominal segment is clearly visible as a narrow crescentic structure in the various species of *Gargara*, the numeration adopted by Funkhouser is followed in the present studies. The length of the anal tube bears a more or less definite relation to body length. Of particular value are the *abdominal dorsal tubercles* and *dorso-lateral* (latero-dorsal) *tubercles* with the spines borne on them, the *abdominal lamellae* which are pleural extensions of abdominal segments 3 to 8 and the nature of individual spines whether long and slender, short and stout, bent and acuminate, or tooth-like. (Text fig. 1b).



Text-fig. 1a. *Pronotal shapes in the last nymphal instars of different membracidae.*



Text-fig. 1b. *Types of lamellae, tubercules and spines met with in the membracid nymphs.*

1. Abdominal lateral lamella in *Tricentrus pilosus*; 2. in *Otinotus indicatus*; 3. in *Coccosterphus paludatus*; 4. in *Leptocentrus leucaspis*; 5. in *Tricentrus albomaculatus*; 6. in *Gargara mixta*; 7. in *Oxyrhachis rufescens*; 8. Abdominal dorsal tubercle in the first instar nymph of the genus *Leptocentrus*; 9. Prothoracic dorsal tubercle in the first instar of *Leptocentrus*; 10. Abdominal dorsal tubercle in fifth instar of *Gargara mixta*; 11. of *Coccosterphus tuberculatus*; 12. of *Leptocentrus taurus*; 13. of *Gargara extrema*.

1a. Long setiform spine borne on lamella in *Tricentrus pilosus*; 2a. bent spine borne on lamella in *Otinotus indicatus*; 3a. penicillate spine borne on lateral lamella of *Coccosterphus* and *Parayasa*; 4a. long acuminate spine, 4b, branched spine borne on lateral lamella of *Leptocentrus leucaspis*; 11a. short stout tooth-like spine on thoracic dorsal tubercle in *Coccosterphus paludatus*; 9a. stout cylindrical spine on thoracic dorsal tubercle in *Leptocentrus*; 12a. subspine on dorsal tubercle in *Leptocentrus*. 14. Sensory setae on cranial tubercles; 15. ? ?

Although Funkhouser (1917) realised the importance of nymphal characters in the taxonomy of the Membracidae, no attempt appears to have hitherto been made in this direction. The present studies have revealed that for each species many of the characters of each nymphal stage appear to be more or less constant. Of the five nymphal instars the first instar of all the species is characterised by a comparatively large, head with the rostral tip often reaching the anal segment. The thorax is simple, devoid of crests or extensions. The most obvious diagnostic feature of this stage in all the species is the presence of two *dorsal tuberculated bristles* on the anal tube. The general trends in the changes occurring in successive nymphal stages following the first, consist of a regular increase in size immediately after every moult, a progressive reduction of tuberculated spines on the head and thorax, a gradual increase in the size of the pronotum, the appearance and gradual development of pronotal processes and wing pads, a gradual increase in the size of the abdominal lateral lamellae and in the number of spines borne on them. Present studies on the postembryonic development of the membracids have also revealed a definite relation between the length of the anal tube and the total body length in the nymphal stages of various species. Since this aspect of the allometry appears to have an increasing value in the membracid taxonomy, an attempt was made here to take the total body length and the length of the analtu be of all the nymphal stages; from these, the growth ratio (k) and the initial growth index (b) were calculated by using the formula, $Y = bx^k$, where Y is the length of anal tube, 'x' is the theoretical value of Y when 'x' equals unity, and 'k' is the constant at which Y grows in relation to 'x' (vide Tables 3 and 3A).

The nymphs of all stages have been figured in most cases; where no appreciable differences of nymphal structure are noticed, only the fifth nymphal stage of those species have been drawn.

Camera lucida drawings were made for all the species presented here. Detailed account of the fifth nymphal stage has been given in view of its importance in the taxonomy of the Membracidae.

LIST OF SPECIES INCLUDED IN THE PRESENT STUDY

Subfamily *OXYRHACHINAE* Haupt, 1929

Tribe *Oxyrhachini* Distant, 1908

Genus *Oxyrhachis* Germar, 1835

1. *Oxyrhachis tarandus* (Fabricius)
2. *O. rufescens* Walker
3. *O. minusculus* n.sp.
4. *O. uncatus* Melichar
5. *O. krusadiensis* n.sp.
6. *O. brevicornutus* n.sp.

Subfamily *CENTROTINAE* Spinola, 1850

Tribe *Leptocentrini* Distant, 1908

Genus *Leptocentrus* Stål, 1866

7. *Leptocentrus rhizophagus* n.sp.
8. *L. mangiferae* n.sp.

9. *L. major* n.sp.
10. *L. bajulans* Distant
11. *L. leucaspis* Walker
12. *L. varicornis* n.sp.
13. *L. taurus* Fabricius
14. *L. nigra* n.sp.
15. *L. bauhiniae* n.sp.
16. *L. moringae* n.sp.

Genus *Telingana* Distant, 1908

17. *Telingana nigroalata* n.sp.
18. *T. consobrina* Distant

Genus *Otinotus* Buckton, 1903

19. *Otinotus oneratus* (Walker)
20. *O. mimicus* Distant
21. *O. indicatus* (Melichar) comb. nov.
22. *O. obliquus* n. sp.

Tribe *Centrotini* Goding, 1892

Genus *Tricentrus* Stål, 1866

23. *T. pilosus* n.sp.
24. *T. purpureus* n.sp.
25. *T. congestus* (Walker)
26. *T. albomaculatus* Distant
27. *T. decornis* n.sp.

Tribe *Gargarini* Distant, 1908

Genus *Gargara* Amyot & Serville, 1843

28. *Gargara mixta* (Buckton)
29. *G. albitarsis* n.sp.
30. *G. madrasensis* n.sp.
31. *G. extrema* Distant
32. *G. malabarica* n.sp.
33. *G. rustica* n.sp.

Tribe *Coccosterphini* Distant, 1908

Genus *Coccosterphus* Stål, 1869

34. *Coccosterphus minutus* (Fabricius)
35. *C. paludatus* Distant
36. *C. tuberculatus* (Motsch.)

Genus *Parayasa* Distant, 1916

37. *Parayasa maculosa* Distant

SYSTEMATIC ACCOUNT

Subfamily *OXYRHACHINAE* Haupt

This subfamily is diagnosed by the presence of a rudimentary scutellum entirely concealed by the pronotum, the presence of a propleural process developed from the lower margin of the propleura and directed downwards and backwards, and a metapleural process developed in a similar manner from the metapleura.

Tribe *Oxyrhachini* Distant

Head wider than long; vertex extended to form a foliate lower margin with a short lateral tooth and a rectangular foliate lobe. Thorax with pronotum with or without suprahumeral horns, posterior process extending beyond posterior angle of inner margin of tegmina ; tegmina with 5 apical and 3 discoidal cells; wings with 3 or 4 apical cells; tibiae somewhat foliate and flattened externally. Male genitalia with U-shaped aedeagus not serrated on inner margin, lateral valves with tuberculate lobes somewhat transverse; tips of parameres club-like; sternal plate trulliform.

Nymph in the last instar with a pair of large or rudimentary cranial tubercules, pronotal crest developed in front into a distinct horn, with a short posterior process extending over mesonotum; prominent spines or tubercles absent; abdominal lateral lamellae of segments 4-8 short, bearing rudimentary spines.

Genus **Oxyrhachis** Germar

(Type of the genus *Membracis taranda* Fabr.)

1835. *Oxyrhachis* Germar, *Rev. ent. Silb.*, **3**: 232.
1903. *Polocentrus* Buckton, *Mon. Memb.*: 254.
1905. *Ouranorthus* Buckton, *Trans. Ent. Soc. Lond.*, **9**: 322.
1908. *Oxyrhachis* Distant, *Fauna Brit. Indis*, **4**: 7.
1962. *Oxyrhachis* Capener, *Repub. S. Afr. Dept. Agr. Tech. Ser. ent. Mem.*, **8**: 9.

Head wider than long; upper margin arcuate and sinuate to eyes; eyes large and globate or subglobate; ocelli equidistant from each other and from the eyes or a little closer to the eyes or closer to each other and located on or above the centro-ocular line; pronotum with or without suprahumeral horns; metopidium convex, vertical or backwardly inclined, wider than high; suprahumeral horns, when present, directed forwards, outwards and upwards; posterior process broad and tectiform at base, with or without a distant gibba, tricarinate, with or without a ventral carina or keel on apical half; humeral angles prominent and blunt; a pair or episternal hooks on mesonotum; tegmina with 5 apical cells and 3 discoidal cells; wings with 3 or 4 apical cells and a strong hamulus on subcostal margin.

Key to South India species of **Oxyrhachis**

1 (10) Suprahumerals well developed; apical area of posterior process slightly or strongly elevated.

2 (7) Suprahumerals as long as or longer than space between bases, horizontal or slightly oblique.

3 (4) Posterior process extending beyond tips of tegmina; inferior margin of apical area of posterior process weakly serrate; ocelli equidistant from each other and from eyes and located on centro-ocular line. *.tarandus.*

4 (3) Posterior process just reaching tips of tegmina.

5 (6) Suprahumerals longer than space between bases; apical area of posterior process slightly elevated; ocelli nearer to each other than from eyes. *.rufescens.*

6 (5) Suprahumerals as long as space between bases; apical area of posteior process strongly elevated; ocelli nearer to eyes than from each other *.minusculus* n.sp.

7 (2) Suprahumerals shorter than space between bases; posterior process not reaching tips of tegmina.

8 (9) Suprahumerals subhorizontal, about two-third as long as space between bases, tips acute; inferior margin of apical area of posterior process strongly serrate; ocelli nearer to eyes than to each other and located on centroocular line. *..uncatus.*

9 (8) Suprahumerals horizontal, about one-fourth as long as space between bases, tips subacute; inferior margin of apical area of posterior process weakly serrate; ocelli closer to each other than to eyes and located just above centro-ocular line. *.krusadiensis* n.sp.

10 (1) Suprahumerals aborted to short stumps; apical area of posterior process not elevated, reaching upto 5th apical cell of tegmina; inferior margin of apical area of posterior process very weakly serrate. *brevicornutus* n.sp.

Oxyrhachis tarandus (Fabricius)

(Text-fig. 2)

1798. *Membracis taranda* Fabricius, *Ent. Syst. Suppl.* : 514.

1803. *Centrotus tarandus:* Fabricius, *Syst. Rhyng.* : 19.

1835. *Oxyrhachis tarandus:* German, *Res. ent. Silb.*, **3:** 232.

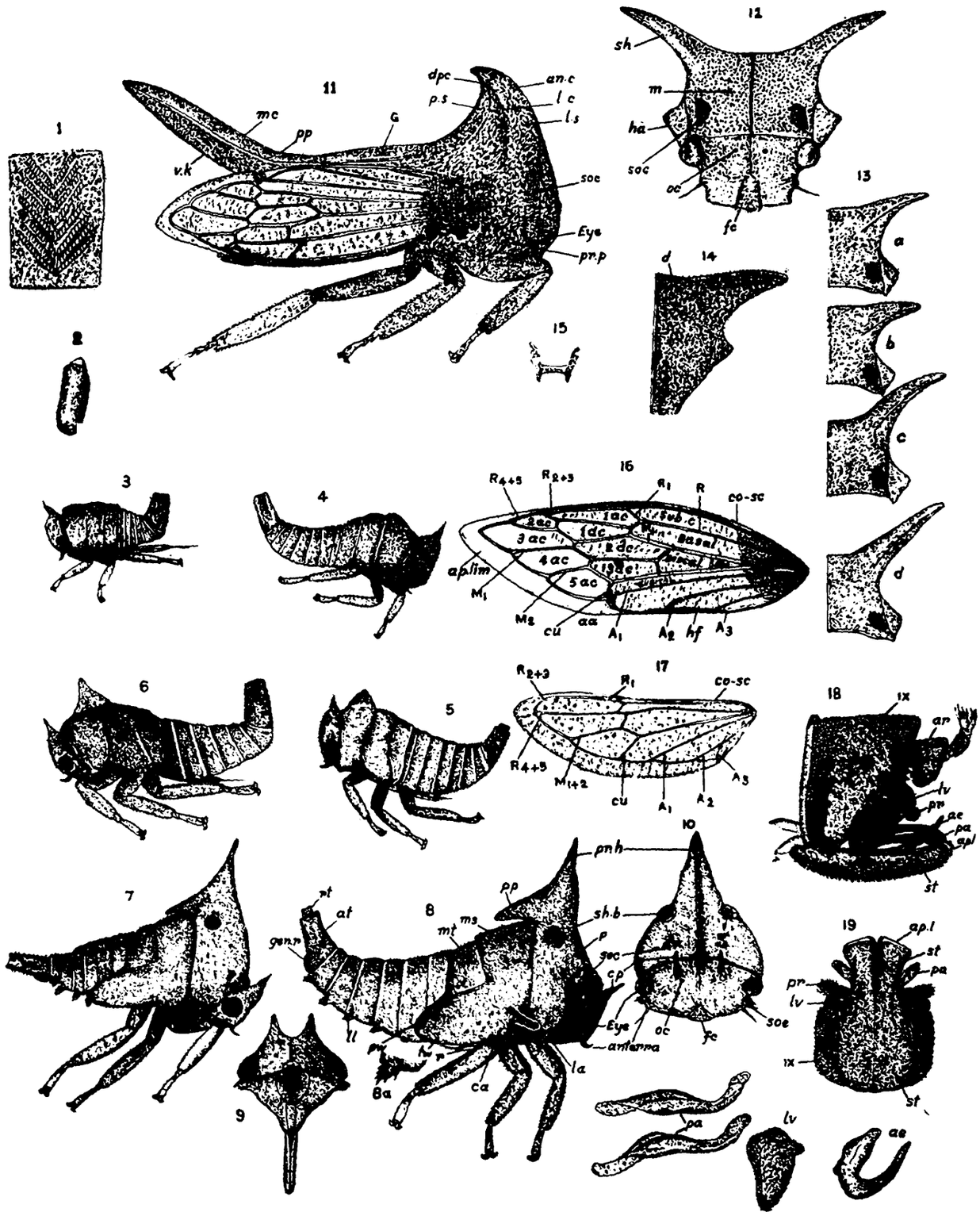
1903. *Polocentrus rufus* Buckton, *Mon. Memb.* : 254.

1903. *Polocentrus neuter* Buckton, *ibid.* : 254.

1962. *Oxyrhachis tarandus:* Capener, *Repub. S. Afr. Tech. Ser. Ent. Mem.*, **6:** 11.

A detailed description of this species has been given by Capener (1962). Specimens collected around Madras exhibit variations in their suprahumerals as illustrated in Text-fig. 2.

Fifth instar nymph.—General colour dark brown; vertex of head nearly twice as wide as long, sparsely covered with hairs, upper margin emarginate with slender, reduced cranial tubercles, each tapering to tip and terminating in a thin tuberculate hair, lower margin convex and sinuate, subocular expansions conical with small tubercles, eyes subglobate, ocelli invisible, frontoclypeus with free end strongly convex, rostral tip



Text-fig. 2. *Oxyrhachis tarandus* (Fabricius)

1. Arrangement of eggs on the host stem. 2. An egg. 3. First instar nymph. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar, male. 8. Fifth instar female. 8a. Addominal lateral lamella of fifth instar. 9. Head of fifth instar: 10. Frontal view of fifth instar. 11. Adult female. 12. Frontal view of female. 13. a, b, c, d. Variations in suprahumerals. 14. Right half of dorsal view of pronotum of male. 15. Scutellum. 16. Tegmina. 17. Hind wing. 18. Male genitalia, lateral view. 19. Male genitalia, ventral view.

reaching 2nd abdominal sternite; thorax sparsely pilose, hairs mounted on short tubercles; metopidium slightly sloping backwards; supraocular callosities black, irregular, bare; suprahumeral buds conspicuous ; pronotal anterior process in the female nymph large, its anterior margin sinuous, tip acuminate, directed upwards; posterior process prominent, gradually tapering backwards extending over basal two-thirds of mesonotum; in the male nymph the anterior process of pronotum broadly conical, tip acuminate; lateral carinae weak; median carina percurrent through metopidium; wing pads prominent, broad, extending beyond 3rd abdominal segment in female, beyond 4th abdominal segment in male; abdominal segments 5 to 8 with short conical lateral lamellae fringed with 4 or 5 short tuberculate spines; anal tube dark brown, closely pilose; genital rudiments conspicuous, being distinct in the two sexes.

Material studied.—A long series of males and females as well as nymphs collected from host plants—*Prosopis spicigera, Acacia arabica, Caesalpinia pulcherrima*—and material reared in the laboratory.

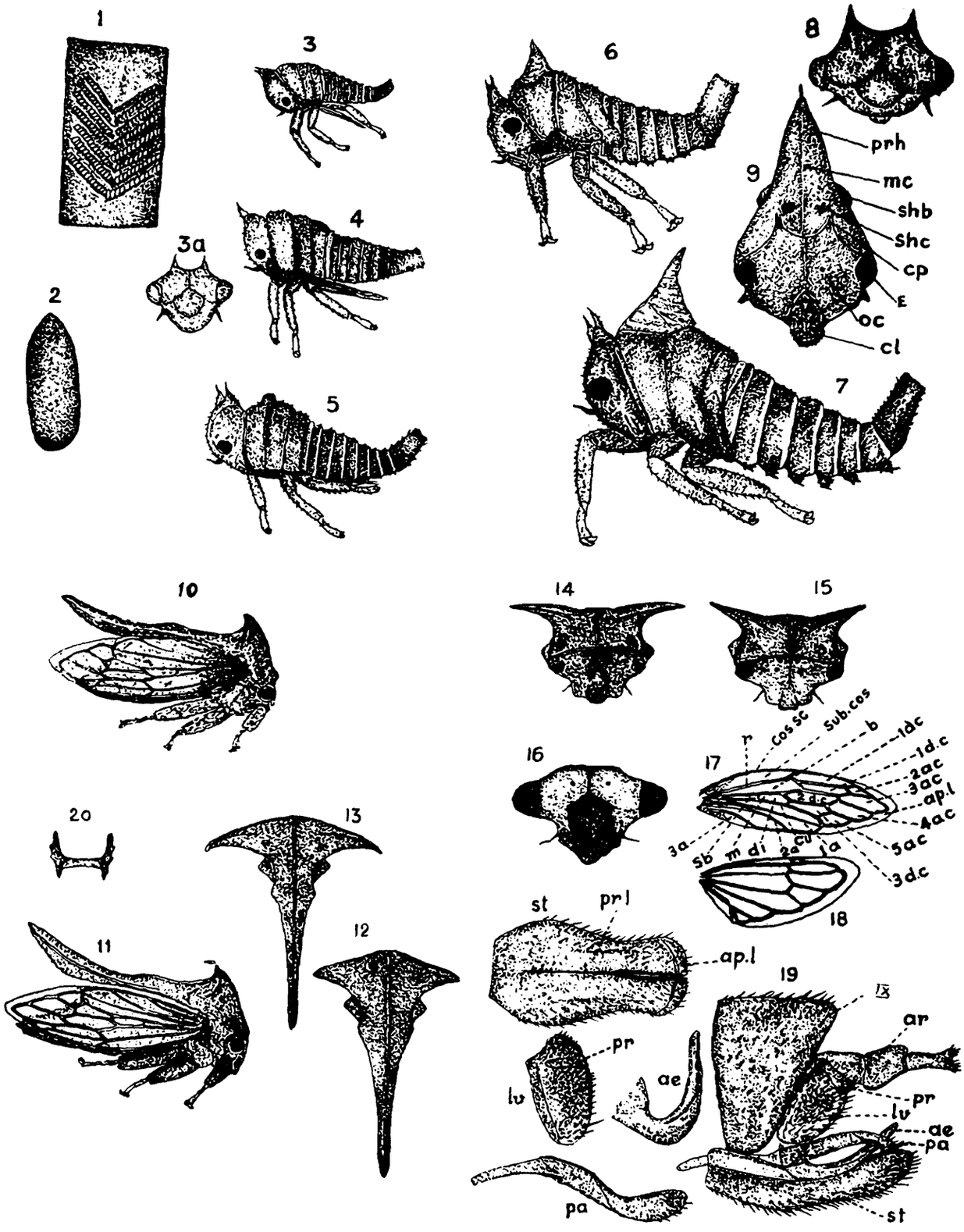
Oxyrhachis rufescens Walker

(Text-fig. 3)

1851. *Oxyrhachis rufescens* Walker, *List. Hom.* ii: 506.
1851. *Oxyrhachis rudis* Walker, *List. Hom.* ii: 509.

Female.—General colour ferruginous brown; head, twice as broad as long, vertex sinuate, punctate with short silvery hairs; cranial callosities not raised, lateral angles of foliate lobes rectangularly rounded, eyes subglobate, projecting lateral, pale white, ocelli convex, nearer to each other than from eyes and located above centro-ocular line; frontoclypeus extending very slightly below lower margins of foliate lobes, free end nearly truncate, fringed with long white hairs; metopidium nearly vertical, very slightly sloping backwards, densely pilose; supraocular callosities prominent, raised, bare, humeral angles prominent, tip subacute; suprahumeral horns broad, almost horizontal, longer than space between bases, seen in lateral view slender with apices subacute and directed backwards, seen from above flat dorsoventrally, seen in front more slender and a little more apically acute; anterior carina dark reddish brown, directed outwards, than backwards, lateral carina nearly straight, dorso-posterior carina curved forwards and outwards joining anterior carina in narrow curve; posterior process moderately gibbous at base, apical area moderately elevated, tip acute, just reaching tegminal apex, anterior margin weakly serrate, median carina strongly percurrent traversing the metopidium, lateral carinae pale brown; tegminathrice as long as broad, dull ochraceous, basal sixth coriaceous, reddish brown, punctate; veins pale brown, 1st apical cell four times longer than wide; hind wings with 3 apical cells; legs testaceous; abdomen dark reddish brown above, greyish tomentose below.

Measurements.—Length from frontal margin to tips of tegmina 6.75-8.0 mm., to tip of posterior process 6.7-7.85 mm.; width across tips of



Text-fig. 3. *Oxyrhachis rufescens* Walker

1. Egg-slits on host stem. 2. An egg. 3. First instar. 3a. Frontal view of first instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 8. Frontal view of head of fifth instar. 9. Frontal view of fifth instar. 10. Adult male. 11. Adult female. 12. Dorsal view of pronotum of female. 13. Dorsal view of pronotum of male. 14. Frontal view of male. 15. Frontal view of female. 16. Frontal elevation of head. 17. Tegmina. 18. Hind wing. 19. Male terminalia, lateral view,

suprahumeral horns 3.5-4.0 mm., at humeral angles 2.4-2.5 mm., at eyes 2.25-2.5 mm.

Male.—Smaller and darker than female; suprahumerals longer than in female, tip more acute with anterior carina more backwardly curved; genitalia as in *tarandus*, but apical lobes of sternal plate narrower, tuberculate process of lateral valve longer.

Measurements.—Length from frontal margin to tips of tegmina 6.25-7.0 mm., to tip of posterior process 6.0-6.8 mm., width across tips of horns 3.25-4.5 mm., at humeral angles 2.2-2.4 mm., at eyes 2.0-2.2 mm.

Fifth instar nymph.—General coloration dark ochraceous brown, but somewhat thickly covered with a white deposit of wax giving it a greyish appearance particularly in the cranial tubercles, suprahumeral buds, bases of pronotal process and ventro-lateral areas of abdomen; head with vertex strongly convex, twice as wide as long, cranial tubercles thorn-like with ribbed base and acute tip, bearing slender hairs throughout; eyes dark maroon; ocelli nearer to each other than from eyes and situated on the c-o-l ; subocular processes slender and tuberculate; frontoclypeus strongly convex, densely pilose, extending beyond lower margins of vertex; pronotum with metopidium convex, slanting forwards, pronotal anterior process broad at base, suddenly narrowed from two-thirds of its length, tip acute slightly inclined backwards; pronotal posterior process abbreviated, extending over base of mesonotum, very blunt and obtuse; suprahumeral buds small, black; wing pads narrow, obliquely directed downwards and backwards, costal angles not distinct; metanotum weakly indented, shallowly concave; abdominal lateral lamellae of segments 4 to 8 conical, bearing 5 to 7 tuberculate spines, those on 3rd segment much shorter; anal tube one-sixth of the body length.

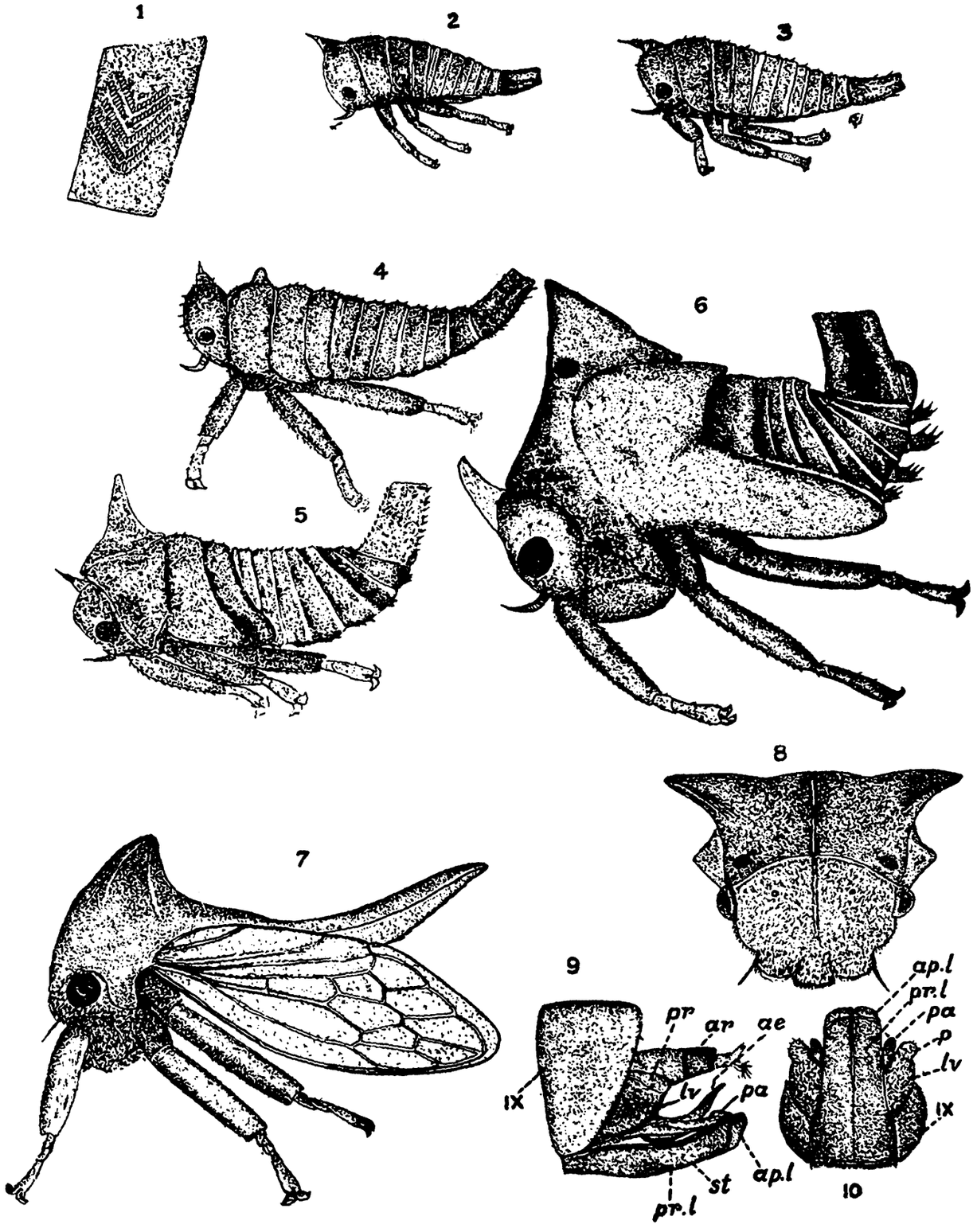
Host plants.—*Acacia arabica*, *Acacia melanoxylon*, *Acacia auriculiformis*, *Prosopis spicigera*, *Erythrina indica*, *Poinciana regia*, *Caesalpinia pulcherrima*, *Caesalpinia coriaria*, *Butea frondosa*, *Albizzia lebbeck*, *Glyricidia maculosa*, *Sesbania aegyptiaca*, *Cassia* sp., *Crotalaria juncea*, *Crotalaria verrucosa*, *Tamarindus indicus*, *Cyamopsis tetragonoloba*.

Material studied.—60 females, 18 males and numerous nymphs, Madras; 10.viii.1966.

Oxyrhachis minusculus n.sp.

(Text-fig. 4)

Female.—General colour ochraceous brown. Head wider than long, greyish brown, vertex weakly convex, subquadrate rather coarsely punctate with short pale white hairs, cranial callosities vestigial, lateral angles of foliate lobes first vertical and then broadly rounded, more densely pilose, eyes semiglobate, dark reddish brown, ocelli dark, distinctly nearer to eyes than to each other and located above centro-ocular line; frontoclypeus light brown, extending slightly beyond lower margins of foliate lobes, lateral angles rounded, tip truncate, pilose; rostrum extending slightly beyond posterior margins of hind coxae. Thorax



Text-fig. 4. *Oxyrhachis minusculus* n. sp.

1. Egg-slits on host stem. 2. First instar. 3. Second instar. 4. Third instar. 5. Fourth instar. 6. Fifth instar. 7. Adult female. 8. Frontal view. 9. Male genitalia, lateral view. 10. Male genitalia, ventral view.

with pronotum distinctly punctate, metopidium almost vertical and slightly sloping backwards, pilosity denser near bases of suprahumerals and posterior process; supraocular callosities small, irregularly shaped; suprahumeral horns, as viewed from lateral aspect directed upwards and a little backwards; viewed from front, directed outwards, then slightly upwards and curving backwards; viewed from above, dorso posterior carina slightly curved forwards and outwards; humeral angles prominent, tips subacute; posterior process tectiform, strongly tricarinate with a weakly developed gibba above the level of metathorax and first abdominal segment, apically laterally compressed rising well above anal angle, ventral keel ampliate, as deep as dorsal keel and weakly serrate, apex acute, not exactly reaching tips of tegmina. Lateral areas of thorax with white tomentose patches; tegmina subhyaline, a little wrinkled, two and two-third times longer than wide, veins brown, basal sixth coriaceous and brownish, a fuscous spot at anal angle, first apical cell as long as second discoidal cell, 1st and 3rd discoidal cells equal in length. Legs with tibiae castaneous, tarsi pale-brown. Abdomen dark-brown, lateral sternal areas with white tomnetose spots.

Measurements.—Length from frontal margin to tips of tegmina 5.0-5.4 mm., to tip of posterior process 4.8-5.0 mm. width across tips of suprahumeral horns 3.5 mm., at humeral angles 2.6-2.8 mm., at eyes 2.2-2.4 mm.

Male.—General colour black with shades of brown; slightly smaller than female.

Measurements.—Length from frontal margin to tips of tegmina 5.0 mm., to tip of posterior process 4.7 mm., width across tips of suprahumeral horns 3.4 mm., at humeral angles 2.0 mm., at eyes 2.3 mm.

Nymph.—Fifth instar. General coloration chocolate brown; head directed backwards, cranial tubercules very prominent, nearly cylindrical, tip subacute; vertex subplanate at base, twice as wide as long, eyes dark-brown, ocelli nearer to eyes than from each other and located on centro-ocular line; pronotum concave in front, somewhat receding, supraocular callosities, in the form of three irregular bare areas; suprahumeral buds prominent, dark brown; anterior process conical, nearly twice as long as posterior process which extends over mesonotum beyond middle; wing pads dark reddish brown, very large, extending upto 6th abdominal segment, costal angles well demarcated, fringed with tuberculated spines, abdominal segments telescoped, tip raised up; lateral lamellae of segments 5 to 8 moderately developed, nearly cylindrical, inclined backwards with posterior margins fringed with 4 or 5 tuberculate spines; anal tube black, one-fifth as long as total body length.

Host plant.—Casuarina equisetifolia.

Holotype female; paratypes 15 females and 8 males; nepionotypes 10, Madras, -.iv.1967, Vellore, 20 females and 8 males, -.v.1967.

O. minusculus appears to be very near to *tarandus* and *rufescens* in possessing well developed, nearly horizontal suprahumeral horns and the posterior process having its apical area upturned, but it differs from both

tarandus and *rufescens* in the smaller size and the shorter suprahumerals which are as long as the space between their bases; from *tarandus* it differs in the nature of the posterior process which just reaches the tegminal apex; from *rufescens* it differs in the position of ocelli which are nearer to eyes than to each other.

Oxyrhachis uncatus Melichar

(Text-fig. 5)

1903. *Oxyrhachis uncatus* Melichar, *Hom. Faun. Ceylon,*: 108.
1903. *Centrotus nectaris* Buckton, *Mon. Memb.* : 246.

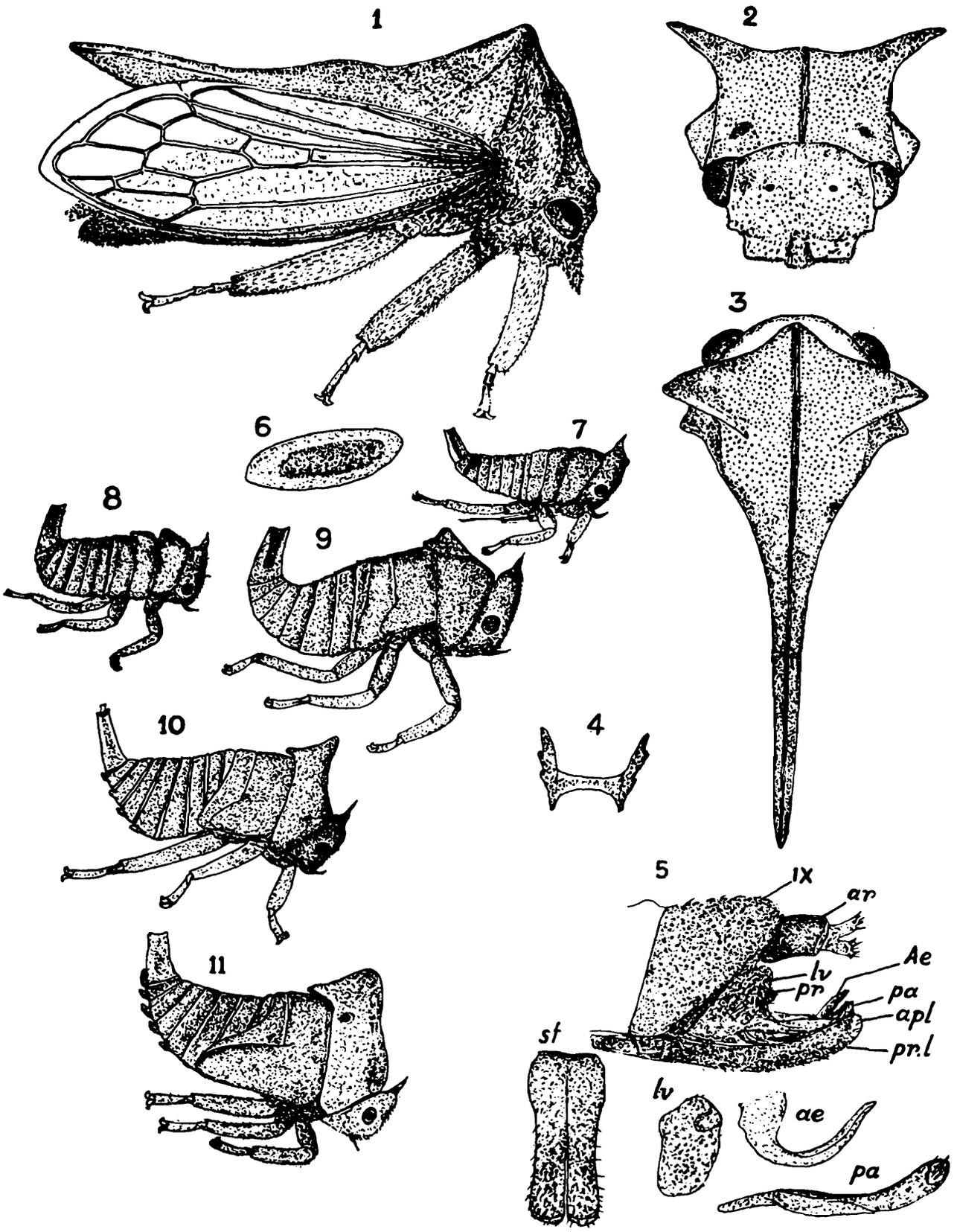
Female.—General coloration brownish ochraceous. Head with vertex subquadrate, broader than long, finely punctate, with long sparse silvery white hairs; upper margin slightly arcuate, sinuate, lateral angles of foliate lobes rectangular, inner angles inwardly acute; eyes nearly subglobate, reddish brown; ocelli succineous, nearer to eyes than to each other and located on the c-o- line; frontoclypeus nearly as wide as long, slightly extending below margins of foliate lobes, tip truncate and pilose with white hairs; rostrum reaching to posterior coxae; pronotum brownish ochraceous, finely punctate with sparse pale white hairs; median carina yellowish brown and strongly percurrent; metopidium twice as broad as high, strongly punctate at bases of horns, convex, gradually sloping backwards; supraocular callosities small, bare, margins obscure; suprahumeral horns about two-third as long as distance between their bases, subhorizontal, apices subacute, viewed from above flattened dorsoventrally with weak yellowish brown dorsal carina; viewed from lateral aspect appearing much shorter, viewed from the front more upwardly curved, tricarinate, apices obtusely acute; posterior process slightly gibbous behind base, hardly reaching apex of tegmina, apex slightly turned upwards, inferior margin weakly serrate; tegmina thrice as long as wide, subhyaline, basal sixth coriaceous and punctate, wrinkled, veins reddish brown, first apical cell three times longer than wide, as long as second discoidal cell; legs ochraceous; lateral areas of body, and abdomen below cretaceously tomentose.

Measurements.—Length from frontal margin to tips of tegmina 6.5-7.0 mm., to tip of posterior process 6.2-6.8 mm., width across tips of suprahumerals 3.0-3.5 mm., at humeral angles 2.3-2.5 mm., at eyes 2.0-2.2 mm.

Male.—Similar to female, with horns slightly shorter. Terminalia, with aedeagus U-shaped, tuberculate process of lateral valve shorter, parameres club-like, sternal plate black, densely pilose, with apical lobes small and inconspicuous.

Measurements.—Length from frontal margin to tips of tegmina 6.3-6.74 mm., to tip of posterior process 6.1-6.6 mm., width across tips of suprahumeral horns 2.75-3.2 mm., at humeral angles 2.2-2.4 mm., at eyes 1.9-2.1 mm.

Fifth instar nymph.—Colour greyish brown with very little deposit of waxy secretion making ventro-lateral parts of abdomen whitish; head turned backwards; vertex nearly twice as wide as long; cranial



Text-fig. 5. *Oxyrhachis uncatus* Melichar

1. Adult female. 2. Frontal view of female. 3. Dorsal view of pronotum. 4. Scutellum. 5. Male genitalia, lateral view. 6. An egg. 7. First instar. 8. Second instar. 9. Third instar. 10. Fourth instar, 11. Fifth instar.

tubercles thin, slender, thorn-like; metopidium slightly convex in front, vertical, anterior process of pronotum short and broadly rounded; posterior process extending over about middle of mesonotum, tip blunt; supraocular callosities indistinct, suprahumeral buds small, concolorous; wing pads greyish, their bases pale ochraceous, extending beyond 3rd abdominal segment, costal angles fringed with tubercles; abdomen brown with a short sharp lateral lamella posteriorly edged with short tuberculate spines on segments 5 to 8; anal tube about one-sixth the length of body, normally held more or less vertically, bordered with rows of fine tuberculate hairs; genital rudiments prominent.

Host plant.—Prosopis spicigera.

Material studied.—26 females, 10 males and numerous nymphs; Madras, 10.viii.1967; 4 females and 10 fifth nymphal instars, Rameswaram, 18.ix.1967.

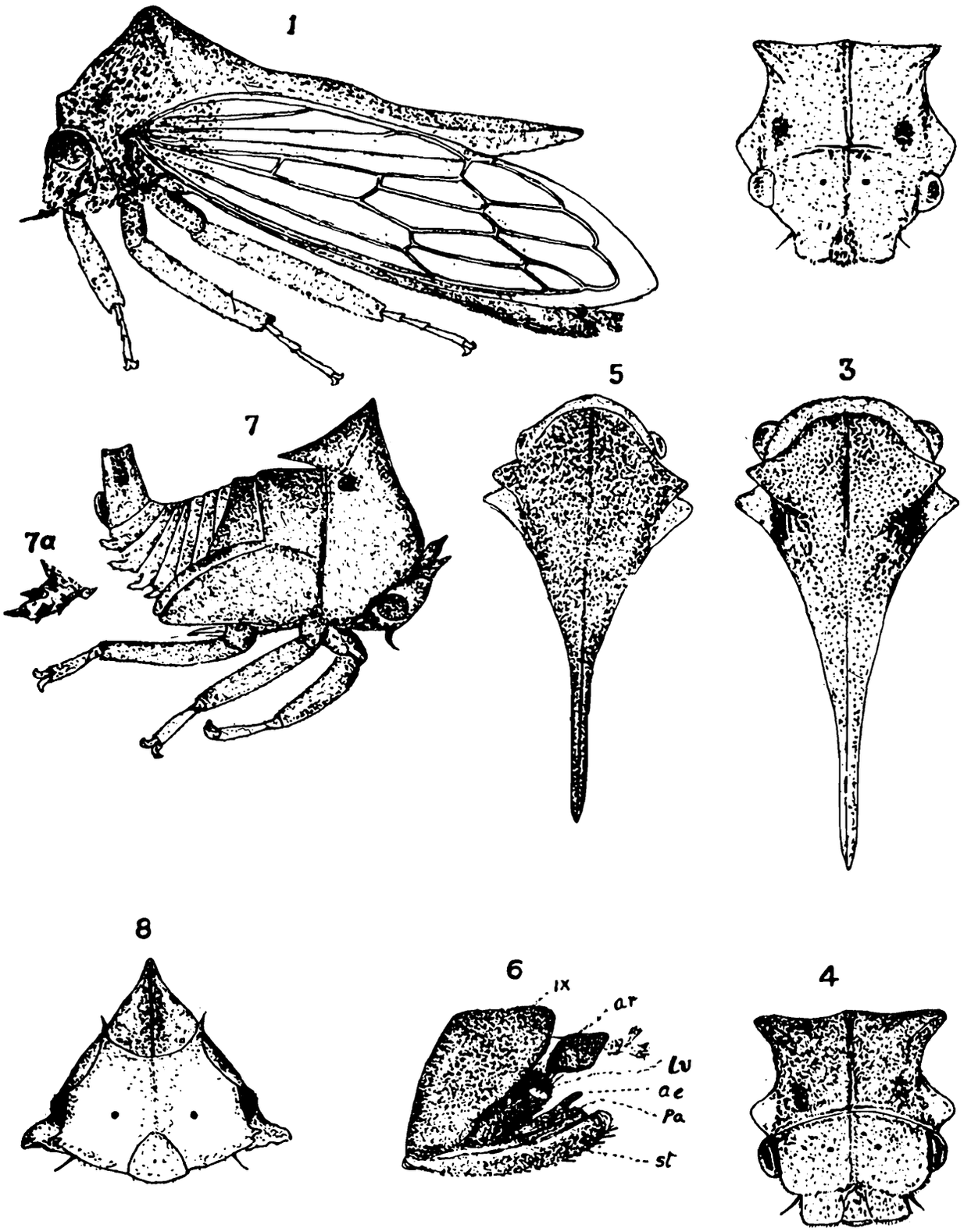
Oxyrhachis krusadiensis n.sp.

(Text-fig. 6)

Female.—General colour reddish brown. Head with vertex subquadrate, about twice as wide as long, yellowish brown, coarsely punctate with short pale adpressed hairs arising from punctures; upper margin slightly arcuate, lower margins gradually slopping to foliate lobes which are reddish brown, nearly truncate and inwardly deflexed to the frontoclypeus, eyes prominent, subglobate, pale white, ocelli dark brown, closer towards each other than from eyes and located just above centro-ocular line; fronto-clypeus reddish brown with tip slightly upturned and truncate; labrum and rostral base whitish pubescent, tip of rostrum reaching base of hind coxae. Thorax, with pronotum light reddish brown, coarsely punctate, with short pale white hairs, lateral areas of sternite with white pubescence; metopidium nearly one and a half times as wide as high, strongly sloping backwards, base convex; supra-ocular callosities inconspicuous, suprahumeral horns short, weakly carinate, subparallel, as viewed from front directed laterad with tips slightly curved downwards, subacute, dark brown, as viewed from above much narrower; posterior process reddish brown, somewhat darker just behind horns, basally tectiform, with a strong gibba above the second abdominal segment, median and lateral carinae parallel upto three-fourths of their length, apex nearly acute and only slightly raised, reaching upto the tip of 5th apical cell of tegmina, ventral keel ampliate and weakly serrate; tegmina hyaline, nearly three and three-fourths as long as wide, base very narrowly coriaceous and punctate, veins reddish brown, fringed with short hairs, 2nd apical cell smallest, 1st and 3rd discoidal cells nearly identical, apical limbus broad, legs with coxae, trochanters and femora dark brown, tibiae slightly foliate, light brown, tarsi paler.

Measurements.—Length from frontal margin to tips of tegmina 6.5 mm., to tip of posterior process 5.5 mm., width across tips of suprahumeral horns 2.0 mm., at humeral angles 2.5 mm., at eyes 2.2 mm.

Male.—Similar to female. Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 5.1 mm., width across tips



Text-fig. 6. *Oxyrhachis krusadiensis* n. sp.

1. Adult female. 2. Frontal view of female. 3. Dorsal of pronotum of female. 4. Frontal view of male. 5. Dorsal view of pronotum of male. 6. Male terminalia, lateral view. 7. Fifth instar, lateral view. 7a. Abdominal lateral lamella of fifth instar. 8. Frontal view of fifth instar.

of suprahumeral horns 1.85 mm., at humeral angles 2.3 mm., at eyes 2.1 mm.

Fifth nymphal instar.—Pale-green in life, changing to greyish brown in cabinet specimens. Head nearly twice as wide as long, cranial tubercules of moderate size; eyes fuscous brown, ocelli distinctly nearer to eyes than from each other and located on centro-ocular line; subocular processes broadly conical with tubercles; fronto-clypeus highly arched at base, nearly truncate at lower margin which never projects beyond the lower margins of vertex; thorax approximately as long as abdomen; metopidium convex in front, slightly sloping backwards, suprahumeral buds inconspicuous; supraocular callosities indistinct; pronotal anterior process conical, projecting upwards and slightly forwards, tip acute, lateral carinae distinct; posterior process less than half as long as anterior process, extending over three-fourths as long as mesonotum, tip acute, wing pads large, extending to 5th abdominal segment, costal angles not demarcated; abdominal segments 5 to 8 fairly large, slightly curved backwards and fringed with 5 or 6 tuberculate spines; anal tube a little less than one-fifth the length of body; genital rudiments large, extending over basal half of anal tube.

Host plant.—Cassia sp.

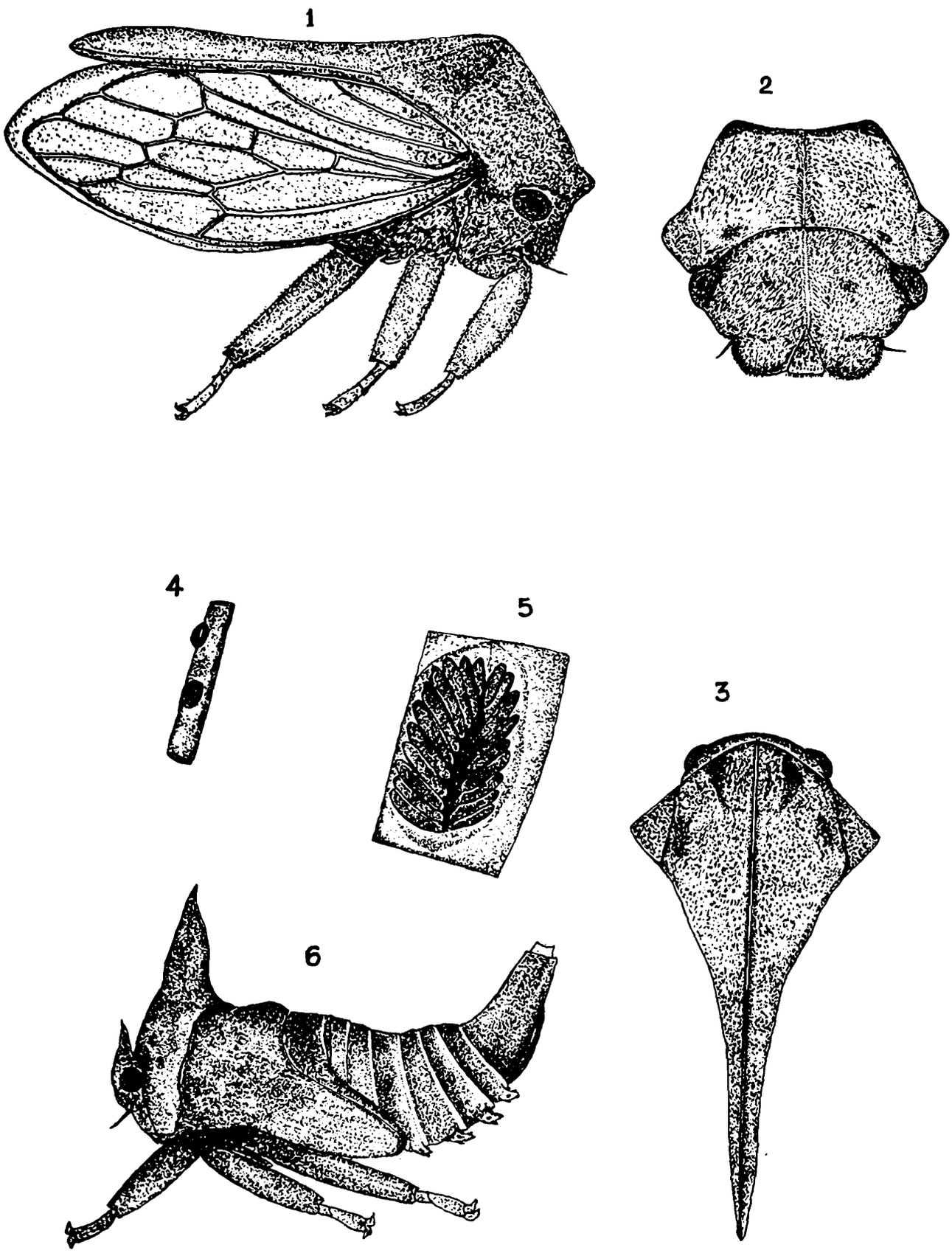
Holotype female; paratypes 25 females and 12 males; nepionotypes 15 fifth instar nymphs; Krusadai Islands, Pamban, 19.ix.1967; 8 females, 8 males and 9 fifth instar nymphs, Madras, 2.x.1968.

O. krusadiensis is nearest to *crinitus* Buckton and *uncatus* Melichar, but differing from both in the much shorter posterior process which extends upto 5th apical cell of tegmina; from *crinitus* it differs in the larger size of body and from *uncatus* in the much shorter suprahumeral horns.

Oxyrhachis brevicornutus n.sp.

(Text-fig. 7)

Female.—General colour ochraceous brown. Head, with vertex wider than long, vertical, declivous, vertex slightly convex, subquadrate, strongly arcuate at base, very finely punctate, with extremely short adpressed sparsely distributed silvery hairs, cranial callosities inconspicuous; lateral angles of foliate lobes reddish brown, broadly obtusely rounded, eyes subglobate, pale white with shades of black, ocelli shining white, nearer to eyes than to each other and located on the c-o-line; fronto-clypeus never extending below lower margins of foliate lobes, tip truncate, pilose; lateral lobes prominent; thorax, with prontum finely punctate, lateral areas somewhat dark ochraceous, devoid of dense pilosity; metopidium strongly backwardly sloping, anterior margin not obumbrant, punctate, short hairs sparsely distributed, supraocular callosities moderate, humeral angles prominent, light brown, tips broadly rounded and somewhat blunt; suprahumeral horns reduced to very short stumps and directed upwards, dark brown; posterior pronotal process tricarinate, broad at base, ampliate beneath, not gibbous at base, nearly straight to two-third its length, apical one-third slightly



Text-fig. 7. *Oxyrhachis brevicornutus* n. sp.

1. Adult female. 2. Frontal view. 3. Pronotum, dorsal view. 4. Egg masses on host stem. 5. Arrangement of eggs. 6. Fifth instar nymph.

broader with lateral and dorsal carinae fuscous, dorsal carina conspicuous, strongly pe:current through metopidium, inferior margin very weakly serrate, tip directed downward reaching to about the tip of fourth apical cell of tegmina; tegmina hyaline, nearly two and a half times as long as wide, basal sixth coriaceous, finely distinctly punctate and dark brown, veins strong, yellowish brown with 3 discoidal cells, the 1st discoidal cell narrowest, discal cell as long as 3rd discoidal cell; hind wings with 3 apical cells. Abdomen reddish brown with shades of black.

Measurements.—Length from frontal margin to tips of tegmina 5.4 mm., to tip of posterior process 4.8 mm., width across tips of suprahumeral horns 1.5 mm., at humeral angles 2.5 mm., at eyes 2.2 mm.

Male.—Similar to female but suprahumeral horns practically obsolete. Length from frontal margin to tips of tegmina 5.2 mm., to tip of posterior process 4.7 mm., width across tips of humeral angles 2.3 mm., at eyes 2.2 mm.

Fifth nymphal instar.—General coloration ochraceous brown; head obliquely directed downwards and backwards; eyes large, vitreous, subglobate, ocelli invisible; cranial tubercules prominent and slender, apically ochraceously tuberculate, about three-fourth as long as the longest abdominal lamella, subocular processes extending outwards, bi-tuberculate; rostrum extending to first abdominal segment; pronotum brown with sparse pilosity, metopidium vertically convex, supraocular callosities imperfectly shaped; anterior process erect, gradually tapering from base, tip acuminate, slightly inclined backwards, posterior process short, extending over basal one-fourths of mesonotum, tip acute, suprahumeral buds absent; wing pads ochraceous and testaceous at base, extending upto middle of 5th abdominal segment, costal angles indistinct; meso-and meta-thoracic tergites dark brown; abdominal tergites light brown with posterior margins greyish; lateral lamellae of segments 5 to 8 with short tubercles inclined backwards, fringed with a few short spines; anal tube slightly less than one-fifth of total body-length; rudimentary ovipositor dark brown, extending over basal two-thirds of anal tube.

Host Plant.—Prosopis spicigera: Holotype female; paratypes 8 females and 5 males; nepionotypes 6 (fifth instar nymphs), Madras; 30.vii. 1968.

This interesting species is nearest to the African species, *Oxyrhachis brevicornis* (Jacobi) in the nature of the posterior process, and to *O. insularis* (Capener) in the suprahumeral horns which are obsolete, but differing from both in having only 3 apical cells in the hind wings.

Key to species of **Oxyrhachis** Germar *based on Fifth instar nymphs*

1 (10) Suprahumeral buds present.

2 (5) Anterior pronotal process projecting vertically upwards; wing pads reachnig the 3rd abdominal segment.

3 (4) Posterior pronotal process prominent, gradually tapering backwards extending over basal two-thirds of mesonotum; wing pads broad.. . .. *tarandus* Fabr.

4 (3) Posterior pronotal process abbreviated, broadly rounded; wing pads narrow. ... .*rufescens* Walker.

5 (2) Anterior pronotal process directed obliquely forwards.

6 (9) Tip of anterior pronotal process acute or subacute; wing pads extending upto 5th abdominal segment; posterior pronotal process extending over basal three-fourth of mesonotum; ocelli visible.

7 (8) Colour chocolate brown; anterior pronotal process nearly twice as long as posterior process; cranial tubercles very prominent; costal angles of wing pads distinctly demarcated..
....*minusculus* n.sp.

8 (7) Colour pale green in life; anterior pronotal process more than two and a half times as long as posterior process; cranial tubercules of moderate size; costal angles of wing pads not demarcated.
.*krusadiensis* n.sp.

9 (6) Tip of anterior pronotal process broadly rounded; wing pads extending upto the 4th abdominal segment; posterior pronotal process extending over basal half of mesonotum; ocelli obscure.
.*uncatus* Melichar.

10(1) Suprahumeral buds absent; anterior pronotal process more than 4 times as long as posterior process; posterior process extending over basal one-fourth of mesonotum.. ..
brevicornutus n.sp.

Subfamily *CENTROTINAE* Spinola

This subfamily is diagnosed by the presence of a well developed scutellum which is always clearly visible if sometimes partly concealed, and the absence of propleural and mesopleural processes. The subfamily is divided into four tribes, *Centrotini*, *Leptocentrini*, *Coccosterphini* and *Gargarini*.

Key to tribes of the South Indian Centrotinae

1(2) Hind wings with 4 apical cells..
Leptocentrini

2(1) Hind wings with 3 apical cells.

3(4) Scutellum clearly visible; suprahumerals present or absent..
Centrotini

4(3) Scutellum partly concealed; suprahumerals absent.

5(6) Scutellum abortive in the middle; tegminal veins finely or coarsely tuberculate; a distinct pterostigma present or absent; pronotum tuberculate or not. ....
Coccosterphini

6(5) Scutellum complete in the middle but weakly chitinised; tegminal veins not tuberculate; a distinct pterostigma absent, rarely an inicpient pterostigma present; pronotum not tuberculate..
Gargarini

Tribe *Leptocentrini* Distant

The diagnostic characters of this tribe are the presence of 4 apical cells in the hind wings, prominent frontoclypeal lobes and the fully exposed scutellum.

Key to the genera of **Leptocentrini**

1(4) Base of posterior process distant from or rarely touching apex of scutellum; posterior process more or less arcuate and declivous.

2(3) Scutellum triangular, about as wide as long, apically emarginate; disc of pronotum convexly elevated.. *Leptocentrus*.

3(2) Scutellum much longer than broad, apex acute; disc of pronotum not or slightly elevated.... .. . *Telingana*.

4(1) Base of posterior process contiguous with or only slightly above scutellum and tegmina; posterior process slender, not arcuate, slightly sinuate; scutellum wider than long.. *Otinotus*.

Genus **Leptocentrus** Stal

(Type of the genus *Centrotus altifrons* Walker)

1866. *Leptocentrus* Stål, *Hem. Afr.* **4**: 87-90.

1903. *Rabduchus* Buckton, *Mon. Memb.*: 270.

1968. *Leptocentrus:* Capener, *Repub. S. Afr. Dept. Agr. Tech. Ser. Ent. Mem.* **17**: 33.

Head vertical, about thrice as wide as long, upper margin of vertex arcuate and sinuate, eyes hemispherical, ocelli closer to eyes than to each other and located above, rarely on, the c-o-line; frontoclypeus with tip rounded; extending well beyond free margins, lateral lobes prominent; pronotum moderately elevated, metopidium about twice as wide as high, humeral angles prominent and blunt; suprahumeral horns well developed, arcuate from dorsal aspect, usually strongly tricarinate; posterior process tricarinate, usually strongly arcuate, emerging dorsally from posterior half of pronotum, distant from scutellum and tegmina, usually impinging on tegmina at tip, extending far beyond apex of clavus; scutellum triangular, about as wide as long, apex emarginate; tegmina without pterostigma, with 5 apical cells and 2 discoidal cells, the apical veins straight; hind wings with 4 apical cells.

Key to South Indian species of **Leptocentrus**

1(4) Posterior process remote from scutellum and inner margins of tegmina from base to apex.

2(3) Posterior process straight; suprahumerals narrow, slightly recurved, about equal in length to width between bases; ocelli slightly above c-o-l; tegmina pale bronzy; small species.. .. *bajulans*

3(2) Posterior process slightly sinuate; suprahumerals broad, rubust, strongly recurved, slightly longer than width between bases; ocelli located on the c-o-l; tegmina smoky hyaline, costal margin, apical limbus and basal sixth dark marooned; large greyish black species ... *major* n.sp.

4 (1) Posterior process distant from scutellum, apex very near to or impinging on inner margins of tegmina.

5 (8) Posterior process substraight from base, slightly arched at middle, tip acuminate; suprahumerals moderately recurved.

6 (7) Dark brown; pronotum not pubescent; suprahumerals longer than space between their bases; lateral areas of sternum white tomentose; ocelli located on the c-o-l. .*rhizophagus* n.sp.

7 (6) Greyish brown; pronotum pubescent; suprahumerals approximately as long as space between bases; lateral areas of sternum greyish, not white tomentose; ocelli located above c-o-l.. .*mangiferae* n.sp.

8 (5) Posterior process moderately or strongly elevated at base, then substraight to tip.

9(12) Suprahumerals robust, strongly recurved; tip of posterior process impinging on inner angles of tegmina.

10(11) Metopidium broader than high; posterior process moderately convexly elavated at base; tip passing beyond 5th apical cell; tegmina pale bronzy ochraceous, base and apical half of costal margin black .*taurus* Fabr.

11(10) Metopidium higher than wide; posterior process prominently abruptly elevated at base; then declivous, apical fourth acuminate, tip not extending beyond 5th apical cell; tegmina shining ochraceous, extreme base, distal half of costal margin, tip of 1st apical cell and adjacent area of apical limbus shaded with black. ... .*nigra* n.sp.

12 (9) Suprahumerals moderately developed, gently recurved; distal fourth of posterior process straight, acuminate, tip never impinging on inner margin of tegmina. .. .*bauhiniae* n.sp.

13(16) Suprahumerals more than two times longer than space between bases; ocelli located above c-o-l.

14(15) Black; pronotum not pilose; suprahumerals basally raised upwards, then divergent; tegmina shining ochraceous, black on costal margin and apical limbus; tarsi yellowish... .. .*leucaspis* Walker.

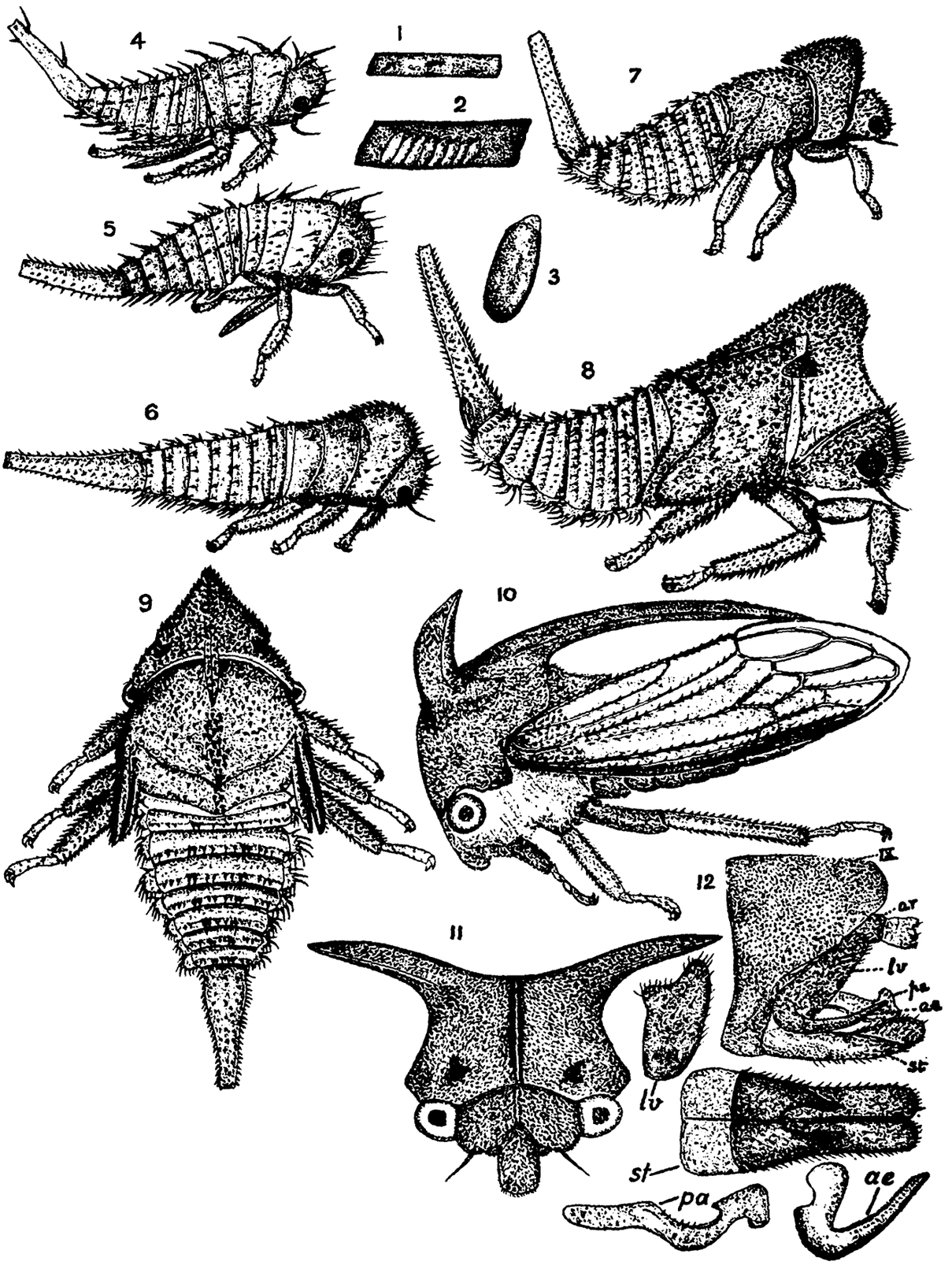
15(14) Greyish brown; pronotum longly pilose; suprahumerals not basally raised upwards, length highly variable; tegmina subhyaline, costal margin not black; tarsi brown. .. .*varicornis* n.sp.

16(13) Suprahumerals shorter than space between bases, horizontal, slender; ocelli located on c-o-l; tarsi light yellow; greyish brown species.. .*moringae* n.sp.

Leptocentrus rhizophagus n.sp.

(Text-fig. 8)

Female.—General colour dark brown. Head obliquely directed backwards, three times wider than long, vertex distinctly arcuate at upper margin, lower margins broadly rounded, greyish white, with scattered silvery hairs; frontoclypeus greyish white, bordered by black streaks with long sparsely distributed hairs, two and a half times longer than wide, extending to two-thirds of its length beyond lower margins of vertex, basal lobes prominent, tip of frontoclypeus nearly truncate; eyes dark reddish brown, prominent, projecting laterad; ocelli located on centro-ocular line, black, distinctly nearer to eyes than to each other; antennae pale white, two-third as long as frontoclypeus; thorax with pronotum light brown with shades of black, pilose, lateral areas of sternum cretaceously sericeous, metopidium much broader than high, vertical upto about half of its height, then gradually sloping backwards



Text-fig. 8. *Leptocentrus rhizophagus* n. sp.

1. Twig showing egg slits. 2. Egg slit cut open. 3. A single egg. 4. First instar. 5. Second instar. 6. Third instar. 7. Fourth instar. 8. Fifth instar (lateral view) 9. Fifth instar (Dorsal view) 10. Adult female. 11. Frontal view. 12. Male genitalia, lateral view.

towards disc; supraocular callosities conspicuous, irregularly shaped, black; humeral angles not prominent, light yellowish brown, tips blunt; suprahumeral horns reddish brown, pilose, longer than space between their bases, as seen from lateral aspect stout at base, obliquely curved forwards, then upwards, distal one-fifth directed backwards, tips acute; as seen in front much narrower, carinae weak; posterior process reddish brown, a little raised from disc and obliquely backwardly directed, more or less arcuate, tip acuminate, passing over three-fourth the length of 5th apical cell of tegmina, impinging on inner angles of tegmina; median carina strongly percurrent along metopidium; tegmina three times as long as wide, hyaline, distal third of costal margin fuscous, base somewhat coriaceous, veins light brown, pilose; scutellum white tomentose at lateral basal angles, wider than long, narrowly emarginate; undersurface of abdomen dark brown, pubescent; trochanters, femora and bases of tibiae dark reddish brown, apical two-thirds of tibiae and tarsi light yellow.

Measurements.—Length from frontal margin to tips of tegmina 6.3 mm., to tip of posterior process 5.3 mm., width across tips of suprahumerals 4.9 mm., at humeral angles 2.4 mm., at eyes 2.3 mm.

Male.—Smaller, nearly similar to female; frontoclypeus jet black, humeral angles more conspicuous; genitalia, with aedeagus finely serrate on inner margin, tip sub-acute, parameres rectangularly truncate in lateral aspect, sparsely setose on inner margin; lateral valves broadly triangular, processes well chitinised and almost concolorous, fringed with short bristles; sternal plate highly chitinised at base, lobes at apex inconspicuous, broadly rounded.

Fifth instar nymph.—General coloration pinkish brown, though variable; head pilose, directed backwards, base of vertex strongly arcuate, eyes prominent, pinkish or dark brown, surrounded by numerous bristles; ocelli closer to eyes than to each other and located on centro-ocular line; rostral tip reaching middle of metathorax; pronotal anterior process broadly rounded, distinctly shorter than posterior process, densely spinose; tip obtuse, posterior process extending over three-fourth the length of mesonotum, suprahumeral buds conspicuously large, dark brown; mesonotal process blunt, partially overlapping metanotum; wing pads dark brown, extending up to 3rd abdominal segment, costal angles distinct; tibiae light brown with distinct transverse bands which disappear in preserved specimens; abdominal dorsal tubercless hort, their spines suberect; lateral lamellae semicircular, each provided with 7 to 9 long curved spines inclined caudad, subspines scattered over lamellae; anal tube black at distal half, as long as the rest of abdomen, highly eversible.

Host plant.—Prop roots of *Ficus bengalensis.*

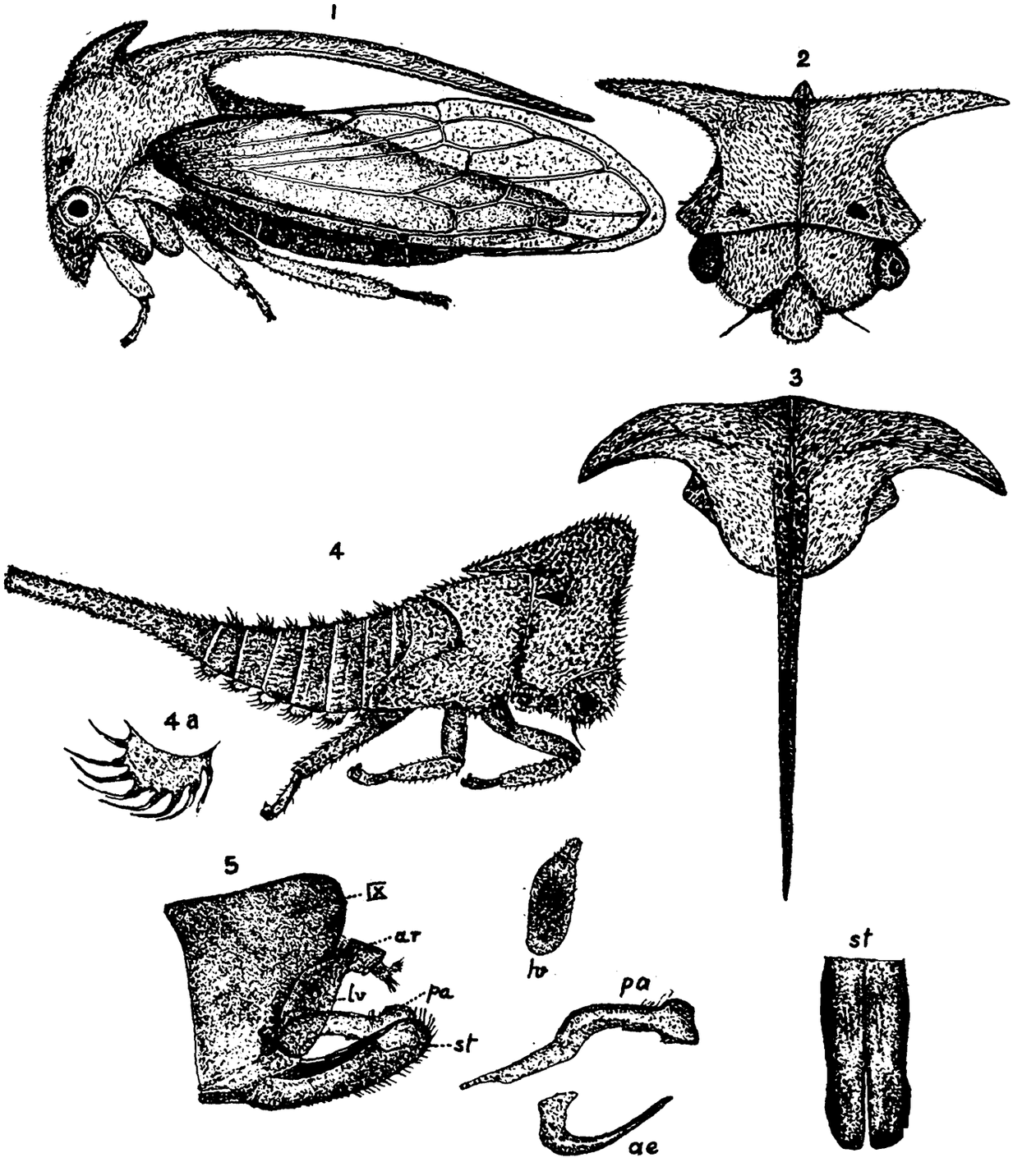
Holotype female; 47 female and 19 male paratypes; 38 nepionotypes, Madras, July to September, 1966.

Leptocentrus rhizophagus is nearest to *obliquus* Walker in the ferruginous body coloration, obliquely straight posterior process which impinges on the tegminal inner margins and in the hyaline tegmina, but differs in the much longer and less oblique suprahumerals and in the position of ocelli.

Leptocentrus mangiferae n.sp.

(Text-fig. 9)

Female.—General coloration greyish brown; head more than twice as wide as long, vertex brown, tinged with shades of black, pilose with



Text-fig. 9. *Leptocentrus mangiferae* n. sp.

1. Adult female. 2. Frontal view of female. 3. Dorsal view of pronotum. 4. Fifth instar nymph. 4a. Abdominal lateral lamella of fifth instar. 5. Male genitalia, lateral view.

short closely adpressed silvery hairs, declivous, upper margin arcuate, lower margins downwardly sloping; frontoclypeus longly pilose, speckled with black spots, longer than wide, extending below lower margins of vertex for about two-thirds its length, tip rounded; eyes pale white, globate, projecting laterad; ocelli shining white, located a little above centro-ocular line, slightly closer to eyes than to each other; pronotum greyish brown, finely punctate, with short pale white hairs, lateral areas of sternum pale brown, not white tomentose; metopidium wide as high, nearly vertical, with an inconspicuous bare supraocular callosity on either side; humeral angles prominent; suprahumeral horns as long as space between bases, as seen from above, stout at base, more or less foliate, from base directed upwards, then gradually turned backwards upto humeral angles, tips subacute; posterior process basally raised above the scutellum, tricarinate, almost straight upto half of its length, then sinuate and acuminate to tip, never impinging on inner angles of tegmina, extending upto middle of 4th apical cell; median carina strongly percurrent; tegmina about three and a half times longer than wide, clearly hyaline, brown pilosity at base, veins basally brown, gradually becoming lighter towards apex; scutellum white tomentose at basal lateral third, rest rusty brown, tip emarginate; abdomen light brown with shades of black, ovipositor concolorous with abdominal sternites.

Measurements.—Length from frontal margin to tips of tegmina 6.9 mm., to tip of posterior process 6.0 mm., width between tips of suprahumerals 5.0 mm., at humeral angles 2.8 mm., at eyes 2.6 mm.

Male.—Differing from female in the dark brown coloration; length from frontal margin to tips of tegmina 6.7 mm., to tip of posterior process 5.9 mm., width across suprahumerals 4.8 mm., at humeral angles 2.5 mm., at eyes 2.5 mm.

Fifth instar nymph.—Closely resembling that of *rhizophagus* from which it differs in the relative length of pronotal anterior and posterior processes and the absence of transverse dark bands on tibiae. General coloration reddish brown; in some, pale brown; head twice as wide as long, reddish brown; vertex planate at base, cranial tubercules obsolete, tuberculate spines slender and closely arranged, eyes reddish, ocelli fuscous brown, as close to eyes as from each other and located on the centro-ocular line; rostrum reaching middle of metathorax; prothorax light brown; metopidium vertical with spines projecting forwards; anterior extension of pronotum blunt, broadly rounded, directed obliquely upwards; pronotal crest as long as or longer than posterior process which is contiguous with mesonotum and extending over two-thirds of its length; suprahumeral buds black, moderately developed, with backwardly directed acute tips; tegminal wing pads reddish brown, extending over 3rd abdominal segment, costal angles distinctly demarcated; legs yellowish on tibiae, dark bands absent; abdomen excluding anal tube as long as thorax; arrangement of dorsal tubercles and lateral lamellae as in *rhizophagus;* anal tube dark brown, as long as rest of abdomen.

Host plant.—Mangifera indica.

Holotype female; 8 female and 9 male paratypes, 12 nepionotypes, Madras, 4.ix.1965.

This species is nearest to *rhizophagus* from which it differs in the greyish brown coloration, pubescent pronotum, absence of tomentosity in the lateral areas of sternum, and in the position of ocelli which are located above the centro-ocular line.

Leptocentrus major n.sp.

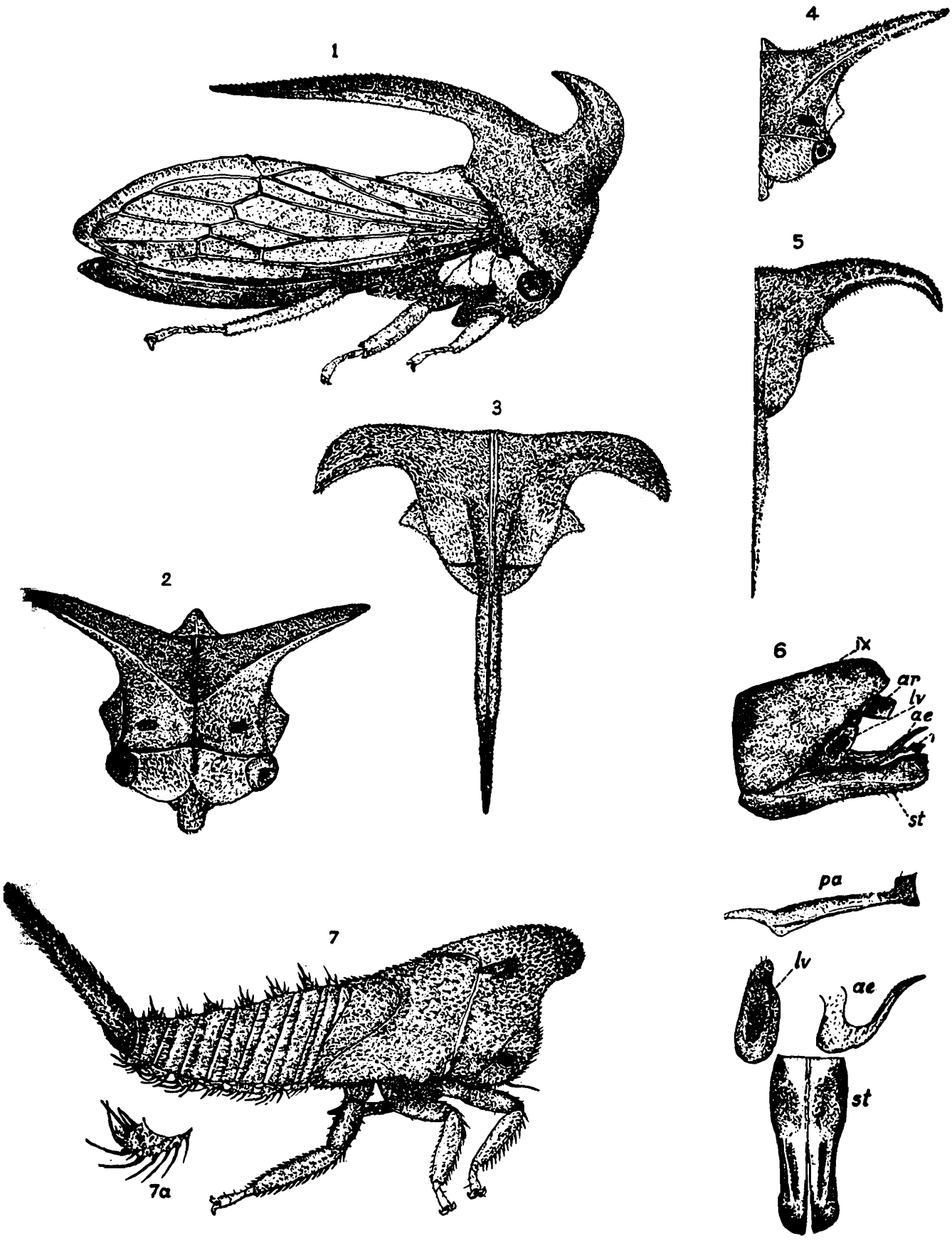
(Text-fig. 10)

Female.—Head greyish black, directed obliquely backwards, densely pilose with silvery hairs; vertex sinuous, eyes chestnut brown; ocelli passing through centro-ocular line and closer to eyes than to each other; frontoclypeus broadly rounded at free end, extending to two-thirds of its length below lower margins of vertex, longly pilose; thorax with pronotum coarsely punctate, black dorsally and cretaceously sericeous laterally; metopidium somewhat obumbrant, convex, slightly wider than high; supraocular callosities irregular in shape, prominent, black; humeral angles broadly conical, tips subacute, sparsely pilose; suprahumeral horns slightly longer than space between their bases, in lateral view obliquely directed forwards, then upwards and strongly recurved backwards beyond middle; tips acute; as viewed in front, much narrower, widely divergent, dorsal carinae shining black, nearer to posterior margin; posterior process robust, obliquely curved immediately after its origin from disc, raised well above scutellum, then extending horizontally backwards, sinuate beyond middle, strongly tricarinate, the central carination finely percurrent through metopidium, apical region black, acuminate, tip sharp, remote from tegmina; scutellum clothed with silvery white hairs, as broad as long, tip emarginate; tegmina about three times longer than wide, base coriaceous, costal margin, apical limbus and basal sixth dark marooned, rest shaded black, veins stout, reddish brown; legs basally black, tibiae brown, tarsi yellowish; abdominal sternites uniformly black; ovipositor robust.

Measurements.—Length from frontal margin to tips of tegmina 9.0 mm., to tip of posterior process 7.0 mm., width across tips of suprahumeral horns 5.9 mm., at humeral angles 3.2 mm., at eyes 3.0 mm.

Male.—Smaller and darker than female; posterior process slender, not sinuate; length from frontal margin to tips of tegmina 7.7 mm., to tip of posterior process 6.0 mm., width across tips of suprahumeral horns 5.4 mm., at humeral angles 2.4 mm., at eyes 2.3 mm.

Fifth instar nymph.—General coloration pale brown; head obliquely turned backwards; vertex emarginate at base, cranial tubercules obsolete; eyes pale white, subglobate, ocelli black, closer to eyes than from each other and located above centro-ocular line; thorax slightly shorter than abdomen excluding anal tube; arrangement of spines on tubercles of thorax similar to that of *rhizophagus*; metopidium receding in front and curving forwards into pronotal crest, somewhat recurved, ending in broadly rounded tip; pronotal posterior process much shorter, contiguous with mesonotum, extending to about half of its length; suprahumeral buds large, tips pointed; wing pads darker than rest of thorax, extending only slightly backwards; costal angles broadly rounded; dorsal tuberculate spines of abdominal segments more or less erect, each



Text-fig. 10. *Leptocentrus major* n. sp.

1. Adult female. 2. Frontal view. 3. Dorsal view of pronotum. 4. Frontal view of male (right half). 5. Dorsal view of male pronotum (right half). 6. Male genitalia. 7. Fifth instar nymph. 7a. Abdominal lateral lamella of fifth instar.

tubercle bearing 4 or 5 spines of varying length; lateral lamellae semicircular, bearing 9 or 10 slender tuberculate spines besides small subspines; anal tube as long as rest of abdomen, characteristically raised and highly eversible.

Host plant.—Michelia champaca.

Holotype female; 9 female and 9 male paratypes, 6 nepionotypes, Madras, 8.viii.1968.

This species is nearest to *bajulans* Dist. in the strongly tricarinate posterior process which is well remote from tegmina; in the black coarsely punctate pronotum, strongly centrally carinate recurved long suprahumerals and in the black colour of tegminal costal margin it comes close to *leucaspis* Walker; it differs from both *bajulans* and *leucaspis* in its larger size, tegmina shaded black all over, and the posterior process sinuous beyond middle.

Leptocentrus bajulans Distant

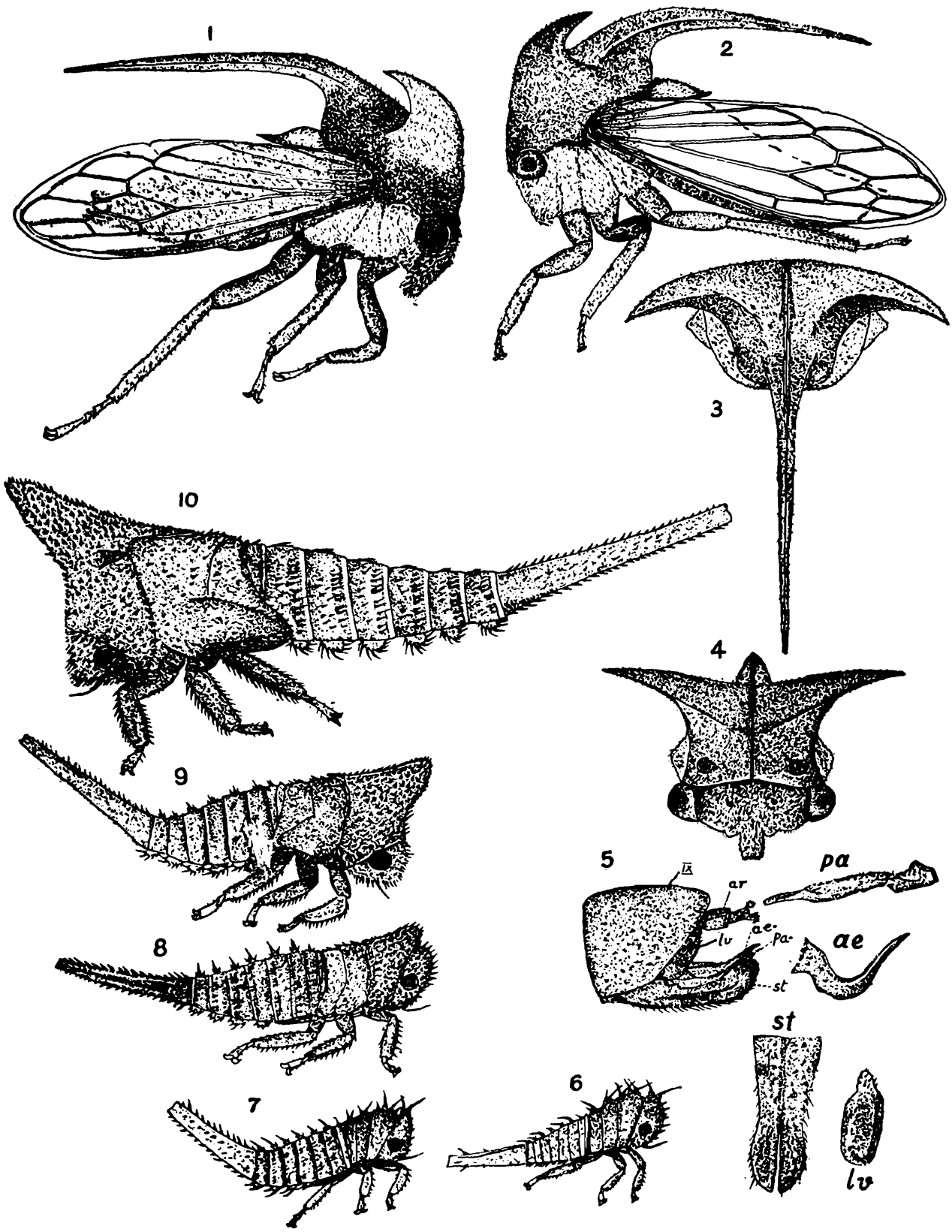
(Text-fig. 11)

1916. *Leptocentrus bajulans* Distant., *Fauna Brit. India, Append.* **6**: 155.

Female.—General coloration black; head thrice as wide as long; longly pilose with pale white hairs; base of vertex arcuate, sides obliquely sloping downwards to clypeus; eyes pinkish, subglobate; ocelli succineous, nearer to eyes than to each other and situated slightly above centro-ocular line; frontoclypeus projecting three-fourths of its length beyond lower margins of vertex, tip truncate, longly pilose, lateral lobes small, distinct; pronotum thickly coarsely punctate, with long white hairs emerging from punctures; metopidium vertical, broader than high, sparsely hairy, supraocular callosities oval, bare; humeral angles brownish, hairly, broadly conical, tips blunt; suprahumeral horns strongly tricarinate, viewed from lateral aspects, broad, directed obliquely outwards and upwards, their tips strongly recurved and acute, anterior carina strong; posterior process slender, arising from posterior half of disc, curved at base, remote from scutellum and tegmina, strongly tricarinate, median carina percurrent through metopidium, lateral carinae reddish brown, apex acute, passing over the posterior angle of inner tegminal margin; scutellum reddish brown, pilose at lateral areas; tegmina thrice as long as broad, pale bronzy, wrinkled, first apical cell nearly eight times longer than broad, basal part slightly dark, coriaceous, veins light reddish brown; legs darker upto distal fourth of femora, tibiae yellowish, tarsi pale white with black spots.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 4.8 mm., width across tips of suprahumerals 4.0 mm., at humeral angles 2.0 mm., at eyes 2.2 mm.

Male.—Similar to female but darker; pilosity denser; posterior process longer, its tip passing beyond fifth apical cell of tegmina; terminalia closely resembling that of *major*.



Text-fig. 11. *Leptocentrus bajulans* Distant

1. Adult male. 2. Adult female. 3. Dorsal aspect of pronotum of female. 4. Frontal view of female. 5. Male genitalia, lateral view. 6. First instar nymph. 7. Second instar. 8. Third instar. 9. Fourth instar. 10. Fifth instar.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 5.3 mm., width across tips of suprahumerals 3.8 mm., at humeral angles 1.8 mm., at eyes 2.0 mm.

Fifth nymphal instar.—General coloration leafy green; head highly bristled; 2.5 times wider than long, inclined backwards; vertex planate; eyes dark brown, ocelli succineous, located slightly above centro-ocular line, closer to eyes than to each other; metopidium slightly convex; suprahumeral buds conspicuously large and directed backwards; pronotal anterior process obliquely extended forwards and upwards, tip blunt; pronotal posterior process about half as long as anterior process, extending over three-fourths of length of mesonotum; wing pads large, reaching the middle of 3rd abdominal segment with distinct costal angles; abdominal dorsal tuberculate spines much reduced and adpressed to body, lateral lamellae semicircular, each with 7 to 9 slender spines; anal tube black at distal one-third, nearly as long as rest of abdomen.

Host plant.—Casuarina equisetifolia

Material studied.—6 females, 4 males, 36 nymphal instars, Madras, 4.ix.1967.

Leptocentrus leucaspis Walker

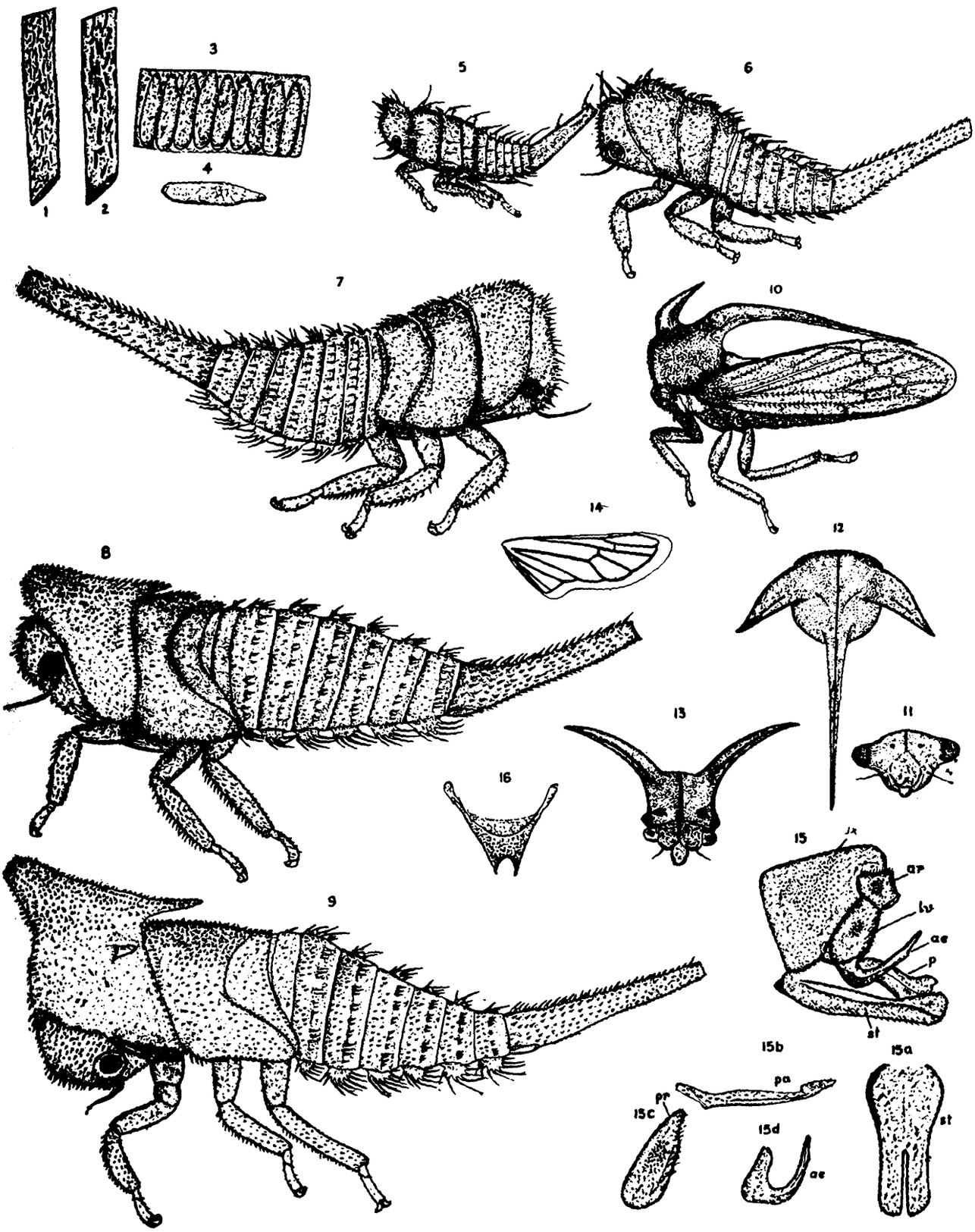
(Text-fig. 12)

1851. *Centrotus taurus* Walker, *List. Hom.* ii: 602.

1858. *Leptocentrus leucaspis* Walker, *List. Hom. Suppl.*: 158.

Female.—General colour black; head nearly thrice as broad as long; upper margin of vertex strongly arcuate and sinuate, lower margins weakly sinuate; eyes hemispherical, black, directed laterad; ocelli slightly closer to eyes than to each other and located just above centro-ocular line; pronotum black, not pilose, strongly punctate, metopidium somewhat convex and vertical, wider than high, disc convex; supra-ocular callosities large, irregularly rounded; humeral angles dark brown, tips acute; suprahumeral horns slender, more than two times as long as space between bases, viewed from front obliquely raised and much divergent, tips acute, viewed from above strongly carinate, flattened, obliquely directed backwards, seen from lateral aspect, raised upwards, then outwards, tips turned backwards; posterior process tricarinate, dorsal carination percurrent over metopidium, strongly convexly recurved from near base, achieving its maximum height above scutellum, then moderately arched, apical fourth impinging on tegminal inner margin, tip acute, touching the posterior end of 5th apical cell or slightly passing beyond it; in some, tip slightly raised; tegmina shining ochraceous, costal margin and apical limbus black, base black, punctate, coriaceous, first apical cell nearly 7 times longer than wide, veins reddish brown; hind wings with 4 apical cells; scutellum black, as broad as long, tip broadly emarginate; basal two-thirds of scutellum and lateral areas of sternum cretaceously sericeous; legs with tibiae yellowish.

