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A TAXONOMIC REVISION OF THE INDIAN SPECIES OF THE FAMILY COSSIDAE (LEPIDOPTERA)

By

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Zoological Survey of India, Calcutta, India

(With 35 Text-figures and 3 Plates)

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INTRODUCTION

(a) General

Members of the family Cossidae, known as the goat-moths, or the carpenter-moths, include certain species which were described as early as 1758 by Linnaeus, 1775 by Fabricius and 1779 by Cramer. Dalla-Torre (1923) who prepared the catalogue of the family recorded nearly 500 species, belonging to 57 genera. It included 35 species belonging to eight genera from the Indian region (including India, Bangladesh, Pakistan, Bhutan, Burma and Srilanka). Although, a large number of species of the family has since been described from various parts of the world, those from the countries mentioned above have been very few. These comprise four species from India, described by Fletcher (1928) (two species) and Arora (1965, 1974) (two species), and two species from Burma described by Bryk (1950). In so far as the species from other parts of the Orient are concerned, considerable advance has been made by Roepke (1948, 1957) who studied the material of this family from Sumatra and Malaysia, and Daniel (1962) who studied South and South-Eastern species of the genus *Zeuzera* Latreille. Roepke (1948) states (p. 216) " This species [*lineata* Gaede] of the genus *Zeuzera* as well as the entire family of eastern Cossids are not yet sufficiently worked out " He (1957) reported and described eight genera and 55 species (including two new genera and 27 new species) from Malaysia. Among these, *Phragmataecia castaneae* Hübner, *Xyleutes ceramicus* (Walker), *X. mineus* (Cramer), *X. pardicolor* (Moore), *X. persona* (Le Guillou), *X. strix* (Linn.), *Zeuzera coffeae* Nietner and *Z. indica* Herrich-Schäffer occur in the Indian region also. As regards the study of the family Cossidae in the Palaearctic region, Daniel's work (1940 to 1965) on the genera *Catopta* Staudinger, *Cossus* Fabricius, and *Holcocerus* Staudinger is important, especially because of the transfer of certain Indian species of the genus *Cossus* Fabricius, viz. *C. cashmirensis* Moore,

C. acronyctoides (Moore) and *C. pallidalae* Hampson to the genus *Catopta* Staudinger, though erroneous in case of *C. acronyctoides* and *C. pallidalae*, and *C. rufidorsia* Hampson to the genus *Holcocerus* Staudinger.

Except for a few references, as above, the taxonomy of the Indian Cossidae has remained almost neglected since the publication of "Moths of India" series by Hampson (1905). The taxonomic study of the Indian species has been undertaken with a view to add to our knowledge of this family which is of considerable economic importance on account of the wood-boring habit of their larvae. These cause considerable damage to a variety of plants in the forests and plantations in India and neighbouring countries. The damage done by different species is of varied nature ; some species are characterised by forming galleries which are not detected unless the tree is sawn, as is the case with *Xyleutes ceramicus* (Walker) which attacks teak. The damage caused by *X. persona* (Le Guillou) is also in the form of numerous galleries and the wounds caused by this species may be sufficient to kill the plant. *Zeuzera coffeae* Nietner is another well-known pest of coffee and is commonly called the coffee-borer or the red-borer, which is also reported to attack as many as 35 different host plants (Beeson, 1941), including sandal-wood, citrus, cotton, jasmine and teak. The larvae, the presence of which is detected by the pellets of frass on the ground below the infested branch, affect only that part of the tree where they bore, but if the tree is young, the attack can be fatal.

Another point of interest regarding the Cossidae is that phylogenetically it is one of the most primitive families in the order Lepidoptera and is believed to have retained the ancient or the generalised type (Turner, 1918 and Seitz, 1929) of neuration among the Lepidoptera-Heteroneura. Seitz (1912) refers to its relationship with the Microlepidopteren families, the Tortricidae and Hepialidae. Turner (1918, 1946) has claimed that presumably all the major families have evolved from Cossidae by a process of reduction of the veins, etc. His hypothesis has led him to propose a new family name *Protocossidae* to denote its ancestral status. Gaede (1929) has commented on the highly remarkable features of the family, e.g., the large and hard wings in certain species (though not active fliers) ; reduced proboscis and labial palpi in certain species or their absence in others, the very large eyes, etc. He, however, opined (p. 539) "We can easily distinguish different types of lepidoptera among the *Cossidae* ; they deviate so much from each other that even the homogeneousness of the family is doubted and some lepidopterologists are of opinion that the characteristics common to the family are for the greater part merely to be considered as resemblance by convergency, produced by endophyte habits of the larvae." These view points on the primitive or specialised features, are of interest and importance in the study of Cossidae.

The taxonomy of the Indian species has been dealt with in detail in the following pages on the basis of the material belonging to 31 species, two of which are new. A new subspecies is also proposed. Apart from a huge collection of this family in the Zoological Survey of India, collections, both determined and undetermined, present in other institutes such as Indian Agricultural Research Institute, New Delhi, Forest Research Institute, Dehra Dun, and British Museum (Natural History), London, were also available for this study. Types of the several species of F. Moore located in Berlin Museum, of F. Bryk's species in Riksmuseum, Stockholm, and those of T. B. Fletcher's in the Indian Agricultural Research Institute, New Delhi, were also available for this study.

I am greatly indebted to Dr. A. P. Kapur, Director, Zoological Survey of India, Calcutta, for suggesting the problem and for his expert and valuable guidance.

My grateful thanks are due to the following persons and authorities who kindly loaned the type material or named collection of various species present in their institutes : to Dr. H. J. Hannemann of the Institute fur Spezielle Zoologie und Zoologische Museum, Berlin ; to the Director, Riksmuseum, Stockholm (Sweden) ; to Dr. S. Pradhan, Head of the Entomology Division, Indian Agricultural Research Institute, New Delhi ; and to Dr. P. N. Chatterji, Forest Research Institute, Dehra Dun.

I am specially thankful to Drs. W. H. T. Tams and A. Watson, of the British Museum (Nat. Hist.), London, for sending the named material, the photographs of the types and their genitalia, present in the Museum.

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I also thank the following persons for sending some valuable literature on this group of moths : Dr. F. Daniel, Zoologische Sammlung des Bayerischen Staates, Munchen ; Dr. Harry K. Clench, Carnegie Museum, Pittsburg, Pennsylvania (USA) ; Dr. P. Viette, Mus. Nat. d'Histoire Nat., Paris ; Dr. L. A. Berger, Department d'Entomology, Musée Royale du Congo Belge, Tervuren (Belgium) ; and Shri M. C. Sardana, Indian Embassy, Brussels.

(b) *Abbreviations used*

A, Anal veins.

a, Areole.

- aa*, Anterior apodeme.
am, Ampulla.
an, Juxta of the anellus.
anl, Anellus lobes.
ar, Arolium.
B.M., British Museum (Nat. Hist.), London.
Ber.Mus., Institute fur Spezielle Zoologie und Zoologische Museum, **Berlin**.
b, Bulla.
c, Clasper.
cb, Corpus bursae.
ch, Costal hump.
cl, Cucullus.
cn, Cornutal spines/process.
coll, Collector.
colln, Collections.
cr, Coiled sclerotised ribbon.
db, Ductus bursae.
dc, Discal cell.
e, Eye.
ex, Example.
ex. colln, From the collections of.
F. R. I., Forest Research Institute, Dehra Dun.
fig, Figure.
fr, Frenulum.
gn, Gnathos.
h, Harpe.
I. A. R. I., Indian Agricultural Research Institute, New Delhi.
Indian Mus., Indian Museum, Calcutta.
j, Juxta.
mc, median cell.
N. P. C., National Pusa Collections.
ob, Ostium bursae.
oc, Ocellus.
Ox. Univ. Mus., Oxford University Museum.
pa, Posterior apodeme.
Paris Mus, Paris Museum.
Rm, Riksmuseum.
rs, Receptaculum seminalis.
rt, Retinaculum.
s, Socii.
sc, Saccus.
scl, Sclerotisation on the dorsal side of the genital plate.
sg, Signum.
sp, Sclerotisation on the ventral side of the genital plate.
spr, Spina basalis process.
tbs, Tibial spurs.
teg, Tegumen.
ts, Tarsal spines.
Type loc, Type locality.
u, Uncus.
usc, Vesica.
Z. S. I., Zoological Survey of India.

REVIEW OF THE TAXONOMY OF THE INDIAN COSSIDAE

(a) *Historical Account*

The word 'Cossida' was proposed by Leach (1815) for a group of those moths which included *Cossus cossus* (Linn.) and its allied species. Boisduval (1829) proposed *Zeuzeridi* for the genus *Zeuzera* Latreille and its allies but subsequently (1834) changed it to *Zeuzerides*. It was Newman (1832) who used the words *Cossidae* and *Zeuzeridae* for the first time and it is probably due to this reason that the family is assigned to Newman by several workers. Dalla-Torre (1923) and Dyar (1937) have, however, assigned the family to Leach (1815) because of the priority of *Cossida* Leach over *Cossidae* Newman. Besides as above, the family has also been referred in the literature under several other names, viz. *Cossides* Herr.-Sch., *Cossina* Heinemann, *Phalaenina Cossites* Newman, etc.

The family has a world-wide distribution of nearly all the genera that are not monotypical and, as Seitz (1929) refers, the global distribution is mainly due to the larvae which are wood-or pith-borers and are easily transportable. He recorded some 500 species from the world, but today the number of known species and subspecies is nearly 1000, increased mainly on account of the taxonomic work on the Cossidae of Palaearctic (Daniel, 1940 to 1965), Australian (Turner, 1945), Neotropical (Clench, 1956, 1957), Ethiopian (Clench, 1959) and Oriental (Roepke, 1957 ; Arora, 1965, 1974) regions.

The first record of Cossidae from India appears to have been given by Donovan (1800), who recorded *Phalaena scalaris* (Fabricius) and *Phalaena mineus* (Cramer) from Bengal, originally described from China and Batavia, respectively. Eschscholtz (1821) described a new species, viz. *Zeuzera viridicans*, now a synonym of *Xyleutes mineus*, for the first time from India (Ganjam, Orissa). Subsequent additions to the Indian fauna were made in a series of papers by Herrich-Schäffer (1854), Walker (1856, 1865), Nietner (1861), Moore (1865-1883), Butler (1880), Swinhoe (1884, 1894), Hampson (1891-1905) and Dudgeon (1899).

Cotes & Swinhoe (1887) prepared a *Catalogue of Moths of India* and included 21 species in the family Cossidae. Kirby (1892) instead, recorded 22 species in the family because the species *Zeuzera asylas* (Cramer) was not recognised by him as a synonym of *Zeuzera scalaris* (Fabricius), as done by the former. Hampson (1892b), however, pointed out that *Zeuzera asylas* (Cramer) was a South African species and, therefore, he excluded it from the Indian Cossids. He also described five new species and synonymised some species to the already known ones, thus recognising only 23 species from the Indian region. Subsequent additions, which followed till the publication

of Dalla-Torre's (1923) catalogue, were by Swinhoe (1894), Hampson (1895-1905) and Dudgeon (1899), who added one, six and one species, respectively.

(b) *Recent Development and Present Position of the Indian Cossidae*

Since the publication of the catalogue of the world Cossidae by Dalla-Torre (1923) very little work has been done on the taxonomy of the Indian Cossidae. Although Dalla-Torre (1923) recorded 35 species from the Indian region under this family, the figure also included those species which were either not considered as belonging to this family, viz. *Cossus stigmatus* Moore (*vide* Hampson, 1892b; and Gaede, 1929) and *Dudgeonea leucosticta* Hampson (*vide* Berger, 1957), or not occurring in Indian region, viz. *Zeuzera asylas* (Cramer) (*vide* Hampson, 1892b), and *Z. crassicornis* (Fabr.) (*vide* Kirby, 1892), or not valid species, viz. *Duomitus pardalis* Dudgeon which was synonymised with *Zeuzera pardicolor* Moore (= *Xyleutes pardicolor*) (*vide* Gaede, 1933 and Roepke, 1957). Further additions to the Indian Cossidae were made by Fletcher (1928) from Pusa, Bihar, India, (2 species); Bryk (1950) from Burma (2 species); and by Arora (1965, 1974) from Sikkim and Bhutan (2 species).

Beeson (1941) recorded some 25 species of Cossidae from the different host-plants, but referred to a number of unidentified Cossidae attacking Indian plants.

Daniel (1940 to 1965) in a series of papers on the Palaearctic and Oriental Cossidae, revised the genera *Catopta* Staudinger, *Holcocerus* Staudinger, *Cossus* Fabricius, *Zeuzera* Latreille, and a few more, which are common to both Palaearctic and Oriental regions and also transferred several species of the genus *Cossus* to various other known or new genera.

Another significant work on the Cossidae is by Clench (1956-1959) who revised mainly the Neotropical (1956), Chilean (1957) and the African fauna (1959b). He (1958) also described a new species from Western-China, viz. *Sinicossus danieli*, which, he considered, possessed its closely related forms in India. He also studied (1959a) the unusual structure and affinities of the Madagascanian genus *Pseudocossus* Kenrick, and for the first time reported the presence of ocelli in this genus. Among the Indian Cossidae the ocelli were hitherto unknown and are being reported for the first time in the genus *Catopta* Staudinger, particularly in the two species which have been studied here, viz. *C. cashmirensis* (Moore) and *C. sikkimensis* (Arora). Clench's revision of the African fauna (1959b) is also of interest as far as the Indian Cossidae is concerned, since he revived the genus *Brachylia* Felder, which was till then generally considered as a synonym of the genus *Cossus*. In fact it was under this genus that

one of the Indian species was described as *Brachylia acronyctoides* Moore, but now has been placed in the genus *Cossus*.

Roepke (1957) revised the Malaysian Cossidae and made a comprehensive study of the male genitalia in several species. Berger (1957) transferred a hitherto-known Cossid-genus *Dudgeonea* Hampson from India, into a distinct family Dudgeonidae due to the presence of tympanum in the latter.

In the present study two more new species and a subspecies have been described, respectively, from Ceylon, S. Andaman and Sangur (W.B.). One species viz., *Holcocerus arenicola* (Staudinger) has been recorded from India (Great Nicobar Island), for the first time, thus bringing the total number of known species and subspecies to 40.

III—MATERIAL AND METHODS

(a) Material

The material for the present study consists of about 400 specimens representing 32 species & subspecies belonging to eight genera, viz. *Catopta* Staudinger (2 species), *Cossus* Fabricius (3 species), *Holcocerus* Staudinger (2 species), *Paracossus* Hampson (1 species), *Azygophelps* Hampson (3 species), *Phragmataecia* Newman (10 species), *Xyleutes* Hübner (7 species) and *Zeuzera* Latreille (3 species and a subspecies). The material of the remaining eight species was not available for study and hence their original descriptions have been quoted so as to show the differences from their closely-related species. The material is mainly present, except otherwise stated, in the National Zoological Collections at the Zoological Survey of India, Calcutta, which also includes extensive collections of, E.E. Green from Ceylon ; G. C. Dudgeon from Kangra valley, Sikkim and Bhutan ; and of T. C. Jordan from Sikkim.

Several types were available for the study from various institutes and museums in India and abroad. These were : F Moore's species viz., *Cossus cashmirensis*, *Phragmataecia minor*, *Phragmataecia saccharum*, *Zeuzera stigmatica* (labelled as *Zenzera bistigma*), *Zeuzera albofasciata*, and *Zeuzera pardicolor* from the Berlin Museum ; F. Bryk's species, viz. *Phragmataecia obliquifascia* and *Phragmataecia clara* from the Riksmuseum, Stockholm ; T. B. Fletcher's species *Phragmataecia purpureus* and *Phragmataecia terebrifer* from the N.P.C. at I.A.R.I., New Delhi. The material for the species *Cossus pallidalae* Hampson [now *Phragmataecia pallidalae*], *Phragmataecia impura* Hampson and *Paracossus parve* Hampson, was available from the B.M. (N.H.), London. Some material both determined and undetermined was also available from F.R.I., Dehra Dun and I.A.R.I., New Delhi.

(b) Methods of Study

The material was studied dry. Special attention was paid to the study of head-appendages and wing-venation, the latter was studied from the under side by applying toluene with the help of a fine sable-hair brush.

The genitalia were studied by cutting a part of abdomen in the male and detaching the whole abdomen in the female. The same was kept in 10 % KOH overnight. This treatment was prolonged if the material did not soften. After washing with the distilled water the genitalia were passed through different grades of alcohol and mostly preserved in spirit.

The sketches were made with the help of camera lucida.

(c) Some Characters of Taxonomic Importance

Both the external as well as genitalic studies have been made with a view to present, as far as possible, the detailed taxonomic account of the Cossid fauna of the Indian region including India, Bangladesh, Pakistan, Burma and Ceylon.

The following characters have been studied in more detail :

Antennae.—Highly variable but taxonomically of great importance. These are either bipectinate upto the tip as in the case of *Catopta* (Text-fig. 1B) ; or unipectinate up to the tip as in *Cossus* (Text-fig. 3 A-B). The length of pectination decreases in several genera : In *Phragmataecia* it is three-fourths the length (Text-fig. 12 C-D) ; in *Xyleutes* and *Zeuzera* the pectination is in the basal half of the length (Text-fig. 25). The antennae are laterally flattened and simple in *Holcocerus* (Text-fig. 6A). In the female the antennae are variable, *i.e.*, either simple and ciliate, or shortly serrate or bipectinate (Text-fig. 12 E-F).

Ocelli.—All the Indian Cossidae are without ocelli except the two species of *Catopta* (Text-figs. 1B, 2B).

Labial palpi.—These are generally always present but are variable in shape and size.

Legs.—The legs have been found to be of considerable taxonomic importance, especially in differentiating the two subfamilies, *viz.* Cossinae and Zeuzerinae and the identity of genera. The former is generally characterised by having dilated hind tibiae, two pairs of hind tibial-spurs, tarsal spines and arolium. In the latter subfamily the hind tibiae are slender, with a single pair of spurs, the tarsal

spines may be present either on all the tarsal segments, or absent on one or more segments, and the arolium may be absent or present.

Venation.—The venation in both the wings is another character which helps in separating the two subfamilies and in determining the identity of the species, *e.g.* in Cossinae the veins R_s and M_1 are mostly connate in the hind wings unlike the case in Zeuzerinae where these veins are always wide separate. The position and origin of veins R_1 to R_3 and M_1 to M_3 , and median cell in the hind wing also offers an important diagnostic character for both the subfamilies.

Genitalia.—The male genitalia in case of Cossinae are characterised by the presence of gnathos which meet below the uncus, unlike in Zeuzerinae where they are free, if present, or completely absent. The shape and structure of uncus, clasper, juxta, aedeagus, etc., is of help in the identity of the different species.

The female genitalia have been studied, wherever available and have offered a good amount of help in the identity of various species, especially by the sclerotisation on dorsal or ventral, or both surfaces of the 8th segment, the shape and size of signum, if present, on the corpus bursae. However, it is observed that the female genitalic characters are quite variable.

IV—TAXONOMIC ACCOUNT

Family COSSIDAE Leach (1815)

- 1815. *Cossida* Leach, *Edinb. Encycl.*, 9 : 131.
- 1821. *Fodicantes teredines*, Hübner, *Verz. bek. Schmett.* : 195.
- 1829. *Zeuzeridi* Boisduval, *Eur. Lep. Index Meth.* : 51.
- 1832. *Zeuzeridae* Newman, *Ent. Mag.* : 68.
- 1832. *Cossidae* Newman, *Ent. Mag.* : 68.
- 1832. *Phalaenina cossites* Newman, *Ent. Mag.* : 68.
- 1834. *Zeuzerides* Boisduval, *Icon. Syst. Lep. Eur.*, 2 : 173.
- 1840. *Zeuzerides* Boisduval, *Gen. et. Index Meth. Eur. Lep.* : 75.
- 1843. *Cossides* Herrich-Schäffer, *Syst. Bearb. Schmett. Eur.* 2 : 14.
- 1854. *Cossina* Herrich-Schäffer, *Samml. Ausser. Schmett.* : 58.
- 1856. *Cossidae*, Walker, *List Lep. Brit. Mus.*, 7 : 1509.
- 1862. *Cossidae*, Walker, *J. Linn. Soc. (Zool.)*, 6 : 177.
- 1865. *Cossidae*, Walker, *List Lep. Brit. Mus.*, 32 : 582.
- 1865. *Cossidae*, Moore, *Proc. zool. Soc. Lond.* : 822.
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- 1877. *Cossidae*, Moore, *Ann. Mag. nat. Hist.*, (4) 20 : 348.
- 1879a. *Cossidae*, Moore, *Proc. zool. Soc. Lond.* : 411.
- 1879b. *Cossidae*, Moore, *Descr. Indian Lep. Atk.* : 85.
- 1880. *Cossidae*, Butler, *Ann. Mag. nat. Hist.*, (5) 6 : 68.
- 1881. *Cossidae*, Moore, *Proc. zool. Soc. Lond.* : 327.
- 1882. *Cossidae*, Butler, *Ann. Mag. nat. Hist.*, (5) 10 : 228.
- 1883. *Cossidae*, Moore, *Lep. Ceylon*, 2 : 153.

1884. *Cossidae*, Staudinger, In Romanoff *Memoir. Lep.*, 1 : 1.
1886. *Zeuzeridae*, Butler, *Ill. Type Lep. Het.*, 6 : 28.
1887. *Cossidae*, Cotes & Swinhoe, *Cat. Moths of India*, 2 : 232.
1891. *Cossidae*, Hampson, *Ill. Lep. Het. Brit. Mus.*, 8 : 10. 66.
- 1892a. *Cossidae*, Hampson, *Ill. Lep. Het. Brit. Mus.*, 9 : 68.
- 1892b. *Cossidae*, Hampson, *Fauna Brit. India, Moths*, 1 : 304.
1892. *Cossidae*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, 1 : 280.
1892. *Zeuzeridae*, Kirby, *Cat. Lep. Het.*, 1 : 860, 930.
1894. *Cossidae*, Swinhoe, *Ann. Mag. nat.-Hist.*, (6) 14 : 440.
1894. *Cossidae*, Hampson, *Ann. Mag. nat. Hist.*, (6) 14 : 254.
- 1894a. *Cossidae*, Neumoegen & Dyar, *J. N. Y. ent. Soc.*, 1 : 97.
- 1894b. *Cossidae*, Neumoegen & Dyar, *J. N. Y. ent. Soc.*, 2 : 1.
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1901. *Cossidae*, Staudinger & Rebel, *Cat. Lep. Pal. Fnggeb.*, 1 : 406.
1904. *Cossidae*, Stebbing, *J. Asiat. Soc. Beng.*, 73 (2) : 25.
1905. *Cossidae*, Hampson, *J. Bombay nat. Hist. Soc.*, 16 : 193, 216.
1909. *Cossidae*, Lefroy, *Indian Insect Life* : 494.
1912. *Cossidae*, in Seitz, *Macrolepidoptera of the World*, 2 : 417.
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1914. *Cossidae*, Bethune-Baker, *Trans. ent. Soc. Lond.* : 327.
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1925. *Cossidae*, Handlirsch, *Handb. Ent.*, 3 : 893.
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1929. *Cossidae*, Gaede, in Seitz *Macrolepidoptera of the World*, 14 : 539.
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1933. *Cossidae*, Mehta, *Rec. Indian Mus.*, 35 : 231.
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1946. *Cossidae*, Turner, *Proc. Linn. Soc. N.S.W.*, 71 : 303.
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1951. *Zeuzeridae*, Essig, *College Entomology* : 445.
- 1951b. *Cossidae*, Viette, *Lambillionea*, 51 (5-12) : 37.
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1955. *Cossidae*, Daniel, *Mitt. münch. ent. Ges.*, 44-45 : 159.
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 1959b. *Cossidae*, Clench, *Veröff. zool. Stsamml. Münch.* 6 : 1.
 1959. *Cossidae*, Daniel, *Mitt. münch. ent. Ges.*, 49 : 102.
 1961. *Cossidae*, Daniel, *Mitt. münch. ent. Ges.*, 51 : 160.
 1962. *Cossidae*, Daniel, *Z. Arb. Gen. öst. Ent.*, 14 (1) : 6.
 1962. *Cossidae*, Comstock, *Introduction to Entomology* : 601.
 1962. *Cossidae*, Agrawal and Agrawal, *Curr. Sci.*, 29 (8) : 311.
 1965. *Cossidae*, Arora, *Bull. syst. Zool.*, 1 (1) : 25.
 1965. *Cossidae*, Daniel, *Mitt. münch. ent. Ges.*, 55 : 77.
 1965. *Cossidae*, Müller, *Dt. ent. Z.*, 12 (3) : 181.

(a) *Characters of the Family COSSIDAE* Leach

The main features of the family Cossidae are as follows :-

Moths of medium to large size. Frons smooth. Antennae in male usually bipectinate ; in female usually simple and minutely ciliate ; eyes generally smooth and large ; ocelli absent (except in *Catopta* and *Pseudocossus*) ; proboscis usually atrophied ; labial palpi variable in size, being well developed to obsolete ; maxillary palpi absent. Frenulum in male generally in the form of a single stout spine, sometimes short and functionless ; in female the number of frenulum spines generally vary from 2 to 3, sometimes up to 30.