Measurements.—Length from frontal margin to tips of tegmina 7.0-7.6 mm., to tip of posterior process 5.5-6.0 mm , width across tips of



Text-fig. 12. *Leptocentrus leucaspis* Walker

1. Egg-slits on host stem. 2. Bark of twig removed to show the egg-slits. 3. An egg-slits cut open. 4. An egg. 5. First instar nymph. 6. Second instar. 7. Third instar. 8. Fourth instar. 9. Fifth instar. 10. Adult female. 11. Head, frontal elevation. 12. Pronotum, dorsal view. 13. Front view. 14. Hind wing. 15. Male genitalia, lateral view. 15a. Sternal plate ; b, paramere, c, lateral valve : d, aedeagus. 16. Scutellum.

suprahumerals 6.4-7.0 mm., at humeral angles 2.5-2.7 mm., at eyes 2.0-2.2 mm.

Fifth nymphal instar.—General coloration light brown, in some greyish, mottled with black spots; head twice as wide as long across eyes; base of vertex strongly sinuate, longly pilose; eyes pale white, ocelli transparent, closer to eyes than to each other and located above centro-ocular line; frontoclypeus greyish white, longly pilose, extending slightly beyond lower margins of vertex; rostral tip reaching hind coxae; prothorax nearly as long as pterothorax, speckled with closely arranged short stout spines on the crest, sparsely arranged on lateral aspects; pronotal anterior process directed obliquely forwards and upwards with broadly rounded tip, nearly two and a half times longer than pronotal potserior process which extends over basal half of mesonotum, tip acute; tuberculate spines on mid dorsal region of pterothorax short and stout; suprahumeraul buds small, with blunt tips; mesonotal process short; tegminal wing pads greyish brown, large, costal angles inconspicuous and sparsely hairy; abdomen laterally compressed with 9 visible segments, the first segment narrow, the ninth one forming anal tube; dorsal tubercles of abdominal segments suberect, inclined backwards; lateral lamellae, of moderate size, crescentic, bordered by 8 or 9 slender spines showing a tendency to fork; anal tube black distally, shorter than the combined length of 1-8 segments of abdomen; dorsal row of spines on anal tube erect and conspicuous.

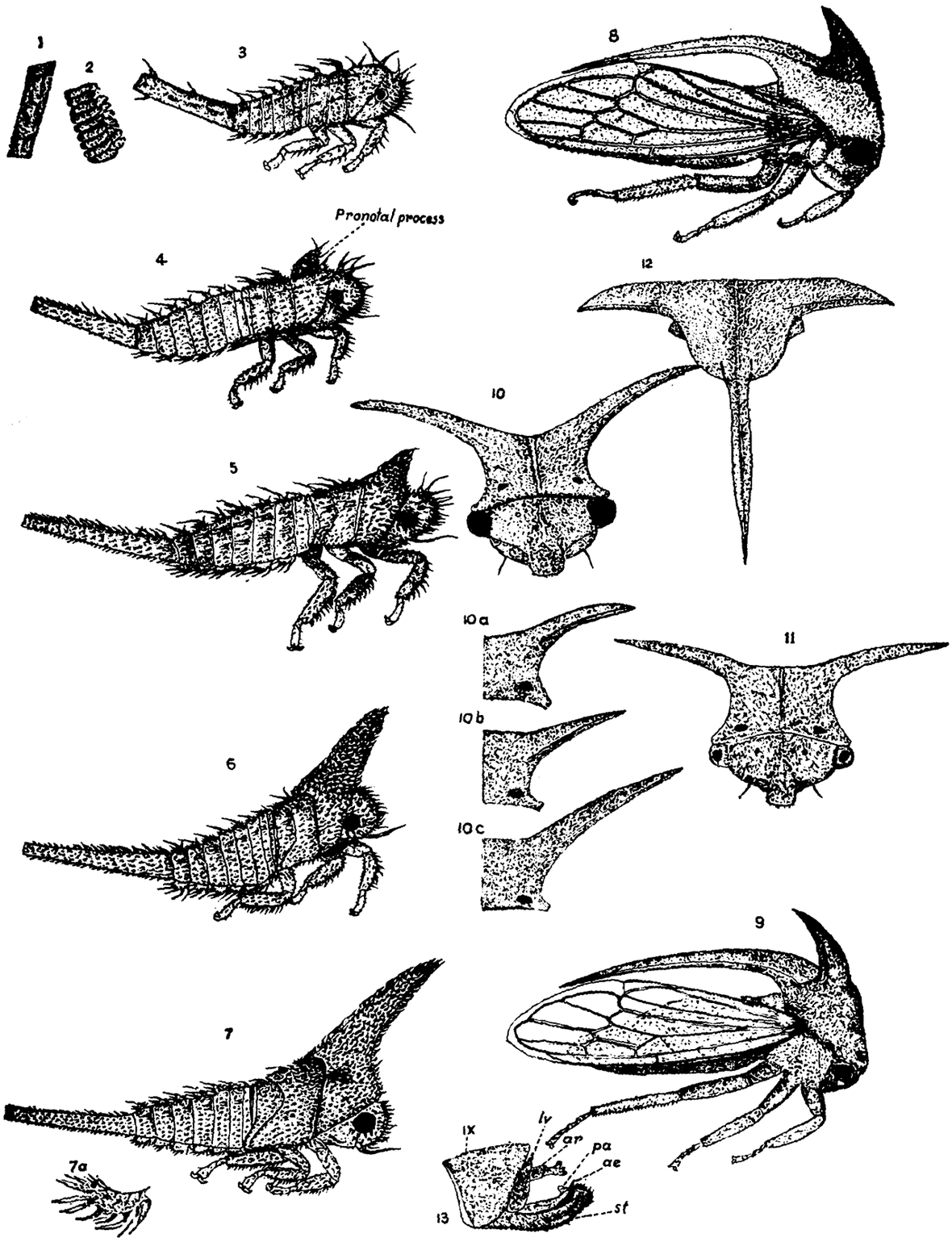
Host plants.—*Terminalia catappa, Pongamia glabra.*

Material studied.—65 females, 60 males and numerous nymphs, Madras, July to October, 1966.

Leptocentrus varicornis n.sp.

(Text-fig. 13)

Female.—General colour greyish brown; head yellowish brown, broader than long declivous, arcuate at base of vertex, coarsely punctate; frontoclypeus greyish with black spots, longly pilose, lower margin extending to one-third of its length beyond vertex; eyes light reddish brown, projecting lateral; ocelli black, located above centro-ocular line, closer to eyes than to each other. Thorax greyish black at sides shading to black dorsally; metopidium one and a half times wider than high; finely punctate, not pilose, supraocular callosities not prominent, humeral angles short, tips subacute, suprahumerals very long, rather slender, widely divergent, not abruptly curved from base, obliquely directed upward, tip acute and moderately curved backward, seen from above much flattened, as seen in front much narrower, finely tricarinate, carinae black, width across tips of suprahumerals more than three times their width at bases; posterior process slender, reddish brown, tricarinate, recurved from near base, widely separated from scutellum, extending as far back as the 4th apical cell of tegmina, gradually acuminate, impinging on tegmina at apex; tegmina subhyaline, base punctate and dark brown, veins stout and yellowish brown; hind wing with 4 apical cells. Legs reddish brown, except tarsi which are yellowish. Abdomen black.



Text-fig. 13. *Leptocentrus varicornis* n. sp.

1. Eggslits on host stem. 2. An egg mass. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 7a. Abdominal lateral lamella of fifth instar. 8. Adult female. 9. Adult male. 10. Frontal view of female. 10a, b, c : Variations in suprahumerals. 11. Frontal view of male. 12. Dorsal aspect of female pronotum. 13. Male genitalia,

Measurements.—Length from frontal margin to tips of tegmina 6.1 mm., to tip of posterior process 5.44 mm., width between tips of suprahumeral horns 5.0 mm., between bases of suprahumerals 1.5 mm., at humeral angles 2.4 mm., at eyes 2.4 mm., length of suprahumeral 2.5 mm.

Male.—Slightly smaller than female; body uniformly yellowish brown except abdominal undersurface which is dark brown; eyes greyish black; metopidium less punctate; sparsely pilose, supraocular callosities more distinct; posterior process amber brown.

The species exhibits notable variations with regard to the length and angle of inclination of suprahumerals, length of horns ranging from 2.1 to 2.6 mm., the degree of divergence ranging from nearly horizontal to distinctly oblique upturned conditions.

Fifth nymphal instar.—General colour light reddish brown. Head highly pilose; vertex somewhat convex with basal margin planate, cranial tubercules obsolete; ocelli slightly closer to eyes than to each other and located on c-o-line; pronotum with vertical metopodium and conspicuous suprahumeral buds; pronotal anterior process extraordinarily long, slightly curved at middle and ending in an acute point; spines on pronotal process dense; pronotal posterior process short, about one-sixth as long as anterior process, extending over just half the length of mesonotum; costal angles of wing pads broadly rounded; dorsal tuberculate spines of thorax and abdomen long, erect or suberect; spines on abdominal lateral lamellae 8 or 9 in number, slender and curved backwards with distinct subspines. Anal tube dark brown, as long as the rest of abdomen.

Host plant.—Zizyphus jujuba.

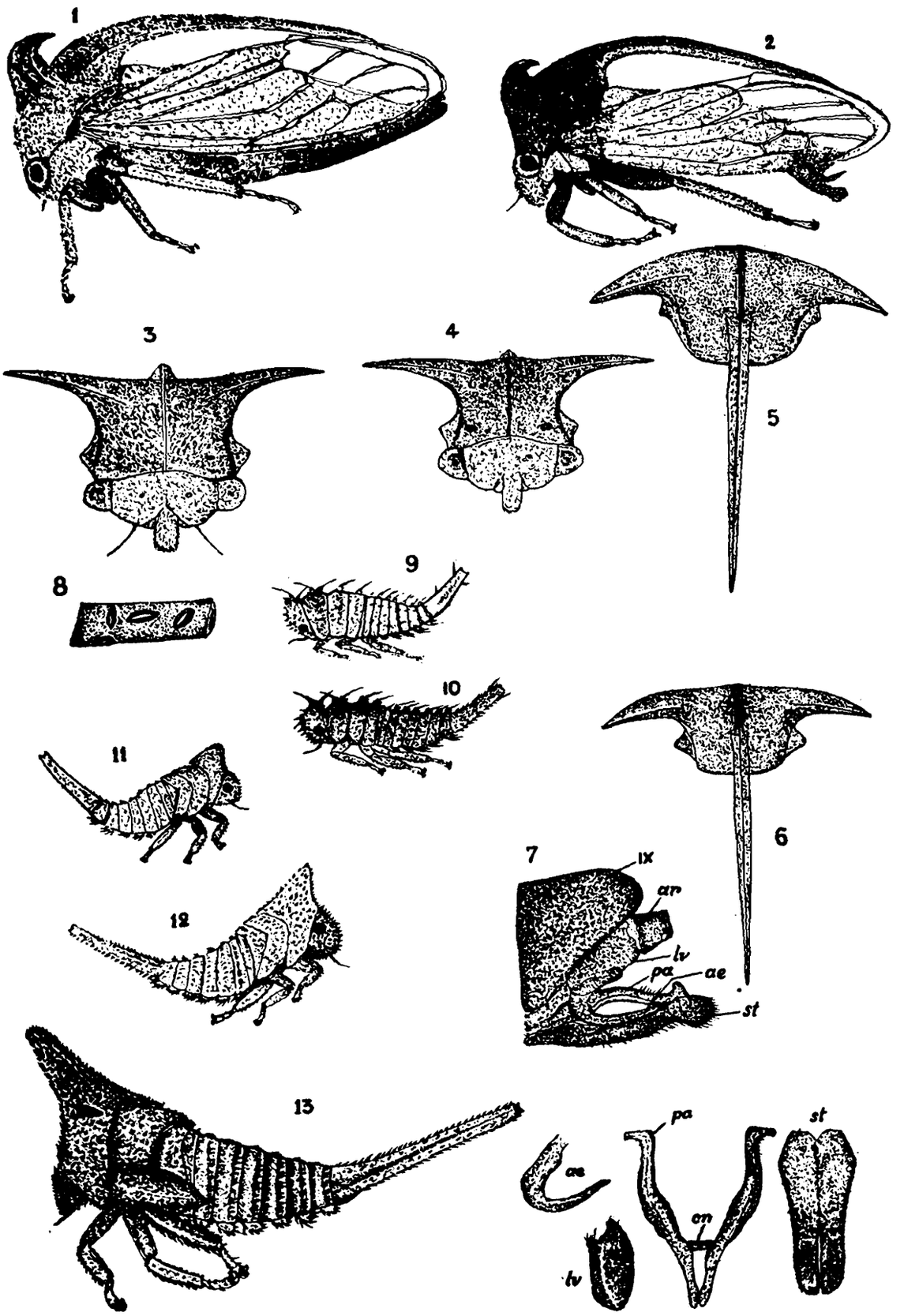
Holotype female; 8 female and 9 male paratypes, 18 nepionotypes, Madras, 6.viii.1966.

This species is related to *leucaspis* Walker and *longispinus* Distant in the presence of very long, slender, divergent, suprahumerals; it differs from both in the smaller size, lighter body coloration, in the highly variable suprahumerals and in the less oblique and more straight posterior process; from *leucaspis* it differs in the subhyaline nature of tegmina which never shows any black shades on costal margin. The 5th instar nymph of *varicornis* is unique in the very long pronotal anterior process.

Leptocentrus taurus Fabricius

(Text-fig. 14)

1775. *Leptocentrus taurus* Fabricius, *Syst. Ent.* 675.
1778. *Cicada taurus:* Goeze, *Hemiptera,* **2:** 147.
1795. *Membracis taurus:* Weber, *Rhyngota,s* 19.
1798. *Membracis rupicapra* Fabricius, *Syst. Suppl.*: 514.
1803. *Centrotus scutellaris* Fabricius, Rhyngota,: 19.
1846. *Membracis tricornis* Fahirmaire, *Soc. Ent. de France, Ann.* **4:** 511.
1851. *Centrotus terminalis* Walker, *List Hom.*, **2:** 694.
1885. *Leptobelus scutellaris:* Atkinson, *J. Asiatic Soc. Bengal,* **54:** 83.



Text-fig. 14. *Leptocentrus taurus* Fabricius

1. Adult female. 2. Adult male. 3. Frontal view of female. 4. Frontal view of male. 5. Dorsal view of pronotum of female. 6. Dorsal view pronotum of male. 7. Male genitalia, lateral view. 8. Twig with egg-slits. 9. First instar. 10. Second instar. 11. Third instar. 12. Fourth instar. 13. Fifth instar.

Female.—General colour black; head three times wider than long, greyish black, coarsely punctate, sparsely pilose, basal margin of vertex convex, lateral margins obliquely sloping downwards, eyes reddish brown, hemispherical; ocelli black, nearer to eyes than to each other and situated slightly above centro-ocular line; antennae as long as frontoclypeus; frontoclypeus slightly convex, thrice as long as broad, with three-fourths of its length extending beyond lower margins of vertex, tip broadly rounded, longly pilose; lateral lobes distinct, small; pronotum black, thickly coarsely punctate with closely adpressed pale white hairs; metopidium dark reddish brown, vertical, nearly twice as wide as high; supraocular callosities inconspicuous; humeral angles greyish brown, sparsely pilose, tips subacute; suprahumeral horns robust, longer than space between their bases, seen in front subhorizontal, much narrower and less recurved, as seen from above strongly tricarinate, the dorsal carina closer to posterior margin, as seen from lateral aspect, turned slightly upwards and then strongly recurved, tips acute; posterior process strongly tricarinate above, abruptly convexly elevated from near base, then sub-straight, passing beyond 5th apical cell, apex black, impinging on the inner margin of tegmina, central carina percurrent through metopidium; tegmina pale bronzy ochraceous, three and a half times longer than wide; distal half of costal margin black, basal sixth opaque, coriaceous and punctate; first apical cell about 8 times longer than wide; hind wings with 4 apical cells; scutellum as broad as long, tip narrowly emarginate; basal part of scutellum and lateral areas of sternum cretaceously sericeous; tibiae reddish brown; abdomen black beneath.

Measurements.—Length from frontal margin to tips of tegmina 7 mm., to tip of posterior process 5.8-6.6 mm., width across tips of suprahumerals 5.0-5.2 mm., at humeral angles 2.4-2.7 mm., at eyes 2.2-2.4 mm.

Male.—General colour jet black; smaller than female; suprahumerals more strongly recurved. Genitalia, with aedeagus 'U' shaped, connective plate of parameres rectangular, lateral valves oblong, twice as long as broad, dark brown, process short, nodular, fringed with short hairs; apical third of sternal plate forked, punctate, longly and densely pilose, lobes inconspicuous.

Measurements.—Length from frontal margin to tips of tegmina 6.0-6.5 mm., length to tip of posterior process 5.0-5.4 mm., width across tips of suprahumerals 4.6-4.8 mm., at humeral angles 2.2-2.4 mm., at eyes 2.0-2.2 mm.

Fifth nymphal instar.—Colour leafy green in life but fading to ochraceous in cabinet specimens; vertex of head convex, covered with sparse bristles, tubercular bases black, rostrum reaching 2nd abdominal segment; base of vertex weakly arcuate without conspicuous cranial tubercules; ocelli somewhat projecting, closer to eyes than to each other and located above centro-ocular line; lower margin of frontoclypeus on a line with lower margins of vertex; lobes distinct; pronotum with vertical metopidium; anterior process obliquely raised forwards and upwards, tip narrowly rounded, covered with closely arranged short tuberculate spines; posterior process about one-third as long as anterior process; extending backwards over mesonotum, tip acuminate; suprahumeral buds black at base, moderately developed; wing pads greenish,

marked with brown or black dots; abdominal segments slightly telescoped, tip raised upwards, dorsal tubercles of abdomen short, their spines adpressed to body; lateral lamellae with 7 to 10 slender spines; anal tube about one and a fourth longer than rest of abdomen; genital rudiments black or dark brown.

Host plants.—*Acacia arabica*, *Acacia melanoxylon*, *Albizzia lebbec*, *Tamarindus indicus*, *Capparis sepiaria*, *Zizyphus jujuba*, *Erythrina indica*, *Vernonia cinerea*, *Artabotrys odoratissimus*, *Crataeva religiosa*, *Ipomea biloba*, *Hibiscus rosasinensis*, *Thespesia populnea*, *Feronia elephantum*, *Anacardium occidentale*, *Cyamopsis tetragonoloba*, *Bauhinia tomentosa*, *Bauhinia purpurea*, *Casuarina equisetifolia*, *Solanum torvum*, *Solanum melongena*, *Eranthemum* sp.

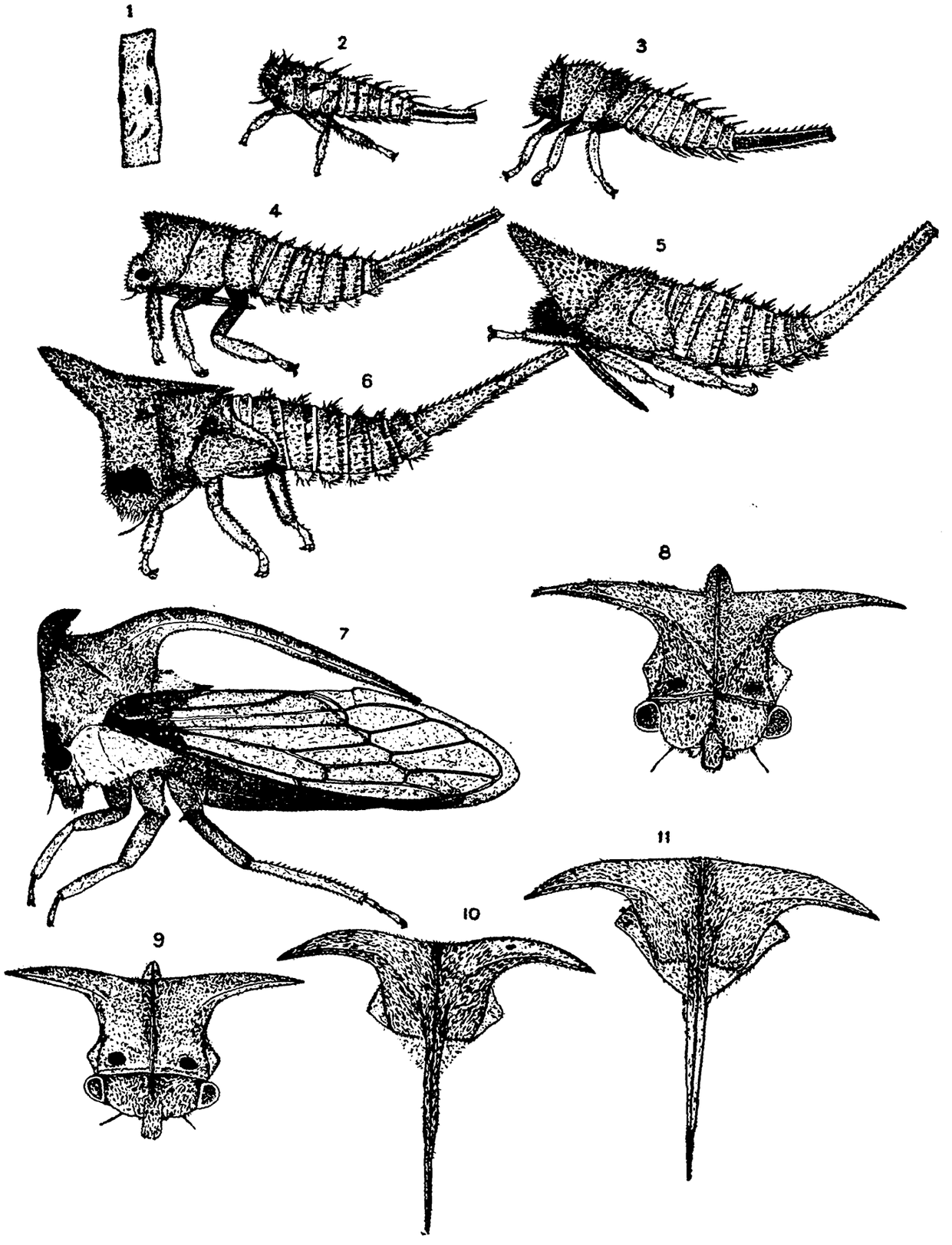
Material studied: 85 females, 50 males and numerous nymphs, Madras, on various dates during the years 1965-68.

Leptocentrus nigra n.sp.

(Text-fig. 15)

Female.—General colour black; head declivous, nearly three times as wide as long, fuscous, somewhat densely pilose with long golden hairs; vertex shallowly arcuate and sinuate at upper margin, lower margins downwardly sloping; frontoclypeus concolorous with vertex, densely pilose, extending more than two-thirds of its length beyond lower margins of vertex, basal lobes prominent, fringed with long golden yellow pilosity; eyes large, globate, reddish brown, moderately projecting laterad; ocelli jet black, a little raised, located above centro-ocular line; closer to eyes than to each other; pronotum jet black, finely punctate, with long suberect golden yellow hairs; lateral and ventral areas of sternum cretaceously sericeous; metopidium slightly higher than wide, vertical, slightly convex; supraocular callosities conspicuous, jet black, bare, somewhat oval, humeral angles prominent and blunt; suprahumeral horns black, about one and a half times longer than width between their bases, as seen from front broad, subparallel, as seen in lateral aspect a little projecting forwards just beyond middle, then obliquely curved backwards and acuminate; as viewed from above somewhat flat, basal one-third gently curved forwards and then laterad, tip sharp; posterior process stout, black, rising obliquely from disc, achieving its greatest height above middle of scutellum, then extending backwards in an almost declivous manner, apical fourth acuminate, impinging on inner margins of tegmina, reaching the extremity of 5th apical cell, distinctly tricarinate, lateral carinae extending upto middle of disc, ventrally posterior face of pronotum vertically raised up, then curving caudad into base of posterior process, median, carina strongly percurrent, finely continued through metopidium, scutellum as wide as long, basal half cretaceously sericeous, apex narrowly emarginate; tegmina 3.5 times as long as wide, shining bronzy ochraceous, extreme base smoky hyaline, distal half of costal margin, tip of 1st apical cell and the adjacent area of apical limbus shaded with black; abdominal undersurface black; legs black upto distal ends of tibiae, tarsi brown.

Measurements.—Length from frontal margin to tips of tegmina 7.7 mm., to tip of posterior process 6.4 mm., width across tips of suprahumerals 6.0 mm., at humeral angles 2.7 mm., at eyes 2.5 mm.



Text-fig. 15. *Leptocentrus nigra* n. sp.

1. Twig with egg-slits. 2. First instar nymph. 3. Second instar. 4. Third instar. 5. Fourth instar. 6. Fifth instar. 7. Adult female. 8. Frontal view of female. 9. Frontal view of male. 10. Dorsal view of pronotum and scutellum of male. 11. Dorsal view of pronotum and scutellum of female.

Male.—Similar to female, but smaller; genitalia similar to *taurus.*

Measurements.—Length from frontal margin to tips of tegmina 7.0 mm., to tip of posterior process 5.9 mm., width across tips of suprahumerals 5.2 mm., at humeral angles 2.5 mm., at eyes 2.3 mm.

Fifth instar nymph.—Closely resembling that of *taurus,* differing in the relative length of anal tube to abdomen and also in the nature of pronotal processes. General colour green; head much inclined backwards, rostral tip extending to 2nd abdominal segment; head densely pilose with long tuberculate bristles, base of vertex nearly truncate; eyes reddish brown; ocelli closer to eyes and located on the centro-ocular line; thorax with metopidium vertical, sprinkled with small tuberculate spines; anterior process of pronotum gradually tapering to an acute tip, directed forwards and upwards; posterior process extending over the entire length of mesonotum, tip acute; suprahumeral buds small, concolorous with metopidium; abdominal segments somewhat attenuated; dorsal tuberculate spines suberect, lateral lamellae crescentic, each lamella bordered with 7 to 9 slender spines; anal tube shorter than the combined length of abdominal segments 1-8.

L. nigra comes nearest to *taurus* from which it differs in the jet black colour, denser pilosity, in the nature of the metopidium which is higher than wide, the strongly abruptly elevated base of posterior process which never extends beyond the 5th apical cell of tegmina.

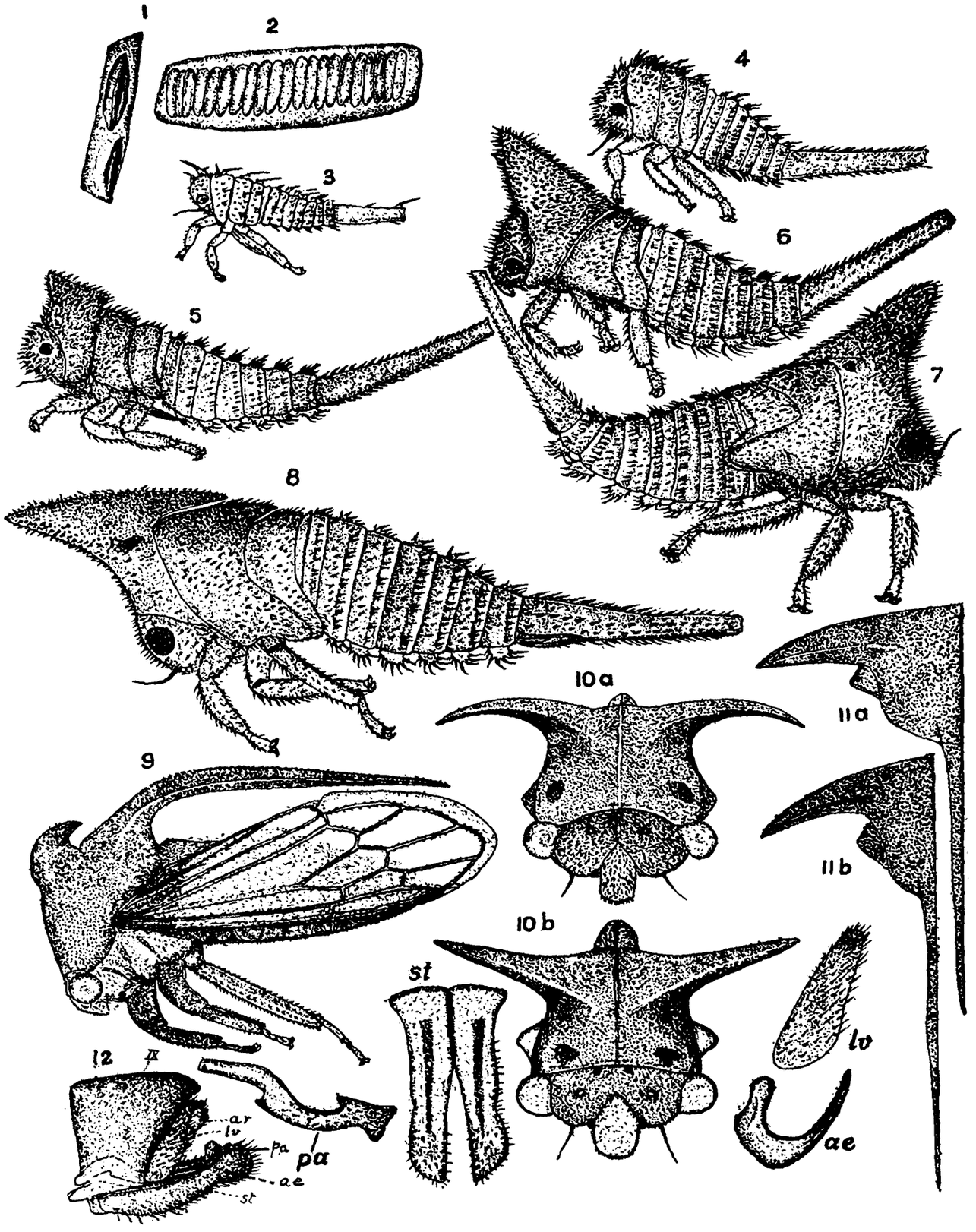
Host plant.—Phyllanthus sp.

Holotype female; 15 female, 6 male paratypes, 10 nepionotypes, Madras, 10.v.1968.

Leptocentrus bauhiniae n.sp.

(Text-fig. 16)

Female.—General colour dark brown. Head nearly thrice as wide as long, vertex arcuate, declivous, finely punctate, black, with more or less closely arranged suberect yellowish hairs; eyes reddish brown with shades of black at centre, ocelli located above centro-ocular line, closer to eyes than to each other; frontoclypeus declivous, with yellow pilosity, extending nearly two-thirds of its length below lower margins of vertex, tip rounded, basal lobes not prominent. Pronotum black, finely punctate, with more or less recumbent yellowish pilosity, metopidium vertical, wider than high, supraocular callosities bare, distinct, humeral angles prominent, tips blunt; suprahumeral horns black, sparsely pilose, strongly quadricarinate, carinae jet black as viewed in lateral aspect slightly projecting forward, as viewed in front, extending outwards and gently curved backwards, as viewed from above, much broader with acute tips. Posterior process punctate at base, black, rising well above disc., gradually sloping backwards achieving its maximum height above posterior end of scutellum, somewhat straight upto half of its length, then slightly declivous, apical fourth tapering, reaching almost the extremity of 4th apical cell of tegmina but never impinging on inner angles of the same, tip sharp; median carina percurrent, continued through metopidium as a fine streak; tegmina three times as long



Text-fig. 16. *Leptocentrus bauhiniae* n. sp.

1. Egg-slits on host stem. 2. Egg slit cut open. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar, male. 8. Fifth instar, female. 9. Adult female. 10a, Frontal view of female. 10b, Frontal view of male. 11a. Dorsal aspect (left half) of pronotum of male. 11b. Dorsal aspect (left half) of pronotum of male. 12. Male genitalia, lateral view,

as broad, shining, pale bronzy ochraceous, apex of costal margin smoky black, base somewhat black, coriaceous and punctate; scutellum nearly as long as broad at base, white tomentose at basal half; coxae, trochanters and proximal three-fourths of femora black, rest of femora and tibiae castaneous, tarsi yellowish brown; abdomen black, sparsely pilose.

Measurements.—Length from frontal margin to tips of tegmina 6.2 mm., to tip of posterior process 5.75 mm., width across tips of suprahumerals 5.0 mm., at humeral angles 2.6 mm., at eyes 2.5 mm.

Male.—Similar to female but slightly smaller; genitalia similar to *taurus*, but with lateral valves narrowly rounded at base, widest at one-third the distance from base, process short, not conspicuously demarcated from main body, fringed with short hairs; sternal plates forked slightly more than half of its length, forked ends divergent.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 5.5 mm., width across tips of suprahumerals 4.5 mm., at humeral angles 2.4 mm., at eyes 2.2 mm.

Fifth instar nymph.—Similar to that of *bajulans* in the general coloration but differing in the relative lengths of pronotal processes, very small suprahumeral buds and suberect abdominal dorsal tuberculate spines which are not adpressed to body. Head sparsely pilose with short bristles, vertex slightly sinuate, eyes prominently reddish brown; ocelli closer to eyes and located along the centro-ocular line; metopidium obliquely extending forwards and produced as anterior crest which is nearly horizontal and slightly inclined downwards; pronotal posterior process less than half as long as anterior process; suprahumeral buds very small and inconspicuous, dorsal tuberculate spines of abdomen prominent, suberect, inclined backwards; lateral lamellae typical to genus, semicircular, 8 or 9 spines bordering each lamella, subspines inconspicuous; anal tube as long as rest of abdomen; genitalic rudiments prominent, sternal plate black.

Sexual dimorphism is found in the 5th instar nymphs of this species. While the above description applies to the female, the male differs in the peculiar disposition of the pronotal anterior process which is obliquely directed upwards and forwards, the suprahumeral buds very inconspicuous, the abdominal tip raised upwards and the genital rudiments distinct from those of female.

Host plant.—Bauhinia tomentosa.

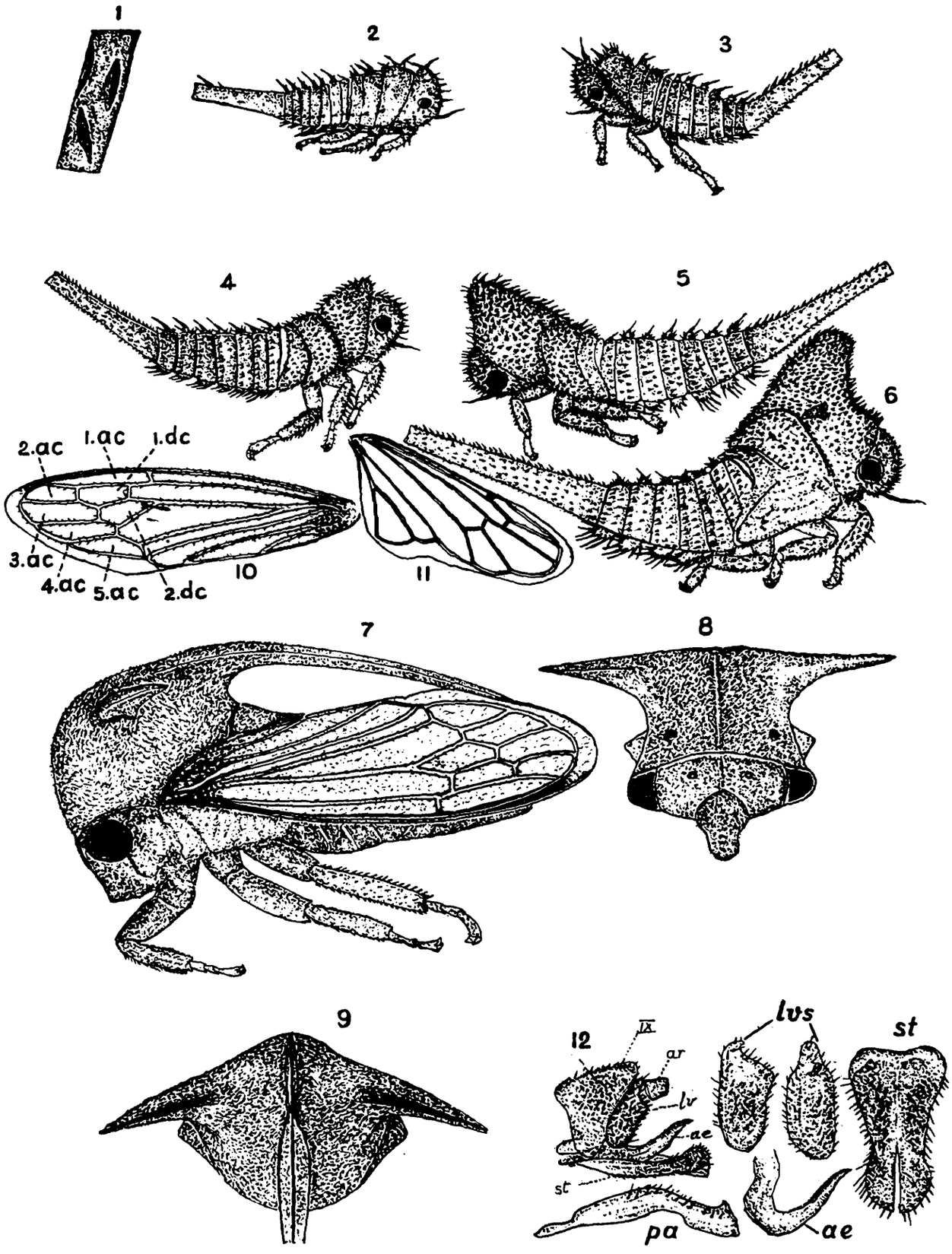
Holotype female; allotype male, paratype 75 females, 35 males, 20 nepionotypes, Madras, August to November, 1968.

The species is nearest to *taurus*, but differing in the nature of the posterior process the distal fourth of which is straight and acuminate, its tip never impinging on the inner angles of tegmina.

Leptocentrus moringae n.sp.

(Text-fig. 17)

Female.—General colour greyish brown; head declivous, nearly 3 times broader than long, vertex broadly convex at base, greyish white,



Text-fig. 17. *Leptocentrus moringae* n. sp.

1. Egg slits on host stem. 2. First instar. 3. Second instar. 4. Third instar. 5. Fourth instar. 6. Fifth instar. 7. Adult female. 8. Frontal view. 9. Dorsal view of pronotum. 10. Tegmina. 11. Hind wing. 12. Male genitalia, lateral view.

with scattered pilosity; eyes scarlet brown, globose, projecting slightly laterad, ocelli black, nearer to eyes than to each other and located distinctly above the centro-ocular line; frontoclypeus densely pilose, extending over two-thirds of its length beyond lower margins of vertex, basal lobes inconspicuous, whitish tomentose, free end broadly rounded; pronotum greyish dorsally; lateral areas of sternum and basal half of scutellum cretaceously sericeous; metopidium slightly broader than high, greyish with sparsely distributed hairs, convex and slightly obumbrant; supraocular callosities not prominent; humeral angles moderate, broadly conical, tips subacute; suprahumerals shorter than width between their bases, as seen in front slender, horizontal, directed outwards, gradually tapering, tips acute, carinae chestnut brown, as seen from above gradually arched backwards beyond middle, viewed from lateral aspect distal one-third of suprahumerals directed backwards, lateral carinae fine; posterior pronotal process slender, tricarinate, slightly raised from disc and obliquely arched to the tip, apex acute, impinging on inner tegminal margins, reaching upto the 4th apical cell; tegmina nearly 3 times longer than wide, hyaline except at apical fourth of costal margin which is fuscous, basal part somewhat darker and coriaceous; abdomen greyish above, lower surface sparingly cretaceously sericeous; ovipositor dark brown; tibiae reddish brown, tarsi light yellow.

Measurements.—Length from frontal margin to tips of tegmina 6.5 mm., to tip of posterior process 5.6 mm., length of suprahumeral 1.5 mm., width across tips of suprahumerals 4.5 mm., at humeral angles 2.5 mm., at eyes 2.4 mm.

Male.—Similar to female. Length from frontal margin to tips of tegmina 6.2 mm., to tip of posterior process 5.3 mm., length of horn 1.4 mm., width across tips of suprahumerals 4.5 mm., at humeral angles 2.4 mm., at eyes 2.2 mm.

Fifth nymphal instar.—Resembling *major* in the shape of the pronotal crest, but differing in the smaller size and much longer anal tube. General colour deep green; head obliquely directed caudad; vertex strongly sinuous with much reduced cranial tubercules; base of tuberculate spines dark-brown; spines on upper margin of vertex closely arranged; eyes reddish brown; ocelli dull white, inconspicuous, equidistant to each other and from eyes, located on the centro-ocular line; frontoclypeus extending a little below the lower margins of vertex; antennae as long as width of frontoclypeus; pronotum, with metopidium as high as long, slightly receding in front and curving forwards and upwards to form the anterior extension of pronotal crest, ending in a broadly rounded tip with thickly arranged spines; pronotal posterior process half as long as anterior process, extending over three-fourths of the length of mesonotum; suprahumeral buds moderate, dark brown at base; mesonotal process extending backwards over the entire length of metanotum; wing pads green with brown dots, faintly revealing the imaginal veins, costal angles not distinct; abdominal segments 1-8 somewhat telescoped, slightly exceeding two-thirds of the length of anal tube; dorsal tubercles dark-brown, longer spines suberect, smaller ones adpressed to body; lateral lamellae with 7 or 8 slender spines; anal tube very long, much longer than rest of abdomen.

Host plant.—Moringa moringa.

Holotype female; 32 female and 19 males paratypes, 20 nepionotypes, Madras, 20.x.1967.

This species is allied to *obortus* Distant in the nature of suprahumerals which are horizontal, obliquely narrowed with tips acute and carinate, the black costal area and the white tomentose lateral areas of sternum, but differing in the coloration of body, in the suprahumerals which are never directed upwards, and the cretaceously sericeous nature of the abdominal sternites.

Key to species of **Leptocentrus** Stål *based on Fifth instar nymphs*

1 (9) Anterior process of pronotum broadly rounded with obtuse tip.

2 (7) Length of abdominal segments 1-8 equal or almost equal to length of anal tube.

3 (6) Body light reddish brown; anal tube as long as the rest of abdomen.

4 (5) Pronotal anterior process shorter than posterior process; tibiae banded. .. ..*rhizophagus* n.sp.

5 (4) Pronotal anterior process as long as or longer than posterior process; tibiae not banded.. .*mangiferae* n.sp.

6 (3) Body pale brown; pronotal anterior process one and a half times as long as posterior process.. .*major* n.sp.

7 (8) Length of abdominal segments 1-8 greater than length of anal tube; anterior pronotal process two and a half times as long as posterior process; tuberculated spines on abdominal lateral lamellae slender with tendency for branching.. .*leucaspis* Walker.

8 (7) Length of abdominal segments 1-8 less than length of anal tube; anterior pronotal process twice as long as posterior process; tegminal venation distinct.. .*moringae* n.sp.

9 (1) Anterior process of pronotum gradually tapering to an acute or subacute tip.

10(15) Length of abdominal segments 1-8 equal or almost equal to length of anal tube.

11(14) Body coloured leafy green; moderately hairy; dorsal tuberculated spines of abdomen inclined backwards, often adpressed to the body.

12(13) Pronotal anterior process twice as long as posterior process; suprahumeral buds well developed; dorsal tuberculated spines of abdomen adpressed to body.. ...*bajulans* Dist.

13(12) Pronotal anterior process more than twice as long as posterior process; suprahumeral buds short and inconspicuous; dorsal tuberculate spines of abdomen inclined backwards. .*bauhiniae* n.sp.

14(11) Body coloured light reddish brown; densely hairy; dorsal tuberculate spines of thorax and abdomen long and erect or suberect; pronotal anterior process nearly six times as long as posterior process, tip acute; spines on abdominal lateral lamellae slender and curved backwards.. .*varicornis* n.sp.

15(16) Length of abdominal segments 1-8 distinctly longer than anal tube; pronotal anterior process nearly one and a third times as long as posterior process. *nigra* n.sp.

16(15) Length of abdominal segments 1-8 about three-fourths the length of anal tube; pronotal anterior process nearly 3 times as long as posterior process. *taurus* Fabr.

Genus **Telingana** Distant

(Type of the genus *Leptobelus curvispinus* Stla)

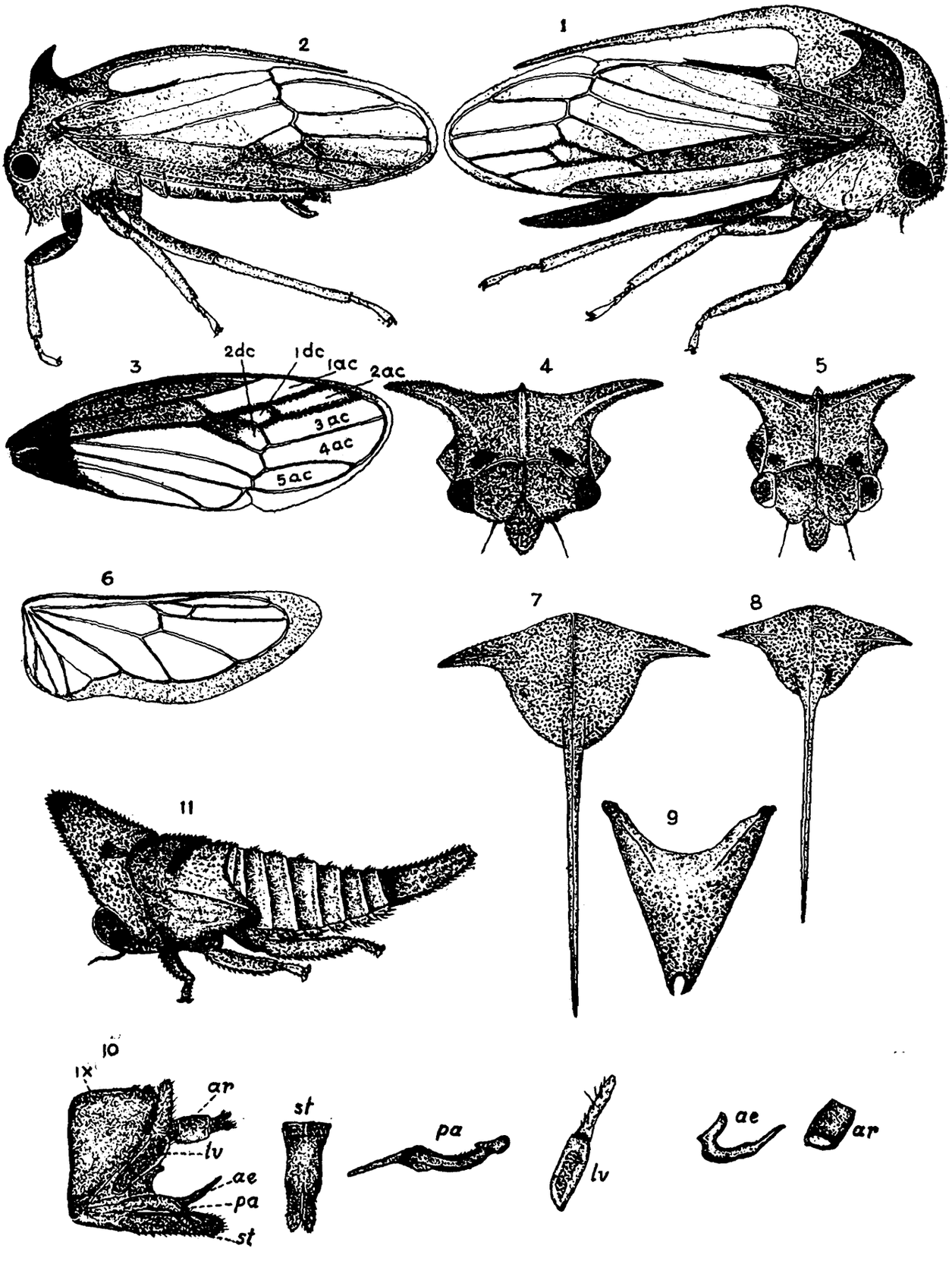
1869. *Leptobelus* Stål, *Ofv. Vet. Ak. Forh.* 284.
1908. *Telingana* Distant, *Fauna Brit. India*, **4**: 17.

Head vertical, two and a half to three times wider than long, upper margin of vertex slightly arcuate; eyes subglobate; ocelli closer to eyes than to each other and located on or above c-o-line; frontoclypeus extending two-thirds to three-fourths of its length below lower margins of vertex, tip broadly rounded, frontoclypeal lobes entirely fused; disc of pronotum not or slightly elevated; metopidium one and a half to two times wider than high; humeral angles prominent and blunt; suprahumeral horns variable; posterior process slender, tricarinate, emerging from posterior half of pronotum, moderately arcuate, distant from scutellum and tegmina, extending beyond apex of clavus, usually impinging on tegminal inner margins; scutellum much longer than broad, apex deeply excavated, tip acute; tegmina three times longer than wide, without pterostigma, with five apical cells, the first apical cell three to five times longer than broad; hind wings with four apical cells. Male genitalia almost similar to that of *Leptocentrus*, but differing in the lateral valves with the process very long and unchitinised.

Telingana nigroalata n.sp.

(Text-fig. 18)

Female.—General colour pitch black; head vertical, about 2.3 times as wide as long, black, lightly shaded to dark brown on genae, finely punctate with very short adpressed silvery white hairs; upper margin of vertex sinuate and weakly concave, lower margins broadly rounded at lateral angles; eyes black or dark brown, subglobate, ocelli black, somewhat elevated, slightly closer to eyes than to each other and located well above centro-ocular line; frontoclypeus nearlyr homboidal with two-thirds of its length extending below lower margins of vertex, lateral lobes entirely fused, tip obtusely rounded, fringed with pale white hairs. Pronotum shining black with shades of dark brown, thickly coarsely punctate, with rather sparse short adpressed silvery white hairs; metopidium almost vertical, twice as high as wide; supraocular callosities conspicuous, pitch black, bare; humeral angles concolorous with disc, tips blunt; disc convex at middle, distinctly punctate and sparsely hairy; suprahumeral horns shorter than intervening space, as seen from above slender, curved, weakly carinate just behind middle, apices acute, as viewed in front slender, long, gently recurved with strong carinae, as viewed laterally slightly directed upwards, then outwards with acute tips curved backwards; posterior process slender, curved and slightly elevated at base, remote from scutellum, declivous, slightly sinuate at middle, apex nearly acute, almost touching tegmina near posterior angle of inner margin but not impinging on them, tricarinate, dorsal carina strongly percurrent through pronotum. Tegmina 3 times longer than wide, with apical area shining ochraceous, subapical area somewhat stramineous, basal sixth black and coriaceous, the whole of costal



Text-fig. 18. *Telinguna nigroalata* n. sp.

1. Adult female. 2. Adult male. 3. Tegmina of female. 4. Frontal view of female. 5. Frontal view of male. 6. Hind wing. 7. Dorsal view of pronotum of female. 8. Dorsal view of pronotum of male. 9. Scutellum. 10. Male terminalia, lateral view.

margin, subcostal and basal areas, half of 2nd discoidal cell, and claval area jet black and strongly punctate, veins pale brown with the exception of R1, R2+3, R4+5, rs and 3rd anal cell which are black and finely punctate; hind wings with four apical cells; scutellum black except at bases, longer than wide, tip deeply excavated, lateral areas coarsely punctate; lateral margins of pronotum, sternum and dorsolateral areas of scutellum cretaceously sericeous; legs with coxae, trochanters, and femora jet black, tibiae of first and second pairs of legs more or less dark ochraceous, posterior tibiae very light brown, tarsi of all legs light brown. Abdomen black, ovipositor dark reddish brown.

Measurements.—Length from frontal margin to tips of tegmina 6.75 mm., to tip of posterior process 5.50 mm., width across tips of suprahumeral horns 3.9 mm., at humeral angles 2.5 mm., at eyes 2.0 mm.

Male.—Smaller; similar to female in general colour; suprahumeral horns shorter, directed more prominently upwards, slightly recurved with tips turned backwards; metopidium one and a half times as high as wide; posterior process not sinuate, obliquely directed backwards; its tip reaching the middle of fifth apical cell of tegmina; coloration of legs as in female.

Measurements.—Length from anterior pronotal margin to tips of tegmina 5.9 mm., to tip of posterior process 4.9 mm., width across tips of suprahumeral horns 2.7 mm., at humeral angles 2.3 mm., at eyes 1.75 mm.

Fifth instar nymph.—General coloration light green with shades of grey; legs with tibiae greyish brown; head inclined backwards, rostrum reaching metasternite; cranial tubercules obsolete; eyes prominent, black, ocelli obscure; length of thorax more or less equal to abdomen excluding anal tube; pronotal anterior process obliquely directed forwards, tip blunt, tuberculate spines on pronotal crest very short; posterior process short, about one-fifth as long as anterior process; suprahumeral buds prominent, dark brown, mesonotal process extending over basal half of metanotum; wing pads well developed reaching upto third abdominal segment, costal angles well demarcated; abdominal dorsal tubercles with their spines much reduced; latero-dorsal tubercles turned caudad; anal tube about one-fifth of the total body length and almost equal to the combined length of the four preceding segments.

Host plants.—*Agapanthus umbellatus.*

Holotype female; 205 female and 25 male paratypes, many nymphal instars, Kodaikanal, Madras, 16.vi.1968.

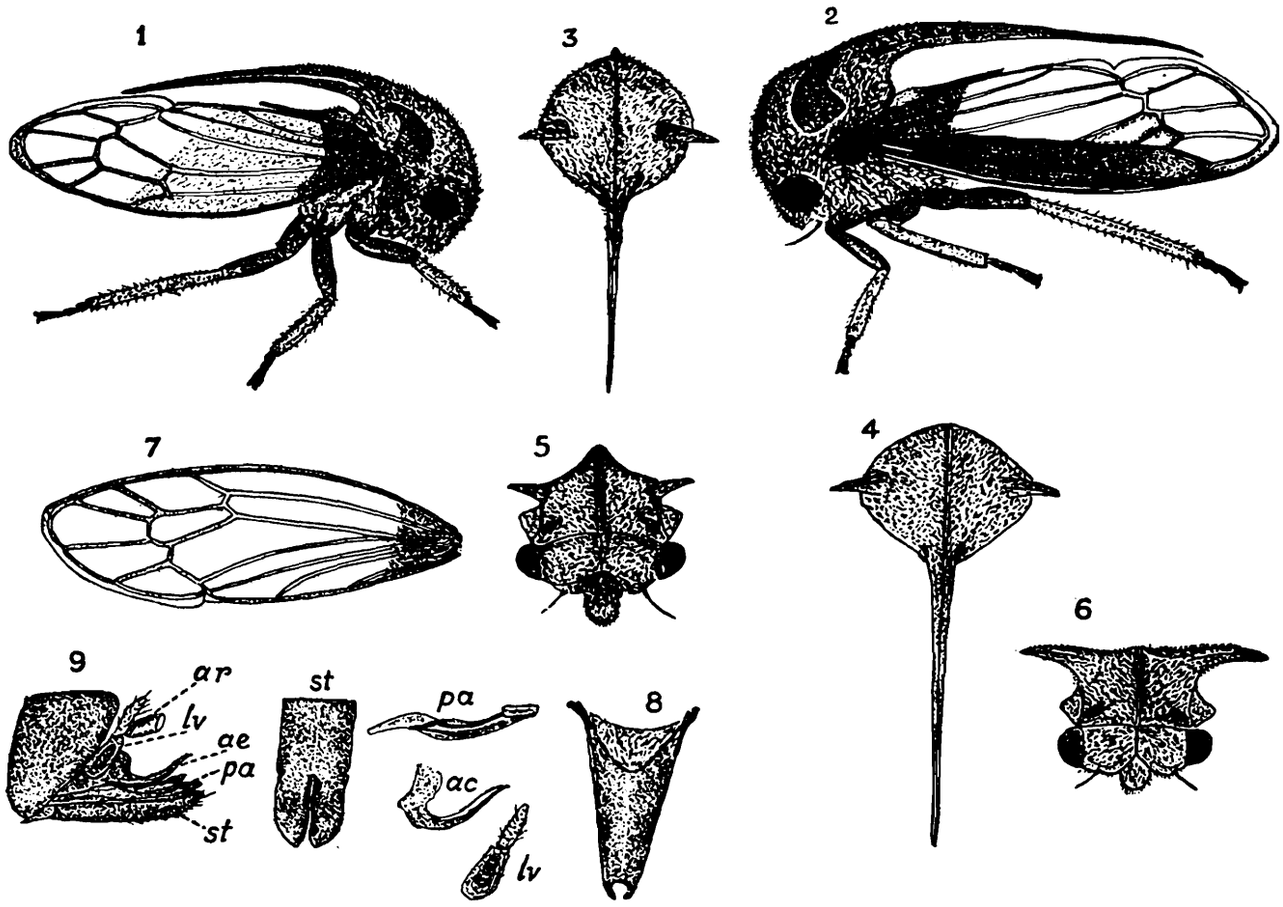
This species is very close to *curvispina* (Stål), differing in the tegminal coloration and the black finely punctate nature of R1, R2+3, R4+5 and 2nd discoidal cell.

Telingana consobrina Distant

(Text-fig. 19)

1916. Distant, *Fauna Brit. India, Append.* **6:** 152.

Distant's (1916) description and figures agree well to the males of this strikingly dimorphic species, the females closely resembling *T. nigroalata.* A more detailed description is given below.



Text-fig. 19. *Telingana consobrina* Distant

1. Adult male. 2. Adult female. 3. Dorsal view of pronotum of male. 4. Dorsal view of pronotum of female. 5. Frontal view of male. 6. Frontal of female. 7. Tegmina of male. 8. Scutellum of female. 9. Male terminalia, lateral view.

Male.—General colour black. Head nearly vertical, about thrice as wide as long, finely punctate, with short silvery hairs; upper margin of vertex sinuate, lower margins broadly rounded; eyes dark brown, ocelli shining white, nearer to eyes than from each other, located above c-o-line, frontoclypeus parallel sided, with two-thirds of its length extending below lower margins of vertex, lateral lobes entirely fused, tip broadly rounded. Pronotum black, often shaded to dark brown, coarsely punctate with sparsely distributed short whitish hairs; metopidium wider than high; strongly convex and obliquely extending backwards; humeral angles short, blunt, never projecting laterad beyond eyes; suprahumeral horns arising from about middle of disc, shorter than width between their bases, viewed from above short, slender, directed outwards and a little backwards, viewed from front much narrower, tips acute, directed slightly upwards. Posterior process obliquely raised from disc, very slender, tricarinate, tip acuminate impinging on tegmina, reaching the middle of 5th apical cell of tegmina, median carina strongly percurrent throughout metopidium, Tegmina hyaline, three times longer than wide, basal sixth coriaceous and ochraceous, veins reddish brown, apical veins darker, five apical cells and one dis-

coidal cell, first apical cell three times longer than wide, apical limbus narrow. Scutellum nearly one and three-fourths as long as wide, coarsely punctate; lateral areas of pronotum, sternum and basal lateral parts of scutellum cretaceously sericeous. Abdomen black beneath, dark ochraceous brown above.

Measurements.—Length from frontal margin to tips of tegmina 4.8 mm., to tip of posterior process 3.6 mm., width across tips of suprahumeral horns 2.0 mm., at humeral angles 1.7 mm., at eyes 1.8 mm.

Female.—General colour black; head about 2.5 times wider than long, punctate with silvery pilosity, base of vertex sinuate, lower margins very slightly rounded, eyes dark brown; ocelli black, closer to eyes than to each other and located slightly above centro-ocular line; frontoclypeus slightly convex, about two-thirds of its length extending below lower margins of vertex, lateral lobes fused, tip obtusely rounded, fringed with short whitish hairs. Pronotum black, shining, closely punctate, hairy; metopidium nearly vertical, supraocular callosities small but distinct, humeral angles short, not extending beyond eyes laterally, tips subacute; suprahumeral horns seen from above slender, shorter than the space between bases, directed outwards and backwards, apices acute; posterior process arising from hind end of disc, slightly sinuate beyond middle, turned downwards, passing over the entire length of 5th apical cell of tegmina. Tegmina shining ochraceous, a little more than three times longer than wide, basal fourth jet black and finely punctate, whole of costal margin, subcostal, basal and claval areas, basal three-fourths of 1st apical cell and veins bordering 1st discoidal cell jet black and finely punctate, 1st discoidal cell petiolate, 1st apical cell about three and a half times longer than wide; lateral areas of pronotum and sternum cretaceously sericeous. Legs fuscous upto base of tibiae, rest ochraceous; hind tibiae light brown. Abdomen black beneath, shaded to dark brown dorsally.

Measurements.—Length from frontal margin to tips of tegmina 6.4 mm., to tip of posterior process 5.3 mm., width across tips of suprahumeral horns 2.9 mm., at humeral angles 2.5 mm., at eyes 1.8 mm.

Fifth instar nymph.—Similar to the 5th instar of *nigroalata*, but smaller. General colour deep green; cranial tubercules distinct, small; ocelli invisible; tip of rostrum extending upto 2nd abdominal segment; thoracic tubercles short, each terminating in a stout spine; pronotal anterior process directed forwards, its tip broadly rounded; suprahumeral buds distinct; posterior process extending over basal of metanotum; costal angles of wing pads not distinctly demarcated; abdominal dorsal tubercles and lateral lamellae similar to those of *nigroalata*. Anal tube one-fifth of the total length of body.

The fifth instar of *consobrina* differs from that of *nigroalata* chiefly in the much reduced pronotal posterior process and in the nature of costal angles of tegminal wing pads which are not distinctly demarcated.

Host plant.—*Aspidium* sp.

Material studied: 10 females, 3 males and 12 nymphs, Kodaikanal, Madras, 16.vi.1967.

Genus **Otinotus** Buckton

(Type of genus *Otinotus ammon* Buckton)

1903. *Otinotus* Buckton, *Mon. Memb.*, 232, 269.

1927. *Convector* Fuankhouser, *Gen. Cat. Hom. Fasc.* 1: 348.

Head wider than long, upper margin of vertex shallowly arcuate and weakly sinuate, lower margins slightly oblique to frontoclypeus and weakly rounded or sinuate; ocelli nearly equidistant from each other and from eyes and located on the centro-ocular line or slightly above it; frontoclypeus about twice as long as wide, its lobes short; pronotum moderately high metopidium convex, humeral angles prominent; median carina percurrent; suprahumeral horns short or long, spatulate or subtriangular, tips acute or obliquely truncate, tricarinate or quadricarinate; posterior process emerging dorsally horizontally from behind disc and ventrally from posterior margin, tricarinate, weakly undulate and contiguous with or very close to scutellum and tegmina; scutellum triangular, wider than long, tip concavely emarginate; tegmina about three times as long as wide, without pterostigma, with five apical and two discoidal cells, the first apical cell four to eight times as long as its greatest width; hind wings with 4 apical cells.

Key to species

1(4) Suprahumerals unicarinate above, tips acute; tegmina not pubescent, second discoidal cell slightly longer than first discodial cell; male genitalia, with process of lateral valve rudimentary; ocelli located above c-o-l.

2(3) Piceous brown; suprahumerals directed obliquely forward; tegmina pale testaceous hyaline, base without a white spot, first apical cell 7 times longer than wide; tip of posterior process extending far beyond fifth apical cell. .*oneratus* (Walker).

3(2) Castaneous brown; suprahumerals subhorizontal, tegmina shining ochraceous, base enclosing a large white spot, first apical cell four and half times as long as wide; tip of posterior process never extending beyond fifth apical cell. .*mimicus* Distant.

4(1) Suprahumerals bicarinate above, tips obliquely truncate; tegmina ferruginous, pubescent, second discoidal cell twice or more as long as 1st discoidal cell; malegenitalia, with process of lateral valve long and prominent; ocelli located on c-o-l.

5(6) Suprahumerals subhorizontal, as long as space between bases..*indicatus* (Melichar).

6(5) Suprahumerals directed obliquely forward, slightly longer than space between bases. ... ..*obliquus* n.sp.

Otinotus oneratus (Walker)

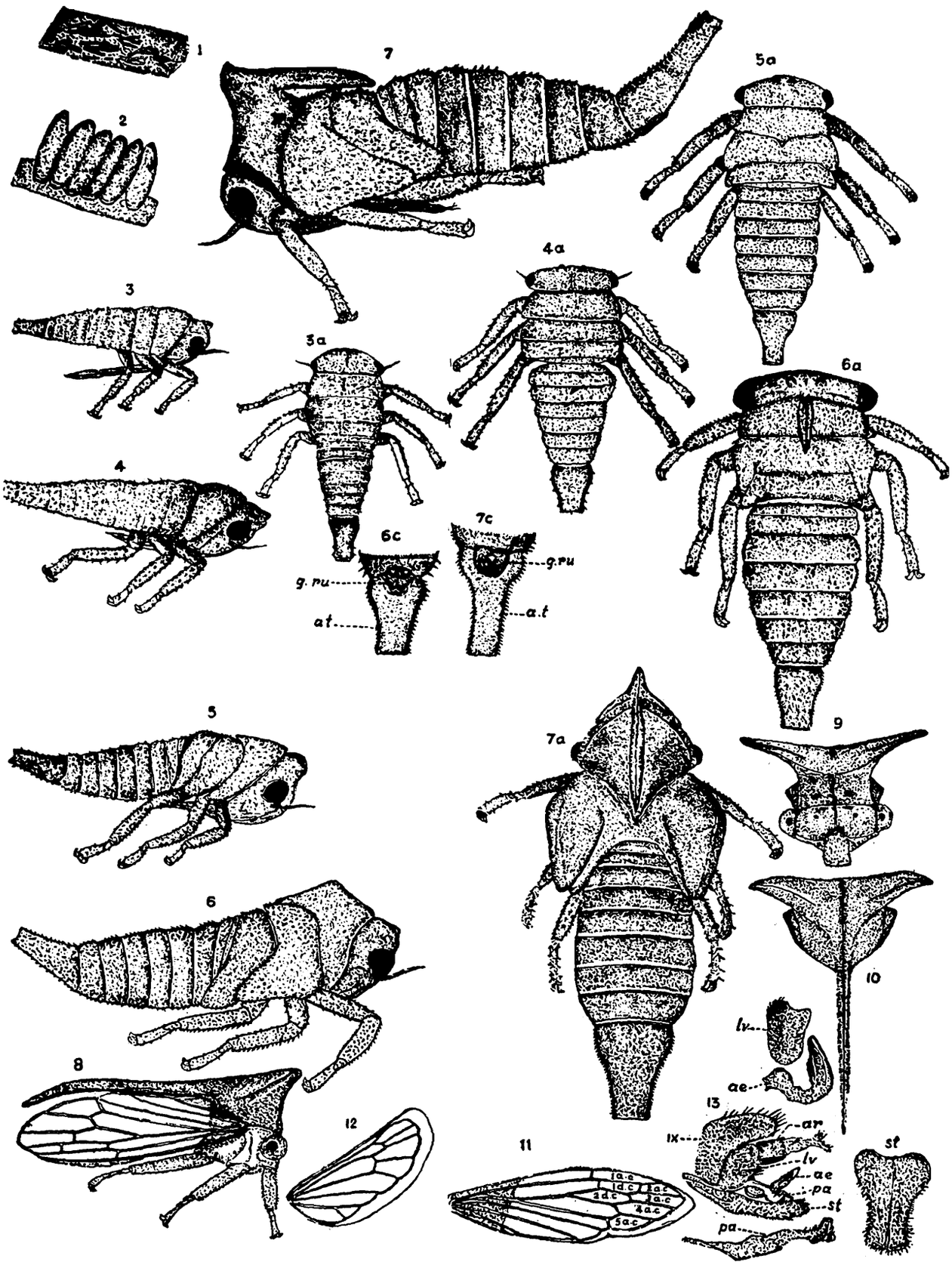
(Text-fig. 20)

1858. *Centrotus oneratus* Walker, *Ins. Saund. Hom.*: 78.

1869. *Centrotypus oneratus:* Stål, *Ofv. Vry.-Ak. Forh.*: 256.

1903. *Oxyrhachis lignicola* Buckton, *Monogr. Membr.*: 261.

1908. *Otinotus oneratus:* Distant, *Fauna Brit. India*, **4**: 40.



Text-fig. 20. *Otinotus oneratus* (Walker)

1. Egg masses on host stem. 2. An egg mass. 3. First instar nymph, lateral view. 3a. First instar nymph, dorsal view. 4. Second instar, lateral view. 4a. Second instar, dorsal view. 5. Third instar, lateral view. 5a. Third instar, dorsal view. 6. Fourth instar, lateral view. 6a. Fourth instar, dorsal view. 7. Fifth instar, lateral view. 7a. Fifth instar, dorsal view. 8. Adult female. 9. Frontal view of female. 10. Dorsal view of pronotum. 11. Tegmina. 12. Hind wing. 13. Male terminalia, lateral view.

Female.—General colour castaneous brown, varying to brownish ochraceous in some specimens; head finely punctate, greyish pilose, nearly thrice as wide across extremities of eyes as length of vertex; vertex nearly twice as wide as long, base of vertex shallowly arcuate, lower margins oblique to frontoclypeus; eyes hemispherical, reddish brown; ocelli a little elevated, almost equidistant from each other and from eyes and located just above centro-ocular line; frontoclypeus twice as long as wide, sides parallel, distal half projecting beyond lower margins of vertex, tip truncate, longly pilose, basal lobes small, indistinct; pronotum dark brown, with short adpressed hairs; metopidium slightly convex, twice as wide as high, humeral angles broadly conical, tips obtuse, posterior angles rounded; supraocular callosities black, bare; suprahumeral horns longer than space between bases, viewed from above centrally carinate, flattened, basal areas of horns darker, thickly pilose, viewed from front appearing slender, gradually narrowing from base to apex, turned outwards and obliquely forwards, tips slightly recurved; posterior process slender, gradually narrowing from base to apex, turned outwards arising from posterior margin of disc, tricarinate, weakly sinuate, almost contiguous with scutellum and impinging on inner margins of tegmina, in some specimens posterior half slightly elevated over tegmina, apex sharp and extending beyond fifth apical cell of tegmina; dorsal carina of posterior process strongly percurrent through metopidium, lateral carinae weak; tegmina thrice as long as wide, pale semi-hyaline, basal sixth opaque and punctate, first apical cell seven times longer than its greatest width, second discoidal cell slightly longer than first discoidal cell; hind wings with four apical cells; scutellum slightly broader than wide, tip emarginate, apices acute; lateral areas of scutellum and sternum cretaceously sericeous; abdomen dark brown; legs dark brown upto distal half of femora, tibiae light brown, tarsi pale white.

Measurements.—Length from frontal margin to tips of tegmina 5.5-7.0 mm., to tip of posterior process 5.0-6.3 mm., width across tips of suprahumerals 2.9-3.5 mm., at humeral angles 2.2-2.4 mm., at eyes 2.0-2.2 mm.

Male.—Smaller; general coloration greyish brown; suprahumeral horns longer, more divergent, apical region more strongly recurved, tips acute; abdomen slender and gradually tapering; genitalia, with sternal plate forked at distal half, lobes distinct, base nearly twice as broad as tip; aedeagus U-shaped, tip obtusely rounded, inner margin strongly serrate, the teeth arranged in 4 rows; lateral valves oblong, about 1.75 times longer than broad, process reduced to a short strongly chitinised stump; parameres similar to those of *Leptocentrus*.

Fifth instar nymph.—Body laterally compressed; general coloration reddish-brown, but variable, rarely light green; head concealed from above by pronotal process, twice as wide as long, base of vertex sinuate, cranial tubercules obsolete; ocelli closer to eyes than to each other and located slightly above centro-ocular line; rostral tip extending a little beyond middle of metathorax; metopidium receding, then curving forwards into the pronotal crest; pronotal posterior process tricarinate, emerging from base of crest; and extending over three-fourths the length of mesonotum, median carina percurrent through anterior process

which is short, about one-fourth as long as posterior process; suprahumeral buds marked off as rounded prominences; mesonotum subquadrate, wing pads extending backwards upto the posterior margin of 2nd abdominal segment; costal angles obtuse; abdominal tergites sparsely hairy, anal segment about one-fourth as long as body, with closely set bristles; genital rudiments distinct in both sexes.

Host plants.—*Prosopis spicigera, Acacia arabica, Cestrum diurnum, Zizyphus jujuba, Bauhinia variegata, B. purpurea, Erythrina indica, Capparis sepiaria, Cassia angustifolia, Cassia fistula, Cassia marginata, Caesalpinia pulcherrima, C. coriaria, Peltophorum* sp., *Psidium guajava, Tamarindus indicus, Pongamia glabra, Butea frondosa, Enterolobium saman, Pithecolobium dulce, Aegle marmelos, Feronia elephantum, Morinda tinctoria, M. citrifolia, Moringa moringa, Thespesia populneu, Sesbania grandiflora, Lagerstroemia flosreginae, Terminalia catappa, Lawsonia alba, Crotalaria* sp., *Solanum torvum, Casuarina equisetifolia,* Prop roots of *Fiscus bengalensis.*

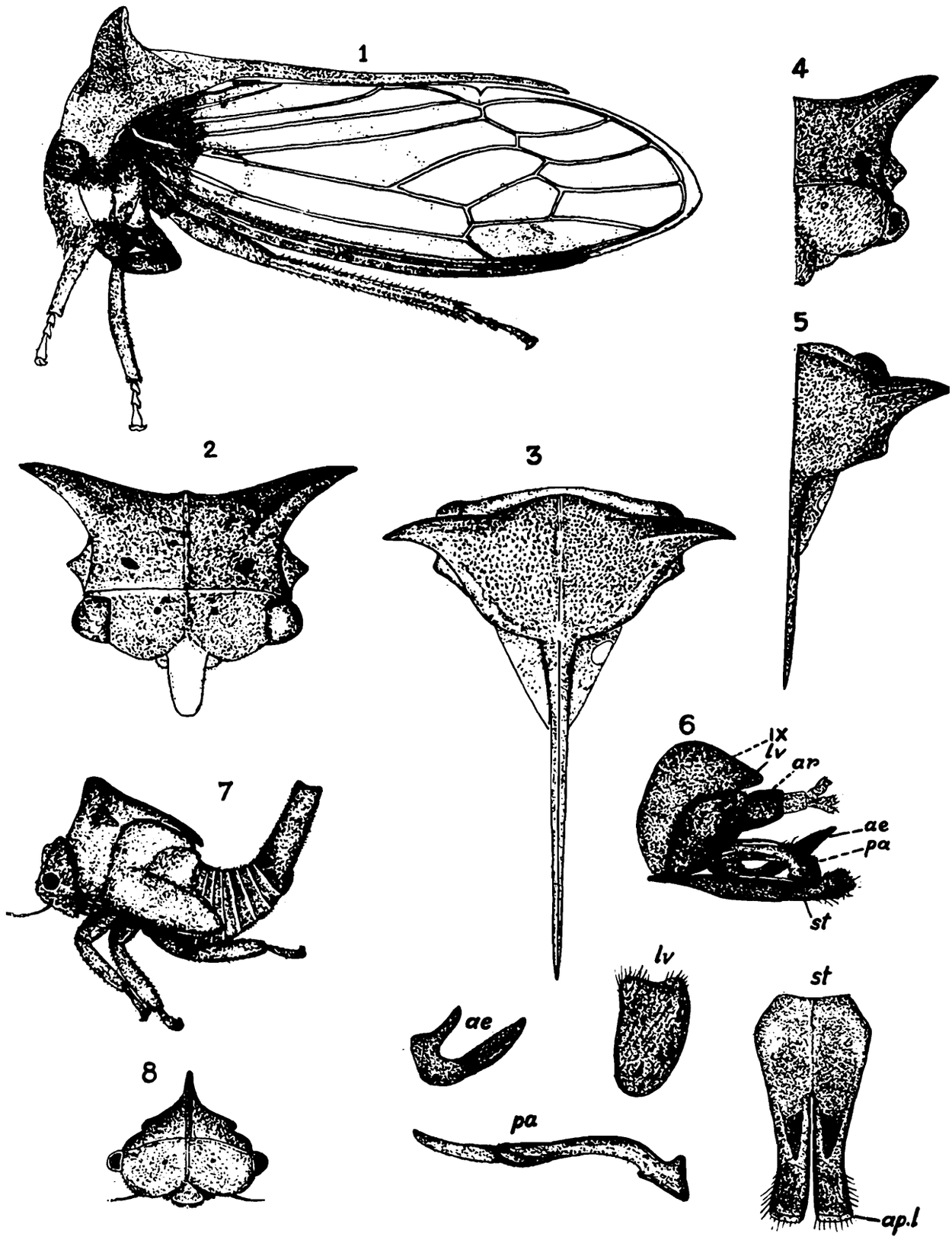
Material studied.—170 females, 80 males and numerous nymphs of all stages, Madras, different dates during the years 1964-67.

Otinotus mimicus Distant

(Text-fig. 21)

1916. *Otinotus mimicus* Distant, *Fauna Brit. India, Append.* **6**: 159.

Female.—General coloration dark reddish brown; head dark brown, slightly declivous, about 3.5 times wider than long, very finely punctate with short adpressed shining white hairs, upper margin almost planate, lower margins obliquely sloping to frontoclypeus; eyes dull white, subglobate, ocelli pale white, almost equidistant from each other and from eyes, and located slightly above centro-ocular line; frontoclypeus extending about three-fourths its length below lower margins of vertex, distinctly lobate at base, tip broadly rounded and sparsely pilose with short adpressed silvery hairs; median carina moderately percurrent; metopidium nearly twice as wide as high, frontal margin not obumbrant; supraocular callosities impunctate, rather inconspicuous; humeral angles prominent with tips blunt; suprahumeral horns short and stout, much shorter than space between their bases, seen from front directed outwards and slightly upwards, terminal region curving a little backwards, anterior carina strongly backwardly curved, apex sharply acute, seen from above dorsal carina weak; posterior process slender, arising from posterior margin of pronotum, slightly raised above base of scutellum, directed backwards, sinuate, apically acuminate, contiguous with inner margins of tegmina, tip sharp and extending along approximately two-thirds of the length of fifth apical cell; scutellum triangular, dark reddish brown with a prominent white spot in each basal angle, wider than long, tip emarginate, apices acute; tegmina nearly three times as long as wide, pale shining ochraceous, basal region dark brown, coriaceous and punctate enclosing a large white spot, veins yellowish brown, apical limbus narrow, first apical cell about 4.5 times longer than wide; hind wings with four apical cells; lateral areas of sternum with confluent white spots; legs dark brown, tibiae yellowish brown, tarsi with black dots,



Text-fig. 21. *Otinotus mimicus* Distant

1. Adult female. 2. Frontal view of female. 3. Dorsal view of pronotum and scutellum of female. 4. Frontal view of male (right half). 5. Dorsal view and scutellum of male (right half). 6. Male genitalia, lateral view. 7. Fifth instar. 8. Frontal view of fifth instar.

Measurements.—Length from frontal margin to tips of tegmina 8.0 mm., to tip of posterior process 6.2 mm., width across tips of suprahumeral horns 4.0 mm., across humeral angles 3.0 mm., across eyes 2.6 mm.

Male.—Smaller than female; suprahumerals shorter, about half as long as distance between their bases, tips less recurved; frontoclypeus with its distal half extending below lower margins of vertex; genitalia similar to *oneratus*.

Measurements.—Length from frontal margin to tips of tegmina 5.6 mm., to tip of posterior process 4.4 mm., width across tips of suprahumeral horns 2.8 mm., across humeral angles 2.4 mm., across eyes 2.3 mm.

Fifth nymphal instar.—General colour leafy green, pale white ventrally; head more than twice as broad as long, base of vertex planate, cranial tubercules short and blunt, each terminating in a slender bristle; frontoclypeus slightly extending beyond lower margins of vertex, its free end truncate, lobes on either side of clypeus distinct; eyes dark reddish brown, semiglobate; ocelli succineous, slightly closer to eyes than to each other and located on the centro-ocular line; length of thorax greater than the combined length of abdominal segments 1-8; metopidium convex, vertical; anterior process of dorsal crest inconspicuous; pronotal posterior process slender, tricarinate, contiguous with mesonotum, reaching just the posterior margin of metanotum, suprahumeral buds prominent with acute tips; wing pads large, extending upto the 4th abdominal segment; costal angles inconspicuous, a row of stout bristles on the costal margin; abdominal segments strongly telescoped; anal tube longer than rest of abdomen, strongly raised up; genital rudiments very distinct.

Host plant.—*Artocarpus integrifolia.*

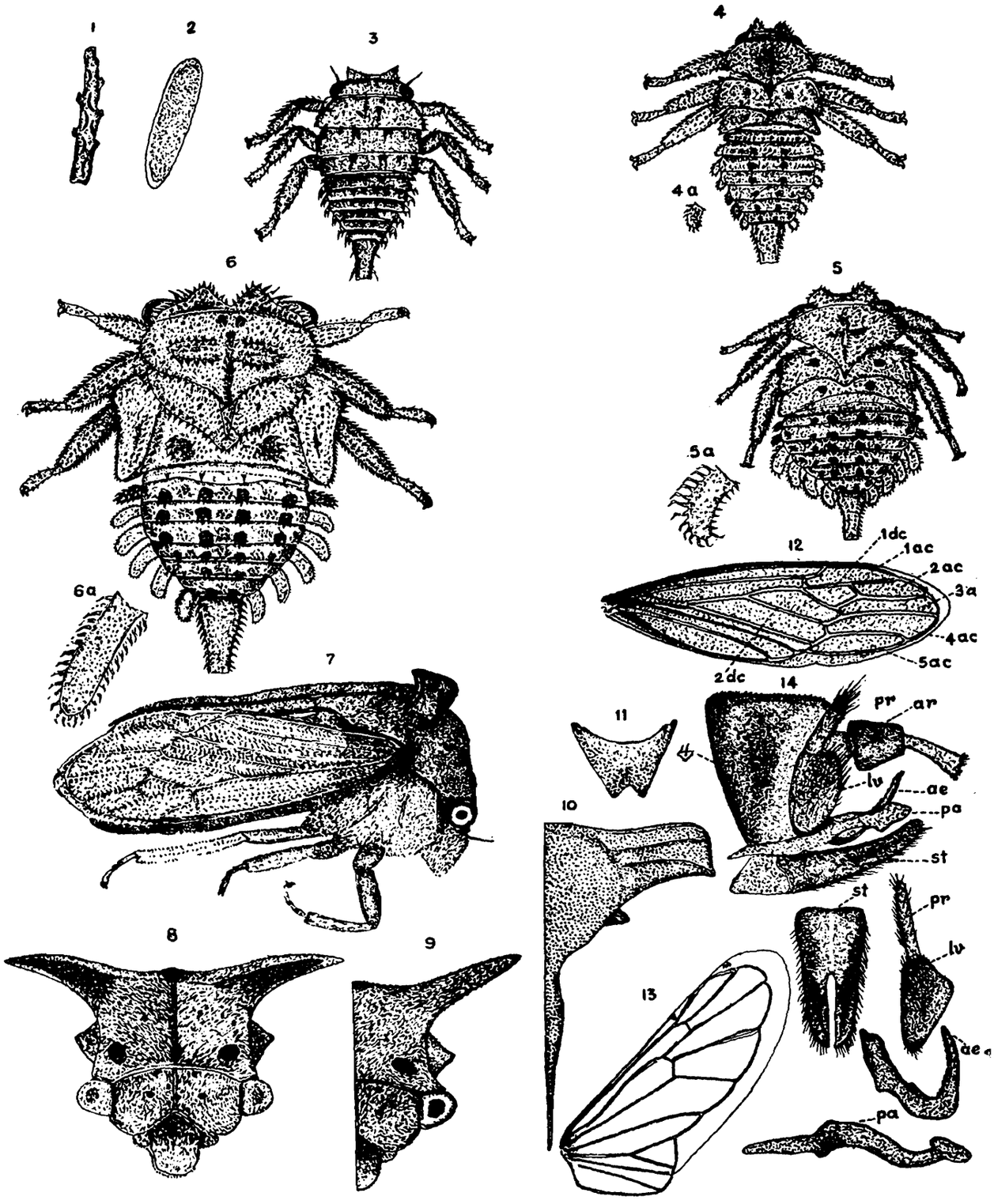
Material studied.—10 females, 6 males and 35 nymphal instars, Madras, 30.viii.1968.

Otinotus indicatus (Melichar) comb. nov.

(Text-fig. 22)

1903. *Centrotus indicatus* Melichar, *Hom. Faun. Ceylon,*: 111.

Female.—General colour dark reddish brown; head thickly ochraceously pilose, thrice as wide as long; upper margin of vertex shallowly arcuate, lower margins obliquely sloping to frontoclypeus; eyes hemispherical, somewhat elongately globate, reddish brown; ocelli black, closer to eyes than to each other and located on the centro-ocular line; cranial callosities a little elevated; frontoclypeus ochraceously pilose with long sparse hairs, slightly longer than broad, extending about three-fourths its length below lower margins of vertex, tip broadly rounded, basal lobes prominent; pronotum reddish brown, coarsely punctate, sparsely pilose; metopidium vertical, slightly convex, nearly twice as wide as high, supra-ocular callosities prominent, humeral angles broadly conical, posterior angles rounded; suprahumeral horns chest-



Text-fig. 22. *Otinotus indicatus* (Melichar) comb. nov.

1. Egg-slits on host stem. 2. An egg. 3. First instar. 4. Second instar. 4a. Abdominal lateral lamella of second instar. 5. Fourth instar. 5a. Lateral lamella of Fourth instar. 6. Fifth instar. 6a. Lateral lamella of fifth instar. 7. Adult female. 8. Frontal view of female. 9. Frontal view of male. 10. Dorsal view of pronotum of male (left half). 11. Scutellum. 12. Tegmina. 13. Hind wing. 14. Male terminalia, lateral view.

nut brown, as long as space between their bases, as viewed from lateral aspect obliquely raised upwards and outwards with apices obliquely truncate, as viewed from above somewhat broad and bicarinate, as viewed from the front much narrower with their apices nearly acute; posterior process tricarinate, slightly elevated from base of scutellum, then sinuate, contiguous with inner margins of tegmina, apical region acuminate, apex passing over three-fourths of the length of fifth apical cell, dorsal carination percurrent through metopidium, lateral carinae weak; tegmina ferruginous, pubescent, thrice as long as wide, basal sixth punctate, dark brown and opaque, veins reddish brown, first apical cell about four times as long as broad, second discoidal cell much smaller than first discoidal cell; hind wings with four apical cells; scutellum broader than long; lateral areas of sternum and a spot on each side of base of scutellum greyish ochraceous; abdomen black, without distinguishing characters.

Measurements.—Length from frontal margin to tips of tegmina 6.0-7.0, mm., to tip of posterior process 5.0-5.8 mm., width across tips of suprahumerals 5.0-5.5 mm., at humeral angles 2.75-3.25 mm., at eyes 2.5-3.0 mm.

Male.—Similar to female. Genitalia with sternal plate, black distal half divided, pubescent, lobes inconspicuous; lateral valves wedge-shaped, punctate, processes very prominent, as long as or slightly longer than main body; aedeagus U-shaped, finely serrate on inner margin; parameres as in *Leptocentrus.*

Measurements.—Length from frontal margin to tips of tegmina 5.7 mm., to tip of posterior process 4.8-5.6 mm., width across tips of suprahumerals 4.7-5.25 mm., at humeral angles 2.5-3.0 mm., at eyes 2.5-3.0 mm.

Fifth nymphal instar.—General colour greyish dorsally, light green ventrally; head about twice as wide as long, cranial tubercules very conspicuous, 0.3 mm. long and 1 mm. wide at base, bordered by small tuberculate spines; tip subacute; eyes nearly reniform, projecting outwards and backwards, dark brown; ocelli nearer to eyes than from each other and located on the c-o-line; upper margin of vertex strongly sinuate, emarginate, set with tuberculate spines, lower margins obliquely sloping to frontoclypeus; rostrum 1.5 mm. long. extending upto the middle of 2nd abdominal segment; thorax as wide as long, metopidium nearly vertical, median carina of dorsal process percurrent and bearing closely set spines; a prominent lateral tuberculated ridge on either side of median carina; pronotal posterior process extending over a little more than half the length of mesonotum, tip bluntly acute; suprahumeral buds black, spinous; mesonotal process reaching three-fourths of length of metanotum; lateral tubercles large,bearing clusters of spines on meso- and metathoracic tergites; wing pads greyish brown, costal angles prominent; tibiae more or less flattened, fringed with bent bristles. Abdomen nearly one and a half times longer than thorax, attaining its maximum width at 4th abdominal segment; anal tube stout, short, one-fifth as long as body, abdominal segments 3-7 with ferruginuus dorsal and dorso-lateral tubercles; each dorsal tubercle tipped with 3 short stout spines, each dorso-lateral tubercle tipped with

one or two spines; 8th abdominal segment with a single pair of tubercles; lateral lamellae of 3rd segment dark brown, smaller than those of 4th segment; lamellae of segments 5 to 8 uniform, light yellowish, flattened and gently curved, each lamella measuring 0.75 mm. long, bordered with 22-27 bent spines mounted on short tubercles; smaller spines scattered over lamellae; extreme bases of lateral lamellae with a cluster of microsetae.

Host plants.—*Thespesia populnea, Syzygium jambolanum, Tecoma stans.*

Material studied.—68 females, 24 males, 18 nymphal instars., Madras, 20.xii.1966.

Otinotus obliquus n.sp.

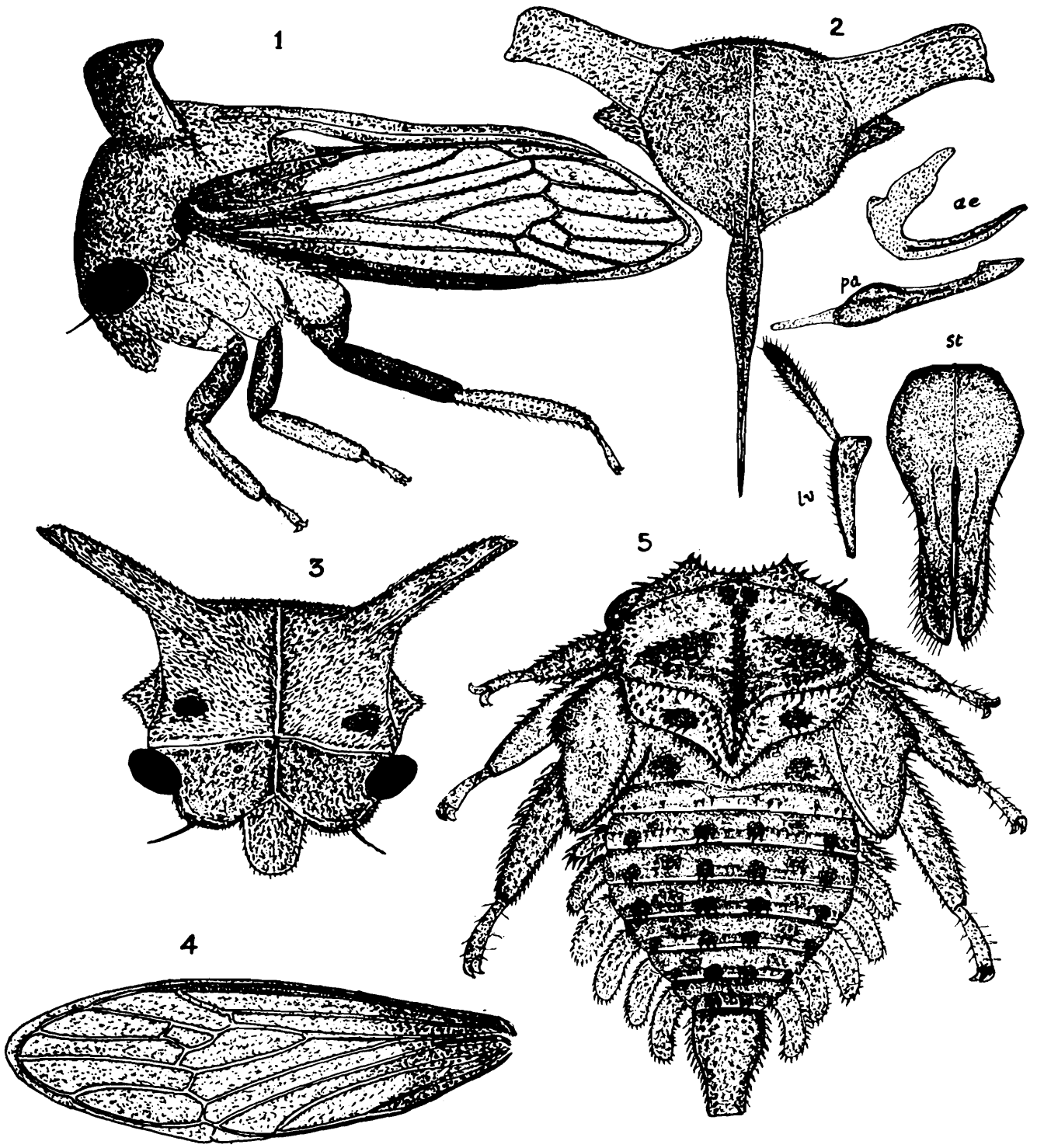
(Text-fig. 23)

Female.—General colour dark brown; head three times wider than long, finely punctate, with long greyish white hairs; upper margin of vertex moderately arcuate and sinuate, lower margins gradually sloping to frontoclypeus; eyes dark brown, ovate, obliquely directed laterad; ocelli small, slightly closer to eyes than to each other and situated on centro-ocular line; frontoclypeus slightly longer than wide at base with three-fourths of its length extending downwards below lower margins of vertex, longly pilose, tip broadly rounded; pronotum finely punctate with short adpressed hairs; metopidium convex in front, vertical, one and a half times as wide as high; supraocular callosities conspicuous; humeral angles prominent, densely hairy, tips subacute; suprahumeral horns dark reddish brown, slightly longer than space between bases, as viewed from lateral aspect obliquely directed upwards and forwards, tips strongly recurved and obliquely truncate, as seen from above much flattened and weakly bicarinate, as viewed from the front much narrower with anterior carinae closer to posterior margin, apices somewhat subacute; posterior process slender, emerging from posterior region of disc, distinctly separated at base from scutellum, then contiguous with inner margins of tegmina, moderately sinuate towards middle, apex passing over half the length of fifth apical cell, tip acute, lateral carinae weak, dorsal carina strongly percurrent through metopidium; tegmina three times as long as wide, dark reddish brown, wrinkled, pubescent, costal margin dark brown, veins castaneous, basal region dark brown and punctate, first apical cell four and a half times longer than its greatest width, second discoidal cell about one-third as long as first discoidal cell, apical limbus narrow; hind wings with 4 apical cells; scutellum triangular, as wide as long; lateral areas of sternum greyish ochraceous; legs black as far as femora, tibiae castaneous, tarsi light brown.

Measurements.—Length from frontal margin to tips of tegmina 8 mm., to tip of posterior process 7.0 mm., width across tips of suprahumeral horns 7.0 mm., at humeral angles 3.4 mm., at eyes 3.2 mm.

Male.—Similar to female, slightly smaller; genitalia similar to *indicatus*, but lateral valves much narrow.

Measurements.—Length from frontal margins to tips of tegmina 7.0 mm., to tip of posterior process 5.6 mm., width across tips of suprahumeral horns 5.3 mm., at humeral angles 3.2 mm., at eyes 3.0 mm.



Text-fig. 23. *Otinotus obliquus* n.sp.

1. Female, adult. 2. Dorsal view of pronotum. 3. Frontal view of female. 4. Tegmina. 5. Fifth instar, dorsal view. st, sternal plate ; pa, paramere ; ae, aedeagus ; lv, lateral valve

Fifth nymphal instar.—General coloration brown with shades of green; closely resembling the fifth instar nymph of *indicatus*, but slightly larger size; tegminal wing pads much broader, abdominal lateral lamellae larger, with the bordering spines shorter and more numerous.

Measurements.—Length from frontal margin to tip of anal tube 6.6 mm., length of anal tube 1.2 mm., length of thorax 2.7 mm., length of abdomen including anal tube 3.9 mm., width of abdomen across 4th segment 2.9 mm., width of thorax 2.7 mm., width of head across eyes 2.6 mm., length 1.5 mm., length of rostrum 1.6 mm., length of tegminal wing pad 1.7 mm., width 0.8 mm., length of lateral lamella 0.9 mm.

Host plants —Trewis nudiflora, Phyllanthus sp., *Premna latifolia.*

Holotype female; 4 female and 11 male paratypes, 6 nepionotypes, Madras, 10.ix.1967.

The species is nearest to *indicatus* from which it differs in the more obliquely forwardly directed suprahumerals which are longer than the width between their bases.

Key to species of **Otinotus** Buckton *based on Fifth instar nymph*

1(4) Body devoid of tuberculate spines and lamellae.

2(3) Reddish brown or shining black; suprahumeral buds short, with tips broadly rounded; wing pads extending upto 2nd abdominal segment; abdominal segments not telescoped; anal tube about one-fourth as long as body, not raised up. .*oneratus* (Walker).

3(2) Leafy green; suprahumeral buds prominent with tips acute; wing pads extending upto 4th abdominal segment; abdominal segments strongly telescoped; anal tube slightly more than one-third as long as body, strongly raised up..... .*mimicus* Distant.

4(1) Body equipped with well developed tuberculate spines and long, frondulose lamellae bearing bent spines.

5(6) General coloration greyish; wing pads somewhat narrow; anal tube about one-fourth as long as body.. . .*indicatus* (Melichar).

6(5) General coloration brown with shades of green; wing pads broad; anal tube about one-sixth as long as body.. . . .*obliquus* n.sp.

Tribe **Centrotini** Goding, 1892

The *Centrotini* is separated from the *Leptocentrini* by the presence of three apical cells in the hind wing; a distinct pterostigma may be present or absent; the fronto-clypeal lobes are either partially or completely fused to the frontoclypeus on their inner margins and are not prominent; the scutellum is normal and exposed.

Genus **Tricentrus** Stål

(Type of genus *Tricentrus convergens* Walker)

1866. *Tricentrus* Stal, *Hem. Afr.* **4:** 89.

1905. *Taloipa* Buckton, *Trans. Linn. Soc. London, Zool.* (2) **9:** 334.

1912. *Centrotus* Matsumura, *Annot. Zool. Japan,* **8:** 90.

Small to moderately large; body robust, ovate or oblong-ovate; head about three times wider than long, obliquely directed backwards,

upper margin of vertex shallowly arcuate and sinuate; lower margins gradually sloping to frontoclypeus; eyes subglobate; ocelli nearer to eyes than to each other and situated above centro-ocular line; frontoclypeus oval or subovate, frontoclypeal lobes almost fused and inconspicuous; rostrum stout, reaching middle of hind coxae, mandibular stylets recurved at tip. Pronotum with posterior process longer than broad; metopidium vertical or sloping; humeral angles prominent, tips subacute or blunt; suprahumeral horns moderately long or short, aborted or totally absent; posterior process moderately short, contiguous with scutellum, tip not reaching or slightly passing apex of clavus, tricarinate, dorsal carina percurrent, often obsolete anteriorly; tegmina about thrice as long as wide, with or without a distinct pterostigma, with five apical cells and two discoidal cells, apical limbus moderately broad; hind wings with three apical cells; scutellum as wide as long, concavely emarginate, apices acute; hind trochanters elevated into a disc inwardly, armed with spines. Male genitalia, with sternal plate cleaved to about one-third its length from apex; lateral valves triangular, processes short, nodular, weakly chitinised, fringed with long slender bristles; aedeagus U-shaped with inner margin finely serrate; parameres straight, weakly chitinised, apex recurved, tip acute.

Key to South Indian species of **Tricentrus**

1(8) Suprahumerals present.

2(5) Suprahumerals projecting forward, about three-fourths as long as width between bases; apex of posterior process impinging on tegmina.

3(4) Dark purplish; apices of suprahumerals subacute; posterior process unicarinate, its basal half normal, apical half straight; tegmina purplish brown, veins fringed with long hairs; lateral areas of sternum white tomentose.. .*purpureus* n.sp.

4(3) Brown; apices of suprahumerals sub-obliquely truncate, posterior process tricarinate, its basal half heavy, laminate, apical half attenuate, slightly arched; tegmina pale bronzy brown; lateral area of sternum pale brown. .*congestus* (Walk,).

5(2) Suprahumerals not projecting forward, about one-third as long as width between bases; apex of posterior process not impinging on tegmina.

6(7) Moderately large brown species; pronotum pilose; suprahumerals variable; apex of posterior process brown, projecting backwards behind clavus; tegmina pale bronzy brown, base opaque, followed by a broad yellow patch. *pilosus* n.sp.

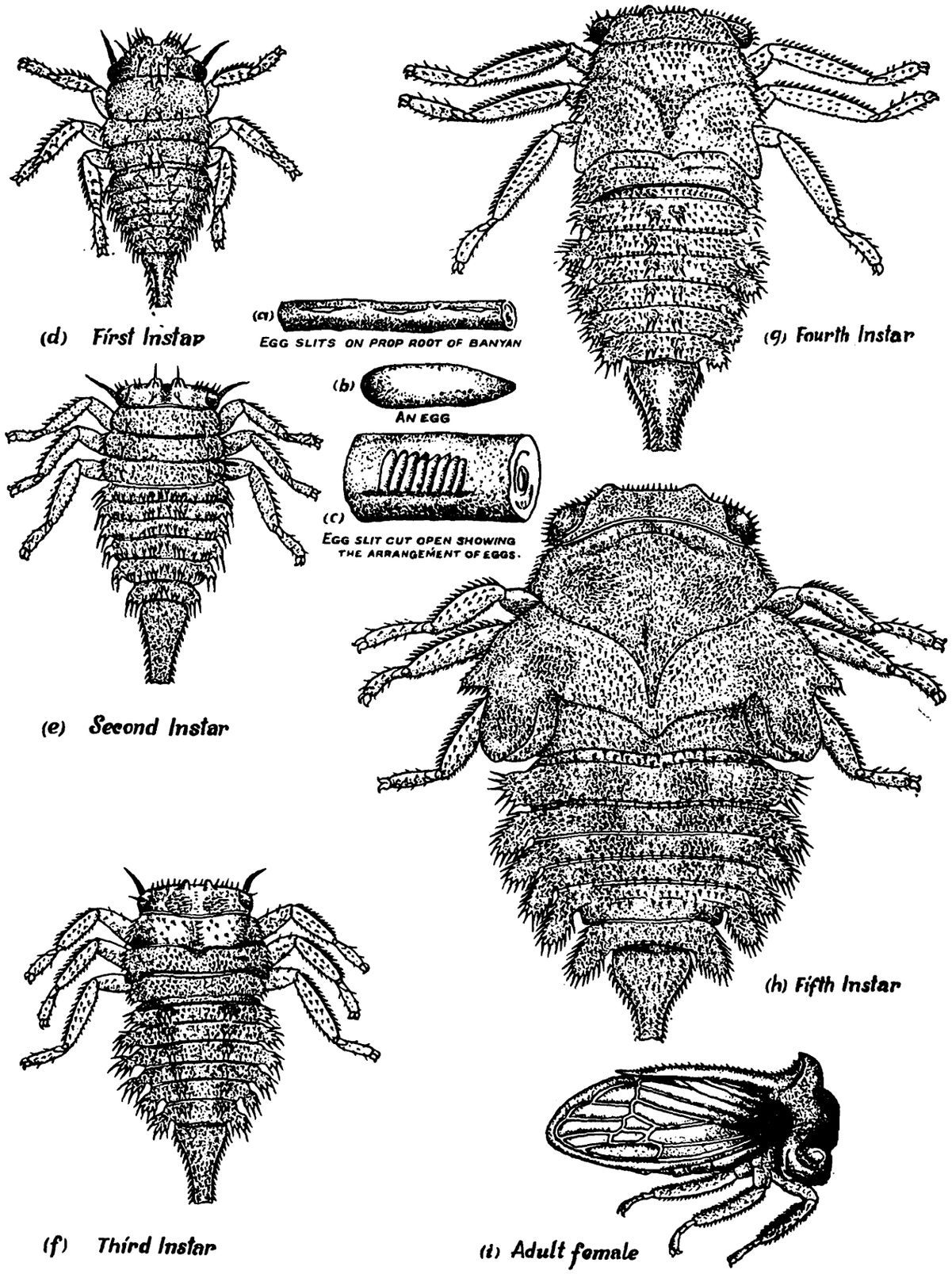
7(6) Small, black species; pronotum finely pilose; suprahumerals not variable; apex of posterior process black, extreme tip upcurved; tegmina dull bronzy subhyaline, base black, yellow patch inconspicuous in some, or absent.. .*albomaculatus* Distant.

8(1) Suprahumerals absent; pronotum dark brown, finely punctate.. *decornis* n.sp.

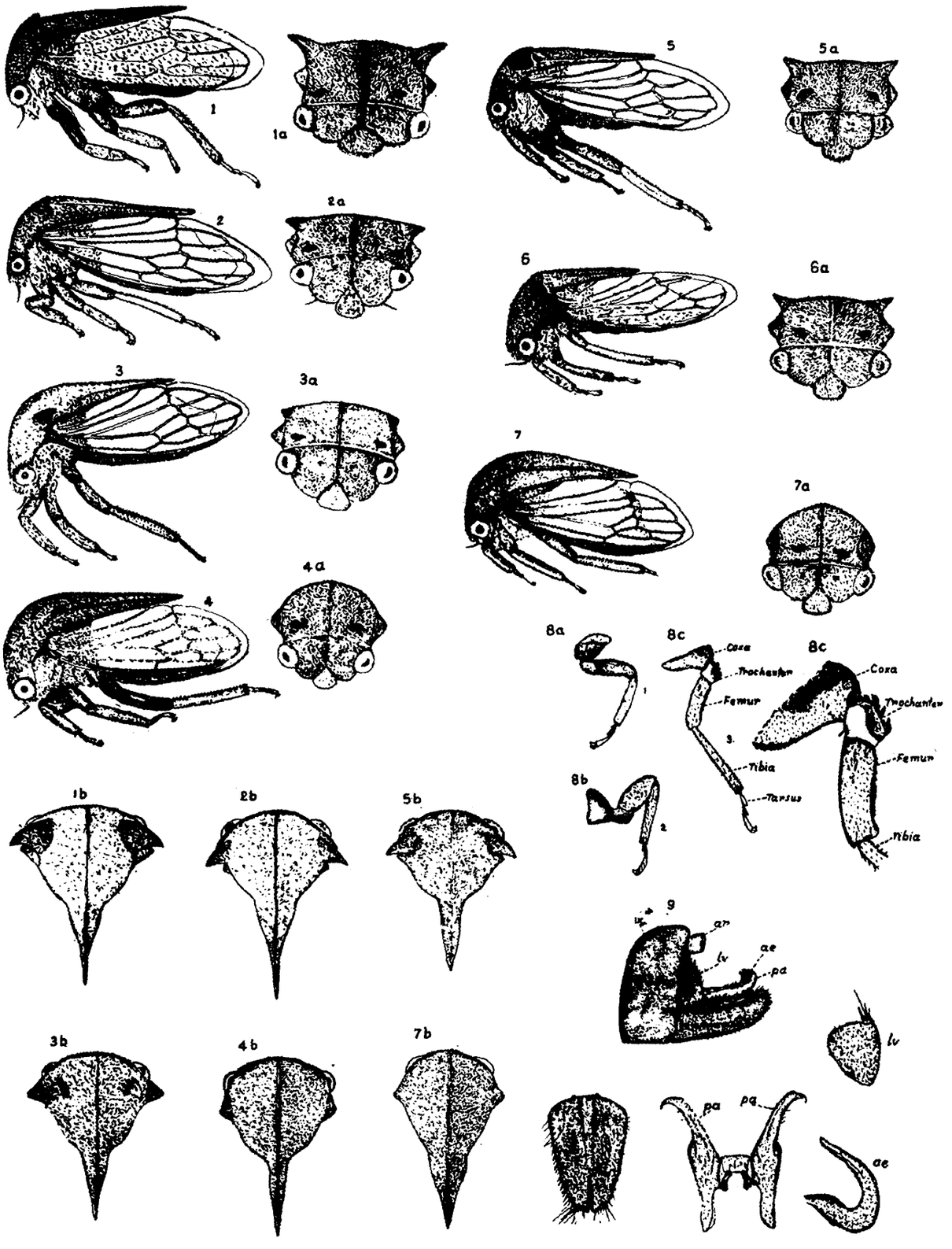
Tricentrus pilosus n.sp.

(Text-figs. 24 & 25)

Female.—General coloration brown; head nearly thrice as wide as long, obliquely directed backwards, longly pilose with silvery hairs;



Text-fig. 24. *Tricentrus pilosus* n. sp.



Text-fig. 25. *Polymorphic forms in Tricentrus pilosus* n. sp.

1. Female with normal horns; 1a. Its frontal view; 1b. 2. Female with reduced horns; 2a. Its frontal view; 2b. 3. Female with aborted horns; 3a. Its frontal view; 3b. 4. Female with no horns; 4a. Its frontal view; 4b. 5. Male with reduced horns; 5a. Its frontal view; 5b. 6. Male with aborted horns; 6a. Its frontal view; 7. Male with no horns; 7a. Its frontal view; 7b. 8a. Foreleg; 8b. Middle leg; 8c. Hind leg showing spines. 9. Male genitalia, lateral view. lv, lateral valve; pa, ae, aedeagus.

upper margin of vertex slightly arcuate, sinuate; eyes dark brown, subglobate projecting outwards, with a central black spot. ocelli black, a little closer to eyes than to each other and located slightly above centro-ocular line; frontoclypeus longly sparsely pilose, subovate, extending about one-third its length below lower margins of vertex, tip broadly rounded and slightly convex. Pronotum light brown laterally, darker ventrally, finely punctate and densely pilose near bases of horns; metopidium almost vertical, wider than high, frontal margin less pilose not obumbrant, supraocular callosities black, punctate, prominent; humeral angles light brown, tips subacute with posterior margins rounded at lateral angles; suprahumeral horns about one-third as long as width between bases, obliquely directed upwards and outwards, then turned backwards, tips subacute, carinae weakly developed; posterior process stout, central and lateral carinations fine, central carination percurrent, extending through metopidium, sprinkled with shining silvery hairs, tip black, directed somewhat upwards, just reaching anal angle of tegmina, extreme tip not impining on tegmina; tegmina about three times as long as wide, hyaline, basal sixth coriaceous, punctate, dark brown, veins reddish brown, apical limbus normal; legs with trochanters and basal three-fourths of femora black, rest light reddish brown, hind trochanters prominently toothed on the dilated internal surface, inner margin of mid- and hind femora corrugated; abdomen dark brown, pubescent ventrally, ovipositor darker.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 4.2 mm., width across tips of suprahumerals 3.6 mm., at humeral angles 2.9 mm., at eyes 3.0 mm.

Male.—Similar to female, but slightly smaller and darker; suprahumeral horns shorter. Genitalia, with sternal plate black, turned upwards, split extending upto one-fourth the length of plate, lower surface pubescent; lateral valves broadly triangular, process of lateral valve bearing very long bristles; parameres with tips recurved, bearing a small subapical process visible from caudal aspect; connecting plate quadrangular, aedeagus finely serrate on inner margin.

Measurements.—Length from frontal margin to tips of tegmina 5.1 mm., to tip of posterior process 3.6 mm., width across tips of suprahumerals 2.4 mm., at humeral angles 2.5 mm., at eyes 2.5 mm.

This species is noted for its polymorphism with reference to the degree of development of suprahumeral horns. Females include four different types : 1. those with horns of normal size as described above; 2. those with short horns; 3. those with much aborted horns and 4. those with no horns. Males include three types: 1. those with short horns comparable to the females of the second type; 2. those with aborted horns, and 3. those with no horns (vide Table 1). Very rarely males with shorter posterior process not reaching the inner angle of tegmina are encountered. But for the presence of intergrading forms, extremes might be regarded as different species.

An analysis of the frequencies of occurrence of the above types of *Tricentrus pilosus* was made out of 5 samples of collections totalling 430. The results which are tabulated (Table 2) indicate that individuals

without horns form the majority, while females with normal horns constitute about one-fifth of the total number. Forms with short suprahumerals comprise about one-third, while aborted condition of suprahumerals is found to be very rare. It is noteworthy that in no male the suprahumerals are found to develop to the normal size.

TABLE 1

	Females				Males		
	I With normal horns	II With short horns	III With aborted horns	IV With no horns	I With short horns	II With aborted horns	III With no horns
Length from frontal margin to tips of tegmina in mm.	6.0	6.1	5.6	5.75	5.1	5.2	5.0
Length from frontal margin to tip of posterior process in mm.	4.2	4.4	3.9	3.75	3.1	3.5	3.6
Width across tips of suprahumeral horns in mm.	3.25	2.75	2.2	—	2.3	2.0	—
Width of disc across bases of suprahumeral horns in mm.	1.75	1.75	1.7	—	1.5	1.5	—
Width at humeral angles in mm.	3.0	2.8	2.7	2.65	2.3	2.4	2.6
Width across eyes in mm.	2.9	2.75	2.6	2.7	2.3	2.35	2.65
Length of suprahumeral horn in mm.	0.75	0.50	0.20	—	0.50	0.2	—

TABLE 2

Collection Number	Total number in each collection	Females				Males		
		With normal horns	With reduced horns	With aborted horns	With no horns	With short horns	With aborted horns	With no horns
1	85	15	16	4	15	8	1	26
2	87	19	20	5	18	10	—	15
3	85	15	17	3	10	14	2	24
4	83	20	18	5	10	8	3	19
5	90	19	18	4	9	13	—	27
Total	430	88	89	21	62	53	6	111
Percentage		20.5	20.7	5	14.4	12.3	1.4	26
Standard error of percentage		1.97%	1.95%	1.05%	1.69%	1.58%	0.57%	2.11%

Fifth instar nymph.—Body dorso-ventrally compressed. densely bristled; general coloration light reddish brown; head about 2.5 times as wide as long, cranial tubercles persistent as small conical projections, vertex truncate at base; eyes reniform, pale white; ocelli conspicuous, nearer to eyes than to each other and located on the centro-ocular line; frontoclypeal tip slightly extending beyond lower margins of vertex; rostrum reaching the hind coxae. Thorax slightly exceeding the length of abdomen excluding anal tube; metopidium sparsely spinose, sloping backwards from its base to disc; lateral angles of pronotum broadly rounded, posterior process gradually tapering to an acute point, extending over three-fourths of length of mesotergite; median carina of posterior process percurrent, beset with short spines, mesonotum about two-thirds of length of protergum, mesonotal process short, tip obtuse; metanotum narrow, sparingly spinose; tegminal wing pads very prominent extending upto 2nd abdominal segment, costal angles projecting out as conical extensions; legs pinkish brown on tibiae which are flat, fringed with long slender tuberculate spines arranged in rows, tarsi yellowish, sparsely setose, trochanters not armed with teeth. Abdominal tergites very broad, dorsal tubercles replaced by two groups of small spines; lateral lamellae of 3rd segment dark brown, shorter than the succeeding ones, bearing only 6 or 7 stiff spines, those of succeeding segments more than twice as long as wide, inclined backwards and bordered with 14-20 long slender spines on tubercles besides minute subspines scattered over lamellae; external genital rudiments extending as far back as middle of anal tube on the ventral aspect; anal tube about one-sixth of length of body, width at base nearly equal to its length.

Host plants.—Prop roots of *Ficus bengalensis, Thespesia populnea.*

Holotype female, 88 female and 54 male paratypes, 45 nepionotypes, Madras, on various dates during July, 1966.

The species is nearest to *subangulatus* Distant in the robust slightly apically projecting posterior process, but differing in the coloration of body and tegminal veins, and also in the extremely variable suprahumeral horns.

Tricentrus purpureus n.sp.

(Text-fig. 26, part)

Female.—General coloration purplish brown; head greyish, speckled with dark spots, about two and a half times as wide as long, densely pilose, with long golden hairs; base slightly convex at junction with metopidium; frontoclypeus extending about half of its length below lower margins of vertex, tip broadly rounded, thickly pilose with short golden hairs; eyes dark brown, ocelli black, located just above centro-ocular line, slightly closer to eyes than to each other; pronotum dark brown dorsally, cretaceously sericeous laterally; metopidium vertical, not sloping, greyish brown, densely pubescent, twice as wide as high; supraocular callosities very conspicuous, margins shaded with black; tips of humeral angles blunt; suprahumeral horns stout, about three-fourths as long as space between bases, longly pilose, pilosity denser at basal one-fourth, projecting obliquely forwards and slightly inclined outwards, tips black, broadly rounded and turned backwards, apices

subacute, tricarinate, dorsal carina weak; posterior process robust, short, unicarinate, apical half straight, tip acute, dark brown, just reaching the posterior angle of the inner margin of tegmina; dorsal carina percurrent extending through metopidium; legs densely pilose, distal end of femur and whole of tibia purplish brown, tarsi light brown, rest black; hind trochanter raised into a disc bearing 5 large teeth in a row besides smaller ones. Tegmina purplish brown, fringed with long hairs, basal portion dark brown and punctate followed by an yellow round fascia, apical limbus broad; abdomen robust, uniformly black.

Measurements.—Length from frontal margin to tips of tegmina 5.3 mm., to tip of posterior process 3.5 mm., to tip of abdomen 4.9 mm., width across tips of horns 2.7 mm., at humeral angles 2.0 mm., at eyes 1.9 mm.

Male.—General coloration of body similar to that of female; slightly smaller; differing from female chiefly in the nature of suprahumerals which are smaller, slightly projecting forwards, more divergent, turned outwards and slightly upwards, tip acutely turned backwards; dorsal carina weak; abdomen slender, extending upto one-third distance of 3rd apical cell of tegmina.

Measurements.—Length from frontal margin to tips of tegmina 5.0 mm., to tip of posterior process 3.5 mm., to tip of abdomen 4.2 mm., width across tips of horns 3.0 mm., at humeral angles 2.0 mm., at eyes 1.8 mm.

Fifth instar nymph.—Body dorso-ventrally flattened as in *pilosus;* general coloration brown; head two times wider than long, inclined backwards; cranial tubercules prominent, broadly conical; eyes subglobate, dark brown; ocelli as close from each other as from eyes and located on the centro-ocular line; thorax sprinkled with sparse tuberculate spines; metopidium gradually sloping from base; posterior process tapering, tip acute, beset with short spines; suprahumeral buds absent; mesonotal process dark brown, densely spinose, obtuse, a row of spines on the distal half of each abdominal segment from 3 to 8; abdominal lateral lamellae of segments 4 to 8 nearly uniform, about twice as long as broad, directed backwards and bordered with 17-22 long, slender, pointed spines; anal tube one-fifth of the total length of body, more than twice as long as its width at base.

Host plant.—*Polygonum* sp.

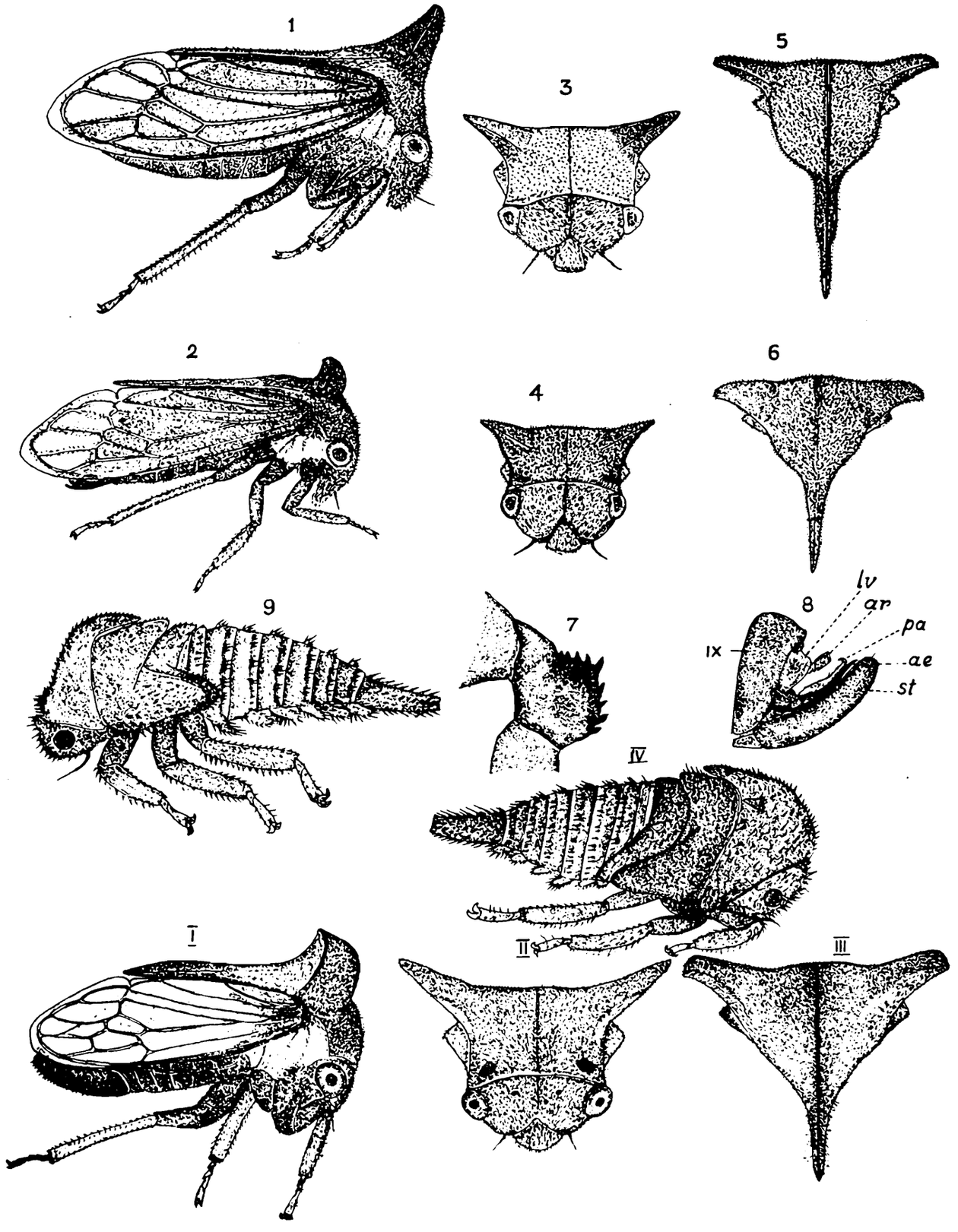
Holotype female; 15 female, 9 male paratypes, 8 nepionotypes, Kodaikanal, Madras, 30.ix.1968.

This species is nearest to *congestus* (Walker) in the backwardly projecting suprahumerals which are about three-fourths as long as width between their bases, and the apex of posterior process impinging on tegmina, but differs in the dark purplish colour, apices of suprahumerals subacute, and in the cretaceously sericeous lateral areas of sternum.

Tricentrus congestus (Walker)

(Text-fig. 26, part)

1870. *Centrotus congestus* Walker, *J. Linn. Soc. Lond. Proc.* **10:** 187.
1908. *Tricentrus congestus:* Distant, *Fauna Brit. India.* **4:** 34.
1934. *Otaris congestus:* Goding, *N. Y. Ent. Soc. Jl.* **42:** 480.



Text-fig. 26. *Tricentrus purpureus* n. sp.

1. Adult female. 2. Adult male. 3. Frontal view of female. 4. Frontal view of male. 5. Dorsal view of female pronotum. 6. Dorsal view of male pronotum. 7. Hind trochanter showing spines. 8. Male genitalia. 9. Fifth instar.

Tricentrus congestus (Walker)

I. Adult female. II. Frontal view. III. Dorsal view of pronotum. IV. Fifth instar.

Female.—General coloration brown; head thickly ochraceously pilose, about three times wider across extremities of eyes than length of vertex; vertex about twice as wide as long; upper margin of vertex very shallowly arcuate, lower margins gradually sloping to frontoclypeus; eyes hemispherical, dull succineous; ocelli slightly nearer to eyes than to each other and situated above centro-ocular line; frontoclypeus extending below lower margins of vertex, extended area semicircular, longly pilose, frontoclypeal lobes almost entirely fused; pronotum dark brown, finely punctate, thickly pilose, with short greyish hairs; metopidium convex, two-thirds as high as wide, densely pilose, ochraceous; supraocular callosities prominent, black and punctate; humeral angles large, sparsely pilose, tips blunt; suprahumeral horns robust, obliquely projecting forwards, about three-fourths as long as width between bases, viewed from lateral aspects, lateral carinae strong, reddish brown, viewed from above moderately broad, obliquely ascendant, posterior carinae obscure behind middle, apices subobliquely truncate, seen from the front much narrower, apices subacute; posterior process robust, tricarinate, basal half heavy, contiguous with scutellum, laminate, apical half attenuate, slightly arched, apex impinging on tegmina, dorsal carination percurrent through metopidium, lateral carinae weak; tegmina pale bronzy brown, nearly thrice as long as wide, veins strong, castaneous, first apical cell nearly five times longer than its greatest width, apical limbus moderately broad; hind wings with three apical cells; lateral areas of sternum pale brown; legs black upto tibiae, tibiae reddish brown, tarsi light brown.

Measurements.—Length from frontal margin to tips of tegmina 5.3 mm., to tip of posterior process 3.7 mm., width across tips of suprahumerals 4.3 mm., at humeral angles 2.8 mm., at eyes 2.4 mm.

Male.—Similar to female, slightly pubescent, humeral angles less prominent, posterior process straight.

Measurements.—Length from frontal margin to tips of tegmina 5.0 mm., to tip of posterior process 3.6 mm., width across tips of suprahumerals 4.0 mm., at humeral angles 2.6 mm., at eyes 2.3 mm.

Fifth instar nymph.—Body robust, dorso-ventrally compressed; general coloration grey, with black spots sprinkled over body; head nearly thrice as wide as long, cranial tubercules reduced; short stout spines scattered all over vertex; eyes light black; ocelli nearer to each other than from eyes and located a little above centro-ocular line; rostral tip extending to hind coxae; thorax greyish, densely pilose, bases of tubercles black; suprahumeral buds very small; metopidium convex in front, concealing head from above; disc with closely set spines; pronotal posterior process extending over three-fourths of the length of mesonotum, mesonotal process much reduced; abdomen sparsely spinose; dorsal tuberculate spines more or less inclined back and adpressed to body; lateral lamellae nearly twice as long as wide, each bordered with 14-18 slender spines; anal tube black at basal one-fourth, genitalic rudiments dark brown.

Host plant.—*Vernonia cinerea.*

Material studied.—12 females, 4 males and many nymphal instars, Madras, 10.v.1966.

Tricentrus albomaculatus Distant

(Text-fig. 27)

1908. *Tricentrus albomaculatus* Distant, *Fauna Brit. India.* **4**: 56.

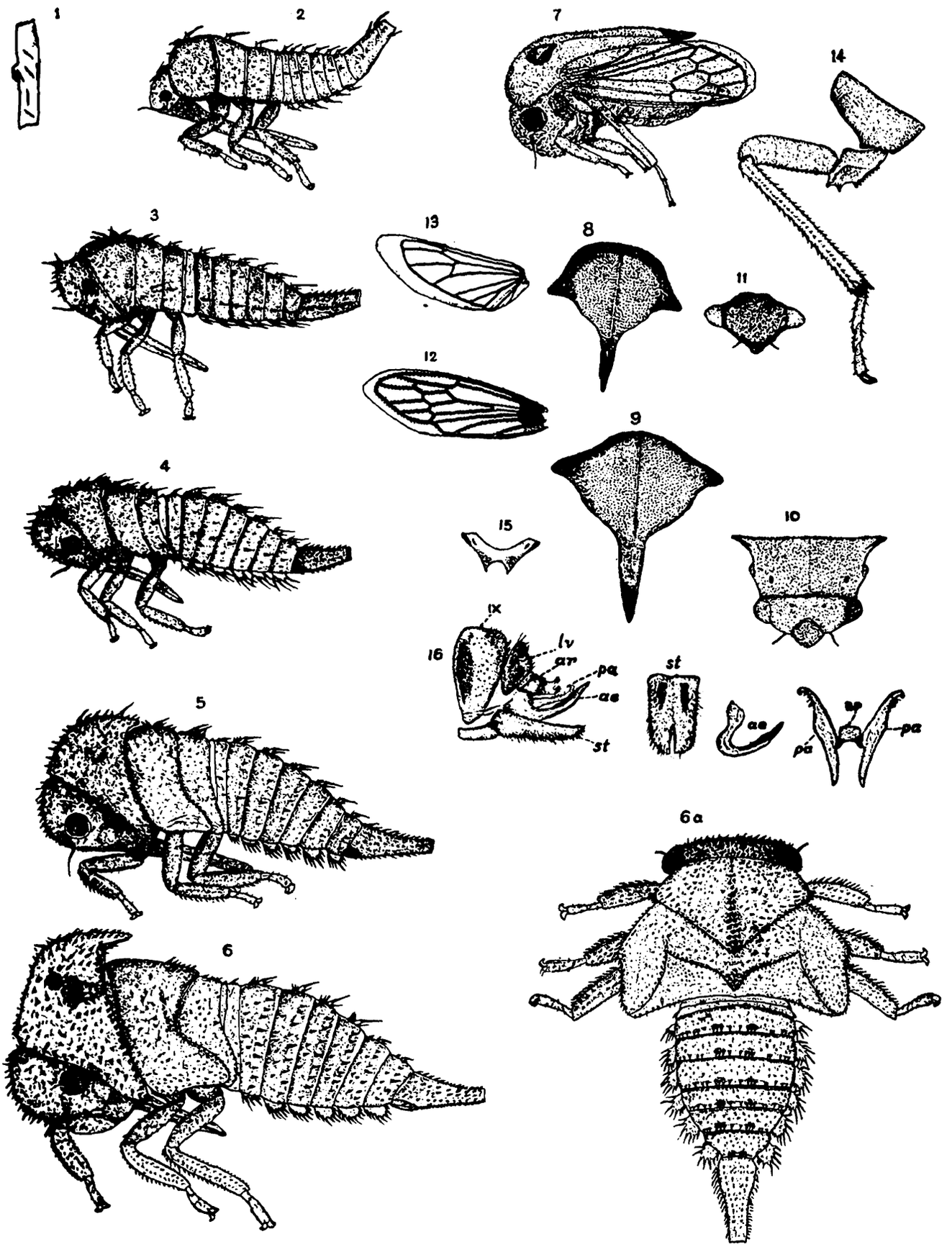
Female.—General coloration black; head thrice as wide as long, finely pilose, with silvery hairs; base of vertex shallowly emarginate; eyes reddish brown, hemispherical; ocelli minute, closer to eyes than to each other and situated above centro-ocular line; frontoclypeus ovate, sparsely pilose, distal half extending below lower margins of vertex, tip broadly rounded, frontoclypeal lobes fused to inner margins of vertex; pronotum black, often shaded with greyish brown, finely punctate, with adpressed silvery hairs; metopidium nearly vertical, slightly obumbrant; supraocular callosities inconspicuous; humeral angles short, not prominent, tips blunt; suprahumeral horns short, black, about one-third as long as space between bases, as seen from sides directed upwards and recurved, as seen from above somewhat broad, apically recurved, anterior margins rounded, apices subacute, dorso-posterior carinae slightly behind middle, as seen from front much narrower and obliquely upcurved; posterior process robust, contiguous with scutellum and inner angles of tegmina, apex reaching posterior angle of inner margin of tegmina, tip acute, black, distinctly upcurved, dorsal carination obscurely percurrent through metopidium; tegmina about thrice as long as wide, dull bronzy, subhyaline, basal sixth black, coriaceous and coarsely punctate, first apical cell about 5 times longer than wide; hind wings with 3 apical cells; scutellum broader than long; lateral areas of pronotum and sternum white tomentose; legs with hind trochanters armed with spines on inner surface.

Measurements.—Length from frontal margin to tips of tegmina 3.8 mm., to tip of posterior process 3.0 mm., width across tips of suprahumerals 2.6 mm., at humeral angles 1.9 mm., at eyes 1.7 mm.

Male.—General colour jet black, much smaller than female; suprahumerals arising from posterior lateral margins of pronotum; genitalia similar to *pilosus.*

Measurements. - Length from frontal margin to tips of tegmina 2.9 mm., to tip of posterior process 2.3 mm., width across tips of suprahumerals 2.0 mm., at humeral angles 1.5 mm., at eyes 1.4 mm.

Fifth instar nymph.—General coloration pale green; base of suprahumeral buds, costal margins of tegminal pads, bases of abdominal dorsal tubercles and distal half of anal tube with shades of black; head nearly twice as broad as long, directed backwards with rostral tip just passing beyond hind coxae; vertex of head truncate; eyes subglobate, ocelli minute, nearer to eyes than to each other, and located above c-o-line; frontoclypeal tip on a line with lower margins of vertex; thorax sparsely spinose on lateral areas; metopidium nearly vertical; posterior process extending over disc; suprahumeral buds very prominent with subacute tip; mesonotal process blunt with closely set spines; legs with coxae, trochanters, and distal half of femora black, tibiae yellowish brown, tarsi pale white. Abdominal segments 3-8 sparsely hairy, dorsal tubercles terminating in suberect spines, a transverse row of short spines towards posterior border of each segment; lateral lamellae nearly similar



Text-fig. 27. *Tricentrus albomaculatus* Distant

1. Egg slits on host stem. 2. First instar. 3. Second instar. 4. Third instar. 5. Fourth instar. 6. Fifth instar. 7. Adult female. 8. Pronotum of male, dorsal view. 9. Pronotum of female, dorsal view. 10. Frontal view of female. 11. Head, frontal elevation. 12. Tegmina. 13. Hind wing. 14. Hind leg. 15. Scutellum. 16. Male genitalia, lateral view.

to those of *Leptocentrus* in shape, each lamella fringed with 7 long spines and 2 short spines at posterior surface; anal tube about one-sixth of total length of body.

Host plant.—*Datura fastuosa.*

Material studied.—75 females, 48 males, and numerous nymphal instars, Madras, —.xii.1966.

Tricentrus decornis n.sp.

(Text-fig. 28)

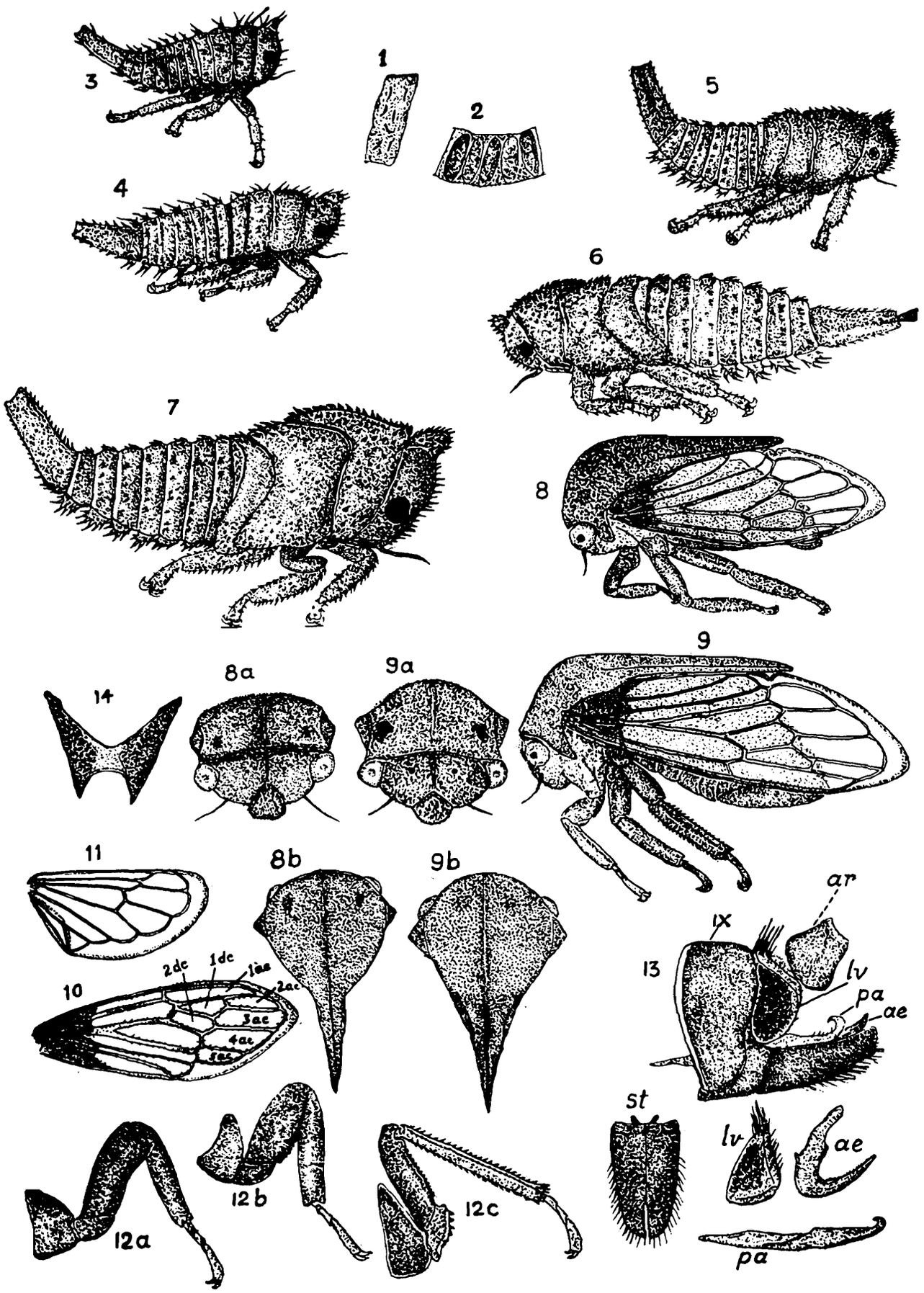
Female.—General coloration of body reddish brown; head nearly one and three-fourths as wide as long; base slightly arcuate and sinuate, distinctly punctate with sparsely scattered short golden hairs; frontoclypeus dark brown, extending a little more than half its length beyond head, sparsely pilose, free end broadest, truncate, margins black. Eyes globate, projecting out, dull white, ocelli silvery white, slightly closer to eyes than to each other and situated above centro-ocular line. Thorax reddish brown, lateral parts cretaceously sericeous, metopidium gradually sloping back, closely punctate, not pilose, supraocular callosities prominent, impunctate, concolorous with metopidium; supra-humeral horns absent; humeral angles dark brown, broadly conical with acute tips; posterior process robust, slightly sinuate, tip acute, extending just beyond the posterior angles of the inner margins of tegmina, lateral carinae black, median carina percurrent, continued over metopidium; scutellum light brown, punctate, one and a half times as wide as length at base; legs reddish brown except coxa and trochanter which are dark brown; hind trochanter set with 4 prominent teeth besides smaller teeth on inner edge of disc; hind femur corrugated on inner edge; tegmina three times longer than wide, pale brown, reflecting the dark abdomen, base dark, punctate, veins stout, dark brown, apical limbus broad.

Measurements.—Length from frontal margin to tips of tegmina 5 mm., to tip of posterior process 3.6 mm , scutellum width at base 1.4 mm., length 0.9 mm., width across humeral angles 2.1 mm., at eyes 2.0 mm., length of tegmina 4.1 mm , width 1.3 mm.

Male.—Similar to female but smaller; general coloration of body dark brown.

Measurements.—Length from frontal margin to tips of tegmina 4.25 mm., to tip of posterior process 3.2 mm., width across humeral angles 1.7 mm., at eyes 1.7 mm., width of scutellum at base 1.2 mm., length 0.8 mm.

Fifth nymphal instar.—General colour dark brown; head declivous; cranial tubercles persistent and very large; eyes reddish brown; vertex with a row of tuberculate spines turned forwards, lower margins broadly rounded; clypeal tip broadly rounded extending a little beyond lower margins of vertex; ocelli conspicuous, closer to eyes and situated above centro-ocular line; pronotal posterior process arched above, contiguous with mesonotum, extending over the length of mesonotum, dorsal carina



Text-fig. 28. *Tricentrus decornis* n. sp.

1. Egg slits on host stem. 2. An egg slit exposed to show the arrangement of eggs. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 8. Adult male. 8a. Frontal view of male. 8b. Pronotum of male, dorsal view. 9. Adult female. 9a. Frontal view of female. 9b. Pronotum of female, dorsal view. 10. Tegmina. 11. Hind wing. 12-a, b, c. legs. 13. Male genitalia. 14. Scutellum.

continued forwards upto anterior border of disc and beset with closely arranged tuberculate spines; suprahumeral buds absent; lateral parts of pronotum sparsely spinose; mesonotal process broadly triangular, fringed with short spines; wing pads of moderate size, costal margins fringed with stiff spines, costal angles not sharply demarcated. Abdomen nearly twice as long as anal tube; dorsal tuberculate spines adpressed to body; base of tubercles black; lateral lamellae short, semicircular, each lamella bearing 5 short spines, besides short subspines scattered on lamellae.

Host plants.—Eugenia caryophyllata, Lagerstroemia sp., *Cryptostegia* sp.

Holotype female; 18 female and 11 male paratypes, 20 nepionotypes, Madras, 3.iii.1967.

This species differs from all other known members of the genus in the complete absence of suprahumeral horns.

Key to species of **Tricentrus** Stål *based upon Fifth nymphal instar*

1(6) Body dorso-ventrally compressed; abdominal lateral lamellae long, bordered by many long spines.

2(5) Cranial tubercules persistent but reduced.

3(4) Suprahumeral buds present or absent; lateral lamellae of abdominal segments 5-8 more than twice as long as wide; coloration of body reddish brown. *pilosus* n.sp.

4(3) Suprahumeral buds always present; lateral lamellae of abdominal segments 5-8 less than twice as long as wide; coloration of body brown.. .*congestus* (Walker).

5(2) Cranial tubercules prominent; suprahumeral buds absent; lateral lamellae of abdominal segments 5-8 nearly thrice as long as wide; coloration of body brown.. .*purpureus* n.sp.

6(1) Body laterally compressed; abdominal lateral lamellae short, bordered with a few short spines.

7(8) Cranial tubercules obsolete; suprahumeral buds present; lateral lamellae bearing 7-9 spines.. .. . *albomaculatus* Dist.

8(7) Cranial tubercules very large; suprahumeral buds absent; lateral lamellae bearing 5 short spines. .*decornis* n.sp.

Tribe **Gargarini** Distant

This tribe is characterised by the partially concealed scutellum exposed laterally and at basal angles and weakly chitinised in the middle, the broad close-fitting posterior process, absence of suprahumeral horns and the hind wings with 3 apical cells. It is distinguished from the closely related tribe, *Coccosterphini*, by the absence of tubercles on veins.

Genus **Gargara** Amyot & Serville

(Type of the genus *Cicada genistae* Fabr.)

1843. *Gargara* Amyot & Serville, *Hemip.:* 537.

1903. *Maerops* Buckton, *Mon. Memb.:* 268.

Small to moderately large; head two and a half to three times wider across extremities of eyes than length of vertex; vertex nearly one and a half times wider than long; eyes subglobate; ocelli slightly closer to eyes than to each other and situated on or above centro-ocular line; frontoclypeus extending from one-third to half its length below lower margins of vertex, its lobes partially or entirely fused, tip broadly rounded or truncate; pronotum rather low, metopidium convex and backwardly sloping, disc slightly convex, suprahumerals absent, humeral angles moderate, tips blunt, posterior angles rounded; posterior process broadly triangular, closely fitting against scutellum and contiguous with tegmina, tip reaching apex of clavus or anal angles of tegmina, ventrally basally shallow; scutellum wider than long, triangular, deeply excavated at tip, incompletely chitinised in middle which is concealed by posterior process; tegmina two and a half times longer than wide, membrane a little chitinised at R1 and rs forming an incipient pterostigma in some species, five apical cells and two discoidal cells; hind wings with 3 apical cells. Male genitalia, with lateral valves broadly triangular and parameres with recurved tips and strikingly resembling those of the genus *Tricentrus*; split of sternal plate extending from one-third to one half of its length from apex.

Key to South Indian species of **Gargara**

1(4) Posterior process just reaching apex of clavus; tip of frontoclypeus broadly rounded; 1st apical cell of tegmina 5 or 6 times longer than wide.

2(3) Light brown, moderately large pronotum thickly ochraceously pilose; ocelli located on centro-ocular line; tegmina greyish, semi-opaque, 1st discoidal cell not pedicellate; tarsi light brown.. .*mixta* (Buckton).

3(2) Black; small; pronotum sparsely pilose; ocelli located above centro-ocular line; apical sixth of tegmina brown, with a sub-apical brown band, 1st discoidal cell pedicellate tarsi; pale white.. .*albitarsis* n.sp.

4(1) Posterior process extending beyond apex of clavus; tip of frotnoclypeus truncate or broadly rounded.

5(8) Tegmina slightly chitinous at R1 and rs forming an incipient pterostigma.

6(7) Black, moderately large; pronotum finely, palely pilose; posterior process slightly sinuous; tegmina subhyaline, broadly black at apical limbus and apical area of costal margin, 1st apical cell six times longer than wide, 1st discoidal cell pedicellate. ..*extrema* Distant.

7(6) Brown, smaller, pronotum coarsely ochraceously pilose; posterior process straight; tegmina hyaline, not fuscous, 1st apical cell about five times longer than wide, 1st discoidal cell not pedicellate.. *malabarica* n.sp.

8(5) Tegmina devoid of an incipient pterostigma.

9(10) Very small, black; tegmina hyaline, devoid of spots or patches; 1st apical cell about three times longer than wide, 1st discoidal cell pedicellate, very much smaller than 2nd discoidal cell.. .*madrasensis* n.sp.

10(9) Moderately large, reddish brown; tegmina with reddish brown patches near end of clavus, apical area of costal cell about five times longer than wide, 1st discoidal cell not pedicellate, about as large as 2nd discoidal cell.. .*rustica* n.sp.

Gargara mixta (Buckton)

(Text-fig. 29)

1903. *Maerops mixta* Buckton, *Mon. Memb.*: 257.
1903. *Gargara variegata* Melichar, *Hom. Faun. Ceylon,*: 122.
1908. *Gargara mixta;* Distant, *Fauna Brit. India* **4**: 65.

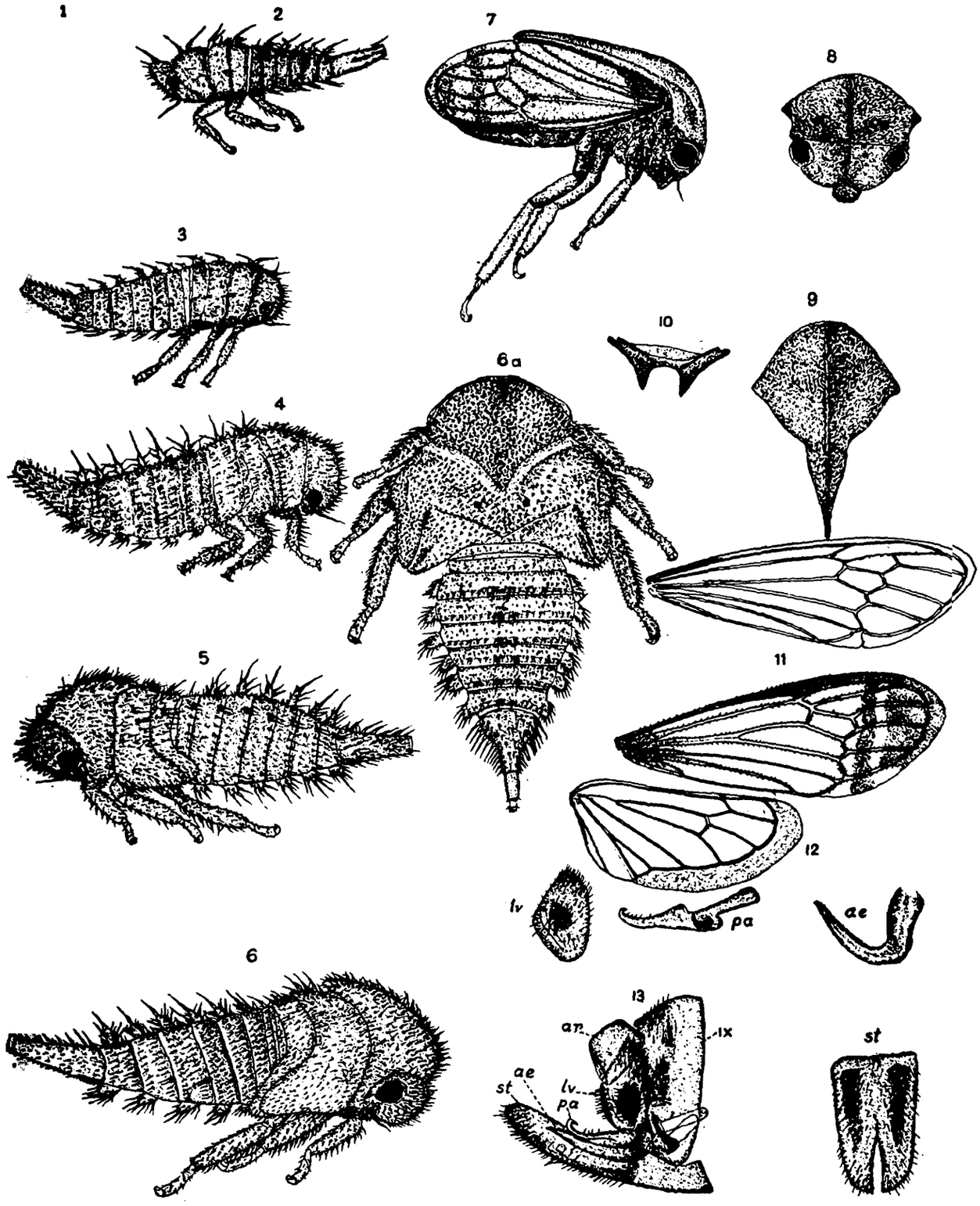
Female.—General colour light brown; head two and a half times wider across extremities of eyes than length of vertex; vertex one and a half times as wide as long, finely punctate with adpressed golden pilosity; base of vertex nearly planate; eyes reddish brown, subhemispherical; ocelli slightly nearer to eyes than to each other and situated on centro-ocular line; frontoclypeus greyish brown, extending to half of its length below lower margins of vertex, tip broadly rounded, frontoclypeal lobes entirely fused, pronotum thickly ochraceously pilose; metopidium 1.75 times as broad as high, convex, backwardly sloping, disc convex; humeral angles short, tips blunt, posterior angles rounded; posterior process broadly triangular, thickly palely pilose, contiguous with scutellum and tegminal inner margins, apex gradually tapering to an acute tip just reaching apex of clavus, dorsal carination finely continued through metopidium; scutellum twice as broad as long, deeply excavated at tip, strongly chitinised at lateral areas, tips acute; tegmina three times longer than broad, more or less speckled with fuscous, greyish semiopaque, base and costal area ochraceous, 1st apical cell nearly 6 times longer than wide, 1st discoidal cell not pedicellate, about as long as 2nd discoidal cell; hind wings with 3 apical cells; legs shaded with black upto basal half of femora, tibiae reddish brown, tarsi light brown; body beneath dark brown.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 4.3 mm., width across humeral angles 2.6 mm., at eyes 2.0 mm.

Male.—Smaller than female; pronotum jet black; tip of posterior process black; tegmina hyaline, basal sixth black, punctate, costal margin shaded with black, apical sixth including apical limbus black; a subapical narrow black band.

Measurements.—Length from frontal margin to tips of tegmina 4.5 mm., to tip of posterior process 3.3 mm., width across tips of humeral angles 2.3 mm., at eyes 1.8 mm.

Fifth instar nymph.—General coloration pale green with castaneous patches sprinkled over tergites; head turned backwards; vertex about twice as wide as long, planate at base, thickly pilose with tuberculate hairs, lower margins broadly rounded; frontoclypeus densely bristled, never extending beyond the level of lower margins of vertex; ocelli faintly visible, closer to eyes than to each other and located above the c-o-line; tip of rostrum extending to metathorax; thorax triangular in a cross section, metopidium convex and backwardly sloping to disc, pronotal posterior process bluntly acute, extending over half the length of mesonotum; supra-ocular callosities obscure; mesonotum with a pair of stout lateral tubercles; mesonotal process produced over base of metanotum



Text-fig. 29. *Gargara mixta* (Buckton)

1. Egg-slits on host stem. 2. First instar. 3. Second instar. 4. Third instar. 5. Fourth instar. 6. Fifth instar. 7. Adult male. 8. Frontal view. 9. Dorsal view of pronotum. 10. Scutellum. 11. Tegmina of male. 11a. Tegmina of female. 12. Hind wing. 13. Male terminalia, lateral view,

which is concave at posterior margin; tegminal wing pads well developed, costal angles broadly rounded and confluent with costal margin; abdomen narrowest at the level of 2nd segment; dorsal tubercles long, twig-like with tuberculate vertical spines, bristles arranged in a characteristically spiral fashion dorso-lateral tubercles and a row of weak tuberculate hairs on posterior margins of abdominal segments giving a highly bristly appearance to the nymph; lateral lamellae long and somewhat tapering, each with 8 or 9 long slender tuberculate bristles arranged in a regular manner; anal tube nearly one-fifth as long as body and fringed with two dorsal and two dorsolateral rows of closely arranged long tuberculate spines; spines at the base of anal tube more than half as long as the tube; anal tube one-fifth of total length of body.

Host plants.—*Lagerstroemia* sp., *Syzygium jambolanum.*

Material studied.—38 females, 8 males and many nymphal instars, Madras, 14.x.1967.

Gargara albitarsis n.sp.

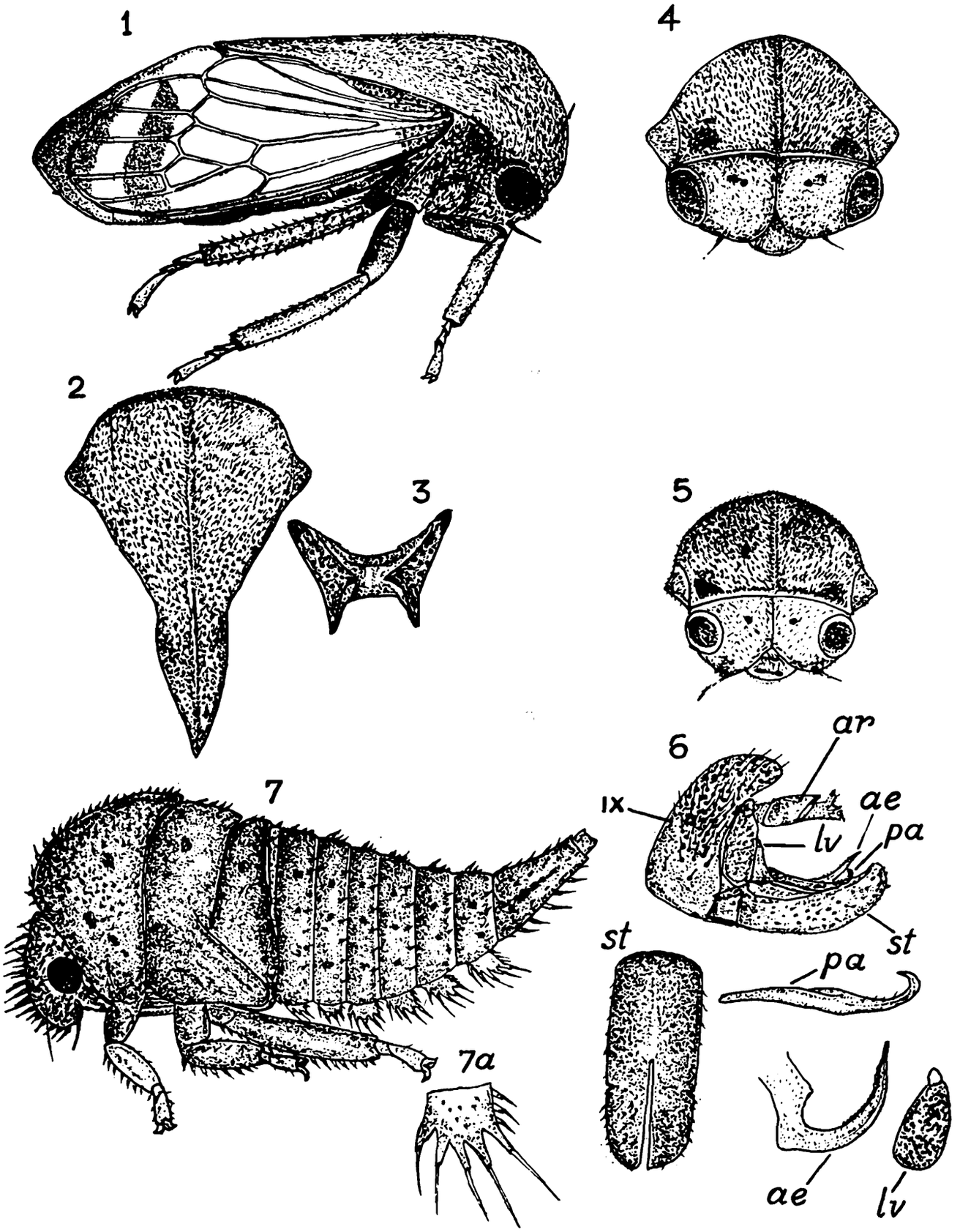
(Text-fig. 30)

Female.—General colour dark brown, shaded to black on dorso-lateral areas of metopidium, lateral carinae and apical fourth of pronotal posterior process; head nearly 2.5 times wider than long; vertex finely punctate, with short yellow hairs, nearly thrice as wide as long, upper margin nearly planate and weakly sinuate, lower margins gradually sloping down to frontoclypeus; eyes dull red, ocelli shining white, closer to eyes than from each other and located above centro-ocular line; a small rounded spot near each ocellus; frontoclypeus dark reddish brown extending slightly below lower margins of vertex, lateral lobes completely fused, tip broadly rounded and hairy. Pronotum ferruginous, strongly punctate, with short adpressed pale yellow hairs; metopidium strongly convex at base and then vertical, gradually sloping backwards to disc; supraocular callosities conspicuous, humeral angles concolorous with disc; posterior process straight, tip acuminate, jet black, reaching anal angles of tegmina, 2.3 times longer than wide, basal sixth of tegmina and three-fourth of costal margin castaneous and punctate; apical limbus broad, with a black or reddish brown fascia extending into the apical cells, a subapical transverse fascia across apical cells; veins light brown; legs with coxae and basal half of trochanters jet black, rest dark brown except tarsi which are pale white or yellowish white; abdominal undersurface pubescent.

Measurements.—Length from frontal margin to tips of tegmina 4.25 mm., to tip of posteiror process 3.0 mm., length of tegmina 3.4 mm., width across tips of humeral angles 2.1 mm., at eyes 1.9 mm.

Male.—Differing from female in being smaller and darker; metopidium less convex, abdominal sternites more pubescent.

Measurements.—Length from frontal margin to tips of tegmina 3.75 mm., to tip of posterior process 2.7 mm., length of tegmina 3.0 mm., width across tips of humeral angles 1.9 mm., at eyes 1.6 mm.



Text-fig. 30. *Gargara albitarsis* n. sp.

1. Adult female. 2. Dorsal view of pronotum. 3. Scutellum. 4. Frontal view of female. 5. Frontal view of male. 6. Male genitalia. 7. Fifth instar, 7a, Abdominal lateral lamella of fifth instar.

Fifth nymphal instar.—General colour deep green; reddish brown patches scattered over; body laterally compressed; head directed downwards, thrice as wide as long; vertex planate, base truncate, clypeus densely pilose; ocelli indistinct; metopidium convex in front, sloping backwards and fringed with short tuberculate spines; pronotal posterior process very short, just overlapping the base of mesonotum; tip broadly rounded; mesonotum about two times longer than metanotum; wing pads moderately developed extending upto 2nd abdominal segment, costal angles not demarcated; legs light reddish brown, except tarsi which are pale white; abdomen excluding anal tube as long as thorax, tuberculate spines arranged in a row near the posterior margin of each segment; dorsal tuberculate spines inconspicuous and adpressed to body; lateral lamellae on segments 3-8 short and broad, resembling those of *Coccosterphus*, each lamella bearing 5 slender pointed spines on tubercles, besides 2 or 3 short spines towards posterior margin; anal tube one-fifth of body length, fringed with rows of spines, each row consisting of 5 or 6 short tuberculate spines.

Host plant.—Tecoma grandiflora

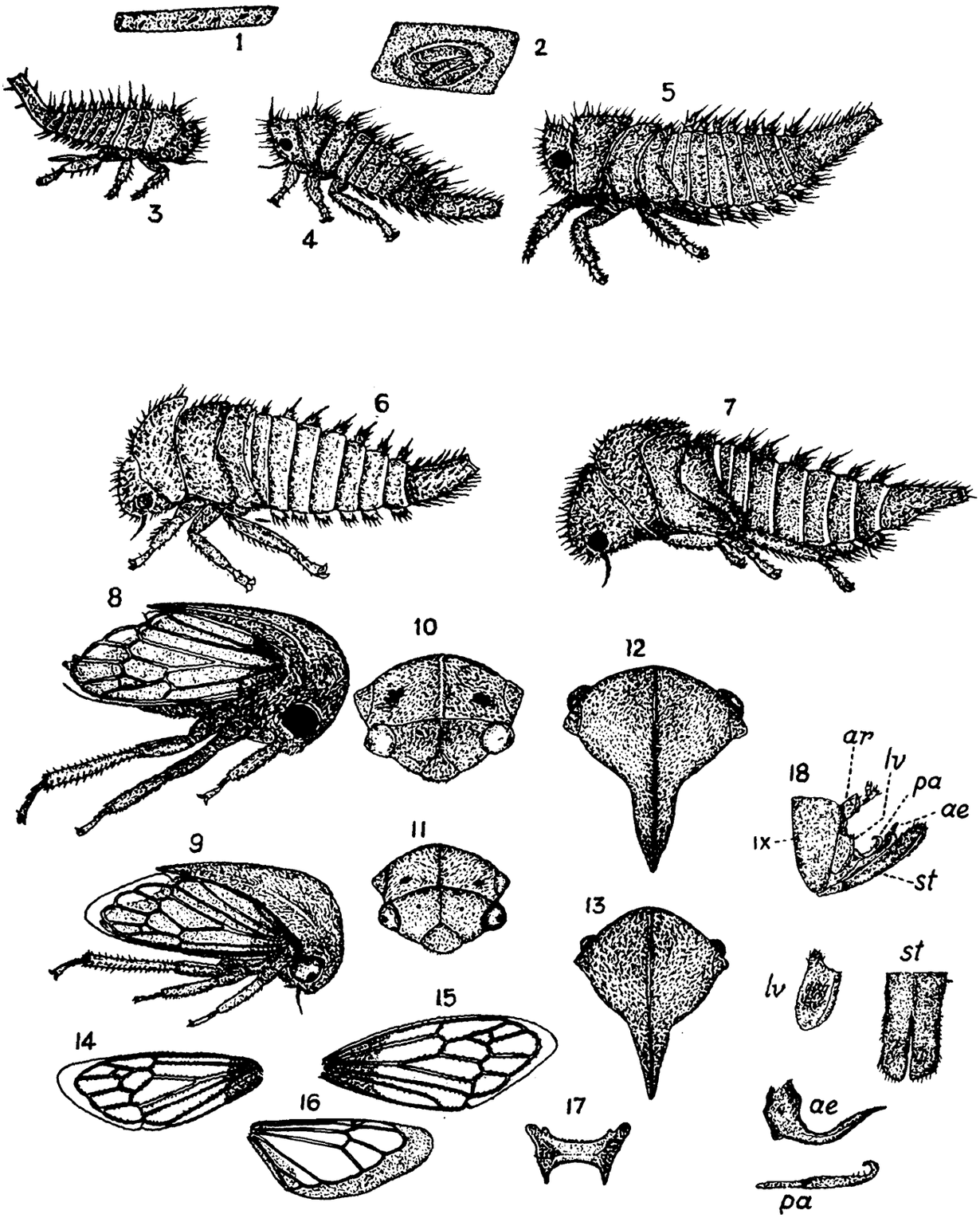
Holotype female; 4 female, 3 male paratypes, 10 nepionotypes, Madras, 2.i.1967.

Gargara albitarsis is nearest to *mixta* but differs in the much smaller size, black colour, in the position of ocelli which are above centro-ocular line, in the pedicellate 1st discoidal cell and in the pale white tarsi; in the presence of a subapical and an apical transverse fasciae, it resembles the male of *mixta*.

Gargara madrasensis n.sp.

(Text-fig. 31)

Female.—General colour black; head vertical, more than twice as wide as long, finely punctate with dense pale yellowish hairs, vertex weakly convex, upper margin somewhat sinuate, lower margins strongly oblique to frontoclypeus, eyes light brown, subglobate, ocelli black, closer to eyes than to each other and located distinctly above c-o-line; frontoclypeus as wide as one-third width of head, lateral lobes entirely fused, tip broadly rounded, fringed with short golden yellow hairs; rostrum reaching bases of hind coxae. Pronotum light brown, densely pilose; metopidium convexly obumbrant and sloping backwards into disc, finely punctate and clothed with short dense golden pilosity; supra-ocular callosities conspicuous, black, partially hidden by pilosity from surrounding areas; humeral angles concolorous with disc, blunt; posterior process broad at base, about two-thirds as wide as long, emerging from posterior margin of disc, contiguous with scutellum, extending horizontally backwards as far as anal angles of tegmina; median carina fine, percurrent, continued through metopidium without any interruption on disc; scutellum aborted centrally, basal lateral parts exposed, punctate, brown, densely pilose at basal angles; tegmina nearly two and a half times longer than wide, uniformly hyaline except the basal fifth which is dark brown, coriaceous and punctate; veins light brown, margined with sparse pale yellow hairs; apical limbus broadest opposite to



Text-fig. 31. *Gargara madrasensis* n. sp.

1. Twig with egg-slits. 2. Egg-slit exposed to show the arrangement of eggs. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 8. Adult female. 9. Adult male. 10. Frontal view of female. 11. Frontal view of male. 12. Dorsal view of pronotum of female. 13. Dorsal view of pronotum of male. 14. Tegmina of male. 15. Tegmina female. 16. Hind wing. 17. Scutellum. 18. Male genitalia, lateral view.

3rd apical cell; 2nd discoidal cell about 2.3 times as long as the 1st discoidal cell which is petiolate; thoracic lateral areas and tergites of abdomen punctate, light brown; ovipositor dark brown; legs light reddish brown.

Measurements.—Length from frontal margin to tips of tegmina 2.75 mm., to tip of posterior process 2.0 mm., width across humeral angles 1.75 mm., across eyes 1.5 mm.

Male.—Smaller; general colour dark brown, more densely pilose, eyes pale white; metopidium sloping backwards; sub-genital plate dark brown.

Measurements.—Length from frontal margin to tips of tegmina 2.3 mm., to tip of posterior process 1.5 mm., width across humeral angles 1.4 mm., at eyes 1.1 mm.

Fifth nymphal instar.—General colour deep green; head directed downwards, two times wider than long; vertex with tuberculate spines directed forwards; ocelli obscure; thorax covered with short spines denser on dorsal region; metopidium sloping backwards; posterior process as long as pronotum, extending over the entire length of mesonotum and terminating in an acute point; wing pads yellowish brown, costal angles not demarcated; abdomen with dorsal tubercles well developed, each tipped by a long tuberculate spine and a cluster of smaller spines emerging from base; lateral regions of abdominal tergites only sparsely and weakly pilose; lateral lamellae short, semicircular, each lamella bearing 5-7 small slender spines on tubercles anal tube a little less than one-fifth the total length of body.

Host plants.—Cestrum diurnum. Caesalpinia pulcherrima, Tecoma stans.

Holotype female; 14 female, 5 male paratypes, 8 nepionotypes, Madras, 1.viii.1967.

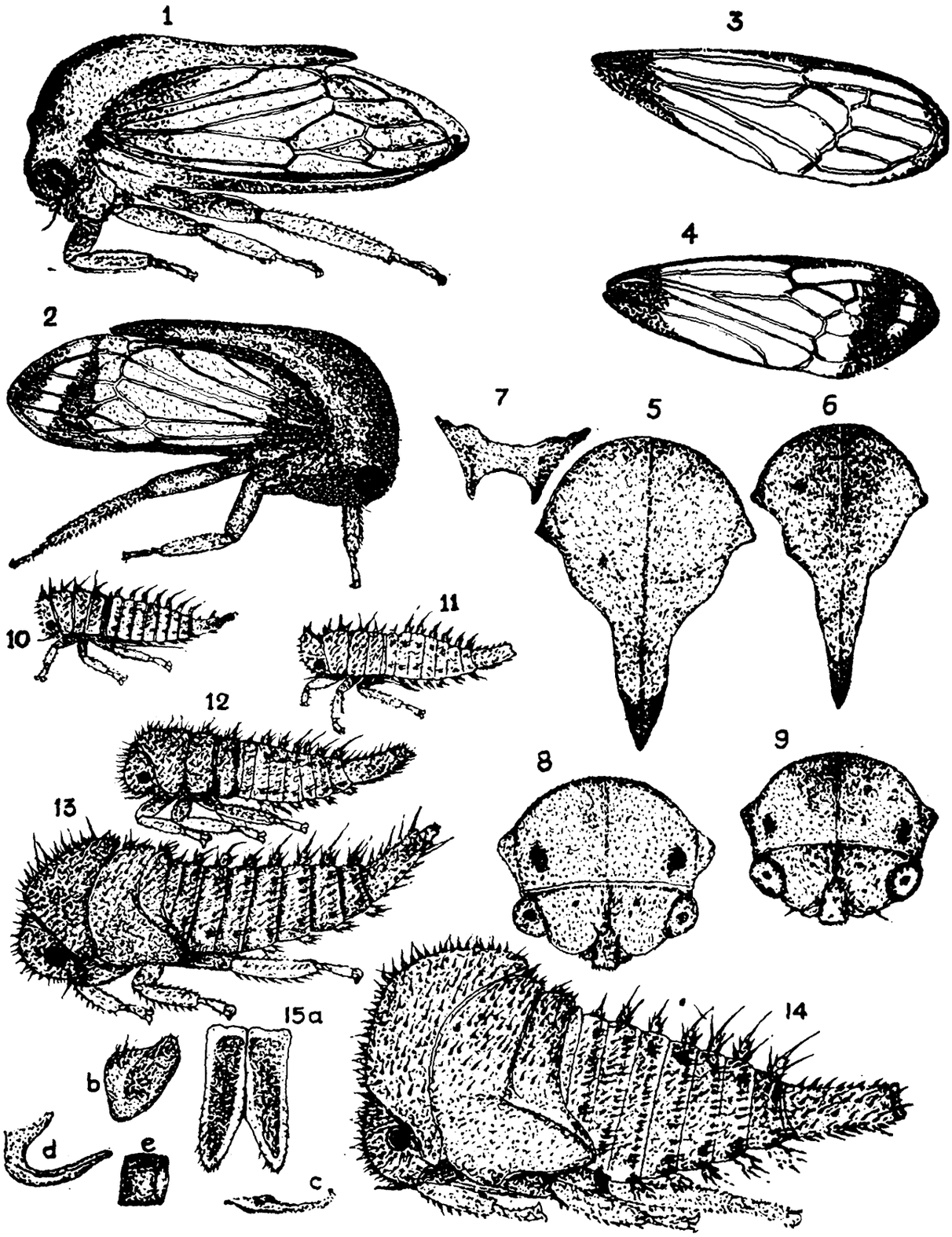
This species comes near *rustica* from which it can be easily distinguished by the much smaller size, black coloration, and the pedicellate first discoidal cell of tegmina which is much smaller than 2nd discoidal cell.

Gargara extrema Distant

(Text-fig. 32)

1916. *Gargara extrema* Distant, *Fauna Brit. India, Append.* **6**: 171.

Female.—General coloration black; head nearly three times wider across extremities of eyes than length of vertex; vertex nearly two times wider than long, finely pilose with silvery hairs; eyes hemispherical, reddish brown; ocelli succineous, a little nearer to eyes than to each other and located above centro-ocular line; frontoclypeus longly sparsely pilose, one-fourth of its length extending below lower margins of vertex, tip truncate; pronotum black, with shades of brown; finely pilose; metopidium about as wide as high, with sparsely adpressed silvery pilosity, convex, slightly sloping; supraocular callosities large, black, impunctate; humeral angles prominent, brown, sparsely hairy, tips nearly



Text-fig. 32. *Gargara extrema* Distant

1. Adult female. 2. Adult male. 3. Tegmina of female. 4. Tegmina of male. 5. Dorsal view of pronotum of female. 6. Dorsal view of pronotum of male. 7. Scutellum. 8. Frontal view of female. 9. Frontal view of male. 10. First instar. 11. Second instar. 12. Third instar. 13. Fourth instar. 14. Fifth instar. 15a, Sternal plate of male genitalia, b, lateral valve; c, paramere; d, aedeagus; e, anal ring.

blunt; posterior process broadly triangular, centrally slightly sinuate, tip black, acute, passing behind apex of clavus and reaching the posterior angle of inner margin of tegmina, dorsal carination strongly percurrent through metopidium; tegmina nearly thrice as long as wide, subhyaline, basal sixth punctate, dark reddish brown, costal margin narrowly black, thickened at R1 forming an incipient pterostigma, apical limbus speckled with black spots, 1st apical cell about six times longer than wide, 1st discoidal cell pedicellate; legs, upto basal half of femora black, tibiae reddish brown, tarsi pale white, with shades of black; body beneath black, with short pale white hairs.

Measurements.—Length from frontal margin to tips of tegmina 6.0 mm., to tip of posterior process 4.3 mm., width across humeral angles 3.0 mm., at eyes 2.4 mm.

Male.—Slightly smaller; general coloration jet black; tegmina with a somewhat narrow apical black band extending over apical limbus and a broad subapical band.

Measurements.—Length from frontal margin to tips of tegmina 5.6 mm., to tip of posterior process 4.2 mm., width across tips of humeral angles 2.7 mm., at eyes 2.2 mm.

Fifth instar nymph.—General coloration deep brown; body robust, highly bristled; head vertical, about 2.5 times wider than long, slightly convex, apex truncate; ocelli obscure; pronotum high, sloping upwards and backwards; metopidium vertical upto three-fourths of its height and then sloping backwards to disc; pronotal process slightly curved behind extending over basal half of mesonotum; tuberculate spines on metopidium directed forwards; spines on lateral aspects of thorax smaller and dense; mesonotum with posterior margin declivous, hardly produced into a process; tegminal wing pads with costal angles distinctly demarcated, fringed with long bristles arranged as in *mixta;* lateral lamellae long, narrow, cylindrical, each lamella fringed with 4 or 5 spines springing from all sides of lamella; anal tube one-fifth the total length of body, with rows of spines which are shorter right from base.

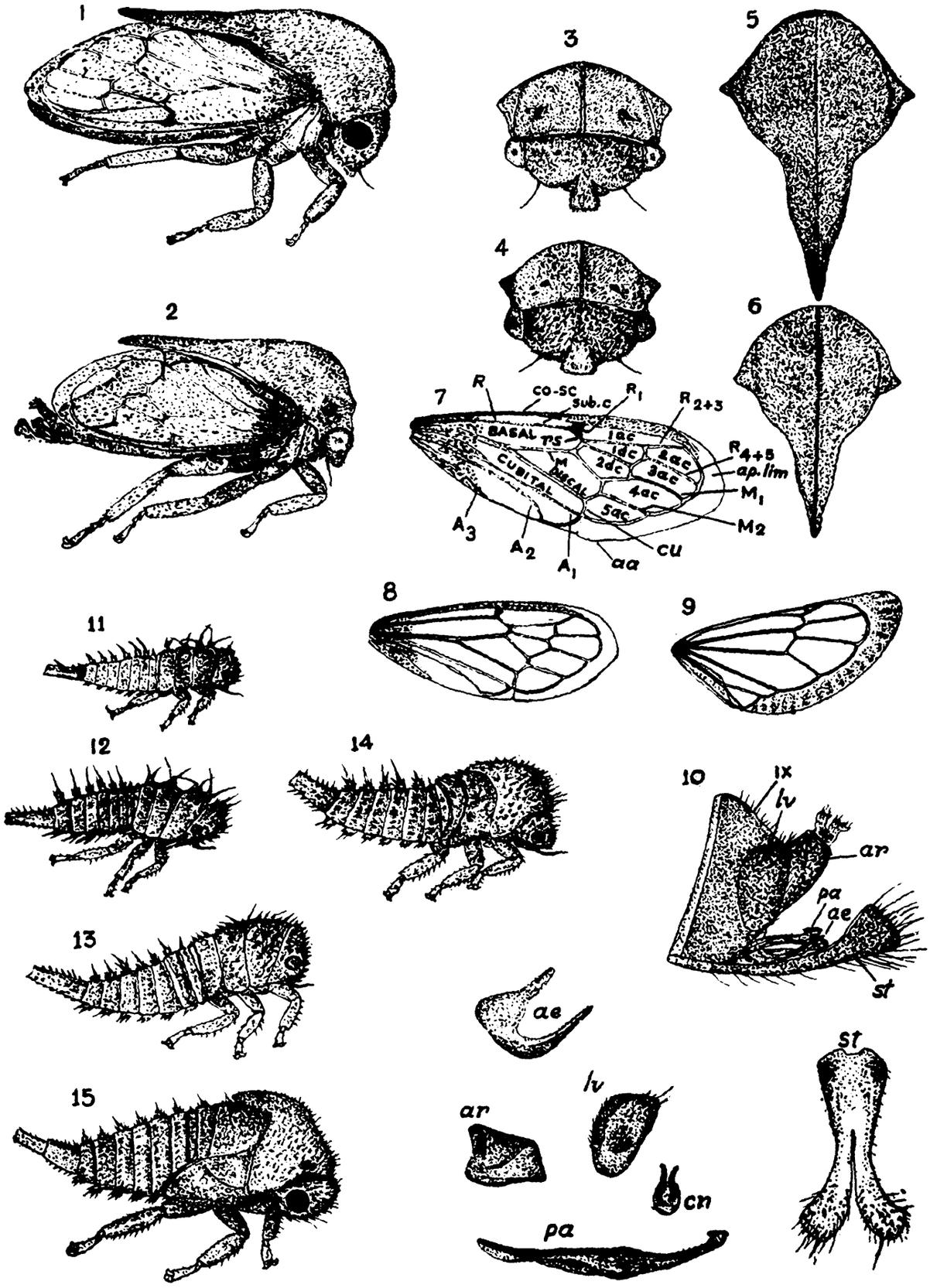
Host plants.—*Solanum melongena*, *Solanum torvum*, *Zizyphus oenoplia*, *Capsicum frutescens.*

Material studied.—40 females, 6 males and numerous nymphal instars, Madras, October to December, 1967.

Gargara malabarica n.sp.

(Text-fig. 33)

Female.—General colour ochraceous brown; head vertical, black with shades of brown, nearly thrice as wide as long; vertex with upper margin nearly planate, finely punctate with short adpressed golden yellow pilosity, lower margins broadly rounded and obliquely continuous to frontoclypeus; eyes dark brown; ocelli dull succineous, a little closer to eyes than to each other and situated slightly above the centro-ocular line; frontoclypeus with half of its length extending below vertex; lateral lobes small, free; tip broad, truncate, fringed with rather long golden pilosity, marginal carinae jet black. Thorax: Pronotum dark



Text-fig 33. *Gargara malabarica* n. sp.

1. Adult female. 2. Adult male. 3. Frontal view of female. 4. Frontal view of male. 5. Dorsal view of pronotum of female. 6. Dorsal view of pronotum of male. 7. Tegmina of female. 8. Tegmina of male. 9. Hind wing. 10. Male genitalia, lateral view. 11. First instar nymph. 12. Second instar. 13. Third instar. 14. Fourth instar. 15. Fifth instar.

brown, shading to jet black on median and lateral carinae and apical fourth of posterior process; metopidium three times as wide as high, covexly sloping backwards into disc; punctate with golden hairs more dense at bases of humeral angles; supra-ocular callosities not prominent; humeral angles prominent, light brown, blunt; posterior process strongly tricarinate, running horizontally backwards as far as the middle of 5th apical cell of tegmina, apical fourth jet black, tip a little curved upwards and acute, median carina finely percurrent on metopidium; scutellum aborted centrally, lateral basal areas exposed, punctate and somewhat tomentose; tegmina about two and two-thirds as long as wide, hyaline, basal fifth reddish brown, leathery and punctate, veins light reddish brown, a distinct reddish brown patch on R1 and rs; a lighter spot at anal angle; 1st apical cell twice as long as 2nd apical cell; lateral areas of thorax densely whitely tomentose; legs reddish brown except coxae which are black. Abdominal tergites dark brown, genital plates densely pubescent.

Measurements.—Length from frontal margin to tips of tegmina 4.5 mm., to tip of posterior process 3.4 mm., width across tips of humeral angles 2.2 mm., at tyes 2.0 mm.

Male.—Smaller, general colour black or almost black; upper margin of vertex arcuate and somewhat sinuate; frontoclypeus with one-third of its length extending beyond vertex, lateral lobes more or less fused to lateral margins of frontoclypeus, tip broader than in female. Thorax: Pronotum black, shaded to brown, finely punctate with closely adpressed pale yellow hairs, tip of posterior process pitch black, bluntly acute, a little decurved and extending as far back as tip of 5th apical cell of tegmina. Tegmina nearly 2.5 times as long as wide. 1st apical cell less than twice as long as 2nd apical; reddish brown patch on R1 and rs less conspicuous than in female; abdominal tergites dark brown with intersegmental membranes lighter, bifid tips of subgenital sternal plate divergent, broad, enlarged and densely pubescent.

Measurements.—Length from frontal margin to tips of tegmina 3.9 mm., to tip of posterior process 2.8 mm., width across tips of humeral angles 1.9 mm., at eyes 1.7 mm.

Nymph.—Fifth instar: Greyish brown; head directed backwards, twice as wide as long, eyes large fuscous; ocelli not visible; pronotum densely pilose dorsally; metopidium somewhat sinuate, sloping backwards to disc; posterior process tapering, extending over three-fourths the length of mesonotum; mesonotal process obscure; metathorax about one-third as long as mesothorax; wing pads large, extending as far as 4th abdominal segment, claval area demarcated from corium, costal margin dark brown, costal angles broadly rounded and not sharply demarcated; abdomen densely hairy; dorsal tubercles as in *rustica;* lateral lamellae, of moderate length, each bearing 5 or 6 thin spines; anal tube one-fifth the total body length, stout and nearly cylindrical, with longitudinal rows of very short tuberculate spines.

Host plant.—Phyllanthus emblica.

Holotype female; 18 female 7 male paratypes, 10 nepionotypes, Walayar, 8.viii.1967; Tambaram, 1.xii.1967.

The species is nearest to *extrema* but differs in the smaller size, in the nature of the pronotum which is coarsely ochraceously pilose, in the straight posterior process, in the hyaline tegmina which is not fuscous, and in the non-pedicellate 1st discoidal cell of tegmina.

Gargara rustica n.sp.

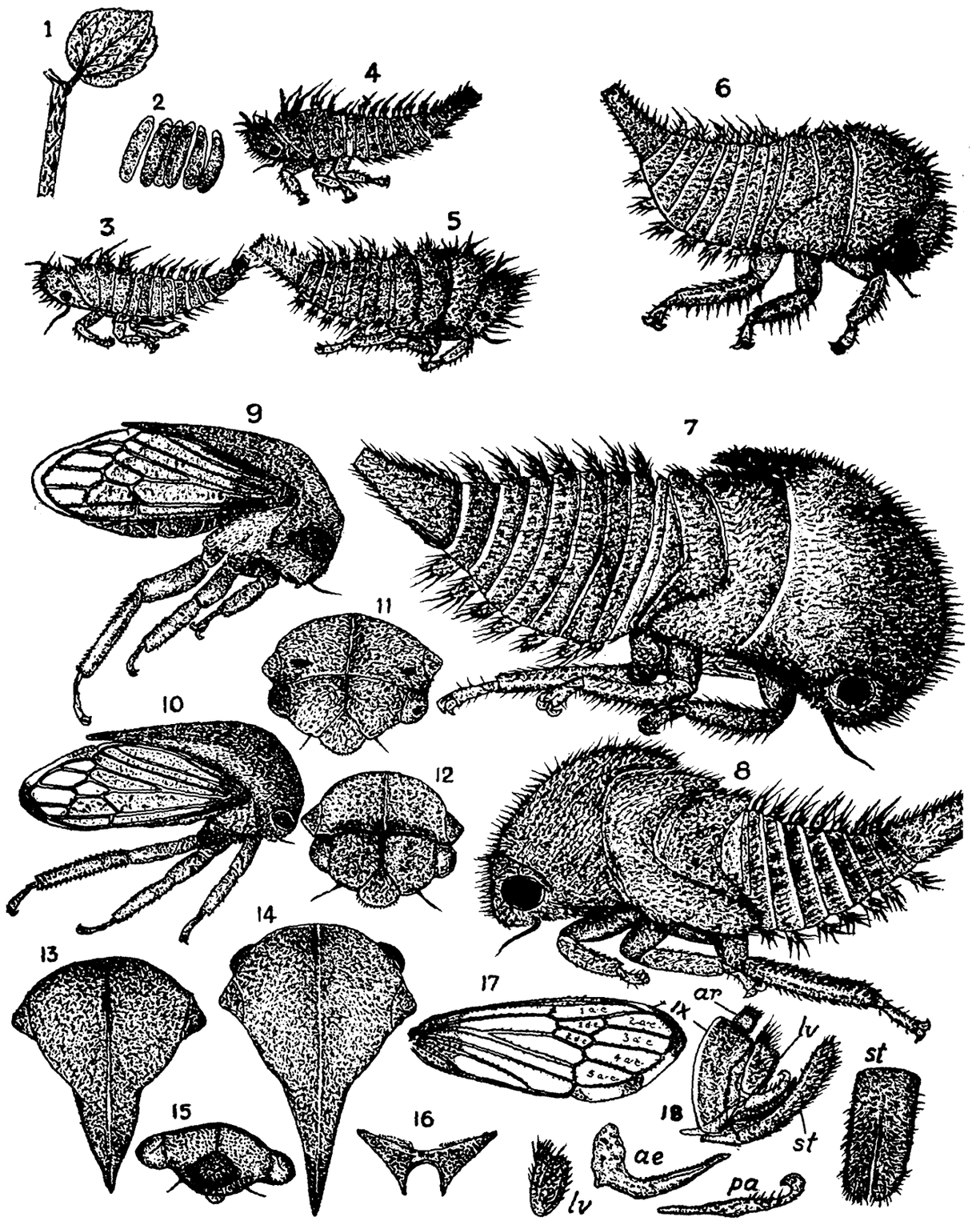
(Text-fig. 34)

Female.—General colour rusty brown; head declivous, about two and a half times wider across extremities of eyes than length of vertex, brown, sprinkled with red spots, densely pilose with golden yellow hairs; vertex about one and three-fourths as wide as long, upper margin planate, lower margins obliquely sloping to frontoclypeus; eyes subglobate, dark brown; ocelli jet black, small, slightly closer to eyes than to each other and located well above c-o-line; frontoclypeus greyish brown, extending about one-third its length below lower margins of vertex, its lobes entirely fused upto tips and together forming a broadly rounded tip fringed with somewhat longer pale yellow hairs; rostrum reaching bases of middle coxae; antennae rusty brown, their length equals half the width of frontoclypeus. Pronotum reddish brown, metopidium convex and sloping backwards, distinctly punctate, with yellow hairs, disc convex, sprinkled with rusty brown spots, humeral angles moderately prominent, light brown, their posterior angles rounded and tips blunt; posterior process arising horizontally from disc, fitting tightly against scutellum and contiguous with tegmina, basally broad and hollow ventrally, tricarinate, median carina finely continued on metopidium, terminal one-fourth of posterior process jet black, tip acute, just passing the anal angles of tegmina; scutellum twice as broad as long, deeply excavated at tip, incompletely chitinised in middle, strongly chitinised and punctate laterally; tegmina hyaline, nearly two and a half times longer than wide, extreme base coriaceous and punctate, veins reddish brown bordered with short hairs, 1st discoidal cell not petiolate, 2nd discoidal cell half as long as 1st apical cell, rusty brown patches on apical limbus opposite to 2nd, 3rd and 5th apical cells and at anal angle; lateral areas of thorax cretaceously sericeous; legs light reddish brown except coxae and trochanters which are black; abdomen dark reddish brown, lateral areas of sternites somewhat whitely tomentose; ovipositor robust, darker.

Measurements.—Length from frontal margin to tips of tegmina 4.0 mm., to tip of posterior process 3.2 mm., width across humeral angles 2.1 mm., at eyes 1.8 mm.

Male.—General colour jet black, smaller than female, eyes pale white with shades of yellow; metopidium, disc and posterior process pitch black with short silvery white adpressed hairs; tegmina subhyaline, sprinkled with rusty spots, veins black.

Measurements.—Length from frontal margin to tips of tegmina 3.3 mm., to tip of posterior process 2.6 mm., width across humeral angles 1.8 mm., at eyes 1.5 mm.



Text-fig. 34. *Gargara rustica* n. sp.

1. Egg-slits on host stem. 2. Eggs. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar of female. 8. Fifth instar of male. 9. Adult female. 10. Adult male. 11. Frontal view of female. 12. Frontal view of male. 13. Dorsal view of pronotum of male. 14. Dorsal view of pronotum of female. 15. Head, frontal elevation. 16. Scutellum. 17. Tegmina. 18. Male terminalia.

Fifth instar.—Strikingly dimorphic. Female larger, pale green, densely hairy; head directed backwards, 2.5 times wider than long, vertex with dense pilosity and long slender tuberculate spines; ocelli not visible; antennae as long as width across frontoclypeus; prothorax longer than pterothorax; metopidium convex, gradually sloping backwards, thickly hairy; posterior process densely pilose, passing over the entire length of mesonotum; tip acute; mesonotal process prominent; wing pads relatively small and narrow, their costal angles not distinctly demarcated; abdominal dorsal tubercles arranged as in *extrema*, but lateral lamellae short, each with 4 or 5 long spines besides smaller ones interspersed; anal tube about one-fifth of total body length, clothed with moderately long tuberculate spines.

Male fifth instar about three-fourths as long as female; head directed downwards, eyes prominent; prothorax shorter than pterothorax; pronotal posterior process some-what broader and blunt, not extending over the entire length of mesonotum; wing pads very large, sprinkled with short hairs, costal angles very distinct; abdominal lateral lamellae with 4 to 6 spines.

Host plant.—Zizyphus jujuba.

Holotype female; 35 female and 13 male paratypes, 21 nepionotypes, Madras, 12.ix.1967.

In this dimorphic species, the male is very near to *robusta* Distant in the general coloration of body and in the spots near the apex of clavus; the female is nearest to *mixta* in the ochraceously pilose pronotum and in the non-pedicellate 1st discoidal cell, but differs in the presence of reddish brown patches in the apical areas of costal margin, apical limbus and near apex of clavus.

Key to species of **Gargara** Amyot and Serville *based upon Fifth instar nymph*

1 (6) Spines on abdominal lamellae regularly arranged along margins.

2 (3) Body large, 4.75-5.25 mm. long; metopidium convex and obumbrant at base and then sloping backwards; pronotal posterior process extending upto one-half the length of mesonotum; lateral lamellae of abdomen long and broad, fringed with 8 or 9 long spines; castaneous patches scattered all over body. .*mixta* Buckton

3 (2) Body small; 2.0-2.75 mm. long; lateral lamellae of abdomen short, fringed with 5-7 moderately long spines.

4 (5) Head thrice as wide as long; pronotal posterior process short, never extending over mesonotum; abdominal dorsal tubercles adpressed to body; reddish brown patches scattered over body. .*albitarsis* n.sp.

5 (4) Head twice as wide as long pronotal posterior process long, extending over the entire length of mesonotum; abdominal dorsal tubercles erect; no red patches scattered over body. .*madrasensis* n.sp.

6 (1) Spines on abdominal lateral lamellae not regularly arranged along margins, but springing from the sides.

7 (8) Body large, 4.0-4.5 mm. long; metopidium vertical upto three-fourths its height and then sloping backwards; pronotal posterior process extending upto one half the length of mesonotum; lateral lamellae of abdomen with 4 or 5 spines, longer thanl amella. .*extrema* Dist.

8 (7) Body of moderate size, 3.25-3.75 mm.

9(10) Pronotal posterior process extending over the entire length of mesonotum, mesonotal process prominent; wing pads of female short and narrow; lateral lamellae of abdomen short and narrow with 4 or 5 spines. .. .*rustica* n.sp.

10 (9) Pronotal posterior process extending upto three-fourths the length of mesonotum; mesonotal process obscure; abdominal lateral lamellae of moderate size, with 5 or 6 spines. .. .*malabarica* n.sp.

Tribe **Cococosterphini** Distant 1908

The tribe Coccosterphini is very closely related to Gargarini from which it is distinguished by the scutellum which is abortive in the middle. The pronotum is either tuberculate or not. The tegminal veins are coarsely or finely tuberculate; a distinct pterostigma may be present or absent.

Genus **Coccosterphus** Stål 1869

1869. *Coccosterphus* Stål, *Hem. Fabr.*, **8**: 67.