Fore wings : Generally with an areole ; vein Sc free ; $R_4 + R_5$ stalked ; median vein strong and usually forked in the cell ; Cu_2 present ; two anal veins present, 2A forming a fork with 1A. Hind wings broad ; Sc either free or connected with Rs by a short cross bar ; median and Cu_2 as in fore wing ; three anal veins present, 2A forming a fork with 1A, 3A short and close to the anal margin.

(b) *General remarks on the classification of the Family COSSIDAE* Leach

Family Cossidae was subdivided for the first time, by Neumoegen and Dyar (1894), into two subfamilies, viz. Cossinae and Zeuzerinae. The classification was followed by Tillyard (1926), Gaede (1933), Mehta (1933), Bryk (1937), Dyar (revised by Schaus) (1937), Clench (1959b), Comstock (1962) and Daniel (1962, 1965). Berger (1957), however, separated the Indian genus *Dudgeonea* Hampson into a distinct family Dudgeonidae on account of the presence of tympanic organ and proposed two subfamilies of the family Cossidae, viz.

Cossinae and Eulophonotinae. He obviously included whole of the Cossid fauna under the subfamily Cossinae. Handlirsch (1925), Janse (1932) and Brues, Melander and Carpenter (1954) went a step further by treating Cossidae in a very broad sense and included several families as its subfamilies, viz. *Argyrotypinae*, *Cossinae*, *Eulophonotinae*, and *Metarbelinae*, and further classified the subfamily Cossinae into several tribes, including Cossini and Zeuzerini. While Turner (1918) believed Cossidae as a compact group and considered rather impossible to divide it, for he commented (p. 166) "that this is a natural and compact family not divisible naturally even into subfamilies. There is, it is true, a considerable and very interesting degree of variation in several directions, but all these lines of development are linked together by forms of intermediate structure.", Essig (1951), on the other hand, recognised both Cossidae and Zeuzeridae as distinct families under the superfamily Cossoidea, and not as subfamilies of Cossidae.

In the present work the earliest classification, as proposed by Neumoegen & Dyar (1894), has been followed, though the basis of classification has been modified in the light of present study, i.e., several important characters have been taken into account, e.g. the antennae in male, the origin of veins Rs and M_1 in hind wing, the hind-tibiae, and in the male genitalia the gnathos, which define rather clearly both Cossinae and Zeuzerinae unlike the earlier system of classification based on more or less a single character.

(c) Key to Subfamilies of the Family COSSIDAE

Only two subfamilies of the family Cossidae are represented in the Indian subregion, and have been based on the following key :

Antennae in male pectinate up to the tip, sometimes simple and flattened ; veins Rs and M_1 generally connate or stalked, rarely separate ; hind tibiae dilated, usually with two pairs of tibial spurs ; gnathos in the male genitalia present, and meeting below the uncus

Cossinae Neumoegen & Dyar

Antennae in male pectinate only in basal half to three-fourths of length, never simple and flattened ; veins Rs and M_1 separate, never connate or stalked ; hind tibiae not dilated, with a single pair of tibial spurs ; gnathos either absent, or free, if present

Zeuzerinae Neumoegen & Dyar

Subfamily (i) COSSINAE Neumoegen & Dyar

- 1894a. *Cossinae* Neumoegen and Dyar, *J.N.Y. ent. Soc.*, 1 : 97.
 1894b. *Cossinae* Neumoegen and Dyar, *J.N.Y. ent. Soc.*, 2 : 1.
 1925. *Cossinae*, Handlirsch, *Handb. Ent.*, 3 : 893.
 1926. *Cossinae*, Tillyard, *The Insects of Australia and New Zealand* : 416.
 1929. *Cossinae*, Seitz, in *Seitz Macrolepidoptera of the World*, 14 : 539.
 1932. *Cossinae*, Janse, *The Moths of S. Africa* : 61.
 1933. *Cossinae*, Mehta, *Rec. Indian Mus.*, 35 : 231.
 1937. *Cossinae*, Bryk, *Lepid. Cat.*, 81 : 3.
 1937. *Cossinae*, Dyar, in *Seitz Macrolepidoptera of the World*, 6 : 1265.
 1954. *Cossinae*, Brues, Melander & Carpenter, *Bull. Mus. comp. Zool. Harv.*, 128 : 234.
 1955. *Cossinae*, Daniel, *Mitt. münch. ent. Ges.*, 44-45 : 159.
 1959b. *Cossinae*, Clench, *Veröff. zool. Stsamml. Münch*, 6 : 15.
 1962. *Cossinae*, Comstock, *Introduction to Entomology* : 601.
 1965. *Cossinae*, Daniel, *Mitt. münch. ent. Ges.*, 55 : 77.

Type-genus : *Cossus* Fabricius (1794).

(a) Characters of the Subfamily COSSINAE

Insects of medium size. Antennae in male 'pectinate up to tip or simple and laterally flattened ; in female generally simple, sometimes with short pectination. Labial palpi well developed, upturned and closely appressed to face, with the third segment short. Proboscis absent. Middle tibiae with a single pair of spurs ; hind tibiae having two pairs of spurs and dilated ; tarsal spines well developed and present on all segments ; tarsal claws with a distinct arolium. Frenulum in the form of a single bristle in the male and eight to ten bristles in the female ; retinaculum generally elongate and simple.

Fore wings with the areole usually small to moderately large, rarely absent ; vein R_1 arises from cell ; median vein usually forked in the cell ; M_2 and M_3 from above the lower angle of cell. Hind wings usually without cross bar between vein Sc and the cell ; Rs and M_1 connate or shortly stalked, rarely separate ; median as in fore wings.

Male genitalia with socii present ; gnathos present, arms fused below the uncus. Female genitalia variable.

(b) General remarks on the Indian COSSINAE

The present study is based on 12 species belonging to the following genera : *Catopta* Staudinger (two species), *Cossus* Fabricius (five species), *Eremocossus* Hampson (one species), *Holcocerus* Staudinger (two species) and *Paracossus* Hampson (two species).

The genus *Catopta* is mainly Palaearctic. Daniel (1940) transferred one of the Indian species, *Cossus cashmirensis* Moore, to this genus and later (1961) recorded the species from China. Another species described recently by the author (Arora, 1965) is transferred now to this genus. The genus *Cossus* is based on the study of five species, one of which, namely *Cossus greeni*, is new to science. The genus *Holcocerus*, like *Catopta*, was hitherto not reported from India till Daniel (1959) transferred one of the species of the genus *Cossus*, namely *C. rufidorsia* Hampson (from Sikkim), to this genus. In the present study this species from Assam (coll. S.K. Tandon and G. S. Arora, 1966) and another palaearctic species, viz. *Holcocerus arenicola* (Staudinger) from India (Great Nicobar Islands) are being reported for the first time. The genus *Paracossus* Hampson is represented by only two species, namely *P. furcata* Hampson and *P. parva* Hampson.

(c) Key to the Indian Genera of the subfamily COSSINAE

1. Ocelli generally present ; antennae in male always bipectinate ; claspers in the male genitalia short, simple, without any sclerotisation and spinabasis ; aedeagus short, slender and always with short spines *Catopta* Staudinger

- Ocelli absent ; antennae in male either bipectinate, or unipectinate or simple ; claspers short or long, usually with the inner side sclerotised and with spinabasis ; aedeagus short or long, and with or without spines 2

2. Antennae unipectinate in male. Clasper in male with generally L-shaped, or somewhat reduced, spinabasis *Cossus* Fabricius

- Antennae in male bipectinate or simple 3

3. Hind wing with veins Rs and M₁ stalked *Eremocossus* Hampson

- Hind wing with Rs and M₁ either connate or free 4

4. Antennae in male simple ; median vein forked in both wings ; clasper in the male genitalia with L-shaped spinabasis *Holcocerus* Staudinger.

Antennae in the male bipectinate ;
 median unforked in both wings ;
 claspers with inverted T-shaped
 spinabasal

Paracossus Hampson

Genus *Catopta* Staudinger

1899. *Catopta*, Staudinger, *Dt. ent. Z. Lep.* : 157.
 1901. *Catopta*, Staudinger and Rebel, *Cat. Lep. Pal. Fngeb.*, 1 : 407.
 1912. *Catopta*, Seitz, in *Seitz Macrolepidoptera of the World*, 2 : 425.
 1923. *Catopta*, Dalla-Torre, *Lepid. Cat.*, 29 : 4.
 1940. *Catopta*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1015.
 1951. *Catopta*, Viette, *Lambillionea*, 51 (5-12) : 39.
 1961. *Catopta*, Daniel, *Mitt. münch. ent. Ges.*, 51 : 174.
 1965. *Catopta*, Müller, *Dt. ent. Z.*, 12 (3) : 189.

Type-species : *Cossus albonubilis* Graeser

(a) General

The genus *Catopta* was erected by Staudinger (1899) to include the palaearctic species *Cossus albonubilis* Graeser. Daniel (1940) transferred one of the Indian species of the genus *Cossus* Fabricius to this genus, and later (1951) included two more species, *viz. acronyctoides* (Moore) and *pallidalae* Hampson, on the basis of the long-hairy appearance of the insect, antennae bipectinate up to the tip, thin labial palpi, broad wings, and long abdomen. He also made the genitalic studies of *cashmirensis* and *albonubilis*. The present study, however, shows that both *acronyctoides* and *pallidalae* do not belong to this genus due to absence of all the above-mentioned characters and are placed in the genera *Cossus* Fabricius and *Phragmataecia* Newman, respectively.

(b) Characters of the Genus *Catopta* Staudinger

Antennae bipectinate up to the tip. Ocelli well developed. Labial palpi short and slender. Fore wings very broad. Hind wings with the retinaculum short, narrow and bar-shaped, curved at its tip. Legs with the tibiae dilated from near the base ; tarsal spines well developed, present on all the segments ; arolium well developed.

Fore wings with moderately long areole ; vein R_1 arises from cell ; R_2 from the distal one-third of the areole ; R_3 connate or connected by a short cross bar with the stalk of veins $R_4 + R_5$; M_1 either from angle or from below the angle of the cell ; M_2 and M_3 close and arise from above the lower angle ; Cu_{1a} from angle ; median vein forked in the cell and forming the median cell, with its branches ending between M_1-M_2 and M_2-M_3 ; other veins as described under the family. Hind wings with the vein Sc free ; Rs connate with M_1 ;

median forked, forming median cell ; the branches of median and other veins as in fore wing.

Claspers in male genitalia short, broad at the base and with a costal hump in the middle ; gnathos short, arms meeting mid-ventrally below uncus ; aedeagus simple and with a few distal spines. Female not known.

(c) *Relationships of the Genus Catopta with the other allied Genera*

The genus *Catopta* resembles other Cossinae genera, viz. *Cossus*, *Holcocerus* and *Paracossus* Hampson, by the presence of dilated hind-tibiae having two pairs of tibial spurs, but, however, differs in having well developed ocelli, bipectinate antennae having long rami, and well developed retinaculum. In the male genitalia the gnathos present, arms unite rather directly below uncus ; claspers small, each with a costal hump.

Other than Ethiopian genus *Pseudocossus* Kenrick, this is the only genus having ocelli. It, however, differs from *Pseudocossus* by the presence of stalked vein $R_4 + R_5$, forked median in both wings and in the uncus being not bifid, unlike in *Pseudocossus* where all the veins are free, median unforked and the uncus bifid.

(d) *Geographical distribution of the Genus Catopta*

The genus *Catopta* is distributed in the Palaearctic (mainly China, U.S.S.R., Iran, Afganistan, Algeria and Tibet) and Oriental (India) regions.

(e) *Key to the Indian Species of the Genus Catopta*

Antennae of male with 67 segments and long branches. Fore wing with the vein R_3 connate with the stalk of veins $R_4 + R_5$; M_1 arises from angle of cell. Uncus, in male genitalia, long and narrowly curved, about two-and-a-half times as long as its width in middle ; each clasper with a strong medial hump ; aedeagus with a few spines. Male 42 mm.

cashmirensis (Moore)

Antennae of male with 61-66 segments, the branches short. Fore wing with the vein R_3 separate from $R_4 + R_5$; M_1 arises from below the angle. Uncus short and rounded, about twice as long as its width ; each clasper with a weak medial hump ; aedeagus with numerous spines. Male 44-46 mm.

sikkimensis (Arora)

(f) *Descriptions of Species*1. *Catopta cashmirensis* (Moore)

(Plate I, fig. 1 ; Text-fig.1)

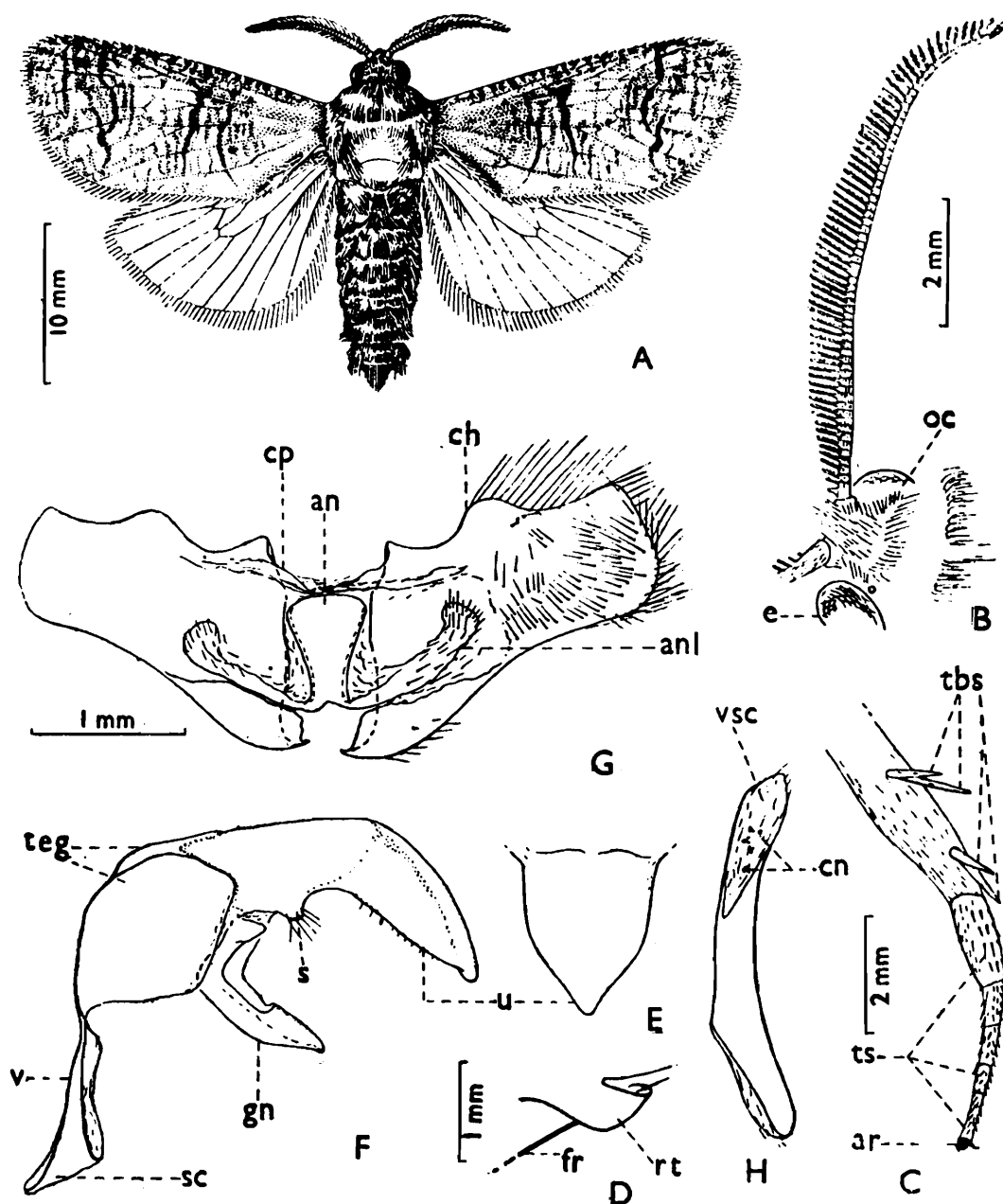
- 1879b. *Cossus cashmirensis* Moore, *Descr. Indian Lep. Atk.* : 87 (Type loc.-Tawi, Jammu & Kashmir, India)
1887. *Cossus cashmirensis*, Cotes and Swinhoe, *Cat. Moths of India*, 2: 232.
1892. *Trypanus cashmirensis*, Kirby, *Cat. Lep. Het.*, 1 : 862.
1892b. *Cossus cashmirensis*, Hampson, *Fauna Brit. India, Moths*, 1 : 305
1905. *Cossus cashmirensis*, Hampson, *J. Bombay nat. Hist. Soc.*, 16 : 194.
1940. *Catopta cashmirensis*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1015.
1961. *Catopta cashmirensis*, Daniel, *Mitt. münch. ent. Ges.*, 51 : 187.
1965. *Catopta cashmirensis*, Daniel, *Mitt. münch. ent. Ges.*, 55 : 105.

Type : A male in Ber. Mus.

Head with the frontal tufts and labial palpi blackish brown. Antennae brown beneath, with the branches cinerous grey above. Vertex cinerous grey. Thorax and fore wings on the upper side cinerous grey, the latter darker at base and paler medially. Fore wings (Pl. I, fig. 1, Text-fig. 1A) marked by several pale-greyish black, irregular, wavy lines across the length ; in the medial area striae coalesce into irregular lines, the prominently marked ones being between the cell and Cu_2 ; in the postmedial area also the striae coalesce to form wavy and irregular lines, the prominent one being between subapical margin and tornal angle at Cu_{1b} ; some scales along the discocellulars, up to the base of areole, pale brown. Hind wings and abdomen fuliginous brown above, with tufts of long hair. The former unmarked. Legs dark brown. Underside of wings pale brown, with dark brown reticulations and streaks, those on the hind wing prominent ; thorax and abdomen pale-cinerous grey.

Antennae (Text-fig. 1A, B) about 8 mm. long ; bipectinate up to tip, the rami short at base, increasing in length gradually up to the middle and thereafter decreasing, the longest ones as long as seven segments in middle ; the shaft with about 67 segments ; basal segments about twice as broad as their length, apical segments gradually becoming long and narrow towards the tip. Labial palpi short, about 1.5 mm. and porrect, not extending beyond the frontal tufts. Ocelli (Text-fig. 1B) and legs (Text-fig. 1C) as given for the genus.

Venation, in general, as described for the genus except that vein M_1 in the fore wing arises from upper angle of cell.



Text-fig. 1. *Catopta cashmirensis* (Moore): (A) An outline drawing of the male type. (B) Male antennae showing pectinations of one side. (C) A portion of the hind leg showing two pairs of tibial spurs and the tarsal spines. (D) Retinaculum, with a portion of frenulum. (E) Uncus in a dorsal view. (F) Male genitalia in a lateral view, without claspers. (G) Claspers in a inner view, with anellus. (H) Aedeagus. (E to H of the same magnifications).

Genitalia.—Male (Text-fig. 1 E-H) ; Uncus broadly triangular, about two-and-a-half times as long as its width in middle and strongly bent from middle downwards. Gnathos short, ribbon-like, bent strongly inwards, meet each other in middle and folded to enclose a small cavity. Tegumen short and broad ; vinculum narrow and

ending in a very short saccus. Clasper short, not extending beyond uncus in a normal course, highly raised mid-dorsally into a hump and curved ventrally outwards at the distal end ; about three times as long as its width at the distal end. Juxta short and broadly conical, with two membranous lobes. Aedeagus short, with a few extremely short spines on vesica. Female : Not known.

Measurements.—Expanse : fore wing, 42 mm. Length : fore wing, 19.5 mm. ; hind wing, 15 mm. ; abdomen, 10.5 mm. ; whole body, 19 mm.

Material examined.—One male (holotype) labelled as “Original, Tawi, Kashmir (coll. Atkinson, coll. Staudinger)” (ex. colln. Ber. Mus.).

Distribution.—India (J. & K.). Also China.

Remarks.—Hampson (1892b) considered this species as a synonym of *Cossus acronyctoides*, treating it as latter's form, and stated (p.305): “The form *cashmirensis* has some of the striae of the fore wing coalescing into somewhat prominent lines, the best marked being one across end of cell, one beyond the cell from vein 6 to 3, and one from the costa before the apex, but these are somewhat variable” Later he (1905) revived the species *cashmirensis* by the following remarks (p. 194) “It is a distinct species from *acronyctoides*, the antennae bipectinate with branches long at the base while in the latter they are unipectinate with the branches short at the base, then increase in length before middle. The former is larger broad winged insect with markings dark” Daniel (1961), while studying *Catopta cashmirensis*, referred to Hampson (1892b), Seitz (1912) and Gaede (1933) but there is no reference to the revival of the species by Hampson (1905) which is quite important especially in the light of observations made by Daniel (1961), who, however, rightly transferred it to the genus *Catopta*. He figured the male genitalia of the species, collected from “North-Yuennan, Li-Kiang”, and “Nw-Karakorum ; Hunza Nagar, Kuto-Darukust”, and identified respectively as “*Catopta cashmirensis* Moore” and *Catopta cashmirensis* Mr. ssp.” The latter was differentiated from the former mainly by the presence of a well developed costal hump in the middle of the clasper. The male genitalia of the holotype of *Catopta cashmirensis* (Moore), however, shows that the clasper has a distinct hump in the middle (Text-fig. 1G), contrary to the observations by Daniel (1961), i.e. the undescribed subspecies of Daniel (1961) resembles the holotype in this respect. It is quite likely that the hump on the clasper is a variable character and not much reliance be given.

C. cashmirensis (Moore) is closely related to the other known species from India, viz. *C. sikkimensis* (Arora) mainly in respect of

the presence of well developed ocelli, the wing venation, and the male genitalia in general. The two species, however, differ in the number of antennal segments and the length of rami, in the wing pattern, and in the shape of uncus in the male genitalia. For detailed differences see under *sikkimensis*.

2. *Catopta sikkimensis* (Arora) comb. nov.

(Pl. I, fig. 2; Text-fig. 2)

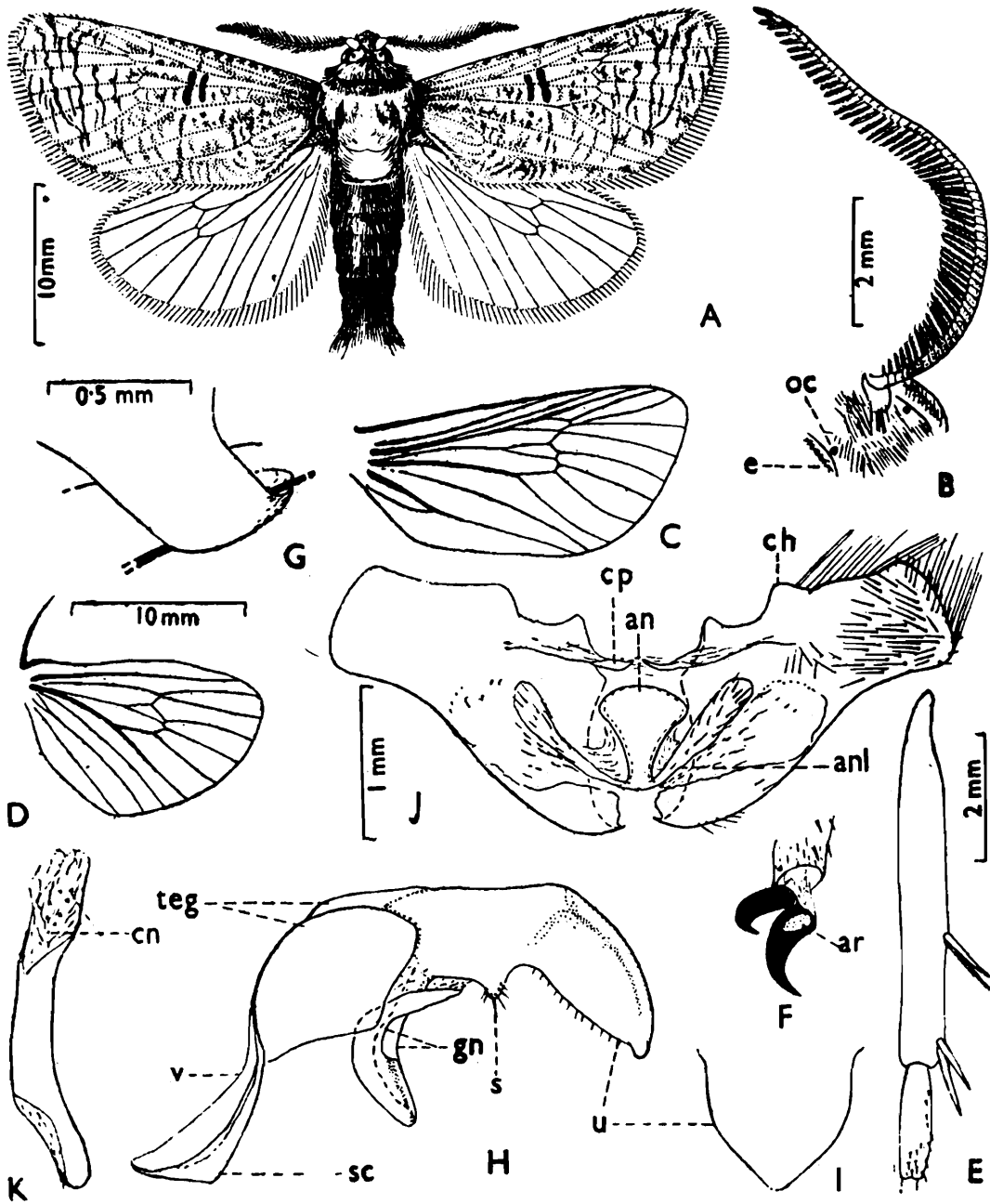
1965. *Cossus sikkimensis* Arora, *Bull. syst. Zool.*, **1** (1) : 25. (Type loc.-Sikkim : Northern Sikkim, Dambung, 298 mm.).

Type : A male in the N.Z.C. at Z.S.I.

Head and abdomen brown, the latter with tufts of scales at the base and extremity. Frontal tufts and labial palpi blackish brown. Antennae brown throughout, without prominent cinerous greyish scaling above. Fore wings brown, darker basally; marked (Text-fig. 2A) with several dark striae across the wing; striae mostly coalescent or partly so beyond the cell in the postmedial and submarginal areas, two striae across the middle of cell broader and darker in colour, one between areole and vein Cu_2 and the other confined to the cell itself; those beyond the cell and between veins R_4-Cu_{1b} prominent only at postmedial area; postmedial line double, with the inner line curved and ending at vein 1A at the inner margin and the outer one curved outwards and ending at vein Cu_{1b} at the tornal angle; subapical area with some prominent striae from the apex to vein M_2 , others forming very wavy, irregular and indistinct lines. Hind wings fuscous brown, with some shine on the costal border. Thorax and abdomen above slightly darker than the underside. Underside with prominent striae on the hind wing which is unmarked on the upperside. Legs at the base darker; tarsal segments with white scaling.

Antennae (Text-fig. 2B) bipectinate up to tip, shaft with 61-66 segments; the rami short and broad at the base, thereafter increasing in length gradually up to the middle and again decreasing in length apically, the longest rami as long as five to six segments in the middle, terminal segment without pectination. Labial palpi short, about 2 mm. long, slender and porrect, slightly reaching the frontal tufts. Wings broad. Fore wings deeply angled near the base; outer margin nearly straight. Ocelli (Text-fig. 2B), legs' spines, spurs, etc. (Text-fig. 2E), and frenulum and retinaculum (Text-fig. 2G) as for the genus.

Venation (Text-fig. 2 C-D) typically *Catopta*-type except that vein M_1 in fore wing arises from well below the angle of cell.



Text-fig. 2. *Catopta sikkimensis* (Arora): (A) An outline drawing of the male paratype. (B) Male antenna showing pectinations of one side. (C) and (D) Fore and hind wing venation, respectively. (E) A portion of the hind leg showing two pairs of tibial spurs and a few tarsal spines. (F) Tarsal claws showing arolium. (G) Retinaculum, with a portion of frenulum. (H) Male genitalia in a lateral view, without claspers. (I) Uncus in a dorsal view. (J) Claspers in an inner view, with anellus. (K) Aedeagus. (C—D; F—G; H to K of the same magnifications).

Genitalia.—Male (Text-fig. 2 H-K) : Uncus broadly triangular, about twice as long as its width in middle; broader in the middle,

and then narrowing distally and ending into a broadly pointed apex. Gnathos present, narrow ribbon-like and curved inwards, meeting each other by their inner margin. Tegumen short and broad; vinculum extremely narrow, continuous ventrally into a short saccus. Claspers as in *cashmirensis* but with a somewhat weaker mid-dorsal hump. Juxta narrowed at base; otherwise as in generic characters. Aedeagus short and slender as in *cashmirensis*, but with more spines on the vesica.

Measurements.—Expanse: fore wing, 44-46 mm. Length: fore wing, 20.5 mm.; hind wing, 16 mm., abdomen, 11 mm.; body, 19 mm.

Material examined.—2 ♂♂ : Sikkim : Dambung (Northern Sikkim) 298 m., 10.vii.1959 (A. G. K. Menon coll.). One holotype (Regd. no. 1098/H10) and one paratype (Regd. no. 1099/H10).

Distribution.—Sikkim.

Remarks.—This species resembles *Catopta cashmirensis* (Moore) in having well developed ocelli, a costal hump on the clasper in the male genitalia, and in general hairy-appearance. This species, however, differs from the other species in having less number of antennal segments, i.e., 61-66, by the origin of veins R_3 and M_1 in the fore wing, and by the shorter uncus in the male genitalia. The aedeagus, in the male genitalia, also has numerous spines (very few in *cashmirensis*).

Genus *Cossus* Fabricius

- 1794. *Cossus*, Fabricius, *Syst. Ent.*, 3 (2) : 3.
- 1834. *Cossus*, Boisduval, *Icon. Hist. Lep. Nouv.*, 2 : 178.
- 1840. *Cossus*, Boisduval, *Gen. et. Index Meth. Eur. Lep.* : 75.
- 1856. *Cossus*, Walker, *List. Lep. Brit. Mus.*, 7 : 1510.
- 1865. *Cossus*, Walker, *List. Lep. Brit. Mus.*, 32 : 582.
- 1865. *Cossus*, Moore, *Proc. zool. Soc. Lond.* : 822.
- 1866. *Trypanus*, Rambur, *Cat. Syst. Lep. Andal.*, 2 : 326.
- 1877. *Cossus*, Piepers & Snellen, *Tijdschr. Ent.*, 20 : 22.
- 1889. *Cossus*, Cotes and Swinhoe, *Cat. Moths of India* : 232.
- 1892b. *Cossus*, Hampson, *Fauna Brit. India, Moths*, 1 : 305.
- 1892. *Trypanus*, Kirby, *Cat. Lep. Het.*, 1 : 860.
- 1892. *Cossus*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, 1 : 284.
- 1899. *Cossus*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 : 645.
- 1900. *Trypanus*, Piepers & Snellen, *Tijdschr. Ent.*, 43 : 37.
- 1901. *Cossus*, Staudinger & Rebel, *Cat. Lep. Pal. Fngel.*, 1 : 406.
- 1903. *Cossus*, Poujade, *Bull. Soc. ent. Fr.* : 122.
- 1905. *Cossus*, Schaus, *Proc. U.S. Nat. Mus.*, 29 : 340.
- 1909. *Cossus*, Lefroy, *Indian Insect Life* : 495.
- 1912. *Cossus*, Seitz, in Seitz *Macrolepidoptera of the World*, 2 : 418.
- 1914. *Cossus*, Bethune-Baker, *Trans. ent. Soc. Lond.* : 327.
- 1917. *Cossus*, Chapman, *Ent. Rec.*, 29 (3) : 5.

1918. *Cossus*, Turner, *Trans. ent. Soc. Lond.*, **66** : 157, 158, 188.
 1923. *Cossus*, Dalla-Torre, *Lepid. Cat.*, **29** : 5.
 1929. *Cossus*, Gaede, in Seitz *Macrolepidoptera of the World*, **14** : 541.
 1933. *Cossus*, Gaede, in Seitz *Macrolepidoptera of the World*, **10** : 809.
 1941. *Cossus*, Beeson, *The Ecology and Control of Forest Insects in India and the Neighbouring Countries* : 572.
 1945. *Cossus*, Gardner, *J. Bombay nat. Hist. Soc.*, **45** (3) : 391.
 1951b. *Cossus*, Viette, *Lambillionea*, **51** (5-12) : 41.
 1956. *Cossus*, Daniel, *Mitt. münch. ent. Ges.*, **46** : 244.
 1957. *Cossus*, Roepke, *Verh. k. ned Akad. Wet. Afd. Nat.*, (2) **52** (1) : 6.
 1959b. *Cossus*, Clench, *Veröff. zool. St. Samml. Münch.*, **6** : 16.
 1965. *Cossus*, Müller, *Dt. ent. Z.*, **12** (3) : 193.
 1965. *Cossus*, Daniel, *Mitt. münch. ent. Ges.*, **55** : 84.

Type-species : *Phalaena Bombyx Cossus* Linn.

(a) General

Moore (1865) described for the first time one species from India (Calcutta), namely *Cossus cadambae* and added (1879b) another species, viz., *C. cashmirensis* from Kashmir, India. Hampson (1892b) considered the genus *Brachylia* Felder as a synonym of *Cossus*. Viette (1951b) and Clench (1959b), however, do not agree with Hampson's synonymy. Hampson (*loc. cit.*) transferred *Brachylia acronyctoides* Moore and *Zeuzera stigmatica* Moore to this genus, treated *cashmirensis* as a synonym of *acronyctoides*, and described three more species, viz., *nigromaculatus*, *pallidulae* and *parvipunctus*, from the Indian subregion. He further added (1895, 1905) a species each from Burma and Sikkim, respectively, and revived the species *cashmirensis* Moore, thus bringing the total number of species from the Indian region to nine. Turner (1918) transferred one of Hampson's species, viz. *Cossus parvipunctus* to the genus *Phragmataecia*. Dalla-Torre (1923), however, recorded eleven species, including *parvipunctus*, and two other species which are either not Indian or do not belong to this family. There was no addition to this genus till 1965, when a species, from Sikkim, was described by the author (*vide* Arora, 1965).

The present study of these species shows that two of these (10 species) belong to the genus *Catopta*, one to *Holcocerus* and three to *Phragmataecia*. Only four species, viz., *acronyctoides* (Moore), *cadambae* Moore, *nigromaculatus* Hampson and *fuscibasis* Hampson (*nec.* Gaede)*, are referred to the genus *Cossus*. Another new species, viz., *greeni*, is also described now.

*Gaede (1929) described a Cossid from Madagascar as *Cossus fuscibasis*. I have not been able to get the types of *fuscibasis* Hampson and *fuscibasis* Gaede, and therefore, cannot say whether these are two different species or not. But in case they are different, which is quite likely, *fuscibasis* Gaede should require a new name.

(b) *Characters of the Genus Cossus Fabricius*

Antennae in male pectinate up to the tip, in female pectination short, reduced and not up to tip. Proboscis absent. Labial palpi well developed, porrect, upturned and closely appressed to the face. Frenulum spine single in male, 8 to 10 in the female ; not held by the retinaculum. Tibiae and the spurs as in subfamily ; tarsi with three to four rows of spines ; arolium distinct.

Fore wing with a reduced areole ; median vein present in both wings and generally forked in cell, sometimes unforked in hind wings. Hind wing with the vein Sc free, rarely a cross bar present between Sc and the cell ; Rs and M₁ either connate or stalked, rarely separate.

Male genitalia with the gnathos fused below the uncus ; claspers generally with spinabasalis and well developed sclerotisation on the mesal side ; aedeagus long, narrow, with or without cornutus, and supported by the well developed anellus lobes.

(c) *Relationships of the Genus Cossus with the other allied Genera*

The genus *Cossus* resembles the other Cossid genera in respect of two pairs of tibial spurs, well developed tarsal spines, and gnathos, which meet in the middle below the uncus.

From *Catopta* it differs by the absence of ocelli and for having unipectinate antennae, and well-sclerotised claspers in the genitalia. From the genus *Eremocossus* it differs in veins Rs and M₁ in the hind wings being connate unlike in the *Eremocossus* where these are stalked ; from *Holcocerus* it differs in the unipectinate antennae, unlike simple and flattened in the latter ; and from the genus *Paracossus* for having a forked median vein in both the wings unlike unforked median in *Paracossus*.

(d) *Geographical distribution of the Genus Cossus*

The genus *Cossus* is universally distributed, with majority of the species are known from Ethiopian and Palaearctic regions. In the Indian subregion this genus is recorded from India (Kashmir, Delhi, Punjab, Madhya Pradesh, Bengal, Orissa, Maharashtra and Tamil Nadu), Sikkim, Pakistan, Burma and Ceylon. The genus is being recorded from Ceylon for the first time.

(e) *Key to the Indian Species of the Genus Cossus*

The following keys are given for only those species of which material was available for study.

1. Antennae, in male, with long and narrow branches, the longest rami, in the middle, about the size of three to four segments. Male genitalia with the uncus truncate and the aedeagus with cornuti *acronyctoides* (Moore)

Antennae, in male, with short and broad branches and shortly bifurcate, the longest rami shorter than three segments. Male genitalia with the uncus rounded or truncate and the aedeagus with or without cornuti 2

2. Wings greyish-brown ; markings on the fore wing thin. Male genitalia with the uncus rounded apically and the aedeagus without cornuti *cadambae* (Moore)

Wings dark-brown ; markings on the wings prominent and thick. Male genitalia with the uncus truncate and the aedeagus with cornuti *greeni* sp. n.

(f) *Description of Species*

3. *Cossus acronyctoides* (Moore)

(Pl. I, fig. 3 ; Text-fig. 3)

1879. *Brachylia arconyctoides* Moore, *Proc. zool. Soc. Lond.* : 411 (Type loc.—Bombay, India).
1884. *Brachylia acronyctoides*, Swinhoe, *Proc. zool. Soc. Lond.* : 551.
1886. *Brachylia acronyctoides*, Swinhoe, *Proc. zool. Soc. Lond.* : 441.
1887. *Zeuzera acronyctoides*, Cotes & Swinhoe, *Cat. Moths of India* : 232.
- 1892b. *Cossus acronyctoides*, Hampson, *Fauna Brit. India, Moths*, 1 : 305.
1899. *Cossus acronyctoides*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 : 645.
1912. *Cossus acronyctoides*. Seitz, in *Seitz Macrolepidoptera of the World*, 2 : 420.
1923. *Cossus acronyctoides* Dalla-Torre, *Lepid. Cat.*, 29 : 6.
1938. *Cossus acronyctoides*, Gaede, in *Seitz Macrolepidoptera of the World*, 10.
1941. *Cossus acronyctoides*, Beeson, *The Ecology and the Control of Forest Insects in India and Neighbouring Countries* : 572.
1945. *Cossus acronyctoides*, Gardner, *J. Bombay nat. Hist. Soc.*, 45 (3) : 392.
1945. *Cossus acronyctoides*, Sevastopulo, *J. Beng. nat. Hist. Soc.*, 19 : 115
- 1961b. *Cossus acronyctoides*, Mathur & Singh, *Forest Bull. Dehra Dun*, 171 (9) : 5.
1961. *Catopta acronyctoides*, Daniel, *Mitt. münch. ent. Ges.*, 51 : 190.

Type : In B. M.

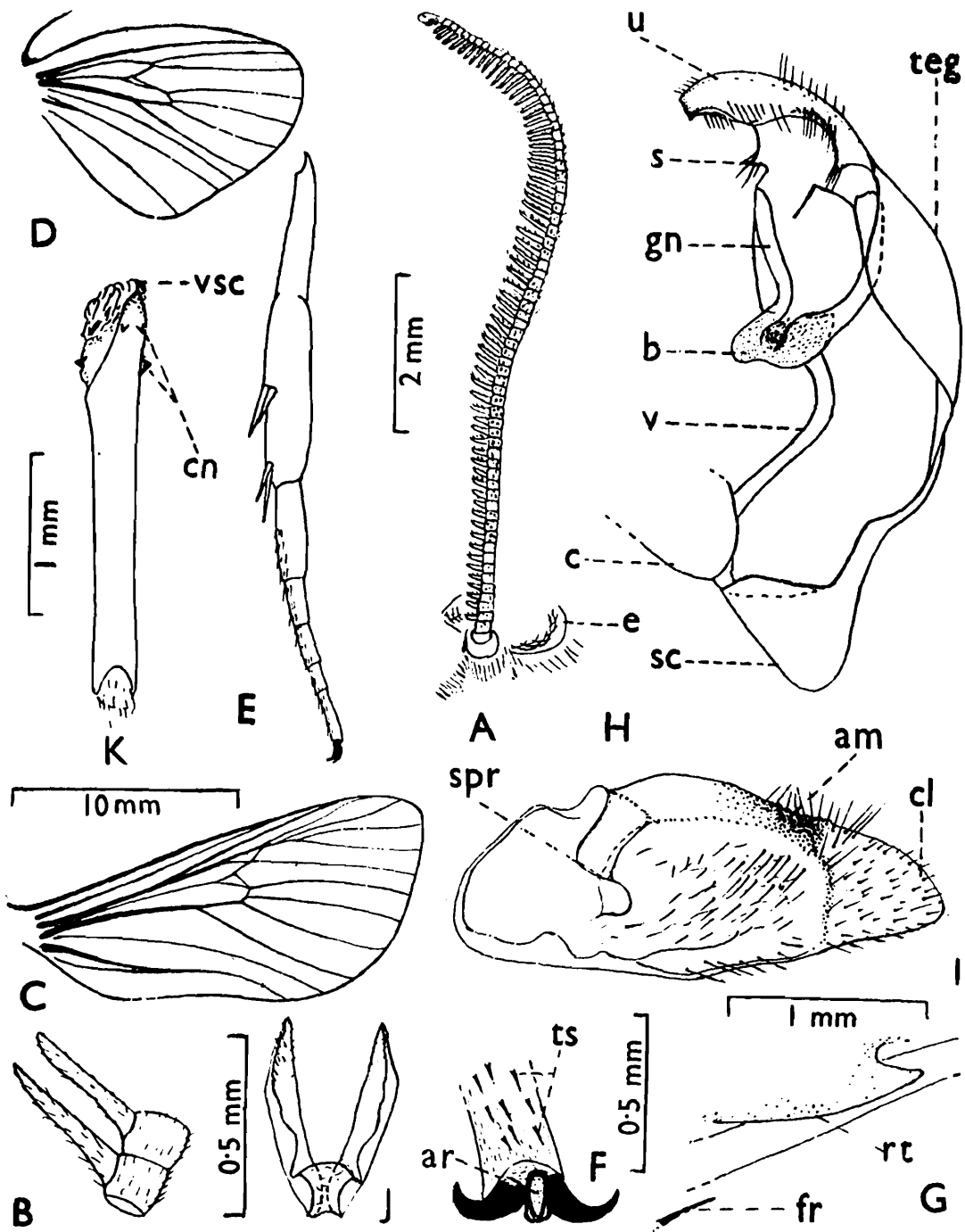
Hosts : *Tamarix articulata* (Punjab), Beeson (1941).

Head and abdomen dark brown. Frontal tufts and thorax greyish-brown. Vertex and antennae brown. Labial palpi greyish-brown beneath, darker on sides. Fore wings greyish-brown, darker in middle and greyish at apex; crossed by numerous short striae some of which coalesce into fine lines in the postmedial area, the most prominent being the subapical patch and the other between vein M_1 and Cu_{1b} . Hind wings brown; striae faint. Underside of wings dark brown, with more prominent striae.

Antennae (Text-fig. 3 A-B) unipectinate up to tip in male, uniseriate in the female; the shaft in male with 67 segments; rami short and broad at base, thereafter increasing in length up to the middle, the longest ones in the middle and as long as three to four segments. Labial palpi upturned, closely appressed to face and reaching beyond the frons; the third joint short. Wings broad (Text-figs. 3 C-D). Hind tibiae (Text-fig. 3E) with two pairs of spurs; tarsi with spines; arolium (Text-fig. 3F) about twice as long as its width in middle. Frenulum short and functionless (Text-fig. 3G); retinaculum short. Abdomen stout, longer than hind wings in both sexes.

Venation.—Fore wing (Text-fig. 3C) : Areole short, projecting about half its length out of the cell angle; R_3 stalked with $R_4 + R_5$ and as far from the areole as from R_4 ; M_1 arising from upper angle, sometimes from above it; median cell with its upper and lower branches ending between $M_1 - M_2$ and at M_2 , respectively; M_3 arising between Cu_{1a} and M_2 . Hind wing (Text-fig. 3D) ; Sc free; $R_s - M_1$ connate; median cell very short, with the branches ending between $M_1 - M_2$, the lower nearer M_2 ; M_3 nearer Cu_{1a} than to M_2 .

Genitalia.—Male (Text-figs. 3 H-K) : Uncus about twice as long as its width in the middle, broad at the base and narrowing distally; apex truncate and produced to an acuminate point directed downwards. Gnathos slender, curved and bent inwards and forwards to meet in the middle through a very fine spiny membrane (*bulla* of Roepke, 1957). Tegumen broad, indistinctly differentiated from uncus; vinculum slender; saccus broad. Claspers about two-and-a-half times as long as wide, with the inner side clearly differentiated into highly sclerotised and poorly dentate region, the ampulla, and membranous cucullus, the latter beset with fine setae; harpe poorly demarcated; costal prolongation short, with only a small lobe. Juxta formed of two short lobes, the latter open throughout on the outer side and with short blunt projection. Aedeagus long and narrow, with its distal portion broad and the apex pointed; distal portion with two short spines below the tip and one on each side. Female: Not studied.



Text-fig. 3. *Cossus acronyctoides* (Moore) : (A) Male antenna, with unipectinate branches. (B) Two antennal segments of (A) highly enlarged. (C) and (D) Fore and hind wing venation, respectively. (E) A portion of the hind leg, with two pairs of tibial spurs and the tarsal spines. (F) Tarsal claws with arolium. (G) Retinaculum, with a portion of frenulum. (H) Male genitalia in a latero-ventral view, without claspers. (I) A clasper in an inner view. (J) Anellus lobes. (K) Aedeagus. (A and E; C—D; and H to K of the same magnifications).

Measurements.—Wing expanse : Male, 43 mm. ; female, 51 mm. ; Length : Fore wing : Male, 18 mm. ; female, 22 mm. Hind wing : Male, 12 mm. ; female, 17 mm. Abdomen : Male, 16 mm. ; female, 15 mm. Whole body : Male, 23 mm. ; female, 22 mm.

Material examined.—Two examples : India : Maharashtra : Poona, 1 ♂, 15.x.1965 (B. S. Lamba coll.). Delhi, 1 ♂, 8.viii.1939 (Gullamullah coll.). At light (ex. colln. I.A.R.I.).

Distribution.—India (Kashmir, Madhya Pradesh, Orissa, Maharashtra, Tamil Nadu, Delhi, Punjab, Bengal, Sikkim) and Pakistan.

Remarks.—This was described as a species of the genus *Brachylia* Felder by Moore (1879b), but Hampson (1892b) considered it as a species of the genus *Cossus* Fabr., and referred it under the category (p. 305) "Fore wing with vein 6 from angle of cell ; the antennae of male bipectinate to tip", and synonymised *Cossus cashmirensis* Moore with it. Later he (1905) revived *cashmirensis* and differentiated *acronyctoides* on the basis of antennae, in males, which he stated as 'unipectinate with the branches short at the base' Daniel (1961), who studied a female from Bombay, however, transferred it to the genus *Catopta* mainly on the basis of published literature, specially that of Hampson (1892b), Seitz (1912) and Gaede (1933), but does not refer to Hampson's (1905) differentiation of *acronyctoides* from *cashmirensis*.

The male specimen, also from Bombay, which happens to be the type locality of this species, resembles in respect of its general appearance and genitalia with the photograph of the type received from B.M.

Cossus acronyctoides can be differentiated from *cadambae* by its antennae which are with long and narrow branches, whereas in the other species these are short and broad ; in respect of claspers in the male genitalia, it differs in having a smaller spinabasalis.

For differences from *greeni* sp. n., see under that species.

4. *Cossus cadambae* Moore

(Pl. I, fig. 4 ; Text-fig. 4).

1865. *Cossus cadambae*, Moore, *Proc. zool. Soc. Lond.* : 822 (Type loc.—Calcutta).
 1887. *Cossus cadambae*, Cotes & Swinhoe, *Cat. Moths of India*, 2 : 232.
 1892. *Cossus cadambae*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, 1 : 285.

1892. *Brachylia cadambae*, Kirby, *Cat. Lep. Het.*, 1 : 865.
 1892b. *Cossus cadambae*, Hampson, *Fauna Brit. India, Moths*, 1 : 306.
 1909. *Cossus cadambae*, Lefroy, *India Insect Life* : 405.
 1923. *Cossus cadambae*, Della-Torre, *Lepid. Cat.*, 29 : 6.
 1933. *Cossus cadambae*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 809.
 1941. *Cossus cadambae*, Beeson, *The Ecology and the Control of Forest Insects in India and Neighbouring Countries* : 572.
 1945. *Cossus cadambae*, Gardner, *J. Bombay nat. Hist. Soc.*, 45 (3) : 391.
 1945. *Cossus cadambae*, Sevastopulo, *J. Beng. nat. Hist. Soc.*, 19 : 115.
 1959. *Cossus cadambae*, Mathur & Singh, *Forest Bull. Dehra-Dun*, 171 (1) : 150.
 1961. *Cossus cadambae*, Mathur & Singh, *Forest Bull. Dehra-Dun*, 171 (9) : 16.

Type : In B.M.