1903. *Phaerotus* Buckton, *Mon. Memb.*: 255.

(Type of the genus *Membracis minutus* Fabr.)

Body small, obovate; head declivous, two and a half to three times as wide as long, width across eyes equal to width of metopidium; eyes somewhat deflexed; ocelli nearer to eyes than to each other and situated on or above centro-ocular line; tip of frontoclypeus on a line with lower margins of vertex or extending below to a variable degree, its lobes entirely fused; pronotum moderately convex, finely or coarsely tuberculate, metopidium about one and a half times as wide as high; suprahumeral horns absent; humeral angles prominent; base of posterior process broadly triangular, depressed from base to middle, closely fitting against scutellum and contiguous with tegminal inner margins, apex laminately convexly raised, reaching apex of clavus; scutellum aborted in the middle, apices spine-like; tegmina with or without a distinct pterostigma, obliquely rounded, apical limbus narrow, base opaque and coriaceous, veins stout, bearing small or large nodulose tubercles, with 5 apical cells and two or three discoidal cells, outer discoidal cell petiolate in some, apical cells often divided by abnormal cross veins; hind wings with three apical cells.

Key to species

1 (4) Tegmina with a distinct pterostigma; tubercles on pronotum and tegminal veins small.

2 (3) Pronotum light brown, with a strong tubercular basal ridge project ing forward, a broader less elevated convex ridge on either side; base of vertex broadly truncate; ocelli located on c-o-l. .. .*paludatus* Distant.

3 (2) Pronotum rusty brown; metopidium with a median and a pair of lateral greyish white streaks; base of vertex strongly arcuate; ocelli located above c-o-l. .*tuberculatus* (Motsch.)

4 (1) Tegmina lacking a pterostigma; tubercles on pronotum and tegminal veins large. .. .*minutus* (Fabricius)

Coccosterphus minutus (Fabricius)

(Text-fig. 35)

1798. *Membracis minuta* Fabricius, *Ent. Syst. Suppl.*: 514.

1803. *Centrotus minutus:* Fabricius, *Syst. Rhyng.*: 22.

1851. *Scaphula* (?) *minuta*: Walker, *List of Hom. Br. Mus.* **2**: 589.

1869. *Coccosterphus minutus:* Stal, *Hom. Fabr.* **8**: 51.

1903. *Scaphula minuta:* Buckton, *Mon. Memb.*: 149.

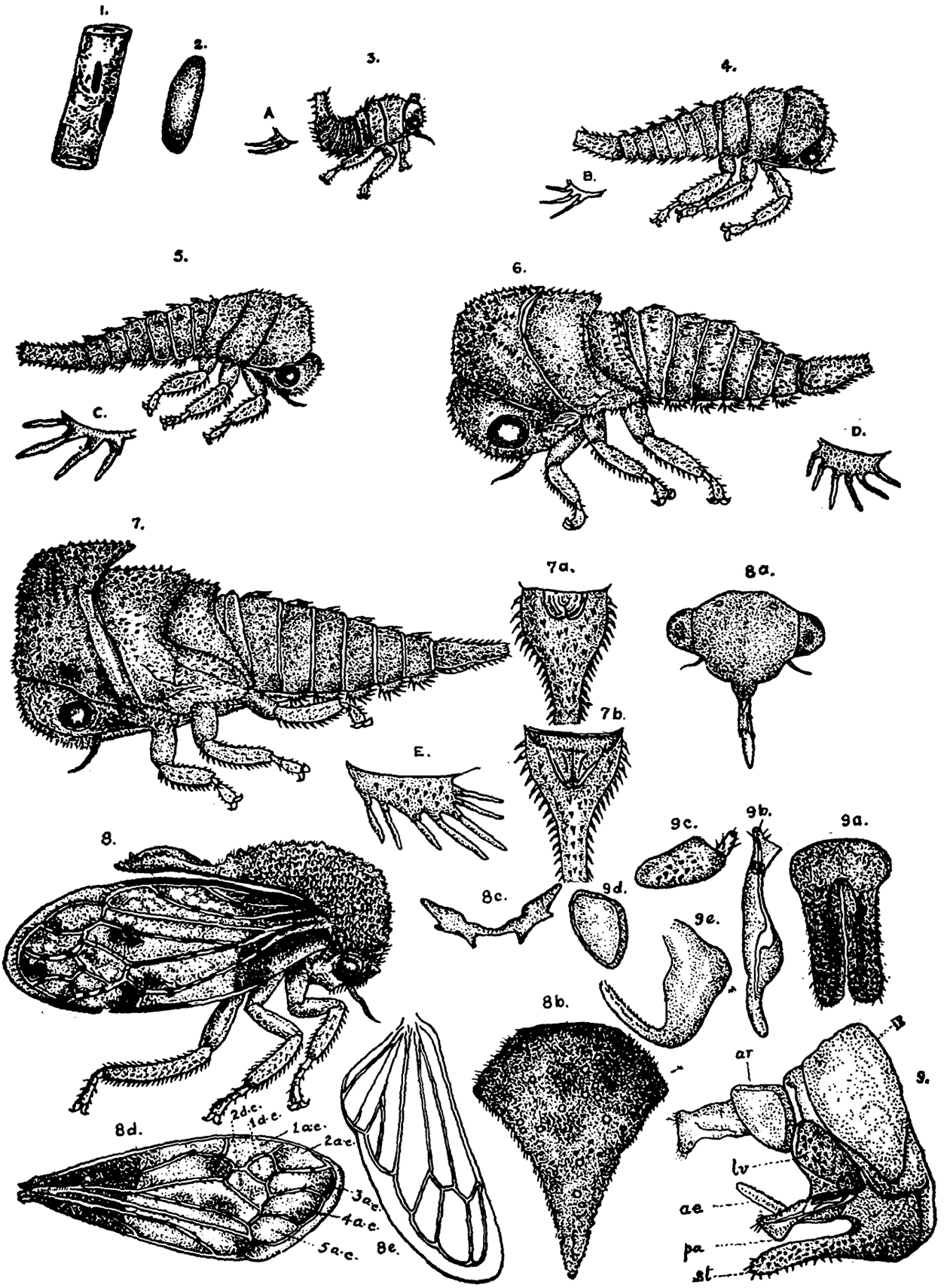
Female.—General colour black; head two and a half times wider than long, sprinkled with granules, sparsely pilose with short adpressed pale white hairs; eyes hemispherical, dull white; ocelli nearer to eyes than to each other and located above centro-ocular line; frontoclypeus nearly oval, about half of its length extending below lower margins of vertex, tip broadly rounded; pronotum black, with large tubercles and granules; metopidium nearly vertical, humeral angles prominent and finely punctate, suprahumeral horns absent; posterior process broadly triangular, slightly elevated behind disc, dorsal carina obsolete anteriorly, interrupted in the median depressed part of posterior process, apical region laminately convexly raised and strongly tuberculate, tip acuminate; tegmina 2.5 times longer than wide, lacking pterostigma, pale greyishly flavescent, basal third coriaceous, punctate and black, veins more or less infuscate, coarsely tuberculous, apical area tinted with reddish brown patches, first apical cell wedge-shaped, twice as long as broad, first discoidal cell stylate; hind wings with 3 apical cells.

Measurements.—Length from frontal margin to tips of tegmina 3.0-3.25 mm., to tip of posterior process 2.2-2.4 mm., width across humeral angles 1.8-2.0 mm., at eyes 1.7-1.8.

Male.—Smaller than female; pronotum and legs black, tegmina as long as abdomen, semilucid yellow with white dots. Genitalia, with sternal plate pitch black, cleaved to about three-fourth of its length from apex; lateral valve wedge-shaped, process very short and unchitinised; aedeagus and parameres as in *tuberculatus*.

Measurements.—Length from frontal margin to tips of tegmina 2.5-2.75 mm., to tip of posterior process 1.8-2.2 mm., width at humeral angles 1.6-1.8 mm., at eyes 1.6 mm.

Fifth instar nymph.—Coloration green; head with closely arranged granules and very short tuberculate spines arranged in a characteristic manner, base of vertex planate, bordered by slender bristles; tip of rostrum extending to basal half of mesothorax; eyes prominent, ocelli inconspicuous; lower margin of frontoclypeus on a line with lower margins of vertex, densely setose; metopidium slightly concave in front, granulose, a transverse keel on either side margined by short closely arranged tubercles; posterior process of pronotum high above mesonotum, passing



Text-fig. 35. *Coccosterphus minutus* (Fabricius)

1. Twig with egg-slits. 2. A single egg. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 7a. Rudiments of male genitalia of fifth instar. 7b. Rudiments of female genitalia of fifth instar. 8. Adult female. 8a. Head, frontal elevation. 8b. Pronotum, dorsal view. 8c. Scutellum. 8d. Tegmina. 8e. Hind wing. 9. Male genitalia, lateral view. 9a. Sternal plate. 9b. Paramere. 9c. Lateral valve. 9d. Anal ring. 9e. Aedeagus.

over basal half of the latter and bearing tubercles tipped with short spines; posterior borders of thoracic tergites fringed with rows of fine hairs; mesonotal process tuberculate, slightly overlapping metanotum; wing pads broad, granules scattered throughout, costal angles very well demarcated, bordered with tuberculate spines; abdomen with 9 segments, the first one is very narrow, the last forming the anal tube; dorsal tuberculate spines adpressed to body; lateral lamellae semicircular, with 7 penicillate spines fringing each lamella; anal tube shorter than the combined length of the three preceding segments; genital rudiments distinct in male and female.

Host plants.—*Prosopis spicigera*, *Cestrum diurnum*, *Tecoma stans*, *Vernonia sinerea*, *Acalypha* sp.

Material studied.—105 females, 39 males, and numerous nymphs, Madras, —.xii.1966.

Coccosterphus paludatus Distant

(Text-fig. 36)

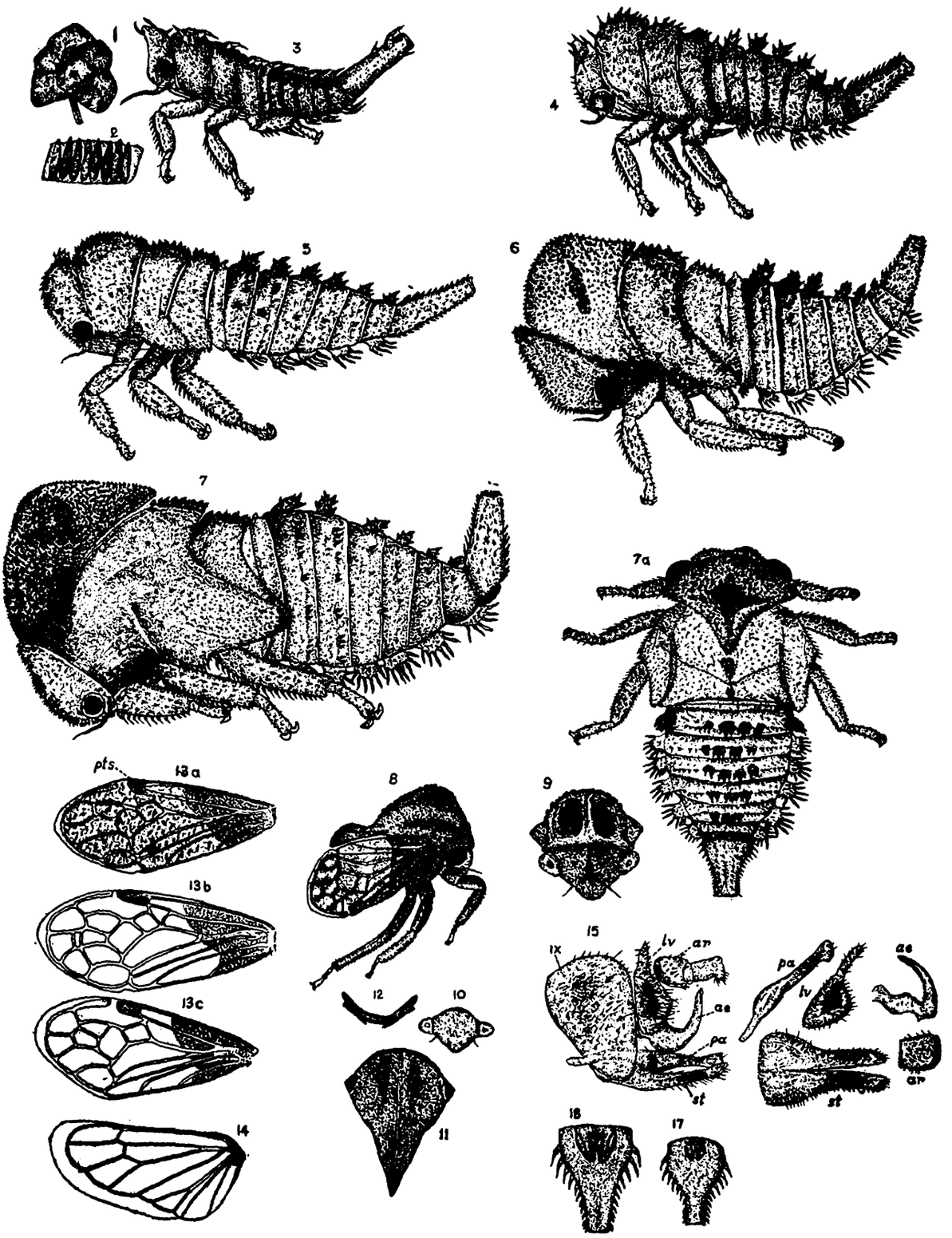
1916. *Coccosterphus paludatus* Distant, *Fauna Brit. India, Append.* **6:** 175.

Female.—General colour light brown; head nearly vertical, two and a half times wider than long, thickly greyishly pilose, base of vertex broadly truncate; eyes hemispherical, pale white; ocelli nearer to eyes than to each other and located on centro-ocular line; frontoclypeus greyish pilose, with its distal half extending below lower margins of vertex, tip broadly rounded, frontoclypeal lobes fused; pronotum light brown, finely tuberculate on median dorsal ridge, with a broad elongate tuberculate ridge on either side; metopidium vertical, with two broad nearly oval ridges one on either side of the median carina which is finely percurrent; suprahumerals absent; humeral angles prominent, thickly pilose; posterior process gradually acuminate, base broadly triangular, concave behind base, apical area black, strongly compressed and convex; scutellum incomplete in the middle; tegmina two and a half times longer than wide, with a distinct pterostigma, greyish white, basal third coriacious and dark brownish ochraceous, followed by a transverse greyish white line, distal half of tegmina with reddish brown patches forming a broad transverse fascia, apical area sprinkled with brown spots, veins reddish brown with small sparse tubercles arranged linearly; legs black upto three-fourths of femora, tibiae ochraceous, tarsi light brown.

Measurements.—Length from frontal margin to tips of tegmina 3.6-4.0 mm., to tip of posterior process 2.7-2.9 mm., width across humeral angles 2.3-2.5 mm., at eyes 1.8-2.0 mm.

Male.—Similar to female. Genitalia, with sternal plate cleaved to two-thirds of its length from apex; lateral valves wedge-shaped, process long and unchitinised; aedeagus *U*-shaped, tip acuminate; tips of parameres slightly expanded; connecting plate rectangular.

Measurements.—Length from frontal margin to tips of tegmina 3.5-3.8 mm., to tip of posterior process 2.6-2.8 mm., width across humeral angles 2.1-2.4 mm., at eyes 1.6-2.0 mm.



Text-fig. 36. *Coccosterphus paludatus* Distant

1. Egg slits on Morinda fruit. 2. Egg slit cut open to show eggs. 3. First instar. 4. Second instar. 5. Third instar. 6. Fourth instar. 7. Fifth instar. 7a. Dorsal view of fifth instar. 8. Adult female. 9. Frontal view. 10. Frontal elevation of head. 11. Pronotum, dorsal view. 12. Scutellum. 13a, b, c. Variations in tegminal venation. 14. Hind wing. 15. Male genitalia, lateral view. 16. Rudiments of female genitalia in fifth instar, 17. Rudiments of male genitalia in fifth instar.

Fifth instar nymph.—Strikingly different from that of *minutus;* body nearly cylindrical, heavily chitinised fore-shadowing the shape and colour of adult; general colour brown dorsally, pale green ventrally; head 2.5 times wider than long, base of vertex planate, cranial tubercules persistent; frontoclypeus never extending beyond lower margins of vertex; rostral tip extending upto middle of hind coxae; thorax nearly as long as abdomen; metopidium convex in front, pronotum sprinkled with granules and short spines on tubercles; a longitudinal carina on disc confluent with a pair of lateral ridges, giving a characteristic cruciform structure, covered with dense tuberculate spines; median ridge continued over posterior process which overlaps the basal half of mesonotum; mesonotum with a median ridge; metanotum narrow, bearing a group of spines on a smaller median ridge; wing pads greyish brown, costal angles distinctly demarcated; abdominal dorsal tubercles tooth-like and heavy; lateral lamellae flat, with 6 or 7 penicillate spines; anal tube about one-seventh the length of body.

Host plants.—*Morinda* sp., *Cestrum diurnum*, *Lawsonia alba*, prop roots of *Ficus bengalensis.*

Material studied: 80 females, 19 males and numerous nymphs, Madras, 1.ix.1965.

Coccosterphus tuberculatus (de Motschulsky)

(Text-fig. 37)

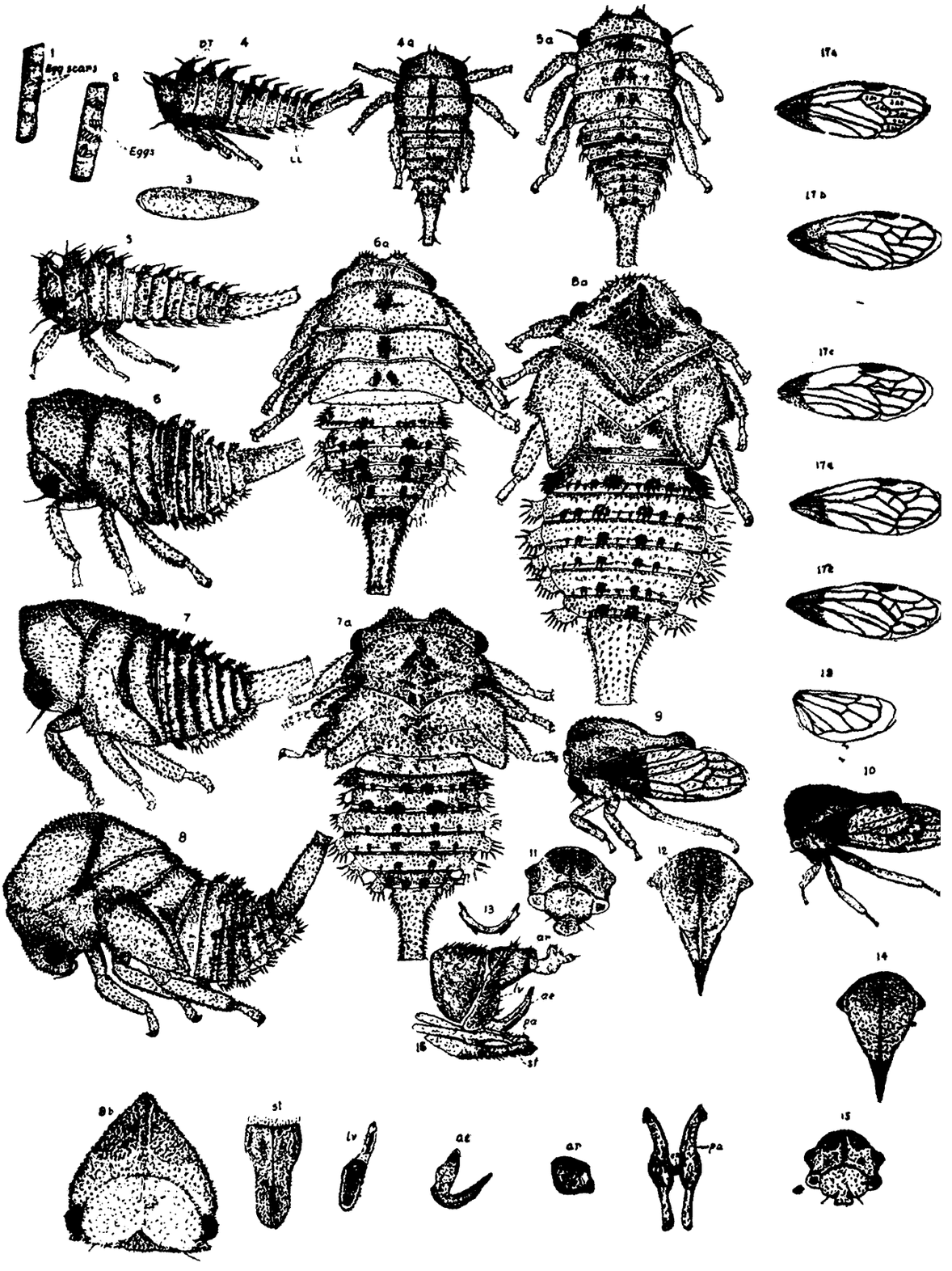
1859. *Anomus tuberculatus* de Motschulsky, *Etud. Ent.* **8**: 109.

1903. *Gargara fasciata* Melichar, *Hom. Faun. Ceylon*, : 122.

1903. *Coccosterphus tuberculatus:* Melichar, *Hom. Faun. Ceylon*, : 121.

Female.—General colour dark brown; head twice as wide as long, rusty brown, sparsely pilose with pale white hairs, base of vertex strongly arcuate and sinuate, eyes prominently projecting laterad; ocelli closer to eyes than to each other and situated slightly above centro-ocular line; frontoclypeus extending three-fourths its length below lower margins of vertex; pronotum rusty brown above, thickly and finely punctate, clothed with short greyish white hairs; metopidium nearly twice as wide as high, with a vertical, median and two lateral greyish white streaks; a pair of broad, oval tuberculate ridges one on either side of median ridge on metopidium; posterior process distinctly keeled dorsally, finely tuberculate, apical area black, strongly compressed and convex, with short tubercles, apex reaching tip of clavus; tegmina about 2.75 times longer than wide, hyaline, with a distinct pterostigma, basal one-third coriaceous and rusty brown, a broad rusty brown transverse fascia beyond middle of tegmina, apical area speckled with reddish brown patches, veins reddish brown, moderately stout, with sparsely arranged tubercles; hind wings with 3 apical cells; legs, with tibiae rusty brown, trochanters and femora black, tarsi yellowish with black spots.

Measurements.—Length from frontal margin to tips of tegmina 3.4-3.8 mm., to tip of posterior process 2.4-2.7 mm., width at humeral angles 1.7-1.9 mm., at eyes 1.7 mm.



Text-fig. 37. *Coccosterphus tuberculatus* (Motsch.)

1. Twig with egg slits. 2. Egg slits exposed. 3. An egg. 4. First instar, lateral view ; 4a. its dorsal view. 5. Second instar, lateral view ; 5a. its dorsal view. 6. Third instar, lateral view ; 6a. its dorsal view. 7. Fourth instar, lateral view ; 7a. its dorsal view. 8. Fifth instar, lateral view ; 8a. its dorsal view. 8b. Frontal view of fifth instar. 9. Adult female. 10. Adult male. 11. Frontal view of female. 12. Pronotum of female, dorsal view. 13. Scutellum. 14. Pronotum of male, dorsal view. 15. Frontal view of male. 16. Male genitalia, lateral view. 17, a-e. Variations in tegminal venation. 18. Hind wing.

Male.—Smaller than female, jet black; genitalia similar to that of *paludatus*.

Measurements. Length from frontal margin to tips of tegmina 3.0-3.5 mm., to tip of posterior process 2.2-2.5 mm., width at humeral angles 1.5-1.7 mm., at eyes 1.5 mm.

Fifth instar nymph.—Similar to *paludatus*, differing only in the colour patterns; general coloration greyish with shades of black; head, pronotum, lateral parts of segments 3 to 6 of abdomen black, dorsal tubercles dark brown, rest of body greyish; lower surface of abdomen pale green; anal tube raised upwards, about one-fifth the length of body.

Host plants.—Phyllanthus emblica, Morinda tinctoria.

Material studied.—85 females, 20 males and many nymphal instars, Madras, 10.i.1966.

Key to species of **Coccosterphus** *based on Fifth instar nymph*

1 (2) Metopidium vertical, dorsal tuberculate spines simple and short; abdominal lateral lamellae small and crescentic bearing 7 penicillate spines; body uniformly green. ..*minutus* Fabr.

2 (1) Metopidium convexly obumbrant; dorsal tubercles of abdominal segments tooth-like, heavy and multispinous; abdominal lateral lamellae larger, flat, each with 6 or 7 short, stout, penicillate spines arranged in a palmate manner.

3 (4) Body yellowish brown.. .. .. .*paludatus* Dist.

4 (3) Body greyish black.. . . .*tuberculatus* (Motsch.)

Genus **Parayasa** Distant

1916. *Parayasa* Distant, *Fauna Brit. India, Append.* **6**: 180.

(Type of genus *Parayasa typica* Distant)

Body small; head 3 times wider across extremities of eyes than length of vertex; eyes subglobate; ocelli about as near to eyes as to each other and situated on centro-ocular line; frontoclypeus extending to one half its length below lower margins of vertex; tips broadly rounded, clypeal lobes fused; pronotum rather low, not tuberculate, metopidium slightly convex; humeral angles prominent with posterior margins rounded; suprahumeral horns absent; posterior process broadly triangular at base, more or less concavely sinuate, closely fitting against scutellum and contiguous with inner margins of tegmina, apical area laminately convex, tip just reaching the apex of 2nd anal cell of tegmina and not reaching the posterior angle of the inner margin of tegmina; scutellum aborted in the middle; tegmina nearly thrice as long as wide, apical limbus narrow, 5 apical cells and 2 discoidal cells, veins finely tuberculous; hind wings with 3 apical cells.

Parayasa maculosa Distant

(Text-fig. 38)

1916. *Parayasa maculosa* Distant, *Fauna Brit. India, Append.* **6**: 127.

Female.—Head brownish ochraceous, thickly pilose, about thrice as wide as long, base of vertex broadly truncate, eyes subglobate, pale white; ocelli equidistant to each other and from eyes and located on centro-ocular line; frontoclypeus sparsely pilose, with half of its length extending below lower margins of vertex; pronotum reddish brown, finely punctate, with short, thickly arranged pale white hairs; metopidium convex in front; posterior process closely fitting against scutellum, nearly straight, tip acute, reaching the 2nd anal cell of tegmina, dorsal carina percurrent through metopidium; tegmina about 3 times longer than wide, basal fourth opaque, dark, thickly punctate, 2nd discoidal cell nearly one and a half times longer than first, first apical cell wedge shaped; scutellum reddish brown, aborted in the middle; legs, with trochanters and femora black, rest light reddish brown.

Measurements.—Length from frontal margin to tips of tegmina 4.0 mm., to tip of posterior process 2.0 mm., width at humeral angles 1.5 mm., at eyes 1.4 mm.

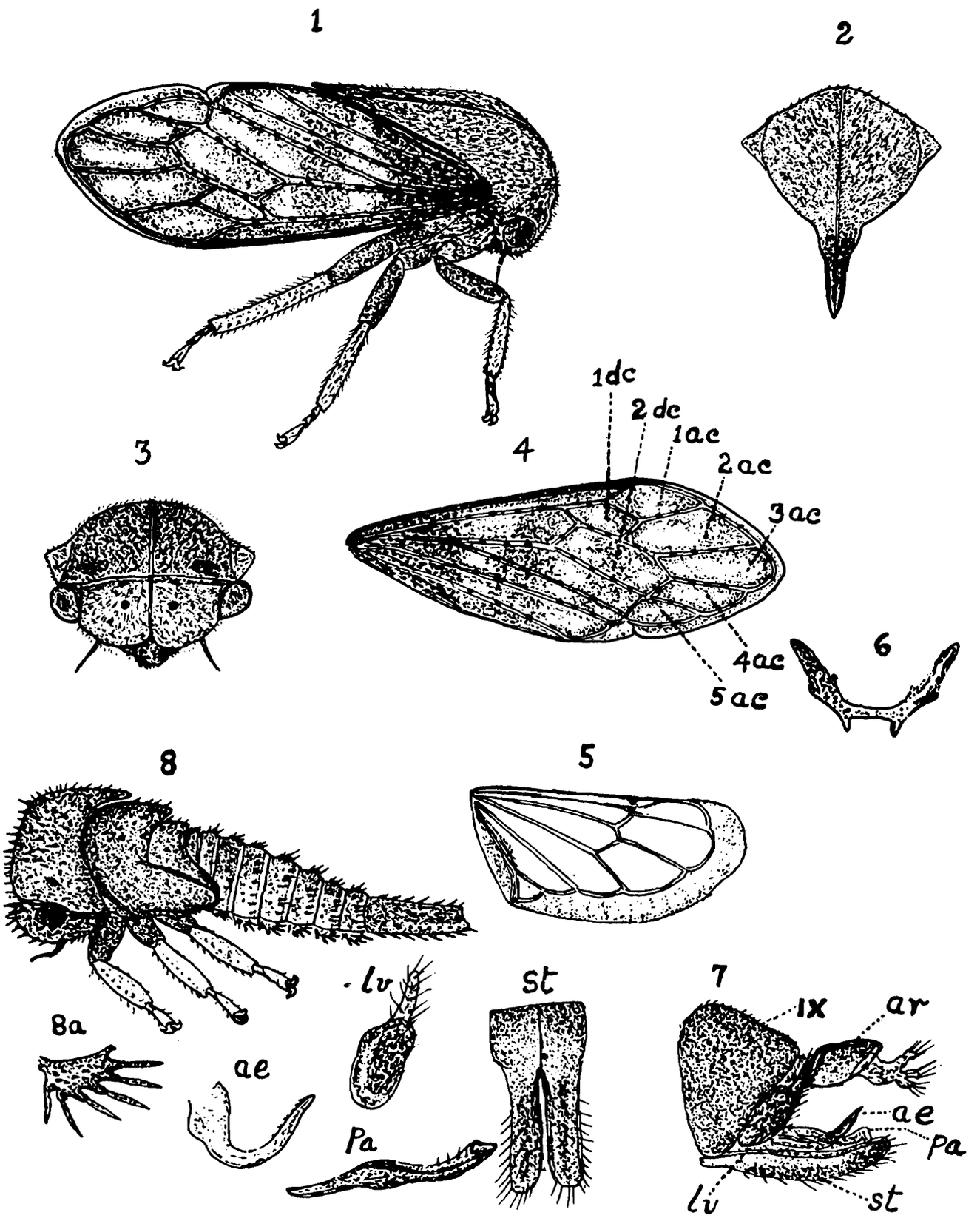
Male.—Similar to female. Genitalia, with sternal plate cleaved to about two-thirds of its length; lateral valves elongate-oval, process about half as long as valve; aedeagus and parameres similar to those of *Coccosterphus.*

Fifth instar nymph.—General colour deep green; body laterally compressed; head directed backwards, rostral tip reaching middle of hind coxae; eyes brown; ocelli inconspicuous; thorax nearly as long as abdomen excluding anal tube; metopidium nearly vertical; posterior process about two-thirds the length of mesonotum; wing pads extending back to 3rd abdominal segment, costal angles distinct; lateral lamellae similar to those of *Coccosterphus*, each lamella bearing 6 penicillate spines.

Material studied.—6 females and 3 males and 6 nymphs, Kodiakanal, 22.vi.1968.

Discussion

The occurrence of considerable intraspecific variation in the Membracidae though generally accepted, has not been emphasised in spite of profound plasticity shown by many species with reference to the pronotal structures and the tegminal characters, which has led to much confusion in the matter of allocating the species to their correct taxa. That the suprahumeral horns are liable to vary considerably within species has been clearly exemplified by *Oxyrhachis tarandus* and *Leptocentrus varicornis* (Text-fig. 2 & 13). Equally significant is the existence of sexual dimorphism, the occurrence of which was not recorded in the past except by Capener (1962, 1968) in the African Oxyrhachinae and Centrotinae. Observations herein presented are in agreement with Capener in that the basic error in the classification was the separation of groups



Text-fig. 38. *Parayasa maculosa* Distant

1. Adult female. 2. Dorsal view of pronotum. 3. Frontal view. 4. Tegmina. 5. Hind wing. 6. Scutellum. 7. Male genitalia, lateral view. 8. Fifth instar. 8a. Lateral lamella of fifth instar.

based on the presence or absence of suprahumeral horns. *Tricentrus purpureus* and *Telingana consobrina* provide typical examples in support of this view since their suprahumeral horns exhibit marked differences in the two sexes. Above all, the discovery of polymorphism with regard to the degree of development of suprahumeral horns in *Tricentrus pilosus* (Text-fig. 24) where both the males and the females exhibit a gradation between individuals with well developed horns and those lacking the horns, is an instance of the extreme lability of these structures and the risks involved in relying too much on them for the determination of the species.

Distant (1908) differentiated *Tricentrus* from *Gargara* by the presence of suprahumeral horns in the former genus, but the apparent weakness of this character is demonstrated by the discovery of *Tricentrus decornis* which lacks the suprahumeral horns in both the sexes and might easily be allocated to the genus *Gargara*, were it not be for the presence of the armed hind trochanters equipped with rows of strong spines on an elevated disc (Text-fig. 28). The spined trochanters were first used by Stal for separating his genera, *Tricentrus* and *Sipylus*. Distant (1908), while (1866) admitting the soundness and reliability of this character, felt that it is "somewhat difficult or obscure character to always distinguish" But as Funkhouser (1917) has stated, Distant's criticism is not valid since the spines on the hind trochanters are plainly visible from a caudal view of the insect. Moreover, removal of one of the hind legs for examining the trochanters will not in any way damage the other useful structures of taxonomic value.

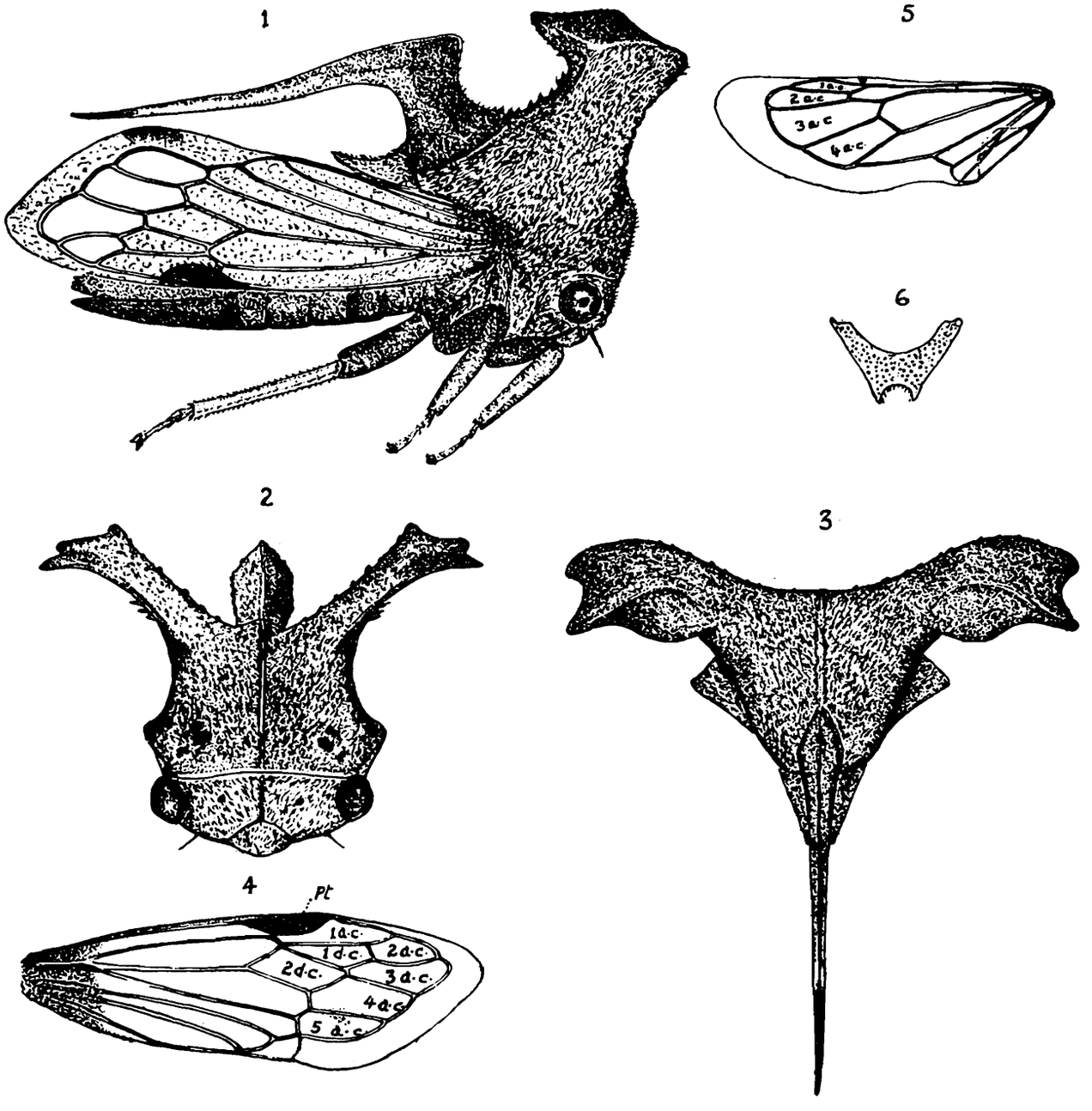
Although of considerable systematic value, the tegmina were not given due importance in the past. Distant (1908) remarked that the number of tegminal apical cells is "an uncertain character owing to the different method of computations used by describers" More recent workers, particularly Evans (1948) and Capener (1968) have stressed the importance of tegminal characters. In all the species studied, the tegmina present 5 apical cells. The relative length and width of the 1st apical cell has proved to be of value at generic level and has been largely used in the present studies in separating genera and species. The 1st and the 2nd discoidal cells are no less important. The former may be stylate in some species and bears a definite relationship in its size to the latter. Sexual dimorphism has been noticed to occur in *Telingana consobrina*, the male tegmina possessing but one discoidal cell (Text-fig. 19). The most striking tegminal character deserving consideration is the presence or absence of a pterostigma. This structure is formed by a chitinised thickening of the tegminal membrane near R1. The tribe Leptocentrini lacks a pterostigma while in the Centrotini it is present in some like *Anchon* and absent in others like *Tricentrus* and *Centrotus*. In the Gargarini an incipient pterostigma has been discovered in *Gargara malabarica* and *G. mixta*, the latter possessing the structure only in the male. In the tribe Coccosterphini, the genus *Coccosterphus* is of particular interest as two of the species, *C. paludatus* Dist. and *C. tuberculatus* (Motsch.) possess a distinct pterostigma while *C. minutus* lacks this structure. According to Capener (personal communication, 1966) the presence or absence of a tegminal pterostigma is a very important character and has been largely used in the separation of African genera. Capener's suggestion of separating *minutus* and

paludatus into two genera finds favour when considered in conjunction with the male genitalia and nymphal characters, which show striking differences to warrant the revision of the genus *Coccosterphus*. In *C. paludatus* and *C. tuberculatus* (Text-figs. 36 & 37) there is also a tendency for the apical cells to get subdivided by abnormal cross veins.

The importance of the hind wings has been recognised by earlier workers in the separation of tribes. In the Leptocentrini and Centrotini the number of apical cells in the hind wings have been found to be 4 and 3 respectively. According to Capener (1968) the number of apical cells in the hind wings of all the tribes of the subfamily Centrotini are remarkably constant. However, many previous workers never made mention in descriptions of species about the number of apical cells in the hind wings which has resulted in confusion. For example, what Distant (1908) thought as *Centrotus indicatus* Melichar has now turned out to be *Otinotus indicatus* (Melichar) in view of the presence of 4 apical cells in the long series of specimens collected from Madras. It may not be out of place to mention here that in the past the genus *Centrotus* has been a clearing house for a wide range of species and to-day most of those originally placed in this genus have been re-allocated to other genera.

Present studies have also shown that intraspecific variations do occur in respect of the number of apical cells in the hind wings. For example, the genus *Anchon* is characterised by three apical cells in the hind wings and as such designated to the tribe Centrotini. However, specimens collected from S. India and identified as *Anchon echinatum* Dist. (Text-fig. 39) and *Anchon ulniforme* Buckton reveal 4 apical cells in the hind wings showing the plasticity of this character previously believed to be rigid.

Funkhouser (1927) and Goding (1931) have called attention to the presence of "mesonotal teeth" as a diagnostic feature of the tribe Coccosterphini; Distant (1908) who erected this tribe also diagnoses it as having the mesonotum armed at the apex with two distinct prolongations, acute or otherwise. However, no such teeth could be distinguished, in any of the species examined. Probably these authors meant the forwardly directed mesopleural processes of Mc Atee and Malloch (1928). Hasenoehrl and Cook (1965) also noted the presence of ventrolateral teeth on the mesothoracic episternum in *Oxyrhachis lefroyi* and *Stictocephala bubalus*. Thus, while no mesonotal teeth appear to be present, mesopleural teeth or processes occur in all membracids and these structures may not be characteristic of Coccosterphini. On a balance of characters that overlap and due to the fluid nature of several characters in the tribe Coccosterphini, Capener (personal communication) remarks that the genus *Coccosterphus* should be placed in the tribe Gargarini and has reiterated the same view in his monographic work on Centrotinae (1968). Though this view finds favour so far as the adult characters are concerned, it appears rather contradictory when the nymphal characters are considered. The abdominal lateral lamellae with their fringing spines in all the species of *Gargara* are so strikingly different from those of *Coccosterphus* that the idea of including the genus *Coccosterphus* in Gargarini has been kept in reserve.



Text-fig. 39. *Anchon echinatum*

1. Adult female. 2. Frontal view. 3. Dorsal view of pronotum and scutellum. 4. Tegmina. 5. Hind wing. 6. Scutellum.

The importance of the genitalia has been stressed by Funkhouser (1917) who states "The male genitalia, while comparatively simple in structure, are extremely interesting and are well deserving of more serious study than has been given to them in the past" He further states in his concluding remarks: "On the whole the male genitalia afford good taxonomic characters. .. The relative position of the plates and the structure of the individual pieces show sufficient variations throughout the family, and are constant enough within a genus, to furnish valuable data at least to supplement the more evident characters of the exoskeleton" Buckton (1903) and Fowler (1897) believed the male genitalia as having very little practical value. Caldwell (1949) who attempted a generic rivision of the American membracids of the

tribe Ceresini pointed out the limitations of the use of genital structure in taxonomy in view of their identical nature in many different genera. Dennis (1960) examined a large number of *Stictocephala bubalus* (F.) with a view to determine the constancy or variability in the genitalia of both sexes of the species and he concludes that except for variations in the anterior arm of the aedeagus of the male and in the second valvula of the female, the uniformity of the genitalia is striking. It may be stated here that while the uniformity of genitalia within the species is certainly advantageous, their similarity in a number of species is disadvantageous in using them as primary diagnosing characters. Capener (1962) dealing with Oxyrhachinae states: "The male genitalia, from which so much was hoped, have proved unsatisfactory, for although on a tribal level they are distinctive, they have proved so similar in general shape and so variable in microscopic details, that they can only be used as subsidiary characters in certain species"

The present studies tend to show the importance of the male genitalia only as subsidiary characters in many of the species in view of their general similarity within the genus. For instance, in all the species of *Leptocentrus* the genitalic structures are remarkably uniform except for their size differences. Of all the genitalic components, the lateral valves with the process attached to them appear to have considerable value since they are distinct in the different genera. In all species of *Oxyrhachis*, the lateral valve is broadly triangular and the tuberculate process is short and roughly globular attached at right angles to the long axis of the valve. In *Leptocentrus* the lateral valves are elongate oval and the process is always short and well chitinised. In *Tricentrus* and *Gargara* the lateral valves are nearly identical being broadly triangular, the process very short and nodular. However, in *Tricentrus* the pilosity on the process is very dense, the hairs as long as the valve, whereas in *Gargara*, the hairs on the process are always short. In *Telingana*, the valves are elongate oval and the process is as long as the valve, while in *Otinotus indicatus* the valves are longly triangular and its process longer than the valve and densely hairy. As stated earlier, the lateral valves of *Coccosterphus paludatus* and *tuberculatus* closely resemble each other, those of *minutus* being very distinct. The aedeagus presents little variation, but differs in the two subfamilies. In Oxyrhachinae the inner surface of the aedeagus is smooth without serrations, the tip blunt and broadly rounded. In Centrotinae the inner surface of this structure is invariably serrated, the teeth being arranged in 3 rows. The parameres in *Oxyrhachis* have rounded tip while in the Centrotinae the tip is shaped like the hood of a snake; however, in all species of *Tricentrus* and *Gargara* examined, the tip of the paramere is characteristically recurved inwards. The sternal plate is invariably bifid, each divided plate terminating in a small apical lobe.

An analysis of the genitalic structures in the species mentioned above indicates a close relation between *Tricentrus* and *Gargara*, rather than *Gargara* and *Coccosterphus; Parayasa* and *Coccosterphus* with the exception of *C. minutus* are very closely related; this fact again indicates the distinctiveness of Coccosterphini and Gargarini. In spite of the usefulness of the male genitalia atleast as subsidiary in the membracid taxonomy, the general paucity of male in collections and the fact that in many

species they are still unknown, precludes the possibility of using their genitalic characters in taxonomy at present.

In the light of the above discussion it is clear that there are so much of overlapping of characters in the different species of adult membracids besides individual variations, added to sexual dimorphism in many instances and much difficulty is experienced to distinguish between closely related species. A knowledge of the nymphal characters will, therefore, help in diagnosing the species especially if one could associate both nymphs and adults so that they can be definitely associated as has been attempted in the present work. That the pronotal structures of the fifth instar nymphs, their dorsal tuberosities and lateral lamellae and the spines borne on them are more or less constant and that they are of considerable value in the determination of species have already been pointed out. Although some earlier workers like Wildermuth (1915) and Haviland (1926) thought that the spines and tuberosities were of a variable nature having little value in taxonomy, Funkhouser (1917) and Yothers (1934) have stressed their importance. The latter author has very accurately figured the tuberosities of all the nymphal instars of *Stictocephala inermis* and pointed out how the arrangement of dorsal spines differed in *Ceresa basalis*. Although the importance of nymphal characters are realised, no attempts were made earlier probably for the simple reason that nymphs were not available for study, as correctly pointed out by Capener (1968): "Nymphs, unfortunately are all too seldom seen in collections and have rarely been associated with definite species" The present studies on nymphs have shown fairly well that it is possible to differentiate closely related species from a consideration of their nymphal differences. For instance, the adults of *Leptocentrus leucaspis* and *L. nigra* are very closely allied but they can be easily separated by examining their nymphs. *Leptocentrus varicornis* is a species exhibiting considerable individual variations in the adult stage, but its nymph with its extraordinarily long pointed pronotal anterior process which is a very stable character, immediately gives the clue about the species. Further, barring a few instances, nymphs never exhibit any sexual dimorphism unlike many adults and this precludes the possibility of any confusion that might arise. Even in the extreme cases of polymorphic species like *Tricentrus pilosus* where the adults exhibit different grades from individuals with well developed horns to those totally lacking the horns, the fifth instar nymphs of all those types are remarkably uniform, at the same time exhibiting characters sufficient enough for distinguishing them from the nymphs of other related species. It was stated in the early part of this chapter that a *Tricentrus* lacking suprahumeral horns is liable to be mistaken for a *Gargara* unless one takes the trouble of examinaing the hind trochanters. But the fifth instar of *Tricentrus* is so strikingly different from the corresponding stage of a *Gargara* that the two can be distinguished most easily even by a casual perusal of their dorsal tubercles and lateral lamellae. It should be emphasized that though the nymphal characters by themselves appear to be distinct enough to identify the species, their form and shape never indicate that of the adult in the species studied here except in two species, *Coccosterphus paludatus* and *C. tuberculatus*, wherein the nearly cylindrical and serrate body of the 5th instar nymph with much shortened anal tube is strongly indicative of the general appearance of the adult.

As stated earlier there appears to be a distinct linear relationship between the anal tube and body in the different stages of nymphs. A study of the relative growth has revealed relationships which, in many cases, appear in conformity with established taxonomic characters of adults.

The number of species based on which the nymphal characters are analysed in the present studies is limited, but all the same they are suggestive of their significance in taxonomy and pave the way for future work on similar lines when more material is available and if new and more reliable characters are discovered they can always be incorporated without difficulty.

TABLE 3

Total length of body and length of anal tube of the nymphal instars (in mm.)
(The figures are mean values of ten individuals at each stage)

	First Instar		Second Instar		Third Instar		Fourth Instar		Fifth Instar	
	Body length	Length of Anal tube	Body length	Length of Anal tube	Body length	Length of Anal tube	Body length	Length of Anal tube	Body length	Length of Anal tube
Oxyrhachis tarandus	1.25	0.34	2.5	0.5	3.25	0.6	4.9	0.8	5.5	0.9
O.rufescens	1.26	0.35	2.2	0.5	3.4	0.7	5.0	1.0	5.8	1.1
O.minusculus	0.8	0.16	1.4	0.28	2.4	0.46	3.3	0.7	4.5	0.88
O. uncatus	1.0	0.20	1.8	0.35	3.0	0.50	4.1	0.7	4.8	0.8
O. krusadiensis	1.0	0.18	1.9	0.35	3.2	0.55	4.1	0.7	5.5	1.0
O. brevicornutus	0.8	0.20	1.4	0.30	2.8	0.50	3.5	0.7	4.8	0.9
Telingana nigroalata	1.8	0.4	3.0	0.6	3.8	0.75	5.5	1.0	6.5	1.3
T. consobrina	1.2	0.3	2.1	0.45	3.0	0.60	4.5	0.9	6.0	1.2
Leptocentrus taurus	1.6	0.45	3.0	0.9	3.7	1.2	7.2	2.5	9.0	3.1
L. rhizophagus	1.3	0.30	2.75	0.5	3.5	0,8	5.5	2.0	9.0	2.6
L. varicornis	1.8	0.60	2.6	0.8	3.9	1.4	5.3	2.2	8.1	3.0
L. leucaspis	1.9	0.40	2.5	1.0	3.8	1.4	7.7	2.6	8.9	3.2
L. moringae	1.3	0.45	2.2	0.8	3.2	1.2	5.2	2.0	7.2	3.0
L. bajulans	1.5	0.53	2.4	0.9	4.0	1.4	7.4	2.7	8.6	3.2
L. nigra	1.6	0.45	2.8	0.95	3.8	1.4	6.0	2.15	8.8	3.1
L. bauhiniae	1.4	0.47	2.7	1.0	3.4	1.3	6.0	2.1	7.8	2.9
L. mangiferae	1.75	0.6	2.75	0.7	3.9	1.7	7.0	2.3	8.1	2.7
L. major	1.9	0.55	3.1	0.9	4.4	1.6	6.9	2.1	9.6	3.5
Otinotus oneratus	1.4	0.3	2.1	0.4	3.3	0.6	4.9	1.0	6.1	1.5
O. mimicus	1.3	0.25	2.2	0.4	3.2	0.7	4.6	0.9	5.3	1.6
O. indicatus	1.2	0.3	2.4	0.48	3.4	0.68	4.5	0.9	6.0	1.4
O. obliquus	1.5	0.3	2.8	0.5	3.6	3.70	5.0	0.8	6.6	1.2
Tricentrus pilosus	1.5	0.3	2.6	0.6	3.2	0.74	4.7	0.9	6.4	1.15
T. albomaculatus	1.25	0.3	2.5	0.5	3.4	0.6	4.1	0.8	5.5	0.9
T. decornis	1.5	0.37	2.2	0.5	2.9	0.7	3.5	0.77	4.1	0.9
T. purpureus	1.4	0.3	2.5	0.52	3.0	0.7	5.5	1.0	6.2	1.2
T. congestus	1.5	0.32	2.6	0.5	3.4	0.7	5.7	0.9	6.5	1.2
Gargara mixta	1.2	0.25	2.1	0.4	2.6	0.6	3.3	0.7	5.0	0.7
G. extrema	1.25	0.25	1.8	0.35	2.5	0.5	3.4	0.7	4.5	0.9
G. malabarica	1.25	0.30	2.0	0.40	2.4	0.5	3.1	0.6	4.0	0.8
G. rustica	1.0	0.25	1.7	0.35	2.5	0.55	2.9	0.61	3.5	0.72
G. albitarsis	0.8	0.2	1.4	0.3	2.0	0.4	2.6	0.5	3.1	0.60
G. madrasensis	0.6	0.15	1.5	0.3	2.1	0.42	2.5	0.5	3.0	0.65
Parayasa maculosa	0.8	0.2	1.6	0.3	2.2	0.45	2.8	0.6	3.2	0.70
Coccosterphus minutus	1.0	0.2	1.7	0.34	2.2	0.44	3.0	0.53	3.2	0.56
C. tuberculatus	1.1	0.26	2.2	0.55	2.9	0.67	3.4	0.8	4.2	0.9
C. paludatus	1.2	0.31	2.0	0.44	2.7	0.45	3.5	0.5	4.0	0.62

TABLE 3A

Growth pattern of anal tube in relation to length of body in membracid nymphs.

Species	Growth ratio (k)	Initial Growth index (b)	r (between log. X and log. Y)	Significance of r. -P-
Oxyrhachis tarandus	0.6509	0.2857	0.4492	>0.1
O. rufescens	0.7648	0.2839	0.9976	<0.001
O. minusculus	1.0020	0.1995	0.9985	<0.001
O. uncatus	0.7829	0.2095	0.9858	>0.001; <0.005
O. krusadiensis	0.9826	0.1807	0.8902	>0.02; <0.05
O. brevicornutus	0.8412	0.2320	0.9948	<0.001
Telingana nigroalata	0.8900	0.2311	0.9953	<0.001
T. consobrina	0.8873	0.2390	0.9912	<0.001
Leptocentrus taurus	1.1267	0.2664	0.9996	<0.001
L. rhizophagus	1.2164	0.1905	0.9730	>0.005; <0.01
L. varicornis	1.1339	0.2972	0.9931	>0.001
L. leucaspis	1.2288	0.2427	0.9641	>0.005; <0.001
L. moringae	1.0982	0.3357	0.9997	<0.001
L. bajulans	1.0146	0.3558	0.9993	<0.001
L. nigra	1.1250	0.2855	0.9957	<0.001
L. bauhiniae	1.0353	0.3456	0.9978	<0.001
L. mangiferae	1.0383	0.3168	0.9617	>0.005; <0.01
L. major	1.1206	0.2679	0.9924	<0.01
Otinotus oneratus	1.0735	0.1897	0.9863	>0.001; <0.005
O. mimicus	1.2289	0.1673	0.9764	>0.001; <0.005
O. indicatus	0.9328	0.2325	0.9862	>0.001; <0.005
O. obliquus	0.9560	0.2675	0.5755	>0.1
Tricentrus pilosus	0.9051	0.2304	0.9820	>0.001; <0.005
T. albomaculatus	0.7616	0.2511	0.9936	<0.001
T. decornis	0.8956	0.2557	0.9955	<0.001
T. purpureus	0.8973	0.2318	0.9913	<0.001
T. congestus	0.8514	0.2281	0.9663	>0.005; <0.01
Gargara mixta	0.7838	0.2370	0.9363	>0.01; <0.02
G. extrema	1.0177	0.1969	0. 999	<0.001
G. malabarica	0.8409	0.2383	0.9921	<0.001
G. rustica	0.8696	0.2403	0.9935	<0.001
G. madrasensis	0.8845	0.2249	0.9941	<0.001
G. albitarsis	0.8035	0.2342	0.9983	<0.001
Parayasa maculosa	0.9130	0.2265	0.9831	>0.001; <0.005
Coccosterphus minutus	0.8809	0.2069	0.9949	<0.001
C. tuberculatus	0.9419	0.2460	0.9955	<0.001
C. paludatus	0.5013	0.2881	0.9392	>0.01; <0.02

Key to lettering of **Text-figures**

A1, A2, A3—Anal veins
aa—anal angle
1 a.c.—first apical cell
2 a.c.—second apical cell
3 a.c.—third apical cell
4 a.c.—fourth apical cell
5 a.c.—fifth apical cell
ae—Aedeagus
an—Anal ring
an.c.—anterior carina
ap.l.—apical lobe of sternal plate
ap.lim.—apical limbus
ca—costal angle
cn—connective
Ms—mesonotum
mt—metanotum
oc—ocellus
P—pronotum
pa—paramere
pp—posterior process
pr.h—pronotal horn
pr.p—propleural process
p.s—posterior surface
pt.s.—pterostigma
p.w—posterior wing pad
R—radius
r—rostrum
sbc—sub-basal cell

c-c-l—centro-ocular line
co-sc—costa-subcosta
cp—cranial process
cu—cubitus
d—disc
1 dc—first discoidal cell
2 dc—second discoidal cell
d.p.c—dorso-posterior carina
f—frontoclypeus
G—gibba
h.f—hamular fold
l.a—lateral angle
l.c.—lateral carina
l.l—lateral lamella
l.s—lateral surface
lv—lateral valve
m—metopidium
M1, M2—media
mc—median carina
sh—suprahumeral horn
sh.b—suprahumeral bud
soc—supraocular callosity
soe—subocular expansion
st—sternal plate
sub.c—subcostal cell
tw—tegminal wing pad
vk—ventral keel

REFERENCES

BUCKRON, G. B., 1903. A Monograph of the Membracidae,: 1-296.

CALDWELL, J. S., 1949. A generic revision of the treehoppers of the Tribe Ceresini in America North of Mexico based on a study of the male genitalia. *U.S. natn. Mus. Proc.*, **98:** 491-521.

CAPENER, A. L., 1962. Taxonomy of the African Membracidae Part I. Oxyrhachinae. *Repub. S. Afr. Dep. agr. tech. Serv. Ent. Mem.*, **6:** 1-164.

CAPENER, A. L., 1968. Taxonomy of the African Membracidae part II. Centrotinae. *Repub. S. Afr. Dep. agr. tech. Serv. Ent. Mem.*, **17:** 1-123.

DISTANT, W. L., 1908. *The Fauna of British India including Ceylon and Burma.* Rhynchota, Homoptera, **4:** 1-501.

DISTANT, W. L., 1916. *The Fauna of British India including Ceylon and Burma.* Rhynchota. Homoptera: Appendix, **6:** 1-248.

EVANS, J. W., 1948. Some observations on the classification of the Membracidae and on the ancestry, phylogeny and distribution of the Jassoidea. *Trans. R. ent. Soc. Lond.*, **99:** 497-515.

FOWLER, W. W., 1897. Order Rhynchota, Suborder Hemiptera-Homoptera (continued). *Biologia Centrali-Americana*, **2:** 137-144.

FUNKHOUSER, W. D., 1917. Biology of the Membracidae of the Cayuga Lake Basin. *Cornell Univ. Agr. Expt. Sta. Mem.*, **2:** 177-445.

FUNKHOUSER, W. D., 1927. *Membracidae. General Catalogne of Hemiptera*, **1:** 1-581.

GODING, F. W., 1931. Classification of the Old World Membracidae. *J. N.Y Ent. Soc.*, **39:** 299-313; Addenda p. 606.

HASENOEHRL, S. G. and P. P. COOK (JR.), 1965. A clarification of ceratin structrues in the thoracic region of *oxyrhachis* (Homoptera: Membracidae). *Ann. ent. Soc. Am.* **58**(2): 219-221.

HAVILAND, M. D., 1926. The Membracidae of Kartabo, Bertica Dist., British Guiana, with descriptions of new species and bionomical notes. *Zoological.*, **6:** 229-290.

MCATEE, W. L., and MALLOCH, J. R., 1928. A character for the recognition of the family Membracidae. *Proc. biol. Soc. Washington.*, **41:** 39-40.

STAL, C., 1866. Hemiptera Homoptera Latr Hemiptera Africana, **4:** 1-276.

WILDERMUTH, V. L., 1915. Three-cornered alfalfa hopper *J. agr. Res.*, **3:** 343-362.

YOTHERS, M. A., 1934. Biology and control of tree-hoppers injurious to fruit trees in the Pacific Northwest. *U.S. Dep. Agric. Tech. Bull.*, **402:** 1-45.

Rec. zool. Surv. India, **68** : 273–286, 1975.

ON SOME NEMATODES BELONGING TO THE ORDERS CHROMADORIDA AND ENOPLIDA FROM INDIA

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(With 5 Text-figures)

INTRODUCTION

The soil and freshwater nematodes in general, and the non-stylet bearing nematodes in particular, have received little attention in India. In the order Enoplida, one new species of the genus *Oncholaimus* Dujardin was described by Stewart (1914); Kreis (1936) reported a single specimen of *Tobrilus gracilis* (Bastian) from Madras and Sukul (1967, 1968, 1968*a*) described three new species belonging to this order. Khera (1970) described the male of *Tripyla* (*Tripyla*) *glomerans* Bastian from Srinagar and attempted a revision of the genus *Tripyla* Bastian; he also recorded the occurrence of *Ironus ignavus* Bastian and *Cryptonchus abnormis* Allgen from India and reviewed both the genera (in press). There is no record of any species belonging to the order Chromadorida from India. Following is an account of some nematodes from Rajasthan, Uttar Pradesh, Orissa and Kerala belonging to these two orders.

I am grateful to Dr. A. P. Kapur, Director, Zoological Survey of India for providing facilities and to Dr. M. Oostenbrink of Landbouwhogeschool, Wageningen, The Netherlands, for advice regarding the genus *Oncholaimium*.

SYSTEMATIC ACCOUNT

Order CHROMADORIDA

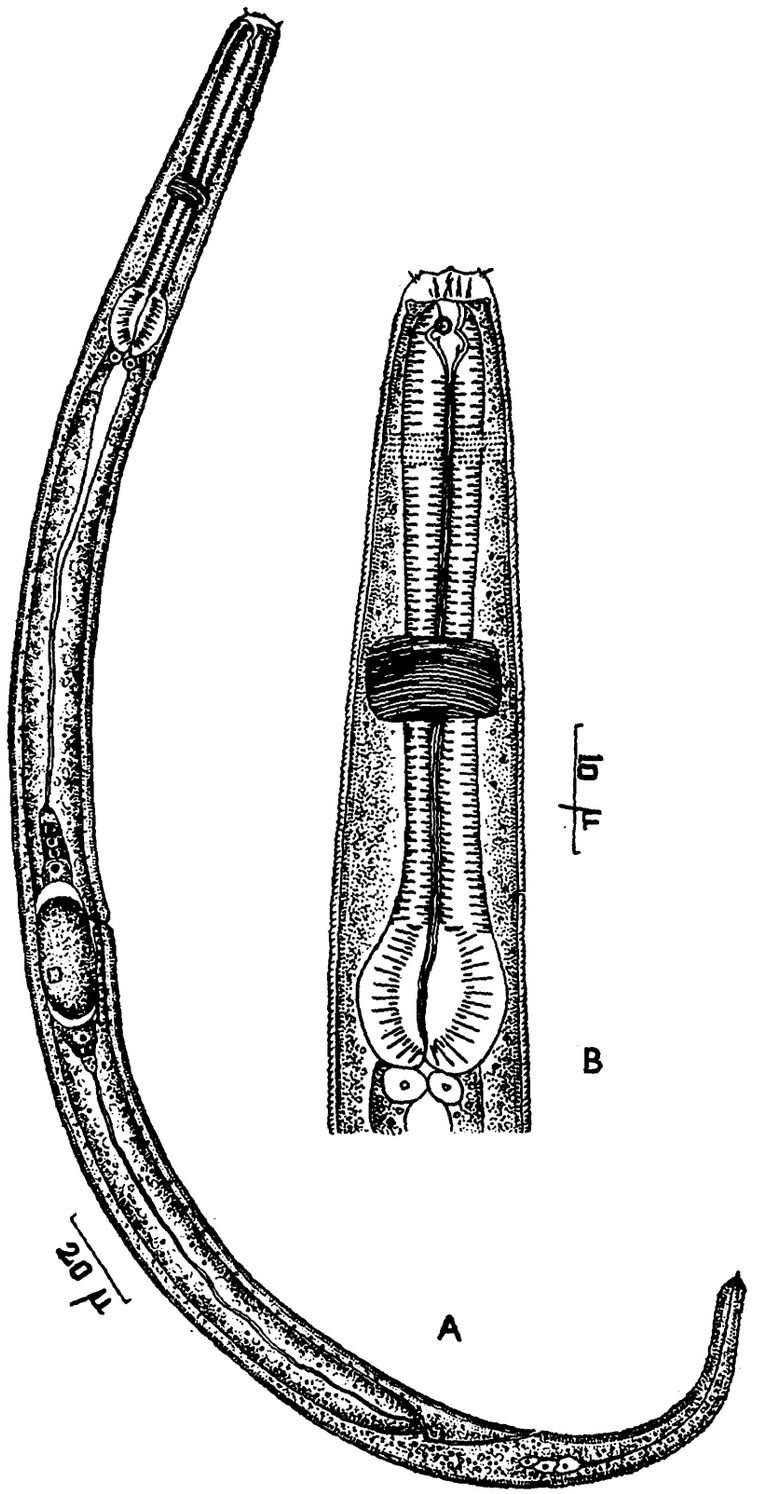
Family CYATHOLAIMIDAE

Genus **Achromadora** Cobb

1. **Achromadora ruricola** (de Man)

(Text-fig. 1)

1880. *Cyatholaimus ruricola* de Man, *Tijdschr. Nederl. Dierk. Vereen.*, **5**: 18.
1893. *Chromadora minima* Cobb, *Macleay Mem. Vol. Linn. Soc. N. South Wales*: 43.
1913. *Achromadora minima:* Cobb, *J. Wash. Acad. Sci.*, **3**: 441.
1922. *Cyatholaimus minimus:* Micoletzky, *Arch. Naturg.*, (1921), Abt. A, **87**: 378.
1922. *Cyatholaimus ruricola:* Micoletzky, *Arch. Naturg.*, (1921), Abt. A, **87**: 379.
1922. *Cyatholaimus ruricola* var. *acutus* Micoletzky, *Arch. Naturg.*, (1921), Abt. A, **87**: 379, 381.
1925. *Achromadora ruricola:* Micoletzky, *K. Danske Vidensk. Selsk. Skr. Naturv. of Math. Afd.*, **8**: R 10 (2): 187.
1963. *Achromadora ruricola:* Goodey, *Soil and freshwater nematodes*: 359.
1964. *Achromadora ruricola:* Loof, *Nematologica*, **10**: 242.



Text-fig. 1.—*Achromadora ruricola* (de Man), ♀, Achalgarh population. (A) Entire nematode. (B) Anterior portion up to the oesophageal region.

Material.—(i) 2♀, 3 Juveniles; Uttar Pradesh: Lucknow, ditches nr. R. Gomti; 13.iv.1967. (ii) 2♀; Rajasthan: Mt. Abu, Achalgarh Tank; 9.v.1965; all *S. Khera* Coll.

Measurements.—Lucknow population: 2♀ : Length = 0.40–0.44 mm; *a* = 22–26; *b* = 5.5–5.8; *c* = 5.7–6.0; V = 45–47.

3 Juveniles: Length = 0.28–0.34 mm; a = 24–27; b = 4.8–5.2; c = 5.4–5.8.

Achalgarh population : 2♀: Length = 0.40–0.42 mm; a = 18–23; b = 5.7–6.3; c = 6.0–6.4; V = 45–47; eggs = 25–28 × 11–12 µm.

Remarks.—The nematodes collected from Achalgarh have outstretched ovaries, and amphids near the proximal end of the stoma. Loof (1964), while describing *A. ruricola*, stated that the amphids had shifted forward during the mounting process. The outstretched condition of the ovary, though unique, is being treated as a variation. This would, however, entail emendation in the generic diagnosis as follows:

Achromadora Cobb

Emended diagnosis: Cyatholaiminae. Cuticle with transverse striae bearing rows of punctations. Amphids spiral. Head not offset, with six indistinct lips, each with a small apical papilla. At the base of lips a circlet of 10 cephalic setae, 2 lateral, 4 subdorsal and 4 subventral. Stoma rather funnel-shaped, with a prominent dorsal tooth medially placed and 1 or 2 smaller subventral teeth situated further back. Oesophagus cylindrical with a terminal pseudobulb. Caudal glands and terminal duct present. Vulva equatorial; gonads paired, opposed. Male with paired spicules and a large gubernaculum.

Type species: *Achromadora ruricola* (de Man).

Goodey (1951, 1963), while giving measurements and description of *A. ruricola*, has stated that male of the species is absent although a diagram of tail of male of this species, based after de Man (1884), has been given in his works. de Man (1880, 1884) described both the male and female of this species—measurements and de Manian formula are common to both the sexes and an account of the male has been given.

Distribution.—Rajasthan and U.P. The genus *Achromadora* is being recorded for the first time from India.

Ethmodora n.g.

Generic diagnosis: Cyatholaiminae. Similar to *Achromadora* Cobb but there are only four cephalic setae and a stomal capsule surrounds the stoma.

Type species: *Ethmodora stagnalis* n.sp.

2. **Ethmodora stagnalis** n.sp.

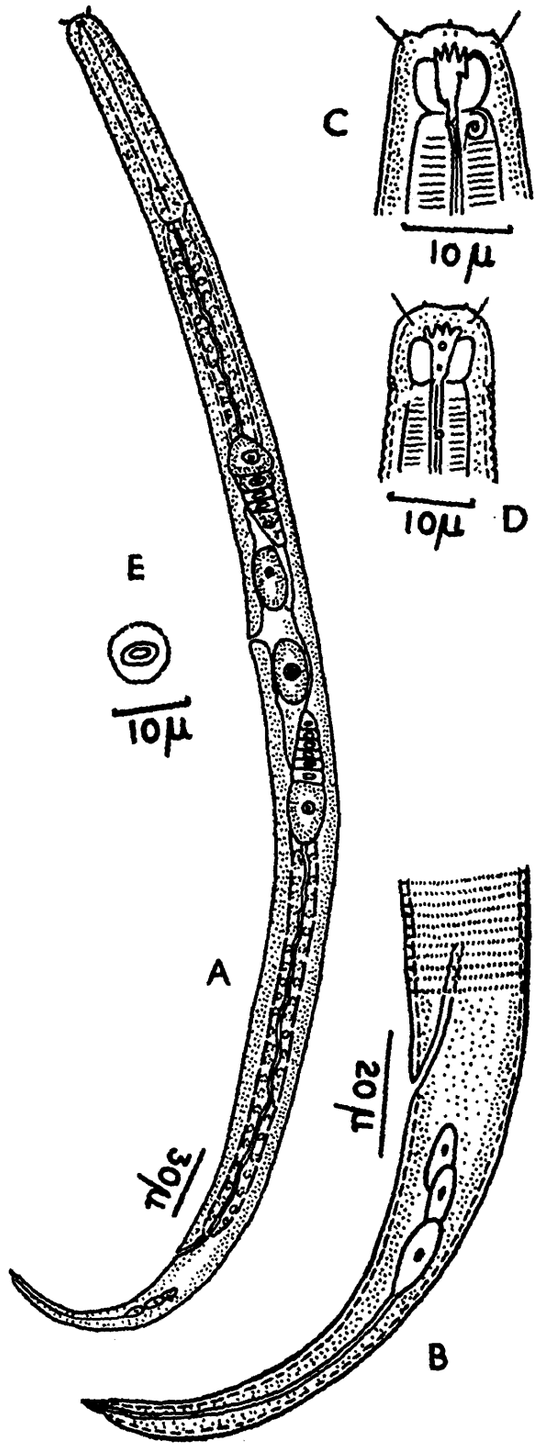
(Text-fig. 2)

Material.—5♀; Kerala: Dist. Trichur, Cranganore, Dalwa Kulam (stagnant freshwater pond); 21.x.1964; *C. Nandakumar* Coll.

Measurements.—5♀; Length = 0.58–0.65 mm; a = 22–26; b = 6.0–6.4; c = 7.0–7.6; V = 42–45; eggs = 22–26 × 12–15 µm.

Male unknown.

Holotype (♀): Length = 0.63 mm; $a = 25$; $b = 6.3$; $c = 7.2$; V = $^{13}43.^{14}$



Text-fig. 2.—*Ethmodora stagnalis* n.g., n.sp. ♀. (A) Entire nematode. (B) Posterior region and tail. (C) Head end, lateral view. (D) Head end, dorsal view. (E) Vulvar opening.

Body slender. Anterior region not markedly attenuated. Tapering tail 78 μm long, ending in a spinneret. Body cuticle bears prominent transverse striae composed of fine punctations. Amphids fine, spiral, just behind the level of the base of stoma. Head not offset, 10 μm wide, flattened-rounded in front, with six partially fused lips, each with a small apical papilla. A circlet of four submedian setae at the base of lips. Stoma 5×3 μm; funnel-shaped with a prominent medial dorsal tooth and one smaller ventral tooth situated further back. Stoma enclosed in a stomal capsule, latter clearly separated from the oesophagus. Oesophagus muscular, 90 μm long, cylindrical for the most part but swollen and ovate terminally forming a pseudobulb. Three oesophago-intestinal cells present. Intestine moderately broad with thick walls and narrow lumen. Rectum 16 μm long, smaller than anal body-diameter. Three caudal glands with a terminal duct ending in a spinneret. Nerve ring and excretory pore not visible.

Gondas paired, opposed and reflexed. Both the ovaries short. One egg in each uterus. Vulva slightly pre-equatorial, transversely elliptical, flush with body surface.

Diagnosis and Relationship.—Of the various genera belonging to the subfamily Cyatholaiminae Micoletzky, the new genus comes close to the genera *Achromadora* Cobb and *Ethmolaimus* de Man, occupying an intermediate position between the two genera. It resembles the genus *Achromadora* in the shape and structure of stoma but differs in possessing a stomal capsule and four cephalic setae. The new genus resembles *Ethmolaimus* in having a stomal capsule surrounding the stoma but differs in the shape and structure of stoma.

Holotype.—♀; Kerala: Dist. Trichur, Cranganore, Dalwa Kulam (stagnant freshwater pond); 21.x.1964; *C. Nandakumar* Coll; Z.S.I.

Paratypes.—4♀; other data as for holotype.

Family CHROMADORIDAE

Chromanema n.g.

Generic diagnosis: Chromadorinae. Cuticle unstriated, ornamented with irregularly arranged, coarse, rounded punctations differentiated all over the body except laterally; the tail, however, bears punctations all over. Two circlets of cephalic setae, anterior circlet with eight and posterior with six setae. Amphids large, crescentic, slit-like. Stoma funnel-shaped, in two portions: proximal portion cup-shaped, comprising cheilostom and protostom with longitudinal folds in cheilostom and with a large pointed tooth on dorsal protorhabdion; distal portion, comprising telostom, becoming narrow as it proceeds distally. A ring (whose homologies are not clear), comprising three plates, at the junction of protostom and telostom. Oesophagus club-shaped. Oesophago-intestinal valve cells prominent. Single testis. Gubernaculum and ventral supplements absent.

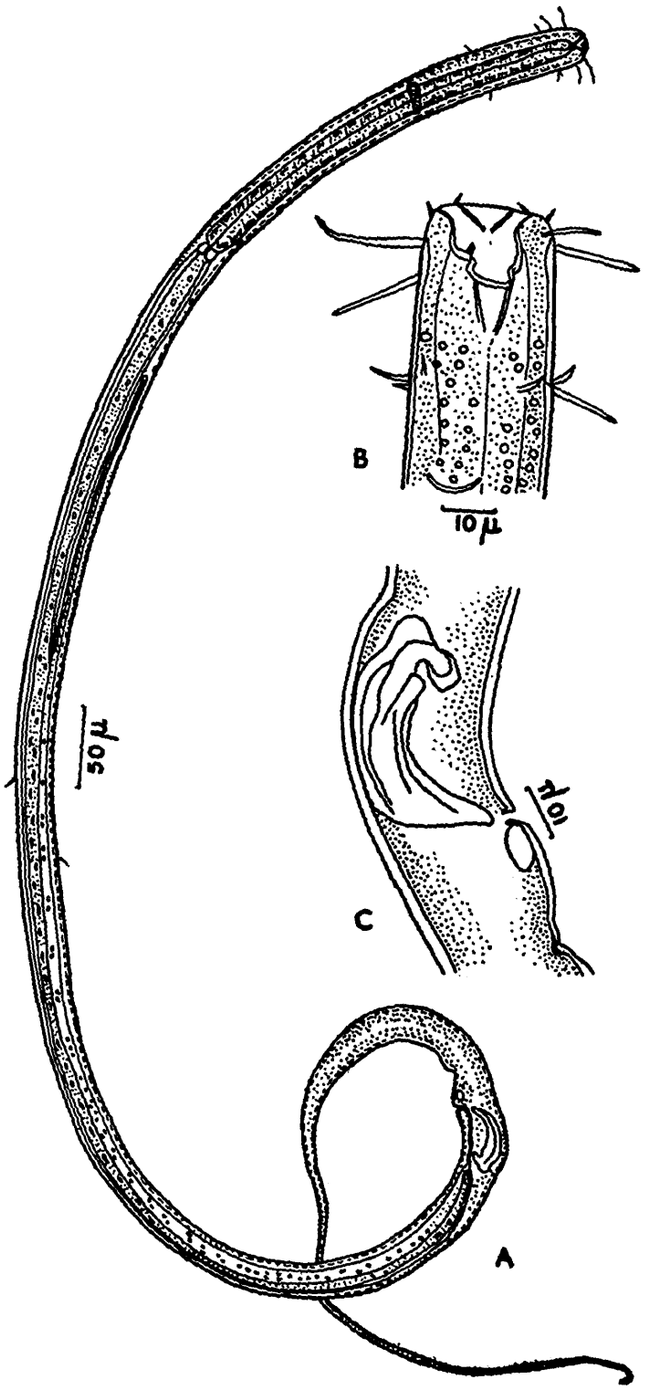
Type species: *Chromanema solitarium* n.sp.

3. **Chromanema solitarium** n.sp.

(Text-fig. 3)

Material.—1♂; Kerala: Dist. Trichur, cranganore (Vattakulam pond); 21.x.1964; *C. Nandakumar* Coll.

Measurements.—Holotype (♂): Length = 1.62 mm; $a = 46.3$; $b = 6.2$; $c = 3.25$; T = 40; spicula = 50 μm.



Text-fig. 3—*Chromanema solitarium* n.g., n.sp. ♂. (A) Entire nematode. (B) Head end. (C) Cloacal region with spicule.

Body elongate, slender, blunt at the anterior extremity, finely pointed posteriorly. Posterior portion of the nematode drawn out, coiled ventrally, attenuating gradually beyond the cloacal aperture. Tail 500 μm long, filiform. Body cuticle as in generic diagnosis. A few bristles here and there on the body. Head continuous, 22 μm wide, with six indistinct lips. Cephalic setae as in genus. Amphids at about two head-widths from the anterior end, immediately behind the posterior circlet of setae. Stoma as in genus, 25 × 18 μm; cheilostom with six longitudinal folds (= cheilorhabdions) in the walls, protostom with three protorhabdions; telostom surrounded by oesophageal collar. Oesophagus 250 μm long without a valvular apparatus. Intestinal wall moderately thick. Caudal glands not observed. Nerve ring surrounds oesophagus anterior to its middle at 105 μm from the anterior end. Excretory pore not seen.

Spicula stout, heavily sclerotized, rose-thorn shaped, ventrally arcuate, tapering towards bluntly pointed tip. Each spicule with a distinctly flanged capitulum bent at right angles to the body of the spicule; the latter also bears longitudinal ridges.

Diagnosis and Relationship.—Of the various freshwater genera included in the family Chromadoridae by Goodey (1963), the new genus comes closest to *Chromadorella* Filipjev in possessing an oesophagus without a distinct bulb—all other genera possess a distinct bulb. The new genus, however, differs from *Chromadorella* in possessing only a single dorsal tooth. The presence of a three-piece ring at the junction of protostom and telostom, absence of ventral supplements (latter absent in some species of the genus *Hypodontolaimus* de Man) and gubernaculum sets the new genus apart from all other genera of Chromadoridae obtained from the freshwater biotope.

Holotype.—♂; Kerala: Dist. Trichur, cranganore (Vattakulam pond); 21.x.1964; *C. Nandakumar* Coll; Z.S.I.

Biological Notes.—The nematode has been found in a freshwater pond near the sea-coast—obviously a vagrant form from marine habitat since the entire group (Chromadoridae) has not been found in ponds away from the sea-coast.

The nematode had a rapid jerky movement.

Order ENOPLIDA

Family ONCHOLAIMIDAE

Genus **Oncholaimium** Cobb

4. **Oncholaimium oxyure** (Ditlevsen)

1912. *Oncholaimus oxyuris* Ditlevsen *Vidensk. Medd.*, **63**: 233.
1926. *Oncholaimus oxyuris* var. *esknaesicus* G. Schneider, *Zool. Anz.*, **66**: 222.
1932. *Oncholaimus oxyuris:* de Coninck, *Bull. Mus. Royal d'Histoire Nat. de Belgigue*, **8**(8): 10.
1934. *Oncholaimium oxyure:* Kreis, *Capita Zool.*, **4**(5): 232.

Material.—1♂, 4 Juveniles; Orissa: Dist. Ganjam, Chilka Lake at Balugaon; 3.xi.1966; *H.S. Nama* Coll.

Measurements.—4 Juveniles: Length = 1.33–1.65 mm; a = 28–35; b = 5.7–6.7; c = 17–30.

1♂: Length = 2.8 mm; *a* = 85; *b* = 7.8; *c* = 40; T = 60; spicula = 37 μm.

The male bears eight pre-cloacal setae; no post-cloacal setae.

Distribution.—Orissa: Dist. Ganjam, Chilka Lake at Balugaon. The genus *Oncholaimium* is being recorded from India for the first time.

Family Tripylidae

Genus **Tobrilus** Andrássy

5. **Tobrilus sexsetiferous** n.sp.

(Text-fig. 4)

Material.—11♀, 8♂; Rajasthan: Jodhpur (Tank nr. Umaid Bhawan Palace), 4.v.1964; *S. Khera* Coll.

Measurements.—11♀: Length = 1.1–1.41 mm; *a* = 26–34; *b* = 6.0–6.8; *c* = 8.5–9.0; V = 39–44; eggs = 38–40 × 20–22 μm.

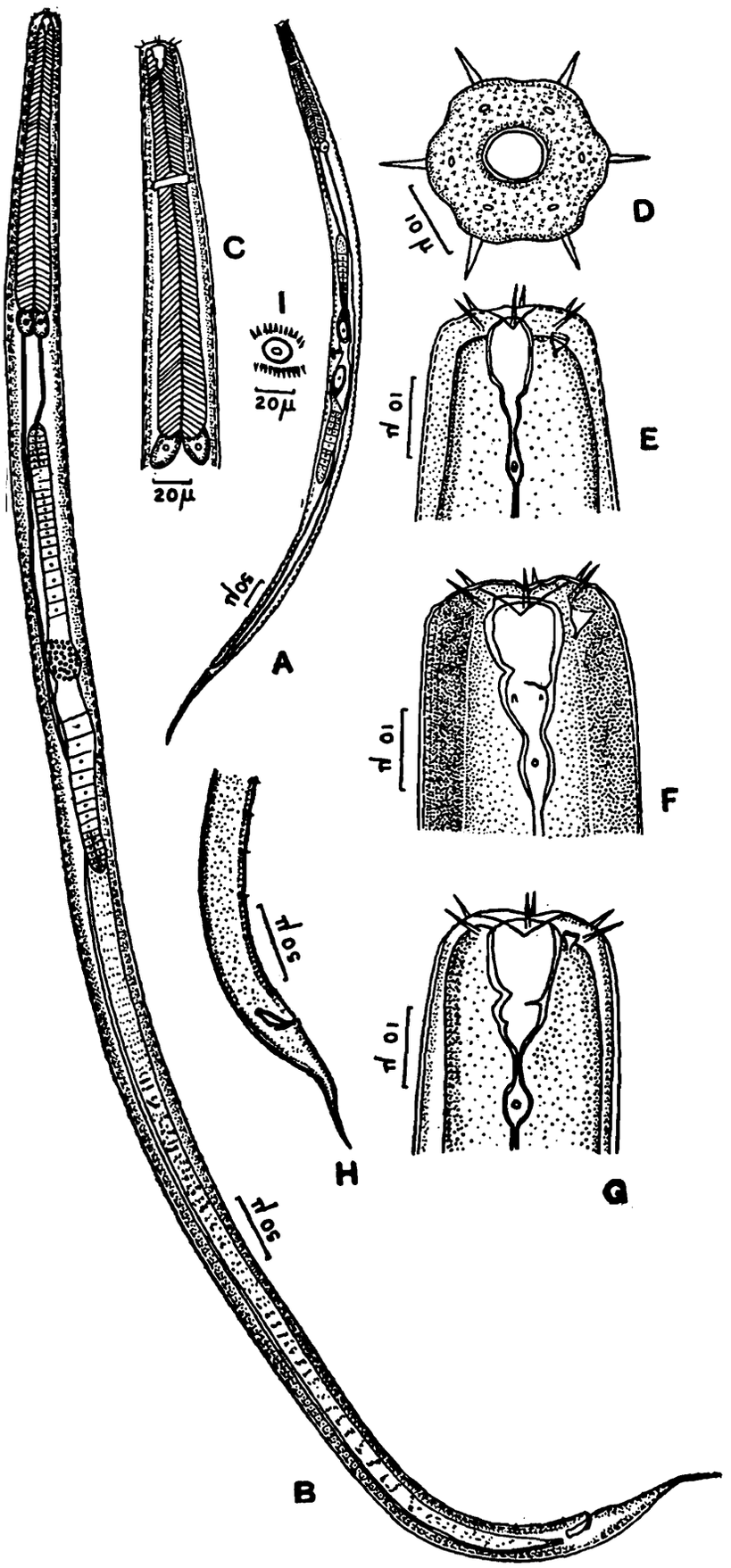
8♂: Length = 0.90–1.37 mm; *a* = 28–38; *b* = 5.6–6.8; *c* = 11.0–13.1; spicula = 20–22 μm; gubernaculum = 10–12 μm.

Holotype (♀): Length = 1.41 mm; *a* = 27.5; *b* = 6.3; *c* = 8.8; $V = 16_{44}16$.

Body transparent. Tail conical, ending in a fine point, 160 μm in length, about eight times the anal body-diameter long. Body cuticle smooth, without setae. Head 22 μm broad. A circlet of six stout cephalic setae at the base of lips, each cephalic seta about 1/4 head-width long. Amphids large, cup-shaped at the base of cephalic setae. Stoma longer than wide, 25 × 10 μm, in three sections, with continuous sclerotized walls: the anteriormost section being the largest, between triangular and subglobular in shape 10 × 10 μm; middle section funnel-shaped, 8 × 7 μm with three teeth, one dorsal and two subventral; the third section elliptical with finer walls and two prominent lateral teeth. At the junction of the first two sections the cuticular walls form a ledge towards the lumen of stoma. Stoma enveloped by an oesophageal collar. Oesophagus 224 μm long with no valvular apparatus. Three large ovoid oesophago-intestinal gland cells. Intestine and its lumen broad except near the female reproductive system where these are narrowed. Rectum 19 μm in length, about one anal body-diameter long. Nerve ring surrounds oesophagus at about 36% of its length from anterior end. Excretory pore absent.

A circular vulva more or less flush with body surface, surrounded by a rosette of cuticular warts. Eggs large and oval, from unicellular to two-celled stage.

Male.—General structure similar to that of female. Posterior end curved slightly ventrally on thermal death. Tail 104 μm long, four times the anal body-diameter in length. Stoma 20 × 5 μm, the anterior-most section most spacious, subglobular, 10 × 5 μm; middle section much reduced, more or less cylindrical, 5 × 2 μm, with three usual teeth; the



Text-fig. 4.—*Tobrilus sexsetiferous* n.sp. (A) Female, entire. (B) Male, entire. (C) Female, anterior portion up to oesophago-intestinal gland cells. (D) *En face* view. (E) Male, anterior end. (F) & (G) Female, anterior end. (H) Male tail. (I) Vulvar opening.

posterior-most section elliptical, $5 \times 1.5\ \mu m$, with two large lateral teeth. Cuticular ledge at the junction of the first two sections in the female not evident here.

Two poorly sclerotized spicules possessing a narrow capitulum and a broad body which narrows towards the tip. Gubernaculum strongly sclerotized. Six pre-cloacal, midventral supplements, nearly of the same size. No caudal alae.

Diagnosis and Relationship.—The new species comes close to *T gracilis* (Bastian), *T allophysis* (Steiner), *T aberrans* (W. Schneider), *T consimilis* (W. Schneider) and *T vibratus* Sukul in possessing cephalic setae which are about 1/4 the head width, a tail without a terminal seta and six supplements nearly of the same size in the males.

The new species differs from these and other species of the genus as enumerated by Andrâssy (1959, 1964) in possessing six cephalic setae at the base of lips, in having a ledge at the junction of the first two sections of stoma in the female and rosettiform cuticular warts surrounding the vulva. Further, there is sexual dimorphism in the structure of stoma, the middle section of the latter being much wider in female than in male.

Holotype.—♀: Rajasthan: Jodhpur (Tank nr. Umaid Bhawan Palace), 4.v.1964; *S. Khera* Coll; Z.S.I.

Paratypes.—10♀, 8♂; other data as for holotype.

Biological Notes.—A large number of female and male nematodes of this species were collected from time to time from the banks to about a depth of two feet from various tanks of Rajasthan and Kerala. Some nematodes were also collected from the banks of R. Yamuna near Wazirabad Pumping Station, Delhi where algal matter was found in abundance, while others were recovered from moist soil of pits, up to four feet deep, dug up in a dried pond during drought to get water for drinking purposes at Khandwai Talai, a village near Agolai about 32 km. west of Jodhpur.

These nematodes, as those of the next species, had rapid wriggling movements followed by uncoiling and coiling movement. All these movements were punctuated by periods of quiescence. The nematodes could anchor themselves to the substratum by means of the tip of their tail thus resting or even wriggling in a vertical position.

6. **Tobrilus confusus** n.sp.

(Text-fig. 5)

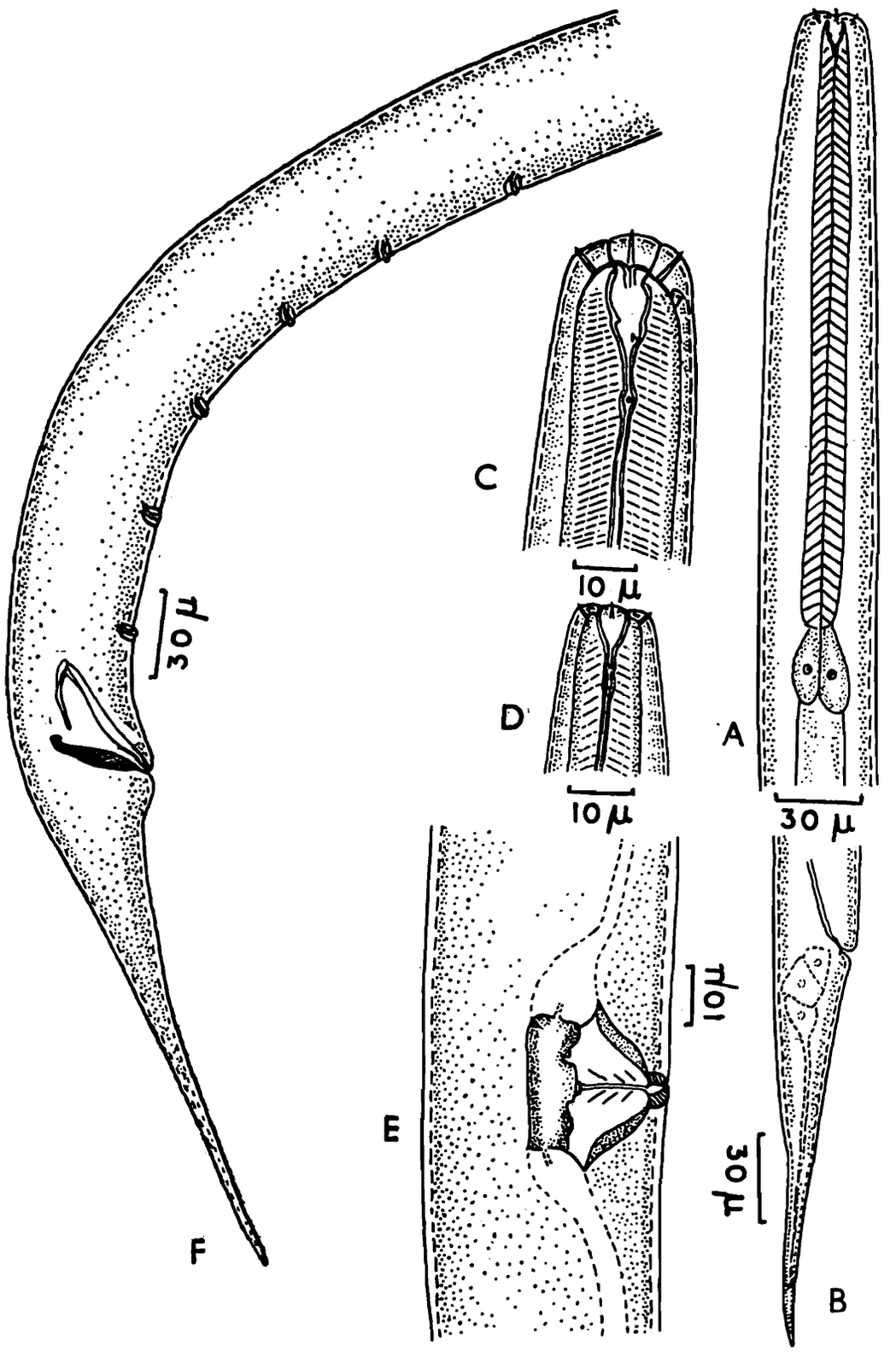
Material.—1♀, 1♂, 5 Juveniles; Rajasthan: Dist. Nagaur, Didwana (ponds); 3.x.1967; *S. C. Verma* Coll.

Measurements.—5 Juveniles: Length = 0.65–0.83 mm; $a = 45$–53; $b = 4.5$–5.0; $c = 9.0$–10.7.

1♂: Length = 1.07 mm; $a = 48$; $b = 7$; $c = 12.75$; $T = 62.6$; spicula = $22.5\ \mu m$; gubernaculum = $15\ \mu m$; accessory piece = $12.5\ \mu m$.

Holotype (♀): Length = 1.57 mm; $a = 38$; $b = 7.5$; $c = 11.6$; $V = 10_{45}8$.

Body transparent. Tail conical ending in a fine point, 135 μm in length, seven times anal body-diameter long. Body cuticle smooth without setae. Head broad, 18 μm wide. Ten small equal-sized setae in two circlets: first circlet of six setae arising from the base of lips; second circlet



Text-fig. 5.—*Tobrilus confusus* n.sp. (A) Anterior portion, male. (B) Female tail. (C) Head end, female. (D) Head end, male. (E) Vaginal region showing ovejector. (F) Male tail.

slightly posterior, of four setae. Each seta about 1/6 the head width long. Amphids large, cup-shaped with ellipsoid opening behind the posterior circlet of cephalic seate. Stoma longer than wide, 18×7 μm, in three sections with continuous well sclerotized, walls: the anterior most section being the largest, cup-shaped, 8×7 μm; middle section funnel-shaped, 5×4 μm, with three teeth, one dorsal and two subventral; the third section tubular, 5×1 μm, with finer walls and two prominent lateral teeth. Stoma enveloped by an oesophageal collar. Oesophagus 209 μm long with no valvular apparatus. Three large, ovoid, oesophago-intestinal gland cells. Intestine and its lumen broad except near the female reproductive system where these are narrowed. Rectum 10 μm in length, being about half the anal body-diameter long. Nerve ring surrounds oesophagus at about 33% of its length from anterior end. Excretory pore absent.

Circular vulva, more or less flush with body surface.

Male.—General structure similar to that in female. Posterior end curved slightly ventrally on thermal death. Tail 84 μm long, and 4½ times the anal body-diameter in length. Stoma 12×4.5 μm. The anterior-most section 6.0×4.5 μm, somewhat funnel-shaped; the middle section much reduced, cylindrical-elliptical, 3.5×1.5 μm, with three teeth; the posterior-most section cylindrical, 2.5×1 μm, with two teeth. Oesophagus 151 μm long.

Two somewhat arcuate, spindle-shaped, poorly sclerotized spicules. The capitulum of each of the two spicules connected to one of the upper (shorter) limbs of a Y-shaped accessory piece. Gubernaculum strongly sclerotized, of the shape of a bowling pin with its head recurved ventrally and with a strong diagonal ridge marking its posterior third from the anterior two-third. Six equal, pre-cloacal, mid-ventral supplements.