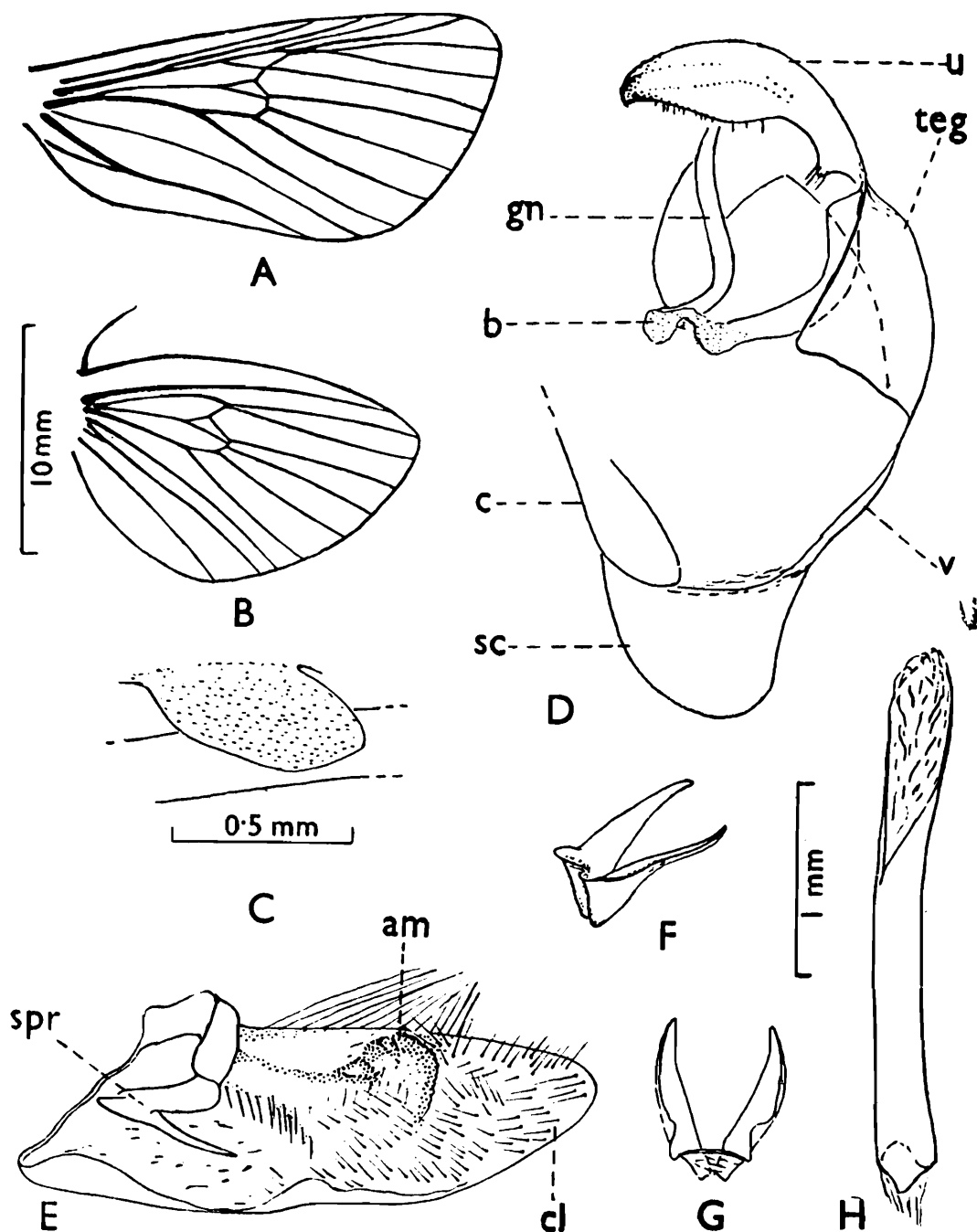
Host : *Ficus*. sp, *Nauclea cadamba* (Calcutta), Moore (1865) ; *Tectona grandis* (South India), Beeson (1941).

Head and thorax dark-greyish brown. Fore wings greyish brown and marked with several short, transverse, black striae and lines ; two lines across the wing, in middle, and two between the base of vein Cu_{1b} and inner margin, prominent ; postmedial line dark, running from costa to M_3 , thereafter incurved towards Cu_{1b} ; some dark, indistinct striae present beyond the postmedial line and excurved at M_3 ; submarginal lines also dark, with some indistinct striae. Hind wings pale-greyish brown, with some faint striae towards outer margin. Abdomen pale-greyish brown. Underside of both the wings pale-greyish brown and marked with numerous short brown striae.

Head with the labial palpi, though incomplete and damaged in the specimen available for study, appears to be well developed and closely appressed to face. Legs with the hind tibiae dilated and beset with two pairs of spurs. Wings broad (Text-figs. 4 A-B). Frenulum as in *acronyctoides*, retinaculum (Text-fig. 4C) short and broad.

Venation.—Fore wing (Text-fig. 4A) : Venation more or less as in *acronyctoides* ; areole, however, longer and projecting outside the cell angle by almost half, or more than its length ; R_3 weakly stalked with $R_4 + R_5$ at base ; M_1 arises from above the cell angle. Hind wing (Text-fig. 4B) : median vein generally forked in cell, forming a median cell, the upper and lower branches of which end between vein $M_1 - M_2$, and $M_2 - M_3$, respectively.

Genitalia.—Male (Text-figs. 4 D-H) : Uncus broad from base to distal one-third, narrowing gradually beyond it ; tip rounded, narrow and pointing downwards. Gnathos, tegumen and vinculum as in *acronyctoides*. Clasper about thrice as long as its width in middle ;



Text-fig. 4. *Cossus cadambae* Moore : (A) and (B) Fore and hind wing venation, respectively. (C) Retinaculum. (D) Male genitalia in a latero-ventral view, without claspers. (E) A clasper in an inner view. (F) and (G) Juxta of the anellus. (H) Aedeagus. (A and B ; and D to H of the same magnifications).

costa produced inwards and meeting with that of the other side and continued below with the highly sclerotised L-shaped spinabasis; mid-dorsal area highly sclerotised, denticulate and with a raised edge, running downwards across the claspers, thus clearly separating the distal membranous cucullus from rest of the portion; cucullus beset with long setae; harpe indistinct. Juxta with slender lobes, the anterior margin of which produced into short prolongations which along

with the spinabasalis support the aedeagus. Aedeagus simple, slender and without differentiation into base and the apex, the latter without spines. Female.—Not known.

Measurements.—Wing expanse : 41 mm. Length : Fore wing, 18 mm. ; hind wing, 12 mm.

Material examined.—Two examples as follows : India : West Bengal ; Calcutta, 1 ♂ (Bred in laboratory) (no other data).

Ceylon : Haragama, 1 ♂, -iv.1900, (*E. F. Green* coll.)

Distribution.—India : West Bengal (Calcutta) ; Travancore ; Bombay ; Mhow ; Nilgiris Hills ; and Ceylon.

Remarks.—This species is recorded here from Ceylon for the first time.

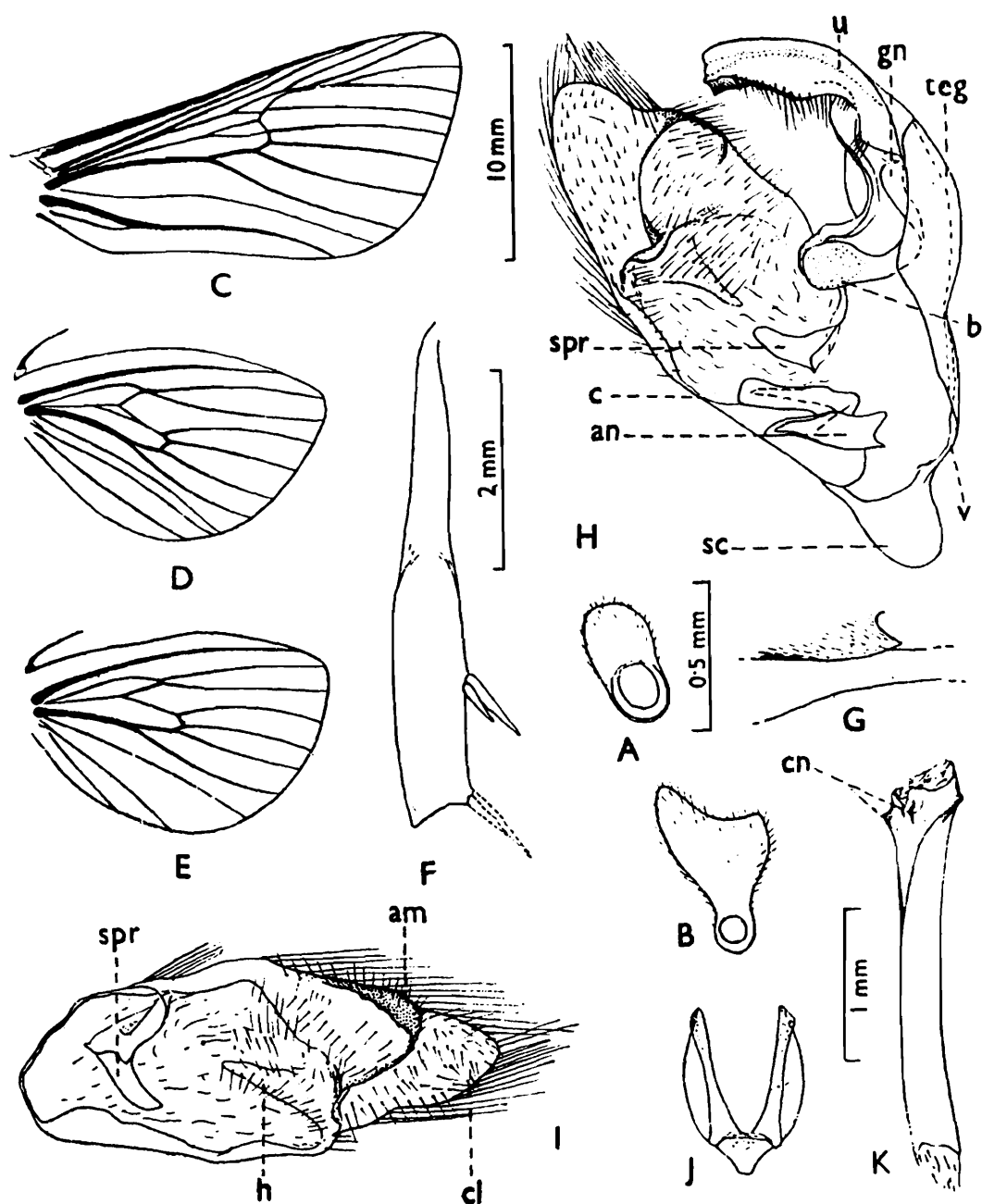
For differences from *acronyetoides* (Moore), see under that species.

5. *Cossus greeni* sp. n.

(Pl. I, fig. 5 ; Text-fig. 5).

Head antennae, thorax and abdomen dark brown. Labial palpi pale brown beneath, darker on the inner and outer sides. Fore wings (Pl. I, fig. 5) brown ; darker at base and medial area ; greyish at the antemedial and apex ; marked with several prominent striae across the wings, some coalescing to form thick lines ; the most prominent lines being one below the cell between Cu_{1a} and inner margin, and the other beyond the cell running between costa and M_3 , and thereafter incurved ; the postmedial series of striae oblique and parallel to the last-mentioned line up to M_3 , thereafter excurved and coming close to another prominent and oblique submarginal line, thus making a characteristic 'V'—shape ; striae beyond the submarginal not forming any definite lines ; the submarginal not forming any definite lines ; the subapical patch indistinct. Hind wings dark fuscous, without or with a few faint striae. Underside of both the wings dark fuscous, with a few markings on the fore wing but with the V-shaped marking prominent.

Antennae unipectinate, the shaft with 63 segments ; the rami short and broad from base to the middle (Text-fig. 5A), thereafter increasing in length towards the tip, indistinctly bifurcate (Text-fig. 5B), with the outer part smaller than the inner one. Labial palpi closely appressed to face, upturned and reaching beyond frons. Wings narrow at base than at the broad apical area (Text-fig. 5C). Legs with spurs,



Text-fig. 5. *Cossus greeni* sp.n. : (A) and (B) Antennal segments showing unipectinate branches. (C) Fore wing venation. (D) and (E) Hind wing venation, without median cell in 'E'. (F) A Portion of the hind leg, with two pairs of tibial spurs. (G) Retinaculum. (H) Male genitalia in a latero-ventral view, without clasper of one side. (I) A clasper in an inner view. (J) Juxta of the anellus. (K) Aedeagus. (A—B; C to E; and G to K of the same magnifications).

spines and arolium (Text-fig. 5F) as in genus. Frenulum short and functionless; retinaculum (Text-fig 5G) short and narrowly pointed.

Venation.—Fore wing (Text-fig. 5C) : Areole small, projecting about two-thirds outside the cell angle; vein R_1 arises from cell;

R_2 from areole ; R_3 either stalked or connate with $R_4 + R_5$; M_1 from above the cell angle ; median cell with its lower branch ending at M_2 . Hind wing (Text-figs. 5 D-E) : venation as in *C. cadambae*, except that the median cell is either reduced, with its branches lying between M_1 and M_2 , or absent.

Genitalia.—Male (Text-figs. 5H-K) : Uncus broad at base ; apical part narrow and ending in a truncate tip, the latter pointed downwards ; when seen from above, uncus appears slightly depressed. Clasper about two-and-a-half times as long as its width in middle, the latter broader ; harpe distinct ; spinabasis L-shaped and stout. Juxta well developed, the two lobes not separate at their bases. Aedeagus long and narrow, distal end broad and ending in a narrow tip and beset with four spines, *i.e.*, two ventrally, on the vesica, and one on each side.

Measurements.—Wing expanse : fore wing, 42 mm. Length : fore wing, 19.5 mm. ; hind wing, 14.5 mm.

Holotype : A male : Ceylon : Kandy, —.xi.1906 (E. E. Green coll.). Paratype : A male, —.x.1907 (E. E. Green coll.). Both deposited in the Z.S.I.

Remarks.—*Cossus greeni* is close to *C. cadambae* Moore in coloration and, to some extent, in the wing pattern except that the submarginal lines in *cadambae* are not prominent as in *greeni* ; the markings in *greeni* are thicker and form a characteristic V-shape mark on the fore wing whereas in *cadambae* the markings are thinner and do not form any clear V-mark on the fore wing. In respect of male genitalia the two species differ as follows : in *greeni* the uncus is truncate at the tip and aedeagus is with cornuti, whereas in *cadambae* the uncus is narrowly rounded at the tip and the aedeagus is without cornuti.

In respect of the genital structure, especially the shape of uncus and presence of cornutal spines on aedeagus it is close to *C. acronyctoides* (Moore) but differs in having shorter rami on the antennae and a well developed spinabasis on the claspers of male genitalia.

6. *Cossus nigromaculatus* Hampson

1892. *Cossus nigromaculatus* Hampson, *Fauna Brit. India, Moths*, 1 : 305 (Type loc.—Nilgiris).
 1923. *Cossus nigromaculatus*, Dalla-Toore, *Lepid. Cat.*, 29 : 12.
 1933. *Cossus nigromaculatus*, Gaede, in Seitz, *Macrolepidoptera of the World*, 10 : 809.

Type ; In B.M.

As no specimen of this species was available, the original description is reproduced here : “♀” Head, thorax, and abdomen blackish brown. Fore wing with the inner margin deeply angled near the base ; colour brown, greyish towards the costa ; a black blotch on the costa near the base ; a small blotch above centre of cell ; a large, very irregular, black blotch beyond the cell from the costa to vein 1c extending along vein 3 towards outer margin ; an apical black blotch ; the outer half of wing reticulated with fine black lines. Hind wing pale.

Hab. Nilgiris, 8000 ft. (*Minchin*). Exp. 66 millim. “Type in coll. Elwes.”

Distribution.—India : Nilgiris Hills.

Remarks.—Hampson (1892b) grouped this species with *acronyctoides* and *cadambae*, under the category of Cossids having bipectinate antennae. Later he (1905) stated that the antennae of *acronyctoides* are unipectinate, but did not mention anything about the antennae of *cadambae* and *nigromaculatus*—probably he had no males of these two species available to him. Gaede (1933) also described the antennae of *nigromaculatus* as bipectinate. I have males of *cadambae* which have unipectinate antennae, and as I did not have access to any material of *nigromaculatus* I am placing this species under the genus *Cossus*, as referred in literature.

7. *Cossus fuscibasis* Hampson

1895. *Cossus fuscibasis* Hampson (nec. Gaede)*, *Trans. ent. Soc. Lond.* : 287 (Type loc.—N. Chin Hills, Burma).
 1896a. *Cossus fuscibasis* Hampson, *Fauna Brit. India, Moths*, 4 : 473.
 1905. *Cossus fuscibasis* Hampson, *J. Bombay nat. Hist. Soc.*, 16 : 194.
 1923. *Cossus fuscibasis* Dalla-Torre, *Lepid. cat.*, 29 : 12.
 1933. *Cossus fuscibasis*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 808.

Type ; In B.M.

No specimen of this species was available, therefore the original description is reproduced here : “♀” Head, thorax and abdomen dark brown, the last greyish towards extremity. Fore wings with vein 6 from angle of cell ; the basal two-thirds brown irrorated with fuscous, a paler patch between median nervure and vein 1, bounded by an irregular black postmedian line highly angled at vein 4 and sending a streak inwards above vein 1 ; outer area grey striated and

*See foot-note on page 23.

reticulated with black. Hind wing with the basal half fuscous ; the outer area grey striated and reticulated with fuscous.

Hab. N. Chin Hills, Burma (*Watson*). Exp. 50 millim. Type B.M."

Distribution.—Burma.

Remarks.—This species differs from other species of the genus *Cossus* in having thick and dentate antennae in the male. Material of this species was not available to me for study, hence the species is referred to the genus *Cossus* as mentioned in literature.

Genus *Eremocossus* Hampson

- 1892b. *Eremocossus* Hampson, *Fauna Brit. India, Moths*, 1 : 313.
- 1896b. *Eremocossus* Hampson, *Proc. zool. Soc. Lond.* : 276.
- 1923. *Eremocossus*, Della-Torre, *Lepid. cat.*, 29 : 48.
- 1929. *Eremocossus*, Gaede, in Seitz *Macrolepidoptera of the World*, 14 : 544.
- 1933. *Eremocossus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 811.
- 1951b. *Eremocossus*, Viette, *Lamillionea*, 51 (5-12) : 42.
- 1952. *Eremocossus*, Viette, *Bull. Mus. Hist. nat.*, (2) 24 : 555.

Type-species : *Phragmataecia foeda* Swinhoe

(a) General

The genus *Eremocossus* Hampson was erected to include *Phragmataecia foeda* Swinhoe, from Karachi, mainly on the basis of external characters, of the antennae, the labial palpi, venation, etc.

Hampson (1896) described one species, viz. *E. proleuca*, from Aden, and Le Cerf (1919) added yet another, viz. *E. senegalensis* from Senegal. The latter, however, was synonymised to *Hypopta saharae* Lucas, by Viette (1952). Thus, there are only two species of this genus known from the world, i.e., *foedus* from Karachi and *proleuca* from Aden.

(b) Characters of the Genus *Eremocossus* Hampson

Antennae in male bipectinate to tips, the branches short. Labial palpi large, the third segment rounded. Legs without spurs on the hind tibiae ; femora hairy. Wings long and narrow. Fore wing with the costal margin weakly concave and the inner one evenly curved ; vein R_1 arising from the cell. Hind wing with the veins R_s and M_1 stalked ; M_2 and M_3 close to each other at base.

(c) Relationships of the Genus *Eremocossus* with the other allied Genera

The genus *Eremocossus* Hampson is characterised by the absence of tibial spurs and having stalked Rs and M₁ in the hind wing which separate it from the other Indian Cossinae. It, however, resembles the other genera in respect of the pectination of antennae in the male and the fore wing venation.

(d) Geographical distribution of the Genus *Eremocossus*

The genus is known only from Pakistan (Karachi) in the Oriental and Arabia (Aden) in the Palaearctic regions.

(e) Description of Species

8. *Eremocossus foedus* (Swinhoe)

1884. *Phragmataecia foede* Swinhoe, *Proc. zool. Soc. Lond.* : 515, pl. XLVII, fig. 1 (Type loc.—Karachi, Pakistan).
 1887. *Phragmataecia foeda*, Cotes & Swinhoe, *Cat. Moths of India*, 2 : 234.
 1892. *Phragmataecia foeda*, Kirby, *Cat. Lep. Het.*, 1 : 876.
 1892b. *Eremocossus foedus* Hampson, *Fauna Brit. India, Moths*, 1 : 314.
 1918. *Eremocossus foedus*, Turner, *Trans. ent. Soc. Lond.*, 66 : 158.
 1923. *Eremocossus foedus*, Dalla-Torke, *Lepid. cat.*, 29 : 48.
 1929. *Eremocossus foedus*, Gaede, in Seitz *Macrolepidoptera of the World*, 14 : 544.
 1933. *Eremocossus foedus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 811.

Type : In B.M

As no specimen of this species was available, the original description is produced here : "*Phragmataecia foeda*, n.sp. (Pl. XLVII, fig.1). Kurrachee, January and February. Colour ashy grey ; thorax and abdomen covered with long grey hairs, the latter conical, extending far beyond the wings. Antennae of the male moderately pectinate throughout, of the female simple. Fore wings with a reddish testaceous band along the costa, extending along the outer border and inner margin, making a complete circle of the wings, and a band of the same colour from the base extending under, and up to the end of the discoidal cell, and then continuing upwards to the costa near the apex. Hind wing immaculate.

Expanse of wings, ♂ $9\frac{1}{10}$, ♀ $1\frac{4}{10}$ inches.

Remarks.—Only two species of the genus *Eremocossus* Hampson, i.e. *E. foedus* (Swinhoe) and *E. proleuca* Hampson, from Karachi,

Pakistan and Aden, respectively, are hitherto known. From the literature I cannot make out any definite difference between the above-mentioned two species.

Genus *Holcocus* Staudinger

1884. *Holcocus* Staudinger, in Romanoff *Memoir. Lep.*, 1 : 139.
 1901. *Holcocus*. Staudinger & Rebel, *Cat. Lep. Pal. Fngch.*, 1 : 407.
 1912. *Holcocus*, Seitz, in Seitz *Macrolepidoptera of the World*, 2 : 421.
 1923. *Holcocus*, Dalla-Torre, *Lepid. Cat.*, 29 : 16.
 1959. *Holcocus*, Daniel, *Mitt. munch. ent. Ges.*, 49 : 102.
 1965. *Holcocus*, Daniel, *Mitt. munch. ent. Ges.*, 55 : 75.
 1965. *Holcocus*, Müller, *Dt. ent. Z.*, 12 (3) : 264.

Type-species : *Cossus nobilis* Staudinger

(a) *General*

The genus *Holcocus* Staudinger (1884) was erected for the palaearctic species *Cossus nobilis* Staudinger from Ashkabad (Turkistan, U.S.S.R.). Dalla-Torre (1923) recorded some 40 species and subspecies, many of which have since been revised. Daniel (1959), while working on the palaearctic *Holcocus*, recognised only 26 species of the Dalla Torre's Catalogue, and the remaining were either transferred to other genera or synonymised with other species. He also (*loc. cit.*) transferred several species of the genera *Cossus* Fabricius and *Paropta* Staudinger (including *Cossus rufidorsia* Hampson, from Sikkim) to this genus, bringing the total number, thus, to thirty five. There had been no further additions to this genus since then.

The present study includes two species, viz. *Holcocus arenicola* Staudinger, and *H. rufidorsia* (Hampson) the former being a new record from India.

(b) *Characters of the Genus Holcocus* Staudinger

Antennae simple and flattened. Labial palpi present. Legs with the hind tibiae dilated and beset with two pairs of spurs ; tarsi with spines. Frenulum and retinaculum short.

Venation.—Fore wing : Areole short ; R_1 arises from cell ; R_2 usually from areole ; $R_4 + R_5$ stalked ; median vein forked in the cell, forming the medial cell, the latter reduced. Hind wing : Cross bar between Sc and cell absent ; R_s and M_1 connate ; median vein forked in the cell and forming a short median cell.

Male genitalia.—Gnathos present and meeting in the middle below the uncus ; clasper with spinabasis ; juxta present.

(c) Relationships of the Genus Holcocerus with the other allied Genera

The genus *Holcocerus* is characterised by the presence of dilated hind tibiae, which are beset with two pairs of tibial spurs, and by the gnathos in the male genitalia which meet in the middle below the uncus. These characters bring the genus close to the other Indian Cossinae genera, especially the genus *Cossus* Fabricious, but differs from latter by the simple and flat antennal shafts. Seitz (1912) comments on the antennae, especially in relation to those in *Holcocerus* and *Cossus*, as (p. 419) : "The absence of woods, the ubiquity of the foodplants, the uniformity of the locality may considerably assists the function of the antennae as an organ of search, and thus organs which were originally complicated may become simplified. We are, therefore, loth to keep *Cossus* and *Holcocerus* separate, and only do so in order to avoid anything in our essentially practical work which would disturb the previous arrangements in collections and literatures and render the work more difficult to use"

Thus, according to above statement, by Seitz (1912), these two genera were kept separate to avoid difficulties but since the antennae, which are flattened and simple in *Holcocerus*, are a good character for differentiating it from the genus *Cossus*, where these are pectinate, and have been used in the identity of different genera, it would be better to keep these separate for the time being.

(d) Geographical distribution of the Genus Holcocerus

The genus *Holcocerus* is known from the Oriental (India, Sikkim) and the Palaearctic (China, Japan, U.S.S.R., Afganistan, Iran, Iraq, Israel, Algeria and Tunisia), regions.