Diagnosis and Relationship.—The new species is unique in having an accessory piece in addition to the usual spicula and gubernaculum.

It comes closest to *T sexsetiferous* n.sp. in the stoma exhibiting sexual dimorphism, in the position of amphids, in the number of teeth in the stoma and in the number of pre-cloacal supplements but differs in having ten cephalic setae, in the absence of a ledge between the first two sections of stoma in the female and cuticular warts around the vulva, in the shape of spicules and gubernaculum, in addition, of course, to the presence of an accessory piece.

Holotype.—♀; Rajasthan: Dist. Nagaur, Didwana (ponds); 3.x.1967; *S. C. Verma* Coll; Z.S.I.

Paratypes.—1♂, 5 Juveniles; other data as for holotype.

Taxonomic note regarding the Genus *Tobrilus*

Owing to the absence of lateral fields, the anterior position of amphids, the division of stoma in three sections and the presence of six cephalic setae in *T. sexsetiferous*, the diagnosis of the genus *Tobrilus*, as given by Goodey (1963), is emended as follows :

Tobrilus Andrássy

Emended diagnosis: Tripylidae. Cuticle smooth, body tapering behind, but very little in front. Amphids cup- or funnel-shaped with a flattened

oval opening situated near the level of stoma. Head not offset, provided with six, more or less roundly conical, lips each provided with a very small apical papilla. Six, ten or more stout setae at the base of lips. Stoma in two or three sections, its walls distinctly sclerotized; the anterior section without teeth or denticles, the posterior section(s) denticulated. Oesophageal collar surrounds the stoma. Oesophagus club-shaped. Three distinct oesophago-intestinal gland cells. Vulva practically equatorial; female gonads didelphic, amphidelphic and reflexed. Testes paired; gubernaculum present. A series of pre-cloacal supplements in male. Tail of both sexes tapering, caudal glands and terminal duct present. A few fine setae irregularly scattered over the body and tail in most of the species. Males unknown in some species.

Type species: *Tobrilus gracilis* (Bastian).

SUMMARY

Ethmodora stagnalis n.g., n.sp. and *Chromanema solitarium* n.g., n.sp., both belonging to order Chromadorida are described. Two new species of *Tobrilus*, *T sexsetiferous* and *T confusus* (order Enoplida) are described, and the generic diagnosis of *Tobrilus* Andrássy and *Achromadora* Cobb emended. Genera *Achromadora* (order Chromadorida) and *Oncholaimium* Cobb (order Enoplida) are recorded from India for the first time.

REFERENCES

ANDRÁSSY, I. 1959. Neubenennungen einiger Homonymen Nematoden-Gattungen. *Nematologica*, **4**: 223-226.

ANDRÁSSY, I. 1964. Ein versuchsschlussel zur Bestimmung der *Tobrilus* Arten (Nematoda). *Ann. Univ. Scient. Budapest. Rolando Eötvos nom.*, Sect. Biol. **7**: 3-18.

GOODEY, T. 1951. *Soil and freshwater nematodes*. London. Methuen, 399 pp.

GOODEY, T 1963. *Soil and freshwater nematodes*. London, Methuen, 544 pp. Revised by J. B. Goodey.

KHERA, S. 1960. Studies on the genus *Tripyla* Bastian (Nematoda: Tripylidae). *Proc. zool. Soc., Calcutta*, **23**: 195-200.

KHERA, S. On the genus *Ironus* Bastian with some remarks on the genus *Cryptonchus* Cobb. (Nematoda: Ironidae) *Indian J. Helminth.*, (in press).

KREIS, H. A., 1936. Süsswasser-Nematoden aus der umbegung von Madras (Indien) *Rev. Suisse Zool.*, **4**: 641-645.

LOOF, P. A. A. 1964. Free-living and plant parasitic nematodes from Venezuela. *Nematologica*, **10**: 201-300.

DE MAN, J. G. 1880. Die Einheimischen, frei in der reinen Erde und im sussen Wasser lebenden Nematoden. Vorlaufiger Bericht und descriptivsystematicher. Theil. *Tijdschr. Nederl. Dierk. Vereen*, **5**: 1-104.

DE MAN, J. G., 1884. *Die frei in der reinen Erde und im süssen Wasser lebenden Nematoden der niederlandischen Fauna.* Eine systematische faunistische Monographie. Leiden, Brill. 206 pp.

STEWART, F. H. 1914. Report on the collection of free living nematodes from Chilka lake on the East coast of India. *Rec. Indian Mus.*, **10**: 245-254.

SUKUL, N. C. 1967. A new species of *Tombrilus* Andrâssy, 1959 (Nematoda: Tripylidae) with notes on its biology. *Indian J. Helminth.*, **19**: 113-117.

SUKUL, N. C. 1968. A new species of soil nematode of the genus *Ironus* Bastian, 1865 (Family *Ironidae*) from Andaman Islands, India. *Indian J. Helminth.*, **20**: 53-56.

SUKUL, N. C., 1968a. A new species of Ironid soil nematode from the Andamans, India, with notes on *Oionchus obtusus* Cobb. *Proc. zool. Soc., Calcutta*, **21**: 153-156.

Rec. zool. Surv. India, **68**: 287–295, 1975

ON SOME TYLENCHID NEMATODES FROM ORISSA

By

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(With 1 Plate)

INTRODUCTION

Soil samples for the nematodes described in this paper were collected by two survey parties of the Zoological Survey of India. Except where specifically mentioned, these samples were collected by the first author and his party when they undertook a survey of the plant parasitic nematodes of paddy and other crops in Orissa.

The authors are grateful to Dr. A. P. Kapur, Director, Zoological Survey of India, for providing facilities in carrying out this project and to Dr. S. Y Padmanabhan, Director, and Dr. Y S. Rao, Nematologist, Central Rice Research Institute, Cuttack, for providing assistance in the collection of soil samples at Cuttack and Bhubneshwar. Shri Raghudeb Bannerji assisted in processing the samples and preparing the slides.

SYSTEMATIC ACCOUNT

Family TYLENCHIDAE

1. **Tylenchus (Filenchus) filiformis** Bütschli

1873. *Tylenchus filiformis* Bütschli, *Nova Acta Acad. Nat. Curios.*, **36** (5): 37.

Material.—6♀, 2♂, Cuttack, Central Rice Research Institute, rhizosphere of paddy, banana tree, sugarcane, and okra; 21, 24 & 26.xii.1970; 1♀, 1♂, Cuttack, Patha, State Agricultural Farm, rhizosphere of paddy and potato; 23.xii.1970; 2♀; Kalupara Ghat (nr. Chilka Lake), rhizosphere of paddy; 7.i.1971; *K. N. Nair* Coll.

Measurements.—9♀: Length = 0.66–0.76 mm; a = 38–43; b = 6.7–7.2; c = 5.8–8.3; V = 66–75; stylet = 12.8 μm.

3♂: Length = 0.55–0.63 mm; a = 35–47; b = 6–7; c = 3.9–5.6; stylet = 9.8 μm; spicula = 15.4–18.2 μm; gubernaculum = 4.2 μm.

Description.—Female: Body slender, head not offset, tail long and subulate, curved ventrally in some specimens. Cuticle finely striated Lateral fields marked with four incisures. Stylet fine, knobs poorly developed and sloping backwards. Ovary single, outstretched, oöcytes arranged in a single row. Postvulvar sac slightly more than one body width long.

Male : Similar to female. Spicules tylenchoid, gubernaculum small and thick. An adanal bursa, 21–33 μm in length, about thrice the anal body width long.

2. **Tylenchorhynchus elegans** Siddiqi

1961. *Tylenchorhynchus elegans* Siddiqi, *Z. PärasitKde.*, **21** : 52.

Material.—1♀; Bhubneshwar, University of Agriculture & Technology Farms, rhizosphere of paddy; 22.xii.1970; 1♀, 1♂, 2 juveniles; Cuttack, Central Rice Research Institute, rhizosphere of paddy, potato and sugarcane; 21–23.xii.1970.

Measurements.—2♀: Length = 0.66–0.67 mm; a = 26–27; b = 5.1–5.3; c = 15; V = 54; stylet = 18.0–19.6 μm.

1♂: Length = 0.53 mm; a = 24; b = 4.9; c = 14; T = 41%; stylet = 16.8 μm; spicula = 19.6 μm; gubernaculum = 11 μm; bursa = 52 μm.

Description.—Female : Tail digitiform, 42 μm long, with 18–21 annulations, ending in a broadly rounded unstriated terminus. Cuticle coarsely striated transversely. Lateral fields marked by four incisures, outer incisures crenate. Lip region continuous with 3–4 annules. Stylet well-developed. Nerve ring at 71–84 μm from anterior end; excretory pore 6–8 μm posterior to nerve ring. Phasmids distinct at about two-fifths to one-third of tail length down the anus. Spermatheca present.

Male : Tail conical, 38 μm long, provided with a crenate bursa which extends up to the tail tip. Phasmids and their ducts very distinct at about two-fifths down the cloaca. Of the four incisures, only one continues along the whole length of the tail, one ends near the beginning of the bursa, the other slightly posterior to it and the fourth near the cloaca.

Family Heteroderidae

3. **Meloidogyne graminicola** Golden & Birchfield

1965. *Meloidogyne graminicola* Golden & Birchfield, *Proc. helminth. Soc. Wash.*, **32** : 228.
1968. *Meloidogyne graminicola:* Whitehead, *Trans. zool. Soc. Lond.*, **31** (3): 332.

Material.—3♀, 10 juveniles; Cuttack, Central Rice Research Institute, roots of paddy seedlings; 22 & 26.xii.1970.

Measurements.—3♀: Length = 0.57–0.66 mm; width = 0.27–0.30 mm; a = 2.1; stylet = 14–15 μm; width of knob= 3.2 μm; interphasmidial distance = 16–19 μm.

10 juveniles: Length = 0.42–0.46 mm; a = 27.2–27.5; c = 6.6–7.6; stylet = 12.6–14.0 μm; width of knob= 1.6–2.4 μm.

5 eggs: 79.2–92.4 × 36.3–42.9 μm.

Description.—Female: Body pear-shaped. Head not offset. Stylet knobs rounded, their anterior margins sloping backward. Dorsal oesophageal gland duct opening 3.2–4.6 μm behind stylet base. Vulva and anus at posterior end of body. Posterior cuticular pattern rounded, composed of closely spaced, fine, smooth striae. Striae form complete circle from dorsal to ventral sector. Dorsal arch slightly raised. Anal fold present. Lateral field and incisures absent. Multiple knots generally. Single knots in finer roots and root hairs.

Juvenile: Head not offset, with three annules. Stylet knobs rounded with their anterior margins sloping backward. Lateral field with four incisures. Tail terminus rounded.

Remarks.—This species has been found only at the seedling stage in the nursery. When the seedlings are uprooted for transplantation, probably the root knots are broken off from the roots and remain in the soil.

4. **Meloidogyne arenaria** (Neal)

1889. *Anguillula arenaria* Neal, *Bull. U.S. Bur. Ent.*, No. 20: 27.
1949. *Meloidogyne arenaria:* Chitwood, *Proc. helminth. Soc. Wash.*, **16** : 92.
1968. *Meloidogyne arenaria:* Whitehead, *Trans. zool. Soc. Lond.*, **31** (3): 303.

Material.—3♀; Cuttack, Central Rice Research Intsitute, roots of banana tree near staff quarters; 26.xii.1970.

Measurements.—Complete specimens not preserved, used up for the study of perineal patterns. Interphasmidial distance = 28 μm.

Description.—Female perineal pattern: striae smooth, round; dorsal arch low and slightly compressed on either side. Some striae directed towards vulva. Lateral line marked faintly.

Remarks.—*M. arenaria* has a wide host range.

5. **Meloidogyne incognita** (Kofoid & White)

(Plate I, 1–3)

1919. *Oxyuris incognita* Kofoid & White, *J. Am. med. Ass.*, **72** : 567.
1949. *Meloidogyne incognita:* Chitwood, *Proc. helminth. Soc. Wash.*, **16** : 91.
1949. *Meloidogyne incognita* var. *acrita* Chitwood, *Proc. helminth. Soc. Wash.*, **16** : 91.
1968. *Meloidogyne incognita:* Whitehead, *Trans. zool. Soc. Lond.*, **31** (3): 336.

Material.—3♀; Bhubneshwar, University of Agriculture & Technology Farm, roots of Brinjal; 22.xii.1970; 5♀; Cuttack, Patha, State Agricultural Farm, roots of tomato; 23.xii.1970.

Measurements.—3♀ (Bhubneshwar brinjal population): Length = 0.59 –0.89 mm; width = 0.30–0.33 mm; *a* = 2–3 (other structures obscured by contents); eggs = 33–40 × 13–20 μm.

5 ♀ (Patha tomato population): Length = 0.80–0.93 mm; width = 0.46–0.48 mm; stylet = 19.8 μm; width of knob = 3.3 μm; excretory pore = 39–48 μm, from anterior end; interphasmidial distance 22–26 μm;

dorsal oesophageal orifice = 24 μm, behind stylet base; embryonated eggs = 82–89 × 30–33 μm.

Description.—Female: Brinjal population: Body pear-shaped. Perineal pattern: striae wavy, inner ones fine and outer and middle coarse, closely spaced; dorsal arch high and rounded; lateral line present. Details as in plate 11. Multiple knots.

Tomato population.—Body pyroid. Base of stylet sloping. Perineal pattern pyriform i.e., ventral arch round and dorsal arch high and flattened (making angle on two sides). Lateral line seen in some specimens, but not so conspicuous. Details as in plate I, 2. Multiple knots.

Remarks.—The specimens from brinjal come close to *M. incognita* (*incognita* type) in all respects except that the middle striae appear coarse.

Most of the specimens from tomato come close to *M. incognita* (*acrita* type) as regards their perineal pattern (cf. Whitehead, 1968) but the size of the stylet is bigger in the present specimens. In one of the specimens the striae are very fine and the dorsal arch is high but only slightly flattened. Still in another specimen the striae are drawn sideways (plate I, 3.) as in *M. thamesi* Chitwood. Either, as Whitehead (*loc. cit.*) has shown, the perineal patterns of this species are very variable, or it is a case of mixed infection, or that *M. thamesi* is a synonym of *M. incognita*. As it is, a number of authors recognise two distinct varieties, viz. *incognita* and *acrita* under this species.

Family Hoplolaimidae

6. **Hoplolaimus indicus** Sher

1963. *Hoplolaimus indicus* Sher, *Nematologica*, **9** : 284.

Material.—7♀, 5♂; Cuttack, Patha, State Agricultural Farm, rhizosphere of potato and brinjal plants; 23.xii.1970. Cuttack, Central Rice Research Institute, rhizosphere of banana tree; 26.xii.1970.

Measurements.—7♀; Length = 1.16–1.17 mm; *a* = 31–33; *b* = 7–9, *b'* = 6.2–6.6; *c* = 58–59; V = 54–55; *o* = 16–20; stylet = 36–39 μm; anterior phasmid not seen; posteiror phasmid = 78–82.

5♂; Length = 0.76–0.87 mm; *a* = 25–28; *b* = 5.5–9.2; *b'* = 5–7; *c* = 28–33; *o* = 12–14; stylet = 33–39 μm; anterior phasmid = 33–35; posterior phasmid = 74–76; spicules = 35–39 μm; gubernaculum 16–17 μm.

Description.—Female: Tail round with 10–12 annules. Lip region with 3–4 annules. Single incisure, indistinct on most of body. Stylet knobs with anterior surfaces irregularly pointing anteriorly. Oesophageal glands with 4–6 distinct nuclei, others obscure. Excretory pore located above the level of oesophago-intestinal valve, a little posterior to the nerve ring, Posterior phasmid on the left side of the body. Overlapping of rectum by intestine not very clear. Two outstretched ovaries, oöcytes arranged in single row, round spermatheca present,

Male: Lip region rounded, with 3–4 annules, Spear knobs rounded with anteriorly projecting processes. Oesophageal glands with 4–5 nuclei. Excretory pore located above oesophago-intestinal valve. Single indistinct incisure. Anterior phasmid on left side of body, posterior phasmid on right side.

Remarks—The specimens appear to be slightly smaller than those described by Sher (1963). The species has been recovered from different plant hosts by various workers.

7. **Helicotylenchus multicinctus** (Cobb)

1893. *Tylenchus multicinctus* Cobb, *Agric. Gaz. N. South Wales*, **4** (10): 52.
1922. *Tylenchorhynchus multicinctus:* Micoletzky, *Arch. Natur.*, **87**(A) : 608.
1936. *Rotylenchus multicincta:* Filipjev, *Proc. helminth. Soc. Wash.*, **3** : 81.
1940. *Anguillulina multicincta:* T. Goodey, *J. Helminth.*, **18** : 22.
1951. *Rotylenchus multicinctus:* T. Goodey, *Soil and freshwater nematodes:* 112.
1956. *Helicotylenchus multicinctus:* Golden, *Bull. Md. agric. Stn.*, 1.
1966. *Helicotylenchus multicinctus:* Sher, *Nematologica*, **12** : 8.

Material.—1♀, 1♂; Cuttack, Central Rice Research Institute, rhizosphere of banana tree; 26.xii.1970.

Measurements.—1♀ : Length = 0.50 mm; $a = 22$; $b = 5.6$; $b' = 4.3$; $c = 44$; V = 68; stylet = 24 μm.

1♂; Length = 0.38 mm; $a = 21$; $b = 4.5$; $b' = 3.5$; $c = 26$; stylet = 21 μm; spicula = 16 μm; gubernaculum = 7 μm.

Description.—Female: Body curved ventrally. Lip region hemispherical with 4 indistinct annules. Stylet knobs rounded, flattened anteriorly. Excretory pore almost at the level of the anterior oesophageal glands. Hemizonid not clear. Phasmids two annules anterior to anus level. Tail terminus hemispherical, 11 annules. Two ovaries, outstretched, oocytes arranged in single row. Spermatheca present.

Male: Body much less curved than in female; almost straight. Tail covered with a bursa extended up to the tail tip. General structure similar to that of female.

Remarks.—The male specimen is smaller than those described by Sher (1966).

Minz *et al.* (1961) and Zuckerman and Strich-Harari (1963) have shown that *H. multicinctus* completes its life cycle within the roots of banana and causes heavy losses to the plantations.

8. **Pratylenchus coffeae** (Zimmermann)

1898. *Tylenchus coffeae* Zimmermann, *Meded. Plantentuin.*, **27** : 16.
1919. *Tylenchus musicola* Cobb, *West Ind. Bull.*, **17** : 179.
1920. *Tylenchus mahogani* Cobb, *J. Parasit.*, **6** : 188.
1941. *Pratylenchus coffeae:* Filipjev & Steckhoven, *Manual of Agr. Helm.*,: 242.
1953. *Pratylenchus coffeae:* Sher & Allen, *Univ. Calif. Publ. Zool.*, **57** : 448.
1960. *Pratylenchus coffeae:* Loof, L.E.B, Fonds, No. 39: 57.

Material.—2 juveniles (vulva just visible in one specimen); Kalupara Ghat (grassy patch nr. R. Kusma); 7.i.1971; *K. N. Nair* Coll.

Mesurements.—2 juveniles: Length = 0.49–0.61 mm; a = 23.3–27.8; b = 5.5–7.0; b' = 4.5–5.6; c = 12.7–12.9; V = 77; stylet = 17–19 μm.

Description.—Cuticular annulation conspicuous. Lateral field with four incisures, outer two incisures more crenate than the inner ones. Lip region of two annules. Anterior margin of apical annule convex-flattened. Tail conoid; tip rounded to rounded with an indentation on one side only. Phasmids slightly anterior to middle of tail.

Remarks.—The tail tip is fairly similar to the figure given by Loof (1960) for *P. neglectus* (Rensch). However, there are no transverse striae in the lateral fields.

As the specimens are juvenile, no reliance can be placed on the de Manian formula. The length of the stylet (19 μm in the less developed and smaller specimen) exceeds that hitherto described even for adult specimens.

9. **Hirschmanniella gracilis** (de Man)

1880. *Tylenchus gracilis* de Man, *Tijdschr. Nederl. Dierk. Vereen,* **5** : 71.
1925. *Tylenchorhynchus gracilis:* Micoletzky, *K. Danske Vidensk. Selsk. Skr.,* (8) **10** : 257.
1932. *Anguillulina gracilis:* T. Goodey, *J. Helminth.,* **10** : 140.
1955. *Radopholus gracilis:* Hirschmann, *Zool. Anz.,* **154** : 288.
1961. *Radopholus gracilis:* Thorne, *Principles of Nematology:* 236.
1962. *Hirchmannia gracilis:* Luc & Goodey, *Nematologica,* **7** : 197.
1963. *Hirchmanniella gracilis:* Luc & Goodey, *Nematologica,* **9** : 471.

Material.—1♀, 1♂; Bhubneshwar, University of Agriculture & Technology Farms, rhizosphere and roots of paddy; 23.xii.1970; 2♀, 1 juvenile; Cuttack, Central Rice Research Institute, rhizosphere of paddy, 21 & 26.xii.1970.

Measurements.—3♀: Length = 0.96–1.14 mm; a = 45–49; b = 8.8–9.8; c = 13.5–14.0; V = 49–52; stylet = 16–17 μm.

1♂: Length = 1.11 mm; a = 52; b = 11.6; c = 15; stylet = 17 μm; spicula = 21 μm; gubernaculum = 7 μm; bursa = 49 μm. (Specimen crushed after examination).

1 juvenile: Length = 0.71 mm; a = 46; b = 9.2; c = 13.

Description.—Female: Lateral fields with four incisures extending to almost tail end. Head not offset, with 4–5 annules; low, rounded, lip region. Cephalic framework developed, basal plates curved posteriorly about two annules. Stylet about as massive as sketched by Thorne (1961) for *R. gracilis.* Basal knobs of stylet strong, directed backward. Isthmus shorter than neck diameter. Hemizonid at the level of the junction of oesophageal lumen and intestine, three annules wide. Excretory pore slightly posterior. Tail elongate-conoid with sub-cylindroid end and a terminal mucro. Phasmids at or just behind the middle of the tail. A prominent spermatheca in each uterus.

Male: Dorsal incisure extends almost to the tail terminus. Phasmids located somewhat anterior to the middle of the tail. Bursa rising well anterior to spicula and extending to about half the tail length. Tail and other general structures as in female.

Remarks.—Hirschmann (1955) synonymized *H. oryzae* (v. Breda de Haan) with *H. gracilis*. This action has not been accepted by Thorne (1961) and Luc and Goodey (1962) who have found it advisable to retain the two species, but on different grounds. Thorne (*loc. cit.*) has distinguished *H. gracilis* from *H. oryzae* "by the low truncate lip region, less massive spear, more angular spear knobs, and longer isthmus. Lateral incisures extend farther back on the tail. Phasmids are near the mid-tail region. The longer tail with subcylindroid ends are especially distinctive" (p. 237). Analyzing these differences, it will be noticed that the present specimens resemble *H. gracilis* in as much as that the lips are low and stylet less massive; the lateral incisures extend further back on the tail; phasmids are near the mid-tail region and the tails are long with subcylindroid ends. The lips, however, are rounded; the stylet knobs directed backward, and the isthmus is shorter as in the case of *H. oryzae*. Further, as Hirschmann (*loc. cit.*) has shown, the shape of the tail and its terminus are variable. Luc and Goodey (*loc. cit.*) reject the synonymy on the basis that the original description and figures of *H. gracilis* make no mention of spermathecae and in the male, bursa surrounds the tail. Thorne (*loc. cit.*), after re-examining specimens loaned by Hirschmann (probably collected from type locality of *H. gracilis*), and those collected from Java (topotype specimens for *H. oryzae*) found that the spermathecae were present in both the species. It is just possible that either these structures were missed in *H. gracilis* by de Man or that the specimens were probably not fully mature, or 'un-mated' The extent of bursa on the tail is again a variable character as shown by Hirschmann (*loc. cit.*) and Thorne (*loc. cit.*). In any case an examination of the types as well as of long series of both the species is called for before a final decision can be arrived at.

This leaves only one character, viz. the position of phasmids relative to the tail—which may be a fairly constant character towards identification of the two species.

Sher (1968) has revised the genus *Hirschmanniella*.

Incidentally, one of female specimens was heavily infected with a sporozoan, as has also been described by Thorne (*loc. cit.*).

Family APHELENCHIDAE

10. **Aphelenchus avenae** Bastian

1865. *Aphelenchus avenae:* Bastian, *Trans. Linn. Soc. Lond.*, **25** : 122.
1963. *Aphelenchus avenae:* Goodey, *Soil and freshwater nematodes:* 134.
1965. *Aphelenchus avenae:* Goodey & Hooper, *Nematologica*, **11** : 55.

Materials.—8♀,1 ♂: Cuttack, Central Rice Research Institute, rhizosphere of pea, spinach, masur, chaulai; 24.xii.1970. 2♀, 2 juveniles; Cuttack, Patha, State Agricultural Farm, rhizosphere of potato and tomato plants, 23.xii.1970.

Measurements.—9♀: Length = 0.73–0.98 mm; *a* = 25–32; *b* = 6–8; *c* = 23–31; V = 72–78; stylet = 11.2–17.6 μm; eggs = 49.5–56.1 × 16.5–19.8 μm.

1♂: length = 0.59 mm; *a* = 36; *b* = 5.7; *c* = 22; stylet = 16.5 μm; spicula = 33 μm; gubernaculum = 16 μm.

Description.—Female: Body tapering anteriorly. Cuticle finely striated. Lateral field marked by 10–12 incisures, occupying 1/3–1/4 of body diameter. Head slightly offset, without striations. Tail cylindrical, short with a rounded terminus. Phasmid not seen. Ovary single, outstretched; oöcytes in single row. Postvulvar sac 2–3 times the body-width.

Male: Body tapering towards extremities. General structure similar to that of female. Tail conical, provided with a bursa supported by 4 pairs of ribs. Phasmids not seen.

Remarks.—The species is polyphagous.

Family Aphelenchoididae

11. **Aphelenchoides asterocaudatus** Das

1960. *Aphelenchoides asterocaudatus* Das, *Z. ParasitKde.*, **19** : 592.

Material.—2♀; Cuttack, Patha, State Agricultural farm, rhizosphere of paddy (IR-8); 23.xii.1970.

Measurements.—2♀: Length = 0.55–0.63 mm; *a* = 38–45; *b* = 7.3–8.6; *c* = 15–17; V = 69–70; stylet = 11.0–12.5 μm.

Description.—Lateral field marked by two incisures, the latter discernible clearly behind the median oesophageal bulb. Head very slightly offset from the body. Basal knobs of stylet poorly developed and not very distinct. Nerve ring at 74 μm (one body width behind the median bulb) and excretory pore at 77–78 μm from the anterior end. Single ovary extending nearly to the posterior end of oesophageal gland. Post-vulvar sac slightly more than three times the body diameter. Tail tip with a star-shaped process of three mucros.

Remarks.—The nematode is probably polyphagous.

12. **Aphelenchoides saprophilus** Franklin

1957. *Aphelenchoides saprophilus* Franklin, *Nematologica*, **2** : 309.

Material.—1♀; 1♂; Cuttack, Central Rice Research Institute, rhizosphere of banana tree, 26.xii.1970.

1♀; Cuttack, Central Rice Research Institute, rhizosphere of spinach, 24.xii.1970.

Measurements.—2♀: Length = 0.35–0.62 mm; *a* = 26.37; *b* = 7.4–8.9; *c* = 15–16; V = 71–72; stylet = 9.9–11.2 μm.

1♂: Length = 0.47; *a* = 25; *b* = 7.5; *c* = 13; T = 67%; stylet = 11.2 μm; spicula = 19 μm.

Description.—Female: Body slender with offset lips. Lateral field marked with four incisures and occupying about 1/5th the body diameter. Tail somewhat arcuate, conoid, bearing a terminal mucro. Stylet very slender, basal knobs very small, represented by mere thickenings; Oesophageal glands form a lobe overlying the intestine dorsally, about three body-widths long. Nerve ring about one body-width behind the valves of the median bulb. Excretory pore approximately at the same level. Post-vulvar sac reaching to about half the distance to anus.

Male: Tail slightly arcuate, conoid, bearing a terminal mucro and three pairs of papillae. Spicula aphelenchoid, dorsal limb 19 μm long, ventral limb 11 μm long, transverse bar 6.5 μm long with a protuberance at the dorsal end.

Remarks.—The species is being recorded from India for the first time.

SUMMARY

Twelve species of tylenchid nematodes are recorded from paddy and other crops in Cuttack and Bhubneswar. Of these, five species, viz. *Tylenchus filiformis*, *Tylenchorhynchus elegans*, *Meloidogyne graminicola*, *Hirschmanniella gracilis* and *Aphelenchoides asterocaudatus* have been recovered either from rhizosphere or roots of paddy or from both. One species, *Aphelenchoides saprophilus*, is recorded from India for the first time.

REFERENCES

HIRSCHMANN, H. 1955. *Tylenchorhynchus gracilis* (de Man., 1880) Filipjev, 1936-*Radopholus gracilis* (de Man, 1880) n.c. und seine Synonyme., *Zool. Anz.*, **154**: 288-301.

LOOF, P. A. A. 1960. Taxonomic studies in the genus *Pratylenchus* (Nematoda). *T Pl. ziekten*, **66** : 29-90.

LUC, M. and GOODEY, J. B. 1962. *Hirschmannia* n.g. differentiated from *Radopholus* Thorne, 1949 (Nematoda : Tylenchoidea). *Nematologica*, **7**: 197-202.

MINZ, G., ZIV, D. and STRICH-HARARI, D. 1961. Spiral nematodes in banana roots in plantations of the Jordan Valley and their control (in Hebrew). Ktavim, **11**: 45-46.

SHER, S. A. 1963. Revision of the Hoplolaiminae (Nematoda) II. *Hoplolaimus* Daday, 1905. and *Aorolaimus* n. gen. *Nematologica*, **9** : 267-295.

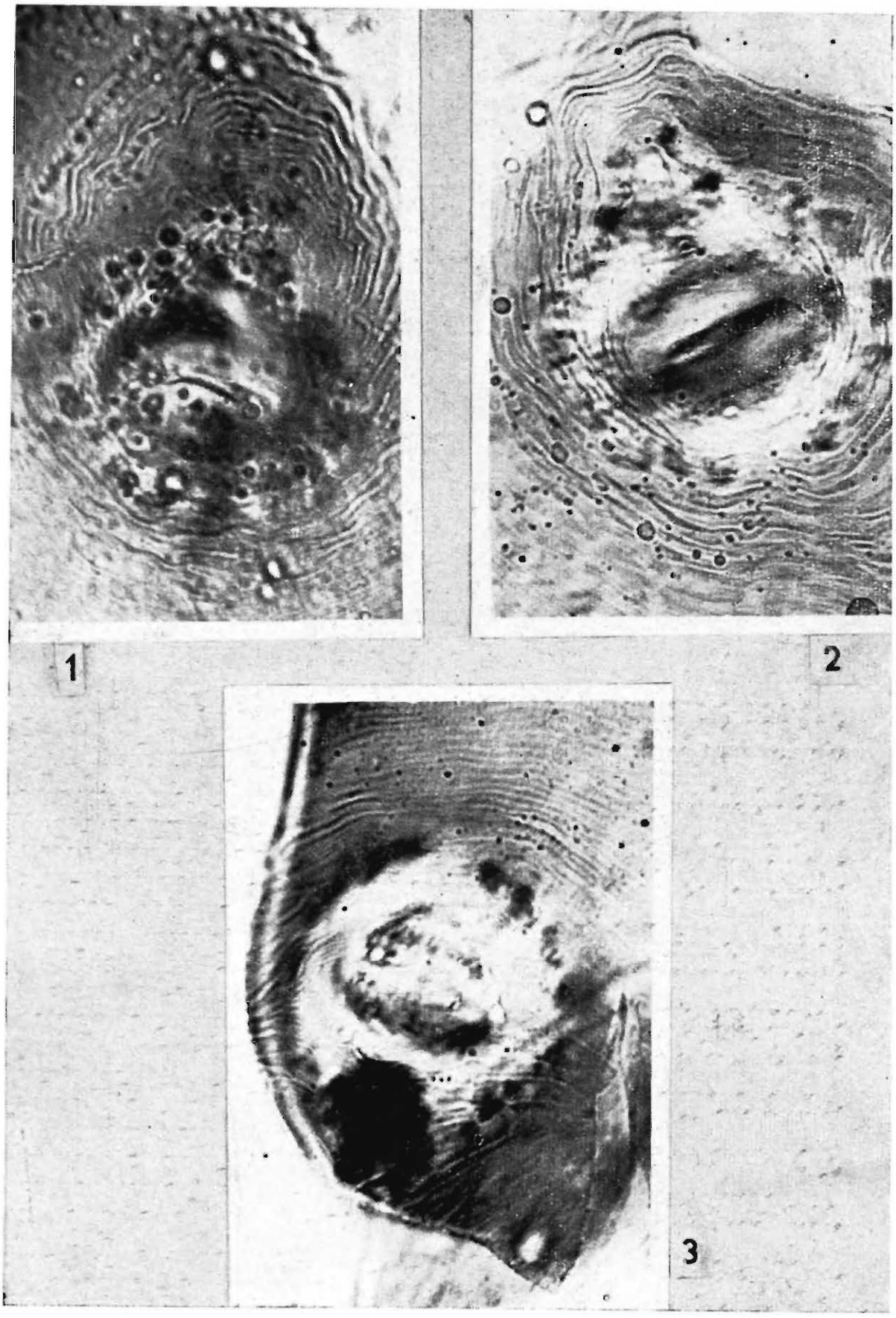
SHER, S. A. 1966. Revision of the Hoplolaiminae (Nematoda) VI. *Helicotylenchus* Steiner, 1945. *Nematologica*, **12**: 1-56.

SHER, S. A. 1968. Revision of the genus *Hirschmanniella* Luc & Goodey, 1963. (Nematoda: Tylenchoidea), *Nematologica*, **14**: 243-275.

THORNE, G. 1961. *Principles of Nematology*, New York, McGraw Hill, 553 pp.

WHITEHEAD, A. G. 1968. Taxonomy of *Meloidogyne* (Nematoda: Heteroderidae) with descriptions of four new species. *Trans. zool. Soc., London*, **31**: 263-401.

ZUCKERMAN, B. M. and STRICH-HARARI, D. 1963. The life stages of *Helicotylenchus multicinctus* (Cobb) in banana roots. *Nematologica*, **9**: 347-353.



Meloidogyne incognita Kofoid & White.

1. Perineal pattern of the female from brinjal (*incognita* type)
2. Perineal pattern of the female from tomato (*acrita* type)
3. Perineal pattern of the female from tomato resembling *M. thamesi* Chitwood.

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RESULTS OF FIFTY YEARS OF FAUNISTIC SURVEY ON INDIAN ISOPODS

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INTRODUCTION

The present paper is based mostly on the results of fifty years of field surveys undertaken by the Zoological Survey of India, specially on the Isopod fauna of India.

The study of Crustaceans has been carried on continuously in the Zoological Survey of India for well over 50 years. Workers like Wood-Mason, Alcock, Annandale, Kemp, Sewell and Chopra made a critical study of different orders of this group and have made the Zoological Survey of India as a centre of research on Indian Carcinology. In recent years, this trend has been maintained by Tiwari, Ramakrishna, Daniel, Reddiah, Ummerkutty, Biswas, and others.

As a result of the work carried out in the Zoological Survey of India for over fifty years, the Department possesses very rich collection of these animals. These collections have been accumulated from various sources, but most of the material has been collected by the officers of the Indian Museum prior to 1916 and the staff of the Zoological Survey of India, since then. The various military and political expeditions, on which zoological specimens were obtained, have enriched very considerably the collections of the Survey. Another important source from which Crustacea collections have been coming in the past is the R.I.M.S. "Investigator" and the Surgeon Naturalists that have successively worked on board the ship. Among the names of Surgeon Naturalists, Alcock and Sewell stand out significantly as having enriched the Crustacea collections of the Survey. Two important surveys undertaken for the collection of zoological specimens with special reference to crustaceans are enumerated, in brief, below.

ABOR EXPEDITION

Of the expeditions that went to the eastern parts of the Himalayas, the Abor Expedition (1911-12) on which permission was given for the first time for a zoologist from the Museum—Dr. S. W. Kemp—to accompany the force in the capacity of a naturalist, must be referred to specially. The collections, including those of crustaceans, brought back by Dr. Kemp were very extensive and of an exceptional interest. Though this expedition was conducted prior to the establishment of the Survey, this has been enumerated here, since most of the crustacea collections with special reference to the Isopods were worked out in later years and the results published during 1912–22 *i.e.*, after the establishment of the Zoological Survey of India in 1916.

Dr. Kemp was accompanied on the Abor Expedition by Mr. R. Hodgart, Zoological Collector in the Indian Museum. The party left

Calcutta on November 13, 1911 and returned to the headquarters on April 3, 1912 after spending about four months in the Abor country.

Abor country lies in the North-East corner of India and bounded on the east by the Mishmi country on the North by Tibet and on the west by the land inhabited by the Miris and on the South by the Brahmaputra river. In a North to South direction, the Abor country extends for about 128 kms. Between the base camp at Kobo and Janakmukh, it consists of an alluvial plain situated at a height of 400 to 600 ft. above sea level, covered with dense jungles interspersed with patches of grass. To the north of this lie hills, often precipitous, and intersected by the boulder-strewn courses of the small streams that drain into the Dihang river.

Majority of the specimens obtained were found comparatively at low altitudes between 400 to 2500 ft. but some were collected at great heights upto about 5000 ft. No lakes or pools of standing water were met with in the Abor country and practically all the aquatic animals obtained were collected from small streams and rivers draining into Dihang or its tributaries. Among the crustaceans, Brachyura (crabs) were not uncommon here, but Macrura (prawns, etc.) appeared to be represented only by a single species of *Macrobrachium*.

Eight species of Isopods pertaining to five genera were collected from the Abor country of which two new genera viz. *Burmoniscus* and *Rotungus* stand out significant. While the former was collected from the caves near Moulmein, the latter was part of the collection made from Kobo at an altitude of 400 ft.

Siju Cave

Before going into the details of the results of the surveys during the past fifty years, mention is made here of yet another important survey undertaken jointly by Drs. Kemp and Chopra to Siju Cave, Garo Hills, Assam. This survey was carried out during January-February, 1922, at a period when the underground streams to which the cave owes its origin was at its lowest and the party spent three weeks examining the cave fauna and also its topography. In general, the character of the Siju Cave may be described as an underground water course running in a tunnel of nummulitic stones with caverns of considerable dimensions at various points in its course. The direction of the cave, speaking generally, is north-west. It extends to a depth of about three-quarters of a mile and admits light only at the entrance as far as the discovery goes. The mouth of the cave is situated in a cliff on the right bank of the Someswari river, between the villages of Upper and Lower Siju, in latitude 25°21′ N. and long. 90°41′ E. The entrance is a passage of about 350 ft. in length, 28 to 35 ft. in breadth and 22 to 25 ft. in height. The floor which is nearly horizontal is composed of fine gravel with occasional stones. The end of the cave system appears to be reached at 3,900 ft. from the entrance in a low, more or less circular chamber, partly filled with limestone boulders. From the walls of this chamber two streams emerge, the larger coming from a passage scarcely 3 ft. broad and containing a considerable depth of water.

The topography of the Siju cave has no doubt exercised a great influence on the fauna which inhabit it.

Among the Crustaceans two species of prawns *viz.*, *Macrobrachium hendersoni* (de Man) and *Macrobrachium cavernicola*, a new species, were collected from 0 to 3,600 ft. One species of freshwater crab *viz.*, *Paratelphusa* (*Barytelphusa*) *falcidigitis* Alcock was also collected at a distance of about 2,400 ft. from the entrance of the cave.

Of the four species of Isopods collected from the Siju cave, two were described as new to science *viz.*, *Porcellio assamensis* and *Philoscia dobakholi*. These were collected at 450 ft. and between 800 to 3,600 ft. from the entrance of the cave respectively. *Cubaris cavernosus* Collinge was obtained between 300 to 3,800 ft. and *Philoscia* sp. from 800 to 1,200 ft. from the entrance of the cave.

The true cave fauna consists of 86 species and of these only 33 penetrate beyond a depth of 600 ft. A considerable part of the collection consists of species which are known to occur in day light and most of the hitherto undescribed forms resemble their outdoor relatives and are not modified in response to their peculiar environment. The number of species showing definite adaptation to cavernicolous conditions is extremely small. The only animals, in cavern which exhibits any modifications which can be correlated with life in total darkness are the Isopod *Cubaris cavernosus* and the mollusc, *Opeas cavernicola*. Among the aquatic fauna the only one species that show any sign of modification is the prawn, *Macrobrachium cavernicola*. No trace of aquatic Isopods or Amphipods were there in the cave.

The Isopod *viz. Philoscia dobakholi* appeared almost white in colour with greatly reduced eyes and found between 600 to 3,600 ft. In *Cubaris cavernosus* Collinge, the eyes are reduced but the colour was not abnormal.

Apart from these two surveys, the officers and staff of the Department carried out other surveys notably of Andaman and Nicobar group of Islands and other areas, though not mainly for the study and collection of Isopods. The accumulated Isopod material has been worked out by various zoologists and the results published.

RESULTS ACHIEVED

Very little was known about the Isopod fauna of India prior to the establishment of the Zoological Survey of India in 1916. It was Stebbing (1907) who initiated the study on Indian Isopods by publishing an account of the genus *Tachaea* and described a new species of the genus from Calcutta. He later (1911) gave a detailed account of Indian Isopods and dealt with two genera of the Tribe Flabellifera and five genera of the tribe Oniscoidea (Terrestrial). Two new genera *viz.*, *Parapericyphis* and *Exalloniscus* were described by him as new to science, based on the material collected from different parts of the country.

It was, however, not until Collinge entered the field and made several contributions that the work received adequate attention. Collinge (1914) published an account of three species pertaining to

three genera *viz.*, *Philoscia*, *Parapericyphis* and *Cubaris* collected from Port Blair, Andamans and from the Annamalai Hills about 4000 ft. above sea level. He again (1912–22) contributed two papers on the terrestrial Isopods obtained from the Abor Expedition. While working out the material, he came across two genera new to science *viz.*, *Rotungus* and *Burmoniscus*, the former obtained from Kobo, Abor country at an altitude of 400 ft. and the latter from the caves near Moulmein. Apart from these two genera, he also described six other species of which three happened to be new to science.

His next contribution to our knowledge of terrestrial Isopods of India dates back to 1914, when he worked out the collection received from Madras Province. Of the ten species dealt with nine species were new to science. *Ennurensis hispidus* and *Hemiporcellio carinatus* stand significant among this collection. Collinge (1916) published another article on the same subject and described 13 species all of them being new to science, pertaining to the genera *Parapericyphis, Cubaris* and *Burmoniscus*. *Burmoniscus kempi* was collected from Maosmai cave near Cherrapunji at an altitude of 4,000 ft. This was the second species of the genus *Burmoniscus* found in a cave, the other being *B. moulmeinus*. He, later, (1917) described another new species of the genus *Synidotea* from the Gulf of Mannar.

Subsequently, Chopra (1923) contributed a monumental monograph on the Bopyrid Isopods of Indian Decapod Macrura. Till then, nothing was known on the Bopyrid Isopod parasites of India and also of the neighbouring countries. These were, however, common in Indian waters since almost all the species of Caridean prawns generally available in Calcutta markets were infested with them. The fauna of Bopyrids is rich in the number of species and also in the number of some individual species. 33 species pertaining to 13 genera were described by him, collected mostly from the Andamans Islands, Delta of Ganges, Madras and other areas.

Later, he (1924) worked out the fauna of Siju cave and described four species of terrestrial Isopods belonging to three genera and two families *viz.*, Oniscidae and Armadillidae. The cave fauna between 300 to 500 ft. from the entrance had the richest fauna and this was true of Isopods too. So far as characters associated with cave-life go, the three species of Isopoda collected in the Siju cave do not show an advanced degree of adaptation to their environment. Of the three, *Philoscia dobakholi* Chopra shows the greatest modification; its colour is almost totally bleached and the eyes are partly reduced. In *Cubaris cavernosus* also the eyes are considerably reduced, but the colouration does not show any indication of a subterranean life. The species lives, however, almost upto the inner end of the cave. The third species (*Porecellio assamensis*) does not seem to have succeeded in penetrating to any great depth. It has well developed eyes and is dark coloured.

Two Myrmecophilous Isopods collected from Barkuda Islands, Chilka Lake were then described by Chopra (1924) brought by Annandale. Of the two, *Cubaris granulatus* was not known to be associated with ants earlier. The species is perhaps only a casual visitor in ants nests and may have taken this mode of life recently. *Platyarthrus aeropyga*

on the other hand shows some adaptations indicative of a subterranean existence. It is almost perfectly white in colour having only scanty pigmentation on the exterior and is totally blind. Chopra (1930) further contributed another interesting paper on the Bopyrid Isopods on Indian Decapod Macrura. The collections included 12 species pertaining to 7 genera collected mostly from Andaman and Nicobar group of Islands, Delta of Ganges, Gulf of Mannar and Bombay.

Chilton (1926) described several species of Isopods and Tanaidacea based on the collection obtained from a tour in the Far East.

Barnard (1935, 1936) reported on some Isopods Tanaidacea, and Amphipoda based on the collection obtained by the R.I.M.S. Investigator. The collections contained littoral, shallow-water and deep-water species from localities in the whole Indian region extending from the Mergui Archipelago in the east to the Arabian sea and mouth of Persian Gulf in the west. The collection contains 34 species of which seven were described as new to science, one of which is a littoral wood louse. Verhoeff (1936) also dealt with several species of terrestrial Isopods collected from Madras and other parts of South India. He further described a new species of the genus, *Protracheoniscus* from Ladakh.

Chopra (1947) gave an account of the first occurrence in India of the ancient suborder Phreatoicoidea (Crustacea: Isopoda), based on material received from Dr. M. Sharif of the Haffkine Institute in 1946 collected in a pucca well at Lohagara Railway station, eighteen miles from Allahabad. Later, several specimens pertaining to this group were collected from the wells at Banaras (U.P.). This suborder is known to have a very interesting distribution, being somewhat plentiful in Australia, Tasmania and New Zealand and having been found outside this region only in Cape Province of South Africa. Its occurrence in South Asia was, therefore, considered to be of particular significance. Chopra and Tiwari (1950) described a genus *Nichollsia kashiense* from the material collected from the well in the outer lawn of the Kaiser Castle, Banaras Cantt. Subsequently Tiwari (1952) dealt with in detail the morphology of *Nichollsia kashiense*. He (1953) described a new species of the rare Cymothoid genus *Agarna*, parasitic on the Clupeid fish *Nematolosa nasus* in the Bay of Bengal. Later, Tiwari (1955) described yet another new species of *Nichollsia*, *viz.*, *N. menoni* collected from an abandoned well at Monghyr (Bihar). Tiwari (1955) contributed yet another article erecting a new family Nichollsidae to accommodate the genus *Nichollsia* of the suborder Phreatoicoidea based on the preserved material.

In recent years, Ramakrishna contributed a paper on the terrestrial Isopods collected by Dr. Jayaramakrishnan in the Kameng Division of the North Eastern Frontier Agency. Although few in numbers, the collection includes fascinating forms. It consists of four species belonging to four genera *viz.*, *Porcellio*, *Philoscia*, *Porcellionides* and *Cubaris*. Of the three genera pertaining to the family Oniscidae, *Porcellio* and *Philoscia* were collected from a comparatively higher altitude *viz.*, 6,500 ft. and 6,600 ft. (1,982 and 2,013 metres), while *Porcellionides* was collected from 2,000 ft. (610 metres).

The family Armidillidae is represented by a single species *viz.*, *Cubaris marmoratus* Collinge in the collection and was collected from an altitude of 6,500 ft. Of these species, *Philoscia muscorum* is reported for the first time from the Kameng Division of NEFA and indeed from India.

Subsequently, Ramakrishna described a new species of *Philoscia* based on material received from Shri Azeez, Entomologist, Coal Mines Welfare Organisation, Dhanbad. The material consisted of four specimens (one male and three females) collected from a pit and the surrounding galleries of Lodna Colliery, 13 km. from Dhanbad, Bihar State.

References

Barnard, K. H. 1935. Report on some Amphipoda, Isopoda and Tanaidacea in the collections of the Indian Museum. *Rec. Indian Mus.*, **37** (3): 279–319.

Barnard, K. H. 1936. Isopoda collected by the R.I.M.S. "Investigator" *Rec. Indian Mus.*, **38** (2): 147–191.

Chilton, C. 1926. Zoological results of a tour in the Far East. The Tanaidacea and Isopoda of Tale Sap. *Rec. Indian Mus.*, **28** (3): 173–185.

Chopra, B. 1923. Bopyrid Isopods parasitic on Indian Decapoda Macrura. *Rec. Indian Mus.*, **25** (5): 411–550, pls. xi–xxi.

Chopra, B. 1924. Isopoda of the Siju Cave, Garo Hills, Assam. *Rec. Indian Mus.*, **26** (1): 49–59.

Chopra, B. 1924. On four Myrmecophilous Isopods from Barkuda. *Rec. Indian Mus.*, **26** (5): 523–528.

Chopra, B. 1930. Further Notes on Bopyrid Isopods parasitic on Indian Decapoda Macrura. *Rec. Indian Mus.*, **32** (2): 113–147, pls. iv to vi.

Chopra, B. 1947. First record of occurrence in India of the ancient Suborder Phreatoicoidea (Crustacea: Isopoda). *Proc. 34th Indian Sci. Congr.* Abstracts: 176.

Chopra, B. and Tiwari, K. K. 1950. On a new genus of Phreatoicid Isopod from wells in Banaras. *Rec. Indian Mus.*, **47** (3 & 4): 277–290, pls. xvii–xx.

Collinge, W. E. 1914. Terrestrial Isopoda. Part I. *Rec. Indian Mus.*, **8** (6): 465–470.

Collinge, W. E. 1914. On some new terrestrial Isopods from the Andaman Islands and Southern India. *Rec. Indian Mus.*, **10** (3): 207–210.

Collinge, W. E. 1914. Description of a new species of Terrestrial Isopod from Borneo. *Rec. Indian Mus.*, **10** (4): 261–262.

Collinge, W. E. 1916. Terrestrial Isopoda. Part II. *Rec. Indian Mus.*, **8** (9): 543–545.

COLLINGE, W. E. 1916. Contributions to a knowledge of the Terrestrial Isopoda of India. Part II. Some new species of *Paraperiscyphis*, *Cubaris*, etc. *Rec. Indian Mus.*, **12** (3): 115–128, pls. ix–xix.

COLLINGE, W. E. 1917. Description of a new species of Isopoda of the genus *Synidotea*, Harger from the Gulf of Mannar. *Rec. Indian Mus.*, **13** : 1–3, pl. i.

RAMAKRISHNA, G. 1969. On a new species of *Philoscia* (Isopoda: Oniscidae) from Lodna Colliery, Bihar. *Bull. syst. Zool.*, **1** (2): 67–70.

RAMAKRISHNA, G. 1970. Studies on the Indian Isopods. Pt. 2. Notes on the Oniscid collection from the Kameng Division of NEFA. *Rec. zool. Surv. India*, **63** (1 to 4): 181–184.

STEBBING, T R. R. 1907. A freshwater Isopod from Calcutta. *Linn. Soc. Journ.*, **30** : 39–42, pl. vi.

STEBBING, T R. R. 1911. Indian Isopods. *Rec. Indian Mus.*, **6** (4): 179–191, pls. x–xii.

TIWARI, K. K. 1952. The Morphology of *Nichollsia* kashiense Chopra and Tiwari (Crustacea: Isopoda Phreatoicoidea). Part I. The head and the Entophragmal system. *Proc. Indian Acad. Sci.*, Sec. B. **35** (2): 69–77.

TIWARI, K. K. 1953. On a new species of the rare Cymothoid genus *Agarna* Schi. & Mein. parasitic on the Clupeid fish, *Nematolosa nasus* (Bl.) in the Bay of Bengal. *Rec. Indian Mus.*, **50** (3 & 4): 295–300.

TIWARI, K. K. 1955. Nichollsidae, a new family of Phreatoicoidea (Crustacea: Isopoda). *Rec. Indian Mus.*, **53** (1 & 2): 293–296.

TIWARI, K. K. 1955. Another new species of *Nichollsia* (Crustacea: Isopoda Phreatoicoidea). *Rec. Indian Mus.*, **53** (3 & 4): 379–381.

VERHOEFF, K. W. 1936. Ueber einen Land-Isopoden aus Ladak. *Mem. Conn. Acad. Arts Sci.* 10; 187–190.

VERHOEFF, K. W. 1936. Ueber einige Isopoda aus Sud-Indian. *Rec. Indian Mus.*, **38** : 97–102.

Rec. zool. Surv. India, **68** : 305-340, 1975.

TAXONOMIC, BIOLOGICAL AND ECOLOGICAL STUDIES ON SOME INDIAN MEMBRACIDS PART—II

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BIOLOGICAL STUDIES

(*a*) *Mating and oviposition.*—Mating in the various species studied here, never appears to be seasonal and occurs throughout the year. Generally copulation takes place during the warmer hours of the day. While in most species mating begins soon after the insects attain maturity, in species of *Leptocentrus*, *Oxyrhachis* and *Otinotus* mating was observed a day or two after the sexes attained maturity. Species of *Gargara*, *Tricentrus* and *Coccosterphus* were observed to mate 3-7 days after the last moult. In *Tricentrus pilosus* in spite of very careful observations copulation could not be noticed. In all species of *Oxyrhachis*, and *Otinotus oneratus* often two or more males congregate around a female prior to mating. The position assumed in mating is such that the opposite sexes face away from each other. Sluggish forms like *Oxyrhachis rufescens*, *Oxyrhachis tarandus* and *Otinotus oneratus* are not easily distracted when disturbed and never get detached even when they are dislodged, while the more active forms such as *Otinotus indicatus*, species of *Leptocentrus* and *Coccosterphus* get disengaged at the slightest disturbance. In *Oxyrhachis tarandus*, *O. rufescens* and *Otinotus oneratus* mating lasts for an hour or two, but actual field observations show that these sluggish forms if undisturbed, remain in copula for hours together. The duration of copulation for *Coccosterphus tuberculatus*, *C. minutus*, *Leptocentrus taurus* and *Gargara mixta* was timed 20-35, 5-15, 10-15 and 35-50 minutes respectively.

The majority of local species prefer the bark of twigs which are one or two years old, for oviposition. This is the usual location for all species of *Oxyrhachis*, *Otinotus*, some species of *Leptocentrus* and *Tricentrus*. Some species like *Leptocentrus moringae* and *L. bauhiniae* choose tender twigs which may be punctured to the extent of being broken off. *Leptocentrus taurus* can successfully oviposit on young as well as woody twigs. *Oxyrhachis tarandus*, *O. rufescens* and *Leptocentrus taurus* often deposit the eggs in punctures produced on the slender twiners of weak-stemmed plants. Midribs and petioles are the preferred sites of oviposition in *Gargara albitarsis* and *Coccosterphus minutus*, while the leaf axils are preferred by *Telingana consobrina* and *Gargara malabarica*. Some species regularly oviposit on the peduncles or pedicels of flowers while

some polyphagous species often do so. For instance, *Telingana nigroalata*, *Coccosterphus paludatus* and *C. tuberculatus* always choose peduncles. *Otinotus oneratus* which normally lays eggs on twigs of one or two years old, has also been noted to oviposit on the peduncles of *Cestrum diurnum*. The species inhabiting herbaceous or semiwoody annuals or biennials invariably oviposit on the basal part of the main stem as illustrated by *Tricentrus albomaculatus*—a monophagous species found on *Datura fastuosa*. It is interesting to note a few species such as *Leptocentrus rhizophagus* ovipositing, as a rule, on slender free-hanging prop roots of *Ficus bengalensis*. *Tricentrus pilosus*, on the other hand, lays eggs on prop roots as well as on young twigs of *Thespesia populnea* and the choice appears to depend on the season. (vide Table 1). The peculiar instance of oviposition in the roots or on the base of the stem below the surface of the ground reported for *Thelia bimaculata* and *Stictocephala festina* by Funkhouser (1916, 1917) has, however, no parallel among the species studied presently.

The nature of the oviposition slit varies. In many instances, the slit appears to be nearly straight and narrow made by an oblique thrust of the ovipositor. The eggs are inserted in the slit arranged in a single slanting row ; the slit soon closes by the springing back of the bark, leaving but a streak superficially. *Leptocentrus moringae*, *Tricentrus pilosus* and many species of *Gargara* illustrate this type of oviposition. In another type of oviposition observed in *Leptocentrus taurus*, *L. bauhiniae*, *L. nigra* and *L. mangiferae* two crescentic slits are made side by side and a single or double row of eggs are deposited; the slit never closes and often remains as a deep elliptical scar for a long time; should this type of ovipotion occur in a tender twiner or herbaceous stem, the injury causes the stem to break off. Rarely as in *Gargara madrasensis* the slit takes the form of a more or less shallow excavation, never reaching the stele. In some cases, the punctures are superficial extending only to the endodermis with the result that the eggs are not entirely hidden, the tips plainly projecting out. This is illustrated by *Otinotus oneratus* and many of the species of *Oxyrhachis*. In the latter genus, the eggs are arranged in a palmate manner, the opposite rows converging at one end and diverging at the other. In *Oxyrhachis brevicornutus* the eggs are arranged in two rows and the egg mass covered by a viscid substance. In *Otinotus oneratus* the eggs are laid in irregular clusters often one row being partially or entirely overlapped by another. In some species such as *Gargara albitarsis* and *Telingana consobrina* the eggs are laid singly.

The number of eggs in each egg mass varies even within the species. The data for all the species taken during the present studies with regard to the number of eggs in one mass are presented in Table 1.

There are mainly two types of movement of ovipositor in the act of oviposition. In the first type exemplified by all the species of *Tricentrus*, *Gargara*, *Coccosterphus* and *Telingana* the female raises her abdomen as high as possible, unsheaths the ovipositor which is held at right angles to the abdomen and slowly pushed into the bark. In this perpendicular thrust, the ovipositor which bends up and down several times due to the resistance offered by the bark and wood, progresses steadily backwards until it turns almost parallel to the body and the eggs are laid

in the slit after which the ovipositor is withdrawn. In *Leptocentrus*, besides the main slit a shallow supplementary slit is made. In the

TABLE 1

Oviposition habits and duration of egg stage.

Name of the membracid species	Minimum No. of eggs in each mass.	Maximum No. of eggs in each mass.	Oviposition site on host.	Duration of egg stage in days
Oxyrhachis rufescens	30	270	Twig of one or two years old slender twiners	7–10
O. tarandus	48	240	,, ,,	7–12
O. minusculus	40	160	,, ,,	6–10
O. krusadiensis	120	160	,, ,,	—
O. uncatus	96	140	,, ,,	—
O. brevicornutus	18	22	,, ,,	—
Leptocentrus taurus	18	27	Young and woody twigs	6–14
L. leucaspis	8	17	Woody branches	8–14
L. bajulans	7	16	,, ,,	5– 9
L. varicornis	18	28	,, ,,	10–15
L. bauhiniae	10	22	Tender twigs	10–15
L. moringae	18	27	Tip of young twigs	10–15
L. mangiferae	5	15	Woody twigs	7–13
L. major	7	16	,, ,,	10–12
L. nigra	5	15	,, ,,	10–14
L. rhizophagus	4	20	Prop roots of Banyan tree	8–10
Otinotus oneratus	3	16	Young or old twigs	7–13
O. mimicus	3	8	,, ,,	—
O. indicatus	6	18	Main trunk of shrubs or two year old twigs of trees	8–11
O.obliquus	4	10	,, ,,	—
Telingana nigroalata	16	40	Peduncles of flowers	—
T. consobrina	1	—	Axil of leaflet	—
Tricentres pilosus	8	20	Prop roots of Banyan tree	9–16
T. decornis	4	8	Young twigs	7– 9
T. albomaculatus	5	15	Basal part of Datura stem	6–11
T. purpureus	6	8	Young twigs	8–14
T. congestus	4	8	Woody twigs	10–13
Gargara mixta	5	18	Tip of twig	7–10
G. extrema	6	18	,, ,,	5–10
G. malabarica	5	8	Leaf axils	7–12
G. albitarsis	1	—	Petioles	6– 9
G. madrasensis	4	8	Young twigs	6– 9
G. rustica	6	20	,, ,,	8–10
Coccosterphus minutus	6	10	Midrib of leaf	5– 7
C. paludatus	6	10	Peduncle of flower or fruit	9–15
C. tuberculatus	4	6	,, ,,	7–12

second type observed in the species of *Oxyrhachis* and *Otinotus*, the ovipositor is held at an angle to the abdomen and thrust obliquely into the bark. It is withdrawn after anchoring each egg in the host tissue and reinserted for the next egg. Some species having high fecundity lay eggs in slits which are very close to each other in the same twig, for instance, in *Gargara mixta* 31-32 egg masses have been deposited within a distance of one inch, in *Otinotus oneratus* 37-98, while *Leptocentrus leucaspis* lays 55-70 egg masses within the same space and this is the case for many other species also.

The ovipositor has sharp saw-like edge for lacerating the host tissue while making the egg slits. A comparison of the ovipositors of many of the species suggests a correlation between the length of this structure and the mechanics of oviposition. It is not unusual for some smaller species to possess comparatively longer and more powerful ovipositors. For example, *Coccosterphus minutus*, *Gargara madrasensis*, *Parayasa maculosa* and *Tricentrus albomaculatus* all of which are small species have relatively long ovipositors enabling them to anchor the eggs deep within the bark.

The eggs of all the species examined are more or less identical in shape, being elongate, with a slight curvature on lateral margins. In most cases, the eggs are shining white with a smooth vitreous chorion. The basal part of the egg is invariably rounded while the tip may either be simple as in the majority of species or slightly drawn out to give a club-like appearance to the egg as in *Leptocentrus leucaspis*. According to Lefroy (1909) the egg of *Oxyrhachis tarandus* has a sharp bent spine at one end which is embedded in the tissue of the host plant. In the present studies, in spite of examining a large number of eggs of this species no such spine was noticed and it appears to be absent in other species of *Oxyrhachis* as well. The eggs of *Oxyrhachis rufescens*, the largest in size found locally, measures 0.9-1.1 mm. long and 0.25-0.3 mm. wide at the maximum diameter. The smallest eggs are those of *Coccosterphus minutus* and *Gargara madrasensis* measuring 0.55-0.6 mm. long and 0.16-0.2 mm. wide. Before hatching, the eggs of all species show an increase in size, the colour in many cases turning to yellowish or light fuscous.

(*b*) *Duration of egg stage.*—The duration of egg stage differs in the different species as shown in the Table 2. A minimum of 5 days and a maximum of 16 days have been noted for incubation. Even within the same species the difference in the incubation period appears to be spectacular during the various seasons of the year due to the effects of the physical factors such as temperature and moisture. However, eggs laid at the same time show variations relating to hatching though the environmental factors are identical. The reason for such a differential rate of embryonic development is not known.

The duration of each instar varies for the different species and even for the individuals hatching from a single egg mass. In general it is found that the duration of the first instar is greater than the succeeding three instars, while the fifth instar has the maximum duration as shown in Table 2.

(*c*) *Hatching.*—Hatching occurs invariably during the early hours of morning when the surrounding temperature is low. Prior to hatching, the egg slightly enlarges and stands conspicuously apart from the neighbouringe ggs. During hatching, the hatching membrane enclosing the embryo breaks up and the chorion splits near the upper end. Then the egg-cap is forced upwards by the cranial tubercules and the head of the nymph projects out. The nymph exhibits rhythmic to and fro movements of its body for working its way out. For a few minutes the insect stands on its anal segment which is still inside the hatching membrane. As soon as it gets a foothold, it pulls the terminal part of the abdomen out of the shell, slowly moves apart and rests for sometime. The whole process of hatching requires from 15 minutes to one hour in the different species.

(*d*) *Ecdysis.*—The region where the ecdysial splitting first appears differs in the different genera. Some species require a firm foothold on the substratum, while others can moult without attachment. In the fifth instar moulting can be easily observed in view of its larger size.

TABLE 2

Duration of nymphal stages in membracids.

Name of species	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total No. of days
Oxyrhachis tarandus	8	6	6	3	10	33
O.rufescens	5	4	5	5	11	30
O.minusculus	5	3	4	4	8	24
O.krusadiensis	8	6	3	3	10	30
O.uncatus	8	5	4	4	8	29
O.brevicornutus	10	3	4	4	9	30
Telingana nigroalata	8	5	4	5	12	34
T.consobrina	6	4	4	5	9	28
Leptocentrus taurus	5	3	3	4	10	25
L.rhizophagus	6	4	5	5	9	29
L.leucaspis	6	4	4	4	11	29
L.bajulans	5	4	6	6	7	28
L.varicornis	4	3	4	4	10	25
L.moringae	7	4	5	4	9	29
L.mangiferae	7	5	4	4	9	29
L.bauhiniae	5	4	3	3	8	23
L.nigra	9	6	5	5	9	34
L.major	8	6	4	4	10	32
Otinotus oneratus	7	5	5	4	8	29
O.mimicus	6	3	3	3	8	23
O.indicatus	9	3	5	4	10	31
O.obliquus	10	3	3	3	7	26
Tricentrus pilosus	8	4	5	5	9	31
T.albomaculatus	7	3	3	3	6	22
T.purpureus	10	6	5	4	10	35
T.decornis	7	4	3	4	7	27
T.congestus	8	5	4	4	9	30
Gargara mixta	4	5	4	3	7	23
G.extrema	5	5	4	3	7	24
G.rustica	4	3	3	3	8	21
G.malabarica	5	4	3	4	7	23
G.madrasensis	4	3	3	4	7	21
G.albitarsis	5	4	3	3	8	23
Parayasa maculosa	7	3	4	3	9	26
Coccosterphus minutus	5	3	3	3	8	22
C.tuberculatus	6	4	4	5	12	31
C.paludatus	7	6	4	4	13	34

In all species of *Leptocentrus* the nymph attaches to the twig by the first two pairs of legs; the splitting commences from the middle of vertex and extends over the thorax, legs, wings and abdomen; the head emerges through the split followed by the other regions of the body. In all the species of *Coccosterphus* and *Gargara* the nymphsattach to the substratum by all the legs; in *Tricentrus albomaculatus* only the forelegs are attached. In all the above examples, the moulted skins or exuviae have been found to be perfect and useful for the study of the chaetotaxy. In *Oxyrhachis* and *Otinotus*, the nymph is not attached; splitting starts over the thorax

followed by the head, legs and abdomen; the exuvium is much torn, parts of it being found attached to the legs of the insect for sometime. Soon after moulting, the various regions of the body become swollen. The new exoskeleton is pale yellowish white, turning to the normal colour in a few hours. The time taken for moulting varies not only in the different species but in the individuals of the same species. The minimum period noted for the process is 10 minutes for *Coccosterphus paludatus* and the greatest is fortyfive minutes for *Leptocentrus rhizophagus*. If the insects are subjected to any mechanical injuries or if the twig of the host plant happens to dry up during the period of moulting, the adults become abnormal, exhibiting unusual twists in the pronotal processes and the wings appear crumpled.

(*e*) *Host Preference*.—Most of the local species of membracids show host specificity to a remarkable extent. Certain species of plants, although occurring in abundance throughout the year, are notably free from membracids. For instance, all plants of the families, *Cucurbitaceae*, *Oleaceae*, *Asclepiadaceae*, *Apocyanaceae*, *Acanthaceae*, *Meliaceae* and *Labiatae* are decidedly avoided by membracids, while *Leguminosae*, the acacias in particular, *Compositae*, *Rubiaceae*, *Solanaceae*, *Myrtaceae* and *Rhamnaceae* are among those most preferred by these insects. The monophagous membracids exhibit absolute host specificity; some which are oligophagous choose closely related plants often belonging to the same family, while others appear to be polyphagous extending their range over a wider variety of plants (Table 3). Monophagous species include *Leptocentrus mangiferae* found only on *Mangifera indica*, *Leptocentrus bauhiniae* on *Bauhinia tomentosa* and *Tricentrus albomaculatus* on *Datura fastuosa*. In a few instances, as Funkhouser (1917) states, the association between the membracid and the host is so specific that a knowledge of the one is sufficient for a recognition of the other. Thus, *Leptocentrus moringae* not only confines itself to *Moringa moringa* but is the only species ever found on this host. *Oxyrhachis rufescens* is notable for its oligophagous habit being found only on the leguminous plants (Table 4), while *Oxyrhachis tarandus*, though found mostly on Leguminosae, is often encountered on *Casurina* and *Morinda tinctoria*. *Leptocentrus taurus* and *Otinotus oneratus* are decidedly polyphagous. *Otinotus oneratus* has so far been recorded from forty host species from South India and the range may be undoubtedly wider (Table 5); some of these plants such as *Prosopis spicigera*, *Cestrum diurnum* and *Zizyphus jujuba* are much preferred.

That membracids are capable of rhizophagous habit, a fact hitherto unrecorded, has been established beyond doubt in the course of the present studies. Four species, *Leptocentrus rhizophagus*, *Coccosterphus paludatus*, *Otinotus oneratus* and *Tricentrus pilosus*—are regularly met with on the slender free-hanging prop roots of *Ficus bengalensis* where oviposition as well as feeding of nymphs and adults have been observed. Strangely enough, none of these membracids have any tendency to feed on the leafy shoots of the banyan tree.

It has been observed that while the majority of the local species utilize specific host plants for oviposition and feeding, a few species choose a particular host for oviposition and feeding during their nymphal period, the adults swarming over and feeding on almost all plants of the locality. Thus, *Telingana nigroalata*, a species common in the

TABLE 3

Host plants of the Indian Membracids.

Oxyrhachis tarandus	Acacia arabica, Prosopis spicigera, Cassia sp. Peltophorum sp. Caesalpinia coriaria, Sesbania grandiflora, Erythrina indica.
O. rufescens	vide Table 7.
O. minusculus	Casuarina equisetifolia.
O. uncatus	Prosopis spicigera.
O. krusadiensis	Prosopis spicigera, Cassia sp.
O. brevicornutus	Prosopis spicigera.
Leptocentrus taurus	Acacia arabica, A. melanoxylon, Albizzia lebbec, Tamarindus indica, Capparis sepiaria Zizyphus jujuba, Vernonia cinerea, Artabotrys odoratissimus, Erythrina indica, Crataeva religiosa, Ipomaea biloba, Hibiscus rosasinensis, Thespesia populnea, Feronia elephantum, Anacardium occidentale, Cyamopsis tetragonoloba, Bauhinia tomentosa, B. purpurea, Casuarina equisetifolia, Solanum torvum, S.melongena, Eranthimum sp.
L. mangiferae	Mangifera indica.
L. major	Michaelia champaka.
L. bajulans	Casuarina equisetifolia.
L. leucaspis	Terminalia cadappa, Pongamia glabra.
L. varicornis	Zizyphus jujuba.
L. rhizophagus	Prop roots of Ficus bengalensis.
L. nigra	Phyllanthus sp.
L. bauhiniae	Bauhinia tomentosa.
Tricentrus pilosus	Prop roots of Ficus bengalensis, Thespesia populnea.
T. decornis	Eugenia caryophyllata, Lagerstroemia sp., Cryptostegia sp.
T. albomaculatus	Datura fastuosa.
T. congestus	Vernonia cinerea.
T. purpureus	Polygonum sp.
Gargara mixta	Lagerstroemia sp., Syzygium jambolanum.
G. rustica	Zizyphus jujuba.
G. madrasensis	Cestrum diurnum, Caesalpinia pulcherrima, Tecoma sp.
G. albitarsis	Tecoma grandiflora.
G. malabarica	Phyllanthus emblica.
G. extrema	Solanum melongena, Zizyphus oenoplia, Capsicum frutescens, Solanum torvum.
Otinotus oneratus	vide Table 8.
O. mimicus	Artocarpus integrifolia.
O. indicatus	Thespesai populnea, Syzygium jambolanum, Tecoma sp.
O. obliquus	Trewia nudiflora, Phyllanthus sp., Premna latifolia.
Coccosterphus minutus	Prosopis spicigera, Cestrum diurnum, Tecoma stans, Vernonia cinerea, Acalypha sp.
C. paludatus	Bauhinia tomentosa, Cestrum diurnum, Lawsonia alba, prop roots of Ficus bengalensis.
C. tuberculatus	Phyllanthus emblica, Morinda tinctoria.
Parayasa maculosa	Cestrum aurantiacum, Acacia melanoxylon.
Telingana nigroalata	Agapanthus umbellatus.
T. consobrina	Aspidium sp.

Kodaikanal hills and sporadic on plains, oviposits on *Agapanthus umbellatus* in the months of March and April; the nymphs feed on the same plant. Emergence of adults occurring during the first and second weeks of June is associated with swarming; subsequently they are found on almost all plants such as *Prunus salicina*, *Acacia auriculiformis*, *Juniperus virginiana*, *Spiraea corymbosa*, *Erythrina cristogalli*, *Cestrumaurantiacum*, and on ferns. Such instances often lead to false conclusions regarding the real host plant of the species.

TABLE 4

Host plants of Oxyrhachis rufescens.

Name of leguminous host plant	Subfamily	Period of occurrence
Acacia arabica	Mimoseae	Throughout the year
A. melanoxylon	,,	Sporadic
A. auriculiformis	,,	,,
Prosopis spicigera	,,	Throughout the year
P. juliflora	,,	,,
Enterolobium saman	,,	September to November
Pithecolobium dulce	,,	Throughout the year
Mimosa sp.	,,	Sporadic and rare
Parkia biglandulosa	,,	,,
Delonix regia	Caesalpiniaceae	July to September
Caesalpinia coriaria	,,	,,
C. pulcherrima	,,	September to December
Cassia fistula	,,	August to December
Cassia sp.	,,	,,
Peltophorum sp.	,,	Rare
Tamarindus indicus	,,	August to December
Bauhinia tomentosa	,,	Rare
B. purpurea	,,	September to November
B. variegata	,,	,,
Parkinsonia aculeata	,,	Rare and sporadic
Crotalaria juncea	Papilionaceae	September to December
C. verrucosa	,,	,,
Erythrina indica	,,	April to June
Butea frondosa	,,	August to November
Sesbania aegyptiaca	,,	Rare and sporadic
Pterocarpus marsupium	,,	,,

It is interesting to note that in South India *Otinotus oneratus* which is very common on a variety of unrelated host plants, is conspicuous by its absence on *Datura fastuosa*. However, the same species reported from North India by Behura (1951, 1956) is stated to prefer *Datura fastuosa* wherever this plant occurs. In the present studies, attempts at rearing this membracid to maturity on *Datura fastuosa* has so far been met with failure. Although no attempt has been made towards a chemical analysis in the present studies, it seems probable that there might be subtle biochemical differences between the host species of the two regions to cause the distinction.

The species whose host plants have been studied appear to have all stages of one or more broods passed through on the same host plant, unlike some American species which are stated by Funkhouser (1917) to require two hosts, one for the feeding of nymphs and the other for the adults to oviposit, the former host being usually herbaceous and succulent, while the latter being woody shrubs or trees. However, certain local species deliberately change their host after completing one or two generations although there is apparently no morphological difference on the host to induce such a behaviour. For instance, *Coccosterphus paludatus* feeds and breeds on *Bauhinia purpurea* from June to September completing two generations, migrating thereafter to *Cestrum diurnum*, *Tecoma stans* and *Lawsonia alba* or taking to a rhizophagous habit on *Ficus bengalensis*.

(*f*) *Communal life.*—While some species of membracids occur solitarily on their host plants, others are decidedly gregarious. Many of the species of *Oxyrhachis* are gregarious though *brevicornutus* forms an exception. In all the strictly solitary species, the eggs are laid either singly or in clusters wide apart and the nymphs immediately on hatching

TABLE 5

Host plants of Otinotus oneratus in the vicinity of Madras.

Name of plant	Family	Period of infestation
Prosopis spicigera	Mimoseae	Throughout the year
P. juliflora	,,	,,
Acacia arabica	,,	,,
Cestrum diurnum	Solanaceae	,,
Zizyphus jujuba	Rhamnaceae	April to December
Z. oenoplia	,,	,,
Bauhinia variegata	Caesalpiniaceae	September to December
B. purpurea	,,	,,
Erythrina indica	Papilionaceae	June to August
Capparis sepiaria	Capparidaceae	April to June
Cassia angustifolia	Caesalpiniaceae	June to September
Cassia fistula	,,	,,
Cassia marginata	,,	,,
Caesalpinia pulcherrima	,,	Sporadic
C. coriaria	,,	,,
Peltophorum sp.	,,	,,
Psidium guajava	Myrtaceae	August to October
Tamarindus indicus	Caesalpiniaceae	November to March
Pongamia glabra	Papilionaceae	Rare and sporadic
Butea frondosa	,,	,,
Sesbania grandiflora	,,	,,
Crotalaria sp.	,,	October-November
Crataeva religiosa	Capparidaceae	April to June
Cadaba indica	,,	,,
Enterolobium saman	Mimoseae	Rare and sporadic
Pithecolobium dulce	,,	October to January
Aegle marmelos	Rutaceae	Sporadic
Feronia elephantum	,,	,,
Morinda tinctoria	Rubiaceae	December to January
Morinda citrifolia	,,	,,
Moringa moringa	Moringaceae	Rare and sporadic
Thespesia populnea	Malvaceae	December to January
Lagerstroemia Flosreginae	Lythraceae	September to January
Terminalia catappa	Combretaceae	September to November
Anona squamosa	Anonaceae	Sporadic
Solanum torvum	Solanaceae	November to January
S. lycopersicum	,,	,,
Prop roots of Ficus bengalensis	Urticaceae	October to December

exhibit a tendency to move along the twigs and become solitary. Some species like *Coccosterphus tuberculatus* are gregarious during their nymphal stages but remain solitarily as adults. Conversely, the adults of a few membracids, for instance, *Leptocentrus moringae* are found in groups on the twigs of *Moringa* while their nymphs are solitary, each occupying a leaf axil. In some, like *Leptocentrus rhizophagus*, the first instar nymphs are gregarious and the later stages are found to be solitary. In a few species, the nymphs appear to be subgregarious, being found in small groups of 5 or 6 individuals.

Gregarious habit in both nymphal and adult stages is observed in many species such as *Oxyrhachis krusadiensis*, *Oxyrhachis uncatus*, *Oxyrhachis minusculus*, *Gargara mixta*, etc. though these species are not observed to live with other species. On the other hand, sometimes the same host plant lodges two gregarious species, the individuals of both the species crowding together and mingling with each other very closely; such close harmony is noticed in *Oxyrhachis tarandus* and *Otinotus oneratus* on *Prosopis spicigera*. The egg masses of these two species are very often laid so close to each other that the egg slits of one species become partially overlapped by the other. In general, the greagarious species happen to be highly prolific and they lay egg masses in close proximity, the nymphs as well as adults showing very little tendency towards migration with the result that several generations are passed through on the same plant, often on the same twig. Nymphs of two species often mingle with each other while the adults are prone to be solitary. Thus, the nymphs of *Gargara rustica* and *Coccosterphus paludatus* live gregariously on *Bauhinia;* the latter species is also found associated with *Tricentrus pilosus* on the prop roots of Banyan. Rarely, an individual nymph of a solitary species has been observed in the midst of a gregarious one. In a few instances, two species which are normally solitary on different host plants live gregariously if they happen to find themselves on the

TABLE 6

Species of Membracid	Type of solitary and communal life
Coccosterphus minutus Gargara albitarsis Tricentrus pilosus Otinotus indicatus Otinotus obliquus Oxyrhachis brevicornutus Telingana consobrina Leptocentrus varicornis Leptocentrus bajulans Leptocentrus nigra Leptocentrus mangiferae	Species entirely solitary as both nymphs and adults.
Leptocentrus moringae Telingana nigroalata	Species gregarious as adults but solitary as nymphs.
Coccosterphus tuberculatus	Species solitary as adults but gregarious as nymphs.
Leptocentrus rhizophagus	Species gregarious in the first instar, but solitary thereafter.
Oxyrhachis krusadiensis Oxyrhachis uncatus Oxyrhachis minusculus Gargara mixta Gargara malabarica	Species gregarious as both nymphs and adults, but not living with other species.
Oxyrhachis tarandus Oxyrhachis rufescens Otinotus oneratus	Gregarious species living with other gregarious species as both nymphs and adults.
Gargara rustica Coccosterphus paludatus Tricentrus pilosus	Species living with other gregarious species as nymphs, but not as adults.
Tricentrus albomaculatus Leptocentrus taurus	Species solitary on different hosts, but living together on the same host.
Leptocentrus bauhiniae	Species found solitarily as nymphs in the midst of another gregarious species.
Leptocentrus taurus Leptocentrus leucaspis	Subgregarious species found in small groups of five or six as nymphs.

same host plant. The various types of communal life observed in local species are summarised in Table 6.

(*g*) *Attendance by Ants.*—That many membracids are attended by ants for the sake of their anal secretion, the so-called 'honey-dew' is well known. In fact, in many instances the hiding places of the membracids are easily located by following the tract of marching ants. As stated earlier, interesting accounts on this subject have been furnished by many workers. The association, though common, is undoubtedly not as indispensable and obligatory as the strict symbiotic relation between ants and some other insects.

Many of the local species of membracids are attended by one or more species of ants, the exceptions so far noted being *Coccosterphus minutus*, *Telingana consobrina*, *Parayasa maculosa*, *Tricentrus purpureus*, *Otinotus mimicus*, *Oxyrhachis brevicornutus* and *Gargara madrasensis* (Table 7).

TABLE 7

Membracid species and their attending ants.

Membracid species	Attending ants
Oxyrhachis tarandus	Camponotus compressus
Oxyrhachis rufescens	Camponotus sericeus, C. compressus
Oxyrhachis uncatus	Camponotus compressus
Oxyrhachis minusculus	Crematogaster sp.
Oxyrhachis brevicornutus	——
Oxyrhachis krusadiensis	Oecophylla smaragdina.
Leptocentrus taurus	Camponotus compressus
Leptocentrus leucaspis	Paratrechina longicornis
Leptocentrus rhizophagus	Camponotus compressus, Myrmecaria brunnea. Crematogaster sp. and Meranoplus bicolor.
Leptocentrus moringae	Crematogaster sp.
Leptocentrus bauhiniae	Anoplolepis longipes, Camponotus compressus
Leptocentrus mangiferae	Camponotus compressus
Leptocentrus major	Camponotus compressus
Leptocentrus varicornis	Camponotus compressus
Leptocentrus bajulans	Camponotus compressus
Otinotus oneratus	Camponotus compressus, Crematogaster sp.
Otinotus mimicus	——
Otinotus indicatus	Paratrechina longicornis
Otinotus obliquus	Paratrechina longicornis
Tricentrus albomaculatus	Solenopsis geminata var. rufa.
Tricentrus pilosus	Camponotus compressus, C. sericeus
Tricentrus decornis	Camponotus compressus
Tricentrus congestus	Camponotus compressus
Tricentrus purpureus	——
Gargara mixta	Camponotus compressus
Gargara extrema	Camponotus compressus
Gargara malabarica	Anoplolepis longipes
Gargara madrasensis	——
Gargara albitarsis	Crematogaster sp.
Gargara rustica	Anoplolepis longipes, Crematogaster sp.
Coccosterphus minutus	——
Coccosterphus paludatus	Crematogaster sp.
Coccosterphus tuberculatus	Crematogaster sp.
Telingana nigroalata	Camponotus sp.
Telingana consobrina	——
Parayasa maculosa	——

The commonest species of ant that is found attending on the majority of membracids in this locality is undoubtedly *Camponotus compressus*, a large black species found throughout India. However, the allied species, *Camponotus sericeus*, is somewhat rare and found attending regularly on *Oxyrhachis rufescens* during the rainy months of September to November, and sporadically on *Tricentrus pilosus*. Other species of ants recorded from this locality are as follows: *Crematogaster* sp. a small shining black ant resting in tree trunks and attending regularly on *Coccosterphus tuberculatus*, *Coccosterphus paludatus* and often on other species as well; this ant has the peculiar habit of turning up its abdomen when excited; *Oecophylla smaragdina*, the red tree ant, attends on *Oxyrhachis krusadiensis*, while *Anoplolepis longipes*, a smaller reddish species visits *Leptocentrus bauhiniae* and *Gargara rustica*, both these species of ants being noted for their virulent nature. *Myrmicaria brunnea* and *Meranoplus bicolor* characterised by backwardly directed prothoracic spines are found associated with *Leptocentrus rhizophagus*. *Solenopsis geminata* var. *rufa*, a small brown-ant nesting on the ground near trees attends on *Tricentrus albomaculatus; Paratrachina longicornis*, a very small species attends in large numbers on *Leptocentrus leucaspis* and *Otinotus indicatus* (vide Table 7).

Funkhouser (1917, 1951), in his admirable account on this subject, has mentioned that one of the unsolved problems in connection with the mutual relationship between ants and membracids is that while some species are attended by ants, others are found unattended although there are apparently no morphological or anatomical differences to cause the distinction. He further states that nymphs of the species unattended by ants show the same extended anal tube as do the nymphs of those that secrete the fluid. Observations made in the course of the present studies have clearly revealed that species without eversible anal tubes never secrete the honey dew to the extent of attracting ants. For instance, *Coccosterphus minutus*, a species collected from different localities in South India, is not attended by ants in any of the localities; hundreds of nymphs of this species which have been examined in their natural habitat, on plants kept indoors, and specimens mounted on Balsam, have not been found to have eversible anal tubes; on the other hand, the two other species—*C. tuberculatus* and *C. paludatus*—whose nymphs have eversible anal tubes are invariably attended by ants of the genus *Crematogaster*. Thus, there appears a definite relation between the possession of an eversible anal tube and attendance by ants.

Another factor deciding the association of ants with membracids is the altitude at which the membracid is situated. For instance, in the present studies, *Telingana nigroalata* recorded from Kodaikanal Hills at an elevation of 5000′ is unattended by ants though this species occurs in numbers sufficiently large to be attracted by ants. The same species collected from plains has been found to be associated with *Camponotus* sp. This difference appears to be evidently due to scarcity of ants in Hill Stations.

As a rule, each species of membracid in a particular locality is attended by the same species of ants throughout the year. Exceptionally, the attendance of ants appears to be seasonal. For instance, *Camponotus compressus* attends on *Oxyrhachis rufescens* for the major part of the year, but during the rainy season the species is attended by *C. sericeus*. In the

same manner, *Leptocentrus bauhiniae* is attended by *C. compressus* throughout the year while *Anoplolepis longipes* attends on the same membracid during the rainy months of September to December. The most noteworthy example, however, is *Leptocentrus rhizophagus* found on prop roots of *Ficus bengalensis* which has been observed to be attended by as many as four species of ants—*Camponotus compressus*, *Myrmicaria brunnea*, *Crematogaster* sp. and *Meranoplus bicolor*—in the months of August, September and October; during the other months this membracid is attended by two species of ants, *C. compressus* and *Crematogaster* sp.

It is also noteworthy that a particular species of ant attending on a particular membracid species in one locality is not very often associated with the same species of membracid in other localities. In the present studies, *Leptocentrus taurus* has been found to be attended by *C. compressus* throughout S. India, while the same species is reported by Misra (1923) to be attended by *Oecophylla smaragdina* in North India. This difference could be attributed only to chance proximity as stated by Capener (1962) and Haviland (1925).

In all the instances noted here, the ants caress the nymphs as well as the adults for the honey dew; however, in *Tricentrus pilosus* only the nymphs are attended. Further, the behaviour of the ant towards the membracid is not uniform in all the cases studied, the pattern being more or less definite for each of the attending species of ant. Some species of ants care only for the honey dew while others extend their solicitude to a greater degree. For instance, *Camponotus compressus* merely derives honey-dew from *Oxyrhachis rufescens* while *C. sericeus*, a seasonal attendant on the same species has been observed to drive the nymphs along the host plant in such a way as to harbour each nymph in a leaf axil. The ants also drive the sluggish adults of *O. rufescens* from one branch to another by nibbling their tegmina, preventing the deposition of eggs in the same localised spot of the host plant. They also consume the moulted skin of their "cattle" The behaviour of *Camponotus compressus* towards *Oxyrhachis rufescens* whcih has been observed cerefully is as follows: The worker ant applies its mouth close to the anal orifice of the larva whereupon the anal tube fringed with circlets of sensory hairs is moderately everted with a drop of liquid at the tip. If, however, the nymph does not emit the honey-dew the ant strokes it with its antennae at the anal tube. When the liquid exudes, the ant presses its jaws into the drop, grips it and moves away. If the nymph fails to respond to the coaxing of the ant, it bites at the sensory hairs of the anal tube and sometimes even thrusts its jaws into the anal tube but does no injury otherwise. In indoor experiments where nymphs have been reared on their host plants, the ants exhibit the same pattern of behaviour but the dying or dead nymphs are most often consumed by the ants. The behaviour of the ant to the intruder is noteworthy. When the twig containing a membracid colony is touched, the smaller worker minors drop down to the ground probably to warn the soldiers of the approach of any enemy. But the bigger worker minors and soldiers present on the twig keep moving excitedly round their "cattle" If the nymphs are touched with a needle, the nearer soldier or worker darts forward, catches the needle with its powerful mandibles and bites it viciously; other ants in the neighbourhood follow to help it and try

to reach parts of the body of the intruder. They fight tenaciously, unless one shakes them off with a jerk of the needle.

The behaviour of *Oecophylla smaragdina* attending on *Oxyrhachis krusadiensis* is of interest. The worker ants enclose and shelter the membracid nymphs of all stages in cobwebby nests constructed by folding the edges of leaves and webbing them together by salivary threads secreted by the ant larvae which are held by the workers between their mandibles and carried to the site of nest construction. When the nymphs become adults, the ants lets them out of the nest so that adults of this membracid species have not been encountered within the nests. The worker ants also keep a fierce watch over their "cattle".—At the slightest disturbance, large numbers of workers drop down to the ground excitedly and climb the body of the intruder. In the meanwhile the nest is surrounded by many workers ready to attack the intruder and also to repair the nest should it be damaged. The bite of this ant is most virulent and painful.

In many instances, close observations have revealed dense aggregations of ants at the cephalic end of the membracids the significance of which remains obscure. Often, groups of ants have been noticed to collect at spots previously occupied by membracid larvae appearing as if feeling on the congealed coagulated anal secretion left by the latter.

The advantages derived by the membracids from the symbiotic relationship with ants in nature are obvious. The ants keep away many of the predators such as spiders, lady bird beetles, riduviid bugs, etc. Further, according to Hood (1952) the expulsion of the anal secretion through the caressing of ants enables the membracids to reduce the pressure with which the plant sap enters the gut. In the absence of ants, the nymphs have to eliminate the honey dew by forcible extrusion. This theory has its own value considering the enormous quantity of the anal secretion expelled by many membracid nymphs and their constant association with ants.

Rice (1893) is of the opinion that disturbance by ants delays metamorphosis in *Entylia sinuata*, while Branch (1913) dealing with the biology of the same species states that in the absence of ants the nymphs fail to moult successfully and die before maturity. The results of rearing experiments conducted in the course of the present studies on local species never support the views of Branch and Rice since nymphs of all species that are normally attended by ants in their natural habitat successfully moulted and metamorphosed into adults irrespective of the presence or absence of ants. Likewise, the feeding habits of the membracids are in no way affected in spite of large numbers of ants swarming over them. The egg-laying process, however, is reported by Mishra (1923) to be affected. Dealing with the relation of *Oxyrhachis tarandus* and *Camponotus compressus* he states: "The ants, at times, are so persistent in their demands for honey dew, that the egg-laying females have been observed to postpone egg-laying to attend to their demand for the supply of the viscid fluid" Present observations on the same species never support this view since the membracids are apparently oblivious of the presence of ants and carry on their functions with equal serenity whether ants are present or not.

No reference has so far been made in literature about the association of membracids with insects other than ants except for Müller (1873, 1874) and Anonymous (1874) and also the interesting account given by Hood (1952) on the relationship of two species of bees—*Trigona hyalinata* var. *branneri* Ckll. and *T pallida* Latr.—with the membracid *Aconophora* sp. at Brazil. The notable feature in this case is that the same membracid colony is stated to be attended by the bees and ants. While the bees are diurnal attendants, the ants, a subspecies of *Camponotus* (*Myrmoturba*) *substitutus* Emery, is stated to be exclusively a nocturnal visitor. Further, each bee is stated to have "its own limited territory of exploitation, for if all the bees are removed from a group of nymphs in the morning, no other bees will take their places during the day" In the course of the present studies, where dense aggregations of *Oxyrhachis tarandus* and *O. rufescens* occur, a dipteran fly of the family Locheidae, identified as *Silba* sp. has been observed as a sporadic visitor. Usually the fly frequents the spots of twigs on the host plant previously occupied by membracid population and appears to dissolve and consume the congealed mass of expelled anal fluid left behind by the nymphs. At times, however, it frequents the nymphs when the latter are found unattended for a while by the ants; the fly caresses the nymphs, licks up the honey-drop and quickly moves away. This fly, which is an exclusive diurnal visitor, appears to be active at first but becomes rather sedate probably under the influence of the honey dew.

Although the camponotine ants guard the membracid nymphs keeping away the intruders from the territory of their exploitation, a beetle of the family Anthicidae identified as *Formicomus* nr. *semiopacus* which mimics the ants in form and action has been noticed to contact nymphs of *heptocentrus taurus* on *Ipomaea biloba*. This bettle mingles freely among the ants. Its behaviour towards the membracid nymphs in the act of caressing for getting the honey dew is identical to that of ants, and it appears to derive most of its food in this manner. Usually four or five beetles are crowded round each nymph. When disturbed, the beetle very often falls down suddenly just like ants do. sometimes, the beetle feigns death on falling to the ground, or sticks on to the host plant of the membracid, hiding itself and remaining quiet. When one attempts to catch the beetle from its hiding place, it runs with great agility.

(*h*) *Protective coloration and mimicry*.—The characteristic colour patterns of the nymphs-brown, green and grey-blend very perfectly with those of the leaves and bark of the host plants affording them excellent protection. For instance, the nymphs of *Coccosterphus minutus* which occupy the terminal parts of the tender twigs of *Prosopis spicigera* closely resemble the tiny unfolding leaves. The extraordinarily long pronotal anterior process of the fifth instar nymph of *Leptocentrus varicornis* strikingly stimulates the shape and colour of the stipular spines of its host plant, *Zizyphus jujuba*. Nymphs of *Tricentrus pilosus*, *T congestus*, *Otinotus oneratus* and *O. obliquus* with their extreme dorso-ventrally flattened bodies remain closely adpressed to their host plants and escape the attention of even the most careful observer. In some cases the dorsal protuberances closely resemble the irregular surface of bark both in colour and texture.

While the nymphs of all species are cryptically coloured, the adults of most of the local species such as *Otinotus*, *Leptocentrus* and *Oxyrhachis*

with their characteristic pronotal processes, are most conspicuous on their host plants. However, *Coccosterphus tuberculatus* with its black or rusty brown colour, and oval shape resembles most effectively the small undeveloped dry fruits of its host plant, *Morinda tinctoria*. The light brown colour of *C. paludatus* matches so perfectly with the colour of the prop roots of *Ficus bengalensis* and the twig of *Lawsonia alba* as to make it inconspicuous.

(*i*) *Ecological factors*.—Physical factors of the environment such as temperature and moisture have been found to have a decided effect on the embryonic development and duration of nymphal stages in the various species of membracids. These factors also play an important role in the population density of the species. Though all the local species appear to be influenced by the environmental factors, detailed observations in laboratory and field records were made only on *Otinotus oneratus* since this species, besides being gregarious, is available throughout the year on several host plants and it can also be reared with the least difficulty; the eggs of this species are only partially embedded in the bark so that actual counting and exact times of hatching could be made. The observations were made for 12 months commencing from April, 1964, and the results with regards to variations in the durations of egg-stage and nymphal period are tabulated (Table 8).

TABLE 8

Duration of egg stage and nymphal stage of Otinotus oneratus *recorded during the year* 1964-'65.