(e) Key to the Indian species of the Genus Holcocerus

Areole in fore wing moderately large, vein R_2 arising from it ; lower branch of median cell in fore wing ending between M_2 and M_3 ; uncus broadly rounded at tip and weakly depressed dorsally ; spinabasis short and stout, with equally long and narrow stems

arenicola (Staudinger)

Areole in fore wing small, R_2 arising from beyond it and stalked with R_3 ; lower branch of median cell in fore wing end at M_2 ; uncus rather pointed at tip and not depressed dorsally ; spinabasis long, with lower stem about twice as long as upper

rufidorsia (Hampson)

(f) *Description of Species*9. *Holcocus arenicola* (Staudinger)

(Pl. I, fig. 6 ; Text-fig. 6)

1879. *Cossus arenicola* Staudinger, *Stett. ent. Ztg.*, **40** : 317 (Type loc.—Ashkabad, Turkestan, U.S.S.R.)
 1892. *Holcocus arenicola*, Kirby, *Cat. Lep. Het.* : 862.
 1901. *Holcocus arenicola*, Staudinger and Rebel, *Cat. Lep. Fngeb.*, **1** : 408.
 1912. *Holcocus arenicola*, Seitz, in *Seitz Macrolepidoptera of the World*, **2** : 421.
 1923. *Holcocus arenicola*, Dalla-Torre, *Lepid. Cat.*, **29** : 16.
 1959. *Holcocus arenicola*, Daniel, *Mitt. münch. ent. Ges.*, **49** : 114.
 1965. *Holcocus arenicola*, Daniel, *Mitt. münch. ent. Ges.*, **55** : 93.
 1965. *Holcocus arenicola*, Müller, *Dt. ent. Z.*, **12** (3) : 212.

Type : Repository not known.

Antennae and eyes dark brown. Vertex, thorax and basal half of abdomen greyish. Fore wings greyish, marked with numerous blackish brown striae some of which coalescing into fine lines across the wings ; the prominent lines being the one at the outer side of subapical patch, running from apical margin to vein R_5 and continued below as a fine line up to vein Cu_{1b} , and another from costa is interrupted at veins Sc and R_1 and runs down as a double line between R_5 and R_2 , thereafter the lines diverge, the inner line bending inwards and up to Cu_{1b} and the outer line reduced to several striae one of which, *i.e.* between M_3 and Cu_2 , prominent and incurved at vein Cu_{1a} ; the medial area irrorated with blackish scales, with the medial line prominent from costa to the anal vein. Hind wings brown, unmarked and with tufts of scale-hairs on anal veins at the inner margin ; costal half pale-greyish brown at the base. Underside of the wings fuscous, marked with prominent striae in fore wing and faint ones in hind wings ; the inner area of the fore wing near the base, and costa of hind wing greyish brown and unmarked. Body greyish.

Antennae about half the length of costa ; shaft with 53 laterally-flattened, simple and minutely ciliate segments (Text-fig. 6A) ; basal segments short and broad, distal ones long and narrow ; the apical one about twice the length of its width. Labial palpi appressed to face and upturned ; the third segment short and blunt, extending beyond fronts. Legs (Text-figs. 6 B-C) as described in generic characters. Retinaculum (Text-fig. 6D) minute, rounded at the tip and partly covering vein R_1 . Abdomen with tufts of scales.

Fore wing (Text-fig. 6E) : Areole large, projecting by about half its length from cell end ; vein R_2 arises from areole ; R_3 connate with

the stalk of R_4+R_5 and running close to vein R_4 for half way and then diverging rapidly towards the apical margin ; M_1 arising from the cell angle ; median cell with the branches ending between M_1-M_2 , and M_2-M_3 ; M_2 and M_3 above the cell end, M_3 nearer M_2 than Cu_{1a} ; the latter arising from angle whereas the vein Cu_{1b} from before the cell angle. Hind wing (Text-fig. 6F) ; with a short veinlet arising from vein Sc and ending abruptly ; median cell with its branches ending between M_1-M_2 , and at M_3 ; otherwise as in fore wing.

Genitalia.—Male (Text-fig. 6 G-M) : Uncus uniformly broad from base to near the tip ; about twice as long as its width in the middle and with a slight dorsal depression near the distal end ; the latter ending in a fine point. Gnathos meeting through a fine membrane, the latter beset with spines. Tegumen short, broadest in middle. Saccus long, broadly quadrangular. Clasper about three times as long as its width in middle ; costal margin produced inwards and meet each other in the middle ; spinabasis L-shaped, short and with its lower stem as long as the upper verticle one ; the mid dorsal area highly sclerotised, denticulate and with numerous short spines, setae and several short parallel ridges which do not reach half way ; distal part membranous. Juxta with long and narrow lobes. Aedeagus simple, not differentiated into base and apex and about twelve to thirteen times as long as its width in middle ; cornuti absent.

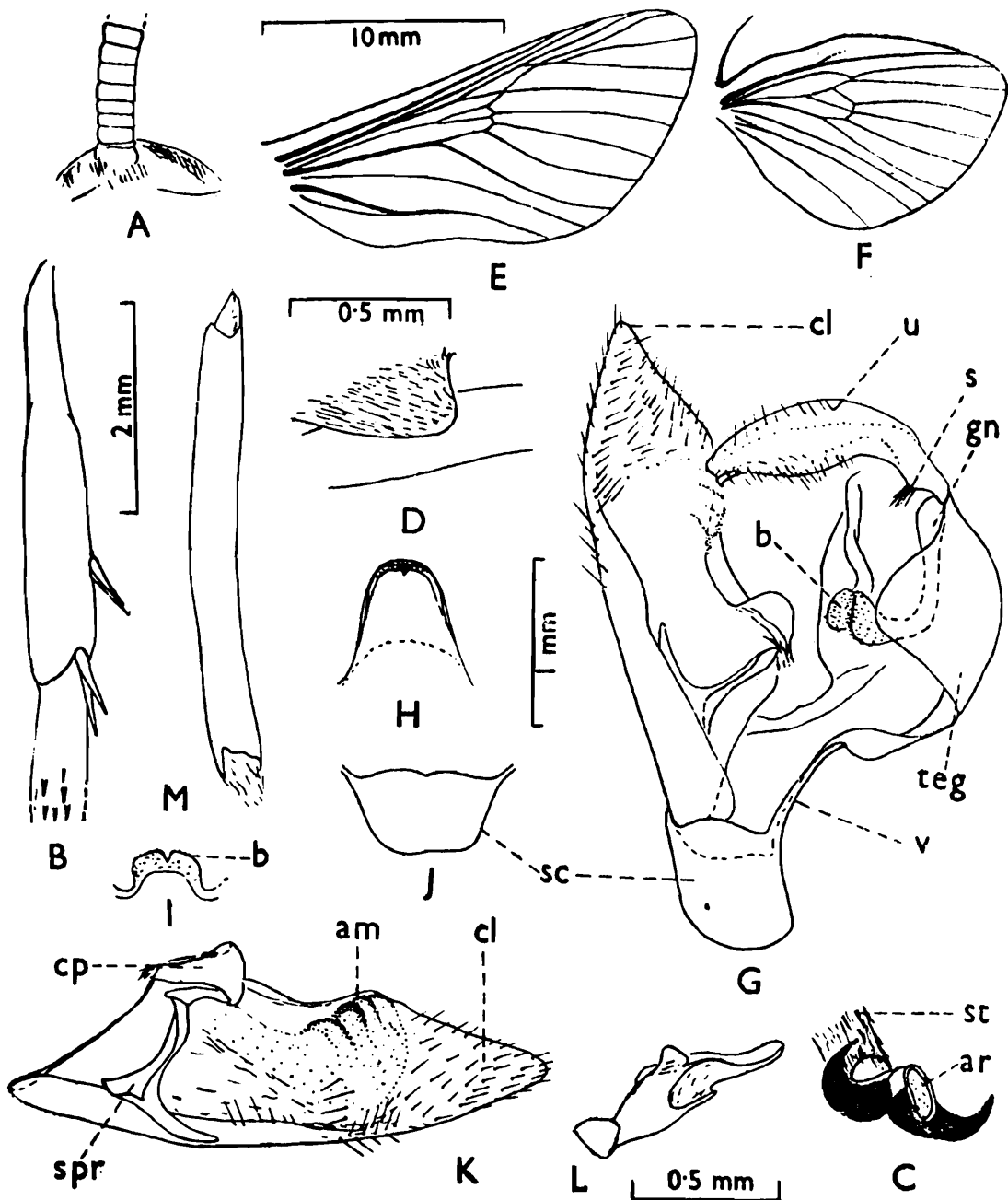
Measurements.—Expanse : fore wing, 40 mm. Length : fore wing, 18 mm. ; hind wing, 12 mm. ; abdomen, 12.5 mm. ; whole body, 22.5 mm.

Material examined.—India : Great Nicobar Islands, Bankol Camp, Bellabay, 1 ♂, 3.iii.1966 (Daniel and Bhowmick coll.).

Distribution.—This species is hitherto known from Pakistan (Baluchistan), Afganistan, China and Russia (Central Asia, Turkestan). The present record from India (Great Nicobar Islands) is being reported for the first time.

Remarks.—*H. arenicola* differs from the other oriental species, viz. *H. rufidorsia* (Hampson) for its larger size, and for having a dark medial patch on the fore wing (absent in *rufidorsia*). In respect of the male genitalia, it differs in having a short and stout spinabasis, where as in *rufidorsia* it is long and narrow.

It is also close to the palaearctic species *H. consobrinus* Püng but can be differentiated by its larger size, shorter antennae and the greyish colour of the body (brownish grey in *consobrinus*).



Text-fig. 6. *Holcocerus arenicola* (Staudinger) : (A) Male antenna showing a few basal segments. (B) A portion of the hind leg, with two pairs of tibial spurs and a few tarsal spines. (C) Tarsal claws, with arolium. (D) Retinaculum. (E) and (F) Fore and hind wing venation, respectively. (G) Male genitalia in a latero-ventral view, without clasper of one side. (H), (I) and (J) Uncus, bulla and saccus, respectively, in a ventral view. (K) A clasper in an inner view. (L) Juxta of the anellus. (M) Aedeagus. (A—B ; C—D ; E—F ; G to K and M, of the same magnifications).

10. *Holcocerus rufidorsia* (Hampson)

(Pl. I, fig. 7 ; Text-fig. 7)

1905. *Cossus rufidorsia* Hampson, *J. Bombay nat. Hist. Soc.*, **16** : 194. (Type loc.—Sikkim).
 1923. *Cossus rufidorsia*, Dalla-Torre, *Lepid. Cat.*, **29** : 13.
 1933. *Cossus rufidorsia*, Gaede, in Seitz *Macrolepidoptera of the World*, **10** : 810.
 1965. *Holcocerus rufidorsia*, Daniel, *Mitt. münch. ent. Ges.*, **55** : 95.

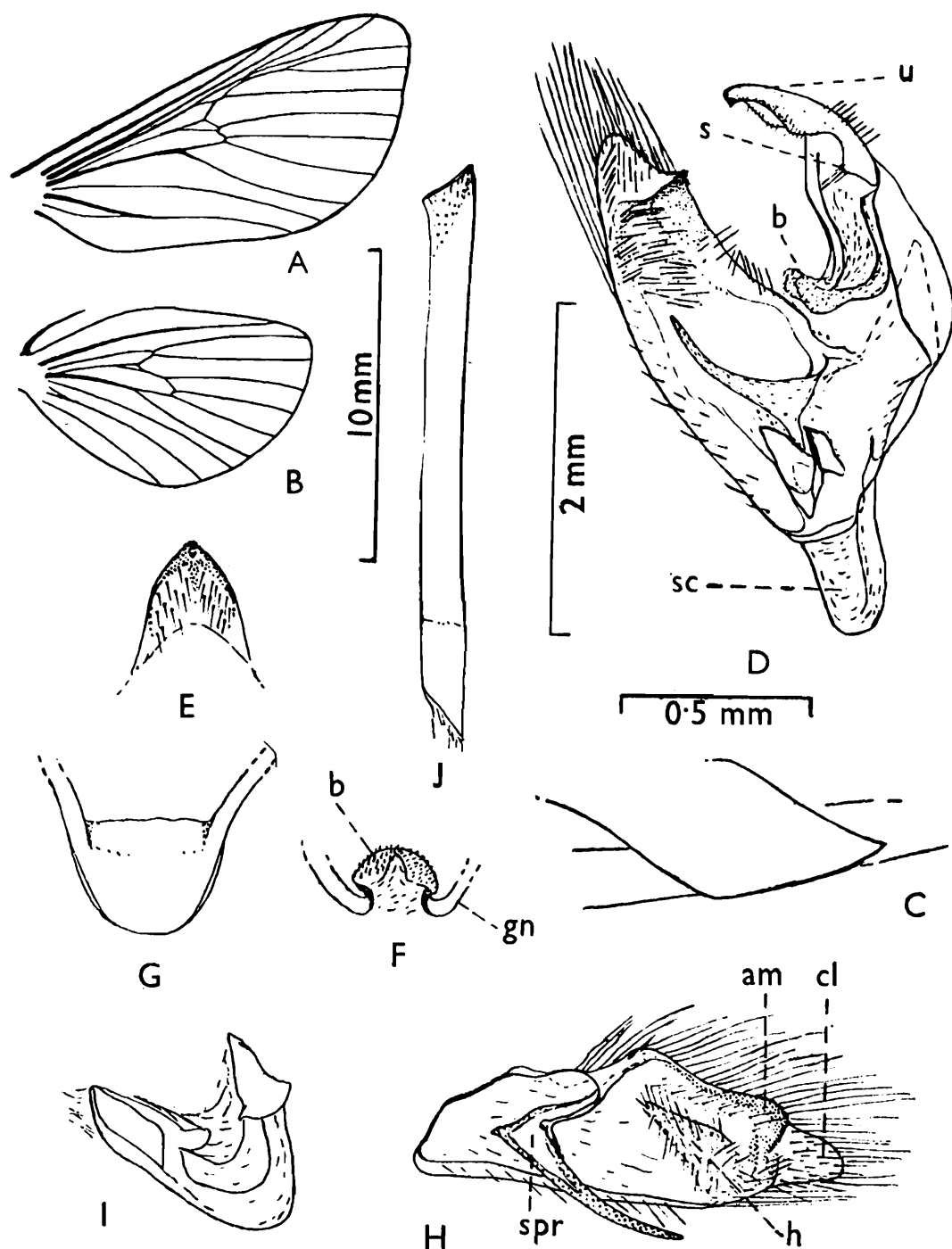
Type : In B.M.

Head, thorax and abdomen dark brown. Antennae and labial palpi paler. Fore wing greyish brown, somewhat paler beyond the middle ; striae blackish brown, faint before the middle but well marked beyond it, some of which coalesce into fine lines across the wings ; the postmedial line double, running from costa to inner margin, with the inner line bifurcating at Cu_{1b} ; the two parallel and narrow lines prominent between costa and M_1 , thereafter faint and diffused ; submarginal line connected with marginal line through short and faint striae. Hind wing blackish brown, unmarked but irrorated with black scales throughout uniformly. Underside of the wings dark brown, marked with faint striae, the striae on the fore wings prominent. Abdomen and abdominal tufts greyish.

Antennae half the length of costa ; the shaft composed of 53 simple, laterally-flattened and minutely ciliate segments ; each segment slightly half or more than its width, a few distal ones longer than wide. Labial palpi closely appressed to face and upturned ; the third segment short, blunt and reaching up to the frontal tufts. Legs with arolium, spurs and spines as given in the generic characters. Retinaculum (Text-fig. 7C) short.

Venation.—Fore wing (Text-fig. 7A) : Areole small, projecting about two-thirds outside the cell ; R_2 stalked with R_3 , the common stem either connate with the base of $R_4 + R_5$ or anastomosing to enclose an areole ; R_3 running close to $R_4 + R_5$, as in *arenicola* ; M_1 arises from above the cell angle ; median cell short, with its branches ending between M_1-M_2 , and M_2-M_3 . Hind wing (Text-fig. 7B) : Median cell with both the branches ending between M_2-M_3 ; otherwise typically *Holcocerus*-type.

Genitalia.—Male (Text-fig. 7 D-J) : Uncus broad from base to middle, thereafter narrowing gradually towards distal end. Tegumen long and narrow. Claspers with the mid-dorsal area sclerotised, not denticulate ; distal part reduced and membranous ; the costal margin not much produced ; spinabasis, especially the lower



Text-fig. 7. *Holcocerus rufidorsia* (Hampson) : (A) and (B) Fore and hind wing venation, respectively. (C) Retinaculum. (D) Male genitalia in a latero-ventral view, without clasper of one side. (E), (F) and (G) Uncus, bulla and saccus, respectively, in a ventral view. (H) Aedeagus in an inner view. (I) Juxta of the anellus. (J) Aedeagus (A—B; C and I; D to H & J of the same magnifications).

horizontal stem, well developed. Juxta with short lobes. Aedeagus as in *arenicola*. Female : Not known.

Measurements.—Expanse : fore wing, 29 mm. Length : fore wing, 13 mm. ; hind wing, 9 mm. ; abdomen, 9 mm. ; whole body, 29 mm.

Material examined.—1 ex, India : Assam : N. Lakhimpur, 1 ♂ 3.x.1966 (S. K. Tandon and G. S. Arora coll.).

Distribution.—India (Assam, Sikkim).

Remarks.—*Holcocerus rufidorsia* (Hampson), which was hitherto known only from Sikkim, is now being reported here from Assam for the first time.

For differences from *H arenicola*, see under the latter.

Genus *Paracossus* Hampson

1905. *Paracossus* Hampson. *J. Bombay nat. Hist. Soc.*, **16** : 194.

1918. *Paracossus*, Turner, *Trans. ent. Soc. Lond* **66** : 178.

1923. *Paracossus* Dalla-Torre, *Lepid. Cat.*, **29** : 15.

1933. *Paracossus* Gaede, in Seitz *Macrolepidoptera of the World*, **10** : 810.

Type Species : *Paracossus furcata* Hampson

(a) General

The genus *Paracossus* is endemic to the Indian subregion and was erected by Hampson (1905) to include his two species, viz. *furcata* from Burma (type), and *parva* from Ceylon. Since then, there have been no further additions to this genus. It is referable to the subfamily Cossinae on account of pectination of antennae, the presence of two pairs of tibial spurs, tarsal spines, and gnathos in the male genitalia which is united below the uncus.

(b) Characters of the Genus *Paracossus* Hampson

Antennae of male bipectinate, rami short and gradually decreasing in size towards the apex. Labial palpi slender, upturned and not quite reaching up to vertex of head. Legs with two pairs of spurs on hind tibiae ; tarsal spines present ; claws with arolium.

Fore wings without areole ; veins R_2 to R_5 stalked, R_5 arising before the origin of R_2 ; median vein unforked in the cell. Hind wings with the veins R_s and M_1 separate ; median. as in fore wing.

Uncus in male genitalia narrowed distally and not ending into a point ; gnathos present, meeting medially below the uncus ; claspers with a sclerotised mid-dorsal area ; juxta well developed.

(c) *Relationships of the Genus Paracossus with the other allied Genera*

The genus *Paracossus* Hampson, both taxonomically and phylogenetically, is very important because of the absence of areole, the stalking of veins R_2 to R_5 in the fore wing and for the unforked median vein in both wings. By briefly reviewing the venation of the Indian genera, namely *Catopta*, *Cossus*, *Ereinocossus* and *Holcocerus*, it appears that the absence of areole and the median cell in this genus has come about or evolved gradually, the intermediate stages are traceable in certain species of the genus *Cossus* Fabricius ; similarly, the genus *Holcocerus* also presents a stage where the areole is not closed by usual anastomosis between vein R_3 and $R_4 + R_5$, but by the anastomosis of the stalks of $R_2 + R_3$ and $R_4 + R_5$. This is very significant since only a small areole is formed in the species *H. rufidorsia* (Text-fig. 7A), the condition which, probably, leads to the complete anastomosis of the stalks of $R_2 + R_3$ and $R_4 + R_5$, resulting in the absence of areole which is a characteristic feature of the genus *Paracossus* Hampson.

(d) *Geographical distribution of the Genus Paracossus*

The genus *Paracossus* Hampson is purely an oriental genus and is known from Ceylon and Burma.

(e) *Key to the species of the Genus Paracossus*

M_1 in the fore wing arising from angle of cell	<i>parva</i> Hampson
M_1 in the fore wing arising from below the angle of cell	<i>furcata</i> Hampson

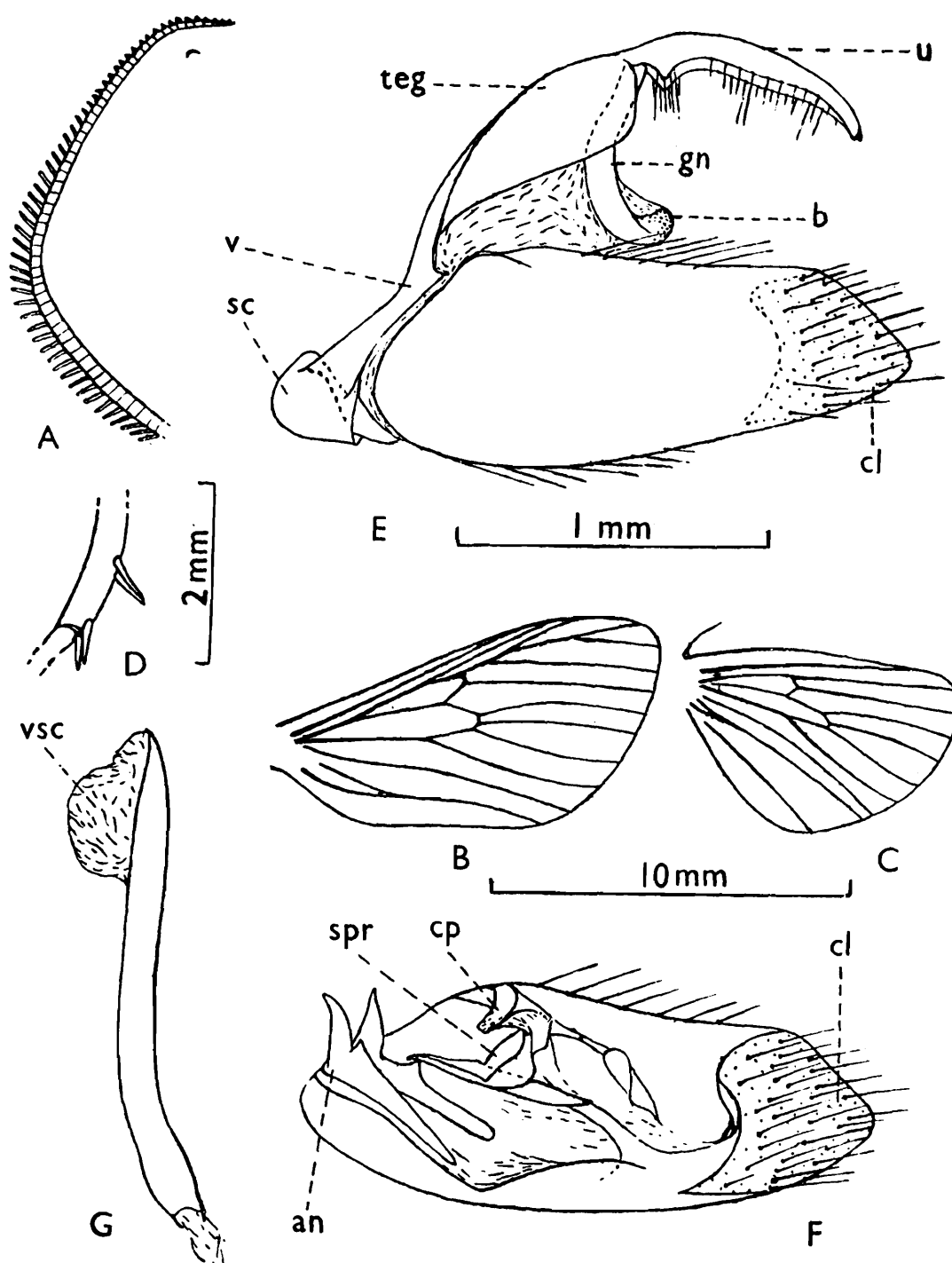
(f) *Description of Species*11. *Paracossus parva* Hampson

(Pl. I, fig. 8 ; Text-fig. 8)

1905. *Paracossus parva* Hampson, *J. Bombay nat. Hist. Soc.*, **16** : 194 (Type loc.—Ceylon, Matale (*Pole*)).
 1918. *Paracossus parva*, Turner, *Trans. ent. Soc. Lond.*, **66** : 178.
 1923. *Paracossus parva*, Dalla-Torre, *Lepid. Cat* **29** : 15.
 1933. *Paracossus parva*, Gaede, in Seitz *Macrolepidoptera of the World*, **10** : 810.

Type : In B.M

Body pale-greyish brown ; abdomen darker dorsally. Fore wing greyish brown, with fine dark striae and lines ; the inner area reddish



Text-fig. 8. *Paracossus parva* Hampson : (A) A portion of male antenna showing pectination of one side. (B) and (C) Fore and hind wing venation, respectively. (D) A portion of the hind leg, with two pairs of tibial spurs. (E) Male genitalia in a lateral view. (F) A clasper in an inner view. (G) Aedeagus. (A & D ; B & C ; and E to G of the same magnifications).

brown ; medial line black and slightly bent outwards at median nervure ; an oblique line running from costa to the upper angle of cell, thereafter following the discocellulars with a slight fork on the outer side and bending inwards on median nervure to angle outwards on

vein Cu_{1b} and then incurving ; a postmedial incurved line from costa to vein M_3 where it angles outwards and then is incurved, and connected at vein M_3 by an oblique streak with the irregularly waved subterminal line. Hind wing semihyaline, fuscous brown and with darker veins.