Months	Max. temp. C.	Rainfall in mm.	R.H. %	Egg stage in days	Nymphal stage	Total No. of days for life-cycle	Average in days
April	35.9	—	62	10—12	30—34	40—46	43
May	39.1	1.6	58	10—14	28—32	38—46	42
June	36.9	27.3	59	9—14	24—30	33—44	38½
July	34.3	104.6	71	9—12	22—27	31—39	35
August	33.2	193.2	76	8—10	22—26	30—36	33
Sept.	32.1	130.9	77	8—10	22—26	30—36	33
Oct.	32.7	144.0	78	7—9	24—28	31—37	34
Nov.	28.7	735.0	86	12—15	29—36	41—51	46
Dec.	28.3	24.8	78	12—15	28—33	40—48	44
Jan.	28.7	0.9	74	10—12	28—34	38—46	42
Feb.	30.1	9.2	79	7—9	22—26	29—35	32
March	31.8	—	75	7—9	23—29	30—38	34

It would appear from the table that the months of November, December and January are marked by lower temperatures, while April,

May and June are characterised by high temperatures, lower relative humidity and almost complete lack of moisture. On the other hand, the months of February, March, August, September and October are noted for moderate temperature and moisture due to occasional rainfalls as well as high relative humidity. Under these ideal conditions the duration of egg-stage was found to range from 7 to 10 days; the duration of nymphal period, likewise, was found to be shorter, ranging from 32-34 days.

The upper limits of 15 days and 36 days respectively for the egg-stage and the nymphal stage noted against the month of November are obviously due to the combined effect of low temperature and excessive rainfall soaking the eggs and bringing about delayed hatching; however, under such conditions egg mortality is insignificant since the eggs are laid high up from ground level and this situation precludes the possibility of the eggs being damaged.

Egg masses kept in test tubes free from moisture never hatch out within the normal time; such eggs when supplied with a little amount of moisture by keeping them on a wet blotting paper, hatch overnight. While this shows that moisture is absolutely essential, presence of too much of water is detrimental. Nymphal development also requires moisture; nymphs reared in the laboratory by keeping them on twigs of host plants dipped in water, congregate towards the bases of twigs. An optimum moisture is indispensable for normal moulting, especially for the last nymphal instar which, when kept on drying twigs take a longer time for moulting; often, the adults emerging from such nymphs present irregularities such as abnormal asymmetrical horns and impaired crippled wings.

Humidity also appears to have some influence on hatching and nymphal development. As indicated in the Table, the months of April to June are characterised by low relative humidity besides lack of moisture, and these conditions not only delay hatching to a considerrble extent, but also retard nymphal development. It may be infeared that the factors entering into the life history of *Otinotus oneratus* are rather complex; two or more factors combine to alter the rate of metabolism which, in turn, accelerates or retards either the embryonic or the nymphal development or both.

(*j*) *Natural Enemies.*—Incidence of parasitism in membracids has been reported by many workers though very few attempts have hitherto been made to make a detailed study. Funkhouser (1951) has stated "A detailed study of egg parasitism by chalcids has been made by the writer for an African species, and which is to appear as a separate report. " However, the report referred to never appears to have been published anywhere! As early as 1886, Jack noted egg parasitism in *Ceresa bubalus.* Ashmead (1888) found *Trichogramma seresarum* attacking the eggs of *Ceresa bubalus.* Funkhouser (1915) was able to rear the same species from *Vanduzea arquata.* Regarding mymarid parasites, Haviland (1925) made mention of an unidentified species and the mode of parasitization. Hodgkiss (1910) reported *Polynema striaticorne* from *Ceresa bubalus* but it was Balduf (1928) who worked out in detail the life history of this parasite. Yothers (1934) made a passing reference to the eulophid parasite, *Tetrastichus* sp. attacking the eggs of *Stictocephala inermis.*

References to the hymenopterous and dipteran parasites attacking the nymphs of membracids have been made by Matausch (1911) and Funkhouser (1951) though the larvae could not be reared to maturity. Nevertheless, it was stated by Matausch (1911) that the parasitic larvae caused castration on the host. Kornhauser (1917, 1919) was successful in rearing to maturity *Aphelopus theliae*, a dryinid nymphal parasite of *Thelia bimaculata* and discussed at length the effects of parasitism on the host. This was followed by contributions from Meisenheimer (1930) on the same topic. More recently, Capener (1962) has brought to light the occurrence of a hymenopterous genus, *Prionomastix* on the nymph of *Oxyrhachis latipes*, and a dipteron, *Dorilas* sp. parasitising the nymphs of an *Oxyrhachis* sp.

Membracids have been found to be prone to stylopisation in their adult stage and studies in this direction have been made by Subramaniam (1927, 1932) on *Indoxenos membraciphagum*), and Panda and Behura (1956) on *Indoxenos* sp. parasitising *Otinotus oneratus* in India. Jordan (1953) reported a strepsipteran parasite on *Stictocephala inermis* while Capener (1962), recording the incidence of stylopisation in *Oxyrhachis imperialis*, states that the stylopised adults, as far as could be judged, suffered only inconvenience.

Besides entomophagous parasites, several predators of membracids are on record. Observations made in this direction by Wildermuth (1915), Funkhouser (1917), Beal (1918), Mc Atee (1918, 1932), Knowlton and Harmston (1941, 1946) and Aldous (1942) indicate that insectivorous birds occasionally prey upon membracids as a regular routine or accidentally, the nymphs being preferred to the adults. Apart from birds, other predators such as spiders, asilids and mantids have been stated to catch membracid nymphs occasionally (Bromley, 1914), Funkhouser (1951). Acarines were reported to feed on membracid eggs (Wildermuth, 1915, Funkhouser, 1917, Yothers, 1934). Reinhard (1925) observed the wasp *Hoplisus costalis* hunting after tree hoppers. Capener (1912) states that nymphs and adults form the prey of a wasp of the genus *Gorytes*.

In the course of the present studies, the eggs of several species of membracids were found parasitised by 10 species of hymenopterous parasites as recorded below. These are of interest as they are recorded for the first time as parasitic on the respective species of membracids.

**PARASITE SPECIES*	*FAMILY*
Gonatocerus sp.	Mymaridae
Gonatocerus narayani (Subba Rao & Kaur)	,,
Lymnaenon sp.	,,
Aphelinoidea sp.	Trichogrammatidae
Ufens sp.	,,
Tumidiclava sp.	,,
Centrodora sp.	Eulophidae
Aphytis sp.	,,
Azotus sp.	,,
Chartocerus sp.	Thysanidae

*Dr. B. D. Burks who examined and determined the parasites states that the specimens not named to species are probably undescribed.

A notable feature in many of these parasites is the lack of absolute host specificity; for instance, the eggs of *Oxyrhachis rufescens* are parasitised by three different species namely, *Gonatocerus* sp., *Aphelinoidea* sp. and *Centrodora* sp., all of which are also capable of attacking the eggs of *Otinotus oneratus*. The incidence of parasitism on the various species of membracids studied here is given in Table 9.

The bionomics of these parasites have been studied along with brief descriptions of their immature stages adopting the methods mentioned earlier, and the degree of infestation by *Gonatocerus* sp., *Aphelinoidea* sp. and *Centrodora* sp. on the eggs of *Oxyrhachis rufescens* and *Otinotus oneratus* was analysed.

Gonatocerus sp.

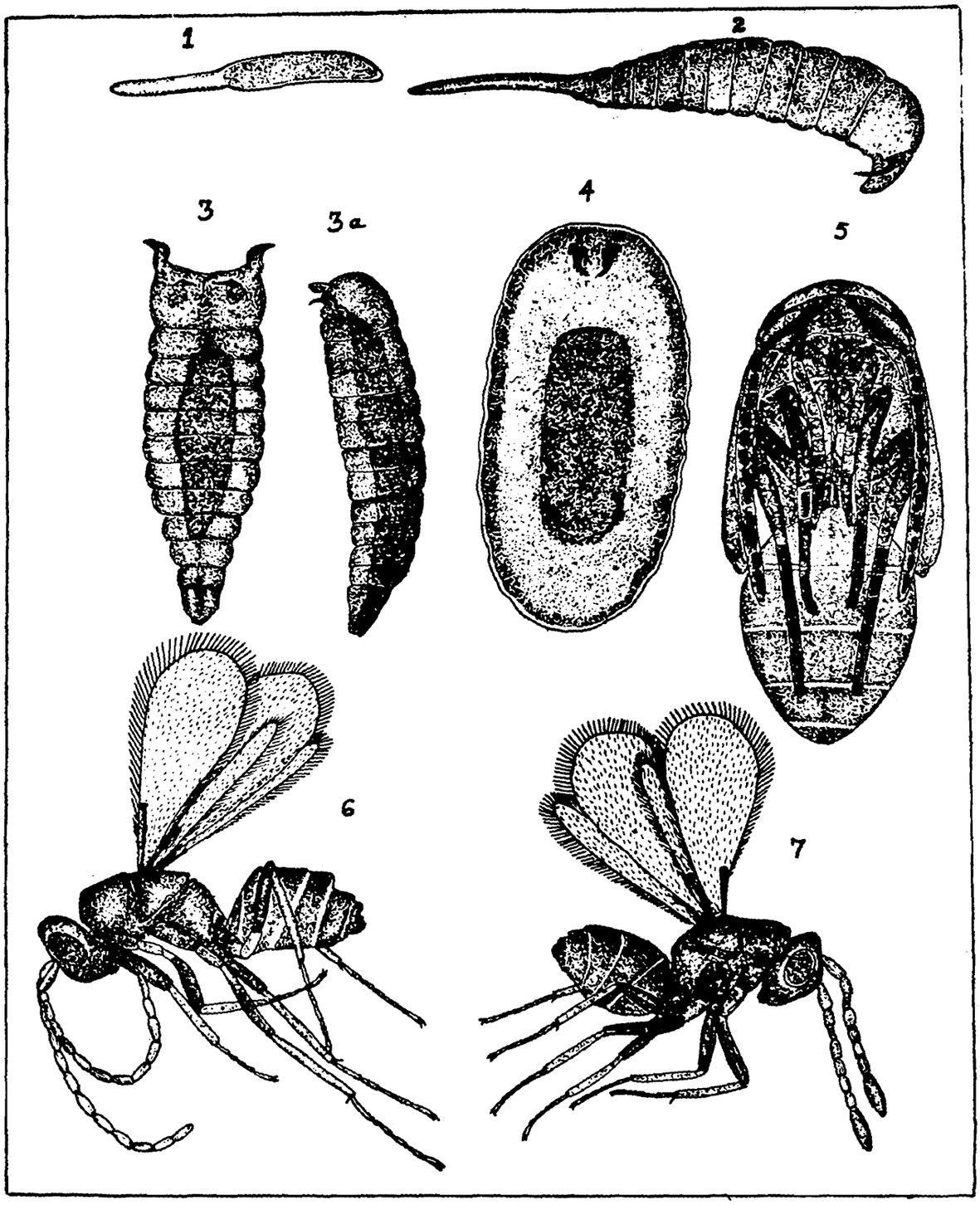
(Text-fig. 1)

Egg, 0.240 mm. long, stalked; stalk 0.056 mm. long, nearly one-third the length of main body; main body 0.179 mm. long, elongate oval with a delicate flexure towards the middle; chorion smooth, lacking sculpture. Duration of egg stage is about one day. First instar, just slightly larger than egg, 0.35 mm. long, mymariform, but devoid of setae, body elongate, spindle-shaped; head followed by ten segments; caudal end attenuated, drawn out into a tapering structure; integument thin and translucent recalling the condition of *Lymnaenon effusi* described by *Bakkendorf* (1934); mandibles prominent, feebly chitinised, movable, capable of closing upon one another; tail about one-third of body length; duration about two days. Second instar, 0.8 mm. long, tail almost disappeared; segmentation indistinct; cephalic end broader with a pair of conical processes, caudal end smoothly rounded; duration about a day. Third instar, 0.95 mm. long, sacciform, filling snugly the entire cavity of host egg; mandibles chitinised and projecting out; immobile; duration 2-2½ days. Pupa, 0.95 mm. long, exarate, colour at first light yellow, gradually turning to black; duration 7-10 days.

The parasitised membracid eggs are readily recognisable by the colour changes they show, associated with the developmental phases of the immature stages; such eggs first become yellow; then the chorion shows white and black hues; subsequently the black colour becomes more pronounced as the pupal stage is reached. It may be mentioned here that eggs of *Ceresa bubalus* parasitised by *Polynema striaticorne* are stated to exhibit a similar colour change (Balduf, 1928) due to the deposition of a black pigment in the vitelline membrane of the host egg.

Adults exhibit sexual dimorphism, the males being about two-thirds as long as the females; male antenna 13-segmented, longer than body, all antennal segments equal in length; female antenna 11-segmented, shorter, segments 3-6 very short, terminal segment longest and club-shaped; specimens reared from *Oxyrhachis rufescens* and *Otinotus oneratus* at Madras have antennal segments 3-6 very much compressed, broader than long and similar to each other, segments 7-10 indentical; all segments uniformly light brown. Specimens reared from *Oxyrhachis krusadiensis* have a different antennal structure in female, the 3rd and 4th segments smallest and similar, 5th segment much longer than 3rd

and equal to 2nd and 7th; 6th segment slightly longer than 4th; 8th segment longer than 6th but shorter than 7th and 9th; coloration of 1st and 2nd antennal segments yellowish, rest dark brown. Dr. B. R. Subba Rao who examined these two types of specimens is of the opinion that they would prove to be distinct species.



Text-fig. 1. *Gonatocerus* sp.

1. Egg. 2. First instar larva. 3. Second instar dorsal view. 3a. Second instar view. 4. Mature larva. 5. Pupa. 6, Adult male. 7. Adult female.

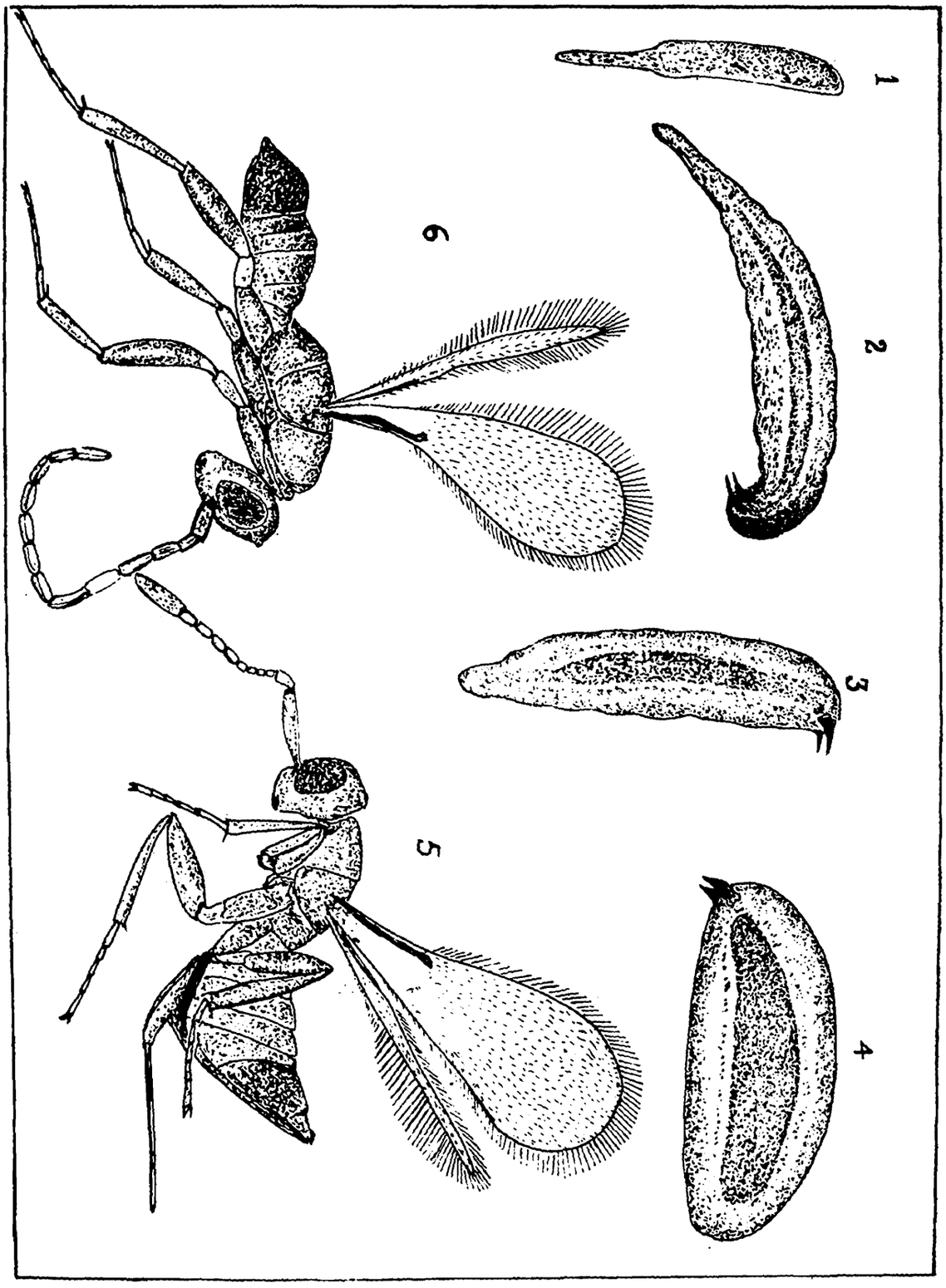
TABLE 9

Incidence of parasitism in the South Indian Membracidae.

Name of membracid	Gonatocerus sp.	G. narayani	Lymnaenon sp.	Aphelinoidea sp.	Ufens sp.	Tumidiclava sp.	Centrodora sp.	Aphytis sp.	Azotus sp.	Chartocerus sp.
Oxyrhachis tarandus	+			+			+			
O. rufescens	+			+			+			
O. krusadiensis	+			+			+			
O. minusculus				+			+			
O. uncatus	+			+			+			
Leptocentrus taurus					+			+		
L. leucaspis		+			+		+		+	
L. rhizophagus								+		
L. varicornis		+								
L. bauhiniae						+				
L. bajulans		+			+					
L. nigra					+					
L. moringae					+				+	
Telingana nigroalata							+		+	
Otinotus oneratus	+			+			+			
Tricentrus pilosus		+								
T. albomaculatus		+		+						
Gargara mixta		+	+							
G. extrema		+		+						+
G. rustica		+	+							+
Coccosterphus minutus			+							+
C. tuberculatus			+							
C. paludatus			+							

Gonatocerus narayani (Subba Rao & Kaur)

(Text-fig. 2)



Text-fig. 2. *Gonatocerus narayani* (Subba Rao and Kaur)

1. Egg. 2. First instar. 3. Second instar. 4. Third instar. 5. Adult female. 6. Adult male.

This species attacks several species of *Leptocentrus*, *Tricentrus* and *Gargara*.

Egg similar to that of *Gonatocerus* sp. but smaller, 0.19 mm. long. First instar, 0.25 mm. long, intermediate between mymariform and sacciform types; body elongate, segmentation obtcure; tail short, cylindrical; mandibles prominent, turned downwards and backwards. Second instar, 0.35 mm. long; body elongate-oblong, caudal end short, broadly rounded; mandibles mobile. Third instar, 0.50 mm. long, robust, sac-like, slightly arched, mandibles short, conically pointed, rigid. Pupa, similar to that of *Gonatocerus* sp. Adults sexually dimorphic; male about two-thirds as long as female with 13-segmented antennae; female with antennal segments 3-6 longer than wide, 7-10 identical.

Lymnaenon sp.

(Text-fig. 3)

A very small mymarid parasitising *Gargara mixta* and *G. rustica*. Egg, 0.18 mm. long, stalked, stalk slender, straight, 0.08 mm. long, body of egg elongate-oval, slightly longer than stalk, translucent. First instar, 0.2 mm. long; modified from typical mymariform larva, body devoid of bristles; head with a pair of blunt lobes and sharp mandibles; anterior one-third of body broader with faint indications of segmentation; posterior two-thirds gradually tapering to tail which is more than one-fourth the body length. Second instar, 0.45 mm. long, typically sacciform. Pupa, 0.7 mm. long, similar to that of *Gonatocerus* sp.

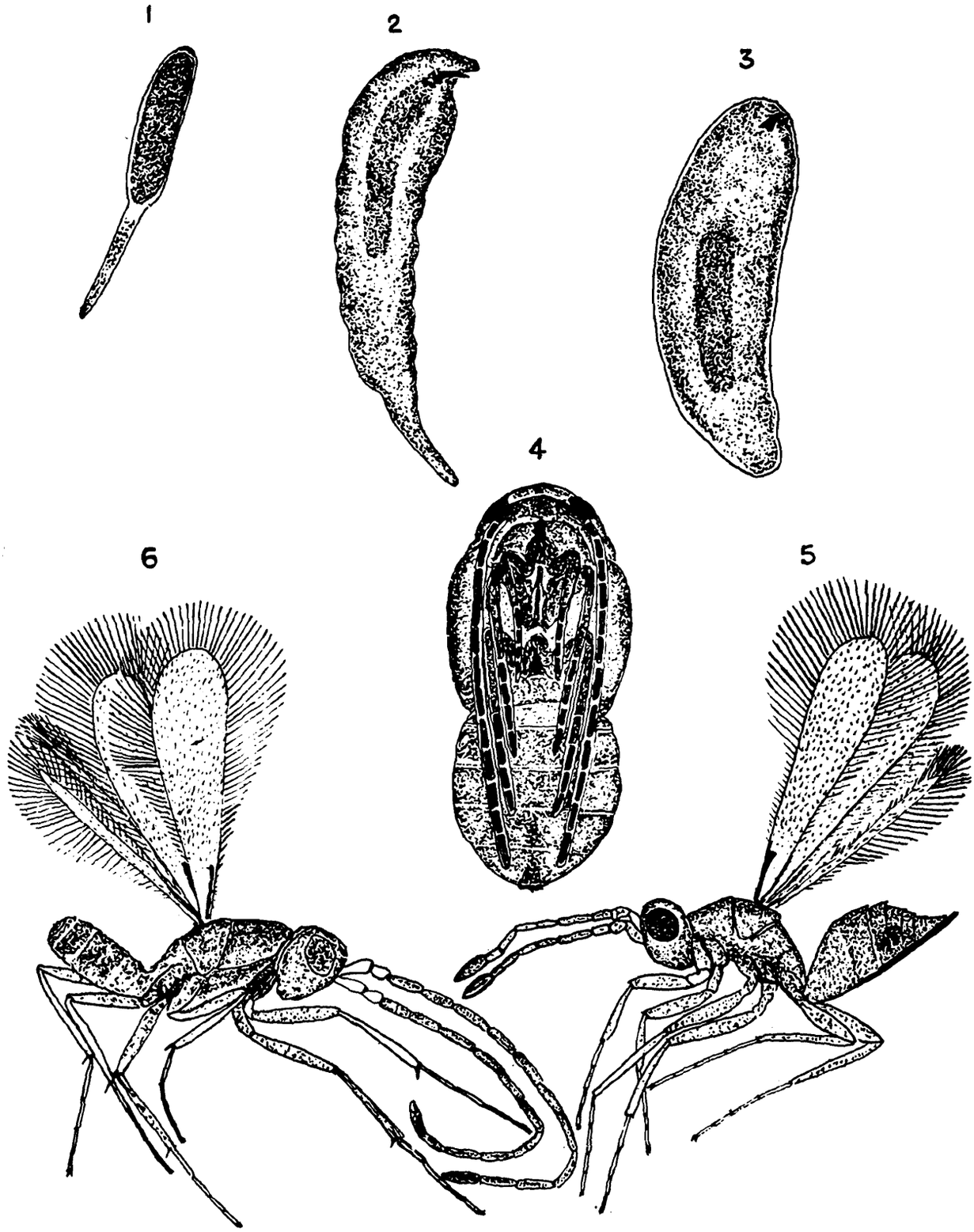
Adults sexually dimorphic, female with posterior end of abdomen tapering, ovipositor half as long as abdomen, antennae 9-segmented, shorter than body; in the male, abdomen shaded with black, posterior end broadly rounded, antennae 13-segmented, about one and three-fourth times longer than body.

Aphelinoidea sp.

(Text-fig. 4, I–VIII)

This trichogrammatid parasite is recorded for the first time as parasitising membracid eggs capable of developing in the eggs of many species of *Oxyrhachis*, all the local species of *Coccosterphus* and in the eggs of *Otinotus oneratus*.

Egg, 0.19 mm. long, maximum width 0.05 mm., stalked, stalk about one-fourth as long as main body, 0.05 mm. long; main body of egg elliptical; chorion smooth. First instar, 0.29 mm. long, sacciform; mandibles prominent, unchitinised, directed upwards; a pair of small fleshy lobes visible at the base of mandibles. Second instar, 0.40 mm. long, similar to preceding stage, Mature larva, 0.95 mm. long, robust, segmented; head distinct, mandibles turned upwards. Prepupa, 0.95 mm. long, body irregular, anterior region more or less segmented;



Text-fig. 3. *Lymnaenon* sp.

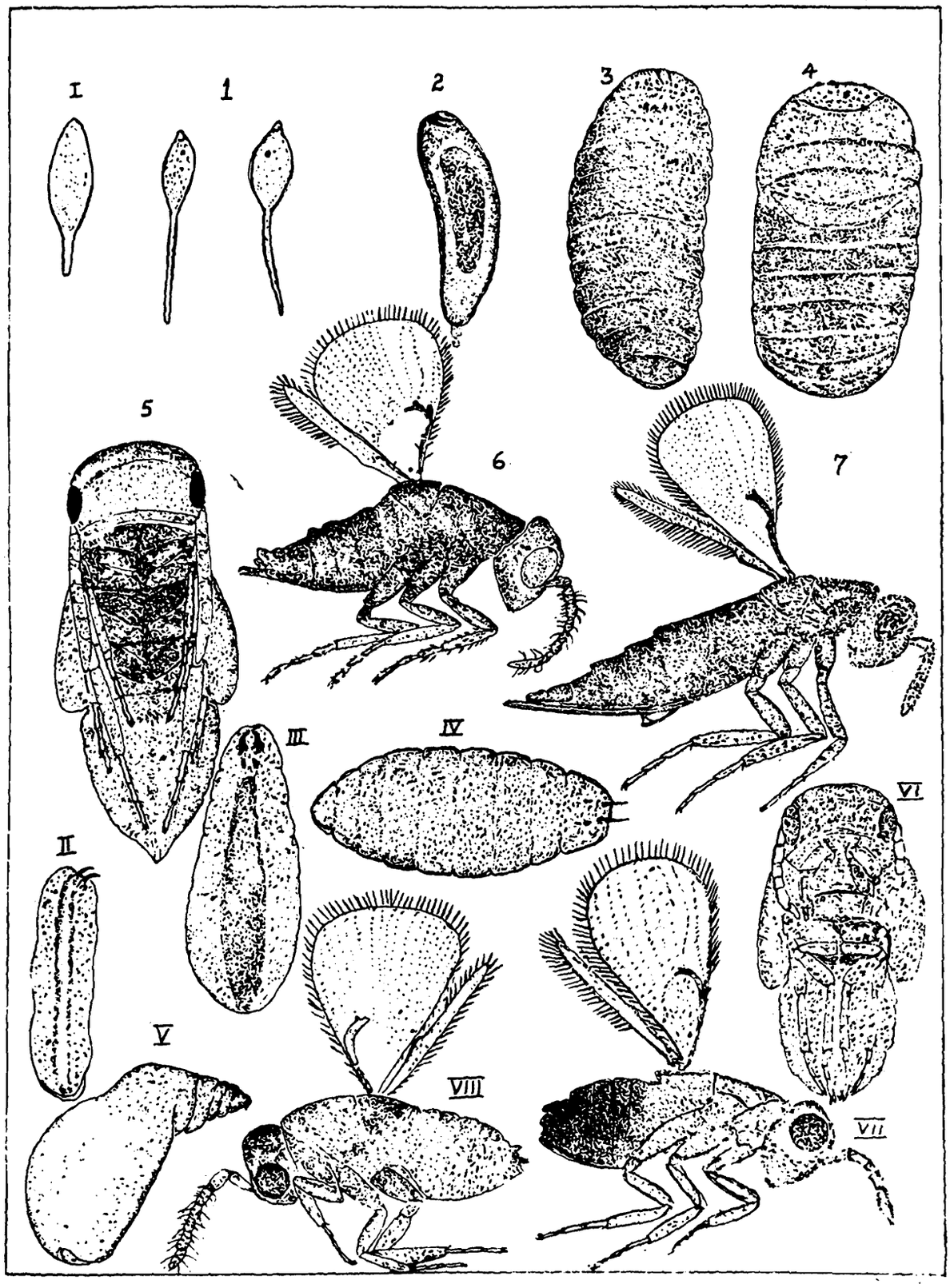
1. Egg. 2. First instar. 3. Second instar. 4. Pupa, ventral view. 5. Adult female. 6. Adult male.

mandibles apparently absent. Pupa, 0.80 mm. long, exarate, at first translucent, subsequently turning to black.

Adults small, measuring 0.85-1.2 mm. long; female with antennae less hairy; male with highly hairy antennae.

Ufens sp.

(Text-fig. 4, 1–7)



Text-fig. 4. 1-7: Life cycle of *Ufens* sp.
1. Eggs. 2. First instar. 3. Second instar. 4. Third instar. 5. Pupa. 6. Adult male. 7. Adult female.

I-VIII: Life cycle of *Aphelinoidea* sp.
I. Egg. II. First instar larva. III. Second instar. IV. Third instar. V. Prepupa. VI. Pupa. VII. Adult female. VIII. Adult male.

Although recorded as an egg parasite of Cicadellid eggs (Clausen, 1940) this trichogrammatid has not hitherto been known to parasitize membracid eggs. The eggs of various species of *Leptocentrus* are attacked by this species.

Egg, 0.27 mm. long, stalked, stalk 0.180 mm. long, slender, flexible, gradually tapering; body of egg 0.084 mm. long, 0.046 mm. wide, broadest at middle and produced into a conical papilla-like outgrowth at the opercular end. First instar, 0.45 mm. long, elongate, unsegmented, caudal end produced as a small tail; mandibles small, more or less chitinised and mobile. Second instar, twice as long as first instar (0.85 mm.), distinctly 13-segmented, mandibles reduced, caudal process absent. Third instar, 1.0 mm. long, segments appearing rather compressed with uneven margins, mandibles inconspicuous; larva motionless, filling the lumen of host egg. Pupa, 1.2 mm. long, similar to that of *Aphelinoidea* sp.

Adults exhibit sexual dimorphism as in *Aphelinoidea* sp.

Tumidiclava sp.

This trichogrammatid which is smaller than *Ufens* sp. has been recorded only from the eggs of *Leptocentrus bauhiniae*.

Egg, 0.18 mm. long, stalked, stalk about one-fourth the main body of egg and very rigid; main body of egg elongate oval with sides parallel. First instar, 0.25 mm. long, sacciform, pale white, caudal process absent; mandibles distinct and movable. Second instar, 0.38 mm. long, rubust, faintly segmented, with undulate margins, mandibles very short. Pupa 0.8 mm. long, similar to that of *Ufens* sp.

Adults, 0.9-1.1 mm. long; similar to *Ufens* sp. but forewings shaded with black.

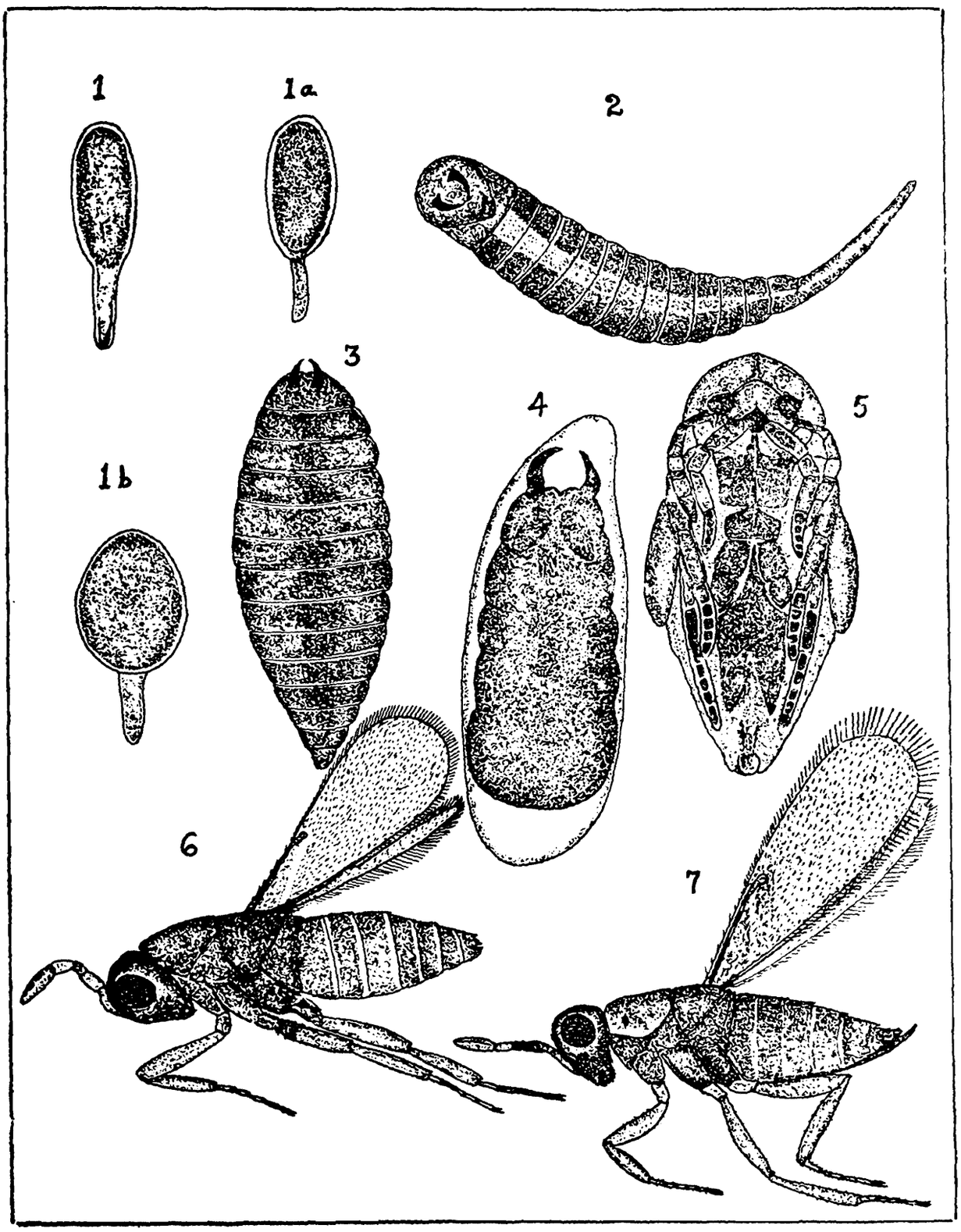
Centrodora sp.

(Text-fig. 5)

Although not recorded so far as parasitizing membracid eggs, species of *Centrodora* have been known to attack other groups of insects. *Centrodora speciosissima* (Girault) is recorded as parasitic on the cecidomyiids; *C. xiphidii* Perk. parasitises the eggs of a locustid, *Xiphidium varipenne* Swezy while *C. cicadae* Silv. develops in the eggs of *Cicada plebeja* Scop. (Clausen, 1940).

Egg, 0.20 mm. long, stalked, main body of egg elongate oval, 0.15 mm. long, stalk robust, 0.05 mm. long; chorion lacking sculpturing. Dissection of ovary revealed only two mature eggs in each ovary in almost all specimens; in one specimen, an exceptionally large egg was noticed. First instar, 0.25 mm. long, caudate; body distinctly segmented, tail about one-fourth as long as body; mandibles short and turned to each other. Second instar, 0.5 mm. long; tail reduced, larva tending towards hymenopteriform; posterior end broadly rounded;

mandibles strongly chitinised and protruding out. Third instar, 0.75 mm. long, segmentation almost obliterated, larva tending towards sacciform; mandibles extraordinarily prominent. Pupa, 0.8 mm. long; flattened dorsoventrally; jet black in colour.



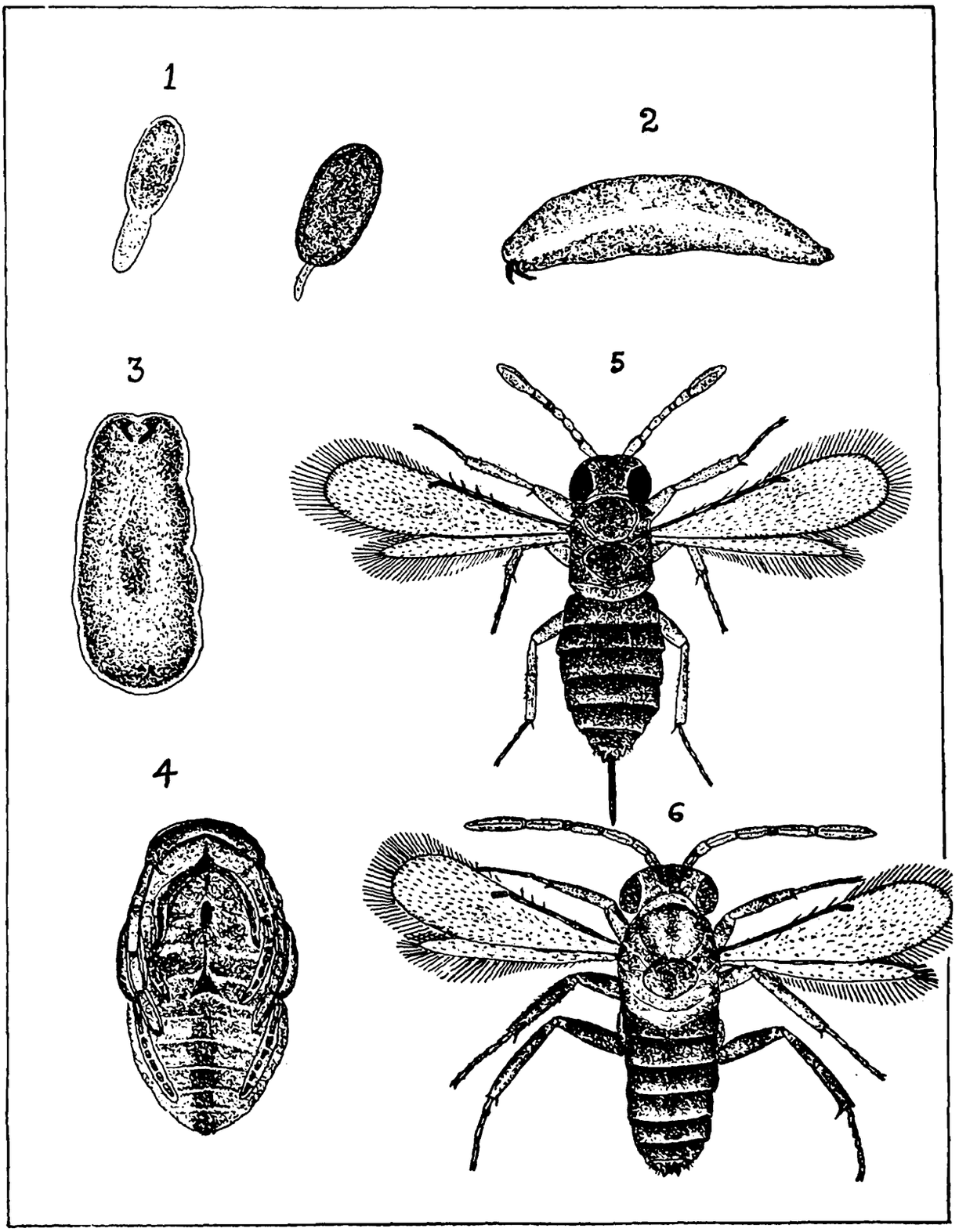
Text-fig. 5. *Centrodora* sp.

1. Ovarian egg. 1a. Egg during incubation. 1b. Abnormal egg. 2. First instar. 3. Second instar. 4. Mature larva. 5. Pupa, ventral view. 6. Adult male. 7. Adult female.

Adult, female 1.2-1.3 mm. long, ovipositor extending a little beyond abdomen; male 1.0-1.1 mm. long.

Aphytis sp.

(Text-fig. 6)



Text-fig. 6. *Aphytis* sp.

1. Ovarian egg. 1a. Egg during incubation. 2. First instar. 3. Second instar. 4. Pupa. 5. Adult female. 6. Adult male.

This eulophid is found to parasitize *Leptocentrus leucaspis* and *L. bajulans*.

Egg, 0.14 mm. long; segmentation almost obscure, body slightly arched in the middle, caudal process absent; mandibles recurved. Second instar, 0.75 mm. long; nearly similar to that of *Centrodora* sp. Pupa, 0.9 mm. long, dark brown, similar to that of *Centrodora* sp.

Adults, exhibiting sexual dimorphism in the antennal structure and abdominal terminalia.

Azotus sp.

This eulophid species is of special interest since it develops as a primary egg parasite of *Leptocentrus rhizophagus*, *L. nigra* and *L. moringae* and as a hyperparasite of *Ufens* sp. The egg and immature stages of *Azotus* sp. are similar to those of *Aphytis* sp. The pupal period, however, is comparatively shorter.

Chartocerus sp.

(Text-fig. 7)

This thysanid parasite is rather rare in its incidence as an egg parasite and recorded from two species of *Gargara*—*G. extrema* and *G. rustica*—and *Coccosterphus tuberculatus*.

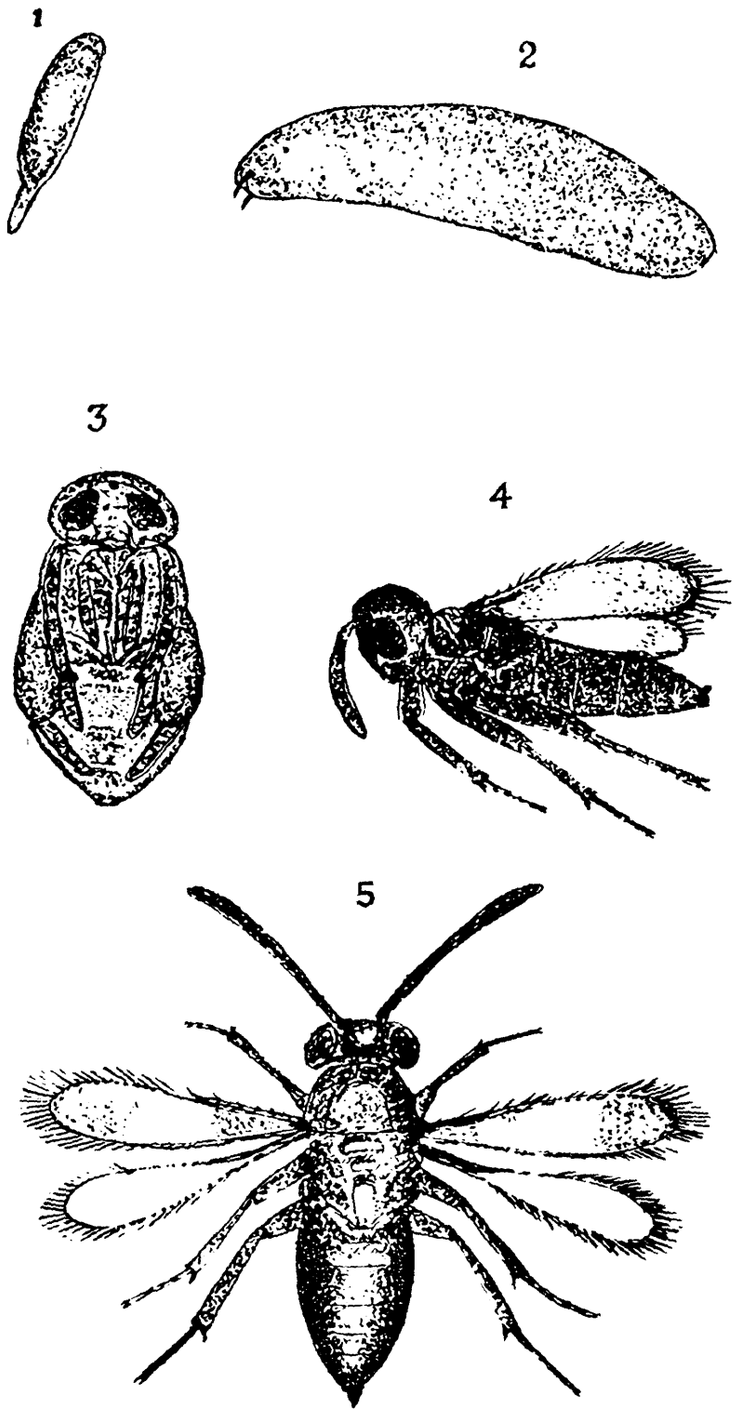
Egg, 0.19 mm. long, stalked, elongate-oval, slightly arched, lacking sculpture; stalk short and rigid, 0.05 mm. long. First instar, 0.22 mm. long, elongate, without any traces of segmentation, mandibles pointed; second instar similar to preceding stage, sacciform, mandibles more prominent. Pupa as in *Centrodora* sp.

Adults are very small, 0.75-1.0 mm. long, black, shining, both the sexes somewhat similar in size.

Degree of infestation:

Twigs containing large numbers of egg masses of *Oxyrhachis rufescens* and *Otinotus oneratus* on the host plant, *Prosopis spicigera*, located within the College campus were cut and each twig kept in test tubes loosely plugged with cotton. Since the eggs of these two membracid species are only partially embedded in the bark projecting out for the most part, it was possible to count the number of eggs in each mass. On the emergence of *Gonatocerus* sp., *Aphelinoidea* sp. and *Centrodora* sp. from their hosts, the number of each species was counted, From these data the percentage of parasitization by each species during the different months was calculated for the two host species. The nature of emergence holes is distinct in these 3 species of parasites (large rounded hole near the exposed end of host egg in *Gonatocerus* sp., small rounded hole either at the pole or at the side of host egg in *Aphelinoidea* sp., irregular hole at the exposed end of host egg in *Centrodora* sp.) making it possible to presume the species of parasite that might have emerged even if

some egg masses contained such emergence holes at the time of their collection.



Text-fig, 7. *Chartocerus* sp.
1. Egg. 2. First instar. 3. Pupa. 4. Adult male. 5. Adult female.

The twigs containing egg masses were kept moist so that young ones could emerge from unparasitized eggs. The numbers and percentage of eggs parasitized, number of young ones emerged and number

TABLE 10

Duration of life-cycle and sex-ratio of the parasites.

Parasite	Larval period	Pupal period	Total number of days for completing life-cycle			Sex-ratio Female: Male
			Min. No. of days	Max No. of days	Average No. of days	
Gonatocerus sp.	3–4	7–10	12	15	13	5:2
G. nárayani	4–5	8–13	15	21	18	3:1
Lymnaenon sp.	2–3	7–9	11	13	12	3:1
Aphelinoidea sp.	2–3	11–16	15	20	18	3:1
Ufens sp.	3–4	10–25	15	30	25	2:1
Tumidiclava sp.	2–3	6–10	10	14	12	5:2
Centrodora sp.	4–5	11–19	17	25	21	3:1
Aphytis sp.	4–5	14–19	20	25	22	3:2
Azotus sp.	3–5	6–9	12	15	14	3:2
Chartocerus sp.	5–7	14–18	22	26	24	1:1

and percentage of egg mortality due to factors other than parasitism are tabulated (Tables 11 & 12).

Incidence of stylopisation appears to be extremely rare as far as the present observations on South Indian membracids have revealed. Only one species, *Leptocentrus taurus*, a very common polyphagous membracid was found to be parasitized by an unidentified strepsipteran. Each stylopised individual had one to three large, oval, nodular outgrowths invariably located at the sides of the abdomen. Since only very few individuals have so far been known to be parasitized, a detailed study was not possible. All the same the incidence is of interest in view of some stylopised membracids appearing normal, while others show abnormalities in the disposition of the pronotal processes (Text-fig. 8). Closer examination of the parasitized individuals revealed that those which suffer abnormal pronotal development present a somewhat shrunken ochraceous appearance without complete skin pigmentation. It is therefore inferred that attack by strepsiptearn parasites on the membracids which have just emerged from the last nymphal skin when complete chitinisation is not effected, brings about structural deformities; adults in which the exoskeleton has become fully chitinised are not apparently affected.

However, more work is needed to determine whether the traumatic variations mentioned above are either merely accidental and teratological in nature coincident with the strepsipteran attack, or really parasite-induced.

TABLE 11

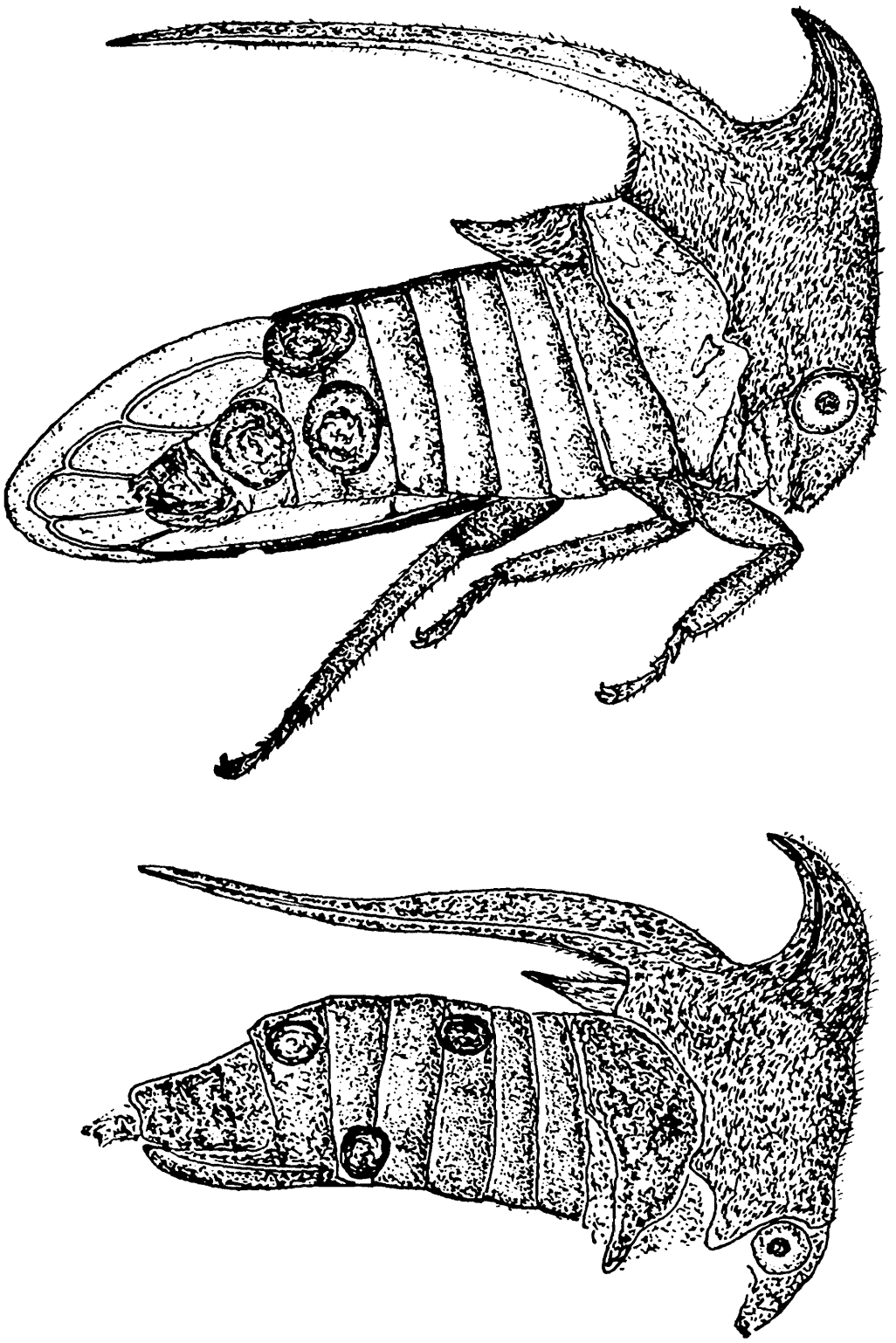
Egg mortality in Oxyrhachis rufescens.

Months	Max. Temp. in °C	Rainfall in mm	Humidity %	Total No. of eggs	No. of eggs parasitized by			Percentage of eggs parasitized by			Total No. of parasitized eggs
					Gonatocerus sp.	Aphelinoidea sp.	Centrodora sp.	Gonatocerus sp.	Aphelinoidea sp.	Centrodora sp.	
1966											
Jan.	28.4	24.2	85	310	12	24	30	3.9	7.7	9.7	66
Feb.	29.9	—	87	295	14	26	25	4.7	8.8	8.5	65
March	34.1	—	75	400	19	28	51	4.75	7.0	12.7	98
April	33.7	0.8	76	250	12	25	17	4.8	10.0	6.8	54
May	37.9	81.7	64	240	10	18	31	4.16	7.5	12.9	59
June	35.5	65.5	71	315	8	30	21	2.54	9.52	6.7	59
July	34.3	102.7	73	390	13	25	62	3.3	6.4	16.0	100
Aug.	33.8	190.2	79	268	9	7	43	3.6	2.6	16.0	59
Sept.	31.8	223.6	81	301	11	24	26	3.65	8.0	8.6	61
Oct.	30.6	230.3	82	330	15	28	18	4.54	8.5	5.45	61
Nov.	30.0	556.3	85	275	12	8	20	4.36	2.9	7.27	40
Dec.	28.3	112.6	81	370	16	22	36	4.32	6.0	9.73	74
1967											
Jan.	28.7	4.3	83	392	17	33	38	4.3	8.4	9.7	88
Feb.	30.5	—	85	504	16	39	52	3.17	7.7	10.3	107
March	31.5	20.3	79	390	18	41	32	4.6	10.5	8.2	91
April	34.1	0.5	76	364	18	32	24	5.0	8.8	6.6	74
May	36.0	92.7	69	394	16	32	6	4.0	8.0	1.6	54
June	35.7	91.6	68	402	7	31	13	1.7	7.7	3.2	51
July	34.1	82.1	71	378	16	24	18	4.2	6.5	4.7	58
Aug.	33.1	259.3	78	384	21	25	12	5.4	6.5	3.1	58
Sept.	33.5	36.9	79	361	18	18	43	5.0	5.0	11.9	79
Oct.	31.1	159.6	82	492	25	45	30	5.0	9.0	6.0	100
Nov.	28.8	128.8	76	480	26	50	26	5.4	10.4	5.4	102
Dec.	28.5	303.7	82	452	21	20	11	4.6	4.4	2.5	52

TABLE 12

Egg mortality in Otinous oneratus.

Months	Total percentage of egg mortality due to parasites	Total No. of eggs	Numbers of eggs parasitized by			Percentage of eggs parasitized by			Total No. of parasitized eggs	Total percentage mortality due to parasites
			Gonatocerus	Aphelinoidea	Centrodora	Gonatocerus	Aphelinoidea	Centrodora		
1966										
Jan.	21.3	331	—	10	69	—	3.0	20.8	79	23.8
Feb.	22.0	291	16	12	43	5.5	4.1	14.4	71	24.0
March	24.0	253	—	6	44	—	2.4	17.4	50	19.8
April	21.6	315	7	23	30	2.2	7.3	9.5	60	19.0
May	24.5	209	—	8	27	—	3.8	13.0	35	16.8
June	18.9	322	—	21	38	—	6.5	11.8	59	18.3
July	23.0	265	—	20	12	—	7.5	4.5	32	12.0
Aug.	22.0	370	—	24	30	—	6.5	8.1	54	14.6
Sept.	20.3	427	—	33	50	—	7.7	11.7	83	19.4
Oct.	18.5	297	8	12	50	2.7	4.0	16.8	70	23.5
Nov.	14.2	224	—	21	40	—	9.4	17.8	61	27.2
Dec.	20.0	246	—	26	45	—	10.6	18.0	71	28.6
1967										
Jan.	22.2	270	17	13	37	6.3	5.0	13.7	67	25.0
Feb.	21.1	439	9	26	61	2.0	6.0	14.0	96	22.0
March	23.3	389	—	41	45	—	10.4	11.6	86	22.0
April	20.4	495	—	20	60	—	4.0	12.1	80	16.1
May	13.6	316	7	15	29	2.2	4.7	9.2	51	16.1
June	12.6	269	4	20	41	1.5	7.4	15.2	65	24.1
July	15.4	300	—	18	21	—	6.0	7.0	39	13.0
Aug.	15.0	410	—	20	27	—	4.8	9.0	47	13.8
Sept.	21.9	255	—	18	33	—	7.0	13.0	51	20.0
Oct.	20.0	320	8	21	51	2.5	6.5	16.0	80	25.0
Nov.	21.2	324	14	33	50	4.3	10.2	15.4	97	29.9
Dec.	11.5	340	—	32	56	—	9.5	16.5	88	26.0



Text-fig. 8. Stylopised *Leptocentrus taurus*, showing abnormal development of posterior process; abdomen bearing galls left by the strepsipteran parasites.

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REFERENCES

ALDOUS, S. C., 1942. The white-necked raven in relation to agriculture. *U.S. Fish and Wildlife Serv. Res. Rpt.*, **5**: 1-56.

ANONYMOUS, 1874. Larvae of membracids serving as milk cattle to a bee. *Am. Nat.*, **8**: 565.

ASHMEAD, W. H., 1888. Descriptions of some new North American Chalcididae. *Canad. Ent.:* 101-107.

BALDUF, W. V., 1928. Observations on the Buffalo treehopper, *Ceresa bubalus* Fabr. (Membracidae: Homoptera). *Ann. ent. Soc. Am.* **21**: 3, 419-435.

BEAL, F. E. L., 1918. Food habits of the swallows. A family of valuable native birds. *U.S. Dept. Agr. Bull.*, **619**: 1-28.

BEHURA, B. K., 1951. Habits of the common membracid, *Otinotus oneratus* Walker. *J. Bombay nat. Hist. Soc.*, **50**: 299-304.

BEHURA, B. K., 1955. Miscellaneous notes 21. Adaptive coloration and camouflage of the common membracid. *Otinotus oneratus* Walker (Homoptera. Rhynchota); *J. Bombay nat. Hist. Soc.*, **53**: 145-146.

BRANCH, H. M., 1913. Morphology and biology of the Membracidae of Kansas. *Kans. Univ. Sci. Bull.*, **8**: 73-115.

BROMLEY, S. W., 1914. Asilids and their prey. *Psyche*, **21**: 172-198.

CAPENER, A. L., 1962. Taxonomy of the African Membracidae Part I, Oxyrhachinae. *Repub. S. Afr. Dept. Agr. Tech. Ser. Ent. Mem.*, **8**: 1-164.

FUNKHOUSER, W. D., 1915. Life history of *Vanduzea arquata* Say. (Membracidae). *Psyche*, **22**: 183-198.

FUNKHOUSER, W. D., 1915. Note on the life history of *Enchenopa binotata* Say (Membracidae) on the butternut. *J. econ. Ent.*, **8**: 368-371.

FUNKHOUSER, W. D., 1917. Biology of the Membracidae of the Cayuga Lake Basin. *Cornell Univ. Agr. Expt. Sta. Mem.*, **2**: 177-445.

FUNKHOUSER, W. D., 1951. Homoptera: Fam. Membracidae. *Genera Insect.*, **208**: 1-383.

HAVILAND, M. D., 1925. The Membracidae of Kartabo, Bartica District, British Guiana, with descriptions of new species and bionomical notes. *Zoologica*, **6**: 229-290.

HODGKISS, H. E., 1910. The apple and pear membracids. *Technical Bulletin No.* 17, *N. Y Agr. Expt. Sta. Geneva:* 81-122.

HOOD, J. D., 1952. A membracid and its milkers (Hemiptera). *Proc. Wash. Ent. Soc.*, **54:** 140-142.

JACK, J. G., 1886. Notes on *Ceresa bubalus* Say. *Canad. Ent.*, **18:** 51-54.

JORDAN, C. R., 1953. A strepsipteran parasite of the three cornered alfalfa hopper. *J. econ. Ent.*, **46:** 505.

KNOWLTON, G. F. and HARMSTON, F. C. 1941. Insect food of the chipping sparrow. *J. econ. Ent.*, **34:** 123-124.

KNOWLTON, G. F. and HARMSTON, F. C., 1946. Insect food of the mountain bluebird. *J. econ. Ent.*, **39:** 384.

KORNHAUSER, S. I., 1919. The sexual characteristics of the membracids *Thelia bimaculata* (Fabr.). 1. External changes induced by *Aphelopus theliae* (Gahan). *J. Morph.*, **32:** 532-636.

LEFROY, H. M. and HOWLETT, F. M. 1909. Homoptera. Indian Insect Life. A manual of the insects of the plains (Tropical India). pp. 1-786.

MATAUSCH, I., 1911. Observations on *Micrutalis calva* Say. *Psyche*, **19:** 66-69.

MC ATEE, W. L., 1918. Bird enemies of tree hoppers (Membracidae). *Auk*, **35:** 373-374.

MC ATEE, W. L., 1932. Effectiveness in nature of the so-called protective adaptations in the animal kingdom, chiefly as illustrated by the food habits of Nearctic birds. *Smithson. Inst. misc. Collns.*, **85**(7): 1-201.

MEISENHEIMER, J., 1930. Die allgameinen probleme. Geschlecht und Geschlechter in Tierreiche, **2:** 1-614.

MISRA, C. S. 1923. Observations on some Rhynchota from Northern India. *Proc. 5th Entomological Meeting, Pusa*, 1923.

MÜLLER, H., 1873. Larvae of *Membracis* serving as milk cattle to a Brazilian species of honeybee. *Nature*, **8:** 201-202.

MÜLLER, H., 1874. *Ibid*, **10:** 31-32.

REINHARD, E. G., 1925. The wasp *Hoplisus costalis*, a hunter of tree hoppers. *Wash. Acad. Sci. J.* **15:** 107-110.

RICE, M. E., 1893. Notes on *Entylia sinuata. Insect Life*, **5:** 243-245.

SUBRAMANIAM, T V., 1927. A new genus and species of the Strepsiptera from S. India, *Indoxenos membraciphaga* gen. & sp. nov. *Trans. ent. Soc. Lond.*, **15:** 131-135.

SUBRAMANIAM, T V., 1932. On a new genus and species of Strepsiptera. *Rec. Indian Mus.*, **34:** 43-46.

WILDERMUTH, V L., 1915. Three-cornered alfalfa hopper. *J. agric. Res.*, **3:** 343-362.

YOTHERS, M. A., 1934. Biology and control of tree-hoppers injurious to fruit trees in the Pacific Northwest. *U.S. Dept. Agr. Tech. Bull.*, **402:** 1-45.

Rec. zool. Surv. India, **68**: 341-353, 1975.

FIFTY YEARS' PROGRESS IN THE TAXONOMY OF COCCIDIA (PROTOZOA: SPOROZOA) FROM INDIA

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(With 1 Table)

Coccidian parasites have attracted the attention of parasitologists since long, mainly because they produce a dreadful disease coccidiosis, which causes a heavy loss in the poultry, cattle, sheep and goats. In our country, research on coccidia was under way as early as the end of the last century, especially in the field of taxonomy, morphology and to some extent the life cycles.

During the fifty years existence of the Zoological Survey of India, it seems reasonable to assess the progress in the field of taxonomy of different groups of animal in India and the part played by this Institution. The present attempt is to review the results so far achieved in the field of taxonomy of Coccidian parasites in India, both from the invertebrate and vertebrate hosts.

The order Coccidia has representatives in all the major land realms of the world. Out of the total 38 genera, only 17 are represented in India, of which 3 are indigenous to this region and are monotypic. These seventeen genera comprise nearly 200 species (Table 1) of which 160 were described as new from India and the rest reported subsequently.

A little work has been done on the parasites of invertebrates. Uptil now, only seven species have been described. de Mello (1921) was the first to report a coccidian parasite *Adelia pachelabrae* from the snail, *Pachelabra moesta* Reeve. Subsequently, Ray and Das Gupta (1937) and Narasimhamurti (1960) described two more species of *Adelia* from centipedes. Setna and Bhatia (1934) reported *Aggregata* sp. from a prawn. Bhatia (1937) recorded *Adelina tribolii* from the beetle, *Tribolium ferrugineum*. Ganapati (1945, 1952) described two species of *Myriospora* from Annelida.

A considerable amount of work has been done on the parasites of vertebrate hosts. For convenience, it is given hereunder group-wise.

FISH

Halawani (1930 *a* and *b*) described *Eimeria southwelli* from shark. Setna (1933) reported Coccidia from fishes. Setna and Bana (1935*a* and *b*) observed *E. harpodoni* from Bombay-Duck. de Mello & Vales

TABLE 1—Showing the distribution of Coccidian parasites in different hosts from India.

Name of the Genera	Invertebrata					Vertebrata				
	Mollusca	Myriapoda	Insecta	Crustacea	Annelida	Fish	Amphibia	Reptiles	Bird	Mammals
1. Aggregata				1						
2. Myriospora					2					
3. Lankesterella							2			
4. Tyzzeria									2	
5. Caryospora								1		
6. Isospora							2	4	22	10
7. Dorisiella									6	
8. Eimeria						4	3	15	30	61
9. Wenyonella									5	1
10. Octospoxella								1		
11. Pythonella								1		
12. Sivatoshella									1	
13. Adelia	1									
14. Adelina		1	1							
15. Haemogregarina						1	3	13		
16. Hepatozoon									1	6
17. Karyolysus								1		

(1936) recorded *Haemogregarina thyrosoideae* from a freshwater eel after examining the specimen from Nova Goa. Chakravarty and Kar (1944) described *E. notopteri* from *Notopterus notopterus* and Chakravarty and Mandal (1961) reported *E. zygaenae* from a hammer-headed shark.

AMPHIBIA

Patton (1906 and 1908) and Shortt (1917) described Haemogregarines from the toads and frogs. Ray (1935) and Ray and Dasgupta (1935) observed two species of Coccidia from toad. Chakravarty and Kar (1952) recorded two more species from toads and frogs. Ray and Mitra (1942) reported *Eimeria himalayanum* from the Himalayan Toad.

REPTILIA

A few species of Coccidia are described by Simond (1901, *a*, *b*, *c* and *d*) from the gharials and crocodiles. Laveran (1902), Shortt (1917), de Mello *et al.* (1917), de Mello (1932) and de Mello and Meyrelles (1937) described Coccidia from the blood of lizards and tortoises. Laveran (1905), Patton (1908) Setna and Bana (1935), Bhatia (1936, 38) Knowles and Dasgupta (1935 *a* & *b*), Mitra and Das Gupta (1937), Das Gupta (1938), Chakravarty and Kar (1943, 48) described several species from reptiles. Ray and Das Gupta (1936, 37) described two species of *Eimeria* from snakes and a genus *Pythonella* from the python. In 1942 Ray and Raghavachari described another genus *Octosporella* and Ray, Raghavachari & Sapre (1942) described a species *E. minetti* from *Mabuia*. Chakravarty and Kar (1947) reported *Caryospora gekkonis* from the wall Lizard. Mandal (1966) described *Isospora rayi* from a lizard.

AVES

Maximum work has been done on avian parasites. Adie (1908) described a species of *Hepatozoon* from the blood of a House sparrow. Hoare (1924) observed another coccidia from an Indian eagle. de Mello and Afonso (1935) reported Haemogregarine from a bird. Mitra and Das Gupta (1937), Malhotra and Ray (1961) and Chatterjee and Ray (1969) recorded Coccidia from pigeon. Naik (1937) observed coccidiosis in crow. Kar (1944), Chakravarty and Kar (1944, 47), and Misra (1944, 47) described several species from different avian hosts. Chakravarty and Basu (1946) recorded *Tyzzeria alleni* from a Cotton Teal. Ray (1945) Gill (1959) and Nath *et al* (1960) observed Coccidia from Chick. Ray (1952), Ray *et al.* (1952 *a* and *b*) noted some parasites from hill birds. Ray and Hiregauder (1959) described some species of avian Coccidia. Dubey and Pande (1963 *a* and *b*), Bhatia and Srivastava (1965) and Sarkar and Ray (1965) recorded few species from domestic duck. Mandal and Chakravarty (1963) described *Dorisiella vagabundae* from Indian Tree-pie. The same authors (1964) recorded some species of *Isospora* from Indian birds. Mandal (1965) reported five species of *Eimeria* with a subspecies of *E. recoviensis* (Labbe) from avian hosts.

Banik and Ray (1961, 64) described *E. pavonina* and *E. mandali* from Indian peacock. *E. pavonis* and *E. cristata* have also been described by Patnaik (1965) from Indian peacock, which are now synonemized with *E. pavonis* Mandal 1965 and *E. patnaiki* Ray 1965. Bhatia and Pande (1965 *a* and *b*) recorded avian coccidia from Mathura. Ray and Sarkar (1967, 68) described some species including *Dorisiella chakravarti* and *D. mandali* and the genus *Sivatoshella* from some passerine birds.

Mammalia

Laveran (1905) reported *Hepatozoon* from rodents. A *Leucocytozoon* (=*Hepatozoon*) was also described by Adie (1906) from *Mus rattus* (=*Rattus rattus*). Patton (1908) reported coccidia from different orders of mammals. Christophers (1912) observed this parasite from wild dog. Cooper (1924, 1926 *a* and *b* 1927), Cooper and Gulati (1926), Rao (1952) Rao and Hiregauder (1954), Hiregauder (1956) Rao and Bhatawadaker (1959) Gill (1960 *a* and 1968) observed bovine Coccidiosis. Mandal and Ray (1961), Patnaik and Ray (1961), Gill, Chhabra and Lall (1963), Patnaik (1964) and Patnaik and Pande (1965) studied this parasite from buffalo. Gill (1960 b), Srivastava and Shah (1968) reviewed the parasites from domestic pig. Rao (1925), Aiyar (1937) Ray and Banik (1965) and Mukherjee and Krassner (1965) described this parasite from *Canis*. Knowles and Das Gupta (1934), Mandal and Ray (1960) reported coccidia from feline group. Kar (1943) and Shah (1965) reported coccidia from goat. Ray and Das Gupta, (1935, 1937), Ray and Singh (1949, 1950) Gill and Ray (1961), Ray and Banik (1965) and Ray, Banik and Mukherjee (1965) observed coccidia from rodents and lagomorphs. Dubey and Pande (1963 *a* & *b*, 1964*a*) recorded this parasite from camel. The same authors (1964*b*) Knowles and Das Gupta (1931), Patnaik and Ray (1965) reported coccidia from Mongoose. Das Gupta (1934), Mukherjee (1948) noted human coccidiosis.

Summary

The coccidian parasites have been a subject of active investigation since the first one was seen by Leuweenhook in 1674. Hundreds of species have been named but their actual number may well be in the tens of thousands.

Coccidian parasites present in the diverse Indian fauna are varied. Uptil now seventeen genera comprising nearly two hundred species have been recorded from this country and most of them are described within the last fifty years. Irrespective of different climatic zones of India, the coccidian parasites are quite frequent.

Bibliography

Adie, J. R. 1906. Notes on a leucocytozoon found in *Mus rattus* in the Punjab. *J. trop. Med.*, **9** : 325–326.

ADIE, J. R. 1908. Note on a parasite in the Sparrow. *Ind. med. Gaz.*, **43** : 176.

AHLUWALIA, S. S. 1959. A note on coccidial infection in Domestic Pig. *Sci. & Cult.*, **25** : 314.

AIYAR, K. R. S. 1937. The occurrence of Coccidia in dogs at Bombay (Abstract). *Proc. Indian Sci. Congr.*, 402.

BANIK, D. C. and RAY, H. N. 1961. New coccidium *Eimeria pavonina* n.sp. from peacock, *Pavo cristatus* Linn. *Bull. Calcutta Sch. trop. Med.*, **9** (2): 61–62.

BANIK, D. C. and RAY, H. N. 1962. On a new coccidium *Isospora bellericae* n.sp. from Cape ground crane, *Bellerica regulorum*. *Bull. Calcutta Sch. trop. Med.*, **10** : 10.

BANIK, D. C. and RAY, H. N. 1964. On a new coccidium, *Eimeria mandali*, n.sp. from the Indian peacock. *Bull. Calcutta Sch. trop. Med.*, **12** (1): 27.

BHATIA, B. L. 1936. Coccidia of Lizards. *Curr. Sci.*, **5** : 177.

BHATIA, B. L. 1938. *Fauna of British India, Protozoa. Sporozoa.* Taylor and Francis, London.

BHATIA, M. L. 1937. On *Adelina tribolli* a coccidian parasite of *Tribolium ferrugeneum*. *J. Parasit.*, **29** : 239–246.

BHATIA, B. B. and PANDE, B. P. 1965*a*. *Eimeria bateri* n.sp. from Indian common grey quail (*Coturnix communis*). *Indian J. Microbiol.*, **5** (4): 61–64.

BHATIA, B. B. and PANDE, B. P. 1965*b*. *Eimeria dauki* n.sp. from white breasted waterhen *Amaurornis phoenicurus* (Pennant). *Indian J. Microbiol.*, **5** (4): 65–66.

BHATIA, B. B. and PANDE, B. P. 1967. Gaint Eimeria schizonts in mesenteric lymph nodes of a kid. *Indian J. Microbiol.*, **7** : 162–164.

BHATIA, B. B. and PANDE, B. P. 1968*a*. Pathogenicity and life cycle of *E. acervulina*. *Indian J. Microbiol.*, **8** (2): 73–82.

BHATIA, B. B. and PANDE, B. P. 1968*b*. A hitherto unknown aspect of histopathology in out break of *E. necatrix* infection. *Indian J. Microbiol.*, **8** (2): 129–134.

CHAKRAVARTY, M. M. and KAR, A. B. 1943. Observation on two Coccidia, *Eimeria trionyxae* n.sp. and *Eimeria triangularis* n.sp. from the intestine of the Turtle *Trionyx gangeticus* Cuv. *J. R. Asiat. Soc. Bengal.*, **9** : 49–54.

CHAKRAVARTY, M. M. and KAR, A. B. 1944*a*. Studies on Coccidia of Indian birds. 1. On the life history of *Isospora lacazei* (Labbe). *J. Dept. Sci. C.U.*, **1** : 76–80.

CHAKRAVARTY, M. M. and KAR. A. B. 1944*b*. A study on the Coccidia of Indian birds. II. Observation on several species of Coccidia of the Sub-families Cyclosporinae and Eimeriinae. *Proc. Indian Acad. Sci.*, **20**(B) : 102–114.

CHAKRAVARTY, M. A. and KAR, A. B. 1944*c*. A new coccidium from the intestine of the fish *Notopterus notopterus* (Palls). *Curr. Sci.*, **13** : 51–52.

CHAKRAVARTY, M. M. and KAR, A. B. 1946. Effect of temperature of the sporulation and mortality of Coccidian oocysts. *Proc. natn. Inst. Sci. India*, **12** : 1–6.

CHAKRAVARTY, M. M. and KAR, A. B. 1947. A study on the Coccidia of Indian birds. *Proc. R. Soc.*, **62** (B): 225–233.

CHAKRAVARTY, M. M. and KAR, A. B. 1948. Observations on two reptilian Coccidia. *J. Asiat. Soc. Bengal* (Sci.), **12** : 3–5.

CHAKRAVARTY, M. M. and BASU, S. P. 1946. On a new coccidium *Tyzzeria alleni* n.sp. from the intestine of a bird Cotton teal. *Sci. & Cult.*, **12** (2): 106.

CHAKRAVARTY, M. M. and KAR, A. B. 1952. The life history and affinities of two salientian coccidia, *Isospora stomaticae* and *Eimeria cyanophlyctis* with a note on *Isospora wenyoni*. *Proc. zool. Soc. Bengal*, **5** : 11–18.

CHAKRAVARTY, M. M. and MANDAL, A. K. 1961. A new coccidium *Eimeria zygaenae* from Hammer headed Shark, *Zygaena blochii*. *Proc. Indian Sci. Congr.*, 413.

CHATTERJEE, D. K. and RAY, H. N. 1969. On *Eimeria kapotei* n.sp. from the domestic pigeon *Columba livia intermedia*. *Proc. 56th Indian Sci. Congr.*: 512.

CHRISTOPHERS, S. R. 1905. *Haemogregarina gerbilli*. *Sci. Mem. off. Med. & San. Dept. Gov. India, N.S.*, **18** : 1–15.

COOPER, H. 1924. Bovine conidions. *Rep. Imp. Bast. Lab. Mukteswar* for 24: 48.

COOPER, H. 1926*a*. The Coccidia of cattle in India (Abstract). *Proc. Indian Sci. Congr.* : 290.

COOPER, H. 1926*b*. The pathogenicity of bovine Coccidia (Abstract). *Proc. Indian Sci. Congr.*: 291.

COOPER, H. 1927. Coccidians, with particular reference to bovine coccidiosis and its significance as an injection of Cattle in India. *Indian. vet. J.*, **4** : 56–64; Also *Agric. J. India*, **22** : 92–97.

COOPER H. and GULATI, A. N. 1926. On the occurrence of *Isospora* and *Balantidium* in Calcutta. *Mem. Dep. Agric. India. vet. Soc.*, **3** : 191–193.

DAS GUPTA, B. M. 1934. Observations on a case of coccidial infection in man (*Isospora belli* Wenyon, 1923). *Indian med. Gaz.*, **69** : 133–134.

DASGUPTA, M. 1938*a*. On a new coccidium, *Eimeria koormae* n.sp. from an Indian tortoise, *Lissemys punctata* Smith. *Proc. Indian Sci. Congr.*: 155.

DASGUPTA, M. 1938*b*. On new coccidium *Eimeria koormae* n.sp. from the intestine of the Indian tortoise *Lissemys punctata* Smith. *Arch. Protistenk.*, **90** : 410–413.

DASGUPTA, M. 1938*c*. On a new coccidium *Isospora minuta* n.sp. from the intestine of a Cobra *Naja naja* Linn. *J. Bombay nat. Hist. Soc.*, **40** : 236–237.

DASGUPTA, M. 1938*d*. Observations on a coccidium *Eimeria columbae* n.sp. from the intestine of Indian pegion, *Columba intermedia*. *Arch. Protistenk.*, **91** : 105–110.

DUBEY, J. P. 1963*a*. Observations on coccidian oocysts from Indian Hyaena (*Hyaena striata*). *Indian J. Microbiol.*, **3** (3): 121–122.

DUBEY, J. P. 1963*b*. Observations on the coccidian oocysts from Indian fox (*Vulpes bengalensis*). *Indian J. Microbiol.*, **3** (4): 143–144.

DUBEY, J. P. and PANDE J. P. 1963. Observations on the coccidian oocysts from Indian Jungle cat (*Felis chaus*). *Indian J. Microbiol.*, **3** (3) : 103-108.

DUBEY, J. P. and PANDEY, J. P. 1963*a*. A preliminary note on *Eimeria battakhi* n.sp. (Protozoa Eimeriidae) from domestic duck (*Anas platyrhynchos platyrhynchos domesticus*). *Curr. Sci.*, **32** : 329–331.

DUBEY, J. P. and PANDEY, J. P. 1963*b*. A note on *Eimeria rejasthani* n.sp. from the Indian *Camelus dromedarius*., *Curr. Sci.*, **32** : 273–274.

DUBEY, J. P. and PANDEY, J. P. 1963*c*. On a coccidian schizonts in the Indian domestic duck. *J. Parasit.*, **49** : 770.

DUBEY, J. P. and PANDEY, J. P. 1964. On Eimerian oocysts recovered from Indian Camel (*Gamelus dromedarius*). *J. vet. Sci. Anim. Husb.*, **34** : 28–34.

GANAPATI, P. N. 1945. The development and sporogony of a Coccidian *Myriospora gopali* n.sp. parasitic in the gut of the Polychaete *Cirratulus filiformes* Keferstein. *Proc. Indian Acad. Sci.*, **22B** : 144–163.

GANAPATI, P. N. 1952. The morphology and life history of a coccidian *Myriospora polydorae* n.sp. in the body cavity of *Polydora ciliata* Johnston. *Arch. Protistenk.*, **98** : 71–90.

GILL, B. S. 1954. Speciation and viability of poultry Coccidia in 120 faecal samples preserved in 2.5 per cent potassium dichromate solution. *Indian J. vet. Sci. and Anim. Husb.*, **24** (4): 245–247.

GILL, B. S. 1960*a*. The Coccidian oocysts of Indian cattle. *Proc. 47th Indian Sci. Congr.*: 340.

GILL, B. S. 1960*b*. The Coccidian oocysts of Indian pigs. *Proc. 47th Indian Sci. Congr.*: 430.

GILL, B. S. and RAY, H. N. 1961. The Coccidia of domestic rabbit and the common field hare of India. *Proc. zool. Soc.*, Calcutta, **13** : 129–142.

GILL, B. S., CHHABRA, M. B. and LALL, N. B. 1963. A new species of Coccidium *Eimeria bareillyi* n.sp. from buffaloes. *Arch. Protistenk.*, **106** : 571–574.

GILL, B. S. 1968. The Coccidian oocysts (Protozoa: Sporozoa) of Indian Cattle. *Proc. zool. Soc.*, **21** : 101–121.

HALAWANI, A. 1930*a*. On a new species of *Eimeria* (*E. southwalli*) from *Aetobatis narinari*. *Ann. trop. Med.* & *Parasit.*, **24** : 1–3.

HALAWANI, A. 1930*b*. A new coccidium *Eimeria southwalli* from a shark, *Trans. R. Soc. trop. Med. Hyg.*, **23** : 326.

HIREGAUDAR, L. S. 1956. A new species of *Eimeria* from a cowcalf in Bombay State. *Curr. Sci.*, **25** : 197.

HOARE, C. A. 1924. *Hepatozoon adiei* n.sp. a blood parasite of an Indian eagle. *Trans. R. Soc. trop. Med. Hyg.*, **18** : 63–66.

KAR, A. B. 1943. Observations on two mammalian coccidia. *Curr. Sci.*, **12** : 331.

KAR, A. B. 1944*a*. Observation on *Eimeria barbeta* n.sp. from the blue throated barbet *Cyanops asistica* (Lath.). *Proc. 31st Indian. Sci. Congr.*, 104–105.

KAR, A. B. 1944*b*. Two new coccidia from pond turtles, *Lissemys punctata* (Bonnateree). *Indian vet. J.*, **20** (5): 1–5.

KNOWLES, R. and DAS GUPTA, B. M. 1931. A note on two intestinal Protozoa of the Indian mangoose. *Indian med. Res. Mem.*, **19** : 175–176.

KNOWLES, R. and DAS GUPTA, B. M. 1934. *Isospora* infection in Indian cats. *Indian med. Gaz.*, **69** : 387–390.

KNOWLES, R. and DAS GUPTA, B. M. 1935. The Coccidia of lizards. *Indian J. med. Res.*, **22** : 701–707.

LAVERAN, A. 1902. Sur quelques hemogregarines des ophidiens. *C. R. Acad. Sci.*, **135** : 1036–1040.

LAVERAN, A. 1905. Sur une hemogregarine des gerboises. *C. R. Acad. Sci.*, **141** : 295–298.

MANDAL, A. K. and CHAKRAVARTY, M. M. 1963. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 1. On a new species of *Dorisiella* from the Indian tree pie, *Crypsirina vagabunda* (Lathm). *Proc. zool. Soc.*, **16** : 147–150.

MANDAL, A. K. and CHAKRAVARTY, M. M. 1964. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 2. Some new species of the genus *Isospora* Schneider (1881). *Proc. zool. Soc.*, **17** : 35–45.

MANDAL, A. K. 1965. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 3. Some new species of the genus *Eimeria* Schneider (1875) with a sub species of *E. roscoviensis* (Labbe). *Proc. zool. Soc.*, **18** : 47–57.

MANDAL, A. K. and CHAKRAVARTY, M. M. 1965. A new Coccidium *Eimeria zygaenae* from Hammer headed shark, *Zygaena blochii*. *Sci. & Cult.*, **31** : 381–382.

MANDAL, A. K. 1971. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 4. Occurrence and distribution of Coccidian Parasites in Indian birds. (with two tables). *Rec. zool. Surv. India*. **63** : 23–39.

MANDAL, A. K. 1965. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 6. The occurrence of *Isospora* sp. in goats with a redescription of *Isospora lacazei* (Labbe, 1893) from some common Indian birds. (with one table and three figures). *J. Assam Sci. Soc.*, **8** : 71–75.

MANDAL, A. K. 1966*a*. Studies on some aspects of avian Coccidia (Protozoa: Sporozoa). 5. The effects of some Physical and Chemical agents on the oocysts of *Dorisiella vagabundae* Mandal and Chakravarty (1963). *Proc. zool. Soc.*, **19** : 23–29.

MANDAL, A. K. 1966*b*. A new coccidian *Isospora rayi* n.sp. from a lizard *Ptyclolaemus* sp. from Shillong. *Sci. & Cult.*, **32** : 507–508.

MANDAL, L. N. and RAY, H. N. 1960. A new coccidium *Isospora leonina*, n.sp. from a lion cub. *Bull. Calcutta Sch. trop. Med.*, **8** : 107–108.

MALHOTRA, M. N. and RAY, H. N. 1961. On a new Coccidian *Eimeria tropicalis* n.sp. from the domestic pigeon, *Columba livia intermedia*. *Proc. 48th Indian Sci. Congr.*: 412.

MELLO, F. DE 1915. Preliminary note on a new haemogragarine found in the pigeon's blood. *Indian J. med. Res.*, **3** : 93–94.

MELLO, F. DE, SA', BRA'S, DE, SOUSA, LORETO, DIAS, A, and NORONHA, R. 1917. Hématozoaires et pseudo-hématozoaires de l' Inde Portugaise. *Ann. Sci.* (*faculd. Med.*), Proto., **3** : 5–24.

MELLO, F. DE 1921. Protozoaires parasites du *Pachelabra moesta* Reeve. *C. R. Soc. Biol.*, **84** : 241–242.

MELLO, F. DE 1932. Contributions á l'étude des hémogrégarinides des tortues indiennes. *Arch. Esc. Med-Cirurg. Nova Goa* (Ser. A)., **8** : 1411–1425: 1426: 1431.

MELLO, F. DE and AFONSO, E. 1935. Blood parasites of *Coracias b. benghalensis*, with special remark on its two types of Leucocytozoon. *Proc. Indian Acad. Sci.*, **11** : 67–73.

MELLO, F. DE and VALES, C. 1936. *Haemogregarina thyrsoideae* n.sp., parasite of the Indian eel *Thyrsoidea macrurus* Bleeker *Proc. Indian Acad. Sci.*, **4** : 403–404.

MELLO, F DE and MEYRELLES, C. C. DE 1937. On the classification and Schizogonic cycle of a blood-parasite of the Indian lizard, *Calotes versicolor* Daud. subspecies *major* Blyth. *Proc. Indian Acad. Sci.*, **5B** : 119–141.

MISRA, P. L. 1944. On a coccidium *Wenyonella balli* n.sp. from the common grey quail. *Proc. natn. Inst. Sci. India*, **10** : 203–204.

MISRA, P. L. 1947. On a three coccidian parasite *Wenyonella mackinnoni* n.sp., *Eimeria lucknowensis* n.sp. and *Isospora* sp. from the intestine of the Wagtail *Motacilla alba* Linn. (Passeriformes, Motacillidae). *Proc. Indian. Acad. Sci.*, **25**(B): 75–85.

MISHRA, G. S. 1967. On intestinal protozoa in piglets. *Indian vet. Jour.*, **44** : 289–291.

MITRA, A. N. and DAS GUPTA, M. 1937*a*. On a species of *Isospora* from the intestine of *Naja naja* Linn. (Abstract) *Proc. Indian Sci. Congr.*,: 291.

MITRA, A. N. and DAS GUPTA, M. 1937*b*. On a species of *Eimeria* from the intestine of a pigeon *Columba intermedia* (Abstract) *Proc. 24th Indian. Sci. Congr.*,: 291.

MUKHERJEE, N. N. 1948. Incidence of Coccidiosis in the Arakan. *Indian med. Gaz.*, **82** : 735–736.

MUKHERJEE, A. K. and KRASSNER, S. M. 1965. A new species of Coccidia (Protozoa: Sporozoa) of the genus *Isospora* Schneider 1881 from the Jackal, *Canis aurius* Linn. *Proc. zool. Soc.*, **18** : 35–40.

NAIK, R. N. 1937. Coccidiosis in Crows (Abstract). *Proc. Indian Sci. Congr.*, 394.

NARASIMHAMURTI, C. C. 1960. Observations on the morphology and sporogony of a new coccidium *Adelea hydlospora* from the gut of a centipede *Rhysida longipes* (new host). *J. zool. Soc. India*, **12** : 60–68.

PANDE, B. P., BHATIA, B. B. and CHAUHAN, P. P. S. 1966. Endogenous stages of *Eimeria intricata* (Sporozoa: Eimeriidae) in Indian Sheep. *J. zool. Soc. India*, **6** (1): 35–39.

PANDE, B. P., BHATIA, B. B., DUBEY, J. P. and SRIVASTAVA, K. M. N. 1964. Study on Eimerian schizonts from clinical cases of coccidiosis in lambs. *J. zool. Soc. India.*, **4** : 67–73.

PANDE, B. P., BHATIA, B. B. and SRIVASTAVA, K. M. N. 1965. *Wenyonella anatis* n.sp. (Protozoa: Eimeriipae) from Indian domestic duck. *Sci. & Cult.*, **31** : 383–384.

PATNAIK, M. M. 1964. On the Coccidian infections of buffalo calves (a study of the oocysts). *Agra. Univ. J. Res. (Sci.).*, **13** : 239–256.

PATNAIK, M. M. 1965*a*. *Eimeria pavonis* n.sp. and *E. cristata* n.sp. from Indian Peacock (*Pavo cristatus*). *J. vet. Sci.*, **5** (4): 45–48.

PATNAIK, M. M. 1965*b*. *Isospora pellerdyi* n.sp. from Indian peacock (*Pavo cristatus*). *Indian J. Microbiol.*, **5** (4): 67–68.

PATNAIK, M. M. and PANDE, B. P. 1965. Some observations on the endogenous stage of species of *Eimeria* and related lesions in naturally infected buffalo-calves (*Bubalus bubalis*). *J. vet. Sci.*, **35** : 33–46.

PATNAIK, M. M. and RAY, S. K. 1965. Coccidia of Indian Mangoose (*Herpestes edwarsi*). *Indian J. Anim. Hlth.*, **4** : 33–36.

PATNAIK, M. M. and MOHANTY, D. N. 1969. *Isospora gypsi* n.sp. from the Indian valture (*Gyps bengalensis*). *Curr. Sci.*, **38** (13): 316.

PATTON, W. S. 1906. On a parasite found in the white corpuscles of the blood of palm squerrels. *Sci. Mem. Off. Med. & San. Dep. Govt. India*, N.S. no. 24: 1–13.

PATTON, W. S. 1908. The haemogragarines of mammals and reptiles. *Parasitology*, **1** : 318–321.

PATTON, W. S. 1909. The haemogregarine of mammals and reptiles a rejoinder to Dr. Sambon. *Parasitology*, **11** : 144–155.

RAO, M. A. N. 1935. *Haemogregarina canis. Indian vet. J.*, 1, No. 4: *Vet. J.*, **81** : 293.

RAO, S. P. 1952. *E. smithi* a cause of dysentry in Cattle in Bombay State. *Bombay vet. Coll. mag.*, **3** : 35.

RAO, S. R. and HIREGAUDER, L. S. 1954. Coccidial fauna of Cattle in Bombay State, with particular reference to a recent outbreak at Aarey Milk Colony, together with a description of two new species *E. bombayansis* and *E. khurodensis. Bombay vet. Coll. Mag.*, **4** : 24–28.

RAO, S. R. and BHATAWADAKAR, M. Y. 1959. Some record of Coccidia of Cattle in Bombay with a description of two new species. *Bombay vet. Coll. Mag.*, **8** : 23.

RAY, D. K. 1952*a*. On a new coccidium, *Eimeria sphenocercae* n.sp. from *Sphenocercus sphenurus* (Kokla green Pigeon). *J. Parasit.*, **38** : 546–547.

RAY, D. K. 1952*b*. On a new coccidium *Eimeria hawkensi* n.sp. from Indian sheep and goats. *Proc. 39th Indian Sci. Congr.*,: 314–315.

RAY, D. K., SHIVNANI, G. A., OOMEN, M. and BHASKARAN, R. 1952*a*. A study on some coccidia of Himalayan birds. *Proc. 39th Indian Sci. Congr.*,: 314.

RAY, D. K., SHIVNANI, G. A., OOMEN, M. and BHASKARAN, R. 1952*b*. A study on the coccidia of some Himalayan birds. *Proc. zool. Soc. Beng.*, **5** : 141–147.

RAY, D. K. 1959. *Coccidia and Coccidiosis in the sheep and goats of India.* Doctoral Thesis., Calcutta University.

RAY, H. N. 1930. Studies on some Sporozoa in Polychaete worms, *Dorisiella scololepidis* n.gen., n.sp. *Parasitology.*, **22** : 471–480.

RAY, H. N. 1935. On a new coccidium *Eimeria laminata* n.sp. from the intestine of an Indian toad, *Bufo melanostictus* Schneid. *Parasitology.*, **27** : 369–372.

RAY, H. N. 1945. On a new coccidium *Wenyonella gallinae* n.sp. from the gut of the domestic fowl, *Gallus gallus domesticus* Linn. *Curr. Sci.*, **14** : 275.

RAY, H. N. and BANIK, D. C. 1965*a*. On a new Coccidium, *Eimeria oryctolagi* n.sp. from the domestic rabbit, *Oryctolagus* (*Lepus*) *cuniculis*. *Proc. Combined 51st and 52nd Indian Sci. Congr.*: 465.

RAY, H. N. and BANIK, D. C. 1965*b*. On a new Coccidium *Isospora canis* n.sp. from dog, *Canis fameliaris*. *Proc. Combined 51st and 52nd Indian Sci. Congr.*: 466–467.

RAY, H. N. 1966. Remarks on *Eimeria pavonis* n.sp. from Indian peacock. *Indian J. Microbiol.*, **6** (4): 51–52.

RAY, H. N., BANIK, D. C. and MUKHERJEE, A. K. 1965. A new coccidium *Eimeria bandipuransis* n.sp. from the Indian palm Squirrel. *Funumbulus palmerum*. *J. Protozool.*, **12** : 478–479.

RAY, H. N. and DAS GUPTA, M. 1935*a*. *Wenyonella* (Coccidia) from an Indian squirrel. *Sci. & Cult.*, **1** : 112–113.

RAY, H. N. and DAS GUPTA, N. 1935*b*. On a new coccidium, *Isospora wenyoni* n.sp. from the intestine of an Indian toad, *Bufo melanostictus*. *Arch. Protistenk.*, **86** : 219–224.

RAY, H. N. and DAS GUPTA, M. 1935*c*. On a species of *Eimeria* (Sporozoa: Coccidia) from the gall bladder of a lizard, *Hemidactylus coctaei*. *Proc. 22nd Indian Sci. Congr.*: 315.

RAY, H. N. and DAS GUPTA, M. 1936*a*. *Eimeria* from *Natrix piscator* (Schneid). *Proc. 22nd Indian Sci. Congr.*: 345.

RAY, H. N. and DAS GUPTA, M. 1936*b*. On an *Eimeria* from *Naja naja* Linn. *Proc. 22nd Indian Sci. Congr.*: 345–346.

RAY, H. N. and DAS GUPTA, 1937*a*. On *Adelina schellacki* n.sp. from the intestine of a Centipede, *Cormocephalus dentipes* Poc. (Abstract). *Proc. 22nd Indian Sci. Congr.*: 291.

RAY, H. N. and DAS GUPTA, M. 1937*b*. On a new coccidium from the intestine of *Python* sp. (Abstract). *Proc. 22nd Indian Sci. Congr.*: 292.

RAY, H. N. and DAS GUPTA, M. 1937*c*. A new coccidium, *Wenyonella boarei* n.sp. from an Indian squirrel. *Parasitology.*, **29** : 117–120.

RAY, H. N. and DAS GUPTA, M. 1937*d*. Observations on a Coccidian, *Eimeria najae* n.sp. from the intenstine of an Indian Cobra *Naja naja*. *Arch. Protistenk.*, **88** : 275–278.

RAY, H. N. and DAS GUPTA, M. 1937*e*. *Isospora knowlesi* n.sp. (Coccidia) from the intestine of a lizard, *Hemidactylus flaviviridis* (Ruppell). *Arch. Protistenk.*, **88** : 269–275.

RAY, H. N. and DAS GUPTA, M. 1938. On a new Coccidium *Eimeria stolatae* n.sp. from the intestine of common grass snake, *Natrix stolata* (Linn.). *Arch. Protistenk.*, **90** : 361–364.

RAY, H. N. and HARBANS, S. 1948. Occurrence of *Isospora dirumpens* Hoare in the intestine of the grass snake *Natrix plalyceps* at Muktes-war. *Sci. & Cult.*, **14** : 119–120.

RAY, H. N. and HIREGAUDAR, L. S. 1959. Coccidia from some birds at Calcutta Zoo. *Bull. Calcutta Sch. trop. Med.*, **7** : 111–112.