Antennae (Text-fig. 8A) bipectinate nearly up to five-sixths of the length from base ; the distal part with short and uniserrate branches. Labial palpi short and slender, not quite reaching vertex. Wings broad (Text-fig. 8 B-C). Legs with the spurs (Text-fig. 8D), spines and claws as in generic characters. Venation typically *Paracossus*-type.

Genitalia.—Male (Text-fig. 8 E-G) : Uncus broad, distally narrower ; apex slightly notched and not ending into a fine point. Tegumen long and narrow, more so at its base than at the upper broader part ; saccus short and subrounded. Claspers with the costal process produced inwards to meet with that of the other side ; spinabasis 'L'-shaped (not L-shaped as in other genera), with the lower horizontal stem running on both sides, i.e., towards distal as well as basal end of claspers. Juxta with well developed lobes, and with short basal prolongations. Aedeagus simple and without cornuti.

Measurements.—Expanse ; fore wing, 25 mm. Length : fore wing, 11.5 mm. ; hind wing, 8.5 mm.

Material examined.—1 example. Ceylon : Mirigama, 1♂, .xii.— (Joicey coll.) (colln. G. C. Altson) (ex. colln. B. M.).

Distribution.—Ceylon.

Remarks.—This species differs from the other species, viz. *P. furcata*, in the origin of vein M_1 in the fore wing being from angle of cell.

12. *Paracossus furcata* Hampson

1905. *Paracossus furcata* Hampson, *J. Bombay nat. Hist. Soc.*, **16** : 195 (Type loc.—Pegu, Burma).
 1918. *Paracossus furcata*, Turner, *Trans. ent. Soc. Lond.*, **66** : 178.
 1923. *Paracossus furcata*, Dalla-Torre, *Lepid. Cat.*, **29** : 15.
 1933. *Paracossus furcata*, Gaede, in Seitz *Macrolepidoptera of the World*, **10** : 810.
 1951b. *Paracossus furcata*, Viette, *Lambillionea*, **51** (5-12) : 66.

Type : In B.M.

As no example of this species was available, the original description is reproduced here : u♂. Brownish-grey. Fore wing with

dark striae, an indistinct oblique brown antemedial line bifurcating and enclosing an elliptical spot in the middle ; a medial line bent obliquely outwards from median nervure to submedian fold where it is connected by a streak with the post-medial line which is strongly incurved below vein 4 where it is connected by an oblique spur with irregularly waved subterminal line which is obscurely furcate in places. Hind wing pale fuscous brown.

Habitat—Pegu, Magene.

Exp.—34 milim.

Remarks.—For differences from *parva* see the latter.

Subfamily (ii) ZEUZERINAE

- 1894a. *Zeuzerinae* Neumoegen and Dyar, *J. N. Y. Ent. Soc.*, 1 : 97.
- 1894b. *Zeuzerinae* Neumoegen and Dyar, *J. N. Y. Ent. Soc.*, 2 : 1.
- 1926. *Zeuzerinae*, Tillyard, *The Insects of Australia and New Zealand* : 417.
- 1929. *Zeuzerinae*, Seitz, in *Seitz Macrolepidoptera of the World*, 14 : 539.
- 1937. *Zeuzerinae*, Dyar, in *Seitz Macrolepidoptera of the World*. 6 : 1264
- 1948. *Zeuzerinae*. Toxopeus, *Treubia*, 19 : 167.
- 1955. *Zeuzerinae*, Daniel, *Mitt. münch. ent. Ges.*, 44—45 : 174.
- 1959b. *Zeuzerinae*, Clench, *Veröff. zool. StSamml. Münch.*, 6 : 9.
- 1962. *Zeuzerinae*, Comstock, *Introduction to Entomology* : 601.

Type-genus : *Zeuzera* Latreille

(a) Characters of the Subfamily ZEUZERINAE

Insects of variable size, varying from 2 cm. to 20 cm. Antennae of male bipectinate for a portion of length, the distal part usually serrate. Proboscis either poorly developed or absent. Labial palpi obsolete or moderately developed. Legs with a single pair of minute spurs in hind tibiae, the latter normal, not dilated ; tarsi with or without spines ; arolium either present or absent. Frenulum in male one ; in female usually from two to three, rarely as many as 30, bristles ; retinaculum elongate.

Fore wing always with areole, the latter usually normal and moderate to hypertrophied in size ; vein R_1 generally arising from the areole, rarely from cell ; R_2 from areole ; median forked ; M_1 usually arising from well below the upper angle of cell, rarely from above. Hind wing with vein Sc usually free and without cross bar, rarely with cross bar ; R_s and M_1 separate ; median vein as in fore wing.

The male genitalia considerably variable ; with or without gnathos. The female genitalia also variable.

(b) *General remarks on the Indian ZEUZERINAE*

The Indian Zeuzerinae includes *Azygophelps* Hampson, *Phragmataecia* Newman, *Xyleutes* Hübner and *Zeuzera* Latreille.

The genus *Azygophelps* Hampson is mainly Ethiopian, and includes four species from the Indian subregion. The genus *Phragmataecia* Newman is a widely distributed genus and is represented by ten species, including four species, viz. *Cossus pallidalae* Hampson, *Xyleutes obliquifascia* Bryk, *X. clara* Bryk, and *Zeuzera stigmatica* Moore, which have been assigned now to this genus in the present study. The genus *Xyleutes* Hübner is well represented in the Indo-Australian region and has eight species (including a new species from S. Andamans) in the Indian subregion. The genus *Zeuzera* Latreille is also a widely distributed one, and is represented by 6 species and a new subspecies.

Thus, in all, 28 species, including a new species and a subspecies, under subfamily Zeuzerinae, are known from the Indian subregion.

(c) *Key to the Indian Genera of the Subfamily ZEUZERINAE*

1. Antennae in male bipectinate beyond the basal half, minutely pectinate in female. Arolium present. Wings with the veins M_2 and M_3 arising separately or from a point. Gnathos present or absent 2

Antennae in male not bipectinate beyond the basal half, simple in female. Arolium absent. Wings with the veins M_2 — M_3 always arising separately. Gnathos present 3

2. Labial palpi well developed. Fore wing with a long areole ; M_2 and M_3 arising from a point in both the wings. Gnathos present, but weak. Aedeagus with well developed cornutal process

Azygophelps Hampson

Labial palpi weak or obsolete. Fore wing with a moderately long areole ; M_2 and M_3 arising separately. Gnathos

absent. Aedeagus without
cornutal process .. *Phragmataecia* Newman

3. Areole in fore wing hypertrophied, projecting much beyond the cell angle. Hind wing without cross bar between Sc and Rs. Abdomen generally shorter than hind wings in the male. Gnathos well developed ; juxta weak. Aedeagus stout and with a cornutal process *Xyleutes* Hübner

Areole in fore wing not much hypertrophied, projecting a little beyond the cell. Hind wing with a cross bar between Sc and Rs. Abdomen longer than hind wings in the male. Gnathos well developed or weak ; juxta well developed. Aedeagus either simple and slender or stout, with or without cornutal process *Zeuzera* Latreille

Genus *Azygophelps* Hampson

- 1892b. *Azygophelps* Hampson, *Fauna Brit. India, Moths*, 1 : 309.
 1894. *Azygophelps*, Swinhoe, *Ann. Mag. nat. Hist.*, (6) 14 : 440.
 1895. *Azygophelps*, Swinhoe, *Trans. ent. Soc. Lond.* : 29.
 1896a. *Azygophelps* Hampson, *Fauna Brit. India, Moths*, 4 : 473.
 1899. *Azygophelps*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
 1905. *Azygophelps*, Schaus, *Proc. U.S. nat. Mus.*, 29 : 339.
 1909. *Azygophelps*, Lefroy, *Indian Insect Life* : 496.
 1918. *Azygophelps*, Turner, *Trans. ent. Soc. Lond.*, 66 : 162 [Synonymised to *Xyleutes* Hübner.]
 1923. *Azygophelps*, Dalla-Torre, *Lepid. Cat.*, 29 : 43.
 1929. *Azygophelps*, Gaede, in Seitz *Macrolepidoptera of the World*, 14 : 545.
 1933. *Azygophelps*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 821.
 1940. *Azygophelps*, Ayyar, *Handbook of Economic Entomology for South India* : 378, 472.
 1945. *Azygophelps*, Gardner, *J. Bombay nat. Hist. Soc.*, 45 (3) : 391, 392.
 1951b. *Azygophelps*, Viette, *Lambillionea*, 51 (5—12) : 39.
 1957. *Azygophelps*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 19.

Type-species ; *Hepialis scalaris* Fabricius.

(a) General

The genus *Azygophelps* was erected by Hampson (1892b) for an Asian species *Hepialis scalaris* Fabricius as the type and two other

Indian species, viz., *Zeuzera albofasciata* Moore and *Z. pusilla* Walker. Later one more species, namely *A. nurella*, from Cherrapunji, was added to this genus by Swinhoe (1894). Thus, there are only four species of this genus known from the Indian subregion.

The present study of the Indian species, is based on the material of three well known species, viz. *albofasciata* (Moore), *pusilla* (Walker) and *scalaris* (Fabr.), including the holotype of *albofasciata*. The material of *A. nurella* Swinhoe was, however, not available.

(b) *Characters of the Genus Azygophelps* Hampson

Antennae bipectinate in both the sexes, shorter in female than in the male. Labial palpi short and porrect. Frenulum in female in the form of three bristles. Legs with a single pair of minute spurs in the hind tibiae, tarsal spines weakly developed ; tarsal claw with a well developed arolium. Abdomen generally longer than hind wing in both sexes.

Fore wing with a large areole ; veins R_1 and R_2 arising from areole, R_1 from the basal one-third and R_2 from near the distal end ; M_1 from well below the angle of cell ; median with the upper branch ending between M_1 — M_2 and the lower one either between M_3 — Cu_{1a} , or at M_3 ; M_2 — M_3 from a point in both the wings.

Gnathos in the male genitalia present and free at their distal end ; aedeagus also well developed and with a sclerotised cornutal process. Female genitalia variable.

(c) *Relationships of the Genus Azygophelps with the other allied Genera*

The genus *Azygophelps* Hampson is close to the genus *Zeuzera* Latreille. In fact most of the Indian species, including the type, were generally treated as the species of the genus *Zeuzera* at the time when Hampson (1892b) erected the genus. It is, however, separable from *Zeuzera* by the presence of arolium and absence of a cross bar between the veins Sc and Rs in the hind wing.

From *Xyleutes*, the genus differs by the presence of arolium and by the antennae which are bipectinate in both sexes, whereas in *Xyleutes* the arolium is absent and antennae bipectinate in the male but simple in the female.

It is close to the genus *Phragmataecia* in respect of antennae which are bipectinate in both sexes, and in the presence of arolium. The two, however, differ from each other as follows : In *Azygophelps* the veins M_2 and M_3 arise from a point in both the wings and gnathos

is present, unlike in *Phragmataecia* where M_2 and M_3 arise separately and gnathos is absent.

(d) *Geographical distribution of the Genus Azygophelps*

The genus *Azygophelps* is known from the Ethiopian (East, West and Central Africa, Madagascar, Transvaal, Uganda, Rhodesia), Oriental (India, Pakistan, Burma, Ceylon, Indo-China, Indonesia, Southern China), and Australian (Australia), regions.

(e) *Key to the Indian species of the Genus Azygophelps*

The following key includes three Indian species of which the material was available for study.

1. Antennae similar in both sexes, the branches long ; frontal tufts and the stripes on thorax orange ; fore wing with the cell area marked, the area below the cell unmarked. Tegumen shorter, vinculum and aedeagus long in male genitalia ; genital plate in female genitalia with a ventral sclerotised patch

scalaris (Fabricius)

Antennae dissimilar in both sexes, branches shorter in female than in the male ; frontal tufts either brown or blackish brown and thorax without any stripes ; fore wing with the cell area unmarked, the area below the cell marked. Tegumen longer, or as long as the vinculum, and aedeagus short ; genital plate without ventral sclerotisation

2

2. Fore wing with the median area unmarked throughout. Hind wing marked. Juxta in male genitalia without median lobes ; corpus bursae, in female genitalia, with a signum

albofasciata (Moore)

Fore wing with the median area unmarked only up to discocellular. Hind wing unmarked. Juxta with a median lobe ; corpus bursae without signum .

pusilla (Walker)

(f) Descriptions of Species

13. *Azygophelps scalaris* (Fabricius)

(Pl. I, fig. 9 ; Pl. II, fig. 13 ; Text-fig. 9).

1775. *Hepialis scalaris* Fabricius, *Syst. Ent. Ins.* : 590 (Type loc.—China).
 1794. *Cossus scalaris* Fabricius, *Ent. Syst.*, 3(2) : 5.
 1800. *Phalaena scalaris*, Donovan, *An Epitome of the Natural History of the Insects of India and the Islands in the Indian seas* : 82.
 1822. *Morpheus scalaris*, Hübner, *Verz. bek. Schmett.* : 196.
 1838. *Zeuzera scalaris*, Westwood, *Nat. Hist. Ins. India* : 83.
 1865. *Zeuzera bivittata* Walker, *List Lep. Brit. Mus.*, 32 : 586 (Type loc.—N. India).
 1887. *Zeuzera bivittata*, Cotes and Swinhoe, *Cat. Moths of India* : 232, (Karachi).
 1892. *Zeuzera scalaris*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, 1 : 281.
 1892. *Zeuzera scalaris*, Kirby, *Cat. Lep. Het.* : 871.
 1892b. *Azygophelps scalaris*, Hampson, *Fauna Brit. India, Moths*, 1 : 310.
 1909. *Azygophelps scalaris*, Lefroy, *Indian Insect Life* : 496.
 1914. *Azygophelps scalaris*, Fletcher, *Some South Indian Insects and other Animals of Importance* : 446.
 1917. *Azygophelps scalaris*, Fletcher, *Rept. Proc. 2nd. Ent. Mtg.* : 73,75,76.
 1918. *Azygophelps scalaris*, Fletcher, *Sci. ent. Rep. agric. Res. Inst. Pusa* : 100.
 1923. *Azygophelps scalaris*, Dalla-Torre, *Lepid. Cat.*, 29 : 44.
 1929. *Azygophelps scalaris*, Gaede, in *Seitz Macrolepidoptera of the World*, 14 : 545.
 1933. *Azygophelps scalaris*, Gaede, in *Seitz Macrolepidoptera of the World*, 10 : 821.
 1939. *Azygophelps scalaris*, Hutson, *Adm. Rept. Agric. Ceylon* : D37—42.
 1940. *Azygophelps scalaris*, Ayyar, *Handbook of Economic Entomology for South India* : 378,379.
 1945. *Azygophelps scalaris*, Gardner *J. Bombay nat. Hist. Soc.*, 45 (3) : 392.
 1945. *Azygophelps scalaris*, Sevastopulo, *J. Beng. nat. Hist. Soc.*, 19 : 115.
 1960. *Azygophelps scalaris*, Agrawal and Agrawal, *Curr. Sci.*, 29 (8) : 311.

Type : In the cabinet of Emperor of Austria (*vide* Westwood, 1838).

Hosts : *Sesbania aculeata* (Bengal) ; *S. grandiflora* ; *S. speciosa* (Ceylon) ; *S. aegyptiaca* ; and Sunnhemp.

Head, thorax, wings and abdomen cinerous white. Head with the frontal tufts and the area around the base of antennae beset with orange scales ; the area in between the antennae with black scales. Antennae cinerous white above. Labial palpi and an area immediately below it, on the underside, blackish. Collar whitish or cinerous white, with a line of black scales across it. Thorax with two

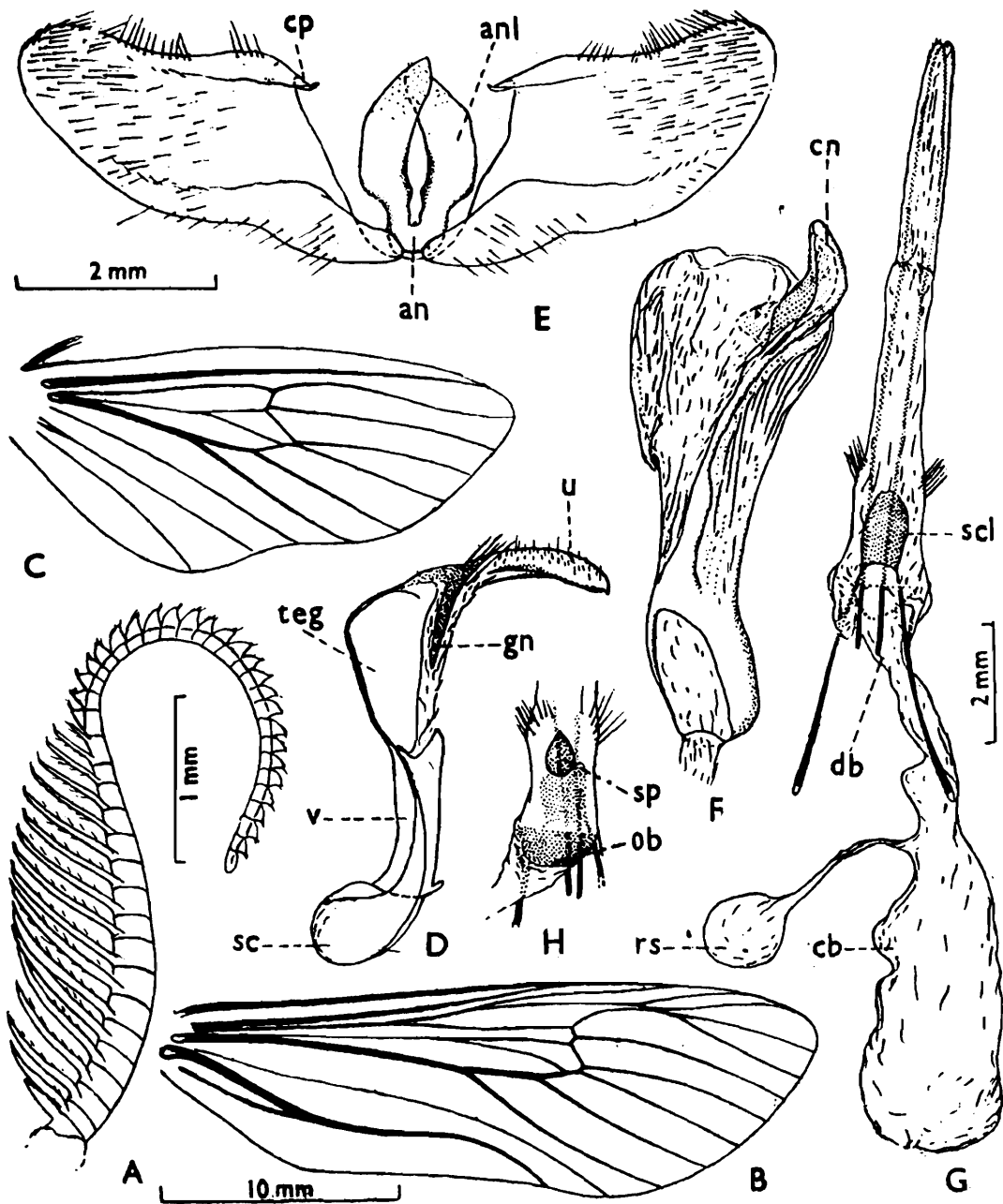
orange stripes dorsally and one each laterally at the base of fore wing, those on the lateral side continuous on the wings and make longitudinal orange markings up to the postmedial area ; orange markings also present on inner margin from base to the end of vein 1A ; several black striae present on the fore wings in and beyond the cell, on costal margin and along the inner margin, and interrupting the orange markings more densely inside the cell ; the area immediately below the cell whitish and without any marking. Hind wings whitish, unmarked. Underside white, except for the thoracical sternite, fore femora, middle and hind tarsi, which are black.

Antennae (Text-fig. 9A) bipectinate up to the basal half in both sexes, pectination much shorter in female than in the male ; the longest rami as long as four to five segments in the male and three to four in the female ; the shaft with 44-54 segments in male, with the pectinate branches up to 16-19 segments, the distal part of antennae, in both sexes, serrate, the tip simple. Labial palpi minute, not projecting beyond the frontal tufts. Wings with a single stout frenulum spine in male and three in female ; retinaculum in the male in the form of an elongate lobe. Claws with a well developed arolium.

Venation (Text-fig. 9 B-C).—Generally as for the genus. Lower branch of median in the fore wing ending between M_3 and Cu_{1a} .

Genitalia.—Male (Text-fig. 9 D-F) : Uncus sclerotised, about four times as long as its width in the middle, the distal portion narrow and ending into a downwardly-pointed acuminate tip. Gnathos weakly developed, slender and free. Tegumen subtriangular, shorter than vinculum ; saccus large and subrounded. Claspers short and broad, only about twice as long as the width in middle ; the distal part narrow and rounded. Juxta semicircular, without median lobe ; lateral lobes broad basally, narrowing gradually towards the apex. Aedeagus with the basal portion smaller than the apical part, the former more sclerotised than the latter which is membranous and striated ; a hard cornutal process, as described in the generic character, present. Female (Text-fig. 9 G-H) : Ostium bursae weakly sclerotised ; ductus bursae unsclerotised, long and tubular ; corpus bursae large sac like, without signum ; receptaculum seminalis almost rounded, connected with the corpus bursae by a fine duct, ductus spermathecae ; the genital plate sclerotised dorsally, the ventral side with a small oval-shaped sclerotised patch.

Measurements.—Wing expanse : Male, 37-44 mm. ; female, 37-60 mm. Length : fore wing ; Male, 18-22 mm. ; female, 18-28 mm. Hind wing : Male, 12-17 mm. ; female, 12-20 mm. Body : Male, 20-27 mm. ; female, 20-35 mm. Abdomen : Male, 15-20 mm. ; female, 14-26 mm.



Text-fig. 9. *Azygophleps scalaris* (Fabricius) : (A) A portion of male antenna showing pectination of one side. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers. (E) Inner view of the claspers, with juxta. (F) Aedeagus. (G) Female genitalia in a dorsal view. (H) A portion of the female genitalia in a ventral view. (B-C ; D to F ; and G-H of the same magnifications).

Material examined.—26 examples as follows : India : Punjab : Bhuin, 1 ♀, 7.vi.1953 (*E. Venugopalan* coll.) (ex. colln. F.R.I.). Bihar : Pusa, 1 ♂, 1 ♀, 26.v.1917 (*N. P. Nandi* coll.) ; 1 ♀, 15.vi.1918, "Boring Daincha Stem" ; 1 ♀, 9.ix.1926 (*Pillai* coll.) at light ;

1 ♂, 20.x.1927 (*Fletcher* coll.) ; 1 ♂, 6.ix.1929 (*A. Miyatake* coll.). Bengal : 1 ♀, "Daincha borer attack Bengal", (No further data). Tamil Nadu : Madras, 1 ♀, from stem of *Sesbania grandiflora* (No further data), Coimbatore, 1 ♂, 15.viii.1914, in Daincha stem (*T.B.R. Rao* coll.), 1 ♀, 20.vi.1918 (*S.R.S. Coll.*), 1, ♀ (*M.S. Pillai* coll.) (No further data) (ex. colln. I.A.R.I.). Andhra Pradesh : Bapatla, 5 ♂ ♂, 9 ♀ ♀, -ii.1965 (on sunnhemp) (no further data).

Distribution.—This species is very widely distributed in India and is also known from Burma, Pakistan, Ceylon, Indochina, Indonesia and China.

Remarks.—*Azygophelps scalaris* has been sometimes confused as a species of the genus *Xyleutes* because of the nature of pectination in the male antennae. It can, however, be differentiated by the presence of well developed arolium, which is absent in *Xyleutes*. This species can be separated from the other species by the conspicuous orange frontal tufts, orange markings or stripes on thorax and for having an unmarked area below the cell in fore wings, whereas in the other species, namely *albofasciata* and *pusilla*, the frontal tufts are either brown or blackish brown, the thorax is immaculate and the area below the cell is marked. In the genitalia the saccus in the male is large and the corpus bursae in the female is without signum, whereas the saccus is small and the corpus bursae with a signum in *albofasciata*. From *pusilla* (Walker) it differs in the absence of medial lobe in the male.

14. *Azygophelps albofasciata* (Moore)

(Pl. I, fig. 10 ; Text-fig. 10)

- 1879 b. *Zenzera albofasciata* Moore, *Descr. Indian Lep. Atk.* : 87 (Type loc.—Darjeeling, India).
 1887. *Zeuzera albofasciata* Cotes & Swinhoe, *Cat. Moths of India* : 232 (Darjeeling).
 1892. *Zeuzera albofasciata*, Kirby, *Cat. Lep. Het.* 872.
 1892 b. *Azygophelps albofasciata*, Hampson, *Fauna Brit. India, Moths*, 1 : 309.
 1899. *Azygophelps albofasciata*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12(4) : 646.
 1923. *Azygophelps albofasciata*, Dalla-Torre, *Lepid. Cat.*, 29 : 43.
 1933. *Azygophelps albofasciata*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 821.
 1934. *Azygophelps albofasciata*, Gaede, in Seitz *Macrolepidoptera of the World*, Suppl. 2 : 244.

Type : In Ber. Mus.