RAY, H. N. and MANDAL, L. N. 1961. On a new Coccidium *Eimeria ovoidales* n.sp. from a buffalo calf and its experimental transmission to cow calf. *Proc. 48th Indian Sci. Congr.*: 411.

RAY, H. N. and MISRA, P. L. 1942. Observation on a new Coccidian *Eimeria himalayanum* n.sp. from the intestine of a Himalayan toad, *Bufo*. sp. *Proc. 28th Indian Sci. Congr.*,: 169.

RAY, H. N. and MISRA, P. L. 1943. On a new Coccidian, *Eimeria himalayanum* n.sp. from the intestine of a Himalayan toad *Bufo himalayanum* Boulenger. *Proc. natn. Inst. Sci. India.*, **9** : 265.

RAY, H. N. and RAGHAVACHARI, K. 1942. Observation on a new *Coccidium, Octosporella mabuiae* n.gen. n.sp. from the intestine of *Mabuia* sp. *Proc. 28th Indian Sci. Congr.*: 170.

RAY, H. N., RAGHAVACHARI, K. and SAPRE, S. N. 1942. On a new Coccidium, *Eimeria minetti* n.sp. from the lizard *Mabuia* sp. *Proc. 28th Indian Sci. Congr.*,: 170.

RAY, H. N. and SARKAR, A. C. 1967*a*. On some new Coccidia from the Indian Pessarine birds, *Zooterops palpebrosa* (Temn), *Lonchura malabarica* (Linn.), *L. punctulata* (Linn.) and *Passer domesticus* (Linn.). *Proc. 54th Indian Sci. Congr.*,: 448–449.

RAY, H. N. and SARKAR, A. C. 1967*b*. On a new Coccidium, *Tyzzeria chenicusae* from cotton Teal, (*Chenicus coromandelianus*) Aves: Anseri-formes). *J. Protozool.*, **74** : 27 (Suppl.).

RAY, H. N. and SARKAR, A. C. 1968. A new Coccidium *Sivatoshella lonchurae* n.gen. n.sp., from *Lonchura malabarica* and *L. punctulata*. *J. Protozool.*, **15** (4): 640–643.

RAY, H. N. and SINGH, H. 1949. On a new Coccidium *Eimeria petauristae*, n.sp. from the intestine of a Himalayan flying squirrel, *Petaurista inornatus* (Geoffery). *Proc. 36th Indian Sci. Congr.*: 156.

RAY, H. N. and SINGH, H. 1950. On a new coccidium *Eimeria petauristae* n.sp. from the intestine of a Himalayan flying squirrel, *Petaurista inornatus* (Geoffery). *Proc. zool. Soc.*, **3** : 65–70.

SARKAR, A. C. and RAY, H. N. 1968. On a new Coccidium *Wenyonella gagari* n.sp. from the domestic duck, *Anas boschas*. *Proc. 58th Indian Sci. Congr.*,: 499–500.

SEN, S. K. 1932. *Coccidiosis. In Rep. Imp. Inst. Vet. Res., Mukteswar, for* 1932: 34.

SETNA, S. B. 1933. Fish and Reptilian Coccidia. *Curr. Sci.*, **2** : 97.

SETNA, S. B. and BENA, R. H. 1935*a*. *Eimeria harpodoni* n.sp., a new Coccidium from *Harpodon neherus* (Ham. & Buch.). *J. R. microse Soc.*, **55** : 165–169.

SETNA, S. B. and BENA, R. H. 1935*b*. *Eimeria flaviviridis* n.sp. from the gall bladder of *Hemidactylus flaviviridis*. *J. R. microse Soc.*, **55** : 256–260.

SHAH, H. L. 1965*a*. The occurrence of the Coccidium *Eimeria christenseni* in goats in India. *Curr. Sci.*, **34** : 564–565.

SHAH, H. L. and JOSHI, S. C. 1965. *Isospora* sp. from domestic fowl in India. *Indian J. Microbiol.*, **5** (3): 27–30.

SHORTT, H. E. 1917. Notes on two haemogregarines of cold blooded vertebrates. *Indian J. med. Res.*, **4** : 402–413.

SIMOND, P. L. 1901*a*. Sur un hematozoaire endaglobulaire pigmentee des tortues. *C.R. Soc. Biol.*, **53** : 150.

SIMOND, P. L. 1901*b*. Sur un hematozoaire endoglobulaire *Haemogregarina hankini*, parasite du gavial. *C.R. Soc. Biol.*, **53** : 183–185.

SIMOND, P. L. 1901*c*. Note sur une Coccidie nouvelle, *Coccidium kermognati* parasite du gavial. *C.R. Soc. Biol.*, **53** : 483–485.

SIMOND, P. L. 1901*d*. Note sur une coccidie nonvelle, *Coccidium legeri*, parasite de *Cryptopus granosus* (*Emyda granosa*). *C.R. Soc. Biol.*, Paris, **13** : 485–486.

SRIVASTAV, H. O. P. and SHAH, H. L. 1968. Coccidia of pigs in Madhya Pradesh, with discription of the sporulated oocysts of seven species. *Indian vet. J.*, **45** (3): 204–212.

SUBRAMANIAN, G. and JHA, D. 1966. Cross transmission of *Eimeria faurei* (Moussu & Marotel 1902) Martin 1902 and *E. ninakohlyakimovae* Yakimoff and Rastegaieff 1930 in closely related hosts. *Indian J. Microbiol.*, **6** : 7–12.

Rec. zool. Surv. India, **68** : 355-363, 1975.

STUDIES ON FRESHWATER FISHES OF BELIAGHATA BHERIES, CALCUTTA

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INTRODUCTION

The reason for taking up the present study is the lack of much detailed taxonomic and ecological studies on freshwater fishes of West Bengal except for a brief account of North Bengal fishes by Shaw and Shabbeare (1937), a study of mullets by Sarojini (1957, 1958), a study on biology and growth of Hooghly catfish, *Mystus*, *Fangasius* and eel, *Anguilla* by Pantulu (1956, 1961, 1962), systematic studies on the Indian siluroid fishes by Jayaram (1954 *et seq.*) in which material from West Bengal was also included and a detailed systematic study of *Mystus* spp. from Bengal region (Babu Rao and Chattopadhyay, 1969). Hora (1943 and 1953) published ecological papers on vegetation of fishing tanks and salinity of Hooghly estuary. It is felt that a detailed systematic study of freshwater fishes of West Bengal with keys for identification is needed so that the future freshwater fish workers of this region can easily take up the field.

Though some biological studies were made in a few commercially important freshwater fishes yet much ecological work has not been done. Some scientific organisations and institutions like Central Inland Fisheries Research Institute are studying the ecology of riverwater but the ecological study of confined freshwater bodies throughout West Bengal is neglected. Since the past one year faunistic and ecological observations are being made at the freshwater Bheries at Beliaghata in Calcutta with special reference to the freshwater fishes. A brief preliminary account of the observations are presented in the following:

MATERIALS AND METHODS

One Bheri (a big freshwater tank) in Beliaghata area, Calcutta, was selected for study. The Bheri was visited fortnightly for collection of specimens and other necessary field observations. Specimens were collected from fishermen immediately after catch and after making necessary notes in fresh condition they were preserved in diluted formaldehyde. Any plant or animal available in the Bheri was collected for study. In the laboratory weight and length data of the fishes selected for study were taken. Plants were preserved in spirit. The present study started on 17th July, 1968 and is still in continuation.

Systematic Account

The following specimens were collected from the Bheri and identified.

Fishes:

Fam. Cyprinidae

Subfam. *CYPRININAE*

Gen. *Labeo*

Labeo rohita (Ham.)

Gen. *Catla*

Catla catla (Ham.)

Gen. *Cirrhina*

Cirrhina mrigala (Ham.)

Cirrhina reba (Ham.)

Gen. *Cyprinus*

Cyprinus sp.

Gen. *Chela*

Chela punjabensis Day

Gen. *Rasbora*

Rasbora sp.

Gen. *Puntius*

Puntius stigma (Cuv. & Val.)

Puntius terio (Ham.)

Puntius ticto (Ham.)

Puntius phutunio (Ham.)

Puntius gelius (Ham.)

Puntius chrysopterus (McClell.)

Fam. Percidae

Group *Apogonina*

Gen. *Ambassis*

Ambassis nama (Ham.)

Ambassis ranga (Ham.)

Fam. Cichlidae

Gen. *Tilapia*

Tilapia mossambica Peters

Fam. Gobiidae

Subdiv. *GOBIIFORMES*

Gen. *Gobius*

Gobius giuris Ham.

Gobius criniger Cuv. & Val.

Fam. NOTOPTERIDAE

Gen. *Notopterus*

Notopterus chitala (Ham.)

Fam. SCOMBRESOCIDAE

Gen. *Belone*

Belone strongylurus Hasselt

Fam. BAGRIDAE

Gen. *Mystus*

Mystus keletius (Cuv. & Val.)

Fam. SILURIDAE

Gen. *Clarias*

Clarias batrachus (Bl. Schn.)

Gen. *Heteropneustes*

Heteropneustes fossilis (Bloch)

Fam. RHYNCHOBDELLIDAE

Gen. *Mastacembelus*

Mastacembelus pancalus (Ham.)

Gen. *Rhynchobdella aculeata* (Bloch)

Fam. ANABANTIDAE

Gen. *Anabas*

Anabas testudineus (Bloch)

Gen. *Trichogaster*

Trichogaster fasciatus (Bl. Schn.)

Fam. OPHIOCEPHALIDAE

Gen. *Channa*

Channa punctatus (Bloch)

Channa gachua (Ham.)

Channa marulius (Ham.)

Channa striatus (Bloch)

Molluscs:

Cl. GASTROPODA

Fam. VIVIPARIDAE

Gen. *Viviparus*

Viviparus bengalensis (Lamarck)

race *annandelei*, Kobelt.

Fam. MELANIIDAE

Gen. *Melanoides*

Melanoides granifera var. *pergranosa* (Nevill.)

Gen. *Melanoides*

Melanoides tuberculatus (Müller)

Fam. PLANORBIDAE

Gen. *Indoplanorbis*

Indoplanorbis exustus (Deshayes)

Crustaceans:

(1) Prawn:

Fam. PALAEMONIDAE

Subfam. *PALAEMONINAE*

Gen. *Macrobrachium lamarrei lamarrei* H.Milne Edwards

(2) Crab:

Class CRUSTACEA

Order DECAPODA

Fam. POTAMONIDAE

Gen. *Paratelphusa* (Paratelphusa)

Paratelphusa (Paratelphusa) *spinigera* Wood Mason

Snake:

Fam. COLUBRIDAE

Subfam. *HOMAPOPSINAE*

Gen. *Enhydrus*

Enhydrus enhydrus Schneider

Insects:

Ord. ODONATA

Subord. *ANISOPTERA*

Nymph of *Anax* sp.

Ord. HEMIPTERA

Subord. *HETEROPTERA*

Fam. NEPIDAE

Gen. *Ranatra*

Ranatra soldidura

Fam. BELASTOMATIDAE

Gen. *Sphaerodema*

Sphaerodema annulatum

Ord. COLEOPTERA

Subord. *ADEPHAGA*

Fam. DYTISCIDAE

Subfam. *CYBISTRINAE*

Gen. *Cybister*

Cybister sp.

Plants:

MONOCOTYLEDONS:

Fam. HYDROCHARIDACEAE

Gen. *Valisneria*

Valisneria sp.

Fam. ARACEAE

Gen. *Pistia*

Pistia stratiotes

DICOTYLEDON:

Fam. EUPHORBIACEAE

Gen. *Croton*

Croton sp.

PTERIDOPHYTA:

Cl. PSILOPHYTINEAE

Ord. PSILOTALES

Gen. *Psilotum*

Psilotum sp.

Six commercially important genera of fishes were selected for seasonal study:

(1) *Puntius*

Puntius stigma is found to occur more or less throughout the year, the other species are mainly restricted to August-October period. Adult specimens of *P. stigma* are found in July-August period.

(2) *Anabas*

Anabas testudineus is found in the catches throughout the year, good numbers are being caught in August-September period. Juveniles were observed to occur during August-September period and again in April.

(3) *Channa*

The four available species of the genus, i.e., *C. punctatus*, *C. gachua*, *C. striatus* and *C. marulius* occurred throughout the year in the catches.

(4) *Mastacembelus*

Mastacembelus pancalus occurs throughout the year, adult specimens being mainly observed during July-August.

(5) *Trichogaster*

Trichogaster fasciatus occurs in good numbers throughout the year. Adult specimens are mainly found in July-August period.

(6) *Heteropneustes*

Heteropneustes fossilis occurs throughout the year, adults occurring in July-August period.

It has been noted that in fishes of the six selected genera, *Puntius* is found to have maximum number of species. In the colouration and meristic data *Puntius* spp. show some variations with Day's description. The presence of the pink lateral band in *P. stigma* seems to be variable seasonally. *Trichogaster* sp. is generally found in two colours—one with grey and bluish stripes and another with pink and grey stripes. Further it has been noted that the pink-grey striped forms fall in smaller length range group than the bluish pink group indicating colour variations with growth of the specimen. *Anabas* sp. shows some variations in colour and counts and *Mastacembelus* sp. in colour. So far *Channa* and *Heteropneustes* have not shown any remarkably variation from previous descriptions. *Channa gachua* is found to occur in smaller numbers in the catches whereas *Channa marulius* and *Channa striatus* occur in larger numbers.

Of the various species of *Puntius*, *P. stigma* is the most common form.

Observations on Ecology

General Ecology:

The Bheri is situated in Beliaghata area and formed due to low embankment of the land. The shape of the Bheri is like a pentagon and the approximate area is 100 acres. It is separated from the other Bheries at the sides by mud bundhs, sufficiently high to prevent water transfer from one to the adjoining Bheri, excepting at the time of heavy rains when the Bheri water level becomes equal with the encircling land. The Bheri is normally fed twice in an year from a canal with factory effluents. But excess mixing of the Bheri water with the sewage even at the time of heavy rains is prevented.

Bheri water is clear, colourless with a salinity value ranging from 0.5 p.p.m. (October-November) to 1.6 p.p.m. (July-August). The water plant, *Pistia stratiotes*, grows in small batches in the Bheri water throughout the year *Valisneria* sp. and *Psilotum* sp. are also found in Bheri water. In early summer (late February and early March) a huge mass of *Pistia* accumulates in the water to cover almost the entire surface so that fishing becomes impossible. Hence these plants are dragged aside by fishermen. In April-May, i.e., pre-monsoon time,

strong wind removes the plants which get accumulated at the banks. Some fishes in trying to avoid fisherman's nets take shelter under the *Pistia* bush resulting in poor catches. Normally juvenile fishes take shelter under this plant and escape fishing; consequently juveniles are found in small numbers in the catches.

So far the size of total catch composition is concerned, a definite seasonal variation is noted. In summer the number of fishes in a catch is quite high. But it declines in winter. Normally in rainy season number of fishes in a catch is good. But in winter rains, the catch size is not high.

Planktological studies:

Plankton is mostly found to contain phytoplankton and that too in the form of blooms. Of the phytoplankton studied the group Chlorophycae (green algae) shows the maximum number of genera followed by Bacillariophyceae (diatoms), Myxophyceae (blue green algae) and Desmidiaceae (desmids). Besides the individual genera identified a non-seasonal phytoplankton bloom formed by blue green algae was observed:

CHLOROPHYTA: This group of algae forms the major part of phytoplankton mass. The genera identified are *Scendesmus, Crucigenia, Microspora, Planktosphaeria, Kirchneviella, Pediastrum, Botryococcus, Protococcus, Ulothrix, Ankistrodesmus, Selenastrum* and *Spirogyra.* Of these *Scendesmus* showed regular occurrence.

BACILLARIOPHYTA: This is the next major group of which the following genera are recorded *Nitzschia, Melosira, Cyclotella, Coscinodiscus, Frustalia, Navicula, Diatoma, Cymbella, Climacoshainia* and *Gyrosigma.* Of these *Melosira, Cyclotella* and *Coscinodiscus* are the comparatively dominant genera.

MYXOPHYTA: This group is represented by the following genera: *Gomosphaeria, Polycystis, Coelosphaerium, Merismopedia, Rivularia* and *Oscillatoria. Merismophedia* and *Oscillatoria* are the most common forms. Beside these, there is a heterogenous bloom formed by blue green algae which is non seasonal.

DESMIDIACEAE: This group is represented by only three genera and hence the smallest group of algae collected from the Bheri water. The genera are *Closterium, Staurastrum* and *Micrasterias,* the last one being the dominant form.

The variety and number of zooplankton collected from the Bheri is comparatively less than phytoplankton. The dominating group is Protozoa. The various groups collected are:

PROTOZOA: *Paramoecium, Euglena, Amoeba, Trinema, Dinobryon* and *Acanthocystis.* Of these *Paramoeciun* is the dominant genus.

ROTIFERS: *Epiphanes, Gastropus, Testudinella* and *Filina* form the rotiferan fauna of the Bheri.

CRUSTACEA: *Nauplius, Cypris, Acroperus,* many other Copepods and Copepodites form the Crustacean fauna. *Nauplius* and *Cypris* are the two dominant groups.

OTHER GROUPS: Occasional occurrence of Gastrotrichs and Nematodes is noted.

SUMMARY

A brief review of freshwater fish work in West Bengal is given and the necessity for ecological work in confined waters of Bengal region with special reference to freshwater fishes is pointed out. A brief account of the observations made on the ecology and fauna of Beliaghata Bheries is presented. The various freshwater fishes occurring in the Bheris are listed and the seasonal occurrence of important commercial species is given.

Ecological observations like the nature of water, other flora and fauna of the Bheris, plankton composition etc., are also presented.

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REFERENCES

BABU RAO, M. and CHATTOPADHYAY, S. K. 1969. Systematic studies on *Mystus* spp. (Pisces: Bagridae) of West Bengal. *J. Bengal nat. Hist. Soc.*, **35** : 86–109.

DAVIS, C. C. 1955. *The marine and freshwater plankton.* Michigan State University Press.

DAY, F. 1878. *The Fishes of India.* Vols. I & II. Dawson, London.

DOWDESWELL, W. H. 1959. *Practical Animal Ecology*, Methuen, London.

HORA, S. L. 1943a. Evidence of distribution of fishes regarding rise in salinity of the river Hooghly. *Curr. Sci.*, **13** (3): 89–90.

HORA, S. L. 1943a. Vegetation in fishery tanks. *Sci. & Cult.*, **9** (4): 146–147.

HORA, S. L. 1943. Vegetation and fishing tanks. *Indian Fmg.*, **4** : 599–601.

HORA, S. L. 1953b. Further evidence from fish distribution of the rise in salinity of the River Hooghly. *Curr. Sci.*, **22** (2): 49–59.

HORA, S. L. 1953j. Rising salinity of the Hooghly river-Fishes provide evidences. *Indian J. Pwr. Riv. Vall. Dev.*, **3** (6): 12–15.

JAYARAM, K. C. 1954. Siluroid fishes of India, Burma and Ceylon. XIV Fishes of the genus *Mystus* Scopoli. *Rec. Indian Mus.*, **51** : 527–558.

NEEDHAM, J. G. and NEEDHAM, R. R. 1962. *A guide to the study of fresh water biology.* London.

PANTULU, V R. 1956. Studies on the biology of the Indian freshwater eel *Anguilla bengalensis* (Grey). *Proc. natn. Inst. Sci. India*, **22** (5): 259–80.

PANTULU, V R. 1961. Determination of age and growth of *Mystus gulio* (Ham.) by the use of pectoral spines, with observations on its Biology and fishery in the Hooghly estuary. *Proc. natn. Inst. Sci. India*, **27** : 1–30.

PANTULU, V R. 1962. On the use of pectoral spines for the determination of age and growth of *Pangasius pangasius* (Ham. Buch.). *J. Cons. perm. int. Explor. Mer.*, **27** : 192–216.

SAROJINI, K. K. 1957. Biology and fisheries of grey mullets of Bengal Biology of *Mugil parsia* (Ham.) with notes on its fishery in Bengal. *Indian J. Fish.*, **4** : 160–207.

SAROJINI, K. K. 1958. Biology and fisheries of the grey mullets of Bengal. Biology of *Mugil cunnesius*. *Indian J. Fish.*, **5** : 56–76.

SHAW, G. E. and SHEBBEARE, E. O. 1937. The fishes of Northern Bengal. *J. R. Asiat. Soc. Beng.*, (*Sci.*) **3** : 1–317.

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REPORT ON THE FAUNISTIC SURVEY (ODONATA) OF THE SOUTH ANDAMAN ISLANDS

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INTRODUCTION

The South Andaman group of islands is situated in between the Middle and Little Andamans in the bay of Bengal. The soil of these islands is mostly loamy clay, except along the shores, where it is sandy. The climate is hot and humid and the rainfall is fairly heavy (about 315 cm. annually). Both South-West (May-September) and North-East (October-December) monsoons occur in these islands.

Having such climatic features, these isolated islands, in the Bay of Bengal, have great economic and Zoogeographic importance. The Zoological Survey of India has conducted a number of surveys of these islands. Fraser (1924) worked out a small collection of Odonata made by Dr. A. Annandale in the year 1923 from Mt. Harriet, South Andaman islands. He reported eleven species including three new species and two new subspecies. These new species and subspecies were again referred to by Fraser in the Fauna of British India, Odonata (volumes 1-3, 1933-1936). The present observations are based on the works done by Fraser and the study of some of the later survey collections which have been worked out by Mrs. G. Chhotani (*nec* Bose), A. R. Lahiri and T. R. Mitra (Mss. stage), the account of which will be published elsewhere. Of these col. R.B.S.Sewell's collection in the year 1928 and Sri B. S. Lamba's collection in the year 1964 are of particular interest.

OBSERVATIONS AND CONCLUSIONS

G. Chhotani *et al* (Mss) have studied collections from 22 different localities from Baratang (12°12'N. and 92°52'E.) in the North to Macpherson strait (11°04'N. to 11°08'N. and 92°37'E. to 92°40'E.) in the South; this gives us a fair picture about the Odonate fauna of South Andamans. Thus, apart from eleven species and subspecies reported by Fraser (1924) twenty more have been found to inhabit these islands as follows:

Suborder I. *ZYGOPTERA*

Family 1. COENAGRIIDAE —12 species

Family 2. AGRIIDAE — 3 species

Suborder II. *ANISOPTERA*

Family 3. AESHNIDAE — 2 species

Family 4. LIBELLULIDAE —14 species

The families Coenagriidae and Libellulidae are the more represented, occupying about 76% of the total number of species present.

Out of 31 species of Odonata occurring in S. Andamans, 5 species are endemic to these islands. Of the remaining ones, three are common with those found in India only; two of these are known to occur in Eastern India only and the other one is fairly distributed throughout the subcontinent. Four are common with those found in Ceylon and Southern India; 10 are common with those distributed all over the Southern Asia; and the rest of the species found in Andamans have a greater range of distribution, *i.e.*, from Africa in the Palaearctic region to Australia through the Oriental region.

This data suggest the existence of a remote land connection between these islands and different parts of the Oriental lands, whereby many of these species got distributed in these islands. During the course of their separate existence over a long period of time, from the cretaceus period, as suggested by Karunakaran (1962) the odonate fauna of these islands have aquired some variations, as a result of which the endemic species have arisen. It is interesting to note that the species do not show any remarkable degree of variation from their representatives found elsewhere. It is expected that some more species of odonata, as well as other facts regarding the species already reported may come to light, if more surveys of these islands are conducted.

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REFERENCES

CHHOTANI, G. (nee BOSE), LAHIRI, A. R. AND MITRA, T. R. Taxonomic studies of the Odonate fauna of Andaman Islands, Indian Ocean. [In manuscript stage].

FRASER, F. C. 1924. Report on a collection of dragonflies (Odonata) from the Andaman Islands. *Rec. Indian Mus.*, **26**(5): 409-414.

FRASER, F. C. 1933. *The fauna of British India.* Odonata. [London] **1**: 1-423.

FRASER, F. C. 1934. *The fauna of British India.* Odonata. [London] **2**: 1-398.

FRASER, F. C. 1936. *The fauna of British India.* Odonata. [London] **3**: 1-461.

KARUNAKARAN, C. 1962. Geology of the Andaman and Nicobar Islands. *Andaman and Nicobar Information* [Port Blair] No. 10. (1962 Pan No.): 64-69; and 75.

Rec. zool. Surv. India, **68**: 367-381, 1975

FIFTY YEARS OF FAUNISTIC SURVEY IN INDIA. HELMINTHOLOGICAL STUDIES AND ZOOLOGICAL SURVEY OF INDIA

By

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The Zoological Survey of India was established as a department of the Government of India in July 1916. Since then the Survey has been actively engaged in studies particularly in the field systematic zoology, field surveys, studies on morphology, anatomy, ecology, distribution, zoo-geography, evolution, etc. In 1969 the Department organised a seminar on fifty years of faunistic survey in India, the junior author as a convenor. The studies made by the Survey in the field of helminthology during the course of last more than fifty years which were presented before the seminar, are dealt with in this paper.

Countries situated in tropical and subtropical regions provide the most optimum conditions for the growth and propagation of helminth parasites. India being in a tropical zone is by no means an exception to this and her helminth fauna are rich both in number and variety. Helminths are mostly endoparasites though a large numbers are ectoparasites and free-living also. They are divided in various broad groups, viz., Trematoda, Cestoda, Nematoda, Acanthocephala, etc. Some of the dreadful diseases such as Schistosomiasis, Fascioliasis, Filariasis, Dracunculiasis, Ankylostomiasis and several other diseases are caused by the infections of various worms which bring untold misery and sufferings to the human beings. Livestock and other animals also fall prey to them. Even agricultural crops, vegetables and flowering plants are not immune from their fierce attacks. Stoll (1947) estimated that 114,400,000 human beings are suffering from Schistosomiasis alone and 32 million people are supposed to be suffering from filarial diseases, throughout the world. Geographical distribution of helminth diseases is even more than that of Malaria, Small pox, Cholera, Typhoid, etc. Therefore, the study of helminths evoked considerable interest from the dawn of civilization. Our Vedic literature bears ample testimony to this. Sushruta in his treatise entitled, 'Krimi Roga Pratisedh' referred to twenty kinds of worms. Charaka and Vab Prakash have also dealt with this group with considerable competance.

Earliest record of helminths in India from modern systematic point of view was made by Gilchrist (1841-1846) in his book entitled 'A practical treatise on the diseases of elephants, camels and horned cattle' He described two types of worms which are possibly *Fasciola jacksoni* and *Pseudodiscus hawkesi*. Cobbold (1882) made the earliest record of Schistosomiasis in India. In a meeting of Medical Chisurgical Society in London, he declared that the cattle and sheeps in India were infected

with schistosomes. Bombford (1886) reported the characteristic schistosome egg—oval with terminal spine, from the transport dept. bullock of Calcutta. He tentatively identified these eggs to be that of *S. haematobium* a parasite of man and monkey. Durjardin (1842), Cobbold (1869-1882), Bomford (1887) Shipley (1903), Gaiger (1906) etc., made sporadic reports of various helminths from India but no systematic surveys were made till recently.

Zoological Survey of India can justifiably be proud for initiating the stimulus and enthusiasm for comprehensive surveys and detailed studies on the helminth fauna of India. Dr. B. Prasad (1918) of this dept., is the first Indian worker to report some helminths from fishes. It is fascinating and very much interesting to trace the history of these studies in Zoological Survey of India by Sewell (1918-22), S. W. Kemp (1919-22), Southwell (1918-26), Chauhan (1945-69), Mukherjee (1960-69), Srivastava (1961-69), Soota (1954-69) and Gupta (1962-69).

R. T. Leiper, head of Bilharzia Mission in Egypt and Middle East first drew the attention of Govt. of India to the possibility of the spread of Schistosomiasis in India through the heavily infected Indian soldiers who were returning back after the First World War from Middle East and South Africa, endemic focus of Schistosome diseases. So the fear of spread of human Schistosomiasis in India became a problem, haunting the parasitologists and medical practitioners from the begining of this century. There were two possibilities to be searched out to confirm if the spread of the Schistosome disease could become a menace in this country. First was to search whether the intermediate mollusc hosts reported in other countries as vectors for schistosomes could be found in India. Secondly, it was to be confirmed also whether the locally available Snails were capable of harbouring the schistosome cerceriae.

Govt. of India initiated a scheme financed jointly by the Education Department and the Indian Medical Research Fund to conduct a survey to know all about the possibilities of the spread of Schistosomiasis in India. In 1918 Zoological Survey of India consisting of four officers only at that time, was invited to assist the medical authorities in their task. This in a way laid the foundation stone for the helminthological research in India in a planned way. Annandale (1918) conducted a survey of the potential mollusc hosts in South India. Kemp and Graveley (1918) started the investigation in the neighbourhood of Hyderabad where more than one hundred soldiers returned from Egypt after First World War were reported to be suffering from schistosomiasis by Dr. A. Lankester, Director of Medical and Sanitation Department, Hyderabad. All together 928 snails were examined, 36 snails were found to harbour fork tailed cercariae of schistosome group. On detailed examination they were found not to belong to human schistosome. 450 snails were exposed to the active miracidium of *Schistosoma haematoboium* obtained from the eggs in the urine of the patients suffering from Schistosomiasis. Results were found to be entirely negative. Efforts to bring the molluscs from the vicinity of Hyderabad to Calcutta were made but most of the snails died in transit, possibly due to the constant vibrations in the train. Ultimately one patient suffering from schistosomiasis was brought to Calcutta. Further experiments were conducted in the laboratories of Zoological Survey of India. Locally available molluscs and some of the living snails brought from different parts of

the country were exposed to the active miracidium obtained from the urine of the said patient. Molluscs of the genera *Melania*, *Amnicola*, *Bithynia*, *Vivipera*, *Pachylabra*, *Lymnaea Planorbis*, *Metania* were tried in this investigation with negative results. Kemp and Graveley (1919) after an exhaustive survey concluded that the intermediate snail hosts reported in other countries belonging to the genus *Bullinus*, *Physopsia* and *Hypsobia* are not represented in India. The other genus *Planorbis* though found in India is not capable of harbouring human schistosome. Annandale and Sewell (1920) continued this work. They surveyed the freshwater gastropods of the Indian empire and Baluchistan. Snails from different districts of Bengal were also exposed to the living miracidium of *S. haematobium*. Results were negative. Sewell (1914) obtained a cercariae from a tank near Russa Road, Calcutta, which he reported to be indistinguishable from the typical cercariae of *S. japonicum* Katsurada except in some variations in length and some other minor characters. This is a very important parasites of man in China and Japan. Sewell described this as *Cercariae indicae* which develops either in *Planorbis exustus* or in *Lymnaea amygdalum*. Ultimately, it was experimentally proved by Rao (1934) that the *Cercariae indicae* actually develops into *Schistosoma nasalis*, a parasite of livestock. It was a great honour for Zoological Survey of India when in 1924 Dr. N. Annandale was invited by the Parasitological Laboratory, Peking Union Medical College to solve the confusion in the identification of Chinese and Japanese snail hosts of *Schistosoma japonicum*. After examining a large collections of snails from China, Japan and Formosa present in the laboratory of Zoological Survey of India, he concluded that all the molluscan hosts reported as the intermediate hosts belonged to a single genus *Oncomelania* Gredler. He suggested to split the genus in two genera, *Katayamae* and *Hemibiae*. Thus a long standing problem of correct identification of intermediate snail hosts of *S. japonicum* had been solved.

Sporadic reports of Schistosome disease were being made from different parts of India against the optimistic view of the workers about the nonpossibility of spread of this disease. Reports by De sa and Monteiro (1949) and, Gadgil and Shah (1952) confirmed beyond doubt that a considerable number of the local population in the village Gimvi, in the Guhagarh Taluka, Ratnagiri District, Bombay, are suffering from Schistosomiasis. Chauhan and Ramakrishna (1954) conducted a survey at the request of the Indian Council of Medical Research, in the village Gimvi, the suspected endemic focus of human Schistosomiasis in this country. After an exhaustive survey they opined the existence of Schistosomiasis was not very new there. Furcocercus cercariae resembling that of *S. haematobium* were found emerging from the locally available mollusc, *Ferrissia tenuis* (Bourg.). Shah and Gadgil (1955-56) and Jhala (1956) obtained from experimental animals in the laboratory the entire worm, *S. haematobium* infecting them with miracidium obtained from the mollusc *Ferrissia tenuis*. This is an epoch making event in the history of Schistosome research as it is in contradiction to the general belief held by specialists that only the planorbid mollusc can act as intermediate host of Schistosomes. Chauhan (1954) obtained two types of bifurcate cercariae, some are regarded as brevicaudate and others as longifurcate. In his opinion the brevicaudates are those of human schistosome and the longifurcate cercariae

are those of some avian schistosome probably belonging to the genus *Ornithobilharzia*. In the final analysis it was felt that further experiments are necessary before finally declaring that the infection at the village Gimvi is by *S. haematobium*. After carefully examining the morphology of characteristic terminal spined eggs and the clinical symptoms of the blood fluke it appeared that if these were not the true cases due to *S. haematobium* it might probably be an infra specific variety or a geographical race, a strain of the type. Chauhan and Chauhan (1956) and Chauhan (1957, 1959, 1963) reviewed in detail the schistosome research in India.

In the foregoing pages an apprisal of the work done by the departmental scientists and the contributions they made for correct diagnosis of schistosomiasis have been made. This is essential to eradicate schistosomiasis, one of the most formidable enemy of human race, which takes a heavy toll in our neighbouring countries such as China, Japan, Formosa, Hongkong, Africa, Phillipine, Madagascar, etc.

Now we shall concentrate on the work done in other fields of helminthology by the departmental scientists and for convenience these works will be dealt groupwise.

Trematoda

Southwell and Prashad (1918) recorded some larval trematodes from fishes of Bengal and described a new species *Clinostomum piscidium* from *Nandus nandus* and *Trichogastor fasciatus*. Sewell (1920) recorded *Mesocoelium sociale* Lühe from *Rana tigrina* from Indian Museum tank and studied the seasonal variations of infection. Sewell (1922) published his monumental work '*Cercariae indicae*' which is still regarded as the most authentic work on the subject done so far. Sewell continued the work of cercariae and in 1930 published a paper tracing the evolution of excretory system in Furcocercus cercariae. Faust (1927) described two strigeids from Kashmir out of some collections sent to him by the Director, Zoological Survey of India. Chauhan (1940) described two new species *Eumegacetes microdiosus* from *Temenuchus pagodarum* and *Prosthogonimus macracetabulus* from *Passer domesticus*. Bhalerao (1942) described *Azygia angusticauda* Stafford 1904—from *Mastacembelus pancalus* out of some collections sent to him from Zoological Survey of India. Chauhan (1943) described a new species *Mehratrema polynemusinis* from marine fishes *Polynemus indicus*, *Muraensox talabunoides* and *Sciaena* sp. Chauhan (1943) studied the gasterostome and described four new species in the family Bucephalidae (Braun, 1883). Chauhan (1945) described six new species belonging to three genera of the family Hemiuridae Lühe, 1901 from marine fishes along with the record of *Stomachicola muraenesocis* Yamaguti, 1934 and transferred *Lecithocladium longicaudum* Shen, 1935 in the genus *Stomachicola*. Chauhan (1945) concentrated on the study of Monogenetic trematodes from the marine fishes for the first time in India in a planned way. In a series of papers (1945, 1950, 1952, 1953) he initiated the studies in this unexplored field of Helminths. Chauhan and Bhalerao (1945) described a new species *Tricocotyle secundus* from dog fish *Scoliodon sorrakowah* and later on in 1945 described it in detail as *Loimos secundus* (Chauhan and Bhalerao, 1945). Chauhan

(1945) established two new genera *Bilateracotyle* with the species *B. chirocentrosus* from the gills of marine fishes *Sciaena belengeri* and *Chirocentrus dorab*. The second genus *Pricea* was established for the reception of three species *P. multae* from *Cybium lanceolatus* and *P. microcotylae* from *Scomber microlepidotus* and *P. minimae* from *Thynnus pelamys*. Chauhan (1945) also described four new forms: *Ancyrocephalus alatus; Lamellodiscus belengeri; Pseudaxone indicana* and *Cyclocotyla multaetesticulae*. The last species was later on transferred to the genus *Choricotyla* and the first one in the genus *Diplectanum*. Elaborate keys for the subfamily *Tetraonchinae* and of the genus *Cyclocotyla* were also included in the paper. A new subfamily *Microcotylinae* was proposed for the reception of *Microcotyle, Bictylophora* and *Centracolpa*. Baugh (1949) described a new species *Psilorchis thapari* from *Athena bramainica*. Chauhan (1950) added two new species *Mazocraeoides prashadi* from Clupeid fishes and *Mazocraes orientalis* also from the same host. In 1952 he reviewed the family Capsalidae and described a new species *Capsala gouri* from *Thynnus thunnin*. Chauhan (1953) reviewed the works on the monogenetic trematodes in India in detail. Chauhan's comprehensive works on the Indian forms of Aspidogastrea, Gasterostomata and Prosostomata published in 1953 are the works of basic reference which stimulated further research in these fields. Hora (1953) studied in detail the possibilities of control of mollusc shell through fish farming with an eye for the control of various trematode diseases of livestock, *viz.*, Fascioliasis, Amphistomiasis, Schistosomiasis, etc. In this paper a very useful table, prepared by Dr. B. S. Chauhan, listing the common helminth paarsites of cattle, goat and sheep in which the molluscs act as intermediate host was included. Chauhan (1955) discussed in detail the taxonomic position and geographical distribution of the fish trematodes *Isoparorchis hypselobagri* Southwell, 1913. Chauhan (1956) reviewed the progress of sciences in India during the years 1935–1950. In the Presidential Address given at the Golden Jubilee Session of Indian Science Congress in 1962 Chauhan traced the development of helminthological research in India and emphasised the need to establish an Institute of Parasitology. Mukherjee and Chauhan (1965) published the fifth part of 'Studies on the trematode fauna of India' in continuation of the series initiated by Chauhan in the year 1953.

Gupta (1959) described a new species *Haematotrephus kashmirensis* from *Himantopus himantopus*. Gupta and Srivastava (1960) published the description of a new species *Fastula chauhani* from *Hilsa illisha*. Srivastava (1961) added two new species in the genus *Phyllodistomum* Braun. 1899 and prepared a host parasite list of the Indian species of the genus. Srivastava (1962) described a new species *Pycnadena komiyai* from *Chela gora*. In 1962 he created a new genus *Rhynchocreadium* to accommodate the species *R. aculeatum* from *Rhynchobdella aculeata*. Mukherjee (1962) described the development and morphology of the miracidium of *Stunkardia dilymphosa* from turtle. Mukherjee (1963) described two new amphistomes from sheep and goat and two new cercariae from freshwater molluscs. Srivastava (1963) added three new species in the genus *Bucephalus* Nicoll, 1914 from freshwater fishes and suggested the synonymy of *Bucephalus indicus* Srivastava 1938 with *B. tridentacularis* Verma, 1936. Srivastava (1963) described a new form *Folliorchis vermai* from *Eutropiichthys vacha*. Mukherjee (1964) described a new

species *Glaphyrostomum indicum* and in 1966 another new species *Prosthogominus elongatus* both from domestic pigeons. Mukherjee (1966) studied the life-history of a common amphistomae of livestock *Fischoederius elongatus* (Poirier, 1883). In 1966 he also redescribed *Calicophron calicophorum* Fischoeder, 1901, *Diplodiscus amphichrus* Tubangui, 1933, *Homalogaster paloniae* Poirier 1883, and added a new species *Calicophoron orientalis* from *Capra hircus*. Mukherjee (1967) added a new species *Mesocoelium burdwanensis* from *Calotes versicolor* and recorded a new metacercaria *Clinostomum orientale* along with the redescription of *C. giganticum* Agarwal 1959. Mukherjee and Ghosh (1967) described two new species *Microphallus dicaecus* and *M. bengalensis* from *Rana tigrina tigrina* and *Artatium schistosomum* respectively. Srivastava and Ghosh (1967) erected a new genus *Paramacrolecithus rasborai* in the family Allocreadiidae from hill stream fish *Rasbora rasbora*. Srivastava and Singh (1967) described *Eucreadium jhingrani* from *Puntius chagunio*. Mukherjee and Ghosh (1968) described *Omnatobrephus bengalensis* n.sp. from *Natrix stolata* with a discussion on validity of different species and prepared a key for the identification of all the species of the genus. Mukherjee and Ghosh (1968) reviewed the genus *Arteyfechinostomum* Lane 1915 and settled a long standing controversy regarding the various allied genus and species. Srivastava (1968) described three new species in the genera *Crowcrocaecum* Skrjabin and Koval, 1956 and *Opegaster* Ozaki, 1928 from *Anguilla bengalensis* and *Mastocembalus armatus*. Srivastava and Ghosh (1968) described a new species *Fellodistomum thapari* and redescribed *F. agnotum* Nicoll, 1909 along with a key for all valid species of the genus. Srivastava and Ghosh (1968) added a new distome from Banded Crait *Bungarus fasciatus* and named it *Encyclometra bungara* with new host records for *Encylometra japonica*. Yoshida et Ozaki, 1929. Soota, Srivastava and Ghosh (1968) studied the collections from Great Nicobar Islands and described four new species *Maculifer spiralis*, *Diacetabulum nicobarensis*, *Acanthoparyphium cambellensis* and *Neodiplostomum elongatum* from fishes and birds.

Cestoda

Southwell and Prashad (1918) initiated the work on parasite of fishes and recorded some cestodes from *Hilsha ilisha* and *Carcharinus gangeticus*. Life-history of a new cestode *Rhynchobothrious ilisha* n.g., n.sp. Southwell and Prashad 1918 was worked out, incidentally this was the first authentic work on the life-history of cestode in India. Southwell and Prashad (1918) provisionally described a new genus *Ilisha parthenogenetica* from *Hilsha ilisha*. Southwell (1930) later found this parasite to be a plecercoid larva which provides the first instance of endogenous reproduction taking place in a plecercoid form. Southwell (1921) recorded a larval cestode from meducae *Acromitus rabanchata*. Southwell (1920) revised the genus *Phyllobothrium* Beneden, 1849. In a series of paper between (1921–1930) Southwell made notable contribution to the study of cestodes. His work on cestode order Pseudophyllidae and Trypanorhyncha are works of reference. He was entrusted to write the, *'Fauna of British India—Cestoda'* Fauna volumes in two parts were published in the year 1930. Chauhan (1949) recorded *Raillietina tetragona* (Molin), *Paronia* sp. from fowls, *Cotugnia cuneata* var *nervosa* Meggitt from pigeon, *Hymenolepis gracilis* (Zeder) and *Hymenolepis*

oweni Moghe from ducks and some other cysts from *Ophiocephalus punctatus*. Chauhan and Ramakrishna (1958) conducted a survey on the *Ligula* infection of fishes in Dams and reservoirs of Damodar Valley Corporation. Chauhan and Ramakrishna (1959) studied the fish mortality due to cestode cysts infection in a tank at Jabalpur (M.P.) and suggested some remedial measures. Mukherjee (1965) described two new species *Anonchotaenia chauhani* and *Choanotaenia srivastavai* both from *Turodoides somervillei*. Mukherjee (1964) added his new species *Choanotaenia dutti* from *Corvus macrorhynchus* and *Choanotaenia sonoti* from *Acridotheres tristis*. Mukherjee (1962) studied extensively large collection of cestodes from Rajasthan and described eight new species and recorded another eighteen species from various vertebrate hosts.

NEMATODA

Dr. N. Annandale, Director, Zoological Survey of India, forwarded a large number of Nematode parasites collected by the various survey parties of the department to Dr. H. A. Baylis. Baylis and Daubney (1922) published their findings—it included fourteen new species and five new genera besides proposing a few new subfamilies and higher taxa. Another lot of collection was sent from Zoological Survey of India to H. A. Stewert for study. After working out part of the collections he forwarded the collection along with his manuscript notes to Baylis and Daubney. They worked out the collection and published the same in the year 1936—it included the descriptions of many known forms along with diagrams. These studies formed the basis for writing, '*Fauna of British India-Nematoda, Part* 1 & 2 published by Baylis in the year 1939. Chauhan (1947) described a new filariid worm *Squamofilaria choprai* from sea-tern. Chauhan (1949) recorded several nematodes from new hosts and localities such as *Porrocaecum pristis* Baylis and Daubney from *Wallago attu*, *Polydelphis sewelai* Baylis and Daubney from *Natrix piscator*, *Ascaridia galli* and *Heterakis gallinae* from fowls and some other nematodes. Soota (1954) recorded some variations in the species *Porrocaecum angusticolle* Baylis and Daubney 1922, *Echinocephalus spinosissimus* Baylis and Lame 1920. Chauhan and Ramakrishna (1958) reviewed the work done in India on Plant parasitic and free-living nematodes and stressed the importance of their studies. Mukherjee (1963) described a new nematode *Philometra rajani* from the ovary of fishes *polynemeus tetradactylus* and *Sciaena coitor*. Majumder (1965) described two new species *Camallinides hemidenta* and *Notopteroides alatae* from *Channa striatus* and *Mastocembalus armatus* respectively. Mukherjee (1967) studied the microfilarial infections in the blood of buffaloes and recorded the period of their maximum concentration. Soota and Chaturvedi (1968) described two new species, *Diplotriaena nepalensis* from *Myiophoneus cheruleus* and *D. mirzapurensis* from *Acridotheres tristis*. Soota, Srivastava and Ghosh (1969) studied the Nematode collections from Great Nicobar Island and described two new species *Ascaridia nicobarensis* from *Psittacula longicaude nicobarica* and *Abbreviata indica* from *Bufo* sp. They have also recorded two known species *Tanqua tiara* (Linstow, 1875) from *Varanus salvator* and *Ophiodascaris filaria* (Duj. 1845) from Python.

ACANTHOCEPHALA

Datta (1927) recorded *Echinorhyuchus* sp. from *Corvus corax* and *C. splendens*. Van Cleave (1929) described two new genera *Eosentis rigidus* n.g., n.sp. from *Schizothorax zarudnyi* and *Filisoma indicum* n.g., n.sp. from *Scatophagus argus*. He also proposed a new family Filisomidae to accommodate the new genus *Filisoma*. This work was made out of some acanthocephalan parasites sent to him from Zoological Survey of India by Dr. N. Annandale and Dr. B. Prashad. Datta (1932) described a new species *Centrorhynchus maryasis* from *Urocissa melanocephala occipitalis* (Blyth.). Datta (1937) worked out the helminth collections of Yale North India Expedition and described four new species *Ancanthocephalus kashmirensis* from *Schizopygopsis stoliczkake*, *Neoechinorhynchus hutchinsoni* from *Diptychus maculatus*, *Eosentis devdevi* from *Schizothorax planifrons*, and *Eosentis yalei* from *Schizothorax esocinus* along with the record of some known species. Datta (1937) described the male *Eosentis rigidis* Van Cleave, 1929 from *Schizothorax zerudnyi*. Datta (1940) described a new genus *Mehrarhynchus prashadi* from *Pangasius pangasius* and in the year 1947 described another new genus *Raosentis podderi* n.g., n.sp. from *Mystus cavasius*. Datta (1954) added a new species *Serrasentis chauhani* from *Psettodes erumei*. Datta and Soota (1954) described two new species *Centrorhynchus knowlesi* from scops owl and *C. bengalensis* from red-backed wood-pecker. Datta and Soota (1954) described a new species *Acanthocephalus kabulensis* from *Rana sp.* and recorded *Centrorhyuchus cinctus* (Rud., 1819) from *Ptyas mucosus*. Soota and Sen (1956) reported a new species *Acanthosentis giuris* from *Glossogobius giuris*. Datta and Soota (1962) added two new species *Filisoma scatophagusi* and *F. hoogliensis* both from *Scatophagusi argus*. Datta and Soota (1963) described a new species *Neoechinorhynchus roonwali* and recorded another species *Pomphorhynchus kashmirensis* both from *Orienus* sp. Soota, Srivastava and Ghosh (1969) worked out the helminth collection of Great Nicobar and described a new species *Mediorhynchus cambellensis* and recorded another species *M. armenicum* Petrochensko.

TREMATODA

ANNANDALE, N. 1924. Studies on *Schistosomiasis japonica*. The molluscan hosts of the human bloodfluke in China and Japan and the species liable to be confused with them. *Amer. J. Hyg. Mong.*, **3**: 269–294.

ANNANDALE, N. and SWELL, R. B. S. 1920. Progress report on the survey of freshwater Gastropod molluscs of the Indian empire and their trematode parasites. *Indian J. med. Res.*, **8** (1): 93–124.

BAUGH, S. C. 1949. On a new avain trematode *Psilorchis thapari* (Fam. Psilostomidae) with a record of *Psilochasmus Oxyrus* (Crep.) from India. *Indian. J. Helminth.*, **1** (2): 79–84.

BHALERAO, G. D. 1943. On two helminths of *Mastacembelus pancalus* (Ham.) including a new record of *Azygia* from India. *Proc. 29th Indian Sci. Cong.* (1942), 152.

CHAUHAN, B. S. 1940. Two new species of Avian trematodes. *Proc. Indian Acad. Sci.*, **12** (3): Sec. B, 75–83.

CHAUHAN, B. S. 1943. Trematodes of Indian marine fishes. Part II. On some trematode of the Gasterostome family Bucephalidae (Braun, 1883) Poche, 1907 with descriptions of four new species. *Proc. Indian Acad. Sci.*, **17** (4): Sec. B, 97–117.

CHAUHAN, B. S. 1943. Trematodes of Indian marine fishes. Part III. Description of a new species of the genus *Mehratrema* (Family Monodhelminthidae Dollfus 1937). *Proc. Indian Acad. Sci.*, **18** (5): 133–137.

CHAUHAN, B. S. 1945. Trematodes of Indian marine fishes. Part I. *Proc. 32nd. Indian Sci. Cong.*, [Abs.] 16.

CHAUHAN, B. S. 1945. Trematodes of Indian marine fishes. Part I. On some new monogenetic trematodes of the suborders Monopisthocotylea Odhner, 1912 and Polyopisthocotylea Odhner, 1912. *Proc. Indian Acad. Sci.*, **21** (3): Sec. B, 129–159.

CHAUHAN, B. S. 1945. Trematodes of Indian marine fishes. Part IV On some trematodes of the Family Hemiuridae, Lühe, 1901, with description of six new forms. *Proc. Indian Acad. Sci.*, **21** (3): 160–173.

CHAUHAN, B. S. 1949. Notes on some helminths in the collection of the Zoological Survey of India. *Rec. Indian Mus.*, **45** (2/3): 133–137.

CHAUHAN, B. S. 1950. Trematodes of Indian marine fishes. Part V Description of a new species of the genus *Mazocreaeoides*. Price, 1936 (Fam. Mazocraeoidae Price, 1936, Diclidophoroidea: Monogenea). *Indian J. Helminth.*, **2** (2): 63–66.

CRAUHAN, B. S. 1950. Trematodes of Indian marine fishes. Part VI. Monogenetic parasites of the Family Mazocraeidae (Diclidophoroidea): Descriptions of a new species of the genus *Mazocraes* Hermann, 1782. *Rec. Indian Mus.*, **48** : 1952, 45–54.

CHAUHAN, B. S. 1952. Trematodes from Indian fishes. Part VII. On Monogenetic parasites of the Family Capsalidae Baird, 1853 (Capsaloidea) from Indian region with description of a new species of the genus *Capsala* Bosc, 1811. *Rec. Indian Mus.*, **46** (1): 45–54.

CHAUHAN, B. S. 1953. Studies on the trematode fauna of India. Part I. Subclass Monogenea. *Rec. Indian Mus.*, **51** : 113–208.

CHAUHAN, B. S. 1953. Studies on the trematode fauna of India. Part II. Subclass Aspidogastrea. *Rec. Indian Mus.*, **51** : 209–230.

CHAUHAN, B. S. 1953. Studies on the trematode fauna of India. Part III. Subclass Digenea (Gasterostomata). *Rec. Indian Mus.*, **51** : 231–287.

CHAUHAN, B. S. 1953. Studies on the trematode fauna of India. Part IV. Subclass Digenea (Prosostomata). A revision of Hemiuroidea from the Indian region. *Rec. Indian Mus.*, **51** : 289–393.

CHAUHAN, B. S. 1953. A brief review of our knowledge of Monogenetic trematodes of the Indian region. *Thapar. Commer. Vol.* **31-40**.

CHAUHAN, B. S. 1955. On the taxonomic position and distribution of the trematode genus *Isoparorchis* Southwell, 1913. *J. zool. Soc. India*, **7** : 87–90.

CHAUHAN, B. S. 1956. Progress of science in India (1935–1950). *Proc. natn. Inst. Sci. India*, Sec. **7** (1): 4–49.

CHAUHAN, B. S. 1956. Progress of science in India (1935–1950). *Proc. natn. Inst. Sci. India*, **7** (5): 170–189.

CHAUHAN, B. S. 1957. Human Schistosomiasis in India. *Dr. Sir Hari Singh Gour Commer. Vol. University of Saugar*, Pt. 1 : 296–306.

CHAUHAN, B. S. 1959. Schistosomiasis in India. *1st All India Congr. Zool.*, 1959: 39.

CHAUHAN, B. S. 1963. Helminthological studies in India. Presidential Address. *Proc. 50th Indian Sci. Congr. Delhi.* Part 2 : 174–185.

CHAUHAN, B. S. and BHALERAO, G. D. 1945. *Tricocotyle secundus*. n.sp. from the gills of the Indian dog fish. (Abstract) *Proc. 32nd Indian Sci. Congr.*, Part III: 98.

CHAUHAN, B. S. and BHALERAO, G. D. 1945. *Loimos secundus* (Monogenea: Trematoda) from the gills of the common Indian dog fish. (*Scoliodon sorrakowah*). *Proc. Indian Acad. Sci.*, Sec. B: **22** (3): 164–167.

CHAUHAN, B. S. and RAMAKRISHNA, G. 1953. *Temnocephala Semperi* Weber, 1870 from the Narmada river with a note on other temnocephalid material in the Zoological Survey of India, Calcutta. *Rec. Indian Mus.*, **51**: 421-425.

CHAUHAN, B. S. and CHAUHAN, Y S. 1956. Schistosomiasis in India. *Proc. Indian Sci. Congr.* [Abs.] **43** : 286.

GUPTA, P. D. 1956. On *Psilorchis mehria* n.sp. (Psilostomidae: Trematoda). *Proc. natn. Acad. Sci.*, **22** (1), Sec. B: 1–5.

GUPTA, P. D. 1957. On *Psilorchcismus indicus* s.np. (Family Psilostomidae: Odhner, 1913). *Parasitology*. **75** (3 & 4): 452–456.

GUPTA, P. D. 1959. On *Haematotrephus kamiharensis* n.sp. (Trematoda: Cyclocoeliidae Kossack, 1911) from Allahabad. *Indian J. Helminth.*, **16** (1): 1–5.

GUPTA, P. D. and SRIVASTAVA, C. B. 1960. On *Faustula chauhani* n.sp. (Family: Fellodistomidae Nicoll, 1913). *Indian J. Helminth.*, **12** : 114–117.

GUPTA, P. D. and SRIVASTAVA, C. B. 1965. On *Cathemasia loossi* n.sp. Tromatoda: Cathaemasiidae). *Indian J. Helminth.*, **17** (1): 63.

HORA, S. L. 1953. Mollusc control through fish farming. *Thapar's Commer. Vol.* 1953: 119–132.

KEMP, S. and GRAVELY, F. H. 1919. On the possible spread of Schistosomiasis in India. *Indian J. med. Res.*, **7** : 251–269.

MOGHE, M. A. and CHAUHAN, B. S. 1946. Blood fluke infection (Schistosomiasis) in cattle, goats and sheep in Central Provinces and Berar and Central India. *Proc. Indian Sci. Congr. Assn.* Pt. 3, Abs. 14 : 121.

MUKHERJEE, R. P. 1962. A study on the development and morphology of the miracidium of *Stunkardia dilymphosa* Bhalerao, 1931 an amphistome parasite of freshwater turtles. *Proc. All India Congr. Zool.*, **2** : 370–374.

MUKHERJEE, R. P. 1963. Studies on two new cercariae from Bareilly, India. *Indian J. Helminth.*, **15** (2): 77–84.

MUKHERJEE, R. P. 1963. On two new species of amphistomes from Indian sheep and goat. *Indian J. Helminth.*, **15** (2): 70–76.

MUKHERJEE, R. P. 1964. *Glaphyrostomum indicum* n.sp. (Brachelaemidae: Trematode) from pigeons. *Indian J. Helminth*, **16** (1): 52–55.

MUKHERJEE, R. P. 1966. On *Calicophoron cauliorchis* (Stiles and Golderger, 1910) Nasmark, 1937 from Indian buffalo. *Indian J. Helminth.*, **18** (1): 1–4.

MUKHERJEE, R. P. 1966. *Prosthogonimus elongatus* n.sp. from pigeon. *Indian J. Helminth.*, **18** (2): 91–93.

MUKHERJEE, R. P. 1966. Studies on the life-history of *Fischoederius elongatus* (Poirier, 1883) Stiles and Goldberger, 1910 an amphistome parasite of cows and buffaloes in India. *Indian J. Helminth.*, **18** (1): 5–14.

MUKHERJEE, R. P. 1966. On some amphistomes of India. *Indian J. Helminth.*, **18** (2): 94–103.

MUKHERJEE, R. P. 1966. Seasonal variations of cercarial infections in snails. *J. zool. Soc. India.*, **18** : 39–45.

MUKHERJEE, R. P. 1967. A new species of trematode of the genus *Mesocoelium* Odhner, 1911 from *Calotes versicolor*. *Indian J. Helminth.*, **19** (2): 188–191.

MUKHERJEE, R. P. 1967. On a new metacercaria *Clinostomum orientale* with a brief description of the metacercaria *Climostomum giganticum* Agarwal, 1959. *Indian J. Helminth.*, 183–187.

MUKHERJEE, R. P. 1968. On two new amphistome cercariae. *Indian J. Helminth.*, **20** (2): 155–166.

MUKHERJEE, R. P. and CHAUHAN, B. S. 1965. Studies on the trematode fauna of India. Part V Subclass Digenea: Paramphistomidae Fishchoeder, 1901. *J. zool. Soc. India*, **17** : 160–225.

MUKHERJEE, R. P. and GHOSH, R. K. 1967. On two trematodes of the genus *Microphallus* Ward, 1901. *Zool. Anz.*, **178** (5/6): 342–347.

MUKHERJEE, R. P. and GHOSH, R. K. 1968. On a new trematode parasite from a common snake, *Natrix stolata* (Linn.). *Proc. Indian Acad. Sci.*, **67** (3): 114–118.

MUKHERJEE, R. P. and GHOSH, R. K. 1968. On the synonymy of the genus *artyfechinostosmum* Lane, 1915 (Trematoda: Echinostoma tidae). *Proc. Indian Acad. Sci.*, **68** (2): 52–58.

RAMAKRISHNA, G. and CHAUHAN, B. S. Description of *Bipalium roonwali* sp. nov. with notes on two other species of the family Bipaliidae from Nilgiris, India. *Rec. Indian Mus.*, **58** : 53–57.

SEWELL, R. B. S. 1919. The possible occurrance of *Schistosoma japonicum* Katsurada in India. *Rec. Indian Mus.*, **16** (6): 425–429.

SEWELL, R. B. S. 1919. Schistosomiasis in India. *Indian med. Gaz.* **54** : 252–253.

SEWELL, R. B. S. 1920. On *Mesocoelium sociale* Lühe. *Rec. Indian Mus.*, **19** : 81–95.

SEWELL, R. B. S. 1922. Cercaria Indicae. *Indian J. med. Res. Suppl.*, No. 3: 1–370.

SEWELL, R. B. S. 1931 Cercariae Nicobaricae. *Indian J. med. Res.*, **18** (3): 785–805.

SEWELL, R. B. S. 1931. A note on *Cercaria anomala* Rao : *Indian J. med. Res.*, **18** (2): 723–726.

SEWELL, R. B. S. 1930. The evolution of excretory system in certain groups of the Furcocercous cercariae. *Rec. Indian Mus.*, **31**(4) : 357–383.

SOOTA, T. D., SRIVASTAVA, C. B. and GHOSH, R. K. 1958. Studies on the helminth fauna of Great Nicobar Island. Part I. Trematoda *Proc. Indian Sci. Congr., Assn.*, Pt. 3:503.

SOUTHWELL, T. and PRASHAD, B. 1918. Notes from the Bengal Fisheries Laboratory. No. 5. Parasites of Indian fishes with a note on carcinome in the climbing perch. *Rec. Indian Mus.* **15**(5): 341-355.

SRIVASTAVA, C. B. 1961. On two phyllodistomes from the urinary bladder of Siluroid fishes (Trematoda: Gorgoderidae). *Indian J. Helminth.*, **13**(2): 93-99.

SRIVASTAVA, C. B. 1962. On *pycnadena komiyai* n. sp. (Trematoda: Allocreadiidae) *Japanese J. med. Sc. Biol.* **15**(5-6): 275-277.

SRIVASTAVA, C. B. 1962. A new Allocreadiid trematode *Rhynchocreadium aculeata* Gen. et sp. nov. from the freshwater eel *Rhynchobdella aculeata* Bloch. *Indian J. Helminth.*, **14**(1): 1-4.

SRIVASTAVA, C. B. 1963. On three new species of the genus *Bucephalus* Baer, 1827 (Trematoda: Bucephalidae Poche, 1907) with remarks on the systematic position of *B. indicus* Srivastava, 1938. *Indian J. Helminth.*, **15**(1): 36-44.

SRIVASTAVA, C. B. 1963. On *Follirchis vermai* sp. nov. (Trematoda: Allocreadiidae) from *Eutropiichthys vacha* (Ham.). *Indian J. Helminth.*, **15**(1): 45-47.

SRIVASTAVA, C. B. 1968. On three new trematode from freshwater eels (Trematoda: Opecoelidae). *Zool. Anz.*, **180**(5/6): 322-328.

SRIVASTAVA, C. B. 1968. A critical study of Verma's "Notes on trematode parasites of Indian Birds" based on his trematode collection. Pt. 1. Families: Diplostomidae and Strigeidae. *J. zool. Soc. India.*, **20**: 59-78.

SRIVASTAVA, C. B. and CHAUHAN, B. S. 1969. On *Pseudocrocodilicola bychowskyi* sp. n. (Trematoda: Proterodiplostomidae) from Indian crocodile, *Gavialis gangeticus. Parazitol. Sobrnik.*, **24**: 244-246.

SRIVASTAVA, C. B. and GHOSH, R. K. 1967. On a new genus *Paramacrolecithus* (Trematoda: Allocreadiidae) from a Cyprinid fish., *Rasbora rasbora* (Ham.). *Proc. Indian Acad. Sci.* B. **66**(5): 179-183.

SRIVASTAVA, C. B. and GHOSH, R. K. 1968. On a new species of the genus *Fellodistomum* Stafford, 1904 with redescription of *F. agnotum* Nicoll, 1909. *Indian J. Helminth.*, **20**(1): 46-52.

SRIVASTAVA, C. B. and GHOSH, R. K. 1968. On *Encyclometra bungara* n.sp. (Trematoda: Plagiorchiidae) from the Indian Banded crait, *Bungarus fasciatus* (Schineider) with a new host records of *E. japonica* Yoshida and Ozaki, 1929. *Indian J. Helminth.*, **20** (2): 132–135.

SRIVASTAVA, C. B. and GHOSH, R. K. 1969. On new hosts of *Prolarioides tropidonotis* Vidyarthi, 1937 (Trematoda: Proterodiplostomidae). *Indian J. Helminth.*, **21** (1): 13–17.

VERMA, S. C. 1936. Notes on trematode parasites of Indian Birds-Pt. 1. *Allahabad Univ. Stud.*, **12** (12): 147–188.

CESTODA

CHAUHAN, B. S. 1947. Notes on some helminths in the collection of Zoological Survey of India. *Rec. Indian Mus.*, **45** (2/3): 133–137.

CHAUHAN, B. S. and RAMAKRISHNA, G. 1959. On the occurance of fish mortality due to helminth infection by cestode cysts in a stocking tank at Nagpur (India). *Indian J. Helminth.*, **10** (1): 53–55.

MUKHERJEE, R. P. 1962. Fauna of Rajasthan. Part 9-Cestoda. *Rec. zool. Surv. India*, **62** (3 & 4): 40–49.

MUKHERJEE, R. P. 1965. On two new species of cestodes from Babbler. *J. zool. Soc. India*, **17** (1 & 2): 32–36.

MUKHERJEE, R. P. 1964. Two cestodes from Passeriformes birds. *Indian J. Helminth.*, **16** (1): 65–70.

SOUTHWELL, T 1920. A revision of the Indian species of the genus *Phyllobothrium*. *Rec. Indian Mus.*, **19** : 1–18.

SOUTHWELL, T 1921. Cestodes from Indian poultry. *Ann. trop. Med. Parasit.*, **15** : 161–166.

SOUTHWELL, T 1921. A new species of cestoda from a Cormorant. *Ann. trop. Med. Parasit.*, **15** : 169–171.

SOUTHWELL, T 1921. Fauna of the Chilka Lake. On a larval cestode from the umbrella of a Jelly Fish. *Mem. Indian Mus.*, **5** : 561–562.

SOUTHWELL, T 1922. Cestodes in the collections of Indian Museum. *Ann. trop. Med. Parasit.*, **16** : 127–152.

SOUTHWELL, T 1922. Cestodes from Indian Birds with a note on *Ligula intestinalis*. *Ann. trop. Med. Parasit.*, **16** : 355–382.

SOUTHWELL, T. 1923. A further note on *Ilisha Parthenogenetica*, a cestode parasite of the India shad. *Rec. Indian Mus.*, **25** : 197–198.

SOUTHWELL, T 1928. Cestodaria from India and Ceylon. *Ann. trop. Med. Parasit.*, **22** : 319–326.

SOUTHWELL, T 1928. Cestodes of the order Pseudophyllidea recorded from India and Ceylon. *Ann. trop. Med. Parasit.*, **22** : 419–448.

SOUTHWELL, T 1929. A monograph on the cestodes of the order Trypanarhyncha from Ceylon and India. *Spolia zeylan,*: 169–312.

SOUTHWELL, T 1930. *Fauna of British India. Cestoda.* Part 1 & 2.

SOUTHWELL, T and HIMLAY, I. S. 1929. On a new species of Phyllobothrium (*Phyllobothrium microstomum*) from an Indian shark. *Ann. trop. Med. Parasit.*, **23** : 381–383.

SOUTHWELL, T and PRASHAD, B. 1918. Notes from the Bengal Fisheries Laboratories. No. 4. Cestode parasites of *Hilsa ilisha* (Ham.). *Rec. Indian Mus.*, **15** (2): 71–88.

SOUTHWELL, T and PRASHAD, B. 1918. Notes from the Bengal Fisheries Laboratory. No. 5. Parasites of Indian fishes with a note on Carcinoma in climbing parch. *Rec. Indian Mus.*, **15** (5): 341–355.

NEMATODA

BAYLIS, H. A. 1939. *Fauna of British India, Ceylon and Burma. Nematoda.* Part 1 & 2. London.

BAYLIS, H. A. and DAUBNEY, R. 1922. Report on the parasitic nematodes in the collection of the Zoological Survey of India. *Mem. Indian Mus.*, **7** : 263–347.

BAYLIS, H. A. and DAUBNEY, R. 1923. A further report on the parasitic nematodes in the collections of the Zoological Survey of India. *Rec. Indian Mus.*, **25** : 551–578.

BAYLIS, H. A. and DAUBNEY, R. 1923. Preliminary descriptions of three new parasitic nematodes. *Ann. Mag. nat. Hist.*, **9**, xi: 333-335.

CHAUHAN, B. S. 1947. Notes on some helminths in the collection of Zoological Survey of India. *Rec. Indian Mus.*, **45**(2/3): 133-137.

CHAUHAN, B. S. 1947. Description of a new filarial worm *Squamofilaria choprai* sp. nov. (Nematoda) from the lung of Sea-tern from Addu Attol, Maldiv Islands. *Rec. Indian Mus.*, **44**(4) 1946. : 367-369.

CHAUHAN, B. S. and RAMAKRISHNA, G. 1958. Our present knowledge of plant parasitic and soil nematodes from the Indian region and importance of their study. *Indian J. Helminth.*, **10**: 64-76.

MAJUMDER, N. 1965. *Camallanides hemidenta* sp. nov. (Nematoda): Camallanidae) occurring in *Channa straitus*. *Zool. Anz.*, **175** (2/3): 222–225.

MAJUMDER, N. 1965. A new nematode *Notopteroides alatae* (Filarioidea: Spiruridae) from a fish in India. *Bull. Syot. Zool.*, **1** (1): 35–37.

MUKHERJEE, R. P. 1963. On a new nematode from the ovary of Indian fishes. *J. zool. Soc. India.*, **15** (1): 76–78.

MUKHERJEE, R. P. 1967. Percentage of microfilarial infections and period of their maximum concentration in the blood of buffaloes. *Indian vet. J.*, **42** (2): 131–133.

SOOTA, T D. 1954. On some variations in the nematode genera *Porrocaecum* and *Echinocephalus*. *Rec. Indian Mus.*, **51** (4): 559–560.

SOOTA T D. and CHATURVEDI, Y 1968. On two nematode species of the genus *Diplotriaena* Railliet and Henery, 1909 from Nepal and India. *J. zool. Soc. India*, **19** (1 & 2): 133–136.

SOOTA, T D. SRIVASTAVA, C. B. and GHOSH, R. K. 1969. Studies on the helminth fauna of Great Nicobar Islands. Pt. II. Nematoda and Acanthocephala. *Proc. 56th Indian Sci. Cong.*, Part III, 504.

ACANTHOCEPHALA

DUTTA, M. N. 1927. On *Echinorhynchus* sp. from the Common crow (*Corvus corax* and *Corvus splendens*). *Proc. 14th Indian Sci. Cong.*, 194.

DUTTA, M. N. 1928. On *Echinorhynchus* sp. inq. from common crows *Corvus corax* and *C. splendens* of Allahabad. *Allahabad Univ. Stud.*, **4** : 41–61.

DUTTA, M. N. 1932. Acanthocephala from North India. II. A new species of *Centrorhynchus* from a himalayan bird *Urocisa melanocephala occipitalis* (Blyth). *Proc. 19th Indian Sci. Cong.*, 261. *Rec. Indian Mus.*, **35** : 325–330.

DUTTA, M. N. 1937. Specific results of the Yale North Indian Expedition Biological Report No. 20. Helminth parasites of fishes from North India, with special refer to Acanthocephalans. *Rec. Indian Mus.*, **38** (2): 211–229.

DUTTA, M. N. 1937. Acanthocephala from India. Description of the male *Eosentis rigidis* Van Cleave occurring in the intestine of *Schizothorax zarudnyi* from Seistan. *Rec. Indian Mus.*, **39** (3): 303–304.

DUTTA, M. N. 1940. Acanthocephala from India. On a new genus of Acanthocephala of the family Rhadinorhynchidae from a local fish *Pangasius pangasius*. *Rec. Indian Mus.*, **42** (1): 81–87.

DUTTA, M. N. 1947. Acanthocephala from India. On a new genus of Acanthocephalan parasite of the Family Quadrigyridae from a Calcutta fish *Mystus cavasius* (Ham.). *Rec. Indian Mus.*, **44** (4): 363–367.

DUTTA, M. N. 1954. On a new species of Acanthocephalan parasite from fishes of Bombay. *Rec. Indian Mus.*, **51** (1): 51–55.

DUTTA, M. N. and PODDER, T N. 1935. Acanthocephalan parasites of certain fishes from Calcutta. *Rec. Indian Mus.*, **37** (2): 231–236.

DUTTA, M. N. and SOOTA, T D. 1955. Two new species of Acanthocephalan parasites of brirds. *Rec. Indian Mus.*, **52** (1): 15–20.

DUTTA, M. N. and SOOTA, T D. 1956. On a new species of the genus *Acanthocephalus* from *Rana* sp. and a new host record of *Centrorhynchus cinctus* (Red.). *Rec. Indian Mus.*, **52** (4): 185–188.

DUTTA, M. N. and SOOTA, T. D. 1962. The new Acanthocephala from the fish, *Scatophagus argus* (Bloch) from India. *Rec. Indian Mus.*, 1960, **58** (2): 67–70.

DUTTA, M. N. and SOOTA, T D. 1963. A new species of Acanthocephala *Neoechinorhynchus roonwali*, from Afganistan and notes on *Pomphorhynchus kashmirensis* Kaw. *Rec. Indian Mus.*, **59** (1 & 2): 35–39.

SOOTA, T D. and SEN, J. K. 1956. On a new species of *Acanthosentis* Verma & Dutta from *Glossogobius giuris* (Hamilton). *Rec. Indian Mus.*, **52** (2-4): 363–365.

SOOTA, T D., SRIVASTAVA, C. B. and GHOSH, R. K. 1969. Studies on the helminth fauna of Great Nicobar Island. Part II. Nematoda and Acanthocephala. *Proc. 56th Indian Sci. Cong.*, Part II, 504.

VAN CLEAVE, H. J. 1929. Two new genera and species of Acanthocephala from fishes in India. *Rec. Indian Mus.*, **30** (2), 1928, 147–149.

Rec. zool. Surv. India, **68** : 383–413, 1975.

FIFTY YEARS (1920-1969) OF FAUNISTIC SURVEY OF RAJASTHAN (INDIA)*

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The political Rajasthan, to which this article is devoted, comprises erstwhile princely states. The rulers of most of these states were interested in wild life for the richness of game found in their areas. Only a few of them got a survey of faunistic wealth conducted. This, in addition to the extreme climate (arid or semi arid) and vast desert areas, seem to have served as restricting factors to attract the attention of earlier zoologists.

The faunistic survey of Rajasthan was done during the past fifty years (1920-1969) by institutions which can be grouped in two broad categories, viz., (i) Zoological Survey of India, and (ii) other organisations.

I. *Surveys conducted by the Zoological Survey of India*

It is a Government of India department established in the year 1916. The Zoological Survey of India started taking interest in Rajasthan (then Rajpootana) since 1941 when the late Dr. B. N. Chopra with Dr. M. L. Roonwal formed the first party to survey the fauna of Ajmer, Dungarpur, Jodhpur and Udaipur district. A concerted effort to have some comprehensive knowledge of the fauna of this area began in 1957 when its Director Dr. M. L. Roonwal, started sending survey parties for specialised collection. Ultimately, the Desert and Gangetic Plains Regional Station was established at Jodhpur in 1960. Since 1965 the Desert Regional Station has been separated from the Gangetic Plains Regional Station established at Patna. Details of the surveys so far conducted by the Zoological Survey are given below, indicating the leader of the party, the duration and areas covered by each party. Appendix 1 shows the main collecting localities visited by the Zoological Survey of India parties from 1941-1969.

*Paper read in the Seminar on "Fifty years of Faunistic survey of India" held at Calcutta in May, 1969.

List of survey parties of the Zoological Survey:

1. Dr. B. N. Chopra, October-November, 1941, Ajmer, Dungarpur, Jodhpur and Udaipur districts.
2. Shri K. S. Pradhan, February-March, 1948, Jodhpur, Sirohi, and Udaipur districts.
3. Dr. B. Biswas, November, 1956-February, 1957, Bikaner, Churu, Jodhpur, Nagaur and Pali districts.
4. Dr. A. K. Mukherji, April-May, 1957, Ajmer, Jaipur (Sambhar Lake area) and Nagaur districts.
5. Dr. K. K. Tiwari, December, 1957-February, 1958, Barmer, Jaisalmer and Jodhpur districts.
6. Dr. A. K. Mukherji, November, 1957-January, 1958, Jaipur (Sambhar Lake area) and Jodhpur districts.
7. Dr. T G. Vazirani, January-July, 1958, Jaipur (Sambhar Lake area), and Nagaur districts.
8. Dr. A. K. Mukherji, July, 1958, Nagaur (Gudah on Sambhar Lake) district.
9. Shri S. Biswas, August, 1958-January, 1959, Nagaur (Gudah on Sambhar Lake) district.
10. Shri R. K. Bhatnagar, June-August, 1960, Jodhpur district.
11. Dr. B. Biswas, August-November, 1960, Bikaner, Ganganagar, Jaisalmer, Jhunjhunu, Nagaur and Sikar districts.
12. Shri R. N. Bhargava, February-March, 1961, Barmer, Bundi, Jaisalmer, Jalore, Kotah, Pali and Udaipur districts.
13. Dr. A. K. Datta, July, November and December, 1961, Pali and Udaipur districts.
14. Dr. A. K. Datta, January, 1962, Bharatpur district.
15. Dr. K. K. Tiwari, January-February, 1962, Bharatpur district.
16. Shri K. K. Mahajan, February-April, 1962, Jaipur (Sambhar Lake area) and Jodhpur districts.
17. Dr. P. D. Gupta, September-November, 1962, Barmer, Bikaner, Jaisalmer and Jodhpur districts.
18. Shri R. N. Bhargava, June-July, 1963, Alwar, Jaipur, Jalore, Jhalawar, Kotah and Sawai Madhopur districts.
19. Shri K. K. Mahajan, 1963, Ajmer, Jaipur, Udaipur, Pali, Jodhpur and Bikaner districts.
20. Dr. V C. Agrawal, March, 1964, Bhilwara, Chittorgarh, Dungarpur, Sirohi and Udaipur districts.
21. Shri K. K. Mahajan, September-October, 1964, Ajmer, Jaisalmer, Jodhpur, Sirohi and Udaipur districts.
22. Dr. P. D. Gupta, September-November, 1964, Ajmer, Chittorgarh, Kotah, Sirohi and Udaipur districts.
23. Shri S. Biswas, August-September, 1965, Ajmer, Bhilwara, Chittorgarh, Kotah, Sirohi and Udaipur districts.

24. Shri Bhola Nath, February, 1966, Kalibangan, Bikaner district, Prehistoric remains of animals.
25. Dr. P. D. Gupta, October, 1966, Barmer, Bikaner and Jaisalmer districts.
26. Dr. P. D. Gupta, February, 1969, Alwar, Bharatpur, Jaipur and Tonk Districts.
27 Regular local survey parties of the Desert Regional Station, Zoological Survey of India, Jodhpur, 1960—upto date, around Jodhpur.

The results of studies of the material collected by these parties led by experts on various groups of animals are in press in a serial form known as "Fauna of Rajasthan, India" (since reading of this paper a number of publications have come out) in the *Records of the Zoological Survey of India*, volume 61 onwards.

II. *Surveys conducted by other agencies*

Following surveys have been conducted by individuals or organisations.

1. Shri H. Whistler (1938) studied birds from Marwar (within Jodhpur State) (now Jodhpur district).
2. Forest Research Institute, Dehradun under Dr. M. L. Roonwal, July-September, 1952, Ajmer, Bikaner, Bundi, Jaipur, Jodhpur, Kotah, Pali and Sawai Madhopur districts.
3. Zoology Department, University of Jodhpur, for free living and plant parasitic nematodes (1965-69).
4. Zoology Department, University of Rajasthan, then located at Jodhpur (1955-60) for reptiles and mammals of western Rajasthan.
5. Bombay Natural History Society organised two surveys of the area (i) From 1911-1929 in connection with its Mammal Survey of India, Burma and Ceylon and (ii) From 1967 onward for migratory birds at Ghana Sanctuary in Bharatpur District.
6. Agricultural Zoology Department, University of Udaipur (1960-64) dealt with mostly insect fauna of Udaipur district.
7. Zoology Department, Birla Institute of Technology and Science, Pilani concentrated its efforts for crustacean and insect fauna of Pilani in Jhunjhunu District.

Jerdon's (1862) account of birds of this area, appears to be the pioneer in the field of Rajasthan zoology. Subsequent to Adams (1899) we find a gradual but sporadically increasing number of references on the fauna of Rajasthan. Recently Gupta (1968 and in press) has reviewed the knowledge about faunal composition of this state, and he has pointed to the groups of animals which have not yet received any attention of zoologists and such other groups which are lesser known from the area.

Impey (1862) was the first author to deal with fossils from this state. He recorded a few ammonites from Jaisalmer area. During this period

of more than a century further fossils have been collected and studied mostly from western districts. These fossils belong to Foriminifera, Ostracoda, Mollusca, Brachiopoda, Echinoidea, Decapoda, Pisces, etc. A paper by this author dealing with a systematic list of the known species along with their geographical and geological distribution is in press.

In order to preserve the coherency of the knowledge about various groups of animals, the account of the living fauna is followed by that of fossils within each group.

Since reading of this paper a number of publications mentioned originally in press have come out. To preserve the originality of text, no change has been made in the text and in the list of references but such references have been marked with an asterisk and completed by giving full details of the publication.

1. *Protozoa*

Bhatia (1936, 38) has reported Ciliophora and Sporozoa respectively then known from the area. Misra (1960) has studied the incidence of opalinids in monitor lizard, *Varanus monitor* Linn., from Bikaner. Mahajan (in press a, b) has contributed to the knowledge of Sarcodina, Flagellata and Ciliata.

Fossil Foraminifera from Bikaner district have been studied by Jacob and Sastri (1950), Jacob, Sastri and Sastri (1952), Singh (1951-57), West (1949), Pascoe (1963) and Bhatia and Khosla (1968). Siddiquie and Iqbaluddin (1963), Siddiquie and Bahl (1965) and Barooah (1946) have recorded a few forms from Barmer district. Chatterji (1960), Hoffman (1962), Poddar (1963), Singh (1955), Subbotina, Datta and Srivastava (1960), Khosla (1967) and Pascoe (1963) devoted their attention to the Foraminifera from Jaisalmer district. As a result of these works more than a dozen new species have been described.

2. *Porifera*

Since Annandale (1911) no further reference is available. However a few unidentified fossil forms have been reported from Jaisalmer by Subbotina, Datta and Srivastava (1960).

3. *Coelenterata*

Unidentified fossil corals were recorded from Kuldhar (Jaisalmer district) by Lubimova, Guha and Mohan (1960).

4. *Bryozoa*

A fossil form, *Polypora ampla* has been reported from Bap (Jodhpur District) by Shah (1963) and other unidentified forms from Jaisalmer by Subbotina, Datta and Srivastava (1960).

5. *Platyhelminthes*

Trematoda: Gupta & Agrawal (1967) have described *Halipegus udaipurensis*. Gupta (in press) has studied these parasites from western Rajasthan.

Cestoda: Southwell (1930 a, b) has included some of the species found in Rajasthan. Rathore, Mathur and Sankarnarayan (1955) have studied cestodes of sheep in Rajasthan. Mukherjee (in press) has given an account of these parasites from western Rajasthan.

6. *Nemathelminthes*

Baylis (1936, 1939) has mentioned many species from this area. Rathore, Mathur and Sankarnarayan (1955) have studied nematodes from sheep. Prakash and Sharma (1955) reported the mortality of hedghogs due to *Trichinella* sp. at Jodhpur. Recently Johnson (1965, 66) has studied nematode parasites of animals. Prasad, Mathur and Sehgal (1959) reported nematodes causing the Molya disease of wheat and barley. Khera (1965-67) has contributed to the knowledge of free living nematodes; Tikyani and Khera (1968 a, b), Tikyani Khera & Bhatnagar (in press) and Kumar and Khera (in press) have studied the nematode parasites of plants. Yadav and Naik (1966) studied the nematodes associated with economic plants of south eastern Rajasthan. Nama and Tikyani (1968) have studied nematodes of certain vegetables of Jodhpur.

7. *Annelida*

Chaetopoda: A few species of earthworms have been recorded by Stephenson (1923).

Hirudinea: Harding & Moore (1927) have described leeches from Rajasthan.

A fossil polychaet, *Nereites* sp. has been recorded from Jaisalmer by Gupta, Srivastava and Agrawal (1966).

8. *Arthropoda*

Crustacea

Lindberg (1942) has studied crustacea of Jodhpur. Brehm (1951) dealt with the fresh water forms. Mathur and Sidhu (1957) reported the occurrence of the genus *Apus* (Notostraca) from Pilani, Sidhu (1959) gave a list of additional forms found near Pilani. Tiwari (1952) has described two new species of the genus *Apus* from southern Rajasthan and he (1959 & 1962b) has described certain other aquatic forms. Ramakrishna (1951) has reported the occurrence of *Paratelphusa (Barytelphusa) jacquemontii* Rathbum., from Dungarpur. Baid (1958) reported *Artemia salina* from Sambhar lake. Biswas (in press) has studied Cladocera of Rajasthan.

Fossil Ostracoda: Barooah (1946) reported *Cythercis* sp. from Nagurda in Barmer district. Jacob and Sastri (1950) studied these forms found in Fuller's earth at Marh near Bikaner. Jacob, Sastry and Sastri (1952) reported a few species from gypsum mines at Jamsar in Bikaner district. Lubimova, Guha and Mohan (1960) studied the material from a few places in Jaisalmer district. Poddar (1963) reported a few species from Kuiala formations near Jaisalmer. Subbotina, Datta and Srivastava (1960) recorded certain unidentified forms from Jaisalmer area.

Fossil Decapoda: Barooah (1950) and Kaul (1951) reported certain unidentifiable forms from Kapurdi. Prasad (1961) reported *Penaeus kapurdi* and Tiwari (1963) has described *Penaeus barmerensis* and *P. glaessneri. Goniocypoda rajasthanica* has been reported from Kapurdi by Glaessner and Rao (1960) and Tiwari (1962a).

Arachnida

Sharif (1928) studied Ixodidae from this area. Tilak (1964) reported *Crossopriza iyoni,* a six legged spider from Pilani. Tikadar (1966) has described three new species of spiders and reported the occurrence of ten other species.

Insecta

General: Mathur, Menon and Rao (1956) and Baid (1959) have studied insect fauna of Pilani. Kundu, Datta Gupta and Gupta (1961) have studied the insect fauna collected with light traps at Pilani. Srivastava (1959) has studied insect pests of maize.

Orthoptera: Dirsh (1951) reported an injurious grasshopper from Ajmer. Venketesh (1968) has given an account of grasshoppers and locusts found in Rajasthan.

Isoptera: Kushwaha (1960 a, b) reported the results of his termite survey around Udaipur. Roonwal and Bose (1960-69) have given a good account of termites of Rajasthan.

Odonata: Fraser (1921-36) has included material from this area along with that of other parts of India.

Thysanoptera: Beeson (1941) has given some information about this group of insects found in Rajasthan. Singh (1950) studied these insects from Ajmer. Ananthakrishnan (1954) provides an account of Thysanoptera of Udaipur. Bhatti (1962, 67) has described *Hyaloptherothrips roonwali* and *Indothrips bhushani* respectively from Jodhpur.

Hemiptera: Kumar (1959) reported *Urentius* species from Pilani. Joseph (1961) studied *Sardia rostrata* Melichor from Ajmer and Mt. Abu. Behura (1963) while summarizing the knowledge of Indian aphids has included those from Rajasthan. Srivastava and Vaish (1964) have reported *Hemaspidoproctus cinereus* Green, a coccid pest of guava from Ajmer, Jaipur and Bharatpur districts.

Lepidoptera: Bell (1909-25) has dealt in detail with the butterflies of India including those from Rajasthan. Bell and Scott (1937) have

similarly dealt with the moths. Macpherson (1927) has described butterflies of Jodhpur and Mt. Abu. Talbot (1939, 47) has again included butterflies of this area. Srivastava (1958) reported a new cutworm pest of potato. Kushwaha (1960) has given an account of lepidopteran fauna of Udaipur. Mathur and Chempakvalli (1961) studied the butterflies of Pilani. Kushwaha, Sharma and Sharma (1964) recorded the occurrence of *Chlumetia transveras* Walker (Noctuidae) a pest of mango at Udaipur.

Coleoptera: Acharya (1938) studied the distribution of *Sternocera nitidicolis* (Fam. Bupoestidae) from Mt. Abu, in Rajasthan and Gujarat. Vazirani (1958) reported a few species belonging to family Grynidae. Kushwaha and Sharma (1961) have studied beetle predators of Udaipur. Srivastava (1961) reported the Lucerne Weevil, *Hypera variabilis* (Hbst.) from south-eastern Rajasthan. Recently, Vazirani (1969 & in press) has studied Dytiscidae beetle fauna of this State. Kapur and Bhaumick (1966) have recorded four species of ladybird beetles one of which is a new record from Indian region.

Hymenoptera: The available references of this group of insects from Rajasthan deal with the period earlier to that under review.

Diptera: The volumes on "*Fauna of British India*" by Brunetti (1920, 23) on Brachycera, and Pipunculidae, Syrphidae, etc., Christophers (1933) on Anophelini, and White, Aubertin and Smart (1940) on Calliphoridae include the material then known from Rajasthan.

9. *Echinodermata*

Fossil Asteroidea: An unidentified form has been reported from Ramgarh by Gupta, Agrawal and Srivastava (1967).

Fossil Echinoidea: The echinoids of Jaisalmer have been studied by Singh (1955), Sahni and Bhatnagar (1958) and Hoffman (1963). Gee (1931), West (1949) and Pascoe (1959) have reported a few species from Marh in Bikaner District. Unidentified forms have been recorded from Kapurdi (District Barmer) by Ghosh (1952) and Tiwari (1962a).

Fossil Crinoidea: Shah (1963) has reported unidentified crinoid stems from Bap.

Fossil Hotothuroidea: Unidentified spines were recorded from Jaisalmer by Subbotina, Datta and Srivastava (1960).

10. *Mollusca*

Gude (1921) has included the material from this state. Recently Ray and Mukherjee (in press) have studied the molluscs of the area.

Fossil Mollusca: Gastropoda have been studied from Bap (Shah, 1963), Dholpur (Pascoe, 1963), and Jaisalmer district by (Hoffman, 1963 and Misra, Srivastava and Jain (1961); and from Marh by West (1949). Lamellibranchia have been studied from Bikaner district by West (1949); from Barmer district by Barooah (1946), Siddiquie and Iqbaluddin (1963), Siddiquie and Bahl (1965) and Tiwari (1966); from Jaisalmer district by Pascoe (1959) and from Dholpur district by Pascoe (1963).

Cephalopoda have been studied from Jaisalmer district by Hoffman (1963), Pascoe (1959), Richter-Bernberg and Schott (1963), Spath (1933), Sahni and Bhatnagar (1958). A single record of *Dentalium* sp. of Scaphopoda is available from Marh (West, 1949).

11. *Brachiopoda*

They are known only through fossils from Jaisalmer district and have been studied by Hoffman (1963), Sahni and Bhatnagar (1955, 58) and Pascoe (1959).

12. *Chordata*

12a. *Pisces*

Hora and Mathur (1952) studied the Palaeo-geographical features of Rajasthan as evidenced by the distribution of fishes. Mathur (1952) contributed to the knowledge of fishes of southern Rajasthan. Krishna and Menon (1958) reported eleven species from Jodhpur. Datta Gupta *et al.* (1961) studied fishes from lakes of this state. Moona (1962) reported 22 species from Bharatpur district. Datta and Majumdar (in press) have studied the fishes of Rajasthan. Mathur and Yazdani (in press) have described *Noemacheilus rajasthanicus* a new species of loach from Jodhpur, and they have separately (in press) recorded *Aplocheilus blochi* (Arnold). Yazdani and Bhargava (in press) have reported *Aphanius dispar* (Ruppell) from Jodhpur district.

Fishes are the highest fossilised organism known mostly through unidentified forms reported by Barrcoah (1950), Glaessner and Rao (1960), Kaul (1951), and White (1952). Tiwari (1969) has described *Kapurdia bhargavai* from Fuller's earth of Kapurdi in Barmer district.

12b. *Amphibia*

McCann (1932) reported some of the Amphibia from this area. Recently Mansukhani, and Murthi (in press) reported altogether eight species found in Rajasthan.

12c. *Reptilia*

Wall (1922) reported the occurrence of *Amblycephalus monticela* near Jaipur and in (1923-25) gave a hand list of snakes including those found in Rajasthan. Krishna and Dave (1956-61) have dealt with the distribution of reptiles found in desert areas of this state. Sunder Singh (1960) studied Ophidia of Pilani.

12d. *Aves*

Stables (1923) reported *Anas platyrhyncha*. Home (1926) recorded *Anas brachyrhynchus* and *A. boscas* from Jaipur. Prater (1926) reported Pallas' Sandgrouse, *Syrrhaptes paradoxyurus* from Bikaner. Simmons (1930) observed pied crested cuckoo, *Coccystes jacobinus* at Ajmer. Acharya

(1931) reported *Clamator jacobinus* Boddaert from northern Gujarat and Rajasthan. Briggs (1932) observed *Tchitrea paradisi*. Singh (1933) recorded Great Crested Grebe, *Podiceps c. cristatus* from Bikaner. Whistler (1938) reported the results of an Ornithological Survey of Jodhpur State.

Lowther (1942-44) has studied some birds found in U.P. and Rajasthan. The Private Secretary to His Highness the Maharaja of Bikaner (1946) reported *Anser fabilis* Barllon from Bikaner. Battye (1947) recorded *Falco jugger* Gray from Mt. Abu. Simmons (1948) reported the occurrence of Cuckoo-shrike, *Lalage sykesii* from Mt. Abu and Ajmer. Biswas (1949) has studied birds of southern Rajasthan. Shivrajakumar (1949) reported woodcock, *Scolopax rusticola* Linn. from Mt. Abu. Grubh, Panday and Shekar (1968a, b) reported *Halcyon pileata* and Greywinged Blackbird, *Turdus boulboul* from Bharatpur. Grubh (1968) has extended the distribution of Greyheaded Lapwing, *Vanellus cinereus* (Blyth) to Rajasthan.

12e. *Mammalia*

Thomas (1923) studied mongoose and rats of the area. Livesay (1922) reported a lion being shot near Kotah. Lindsay (1929) has given the results of his studies on the shrews collected by Mammal Survey of India parties.

Pocock (1936, 37, 40) dealt with foxes, mongoose and otters respectively from this area. Singh (1946) reported the occurrence of an albino boar from Udaipur. Krishna and Prakash (1955) studied distribution of hedgehogs. Gee (1958) has studied 'wild' cattle of Bharatpur. Prakash (1958) dealt with extinct and vanishing mammals of Rajasthan and problems of their preservation. Prakash (1960, 63a, 63b) dealt with the systematics and zoogeography of mammalian fauna of this area.

Recently Gupta and Agrawal (1966) reported Indian hairy-footed gerbill, *Gerbillus gleadowi* Murray from Kolayat, Sikar and Jodhpur. Agrawal (1967) has recorded *Rattus* (*Millardia*) *gleadowi* (Murray) and *Pipistrellus dormeri caurinus* (Thomas) from Jodhpur. Prakash and Jain (1967) reported occurrence of *Rattus meltada* Gray and *Gerbillus dasyurus* from Jodhpur. Biswas and Ghosh (1968) have recorded *Pipistrellus mimus mimus* Wroughton and *Herpestes edwardsi nyula* Hodson from this State.

CONCLUSION

A review of the literature reveals two types of faunistic surveys which need attention of workers on the fauna of Rajasthan. The first category is of those groups of animals like Turbellaria, Monogenetic Trematodes, Acanthocephala, Acarina, Myriapoda and certain orders of Insecta such as Mallophaga, Collembola, etc., which have remained untouched so far. These animals need immediate attention of zoologists. The second category of animals includes such groups like mammals, fishes, reptiles, helminths (digenetic trematodes, cestodes and nematodes) etc., which have been studied from parts of this State but

in order to have a complete picture about the group they should be studied from areas bordering other states. This type of work is likely to reveal the richness of the variety existing in various ecological regions of Rajasthan which has terrains ranging from desert in western parts to hilly and forest areas in southern and south eastern parts. The eastern districts forming the catchment areas of River Yamuna form an ecological area of their own.

Also there is a possibility of getting interesting results from the survey of fauna existing in deep-wells with water level at depths of 80-150 metres. Such wells are found in western districts of Barmer, Bikaner and Jaisalmer. Existence of aquatic life has been confirmed by this author (unpublished).

Attention has also been invited of palaeontologists to the lesser known fossil animal groups like Bryozoa, Coelenterata, Echinodermata and Pisces. A detailed study of these forms should reveal information which could be interesting to both the palaeontologists and the zoologists.

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References

Acharya, H. G. 1938. Distribution of *Sternocera nitidicolis* C. and G. (Buprestidae). *J. Bombay nat. Hist. Soc.*, **40**(3): 579.

Acharya, H. N. 1931. The occurrence of Pied Crested Cuckoo (*Clamator jacobinus* Boddaert) in North Gujarat. *J. Bombay nat. Hist. Soc.*, **35**(2): 458-459.