Head with blackish brown frontal tufts and antennae. Labial palpi blackish on sides, paler beneath. Vertex blackish. Collar and

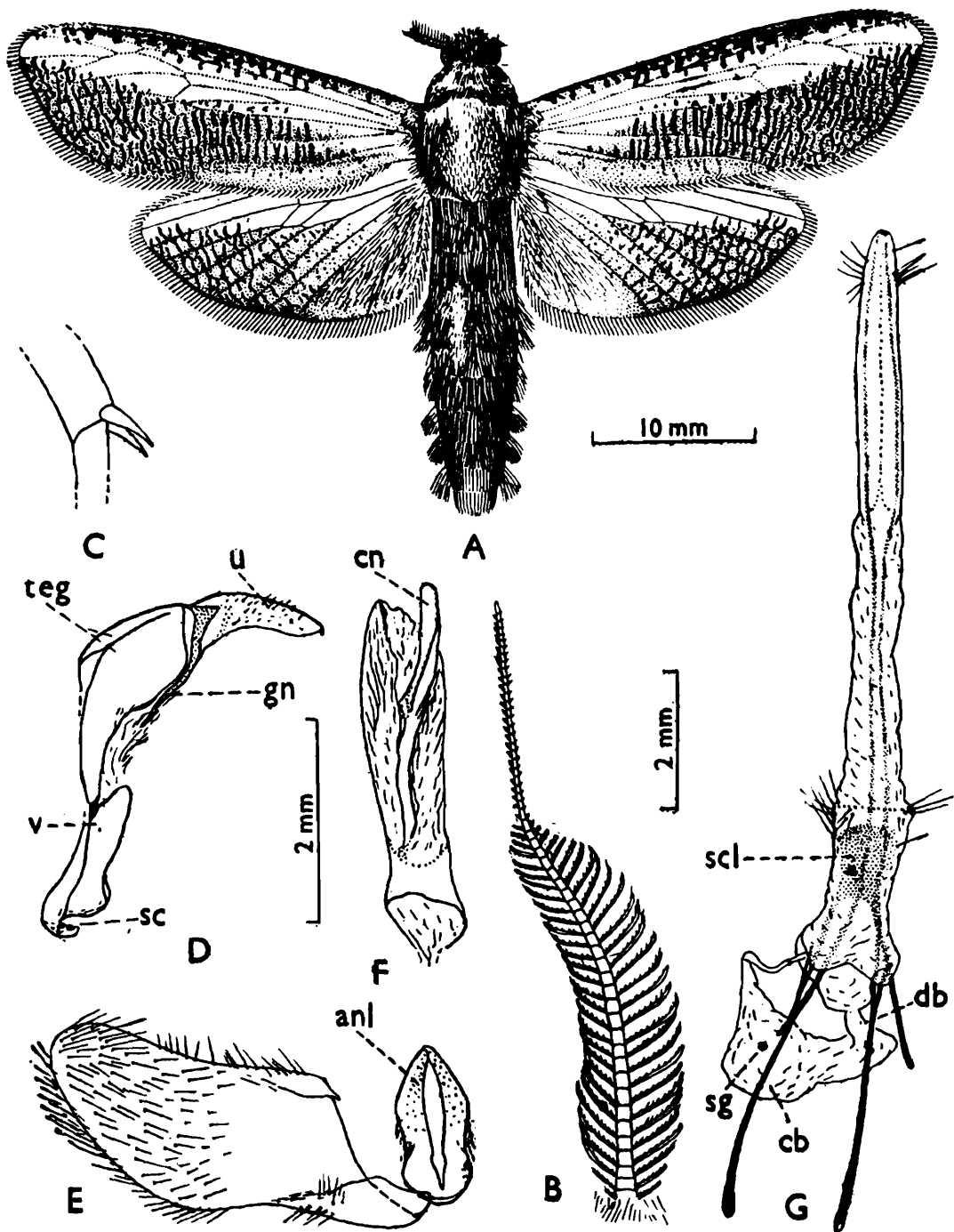
some anterior portion of thorax pale ochreous, the remaining portion of thorax dark-greyish brown. Fore wings greyish-white above the cell, and crossed by several black, confluent striae in the costal area, medial area unmarked, the area below the cell greyish brown and crossed by several black, confluent lines. Hind wings pale greyish ; crossed by several delicate and confluent lines below the cell extending from near the middle of vein Cu_2 to the outer margin up to vein Rs; the area below and above the cell unmarked. Abdomen dark greyish brown, darker apically. Underside of both wings marked as on the upper side, but not so prominently ; that of abdomen darker and with dark brown lateral tufts. Legs brownish black above, pale beneath.

Antennae (Text-fig. 10B) with 57 segments ; bipectinate from base to about two-thirds (up to 32 segments) of length (antennae of the type broken and have only 16 basal segments which have the pectination) ; pectination nearly of equal length, except at base and the tip, the longest rami about the length of five segments of shaft ; the distal one-third part serrate, the last segment simple and conical. Labial palpi short, nearly porrect. Frenulum and retinaculum as given in generic characters. Tibial spurs (Text-fig. 10C) and tarsal spines in the hind legs weakly developed ; arolium distinct. Abdomen with lateral tufts.

Venation (Text-fig. 10A).—As given in the generic characters ; areole, however, projecting out of the cell angle by about one-third of its length.

Genitalia.—Male (Text-fig. 10D-F) : Uncus about two and a half times as long as its width in middle ; broad at base and gradually narrowing apically into a downwardly directed acuminate tip. Gnathos very short and narrow, joined to the tegumen on sides. Tegumen broad at apex and narrowing basally. Vinculum short and broad, ending into a short flattened saccus. Clasper short and broad, a little more than two and a half times as long as its width in middle ; ventral margin sharply curved inwards at base. Juxta horse-shoe shaped, with long and narrow anellus lobes. Aedeagus short at base ; distal portion membranous and weakly striated but with a hard sclerotised process. Female (Text-fig. 10 G) : Ostium bursae leading into ductus bursae through a sclerotised pouch ; corpus bursae more or less quadrangular and membranous, a short signum present, with a shallow cavity and minute black spines on it ; a fine duct arises from the corpus bursae and entering into genital tube to open distally at the ovopore ; papilla anales of ovipositor beset with long setae.

Measurements.—Type material.—Expanse : fore wing, 55.5 mm. Length : fore wing, 25 mm. ; hind wing, 18.5 mm. ; abdomen, 20.5 mm. ; whole body, 29 mm.



Text-fig. 10. *Azygophelps albofasciata* (Moore) : (A) An outline drawing of the male type (B) A male antenna showing pectination. (C) A portion of the hind leg with a single pair of tibial spurs. (D) Male genitalia in a lateral view, without claspers. (E) A clasper in inner view, with juxta. (F) Aedeagus. (G) Female genitalia, in a dorsal view. (B, C and G ; and D to F of the same magnifications).

Other material.—Expanse : fore wing, 54-55 mm. Length : fore wing, 25 mm. ; hind wing, 18-19 mm. ; abdomen, 15-20 mm. ; whole body, 25-29 mm.

Material examined.—Five examples as follows : India : West Bengal : Darjeeling : labelled as "Darjeeling 1870", "Zenzera albo-fasciata type ♂ Moore", "Original", "Coll. *Staudinger*", "Colln. *Atkinson*" (ex. colln. Ber. Mus.) ; Punjeet Valley, 2 ♂♂, 13. iv. 1879, -v.1879 (*C. Z. Peters* coll.). Punjab : 1 ♀ (no further data). Burma : Zibingyi, Maymyi, 1 ♂, 2.iv. 1937, (*P. F. Garthwaite* coll.) (ex. colln. F.R.I.).

Distribution.—India, (Kashmir, Punjab, West Bengal and Sikkim).

Remarks.—Referable to the genus *Azygophelps* it is characterised by the presence of a well developed arolium between the claws, spines on tarsi and well developed labial palpi. This species can be confused as a species of the genus *Phragmataecia* for having the antennal-pectination up to the basal two-thirds but is distinctly separable by the above characters.

It can be differentiated from the other species of the genus by the unmarked median area, whereas in the other species, except *nurella*, the median area is marked either completely or partly.

In respect of female genitalia it is also characterised by the presence of signum on corpus bursae unlike in *pusilla* (Walker) and *scalaris* (Fabricius), where it is absent.

15. *Azygophelps pusilla* (Walker)

(Pl. I, figs. 11, 12; Text-fig. 11)

- 1856. *Zeuzera pusilla* Walker, *List. Lep. Brit. Mus.*, 7 : 1538 (Type loc.—N. India).
- 1886. *Zenzera pusilla*, Butler, *Ill. Lep. Het.*, 6 : 28, pl. cvii, fig. 9.
- 1887. *Zeuzera pusilla*, Cotes & Swinhoe, *Cat. Moths of India* : 234.
- 1892. *Zeuzera pusilla*, Swinhoe, *Cat. East. & Aust. Lep. Ox. Univ. Mus.*, 1 : 281.
- 1892. *Zeuzera pusilla*, Kirby, *Cat. Lep. Het.* : 872.
- 1892 b. *Azygophelps pusilla*, Hampson, *Fauna Brit. India, Moths*, 1 : 310.
- 1909. *Azygophelps pusilla*, Lefroy, *Indian Insect Life* : 496.
- 1923. *Azygophelps pusilla*, Dalla-Torre, *Lepid. Cat.*, 29 : 43.
- 1933. *Azygophelps pusilla*, Gaede, in *Seitz Macrolepidoptera of the World*, 10 : 821.

Type : In B. M

Head, thorax, abdomen and wings brownish or whitish to pale brown. Antennae, labial palpi and frontal tufts brown. Fore wing marked with several dark brown striae all along its length except in the cell ; some striae beyond the cell, coalescing into fine lines, marginal spots dark brown and prominent. Hind wings whitish, without

any markings. Underside of the fore wings pale brown, markings as on the upper side ; hind wings pale brown ; abdomen brown or dark brown beneath. Legs blackish above and somewhat paler on the underside ; with a prominent segmental band on tarsi.

Antennae with 43-45 segments and bipectinate in the basal 20-23 segments in both the sexes ; the distal half with uniserrate branches, rami longer in male than in the female, the longest rami as long as four to five segments. Labial palpi short and porrect. Frenulum bristle single in male and three in female ; retinaculum in the male reduced to a small elongate lobe. Legs with a single pair of short spurs on the hind tibia ; tarsal spines rather poorly developed ; claws with a well developed arolium.

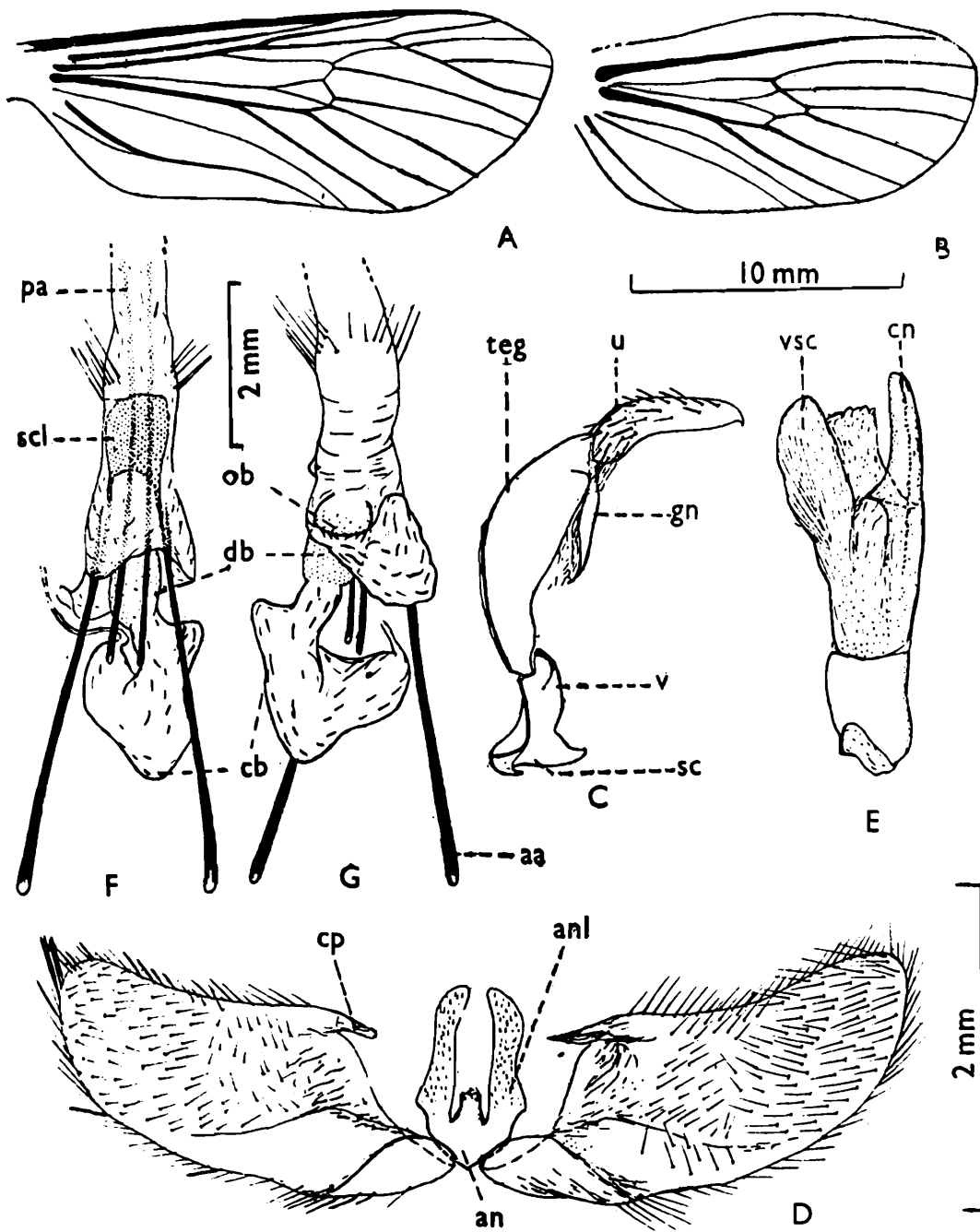
Venation (Text-fig. 11 A-B).—As for the genus. The lower branch of median in fore wing, however, ending at M_3 ; areole projecting half its length, or slightly more, outside the cell.

Genitalia.—Male (Text-fig. 11 C-E) : Uncus about two-and-a-half times as long as its width in the middle, broad at base and gradually narrowing distally to a shortly acuminate, downwardly pointed tip. Gnathos short, narrow and attached to tegumen on sides. Tegumen long and narrow, somewhat broader apically ; saccus very small. Clasper short and broad, about twice as long as the width in middle ; costa produced inside into a costal prolongation. Juxta short, with a median and two lateral lobes. Aedeagus well built ; the base short and more sclerotised than the large, rather membranous and striated distal part ; with hard sclerotised process on one side from the middle. Female (Text-fig. 11 F-G) : Ostium bursae simple, weakly sclerotised ; ductus bursae short and broad, sclerotised in its basal half ; corpus bursae more or less triangular, without signum and receptaculum seminalis ; a fine duct arises from the corpus bursae directly and enters into the genital tube to open at the ovopore. Other features as in *albofasciata*.

Measurements.—Expanse : fore wing ; Male, 29-31 mm. ; female, 35-38 mm. Length : Fore wing : Male, 12-13.5 mm. ; female, 15 mm. Hind wing : Male, 8.5-10 mm. ; female, incomplete and damaged in the material. Whole body : Male, 14 mm. ; female, incomplete and damaged.

Material examined.—India : Mysore : Bangalore, 1 ♀ (no further data), 1 ♂, 17.vii.1912 (*Fletcher* coll.) ; Bababundin Hills, 1219.2m.—1524 m., 1 ♂, 2-12.xi.1942 (*Fletcher* coll.). Bihar : Pusa, 1 ♂, 7.vii.1926 (*G. P. Pillai* coll.) ; Chapra, 3 ♂ ♂, 1 ♀ (*Mackenzie* coll.) (no date) (all, ex. colln. I.A.R.I.).

Distribution.—India (N. India, Bengal, Bihar, Mysore, Deccan, Tamil Nadu).



Text-fig. 11. *Azygophelps pusilla* (Walker) : (A) and (B) Fore and hind wing venation, respectively. (C) Male genitalia in a lateral view, without claspers. (D) Inner view of the claspers, with juxta. (E) Aedeagus. (F) A portion of the female genitalia in a dorsal view. (G) A portion of the female genitalia in a ventral view. (A-B ; C to E ; and F-G of the same magnifications).

Remarks.—Referable to the genus *Azygophelps*, it is close to the other Indian species in respect of its bipectinate antennae and the male genitalia. It, however, can be easily differentiated for having the fore wings marked with dark brown striae throughout their length except in the cell. For detailed differences see under *scalaris* and *albofasciata*.

16. *Azygophelps nurella* Swinhoe

1894. *Azygophelps nurella* Swinhoe, *Ann. Mag. nat. Hist.*, (6) 14 : 440 (Type loc.—Cherrapunji, Assam) (Now Meghalaya, India).
 1895. *Azygophelps nurella* Swinhoe, *Trans. ent. Soc. Lond.* : 29.
 1896a. *Azygophelps nurella*, Hampson, *Fauna Brit. India, Moths*, 4 : 473.
 1923. *Azygophelps nurella*, Dalla-Torre, *Lepid. Cat.*, 29 : 43.
 1933. *Azygophelps nurella*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 821.

Type : In B.M

As specimens of this species were not available for study, the original description of the species is reproduced here. “♂ Palpi and Frons black ; top of head, thorax, abdomen, and both wings, grey, tinged with ochreous ; a brown band behind the head ; abdomen with grey bands. Fore wing with a grey costal border, the inner portion of the wing suffused with darker ochreous ; both wings without markings. Below, of the same uniform colour, without markings, except the legs, which have black bands on the tarsi.

Expanse of wings $2 \frac{1}{10}$ inches.

Cherrapunji, “One example.”

Distribution.—India (Meghalaya, Assam).

Remarks.—From the above description it can be differentiated from the other species of *Azygophelps* by the complete absence of markings on the wings, unlike other species where the wings are marked by striae, either in cell or outside.

Genus *Phragmataecia* Newman

1822. *Zeuzera* Hübner [*nec* Lat.], *Verz. bek. Schmett.* : 196 (Type *Bombyx arundinis* Hübner) [generic name preoccupied].
 1836. *Macrogaster* Duponchel, *Hist. Nat. Lep. Fr.* : 136 (Type *Bombyx arundinis* Hübner) [generic name preoccupied].
 1844. *Macrogaster* Duponchel, *Cat. Lep. d' Eur.* : 81.
 1850. *Phragmataecia* Newman, *Zoologist*, 8 : 2931 (Type *Bombyx castaneae* Hübner from Europe)
 1854. *Rhizoma* Herrich-Schäffer, *Samml. Ausser. Schmett.* : 7 (Type *R. pallens* Herr.—Sch.)
 1854. *Phragmataecia*, Herrich-Schäffer, *Samml. Ausser. Schmett.* : 58.
 1856. *Phragmataecia*, Walker, *List Lep. Brit. Mus.*, 7 : 1549.
 1865. *Phragmataecia*, Walker, *List Lep. Brit. Mus.*, 32 : 590.
 1879b. *Phragmataecia*, Moore, *Descr. Indian Lep. Atk.* : 87.
 1880. *Phragmataecia*, Snellen, in Veth *Midden Sumatra Lep.* : 39.

1884. *Phragmataecia*, Swinhoe, *Proc. zool. Soc. Lond.* : 515.
 1886. *Phragmataecia*, Swinhoe, *Proc. zool. Soc. Lond.* : 441.
 1887. *Phragmataecia*, Cotes & Swinhoe, *Cat. Moths of India* : 234.
 1890. *Phragmataecia*, Swinhoe, *Trans. ent. Soc. Lond.* : 199.
 1891. *Phragmataecia*, Hampson, *Ill. Lep. Het. Brit. Mus.*, 8 : 11, 16.
 1892. *Phragmataecia*, Swinhoe, *Cat. East & Aust. Lep. Het. Ox. Univ. Mus.* : 285.
 1892b. *Phragmataecia*, Hampson, *Fauna Brit. India, Moths*, 1 : 312.
 1892. *Phragmataecia*, Kirby, *Cat. Lep. Het.*, 1 : 876.
 1899. *Phragmataecia*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
 1900. *Phragmataecia*, Piepers & Snellen, *Tijdschr. Ent.*, 43 : 37, 43.
 1901. *Phragmataecia*, Staudinger & Rebel, *Cat. Lep. Pal. Fnggeb.*, 1 : 409.
 1912. *Phragmataecia*, Seitz, in *Seitz Macrolepidoptera of the World*, 2 : 429.
 1918. *Phragmataecia*, Turner, *Trans. ent. Soc. Lond.*, 66 : 160, 163, 179.
 1923. *Phragmataecia*, Dalla-Torre, *Lepid. Cat.*, 29 : 45.
 1929. *Phragmataecia*, Gaede, in *Seitz Macrolepidoptera of the World*, 14 : 541.
 1933. *Phragmataecia*, Gaede, in *Seitz Macrolepidoptera of the World*, 10 : 821.
 1933. *Phragmataecia*, Mehta, *Rec. Indian Mus.*, 35 : 232.
 1940. *Phragmataecia*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1017.
 1951b. *Phragmataecia*, Viette, *Lambillionea*, 51 (11—12) : 68.
 1957. *Phragmataecia*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 39.
 1959b. *Phragmataecia*, Clench, *Veröff. Zool. StSamml. Münch.*, 6 : 9.
 1965. *Phragmataecia*, Müller, *Dt. ent. Z.*, 12 (3) : 240.

Type-species : *Bombyx castaneae* Hübner

(a) General

The genus *Phragmataecia* was erected by Newman (1850) to include an European species *Bombyx castaneae* Hübner which is also known from the Indian subregion. Hampson (1892b) in his '*Fauna of British India*' recognised only two species, viz. *P. castaneae* Hübner and *P. impura* Hampson. The species *P. saccharum* Moore from Darjeeling (India), *P. minor* Moore from Sylhet (Bangladesh) and *P. minima* Hampson, from Nilgiris (India), described earlier, were treated by him (*loc. cit.*) as synonyms of the species *castaneae*. Piepers and Snellen (1900), however, recognised *P. minima* as a synonym of *P. sumatrensis* Snellen. Turner (1918) transferred *Cossus parvipunctus* Hampson to this genus. Fletcher (1928) added two species by describing *P. terebrifer* and *P. purpureus*, from Pusa (Bihar) and Arora (1974) added another species, i.e., *P. dudgeoni* from Bhutan. Thus, so far only six species were known from the Indian subregion.

During the present study of the Indian Cossidae a few more species, viz. *Zeuzera stigmatica* Moore, *Cossus pallidalae* Hampson, *Xyleutes clara* Bryk and *X. obliquifascia* Bryk have also been transferred to the genus *Phragmataecia* Newman. All the ten species,

thus recorded, are redescribed here and adequately figured from the actual specimens. Types of the species *stigmaticus* (Moore), *clara* (Bryk), *obliquifascia* (Bryk), *terebrifer* Fletcher, *purpureus* Fletcher, *saccharum* Moore and *minor* Moore, of which the latter two are synonymised with *P. castaneae*, have been examined and figured.

(b) *Characters of the Genus Phragmataecia* Newman

Antennae bipectinate, nearly up to three-fourths of their length in male and up to the basal half in female ; distal part serrate and the tip simple. Labial palpi short and either porrect or slightly directed downwards. Wings long and narrow in female, somewhat broader in male. Frenulum spines single in male, 3 to 4 in female ; retinaculum in male in the form of a short or elongate lobe. Legs without tarsal spines ; hind tibiae with a single pair of minute spurs ; claws with a distinct arolium.

Fore wing with a small to moderately long areole ; the latter projecting outside the cell by about one-fifth to half its length and either normal or distorted by the union of upper branch of median with chorda ; veins R_1 and R_2 arise from areole ; R_3 generally connate with $R_4 + R_5$ or stalked ; M_1 either from above the upper angle, or from angle or from below the angle of cell ; M_2 and M_3 close to one another ; median cell with the lower branch ending variably between veins M_1 and Cu_{1b} . Hind wings with the vein Sc free ; veins Rs— M_1 wide apart ; the upper and lower branches of median vein ending between M_1 — M_2 and Cu_{1b} — M_3 , respectively. Male genitalia simple : Uncus either pointed into a hook-like apex (*castaneae*, *impura*, *pallidulae* and *purpureus*) or simply narrowed (*stigmaticus*, *clara* and *obliquifascia*) or blunt and rounded (*parvipunctus*, *terebrifer* and *dudgeoni*). Gnathos absent. Claspers simple, without any chitination. Juxta present. Aedeagus usually simple, long and slender.

Female genitalia short and stout ; genital plate generally sclerotised on both dorsal and ventral sides.

(c) *Relationships of the genus Phragmataecia*
with the other allied Genera

The genus *Phragmataecia* Newman can be well differentiated from other Zeuserinae genera by the antennae which are bipectinate up to two-thirds or three-fourths of length in the male, and slightly less so in the female. By this character and by the presence of arolium in between the claws, it comes close to the genus *Azygophelps*, but differs from the latter in the absence of tarsal spines and gnathos in the male genitalia. From *Xyleutes* and *Zeuzera*, it differs in the antennae which are bipectinate up to two-thirds or three-fourths, whereas

in the other two genera the pectination is up to the basal half, and by the absence of tarsal spines which are present in *Xyleutes* and *Zeuzera*. It can also be differentiated from *Xyleutes* by the presence of arolium which is absent in the latter.