Adams, A. 1899. The Western Rajputana States. A Medico-Topographical and General Account of Marwar, Sirohi and Jaisalmer. xi+455 pp., 63 pls., London (Junior Army and Navy Stores Ltd.).

Agrawal, V. C. 1967. New Mammal Records from Rajasthan.—*Labdev* (*J. Sci. & Tech.*), **5**(4): 342-344.

Ananthakrishnan, T. N. 1954. New and little known Indian Thysanoptera. *J. zool. Soc. India*, **6**(2): 159-166.

Annandale, N. 1911. *The Fauna of British India, including Ceylon and Burma, Freshwater sponges, Hydroids and Polyzoa*, viii+252+10 (unnumbered) pp., 5 pls. London (Taylor & Francis Ltd.).

Baid, I. C. 1958. Occurrence of *Artemia salina* in Sambhar Lake, Rajasthan. *Curr. Sci.*, **27**(2): 58-59.

Baid, I. C. 1959. Some preliminary notes on the insect life in Sambhar Lake. *J. Bombay nat. Hist. Soc.*, **56**(2): 361-363.

Barooah, S. K. 1946. The occurrence of the Laki series in Jodhpur State. *Curr. Sci.*, **15**(11): 317.

BAROOAH, S. K. 1950. Fossil fish and crabs in the Fullers' earth bed at Kapurdi, Jodhpur, Rajasthan, *Curr. Sci.*, **19**(5): 165.

BATTYE, R. K. M. 1947. Occurrence of the Laggar Falcon (*Falco jugger* (Gray) at Mt. Abu. *J. Bombay nat. Hist. Soc.*, **47**(2): 383-384.

BAYLIS, H. A. 1936. *The Fauna of British India, including Ceylon and Burma. Nematoda.* Vol. 1. (Ascaroidea and Stronguloidea). xxxvi+408+6+2 blank pp., 1 figd map.—London (Taylor & Francis Ltd.).

BAYLIS, H. A. 1939. *The Fauna of British India, including Ceylon and Burma. Nematoda.* Vol. 2. (Filarioidea, Diotophymoidea and Trichinelloidea, xxviii+274+6 p., 1 flagd map.—London (Taylor & Francis).

BEESON, C. F. C. 1941. *The Ecology and control of Forest Insects of India and the neighbouring countries.*—ii+1007 pp., 20 figs., Dehra Dun (Vasant Press).

BEHURA, B. K. 1963. Aphids of India: A survey of published information. In: *Recent Advances in Zoology*; Calcutta (Zoological Survey of India).

BELL, T. R. 1909-25. The common butterflies of the plains of India (Including those met with in the hill stations of Bombay Presidency).

Part 4. *J. Bombay nat. Hist. Soc.*, **19**(1): 16-58, 1 pl. (1909).

Part 5. *J. Bombay nat. Hist. Soc.*, **19**(2): 438-474, 2 pl. (1909).

Part 7. *J. Bombay nat. Hist. Soc.*, **19**(4): 846-879, (1910).

Part 8. *J. Bombay nat. Hist. Soc.*, **20**(2): 279-330, (1910).

Part 9. *J. Bombay nat. Hist. Soc.*, **20**(4): 1115-1136, 1 pl. (1911).

Part 10. *J. Bombay nat. Hist. Soc.*, **21**(2): 517-544. 3 pls. (1912).

Part 11. *J. Bombay nat. Hist. Soc.*, **21**(3): 740-766, (1912).

Part 12. *J. Bombay nat. Hist. Soc.*, **21** (4): 1131-1157, 2 pls. col. (1912).

Part 13. *J. Bombay nat. Hist. Soc.*, **22**(1): 92-100, (1913).

Part 14. *J. Bombay nat. Hist. Soc.*, **22**(2): 322-344, (1913).

Part 15. *J. Bombay nat. Hist. Soc.*, **22**(3): 517-531, 2 pls. (1913).

Part 16. *J. Bombay nat. Hist. Soc.*, **23**(1): 73-103, (1914).

Part 17. *J. Bombay nat. Hist. Soc.*, **23**(3): 481-497, 1 pl. (1915).

Part 19. *J. Bombay nat. Hist. Soc.*, **25**(3): 430-453 (1918).

Part 20. *J. Bombay nat. Hist. Soc.*, **25**(4): 636-664, (1918).

Part 21. *J. Bombay nat. Hist. Soc.*, **26**(1): 98-140, (1918).

Part 22. *J. Bombay nat. Hist. Soc.*, **26**(2): 438-487, 1 pl., (1919).

Part 23. *J. Bombay nat. Hist. Soc.*, **26**(3): 750-769, (1919).

Part 24. *J. Bombay nat. Hist. Soc.*, **25**(4): 941-954, (1920).

Part 33. *J. Bombay nat. Hist. Soc.*, **30**(2): 285-305 (1925).

BELL, T B. D. and SCOTT, F. B. 1937. *The Fauna of British India, including Ceylon and Burma.* Moths. Vol. 5. *Sphingidae.* xviii+538+30 (unnumbered) 8 pp., 15 pls. (12 col.), 1 flgd. map.—London (Taylor & Francis Ltd.).

BHATIA, B. L. 1936. *The Fauna of British India, including Ceylon and Burma. Protozoa: Ciliophora.* xxii+494+22 (unnumbered)+6 pp., 11 pls., 1 flgd. map.—London (Taylor & Francis Ltd.).

BHATIA, B. L. 1938. *The Fauna of British India, including Ceylon and Burma. Protozoa: Sporozoa.* xx+498+4 (unnumbered)+6 pp., 2 col. pls., 1 flgd. map.—London (Taylor & Francis Ltd.).

BHATIA, S. B. and KHOSLA, S. C. 1968. Some smaller foraminifera from the Kirthar beds near Mudh (Rajasthan). *Proc. Symp. natur. Res. Rajasthan,* Jodhpur (University of Jodhpur). Abstr: e 5.

BHATTI, J. S. 1962. *Hyalothrips roonwali,* A new Thripid from India (Thysanoptera: Thripidae). *J. zool. Soc. India,* Calcutta, **14**(2): 176-178.

BHATTI, J. S. 1967. *Thysanoptera Nova Indica.* pp. 1-23, Delhi, Published by the author.

BIKANER: (Private Secretary to H.H. the Maharaja of) 1946. Occurrence of the Pink-footed Goose (*Anser fabalis brachyrhynchus* Baillon) in India; An authentic record. *J. Bombay nat. Hist. Soc.,* Bombay, **46**(1): 185-187.

BISWAS, B. 1949. On a collection of birds from Rajputana. *Rec. Indian Mus.,* **45**(2-3) (1947): 245-265.

BISWAS, B. and GHOSH, R. K. 1968. New records of mammals from Rajasthan, India. *J. Bombay nat. Hist. Soc.,* **65**(2): 481-482.

BISWAS, S. (In press). Fauna of Rajasthan, India. Part 11. Crustacea: Cladocera. *Rec. zool. Surv. India,* **63**(1-2), (1965).

BREHM, V. 1951. Contributions to the freshwater Fauna of India. Part II. *Rec. Indian Mus.,* **48**(1): 9-28, (1950).

BRIGGS, F S. 1932. The migration of the Paradise Fly-catcher (*Tchitrea paradisi*). *J. Bombay nat. Hist. Soc.,* **35**(3): 675-680.

BRUNETTI, E. 1920. *The fauna of British India, including Ceylon and Burma, Diptera, Brachycera* Vol. 1, x+402+8 (unnumbered) pp., 4 pls.—London (Taylor & Francis Ltd.).

BRUNETTI, E. 1923. *The Fauna of British India, including Ceylon and Burma, Diptera,* Vol. 3, *Pipunculidae, Syrphidae, Conopidae, Oestridae,* xii+424+12 (unnumbered) pp., 6 pls.—London (Taylor & Francis Ltd.).

CARTER, H. J. 1862. On contribution to the Geology of Western India, including Sind and Baloochistan. *J. Roy. Asiatic. Soc. Bombay Br.* **6**(21): 161-206.

CHATTERJI, A. K. 1960. On the occurrence of Kirthar in Jaisalmer, Rajasthan. *Proc. 47th Indian Sci. Congr.,* Calcutta, Pt. III: 279.

CHRISTOPHERS, S. R. 1933. *The Fauna of British India, including Ceylon and Burma, Diptera.* Vol. 4. *Family Culicidae, Tribe-Anophelini.* vi+372 pp., 3 pls.—London (Taylor & Francis Ltd.).

*DATTA, A. K. and MAJUMDAR, N. (In press). Fauna of Rajasthan, India, Part 7. Fishes. *Rec. zool. Surv. India*, **62**(1-2): (1964): 63-100, 7 pls. (1970).

DATTA GUPTA, A. K., MENON, P. K. B., NAIR, C. K. G. and DAS, C. R. 1961. An annotated list of fishes of Rajasthan. *Proc. Rajasthan Acad. Sci.*, **8**(1 & 2): 129-134.

DIRSH, Y M. 1951. A new injurious Indian grasshopper (Orthoptera: Acrididae). *Bull. ent. Res.*, **41**(3): 5999-6001.

FERMOR, L. L. 1931. General Report of the Geological Survey of India for the year 1930. *Rec. geol. Surv. India*, **65**(1): 1-60.

FRASER, F. C. 1921. Indian dragonflies. Part 11. *J. Bombay nat. Hist. Soc.*, **28**(1): 107-122.

FRASER, F. C. 1927. Indian dragonflies. Part 28. *J. Bombay nat. Hist. Soc.*, **32**(2): 311-319, 3 pls.

FRASER, F. C. 1933. *The Fauna of British India, including Ceylon and Burma, Odonata* Vol. 1. xiv+424 pp., 1 figd. map. London (Taylor & Francis Ltd.).

FRASER, F. C. 1934, *The Fauna of British India, including Burma and Ceylon, Odonata*. Vol. 2, xxiv+398+12 (unnumbered) pp., 4 pls., (all col.). London (Taylor & Francis Ltd.).

FRASER, F. C. 1936, *The Fauna of British India, including Burma and Ceylon*, Odonata. Vol. 3, xii+462+4 (unnumbered)+6 pp., 2 pls., 1 figd. map. London (Taylor & Francis Ltd.).

GEE, E. P. 1958, Bharatpur 'Wild' Cattle. *J. Bombay nat. Hist. Soc.*, **55**(2): 338-339, 1 pl.

GEE, E. R. 1931, (See Fermor, L.L. 1931).

GHOSH, P. K. 1952. Western Rajputana. Its tectonics and minerals including evaporites. *Bull. natn. Inst. Sci. India*, No. 1: 101-130.

GLAESSNER, M. F. and RAO, R. 1960. A new species of crab from the early Tertiary Fuller's Earth deposits of Kapurdi, Rajasthan, India *Rec. geol. Surv. India*, **86**(4): 675-682.

GRUBH, B. R. 1968. Greyheaded Lapwing *Vanellus cinereus* (Blyth): New record for Rajasthan. *J. Bombay nat. Hist. Soc.*, **65**(2): 484.

GRUBH, B. R., PANDAY, J. D. and SHEKAR, P. B. 1968*a*. Blackcapped Kingfisher, *Halcyon pileata* (Boddaert) at Bharatpur, Rajasthan. *J. Bombay nat. Hist. Soc.*, **65**(2): 486.

GRUBH, B. R., PANDAY, J. D. and SHEKAR, P. B. 1968*b*. Greywinged Blackbird, *Turdus boulboul* (Latham) at Bharatpur, Rajasthan. *J. Bombay nat. Hist. Soc.*, **65**(2): 490.

GUPTA, P. D. 1968. Faunal composition of Rajasthan. *Proc. Symp. natur. Res. Rajasthan.*, Jodhpur (University of Jodhpur) Abstract: b2.

*GUPTA, P. D. (In press) Fauna of Rajasthan, India, Part 8. Trematoda. *Rec. zool. Surv. India*, (1964), **62** (3-4): 171-190 (1970).

GUPTA, P. D. (In press). Fossil fauna of Rajasthan (India). *Rec. zool. Surv. India*, Delhi 66(1-4) (Abstract in *Proc. 55th Indian Sci. Congr.*, Calcutta, Part III: 446.

GUPTA, P. D. (Unpublished). Preliminary survey of deep well Fauna of Rajasthan (India).

GUPTA, P. D. and AGRAWAL, V C. 1966. Distribution of Indian hairy footed gerbil, *Gerbillus gleadowi*. *Sci. & Cult.*, **32**(9): 470-471.

GUPTA, P. D., AGRAWAL, V C. and SRIVASTAVA, M. L. 1967. Fossil Asteroid (Echinodermata) from Ramgarh, Rajasthan (India) *Labdev.* (*J. Sci. & Tech.*), **5**(1): 71.

GUPTA, P. D., SRIVASTAVA, M. L. and AGRAWAL, V C. 1966. Occurrence of *Nereites*, A fossil Polychaet (Annelida in Rajasthan). *Curr. Sci.*, **35**(24): 624.

GUPTA, S. P. and AGRAWAL, V 1967. On a new trematode, *Halipegus udaipurensis*, n.sp. from *Rana cyanophlyctis* from Udaipur, (Rajasthan). *Indian J. Helminth.*, **19**(1): 77-80.

GUDE, G. K. 1921, *The Fauna of British India, including Ceylon and Burma. Mollusca. 3. Land Operculates* (*Cyclophorida, Truncatellidae, Assimineidae, Helicinidae*). xiv+386pp.—London (Taylor & Francis Ltd.).

HARDING, W. A. and MOORE, J. P. 1927. *The Fauna of British India, including Ceylon and Burma. Hirudinea.* xxxviii+302+2 (blank) pp., 9 pls. (4 col.)., 1 figd. map. —London (Taylor & Francis Ltd.).

HOFFMAN, K. 1963. Appendix: Palaeontological determination of fossils. (See Richter-Bernburg and Schott, 1963).

HOME, W. M. L. 1926. The occurrence of the Pink-footed Goose (*Anas brachyrhynchus*) and the mallard (*Anas boscas*) in Jaipur, Rajputana. *J. Bombay nat. Hist. Soc.*, **31**(2): 522.

HORA, S. L. and MATHUR, B. B. L. 1952. On certain palaeogeographical features of Rajasthan as evidenced by the distribution of fishes. *Bull. natn. Inst. Sci. India*, No. 1: 32-36.

IMPEY, 1862. Discovery of Ammoniferous Limestone near Jeyselmer in the Great Desert & C. (see Carter, 1862).

JACOB, K. and SASTRI, V V 1950. Some new Microforaminifera from the Fuller's earth Bikaner, Rajputana. *Sci. & Cult.*, **16**: 80-82.

JACOB, K., SASTRY, M. V A. and SASTRI, V V 1952. A note on the microfossils of the impure gypsum from the Jamser mine, Bikaner, and on the possible origin of the gypsum. *Bull. natn. Inst. Sci. India*, No. 1: 68-69.

JERDON, T C. 1862. *The Birds of India.* Vol I, xv+535 pp. Calcutta (Military Orphan Press).

JOHNSON, S. 1965. Observations on the systematic position of the *genus Gaigeria* Railliet & Henry, 1910 (subfamily Necatorinae Lane, 1907: Family Ancylostomidae Lane, 1907: Nematoda). *Rev. Biol. Trop.*, **13**(2): 213-217.

JOHNSON, S. 1966. On a *Spinitectus* larva (Spiruroidea: Nematoda) from a shrimp (Crustacea) in India. *Indian J. Helminth.*, **18**(1): 49-52.

JOSEPH, A. N. T 1961. Taxonomic notes on *Sardia rostrata* Melichar (Homoptera, Fulgoroidea, Delphacidea (=Araeopidae). *J. Bombay nat. Hist. Soc.*, **58**(1): 48-52, 2 pls.

KAPUR, A. P. and BHAUMIK, A. R. 1966. A note on Lady-Bird beetles (Coleoptera: Coccinellidae) from Rajasthan, with first record of *Bullaea lichatschovi* (Hummel) from India. *Rec. Indian Mus.*, (1961), **59**(4): 445-448.

KAUL, K. N. 1951. A fossil Nariel from Rajputana Desert. *Agriculture & Anim. Husb.* U.P., **2**(3): 9-11, 1 pl.

KHERA, S. 1965. Nematodes from the banks of still and running waters. I. *Tridonatus longicaudatus* n.g. n.sp., Subfamily Diplogasterinae Micoletzky, 1922 from India. *Nematologica*, **11**: 249-254.

KHERA, S. 1966. Nematodes from the banks of still and running waters. III. *Rogerus rajasthanensis* n.sp., Subfamily Cylindrolaiminae and *Monhystrella gracilis* n.sp. Subfamily Monhysterinae from India. *Nematologica*, **12**: 403-408.

KHERA, S. 1967, Nematodes from the banks of still and running waters. V *Tetraocephalus annulatus* n.sp., Family Tetraocephalidae from India. *Indian J. Helminth.*, **19**(2): 97-101.

KHERA, S. 1967. *Acrobelinema cornis* n.g., n.sp., Subfamily Acrobelinae Thorne from rhizosphere of millets from India. *Indian J. Helminth.*, **19**(2): 159-163.

KHOSLA, S. C. 1967. A note on the stratigraphy and microfauna of the Kirthar beds of the Jaisalmer area. *Curr. Sci.*, **36**(24): 670-671.

KRISHNA, D. and DAVE, K. C. 1956. On the distribution of reptiles in the desert of Rajasthan. *Proc. 43rd Indian Sci. Congr.*, Part 4: 34-35 (Abstract).

KRISHNA, D. and DAVE, K. C. 1959*a*. Contributions to the systematics, distribution and ecology of the reptiles of the desert of Rajasthan, with special reference to lizards. Part II. Fossorial habits. *Proc. 46th Indian Sci. Congr.*, Pt. 3. 407-408.

KRISHNA, D. and DAVE, K. C. 1959*b*. Contributions to the systematics, distribution and ecology of the reptiles of the desert of Rajasthan, with special reference to lizards. Part III. Food and feeding habits. *Proc. 46th Indian Sci. Congr.*, Pt. 3: 408.

KRISHNA, D. and DAVE, K. C. 1961. Contribution to the systematics distribution and ecology of the reptiles of the Rajasthan desert with special reference to lizards. Part IV Fossorial habits, Part(iii) Food and feeding habits. *Proc. 46th Indian Sci. Congr.*, Pt. 3: 407-408.

KRISHNA, D. and MENON, C. B. 1958. A note on the fishes of Jodhpur (Rajasthan). *Vigyana Parishad Anusandhan Patrika*, Allahabad, **1**(4): 207-208 (In Hindi).

KRISHNA, D. and PRAKASH, I. 1955. Hedgehogs of the desert of Rajasthan. I. Distribution and fossorial habits. *J. Bombay nat. Hist. Soc.*, **53**(1): 38-43.

KUMAR, C. N. and KHERA, S. (In press). Plant parasitic nematodes from the rhizosphere of pearl millet (*Pennisetum typhoides*) in Rajasthan (India). *Pl. Dis. Rptr.*

*KUMAR, C. N. and KHERA, S. (In press) *Paurodontus abberans* n.sp. (Tylenchida, Nematoda) with the note on the branch of the oviduct. *Indian J. Helminth.*, **21**(1): 1-5 (1969).

KUMAR, R. 1959. On a *Urentius* species (Tingididae) Heteroptera from Pilani (Rajasthan) *Proc. 46th Indian Sci. Congr.*, pt. **3**: 389.

KUNDU, H. L., DATTA GUPTA, A. K. and GUPTA, B. B. 1961. A study of abundance of certain insects of Pilani with the help of a light trap. *Proc. Rajasthan Acad. Sci.*, **8**(1 & 2): 79-87.

KUSHWAHA, K. S. 1960*a*. A survey of termite fauna (Insecta; Isoptera) around Udaipur (Rajasthan). *Proc. 47th Indian. Sci. Congr.*, Pt. **3**: 455.

KUSHWAHA, K. S. 1960*b*. Common lepidopteran fauna of Udaipur, including several common pests of Rajasthan, together with brief notes of their infestation. *Proc. 47th Indian Sci. Congr.*, Pt. 3: 455.

KUSHWAHA, K. S., SHARMA, J. C. and SHARMA, L. S. 1964. A note on Mango shoot Borer, *Chlumetia transversa* (Lepidoptera: Noctuidae). *Indian J. Ent.*, **25**(1): 115-117, 3 figs.

KUSHWAHA, K. S. and SHARMA, L. S. 1961. Some common beetle predators (Insecta: Coleoptera) of Udaipur (Rajasthan), with brief notes on their seasonal occurrence and habitat. *Proc. 48th Indian Sci. Congr.*, Pt. **3**: 427.

LINDBERG, K. 1942. Crustaces de l'etat de Djodhpour (Rajpoutana). *Rec. Indian Mus.*, **44**(3): 341-345.

LINDSAY, H. M. 1929. Scientific Results from the Mammals survey No. 68. Indian shrews. *J. Bombay nat. Hist. Soc.*, **33**(2): 326-340.

LIVESAY, T R. 1922. The Indian Lion. *J. Bombay nat. Hist. Soc.*, **28**(3): 795.

LOWTHER, E. H. N. 1942. Notes on some Indian birds. Part 7. *J. Bombay nat. Hist. Soc.*, **43**(3): 389-401, 8 pls.

LOWTHER, E. H. N. 1944*a*. Notes on some Indian birds. Part 8. *J. Bombay nat. Hist. Soc.*, Bombay, **45**(3): 355-373, 12 pls.

LOWTHER, E. H. N. 1944*b*, Notes on some Indian birds. Part 9. *J. Bombay nat. Hist. Soc.*, **45**(1): 5-16, 10 pls.

LUBINOVA, P. S., GUHA, D. K. and MOHAN, M. 1960. Ostracoda of Jurassic and Tertiary deposits from Kutch and Rajasthan (Jaisalmer) India.—*Bull. geol. Min. Met. Soc. India*, No. 22: 1-60.

MACPHERSON, A. D. 1927. Notes on a collection of butterflies made in Jodhpur and Mount Abu during the years 1924, 1925 and 1926. *J. Bombay nat. Hist. Soc.*, **32**(1): 228-230.

*MAHAJAN, K. K. (In press). Fauna of Rajasthan, India, Part 2. Protozoa (No. 1). *Rec. zool. Surv. India*, (1963). **61**(3-4): 377-402 (1969).

MAHAJAN, K. K. (In press). Fauna of Rajasthan, India. Part 10. Protozoa. (No. 2). *Rec. zool. Surv. India*, **63**(1 & 2) (1965).

*MANSUKHANI, M. B., and MURTHI, T S. N. (In press). Fauna of Rajasthan, India. Part 6. Amphibia. *Rec. zool. Surv. India*, (1964); **62**(1-2): 51-60, 1 pl. (1970).

MATHUR, B. B. L. 1952. Notes on fishes from Rajasthan, India. *Rec. Indian Mus.*, **50**(1): 105-110.

*MATHUR, D. S. and YAZDANI, G. M. (In press), Occurrence of *Aplocheilus blochii* (Arnold) in Rajasthan. *Labdev (J. Sci. & Tech.)*, (1969) B, **7**(1): 77.

MATHUR, D. S. and YAZDANI, G. M. (In press). *Noemacheilus rajasthanicus* a new species of loach from Rajasthan (India) *J. zool. Soc. India.*

MATHUR, S. N. and CHEMPAKVALLI, K. R. 1961. Butterflies of Pilani. *Proc. Rajasthan Acad. Sci.*, **8**(1 & 2): 135-139.

MATHUR, S. N., MENON, K. B. and RAO, S. R. V 1956. Insect fauna of Pilani. *Proc. Rajasthan Acad. Sci.*, **6**: 20-23.

MATHUR, S. N. and SIDHU, N. S. 1957. Occurrence of *Apus* (Crustacea: Notostraca) in Pilani, Rajasthan. *J. Bombay nat. Hist. Soc.*, **54**(4): 961-962.

MCCANN, C. 1932. Notes on Indian Batrachians. *J. Bombay nat. Hist. Soc.*, **36**(1): 152-180.

MISRA, J. S., SRIVASTAVA. B. P. and JAIN, S. K. 1961, Discovery of Marine Fermocarboniferous in the W. Rajasthan. *Curr. Sci.*, **30**(7): 262-263.

MISRA, P. L. 1960. Incidence of opalinid infections in certain monitor lizards. *J. zool. Soc. India*, **12**(2): 201-208.

MOONA, J. C. 1962. Notes on fishes from Bharatpur District, Rajasthan. *Rec. Indian Mus.*, **58**(2): 59-66, 1 fig.

MUKHERJEE, R. P. (In press). Fauna of Rajasthan, India. Part 9. Cestoda. *Rec. zool. Surv. India*, (1964), **62**(3-4): 191-216. (1970).

NAMA, H. S. and TIKYANI, M. G. 1968. Nematode pests of certain vegetables of Jodhpur. *Proc. Symp. natur. Res. Rajasthan*, Jodhpur (University of Jodhpur). Abstract: b 13.

PASCOE, E. H. 1959. *A mannual of the Geology of India and Burma.* Vol. II. pp. 486-1344+1 map., Delhi (Govt. of India).

PASCOE, E. H. 1963. *A mannual of Geology of India and Burma.* Vol. III. xxiv+1345—2130+1 map, Delhi (Govt. of India).

POCOCK, R. I. 1936. The foxes of British India, including Ceylon and Burma. *J. Bombay nat. Hist. Soc.*, **39**(1): 36-57.

POCOCK, R. I. 1937. The mongoose of British India, including Ceylon and Burma. *J. Bombay nat. Hist. Soc.*, **39**(2): 211-245.

POCOCK, R. I. 1940. Notes on some British Indian otters, with descriptions of two new subspecies. *J. Bombay nat. Hist. Soc.*, **41**(3): 514-517.

PODDAR, M. C. 1963. Geology and oil possibilities of the Tertiary Rocks in Western India. *Proc. IInd Symp. on Dev. of Petr. Res. of Asia and Far East. Mineral Resources Div. Ser.*, New York, No. 18, vol. I: 226-230.

PRAKASH, I. 1958. Extinct and vanishing mammals from the desert of Rajasthan and the problem of their preservation. *Indian For.*, **84**(10): 642-645.

PRAKASH, I. 1960. New mammal records and zoogeography of mammals in Rajasthan desert. *Proc. 47th Indian Sci. Congr.*, Pt. 3: 488-489.

PRAKASH, I. 1963*a*. Taxonomic and biological observations on the bats of the Rajasthan desert. *Rec. Indian Mus.*, **59**(1 & 2): 149-170 (1961).

PRAKASH, I. 1963*b*. Taxonomical and ecological account of the mammals of Rajasthan desert. *Ann. Arid Zone*, **1**(2): 142-162.

PRAKASH, I. and JAIN, A. P. 1967. Occurrence of *Rattus meltada* and *Cerbillus dasyurus* in the Rajasthan desert. *Ann. Arid Zone*, **6**(2): 235.

PRAKASH, I. and SHARMA, S. C. 1955, Nematodes and hedgehog mortality. *J. Bombay nat. Hist. Soc.*, **53**(1): 123.

PRASAD, K. N. 1961. Decapoda Crustacea from the Fuller's Earth's deposits of Kapurdi (Rajasthan). *Indian Min.*, **15**: 435.

PRASAD, N., MATHUR, R. S. and SEHGAL, P. S. 1959. Molya disease of wheat and barley in Rajasthan. *Curr. Sci.*, **28**: 453.

PRATER, S. H. 1926. On the occurrence of Pallas' Sandgrouse (*Syrrhaptes paradoxurus*) within Indian limits. *J. Bombay nat. Hist. Soc.*, **31**(2): 522.

RAMAKRISHNA, G. 1951. Notes on some Indian Potamonid crabs (Crustacea: Decapoda). *Rec. Indian Mus.*, **48** (2): 89-92.

RATHORE, G. S., MATHUR, P. D. and SANKARNARAYAN, N. S. 1955. *Haemonchosis* in sheep in Rajasthan and its control. *Indian J. vet. Sci. & Anim. Husb.*, **25**(1): 1-16.

RAY, H. C. and MUKHERJEE, A. (In press). Fauna of Rajasthan, India, Part 3. Mollusca. *Rec. zool. Surv. India*, (1963), **61**(3-4): 403-436, 3 pls. (1969).

RICHTER-BERNBURG, G. and SCHOTT, W. 1963. Jurassic and Cretaceous at the western border of the Gondwana shield in India, and the stratigraphy and oil possibilities. *Proc. 2nd Symp. Dev. Petr. Res. of Asia and the Far East. Mineral Resources Division Ser.*, New York, No. 18, Vol. 1: 230-236.

ROONWAL, M. L. and BOSE, G. 1960. A new termite *Psammotermes rajasthanicus* sp. nov. from Rajasthan, India. *Sci. & Cult.*, **26**(1): 38-39.

ROONWAL, M. L. and Bose, G. 1964. Termite fauna of Rajasthan, India. *Zoologica*, B. 40: Lf. 3, Mf. 113: vi+58 pp., 5 pls.

*ROONWAL, M. L. and BOSE, G. (In press). Fauna of Rajasthan, India Part 4. A check list of Rajasthan termites (Insecta: Isoptera). *Rec. zool. Surv. India.*, (1963), **61** (3-4): 437-449, 4 pls. (1969).

SHAH, S. C. 1963. Marine Permian fauna from Bap Boulder bed, Rajasthan. *Indian Min.*, **17**(2): 195-197.

SAHNI, M. R. and BHATNAGAR, N. C. 1955. New fossils from the Jurassic rocks of Jaisalmer, Rajasthan. *Curr. Sci.*, **24**(6): 187.

SAHNI, M. R. and BHATNAGAR, N. C. 1958. New fossils from the Jurassic rocks of Jaisalmer. *Rec. geol. Surv. India*, **87**(2): 418-437.

SHARIF, M. 1928. A revision of the Indian Ixodidae with special reference to the collection in the Indian Museum. *Rec. Indian Mus.*, **30**(2): 217-334, 2 pls.

SHIVKUMAR, Y S. 1949. Occurrence of the woodcock (*Scolopax rusticola* L) at Mount Abu. *J. Bombay nat. Hist. Soc.*, **48**(3): 585.

SIDDIQUI, H. N. and BAHL, D. P. 1965. Geology of the Bentonite deposits of Barmer District, Rajasthan. *Mem. geol. Surv. India* (1962) **96**: 1-96, pls. 1-13.

SIDDIQUI, H. N. and IQBALUDDIN, 1963. On the occurrence of Palaeocene and Eocene bed in the Barmer District: Rajasthan—*Curr. Sci.*, **32**: 575.

SIDHU, N. S. 1959. Identification of certain crustaceans collected from rainwater pools near Pilani, Rajasthan. *J. Bombay nat. Hist. Soc.*, **56** (1): 159.

SIMMONS, R. M. 1930. Migration of the Pied Crested Cuckoo (*Coccystes jacobinus*). *J. Bombay nat. Hist. Soc.*, **3**(1): 252-253.

SIMMONS, R. M. 1948. On the occurrence of the Black-headed Cuckoo-shrike (*Lalage sykesii*) at Ahmedabad, Abu Road, and Ajmer. *J. Bombay nat. Hist. Soc.*, **47**(4): 734-736.

SINGH, R. D. 1946. An albino boar. *J. Bombay nat. Hist. Soc.*, **46**(3): 542-543.

SINGH, S. 1933. Occurrence of the Great Crested Grebe (*Podiceps cristatus cristatus*) in Bikaner. *J. Bombay nat. Hist. Soc.*, **36**(3): 753.

SINGH, S. N. 1951. Kirthar Foraminifera from Rajasthan. *Curr. Sci.*, **20**(9): 230.

SINGH, S. N. 1952. On the extension of Kirthar sea to Rajasthan. *Proc. natn. Acad. Sci. India*, B, **22**(1): 7-10.

SINGH, S. N. 1953*a*. Geology of area WSW of Marh village near Kolayat, Bikaner, Rajasthan. *Proc. natn. Acad. Sci. India*, B, **23**(1-3): 13-20.

SINGH, S. N. 1953*b*. Species of the genus *Linderina* from the Kirthars of Kolayat, Bikaner, Rajasthan, India. *Proc. natn. Acad. Sci. India*, B. 23(1-3): 21-28.

SINGH, S. N. 1953*c*. Foraminiferal Genera and species from the Kirthars near Kolayat (Bikaner) Rajasthan. *Proc. 40th Indian Sci. Congr.*, Pt. III. 25-26.

SINGH, S. N. 1955. On the Laki formation near Khewarisar (Rajasthan). *Proc. 42nd Indian Sci. Congr.*, Pt. III: 182.

SINGH, S. N. 1957. Two aberrant types of Nummulitidae from the Eocene of Rajasthan, India. *J. Palaeont. Soc. India*, **2**: 208-212.

SINGH, SUMSHER, 1950. Studies on Indian Thysanoptera. II. *Rec. Indian Mus.*, **45**(2-3): 201-206.

SOUTHWELL, T 1930*a*. *The Fauna of British India, including Ceylon and Burma. Cestoda.* Vol. I, xxxii+392 pp., 1 figd. map. London (Taylor & Francis Ltd.).

SOUTHWELL, T. 1930*b*. *The Fauna of British India, including Ceylon and Burma. Cestoda.* Vol. 2., x+262 pp. London (Taylor & Francis Ltd.).

SPATH, L. F. 1933. Revision of the Jurassic Cephalopod Fauna of Kutch (Cutch). *Pal. India New Ser.*, **9**, Mem. 2., Pt. 6, 639-945, pls. 126-131.

STEPHENSON, J. 1923. *The Fauna of British India, including Ceylon and Burma. Oligochaeta.* xxiv+518+2 (blank) pp. London (Taylor & Francis Ltd.).

SRIVASTAVA, B. K. 1958. A new cutworm pest of potato in Rajasthan. *Curr. Sci.*, **27**(12): 503-504.

SRIVASTAVA, B. K. 1959. Insect pests of maize in Rajasthan. *J. Bombay nat. Hist. Soc.*, **56**(3): 665-668.

SRIVASTAVA, B. K. 1961. Discovery of the Lucerne Weevil, *Hypera variabilis* (Hbst.), from south-east plateau of Rajasthan. *Indian J. Ent.*, **21**(2) (1959): 143-144.

SRIVASTAVA, B. K. and VAISH, O. P. 1964. *Hemaspidoproctus sinereus* Green, A new coccid Pest of Guava. *Indian J. Ent.*, **26**(1): 117-118.

STABLES, R. H. 1923. The occurrence of the mallard (*Anas platyrhyncha*) in Rajputana *J. Bombay nat. Hist. Soc.*, **29**(1): 277.

SUBBOTINA, N. N., DATTA, A. K. and SRIVASTAVA, B. N. 1960. Foraminifera from the upper Jurassic deposits of Rajasthan (Jaisalmer) and Kutch, India. *Bull. geol. Min. Soc. India*, No. 23: 1-48.

SUNDERSINGH, P. P. H. 1960. Reptilian fauna of Pilani with a note on the food contents. Part 1. Ophidia. *Proc. Rajasthan Acad. Sci.*, **7**: 52-59.

TALBOT, G. 1939. *The Fauna of British India, including Ceylon and Burma. Butterflies.* (2nd ed.). Vol. 1, xxx+600+6 (unnumbered)+6 pp., 3 pls. (all col.)., 1 figd. map. London (Taylor & Francis Ltd.).

TALBOT, G. 1947. *The Fauna of British India, including Pakistan, Ceylon and Burma. Butterflies.* (2nd ed.). Vol. 2, An errata slip regarding title+xvi+506+4 (unnumbered) pp. 2 pls. (Both col.). London (Taylor & Francis Ltd.).

THOMAS, O. 1923. Scientific Results from the mammal survey No. 42. The distribution and geographical races of the gulandi bush rats (*Golunda ellioti*). *J. Bombay nat. Hist. Soc.*, **29**(2): 373-377.

TIKADER, B. K. 1966. On a collection of Spiders (Araneae) from the desert areas of Rajasthan (India). *Rec. Indian Mus.*, (1961), **59**(4): 435-444.

TIKYANI, M. G. and KHERA, S. 1968*a*. A survey of plant parasitic nematodes around the roots of great millet (*Sorghum vulgare* Pers.) from Rajasthan, India. *Plant. Dis. Reptr.*, **52**: 396-398.

TIKYANI, M. G. and KHERA, S. 1968*b*. *Neopaurodontus asymmetricus* n.g., n.sp. (Nematoda: Paurodontinae) from rhizosphere of great millet. *Indian J. Helminth.*, **20**(1): 34-39.

*TIKYANI, M. G., KHERA, S. and BHATNAGAR, G. C. (In press) *Helicotylenchus goodi* n.sp. from rhizosphere of great millet. *Zool. Anz.*, **18**(5-6): 420-423 (1969).

TILAK, R. 1964. A six legged spider of the family Pholeidae (Arachnida). *Sci. & Cult.*, **30**(4): 206-207.

TIWARI, K. K. 1952. Indian species of the genus *Apus* (Crustacea, Branchiopoda) with description of two new species. *Rec. Indian Mus.*, **49**(2): 197-205, (1951).

TIWARI, K. K. 1959. New species of Conchostraca (Crustacea: Phyllopoda) from Rajasthan. *Abstract of Papers 1st All India Congr. Zool.*, 18 (Fuller paper in *Proc.*, Pt. 2, 1962; pp. 180-190).

TIWARI, K. K. 1962*a*. Occurrence of a fossil Penaeid prawn in the Fuller's Earth deposits of Kapurdi (Barmer District), Rajasthan. *Sci. & Cult.*, **28**(5): 244-245.

TIWARI, K. K. 1962*b*, New species of Conchostraca (Crustacea: Phyllopoda) from Rajasthan. *Proc. 1st All-India Congr. Zool.*, Pt. 2 (Sci. Papers). 180-190.

TIWARI, K. K. 1963. Lower Tertiary penaeid snrimps from Kapurdi (Barmer District, Rajasthan, India). *Crustaceana*, **5**: 205-212. 2 pls.

TIWARI, K. K. 1966. A new species of *Nuculana* Link (Mollusca: Bivalvia) from Lower Eocene Fuller's earth deposits of Kapurdi, Rajasthan (western India). *Ann. Mag. nat. Hist. Ser.*, **13**, 9: 161-165.

TIWARI, K. K. 1969. A new fossil percoid fish from the Lower Tertiary Fuller's earth deposits of Kapurdi, Barmer District, Rajasthan. *J. zool. Soc. India*, Calcutta, **20**(1 & 2): 95-103 (1968).

VAZIRANI, T G. 1958. On a collection of Gyrinidae (Coleoptera) in the Zoological Survey of India, with the descriptions of two new species. *Rec. Indian Mus.*, **53** (1-2): 13-17 (1955).

VAZIRANI, T G. 1969. Contributions to the study of aquatic beetles (Coleoptera) 2. A review of the subfamilies Noterinae, Laccophilinae, Dytiscinae and Hydroporinae (in part) from India. *Orient. Ins.*, **2**(3-4): 221-324.

*VAZIRANI, T G. (In press). Fauna of Rajasthan, India, Part 5. Aquatic Beetles (Insecta: Coleoptera: Dytiscidae). *Rec. zool. Surv. India*, (1964), 62(1-2): 29-50, 1970).

VENKETESH, M. 1968. Some grasshoppers and locusts of Rajasthan. *Proc. Symp. natur. Res. Rajasthan*, Jodhpur: 64 (Abstract).

WALL, F 1922. A review of the Indian species of *Amblycephalus*. *Rec. Indian Mus.*, **24**(1): 19-27.

WALL, F. 1924. A hand-list of snakes of the Indian Empire. Part 3. *J. Bombay nat. Hist. Soc.*, **29**(4): 864-878.

WALL, F. 1924. A hand-list of snakes of the Indian Empire. Part 4. *J. Bombay nat. Hist. Soc.*, **30**(1): 12-24.

WEST, W. D. 1949. General Report of the Geological Survey of India for the year 1948. *Rec. geol. Surv. India*, **82**(1): 1-258.

WHISTLER, H. 1938. The ornithological survey of Jodhpur State. *J. Bombay nat. Hist. Soc.*, **40**(2): 213-235.

WHITE, E. I. 1952. Sharks tooth from a boring near Gunga, Jodhpur State, (see Ghosh, P. K. 1952).

WHITE, R. S., AUBERTIN, D. and SMART, J. 1940, *The Fauna of British India, including remainder of the Oriental region. Diptera.* Vol. 6. *Family, Calliphoridae.* xiv+288+6 pp., 1 figd. map. London. (Taylor & Francis Ltd.).

YADAV, B. S. and NAIK, S. M. 1966. Nematodes associated with economic plants of south east plateau of Rajasthan. *Labdev* (*J. Sci. & Tech.*), Kanpur, **4**: 184-186.

*YAZDANI, G. M. and BHARGAVA, R. N. (In press). On a new record of a minnow, *Aphanius dispar* (Ruppell) from Rajasthan. *Labdev* (*J. Sci. & Tech.*), B, **7**(4): 332-333 (1969).

* Papers published after this paper was read.

APPENDIX I

List of main localities surveyed by the Zoological Survey of India parties (1941 1969).

Sl. No.	*Collecting station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
	1. AJMER DISTRICT		
1.	Ajmer	26°27′	74°42′
2.	Anasagar Lake, Ajmer	26°25′	74°35′
3.	Bir Tank	26°24′	74°44′
4.	Danta Forest	26°20′	74°40′
5.	Kishangarh	26°35′	74°50′
6.	Motisar	26°28′	74°31′
7.	Nasirabad	26°11′	74°28′
8.	Panch Kund	26°29′	74°34′
9.	Pushkar	26°32′	74°35′
10.	Rajosi	26°20′	74°40′
11.	Raoli	25°46′	73°59′
12.	Sanod Tank	26°17′	74°50′
	2. ALWAR DISTRICT		
13.	Agyarah Dam	27°31′	76°45′
14.	Alwar	27°34′	76°36′
15.	Bedkesharpur	27°10′	76°38′
16.	Jaisamand	27°25′	76°36′
17.	Jeysagar	27°10′	76°36′
18.	Mansarovar	27°15′	76°36′
19.	Sariska	27°24′	76°24′
20.	Siliserh	27°25′	76°36′
	3. BARMER DISTRICT		
21.	Balasar	26°07′	71°08′
22.	Balotra	25°50′	72°15′
23.	Barmer	25°45′	71°23′

Sl. No.	*Collecting station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
24.	Bhap Tank	25°51′	71°26′
25.	Bisu	26°18′	71°21′
26.	Datani Village	25°48′	70°46′
27.	Gadra Road	25°45′	70°35′
28.	Jhalon Forest	25°50′	70°45′
29.	Kapurdi	25°50′	71°20′
30.	Luni River (Near Balotra)	25°45′	72°15′
31.	Neemla	26°03′	71°20′
32.	Pachpadra Salt Depot	25°55′	72°20′
33.	Ranasar	25°50′	70°44′
34.	Sura	25°55′	71°05′
35.	Tamlor	25°44′	70°33′
36.	Uttarlai	25°45′	71°25′
	4. BHARATPUR DISTRICT		
37.	Badalgarh	26°52′	77°15′
38.	Baretha	26°54′	77°22′
39.	Bharatpur (Ghana Sanctuary)	27°15′	77°27′
40.	Dig Fort	27°27′	77°20′
41.	Gundgaon	27°42′	77°14′
42.	Kherli village	27°00′	77°15′
43.	Nekpur Head	27°06′	77°24′
44.	Seola Head Works on River Gambhir	26°59′	77°22′
45.	Sheetla	27°39′	77°15′
	5. BHILWARA DISTRICT		
46.	Pandal or Mandal Tank	25°25′	74°34′
	6. BIKANER DISTRICT		
47.	Bikaner	28°01′	73°22′
48.	Gajner	27°55′	73°04′
49.	Jhajju	27°46′	73°00′
50.	Jorbir	27°58′	73°14′
51.	'Khans' West of Bikaner	28°06′	73°14′

Sl. No.	*Collecting station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
52.	Khetolai	27°44′	72°55′
53.	Kodamdesar	28°00′	73°05′
54.	Kolayat	27°50′	72°58′
55.	Marh	27°52′	72°57′
56.	Nayagaon	27°58′	72°57′
57.	Palana	27°50′	73°15′
58.	Pugal	28°30′	72°48′
59.	Siasar	28°35′	72°34′
60.	Sobasar	28°08′	73°10′
	7. BUNDI DISTRICT		
61.	Bardah-ka-Talab	25°20′	75°40′
62.	Bundi	25°27′	75°41′
63.	Khatkar	25°34′	75°46′
64.	Phulsagar	25°25′	75°55′
	8. CHITTORGARH DISTRICT		
65.	Berach River	24°50′	74°37′
66.	Chittorgarh	25°00′	74°45′
67.	Chittorgarh Rly. Station	24°53′	74°37′
68.	Confluence of R. Berach & R. Gambhiri	24°55′	74°38′
69.	Gambhiri River South of Fort	24°51′	74°39′
70.	Manpura	24°51′	74°27′
71.	Zalimpura	24°48′	74°38′
	9. CHURU DISTRICT		
72.	Churu	28°11′	75°06′
73.	Hudera Rly. Station	28°00′	74°35′
74.	Rattangarh Rly. Station	28°07′	74°35′
75.	Sardarshahar	28°30′	74°29′
76.	Taranagar town	28°40′	75°02′
	10. DUNGARPUR DISTRICT		
77.	Dungarpur	23°50′	73°40′
78.	Som River	24°00′	73°40′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
	11. GANGANAGAR DISTRICT		
79.	Asarjana	29°10′	74°38′
80.	Badbirana	29°08′	74°53′
81.	Deidas	29°16′	74°41′
82.	Diplana	29°11′	74°53′
83.	Guria	29°18′	74°54′
84.	Kishanpura	29°19′	73°58′
85.	Nohar	29°11′	74°46′
86.	Padampura	29°18′	74°56′
87.	Rangmahal	29°21′	73°58′
88.	Sardarpurabas	29°10′	74°48′
89.	Suratgarh	29°19′	73°54′
90.	Surpura	29°05′	74°50′
	12. JAIPUR DISTRICT		
91.	Achnol forest	27°05′	75°52′
92.	Asalpur Dam	26°52′	75°26′
93.	Bagru	26°50′	75°32′
94.	Bahadurpur	26°52′	75°16′
95.	Chittoli Bund	27°42′	76°10′
96.	Dausa	26°55′	75°20′
97.	Devdyani	26°55′	75°13′
98.	Dudu	26°40′	75°10′
99.	Galta	27°00′	75°52′
100.	Gudha near Sambhar lake	26°55′	75°25′
101.	Jaipur and vicinity	26°55′	75°52′
102.	Jamwa Ramgarh	27°10′	76°05′
103.	Kotputli-ka-Talao	27°42′	76°12′
104.	Kukus	27°03′	75°55′
105.	Lihorana	27°02′	75°25′
106.	Manoharpur	27°18′	75°57′
107.	Naraina village	26°45′	75°10′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
108.	Padasauli	26°35′	76°20′
109.	Phulera	26°52′	75°16′
110.	Sambhar	26°54′	75°13′
	13. JAISALMER DISTRICT		
111.	Badebagh	26°55′	71°00′
112.	Balana	27°15′	71°20′
113.	Biprasar	27°18′	70°30′
114.	Devikot	27°42′	71°12′
115.	Geodesar or Jaidesar	27°16′	70°32′
116.	Jaisalmer and vicinity	26°55′	70°57′
117.	Jedbaisar	26°54′	71°10′
118.	Josirasar	26°55′	71°00′
119.	Khejadi area	27°29′	70°22′
120.	Madanganj	27°55′	70°35′
121.	Mohangarh	27°20′	71°15′
122.	Mulasagar	26°55′	70°50′
123.	Nokh	27°33′	72°15′
124.	Pariwar	27°12′	70°40′
125.	Pokaran	26°55′	71°56′
126.	Rama	26°33′	71°00′
127.	Ramgarh	27°23′	70°30′
128.	Sanu	27°13′	70°35′
	14. JALORE DISTRICT		
129.	Dadli-ka-Talao	25°00′	72°16′
130.	Jalore town	25°22′	72°58′
131.	Jaswantpura	24°50′	72°15′
132.	Sagi River	24°50′	72°15′
	15. JHALAWAR DISTRICT		
133.	Ahu River	24°20′	76°05′
134.	Aklera	24°20′	76°30′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
135.	Chandra Sarovar	24°36′	76°10′
136.	Gaduli Talai (Tank)	24°40′	76°30′
137.	Gomti Sagar	24°34′	76°10′
138.	Mudlia Kheri (Jhalrapatan)	24°32′	76°10′
139.	Shergarh	24°40′	76°30′
140.	Sunel	24°20′	76°05′
	16. JHUNJHUNU DISTRICT		
141.	Alsisar	28°19′	75°18′
142.	Bagar	28°11′	75°30′
143.	Basni	28°14′	75°20′
144.	Desusar	28°12′	75°28′
145.	Jhunjhunu	28°06′	75°24′
146.	Malsidar	28°21′	75°18′
147.	Mandawa	28°03′	75°09′
148.	Pura-ki-Dhani	28°05′	75°22′
	17. JODHPUR DISTRICT		
149.	Agolai	26°15′	72°35′
150.	Akhrajji-ka-Talab	26°15′	72°53′
151.	Balsamand	26°18′	73°04′
152.	Bariganga (Beriganga)	26°25′	73°04′
153.	Barli Tank	26°26′	72°55′
154.	Basni village	26°18′	72°50′
155.	Bisalpur Dam	26°18′	73°27′
156.	Bishalpur	26°10′	73°15′
157.	Hanwant village	26°15′	72°48′
158.	Jodhpur and vicinity	26°18′	73°04′
159.	Kaylana Desert Afforestation Demonstration Station	26°15′	72°45′
160.	Kaylana Desert Control Demonstration Station	26°18′	72°59′
161.	Khokhra village	26°28′	73°05′
162.	Kolu	26°56′	72°17′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
163.	Kutri Bhensar	26°24′	72°41′
164.	Loridi village	26°22′	72°53′
165.	Luni	26°18′	72°38′
166.	Mataji-ki-Bhakari	25°58′	73°04′
167.	Nandri village	26°15′	73°05′
168.	Nettra	26°20′	73°15′
169.	Phalodi	27°09′	72°24′
170.	Pipar city	26°34′	73°10′
171.	Pipar Road village	26°34′	73°04′
172.	Ranisar	27°13′	72°43′
	18. KOTAH DISTRICT		
173.	Alani tank	25°00′	75°03′
174.	Chitenpur (Forest School)	25°05′	75°52′
175.	Chambal Barage	25°12′	75°51′
176.	Dadhdevi	25°03′	75°55′
177.	Darah	24°49′	76°02′
178.	Jagupura	24°55′	76°35′
179.	Kolipura	24°55′	75°40′
180.	Kotah Town	25°10′	75°52′
181.	Mandana	24°56′	75°55′
182.	Morak	24°45′	75°55′
183.	Palaita	25°05′	76°10′
184.	Umedganj	25°05′	75°55′
	19. NAGAUR DISTRICT		
185.	Balaia	27°03′	73°40′
186.	Barni	27°11′	73°37′
187.	Bhakrod	27°03′	73°36′
188.	Chhapparwara (37 km.S. of Sambhar)	26°55′	75°02′
189.	Didia	27°07′	73°55′
190.	Gogolai	27°15′	73°39′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
191.	Gurha	27°13′	73°29′
192.	Harsnath	27°03′	75°12′
193.	Imirti	27°06′	73°39′
194.	Merta city	26°35′	74°06′
195.	Nagaur	27°11′	73°41′
196.	Nandana Nadi	27°00′	75°00′
197.	Parli	27°03′	73°38′
198.	Rol Quazian	27°09′	73°56′
199.	Sanodia	26°55′	74°55′
200.	Sarau	27°15′	73°44′
201.	Singar	27°13′	73°37′
	20. PALI DISTRICT		
202.	Aravalli Hills base ca. 12 km. from Sadri	25°04′	73°25′
203.	Awa village	25°45′	73°50′
204.	Erinpura	25°29′	73°04′
205.	Falna	25°10′	73°10′
206.	Marwar	25°45′	73°38′
207.	Pali	25°46′	73°25′
208.	Phulad Rly. Station	25°35′	73°48′
209.	Pipli	25°55′	73°45′
210.	Sadri and vicinity	25°10′	73°25′
211.	Saran village	25°29′	73°47′
212.	Sardar Samand	25°54′	73°25′
	21. SAWAI MADHOPUR DISTRICT		
213.	Bhagwatigarh Bund	25°58′	76°23′
214.	Hindaun	26°45′	77°02′
215.	Karauli	26°30′	77°02′
216.	Mui Bund	26°00′	76°23′
217.	Sawai Madhopur	25°58′	76°30′
218.	Srimahabirji	26°40′	76°55′
219.	Surwal Bund	26°00′	76°21′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
	22. SIKAR DISTRICT		
220.	Chokha-ka-Bas	27°29′	75°08′
221.	Dadhia	27°35′	75°14′
222.	Gotera	27°44′	75°10′
223.	Gungara	27°41′	75°17′
224.	Kadma-ka-Bar	27°30′	75°08′
225.	Kasli	27°33′	75°10′
226.	Khori	27°31′	75°04′
227.	Molasi	27°36′	75°00′
228.	Mundaora	27°29′	75°05′
229.	Phagalwa	27°38′	74°59′
230.	Piprali	27°38′	75°16′
231.	Puran Bari	27°31′	75°06′
232.	Puran Chhoti	27°31′	75°05′
233.	Purat-ki-Dhani	27°38′	75°18′
234.	Rashidpura	27°43′	75°05′
235.	Sikar and vicinity	27°38′	75°08′
	23. SIROHI DISTRICT		
236.	Achalgarh	24°38′	72°46′
237.	Akrabhatta	24°31′	72°48′
238.	Anadra Point	24°38′	72°39′
239.	Mount Abu	24°35′	72°45′
240.	Nakki Lake	24°34′	72°42′
	24. TONK DISTRICT		
241.	Banas River (near Tonk)	26°11′	75°52′
	25. UDAIPUR DISTRICT		
242.	Balicha	24°20′	73°40′
243.	Banas River near Nathdwara	24°57′	73°49′
244.	Barapal village	24°20′	73°35′
245.	Bhupalsagar	24°35′	73°40′

Sl. No.	*Collecting Station*	*Approximate latitude (N.)*	*Approximate longitude (E.)*
246.	Dewali	24°36′	73°38′
247.	Fatehsagar	24°35′	73°35′
248.	Game Sanctuary near Jaisamand	24°55′	73°35′
249.	Jogmande Jharna	25°35′	74°00′
250.	Kotra	24°22′	73°13′
251.	Madri	24°30′	73°40′
252.	Nethala Tank	24°54′	73°42′
253.	Parshad	24°12′	73°43′
254.	Udaipur	24°35′	73°42′
255.	Vithal Niwas	25°05′	73°50′
256.	Madar Tank	24°40′	73°37′

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TWO NEW SPECIES OF APHIDIIDAE (HYMENOPTERA) FROM INDIA

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(With 1 Text-figure)

Genus: **Lysiphlebia** Stary' & Schlinger.

The genus *Lysiphlebia* was erected by Stary' & Schlinger (1967) for the reception of *Lysiphlebia japonica* (Ashmead), which was previously in the genus *Lysiphlebus* Förster. *Lysiphlebia* differs from *Lysiphlebus* for having the propodeum completely areolated and strongly declivous in its lower part and also in the structure of the petiole. The genus is reported for the first time from India and a new species is described. Key to the species given by Stary' & Schlinger (1967) is also revised to accommodate the new species.

Revised key to the species of the genus Lysiphlebia based on females

1—Metacarp (R_1) and pterostigma subequal. Propodeum with a distinct mid-longitudinal carina. Petiole coarsely rugose with a central longitudinal carina. .. .. .2.

—Metacarp (R_1) distinctly longer than pterostigma. Propodeum without mid-longitudinal carina. Petiole smooth without central longitudinal carina. .*L. mirzai* n.sp.

2—Distance between spiracular tubercle and apex of petiole 1/2 times more than width at spiracles. .. .*L. japonica* (Ashmead)

—Distance between spiracular tubercle and apex of petiole a little shorter than width at spiracles. .*L. rugosa* Stary' & Schlinger.

Lysiphlebia mirzai n.sp.[1]

(Text-fig. 1, 1-5)

Female

Head.—Brown excepting middle of frons, posterior of occiput and facia which are yellowish brown; clypeus and palpi yellow; transverse, smooth, hairy, wider than thorax width at tegulae (0.442: 0.314 mm); occiput margined; temple 1/4 narrower than eye width (0.128: 0.171 mm), equal to clypeo-antennal line; inter-ocular line as long as facial line, distinctly longer than transfacial line (0.30: 0.228 mm);

[1] This species is named after Prof. M. B. Mirza, formerly Head, Department of Zoology, Aligarh Muslim University, Aligarh, India.

transfacial line 1/2 head width; socket-ocular line shorter than socket diameter (0.042: 0.071 mm); malar space 1/3 of eye length (0.071: 0.20 mm), as wide as mandible width; tentorio-ocular line shorter than intertentorial line (0.074: 0.096 mm); ocular-ocellar line[2] (OOL): post-ocellar line[3] (POL): ant-ocellar line[4] (AOL) = 9: 6: 4; eyes large, prominent, oval, bare and somewhat convergent towards clypeus; clypeus oval with 10 long hairs.

Antennae.—Scape, pedicel, annellus and underside of first and second flagellar segments yellow, rest brown; 1.28 mm long; 13-14 segmented; first and second flagellar segments subequal, each two and a half times longer than wide; apical segment longer than penultimate segment (0.151: 0.092 mm).

Thorax.—Prothorax yellowish, mesoscutum brown or yellow in the later condition with one brown spot in each parapsis and another on scutal portion between parapside; tegulae, mesonotal furrow, axillae, anterolateral margins of mesoscutellum and propodeum yellowish, rest brown; parapsidal furrows distinct anteriorly, slightly crenulate, effaced on disc; propodeum (Text-fig. 1, 5) areolated, strongly declivous behind lateral carinae mid-longitudinal carina absent.

Fore wings (Text-fig. 1, 1).—Hyaline; less than three times longer than wide (1.542: 0.557 mm); venation brown except 2r-m; pterostigma yellowish in the middle, four times as long as wide, shorter than metacarp (R_1) (0.357: 0.457 mm); r & Rs shorter than pterostigma; 2r-m 1/4 of r & Rs (0.071: 0.285 mm).

Hind wings.—Hyaline; slightly more than five times as long as wide (1.140: 0.214 mm); venation brown; marginal fringe 1/3 wing width (0.071: 0.214 mm).

Legs.—Yellow, tarsal segments yellowish brown.

Abdomen.—Brown excepting petiole and anterior end of third tergum which are yellow, apex of abdomen brownish black; lanceolate; petiole (Text-fig. 1, 2) two times longer than wide at apex, slightly more than twice as long as wide at spiracular tubercles; distance between spiracular tubercle and apex of petiole about 1/6 longer than width at spiracles; post-petiolar terga smooth, sparsely hairy; external genitalia (Text-fig. 1, 3) black, third valvulae (Text-fig. 1, 4) with straight dorsal margin and 7 pegs at its tip.

Length.—1.88 mm.

Male.—Resembles female except in the following characters: Antennae 14-15 segmented; coloration dark brown.

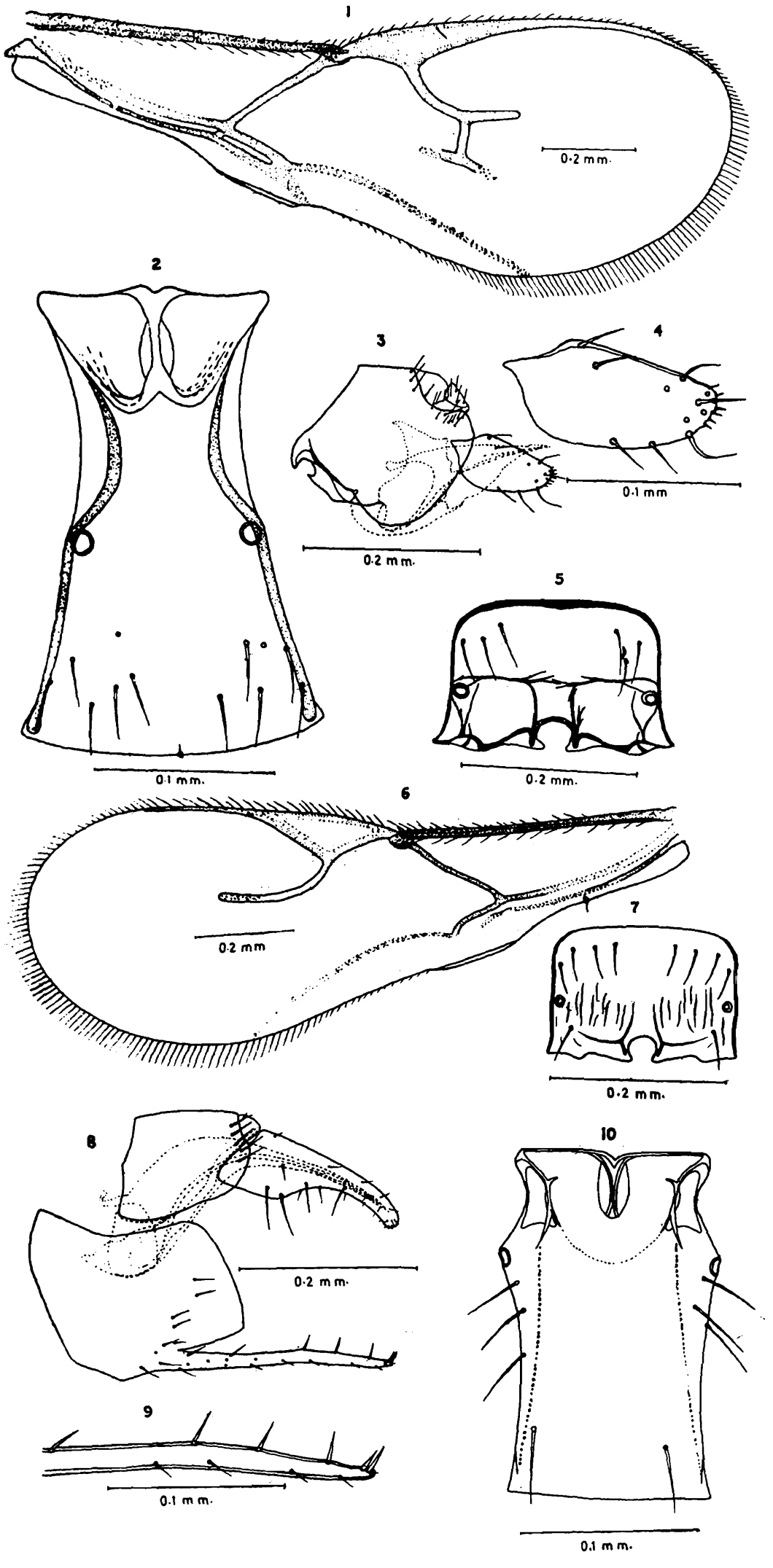
Holotype ♀, paratypes, 75♀♀, 25♂♂, INDIA: Uttar Pradesh, Meerut, ex. *Longiunguis sacchari* (Zehnt.) on *Saccharum officinarum* L., 25.11.1968 (*Shuja-uddin*). Types deposited in the Zoological Museum, Aligarh Muslim University, Aligarh.

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[2] Distance from the outer edge of a lateral ocellus to the compound eye.

[3] Distance between the inner edges of the two lateral ocelli.

[4] Distance between the inner edges of anterior and lateral ocellus.



Text-fig. 1-10. (1-5) *Lysiphlebia mirzai* n.sp. ♀, (1) Fore wing, (2) Petiole, (3) External genitalia, (4) Third valvula, (5) Propodeum; (6-10) *Trioxys* (*Betuloxys*) *intermedius* n.sp. ♀. (6) Fore wing, (7) Propodeum, (8) External genitalia, (9) Prong of the subgenital plate, (10) Petiole.

Genus: **Trioxys** Haliday.

Subgenus: **Betuloxys** Mackauer.

The subgenus *Betuloxys* was raised by Mackauer (1960) to accommodate *Trioxys* (*Betuloxys*) *compressicornis* Ruthe, for having (1) the prongs of the subgenital plate with a knee-bend in the middle and well developed bristles, and (2) petiole parallel sided without spiracular tubercles. The present author, however, considers the second character as non-persistent. Two more species, namely, *Trioxys* (*Betuloxys*) *affinis* Mackauer, and *Trioxys* (*Betuloxys*) *hortorum* Stary' were added to it. *Trioxys* (*Betuloxys*) *intermedius* n. sp. was reared from the aphids infesting *Centaurea iberica* (Trevir) (Star thistle). This is the first record of the subgenus from India. A key to the species of the subgenus *Betuloxys* is proposed.

Key to the species of the subgenus Betuloxys based on females

1—Prongs of the subgenital plate distinctly curved upwards before knee-bend..2

—Prongs of the subgenital plate straight upto knee-bend. . .3

2—Propodeum with complete pentagonal areola. Petiole's width at spiracles distinctly greater than width at posterior end. *T* (*B.*) *affinis* Mackauer.

—Propodeum without areola. Petiole's width at spiracles slightly shorter than width at posterior end. *T* (*B.*) *compressicornis* Ruthe.

3—Metacarp (R_1) distinctly shorter than r & Rs. Propodeum with complete pentagonal areola. Length of post knee-bend portion of prong two times greater than width of knee-bend. *T* (*B.*) *hortorum* Stary'.

—Metacarp (R_1) subequal to r & Rs. Propodeum without areola. Length of post knee-bend portion of prong six and a half times greater than width of knee-bend. *T* (*B.*) *intermedius* n.sp.

Trioxys (Betuloxys) intermedius n.sp.

(Text-fig. 1, 6-10)

Female

Head.—Dark brown, facia yellowish brown, malar space, clypeus and palpi yellow; transverse, rugulose, sparsely hairy; wider than width of thorax at tegulae (0.385: 0.271 mm); occiput margined; inter-ocular line almost one and a half times longer than transfacial line (0.228: 0.142 mm), shorter than facial line (0.228: 0.271 mm); tentorio-ocular line 1/6-1/7 of intertentorial line; socket-ocular almost 1/2 socket diameter; inter-socket line somewhat longer than socket-ocular line (0.037: 0.029 mm); OOL: POL: AOL = 8: 4.5: 3.5; eyes large, oval, bulging, strongly convergent towards clypeus, sparsely hairy; clypeus oval, convex, smooth with 8 long hairs; mandibles width equal to intertentorial line, nearly 1/2 of clypeoantennal line (0.071: 0.128 mm).

Antennae.—Scape, pedicel, annellus, first flagellar segment yellow, second segment yellowish brown, rest flagellar segments brown and thickened; length 1.285 mm.; 12 segmented; reaching upto base of fifth tergum; first flagellar segment somewhat longer than second segment (0.114: 0.103 mm), each four and a half times longer than wide;

flagellar segments 3-7 almost three times longer than wide; flagellar segments 8 & 9 almost two and a half times longer than wide; apical segment pointed, four times longer than wide.

Thorax.—Dark brown, prothorax and mesosternum yellowish, propodeum and mesopleura brown; mesoscutum falling vertically to prothorax somewhat covering it dorsally; sparsely hairy anteriorly, along margins and effaced parapsidal furrows on disc; parapsidal furrows distinct and crenulate anteriorly, effaced on disc; propodeum (Text-fig. 1, 7) with few rugosities and two semicircular carinae in the lower half.

Legs.—Yellow, pretarsi yellowish brown.

Fore wings (Text-fig. 1, 6).—Hyaline; almost two and a half times longer than wide (1.428:0.514 mm); venation brown; pterostigma yellowish in the middle, three times longer than wide; metacarp (R_1) shorter than pterostigma (0.257: 0.30 mm) and almost as long as r & Rs.

Hind wings.—Hyaline; almost five times longer than wide (1.071: 0.20 mm); marginal fringe 1/3 wing width.

Abdomen.—Brown excepting petiole, anterior and postero-lateral margins of third tergum and terga 8 & 9 which are yellowish; lanceolate; petiole (Text-fig. 1, 10) smooth, sparsely hairy, one and a half times longer than wide at spiracles, width at spiracles equal to the distance between spiracle and posterior end; external genitalia (Text-fig. 1, 8) yellowish brown, subgenital plate with prongs yellowish; length of post knee-bend portion of prongs six and a half times greater than width of knee-bend (Text-fig. 1, 9).

Length.—1.84 mm.

Male.—Resembles female except in the following characters: Antennae 14 segmented; coloration darker than in the female.

Holotype ♀, paratypes, 12♀♀, 6♂♂, INDIA: Kashmir, Sopore, Wadoora, ex. green aphids on *Centaurea iberica*, 12.9.1969. (*Shuja-uddin*). Types deposited in the Zoological Museum, Aligarh Muslim University, Aligarh.

SUMMARY

The genus *Lysiphlebia* Stary' & Schlinger and the subgenus *Betuloxys* Mackauer (genus *Trioxys* Haliday) are being reported for the first time from the subcontinent of India. Two new species belonging to the above genera are described along with keys for identification of hitherto described species. Alam (1951, '53), Richards (1956), Riegel (1948) and Eady (1968) have been followed for various morphological structures and their terminologies, including wing venation and microsculpture.

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References

ALAM, S. M., 1951. The skeleto-muscular mechanism of *Stednobracon deesae* Cameron (Braconidae: Hymenoptera) an ectoparasite of sugarcane and Juar borers of India. Part I. Head and Thorax. *Alig. Musl. Univ. Publ.* (*Zool. Ser.*) *Ind. Ins. Typ.*, **3**(1): 74 pp.

ALAM, S. M., 1953. Part II. Abdomen and Internal Anatomy. *Alig. Musl. Univ. Publ.* (*Zool. Ser.*) *Ind. Ins. Typ.*, **3**(2): 75 pp.

EADY, R. D., 1968. Some illustrations of microsculpture in the Hymenoptera. *Proc. R. ent. Soc. Lond.* (A), **43**: 66-72.

MACKAUER, M., 1960(a). Zur Systematic der Gattung *Trioxys* Haliday (Hymenoptera: Braconidae, Aphidiinae). *Beitr. Ent.*, **10**: 137-160.

MACKAUER, M., 1960(b). Ein Weitrer Vertreter der untergattung *Betuloxys* Mackauer (Hymenoptera: Braconidae, Aphidiinae). *Mitt. dtsch. etc. Ges., Berlin*, **19**: 96-98.

RICHARDS, O. W., 1956. Hymenoptera, Introduction and keys to families. *Hndbk. Ident. Brit. Ins.*, **6**(1): 1-94. (*R. ent. Soc. Lond.*).

RIEGEL, G. T., 1948. The wings of the Braconidae (Hymenoptera). *Ann. ent. Soc. Amer.*, **4**: 439-449.

STARY', P., 1960. Two new species of *Trioxys* Haliday from Central Europe (Hymenoptera: Aphidiidae). *Acta. Soc. Ent. Cechol*, **57**: 365-368.

STARY', P. and SCHLINGER, E. I., 1967. A revision of the Far East Asian Aphidiidae (Hymenoptera). *Series entomologica*, **3**: 68-73; (Dr. W. Junk, Hague).

Rec. zool. Surv. India, **68**: 421—429, 1975.

COMMERCIAL MARINE MOLLUSCS OF INDIA AND THE NEED FOR THEIR SURVEY

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Marine molluscs have been known to play an important role in the life of the mankind especially of the coastal region, since time immemorial. Shell heaps and thousands of pits filled with shells along the tidal creeks, estuaries and such other places have been known to exist all over the world. Some of these shell-filled pits are, of course, of geological age, dating back to 80 million years while others are man-made and of thousands of years old harbouring the weapons and tools of the early man. These shell-dumps are not only the testimony of the part played by the molluscs in the human life but they form an excellent material for the study of early climatology and also the archaeology and sociology of the then human habitation.

In India, such shell-dumps have been located at several places all along the coast, the huge dump of the kind worthy of mention here is at Vembanad lake in Kerala, where the ancient shells of bivalves *Meretrix*, *Arca* and *Vellorita* support prosperous lime manufacturing industry.

Several attempts have been made in the past to classify the Indian Marine molluscs, the earliest being by Melvill and Abercrombie (1893), Melvill (1893, 1896). Later, Hornell (1916, 1917, 1918, 1921, 1949 and 1951) made a significant contribution to the study of Indian molluscs. Prashad (1932) while giving the taxonomic account of the lamellibranchs of the Siboga expedition, has described several forms from the Indian region. Others who have contributed to our understanding of marine molluscs of India, are Preston (1908, 1914, 1915 and 1916), Annandale and Kemp (1916), Coggin-brown (1923), Annandale (1924), Gravely (1927, 1941) and Crichton (1941). In recent years, several workers have studied the molluscan fauna of some best collection grounds on our coast. Amongst these, works of Patil (1952), Satyamurti (1956), Subramanyam *et al.* (1952), Gidean *et al.* (1957), Menon *et al.* (1961) and Kundu (1965) merit mention.

Intensive study of a single family or a genus as has been done in the case of freshwater molluscs by Prashad (1928), Annandale and Rao (1925) and several others, is not seen in the available literature on Indian marine molluscs. However, attempts of Hornell (1916b, 1917) in giving the account of the varieties and races of the genus *Turbinella* (*Xancus*) and revising the species of *Meretrix* respectively, and by Ghosh

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(1920) on the taxonomic studies on the soft parts of Solenidae are noteworthy. The publication of an excellent memoir "Mitres of Indian waters" by Ray (1956) is another landmark in this direction.

In spite of all these, the molluscan fauna of Indian waters remains a poorly surveyed group. This is especially so in respect of economically important families like Cymatiidae, Muricidae, Strombidae, Cypraeidae, Harpidae *etc.*, amongst Gastropods and Ostreidae, Veneridae, Cardiidae (Cockles), Carditidae (false cockles), Pectinidae, Arcidae *etc.*, amongst Pelecypods.

The commercially important molluscs of Indian coast, fall into four categories: (1) Food molluscs (2) Molluscs yielding pearls, medicines and lime (3) Molluscs used in the manufacture of ornamental and utilityarticles (4) Molluscs which cause damage to our ships and marine structures as foulers and borers. The members of the last category, though not commercially important directly, are perhaps of greater importance than all the earlier categories. The molluscs which contribute to the first category come from all the three major classes of the phylum *i.e.*, Gastropoda, Pelecypoda and Cephalopoda, while the next two categories are formed by Gastropods and Pelecypods and the last one by Pelecypods alone.

Food molluscs.—Among the shellfish utilized for food; oysters, clams, mussels, squids, cuttlefishes and Octopi are the most important. The survey of the edible oysters of India has not been done and our knowledge about the Indian oysters is limited to the excellent works of Awati and Rai (1931), Rai (1932), Rao (1956), and Rao and Nair (1956). I have made some contribution towards the understanding of the systematics, biology and biochemistry of the edible oyster (*Crassostrea gryphoides*) of the west coast of India (Durve, 1961a, & b, 1962, 1964 1965, 1967 and 1974). At present, only two oysters *viz.*, *Crassostrea gryphoides* (Schlotheim) occurring from Saurashtra to Karwar on the west coast and *C. madrasensis* Preston from the Malabar coast and the major part of the east coast of India have been known as the true edible oysters of this country. Despite the detailed work cited above on these two oysters, much is still to be done to assess the density distribution of these oysters, their races and varieties if any, in the numerous estuaries and backwaters of our country. It is reported that the individuals of these oysters living on permanently submerged rocks grow to enormous sizes of 12-14 inches in height. But nothing has been done so far to survey these oysters and assess their fishery potential.

The rock-oyster, *C. cucullata* which is wide-spread on the inter-tidal rocky regions throughout the Indian coast, is a delicacy but little is known about it except for its anatomy (Awati and Rai, 1931). It is likely that there may be more than one species of this oyster. I feel, this oyster has a great fishery potential and much work is needed on its systematics, ecology and biology. The large oysters of the Orissa coast (*Ostrea gryphoides* var. *cuttackensis*) of which much is written by Vredenburg (1904) and Newton and Smith (1911), is further available for the study of its horizontal and vertical distribution along the east coast and the continental shelf. Other possible fishable oysters are *C. discoidea* (Gould) and *Ostrea cristagalli* which are known to occur on the Indian coast but nothing is mentioned about their abundance and the exact localities of occurrence. It is more likely that *C. discoidea*

may prove itself an aberrent environmental variety of some already known species. *Ostrea cristagalli* is likely to be the member of the genus *Lopha* and not *Ostrea*. However, much work is needed in this direction.

A well-planned survey of Ostreidae of the Indian region is essential both from the academic and fishery points of view. This will not only lead to gaining of knowledge about these economic molluscs but may yield some interesting species and genera unrecorded from the Indian region and perhaps even unknown to science.

Clams play a dominant role in the kitchen of coastal people especially during monsoon when the fish is not readily available. They are highly nutritious and delicious. On the west coast, the important edible clams are *Meretrix meretrix* (Linn.) and *Katelysia marmorata*. These form extensive beds on the Kathiawar Saurashtra and Bombay regions. On the southern parts of the west coast, these clams are replaced by *Vellorita cyprinoides* (Gray) and *Meretrix casta* (Chemnitz). On the east coast, the food-clams are *Meretrix casta* (Chemnitz) and *Katelysia opima* (Gmelin) which form extensive beds in the estuaries of south India. The species of Razorclam *Solen* have a wide-spread distribution on the Indian coast. Rao *et al.* (1962) describe eight species of this genus. Members of the family Solenidae are of food-value and contribute to local fishery in several parts of the country.

Besides the above mentioned clams, there are several species of *Gafrarium*, *Donax*, *Arca*, *Cardium*, *Paphia*, *Mactra* etc. which form a good source of food but very little is known about their systematics, ecology and distribution. These resources, thus, still remain largely untapped on commercial basis. In this connection, it may be mentioned that the majority of edible clams belong to the family Veneridae which is practically untouched by Indian workers.

Several Gastropods like *Thais* sp., *Telescopium telescopium*, *Natica* sp. and *Umbonium vestiarum* are also used for food purposes, but nothing is known about their systematics, ecology and distribution.

Mussels form thick carpet of growth on the submerged rocks. Two main species which contribute to mussel fishery are green mussel or *Mytilus viridis* Linne and brown mussel, *Mytilus* sp. The former is a little widely distributed being abundant off Cochin, Malabar, north Kerala and Karwar. It also occurs off Bombay and Ratnagiri but the extent of its abundance is not known. The brown mussel is confined to south of Quilon on Kerala coast to Cape comorin. On the east coast, it is available off Tuticorin. Several small individuals of *Mytilidae* are often seen on the rocky beaches but no literature is available except for stray accounts, on their systematics.

Cuttle fishes, Squids and Octopi are common in the seas around India and are caught in fishing nets in the inshore waters. Early works on the Cephalopods of the Indian waters are by Goodrich (1896), Massy (1916) and Adams (1939). As such, comprehensive treatise on this group is still wanting. Recently, Silas (1968) has given an account of Cephalopods of the west coast of India. Filippova (1968) has added five more species of Cephalopoda to the existing list from the Indian ocean, based on the collections made by the Russian ships participating in the Indian Ocean expedition. In his work (Filippova,

op. cit.) he also gives the abundance of different species in the coastal and open waters around India.

Cephalopods do not form regular fishery around the Indian coast except some parts of east coast especially in Palk bay and Gulf of Mannar where a single species *Sepioteuthis arctipinnis* Gould contributes to the entire fishery (Rao, 1954). *Symplectoleuthis oualaniensis* reported as abundantly available species in the Indian region by Filippova (1968) should be further investigated for its fishery potential.

Molluscs yielding pearls, medicines and lime:—

Almost all bivalves yield pearls, but those obtained from the pearl oysters fetch the highest price. The pearl oyster of India is *Pinctada vulgaris*. Besides, four more species are known to occur in the Indian region. On the west coast, the pearl fishing is restricted only to Jamnagar and northern parts of Halar district of Saurashtra. On the east coast the pearl oyster beds extend from Cape Comorin to Kilakarai in the Gulf of Mannar, with a most productive Central Zone off Tuticorin. Very recently, a sixth species namely *P. sugillata* has been discovered from the Indian waters. The distribution of pearl-oysters of the Indian region has been well reviewed by Rao (1968). Due to the depletion of pearl-oyster beds in the recent years, the pearl fishing is greatly hampered and the proper survey of pearl banks is necessary to ensure the sustained yield of this foreign exchange earner.

Medicinal pearls are mostly obtained from *Placuna*, presently called *Placenta placenta* (Linnaeus) and popularly known as windowpane oyster. These pearls are small, soft and of inferior quality so far as ornamental value is concerned. They are, therefore, used in preparation of medicines, well-known amongst which is the Ayurvedic preparation "Mouktik Bhasma" (मौक्तिक भस्म). Large beds of these windowpane oysters occur on Balarpur area and the Rana Bay in the Gulf of Kutch. They are also found along the Bombay and Goa Coasts, where a sizable fishery exists. Further south, they become sparse. The shells are used as decorative articles and for glazing windows and roofs in China, Far East and Goa. The knowledge about the systematics, distribution, ecology and biology of Anomiidae is scanty, the only notable work being of Hornell (1909) on the anatomy.

All the molluscan shells yield lime after burning in kilns. However, genera like *Meretrix*, *Arca*, *Vellorita*, *Katelysia* and oysters which form extensive beds and the shells of which are readily available in sufficient quantities are generally used for the purpose. Even the dead shells of all the molluscs washed ashore are also collected and burnt to obtain lime. Shell-lime is mainly used in betel leaves. Expensive lime is prepared from the pearls of *Placenta placenta*.

Molluscs used for ornamental and utility articles:—

In this category comes the famous sacred chank *Xancus pyrum* (Linnaeus) earlier known as *Turbinella pyrum*. Besides, species of *Trochus*, *Turbo*, *Lambis*, *Haliotis*, *Harpa*, *Cassis*, *Murex*, *Cyprea* and *Tridacna* —the largest bivalve of the world, have also the importance as curios and decorative articles. Chank beds occur on the west coast in the

Gulf of Kutch near Port Okha and in the Arabian sea off Trivandrum. On the east coast, the most productive beds are chiefly in the Gulf of Mannar near Tuticorin and Kilakarai and in the Palk bay near Devipatnam and Rameshwaram. Large specimens of the rest of the ornamental shells are also found around Rameshwaram, Andaman and Nicobar islands. Hornell (1916b) and Vredenburg (1916) have done commendable work on the sacred chank *Xancus pyrum* (*Turbinella*). However, this work now needs revision. Chank beds also need a careful survey lest they get dangerously depleted due to over fishing. Regarding the work on the family Strombidae, mention may be made of the works of Ray (1956). Abbott (1960, 61, 67). Jung and Abbott (1967) and Subba Rao (1970). However, much of this work is based on collections made from a very wide coverage of the Indo-Pacific region and does not represent a true picture of Indian coast line. The other ornamental molluscs including those mentioned above have not been touched by molluscan workers and it is necessary to give a thought to this problem.

Varieties of large and small shells collected from the sea-shore all along our coast for the preparation of decorative articles like dolls, curios *etc.* belong to different families, genera and species about which no systematic account is available.

Molluscs causing damage to ships and marine structures:—

In this category come the shipworms *Teredo* and *Bankia* along with *Martesia*, *Pholas* etc. Our knowledge about these is mainly due to the workers of wood-preservation schemes of the Forest Research Institute, presently running at several universities in India. Mention may be made here of the works of Palekar and Bal (1957), Nair (1957ab, 1965), Rajagopal (1961) and Subba Rao (1968). In spite of this, the systematic work on this group of molluscs is needed and is evidenced by several new species and records made by these workers.

From the account given above, it will be noticed that the works of Preston (1908, 1914, 1915, 1916), Annandale and Kemp (1916), Annandale (1924), Gravely (1927, 1941), Prashad (1932), Satyamurti (1956), Subramanyam *et al.* (1949, 1951, 1952), Kundu (1965) and several others have given us much needed information about the systematics of Indian molluscs. However, their work touched several groups at a time and as such, especially in the case of recent works, lacks the thoroughness required for the understanding of the taxonomy and distribution of each family. In some cases the illustrations need redrawing to represent the specimens correctly. The material of the recent workers cited above came in most cases from the dead shells found along the shore, with the result, the identifications are, at times, incomplete, obscure and in several cases even doubtful. It is necessary, therefore, to work out this vast phylum of Mollusca familywise and it is needless to state here that priority should be given to such orders and families which are commercially important so that, while filling the lacunae in the taxonomy of the Indian marine molluscs, we will have satisfaction of having contributed indirectly to the welfare of our countrymen.

References

Abott, R. T 1960. The genus *Strombus* in the Indo-Pacific. *Indo-Pacific Mollusca*, **1** (2) : 33-146.

Abott, R. T. 1961. The genus *Lambus* in the Indo-Pacific. *Indo-Pacific Mollusca*, **1**(3): 147-174.

Abott, R. T 1967. *Strombus (Canarium) Wilsoni*, new species from Indo-Pacific *Indo-Pacific Mollusca*, **1**(7): 455-456.

Adams, W. 1939. Cephalopoda in the Indian Museum, Calcutta, *Rec. Indian Mus.*, **41**: 61-110.

Annandale, N. 1924. Fauna of Chilka Lake, Mollusca Gastropoda (Revision) *Mem. Indian Mus.*, **5** (4): 855-873.

Annandale, N. and Kemp, S. 1916. Fauna of Chilka Lake. *Mem. Indian Mus.*, **5** (4): 327–374.

Annandale, N. and Rao, H. S. 1925. Material for the revision of the recent Indian Limnaeidae (Mollusca Pulmonata). *Rec. Indian Mus.*, **27** : 137–189.

Awati, P. R. and Rai, H. S. 1931. *The Indian Zoological Memoir III. Ostrea cucullata* (The Bombay oyster) Ed. K. N. Bahl, Methodist Publication House, Lucknow.

Coggin Brown, J. 1923. On the occurrence of *Ostrea gryphoides* (Schlotheim) in Calcutta. *J. Proc. Asiatic Soc. Beng.*, **19** : 75–80.

Crichton, M. D. 1941. Marine shells of Madras. *J. Bombay nat. Hist. Soc.*, **42** : 323–341.

Durve, V S. and Bal, D. V. 1961. Some observations on the shell-deposits of the oyster *Crassostrea gryphoides* (Schlotheim). *Proc. Indian Acad. Sci.*, **55** : 45–55.

Durve, V. S. and Bal, D. V 1961. Studies on the chemical composition of the oyster, *Crassostrea gryphoides* (Schlotheim). *J. zool. Soc. India*, **13** : 70–77.

Durve, V. S. and Bal, D. V. 1962. Preliminary observations on the growth of the spat of the oyster *Crassostrea gryphoides* (Schlotheim). *J. mar. biol. Ass. India*, **4** (2): 206–213.

Durve, V. S. 1964. On the percentage edibility and the index of condition of the oyster, *Crassostrea gryphoides* (Schlotheim). *J. mar. biol. Ass. India*, **6** (1): 128–134.

Durve, V. S. 1965. On the seasonal gonadal changes and spawnig in the adult oyster *Crassostrea gryphoides* (Schlotheim). *J. mar. biol. Ass. India*, **7** (2): 328–344.

Durve, V S. 1967. On the nomenclature of two Indian backwater oysters. *J. mar. biol. Ass. India*, **9** (1): 173–178.

Durve, V. S. 1974. On the specificity of Madras backwater oyster *Crassostrea madrasensis* Preston and the American oyster, *Crassostrea virginica* Gmelin. *J. Bombay nat. Hist. Soc.* 71(2).

Filippova, J. A. 1968. New data on the Cephalopoda of the Indian Ocean. *Symposium on Mollusca* pt I: 257-264. Marine Biological Association of India.

GHOSH, E. 1920. Taxonomic studies on the soft parts of the Soleniidae. *Rec. Indian Mus.*, **19** : 47–78.

GIDEAN, P. W., MENON, P. K. B., RAO, S. R. V and JOSE, K. V 1957. On the marine fauna of Gulf of Kutch: A preliminary survey. *J. Bombay nat. Hist. Soc.*, **54** : 690–706.

GOODRICH, E. S. 1896. Report on a collection of Cephalopoda from the Calcutta Museum. *Trans. Linn. Soc. London*, **7** : 1–24.

GRAVELY, F. H. 1927. Littoral fauna of Krusadai island Mollusca. *Bull. Madras Govt. Mus.*, (Nat. Hist.), **1** : 1–196.

GRAVELY, F H. 1941. Shells and other animal remains found on the Madras beach I. Groups other than snails etc. (Mollusca. Gastropada) *Bull. Madras Govt. Mus.*, (*N. S.*), *Nat. Hist Soc.*, **5** (1): 62-64.

GRAVELY, F. H. 1942. Shells and other animal remains found on the Madras beach. *Bull. Madras Govt. Mus.* (Nat. Hist.), **5** (2): 1–104.

HORNELL, J. 1909. Report on the anatomy of *Placuna placenta*. The report to the Government of Baroda on the Marine Zoology of Okhamandal in Kattiawar, London, pt. 1: 43–97.

HORNELL, J. 1916. Note on the identification of the edible oyster of Okhamandal. Report on the Marine Zoology of Okhamandal in Kattiawar, Pt. 2.

HORNELL, J. 1916. The Indian varieties and races of the genus *Turbinella*. *Mem. Indian Mus.*, **6** : 109–122.

HORNELL, J. 1917. A revision of the Indian species of *Meretrix*. *Rec. Indian Mus.*, **13** : 154–173.

HORNELL, J. 1918. The edible molluscs of Madras Presidency. *Bull. Madras Fish. Dept.*, **11** : 10–16.

HORNELL, J. 1921. The common molluscs of South India. *Madras Fish. Bull.*, **14** : 97–215.

HORNELL, J. 1949. The study of the Indian molluscs, Pts. 1–III. *J. Bombay nat. Hist. Soc.*, **48** : 303–334, 543–569, 750–774.

HORNELL, J. 1951. *Indian Molluscs*. The Bombay Natural History Society.

JUNG, P. and Abbott, R. T 1967. The genus *Terebellum* (Gastropoda: Strombidae) *Indo-Pacific Mollusca*, **1**(7): 445-454 pts. 318-327.

KUNDU, H. L. 1965. On the marine fauna of Gulf of Kutch, Pt. III, Pelecypoda. *J. Bombay nat. Hist. Soc.*, **62** : 84–103 and 211–236.

MASSY, ANNE L. 1916. The Cephalopoda of the Indian Museum. *Rec. Indian Mus.*, **12** : 185–248.

MELVILL, J. C. 1893. Description of 25 new species of Marine shells from Bombay. *Mem. Proc. Manch. lit. phil. Soc.* Ser., **7** (4): 52–66.

MELVILL, J. C. 1896. Description of new species of minute marine shells from Bombay. *Mem. Proc. Manch. lit. phil. Soc.*, **2** (8): 108–116.

MELVILL, J. C. and ABERCROMBIE, A. 1893. The marine mollusca of Bombay. *Mem. Proc. Manch. lit. phil. Soc.*, Ser., **7** (4): 17–51.

MENON, P. K. B., DATTA GUPTA, A. K. and DAS GUPTA, D. 1961. On the marine fauna of Gulf of Kutch Pt II—Gastropods. *J. Bombay nat. Hist. Soc.*, **58** (2): 475–494.

NAIR, B. N. 1957. The shipworms of south India with a note on the breeding season of *Bankia indica* Nair. *J. Bombay nat. Hist. Soc.*, **54** 344, 357.

NAIR, B. N. 1965. Marine timber boring organisms of the Indian Coast "Report on a collection from the South-east coast of India with notes on distribution in the Indo-Pacific area" *J. Bombay nat. Hist. Soc.*, **62** (1): 120–131.

NAIR, B. N. and GURUMANI, O. N. 1957. Timber boring molluscs of the Indian coast. I Report on a collection from Tondi and Adirampatnam, east coast. *J. Bombay nat. Hist. Soc.*, **54** : 663–673.

NEWTON, R. B. and Smith, E. A. 1912, On the survival of the Mioceric oyster in recent seas. *Rec. geol. Surv. India*, **42** : 1–15.

PALEKAR, V C. and BAL, D. V 1957. Distruction of timber by marine organisms in the Karwar port. *J. Bombay nat. Hist. Soc.*, **54** (4): 962.

PATIL, A. M. 1952. Study of the marine fauna of the Karwar coast and neighbouring islands. Part III. Mollusca (contd.)—Scaphopoda, Pelecypoda and Cephalopoda. *J. Bombay nat. Hist. Soc.*, **51** (1): 29–41.

PRASHAD, B. 1932. The lamellibranchia of the Siboga Expedition. Siboga Expeditie, Pelecypoda, Monograph, **53**C.

PRASHAD, B. 1928. Recent and fossil Viviparidae. *Mem. Indian Mus.*, **8** : 153–251.

PRESTON, H. B. 1908. Descriptions of new species of land, marine and freshwater shells from the Andaman Islands. *Rec. Indian Mus.*, **2** : 209.

PRESTON, H. B. 1914. Mollusca from the Chilka on the east coast of India. *Rec. Indian Mus.*, **10** : 297–310.

PRESTON, H. B. 1915. A further note on Mollusca from Lake Chilka on the east coast of India: Family Solenidae. *Rec. Indian Mus.*, **11** : 304–305.

PRESTON, H. B. 1916. Report on a collection of mollusca from the Cochin and Ennur backwaters. *Rec. Indian Mus.*, **12** : 27–39.

RAI, H. S. 1932. The shell-fisheries of the Bombay Presidecy. *J. Bombay nat. Hist. Soc.*, **35** : 826–847.

RAO, K. V 1954. Biology and fishery of the Palk-Bay Squid, *Sepioteuthis arctipinnis* Gould. *Indian J. Fish.*, **1** : 37–66.

RAO, K. V 1956. Seasonal gonadal changes in the adult backwater oyster, *Ostrea (Crassostrea) madrasensis* Preston from Ennur near Madras. *Proc. Indian Acad. Sci.*, **54** : 332–356.

Rao, K. V 1968. Pearl oysters of the Indian region *Symposium on Mollusca*. Pt III : 1017-1028. Marine Biological Association of India.

RAO, K. V. and NAYAR, K. N. 1956. Rate of growth in spat and yearlings of the Indian backwater oyster, *Ostrea madrasensis* Preston. *Indian J. Fish.*, **3** : 231–260.

Rao, K. V., Narsimhan, K. A. and Algarswami, K. 1962. A preliminary account of the biology and fishery of the razor-shell, *Solen Kempi* Preston, from Ratnagiri in Maharashtra state. *Indian J. Fish.*, **9** (2): 542-599.

RAY, H. C. 1956. Mitres of Indian waters (Mollusca Gastropida : Family Mitridae). *Mem. Indian Mus.*, **14** : 1–72.

SATYAMURTHI, T 1952. The mollusca of Krusadai island. I. Amphineura and Gastropoda. *Bull. Madras Govt. Mus.* (Nat. Hist.), **1** (2), pt. 6.

SATYAMURTHI, T 1956. The mollusca of Krusadai island (in the Gulf of Mannar)—II—Scaphopoda, Pelecypoda and Cephalopoda. *Bull. Madras Govt. Mus.*, N.S.—Nat. Hist., **1** (2): Pt. 7: 1–202.

SILAS, E. G. 1968. Cephalopoda of the west coast of India collected during the cruises of the research vessel *Varuna*. *Symposium on Mollusca*, Pt. I: 277-359. Marine Biological Association of India.

SUBBA RAO, N. V 1968. Report on a collection of wood-boring molluscs from Mahanadi estuary, Orissa, India. *Symposium on Mollusca*, Pt. I: 85-93. Marine Biological Association of India.

SUBBA RAO, N. V 1970. On the collection of Strombidae (Mollusca: Gastropoda) from Bay of Bengal, Arabian sea and Western Indian Ocean, with some new records I. Genus-*Strombus*.

SUBRAHMANYAM, T V., KARANDIKAR, K. R. and MURTI, N. N. 1949. The marine Pelecypoda of Bombay. *J. Univ. Bombay*, **17** (New series), Pt. 5(B): 50–81.

SUBRAHMANYAM, T V., KARANDIKAR, K. R. and MURTI, N. N. 1951. The marine Gastropoda of Bombay. *J. Univ. Bombay*, **20** (1): 21–34.

SUBRAHMANYAM, T V., KARANDIKAR, K. R. and MURTI, N. N. 1952. The marine Gastropoda of Bombay. Pt. 2. *J. Univ. Bombay*, **21** : 26–73.

VREDENBURG, E. 1904. Recent and sub-recent marine bed in Calcutta. *Rec. geol. Surv. India.*, **31**: 174-176.

VREDENBURG, E. 1916. A note on the Geological History of the genus *Turbinella*. *Mem. Indian Mus.*, **6** : 123–126.