In respect of the wing venation the genus is very important. On one hand it resembles the Cossinae group of genera due to the ending of the lower branch of the median veins between veins M_1-M_3 or at M_3 in the fore wing, and on the other hand it resembles the other Zeuzerinae group of genera where the lower branch of the median ends either at the vein M_3 or between the veins Cu_{1a} and M_3 . In the male genitalia too it shows an interesting change in the shape of the uncus which is either rounded apically (*P. dudgeoni*, *P. parvipunctus* and *P. terebrifer*), resembling species of the genus *Catopta*, viz. *cashmirensis* (Moore) and *sikkimensis* (Arora), or acuminate as in most of the other Zeuzerinae genera. Gnathos is also absent which brings it close to some of the *Zeuzera* species, in this respect.

(d) *Geographical distribution of the Genus Phragmataecia*

The genus *Phragmataecia* Newman is widely distributed and is known from the Oriental, Australian, Palaearctic, Ethiopian and Neotropical regions.

In the Indian subregion it is known from India (Bihar, West Bengal, Assam, Arunachal Pradesh, Tamil Nadu, Sikkim), Bhutan, Bangladesh, Burma and Ceylon.

(e) *Key to the Indian species of the Genus Phragmataecia*

1. Fore wing without stigmata	2
Fore wing with stigmata	8
2. Uncus in male genitalia ending apically in a hooked tip; aedeagus simple and not differentiated. Lower branch of median in fore wing ending either between $Cu_{1a}-M_3$ or between M_2-M_3 or beyond M_3	3
Uncus ending apically in a rounded tip; aedeagus differentiated into basal and apical portion. Lower branch of median always ending between M_2-M_3	6
3. Areole in fore wing distorted	4
Areole in fore wing normal	5

4. Lower branch of median in fore wing ending at discocellular near M_2 , and that of hind wing between Cu_{1a} — M_3 but nearer Cu_{1a} . Uncus in male genitalia long and narrow

castaneae (Hübner)

Lower branch of median in fore wing ending at M_3 , and that of hind wing between Cu_{1a} — M_3 but nearer M_3 . Uncus short and stout..

impura Hampson

5. Areole in fore wing large, projecting outside the cell by more than half its length; vein M_1 arises from above the cell angle. Tegumen broadly quadrangular. Claspers slightly and narrowly produced at the costal end

purpureus Fletcher

Areole in fore wing small, projecting outside the cell angle by about one-third its length; vein M_1 arises from below the cell angle. Tegumen long and narrow. Claspers strongly and broadly produced into a large fold at the costal end

pallidulae (Hampson) comb.nov.

6. Areole in fore wing projecting outside the cell angle by about one-fifth of its length. Aedeagus small, apical portion narrower than base

terebrifer Fletcher

Areole in fore wing projecting by one-third or half its length. Aedeagus large, apical portion broader than base

7

7. Fore wing without any oblique row of striae in postmedial area; vein 1A in fore wing with a row of three prominent spots. Uncus long, about thrice its width in middle and with straight lateral margins; juxta with oblique margins

parvipunctus (Hampson)

Fore wing with an oblique row of some prominent striae in post-medial area; vein 1A in fore wing

without any row of distinct spots.
Uncus short, about one-and-a-half
times its width in middle and with
excurred sides ; juxta with rounded
margins

dudgeoni Arora

8. Fore wing without any coloured band.
Juxta horse-shoe shaped, not pro-
duced medially

clara (Bryk) comb.nov.

Fore wing with an oblique dark brown
band from apex to vein Cu_2 . Juxta
rounded and weakly produced
medially

9

9. Antennal branches whitish at tips. Obli-
que band on fore wing ill-defined.
Abdomen golden yellow below.
Legs with black segmental bands

stigmaticus
(Moore) comb.nov.

Antennal branches dark brown at tips.
Oblique band well defined and pro-
minent. Abdomen blackish below.
Legs with whitish bands

obliquifascia
(Bryk) comb. nov.

(f) *Description of Species*

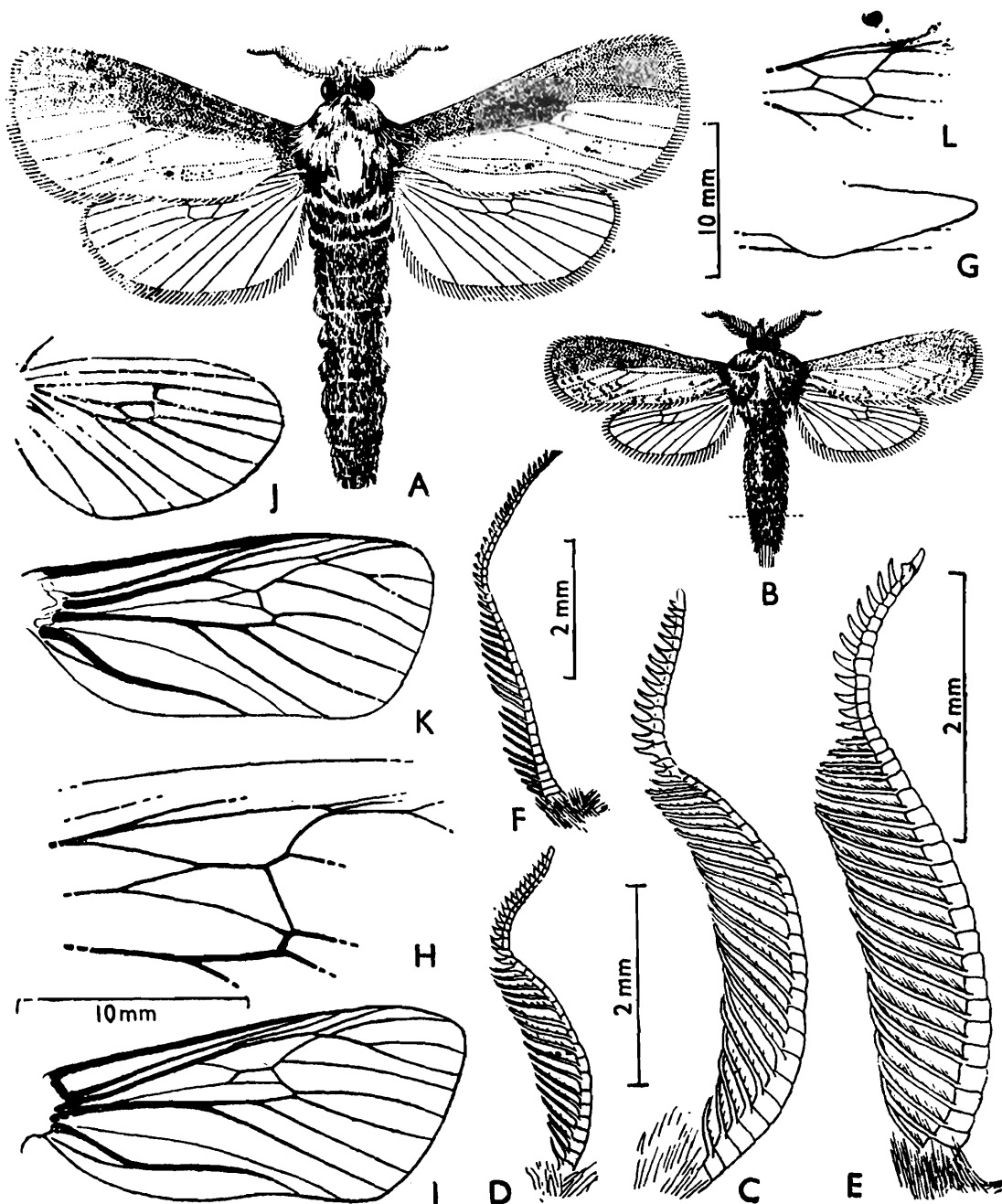
17. *Phragmataecia castaneae* (Hübner)

(Pl. I, figs. 14-16 ; Text-figs. 12-13)

1790. *Bombyx castaneae* Hübner, *Beitr. Ges. Schmett.*, 2 (1) : 9 (Type loc.—Europe).
1803. *Bombyx arundinis* Hübner, *Samml. Eur. Schmett.* : 151 (Type loc.—Europe).
1807. *Cossus castaneae*, Esper, *Schmett.*, 3 : 97.
1822. *Zeuzera arundinis*, Hübner, *Verz. beck. Schmett.* : 196.
1834. *Zeuzera arundinis*, Boisduval, *Icon. Syst. Lep. Eur.*, 2 : 183.
1836. *Macrogaster arundinis* Duponchel, *Hist. Nat. Lep. Fr.* : 136.
1840. *Zeuzera castaneae*, Boisduval, *Gen. et. Index Meth.* : 76.
1844. *Macrogaster arundinis*, Duponchel, *Cat. Lep. d' Eur.* : 81.
1850. *Zeuzera arundinis*, Harding, *Zoologist*, 8 : 2931.
1850. *Phragmataecia arundinis*, Newman, *Zoologist*, 8 : 2931.
1856. *Phragmataecia arundinis*, Walker, *List Lep. Brit. Mus.*, 7 : 1543.
1865. *Zeuzera innotata* Walker, *List Lep. Brit. Mus.*, 32 : 587 (Type loc.—Shanghai, China) (*syn.* Hampson, 1892b).
1879b. *Phragmataecia minor* Moore, *Descr. Indian Lep. Atk.* : 87 (Type loc.—Sylhet, Bangladesh) (*syn.* Hampson, 1892b).

- 1879b. *Phragmataecia saccharum* Moore, *Descr. Indian Lep. Atk.* : 87 (Type loc.—Darjeeling, India) (syn. Hampson, 1892b).
1880. *Phragmataecia sumatrensis*, Snellen, in Veth *Midden Sumatra Lep.* : 39 (Type loc.—Sumatra) (syn. Seitz, 1912)
1886. *Phragmataecia minor*, Swinhoe, *Proc. zool. Soc. Lond.*, 441 (Mhow).
1887. *Phragmataecia saccharum*, Cotes & Swinhoe, *Cat. Moths of India* : 234.
1887. *Phragmataecia minor*, Cotes & Swinhoe, *Cat. Moths of India* : 234.
1890. *Phragmataecia minor*, Swinhoe, *Trans. ent. Soc. Lond.* : 199.
1891. *Phragmataecia minima* Hampson, *Ill. Lep. Brit. Het. Mus.*, 8 : 11 (Type loc.—Nilgiris) (syn. Hampson, 1892b, Piepers & Snellen, 1900).
1891. *Phragmataecia castaneae*, Hampson, *Ill. Lep. Het. Brit. Mus.*, 8 : 11.
- 1892b. *Phragmataecia castaneae*, Hampson, *Fauna Brit. India Moths*, 1 : 313.
1892. *Phragmataecia castaneae*, Swinhoe, *Cat. East. & Aust. Lep. Ox. Univ. Mus.* : 285.
1892. *Phragmataecia castaneae*, Kirby, *Cat. Lep. Het.* : 876.
1892. *Phragmataecia saccharum*, Kirby, *Cat. Lep. Het.* : 876.
1892. *Phragmataecia minor*, Kirby, *Cat. Lep. Het.* : 876.
1892. *Phragmataecia innotata*, Kirby, *Cat. Lep. Het.* : 876.
1892. *Phragmataecia minima*, Kirby, *Cat. Lep. Het.* : 876.
1899. *Phragmataecia castaneae*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
1900. *Phragmataecia sumatrensis*, Piepers & Snellen, *Tijdschr. Ent.*, 43 : 43-44.
1901. *Phragmataecia castaneae*, Staudinger and Rebel, *Cat. Lep. Pal. Fnggeb.* : 409.
1912. *Phragmataecia castaneae*, Seitz, in Seitz *Macrolepidoptera of the World*, 2 : 429—430.
1917. *Phragmataecia castaneae*, Fletcher, *Rept. 2nd. Ent. Mtg.* : 152.
1918. *Phragmataecia castaneae*, Turner, *Trans. Ent. Soc. Lond.*, 66 : 160, 180.
1923. *Phragmataecia castaneae*, Dalla-Torre, *Lepid. Cat.*, 29 : 45.
1929. *Phragmataecia castaneae*, Gaede, in Seitz *Macrolepidoptera of the World*, 14 : 548.
1933. *Phragmataecia castaneae*, Mehta, *Rec. Indian Mus.*, 35 : 232.
1933. *Phragmataecia castaneae*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 821.
1934. *Phragmataecia castaneae*, Gaede, in Seitz *Macrolepidoptera of the World*, Suppl. 2 : 244.
1940. *Phragmataecia castaneae*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1017.
1951. *Phragmataecia castaneae*, Viette, *Lambillionea*, 51 (11—12) : 68.
1957. *Phragmataecia castaneae*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nad.*, (2) 52 (1) : 39.
- 1959b. *Phragmataecia castaneae*, Clench, *Veröff. Zool. StSamml. Münch.*, 6 : 9.
1965. *Phragmataecia castaneae*, Müller, *Dt. ent. Z.*, 12 (3) : 240.

Types : *castaneae* (Hübner).—repository not known; *innotata* (Walker) and *minima* Hampson—in B.M.; *saccharum* Moore and *minor*—in Ber. Mus.



Text-fig. 12. *Phragmataecia castaneae* (Hübner) : (A) and (B) Outline drawings of the male types of *saccharum* and *minor*, respectively. (C) and (D) Antennae of the type specimens 'A' and 'B', respectively, showing pectinations of one side. (E) and (F) Male and female antennae, respectively, of other specimens. (G) Retinaculum in *saccharum*. (H) A portion of fore wing in *saccharum* showing venation. (I) and (J) Fore and hind wing venation, respectively in other specimens. (K) and (L) Portions of fore wing of two different specimens showing some variations in venation. (A-B ; C-D and G-H ; and I to L of the same magnifications).

Hosts : *Arundo phragmites* and *Saccharum spontaneum*.

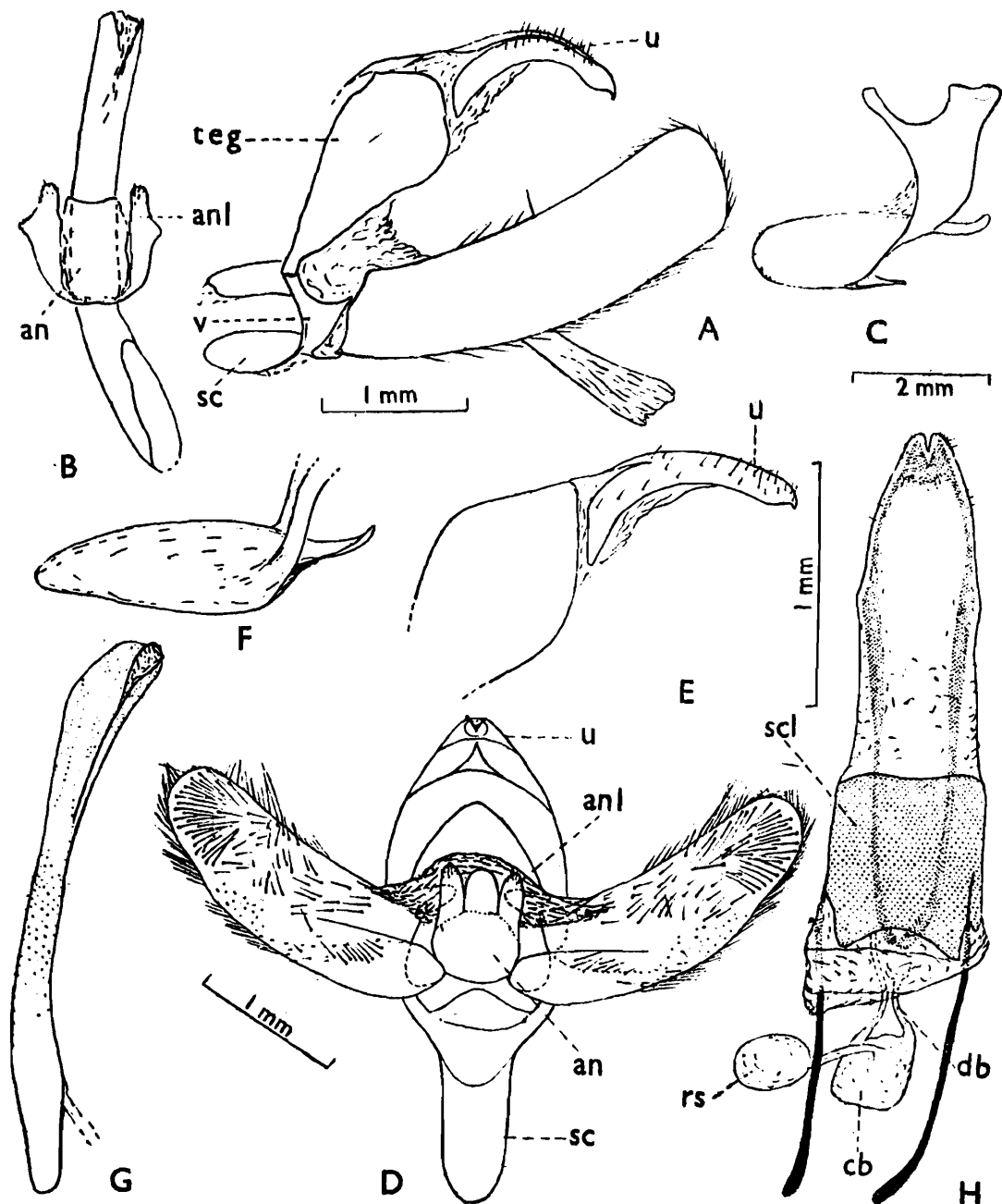
Head and thorax ochreous brown. Frontal tufts brownish ochreous. Antennae with shafts and branches ochreous above and brown beneath. Labial palpi greyish ochreous beneath, brownish ochreous above. Fore wings brownish ochreous in upper half and a part of the inner margin ; with an indistinct brownish spot above the submedian ; striae forming an indistinct brownish patch in the inner area and a spot at the lower angle of cell. Hind wings ochreous. Abdomen greyish ochreous. Underside, immediately behind the head, blackish brown. Legs and thoracical sternites brownish ochreous.

Antennae (Text-fig. 12C-F) with 36-41 segments ; bipectinate up to basal half or two-thirds its length, the distal part serrate ; the tip simple ; branches or the rami longest in middle, and gradually decreasing both towards the base and the apex, the longest ones as long as six middle segments in male and four in the female. Labial/palpi short. Wings about twice the width in the middle ; frenulum bristle single in male and four in female ; retinaculum (Text-fig. 12G) elongate. Hind tibiae with a pair of minute tibial spurs ; tarsal spines wanting ; claws with a well developed arolium. Abdomen longer than hind wings and about as long as the fore wings.

Venation.—Fore wing (Text-fig. 12H-I, K-L) : Areole moderately large ; projecting outside the cell angle by one-third its length and distorted by the union of chorda with upper median branch ; vein R_1 arises from areole, near its origin, and in line with the origin of the median cell ; R_2 from near the tip of areole ; R_3 shortly anastomosed with $R_4 + R_5$; M_1 from above the upper angle and M_2 from above the lower angle of cell ; Cu_{1a} from the lower angle and close to M_3 ; lower median ending at M_2 or between M_1-M_2 . Hind wings (Text-fig. 12J) : the venation as given in generic characters.

In certain examples, the upper median in fore wing ends at the upper angle of cell or rarely below it, the lower median ending at Cu_{1a} ; and Cu_{1a} and M_3 separate at bases in fore wings.

Genitalia.—Male (Text-fig. 13 A-G) : Uncus sclerotised on sides ; about three times as long as its width in middle ; distal half narrow and curved at about right angle to the lower half from the middle ; the basal portion broad ; the apex pointing downwards. Tegumen broadly conical. Saccus cylindrical and variable in size. Clasper simple, about three times as long as its width and either uniformly broad or weakly narrowed distally ; costa produced inwards into a short prolongation. Juxta with a reduced median lobe, and two lateral blunt elongations (in one example with a distinct median lobe



Text-fig. 13. *Phragmataecia castaneae* (Hübner) : (A) Male genitalia in a lateral view, of the type of *saccharum*. (B) Aedeagus and anellus of 'A'. (C) Vinculum and saccus of another specimen. (D) Male genitalia in an inner view, with claspers. (E) and (F) Uncus and saccus, respectively, of 'D'. (G) Aedeagus of 'D'. (H) Female genitalia in a dorsal view. (A-B; C, E & F; D & G of the same magnifications).

and two shorter lateral ones), the latter with short and fine setae. Aedeagus simple, slender, elongate and not differentiated into base and apex. Female (Text-fig. 13H) : Ostium bursae simple ; ductus bursae weakly sclerotised ; corpus bursae membranous, more or less rectangular in shape and without signum ; receptaculum seminalis connected with the former by a fine duct, posterior apodemes slightly extending beyond the genital plates.

Measurements.—Type material.—Expanse : fore wing, 26 mm. (*minor*) and 42 mm. (*saccharum*). Length : fore wing, 11 mm. (*minor*) and 19 mm. (*saccharum*) ; hind wing, 8 mm. (*minor*) and 15 mm. (*saccharum*) ; abdomen, 19 mm. (*saccharum*) whole body, 27 mm. (*saccharum*).

Other material.—Expanse : male, 26-42 mm.; female, 31-57 mm. Length : Fore wing ; male, 11-19 mm., female, 14-25 mm. Hind wing : male, 8-15 mm. ; female, 10.5-19 mm. Abdomen : male, 9-19 mm. ; female, 11-21 mm. Body : male, 12-27 mm., female, 15-32 mm.

Material examined.—19 examples as follows : India : West Bengal : Darjeeling, 1 ♂, labelled as “Darjeeling, 1870 coll. *Staudinger*, coll. *Atkinson*”, (Type of *saccharum* Moore ; ex. colln. Ber. Mus.). Assam : Kaziranga, 1 ♀, 6.x.1961 (*R. N. Katiyar* coll.) ; Gauhati, 1 ♂, (labelled as *P. minor*) (*Fletcher* coll.). Bihar : Pusa, 1 ♀, 10.x.1933 (*H. N. Batri* coll.), 1 ♀, 11.xi.1923 (*Peries* coll.) (ex. colln. I.A.R.I.). Sikkim : 1 ♂, -.vi.1896 ; 2 ♂ ♂, -.vii.1896 ; 1 ♂, —.ix.1897 ; 1 ♂, 2 ♀ ♀, —.x.1897 ; (all *G. C. Dudgeon* coll.). Burma : Mohnyin R., Katha Burma, 1 ♂, 1 ♀, 20.v.1919 (*C.F.C. Beeson* coll.) (ex. colln. F.R.I.). Ceylon : Tangla, 2 ♂ ♂, -.iii.1902 ; Eppawala, 1 ♂, -.ix.1905 ; Kandy, 1 ♂, -.v.1911 (all *E. E. Green* coll.). Bangladesh : Sylhet 1 ♂, labelled as “Sylhet Jheels, Sept., 1867, coll. *Staudinger*, coll. *Atkinson*”, (Type of *P. minor* ; ex. colln. Ber. Mus.).

Distribution.—It is mainly a Palaearctic species and is known from north and middle Europe, northern Asia, from Turkistan to China and Japan. In Oriental region, it is known from India (West Bengal, Assam, Madhya Pradesh, Tamil Nadu and Sikkim), Bhutan, Bangladesh (Sylhet), Burma, Ceylon and Indonesia.

Remarks.—The species is very variable and it is one of the reasons that it has been described under several different names. The types of *P. saccharum* Moore and *P. minor* Moore, received from Berlin Museum, were examined. They were found to be generally identical with the other material of the species available to me for study. The size, however, is very variable and the measurements of the types of both species fall in the range of variations.

It can be differentiated from *P. impura*, by the colouration of fore wing which is brownish ochreous (blackish brown in *P. impura*) ; from *P. clara*, *P. stigmaticus* and *P. obliquifascia* by the absence of stigmata ; from *P. parvipunctus* and *P. dudgeoni* by the absence of strigae on fore wings, and *P. pallidalae*, *P. purpureus* and *P. terebrifer* by the distorted areole in the fore wings.

In respect of male genitalia the species is characterised by the presence of hooked-tip of uncus. By this character it comes close to the species *impura*, *purpureus* and *pallidulae*, but can be easily separated for its long and narrow uncus from *impura*; by its broadly conical tegumen, which is broadly quadrate in *purpureus* and long and sharply conical in *pallidulae*.

18. *Phragmataecia impura* Hampson

(Pl. II, figs. 17-18; Text-fig. 14)

1891. *Phragmataecia impura* Hampson, *Ill. Lep. Het. Brit. Mus.*, 8 : 66 (Type loc.—Nilgiris, India).
 1892b. *Phragmataecia impura* Hampson, *Fauna Brit. India, Moths*, 1 : 313.
 1892. *Phragmataecia impura*, Kirby, *Cat. Lep. Het.* : 876.
 1892. *Phragmataecia gummata* Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, : 285 (Type loc.—Java).
 1900. *Phragmataecia impura*, Piepers and Snellen, *Tijdsch. Ent.*, 43 : 44, 45.
 1918. *Phragmataecia impura*, Turner, *Trans. ent. Soc. Lond.*, 66 : 161.
 1923. *Phragmataecia impura*, Dalla-Torre, *Lepid. Cat.*, 29 : 47.

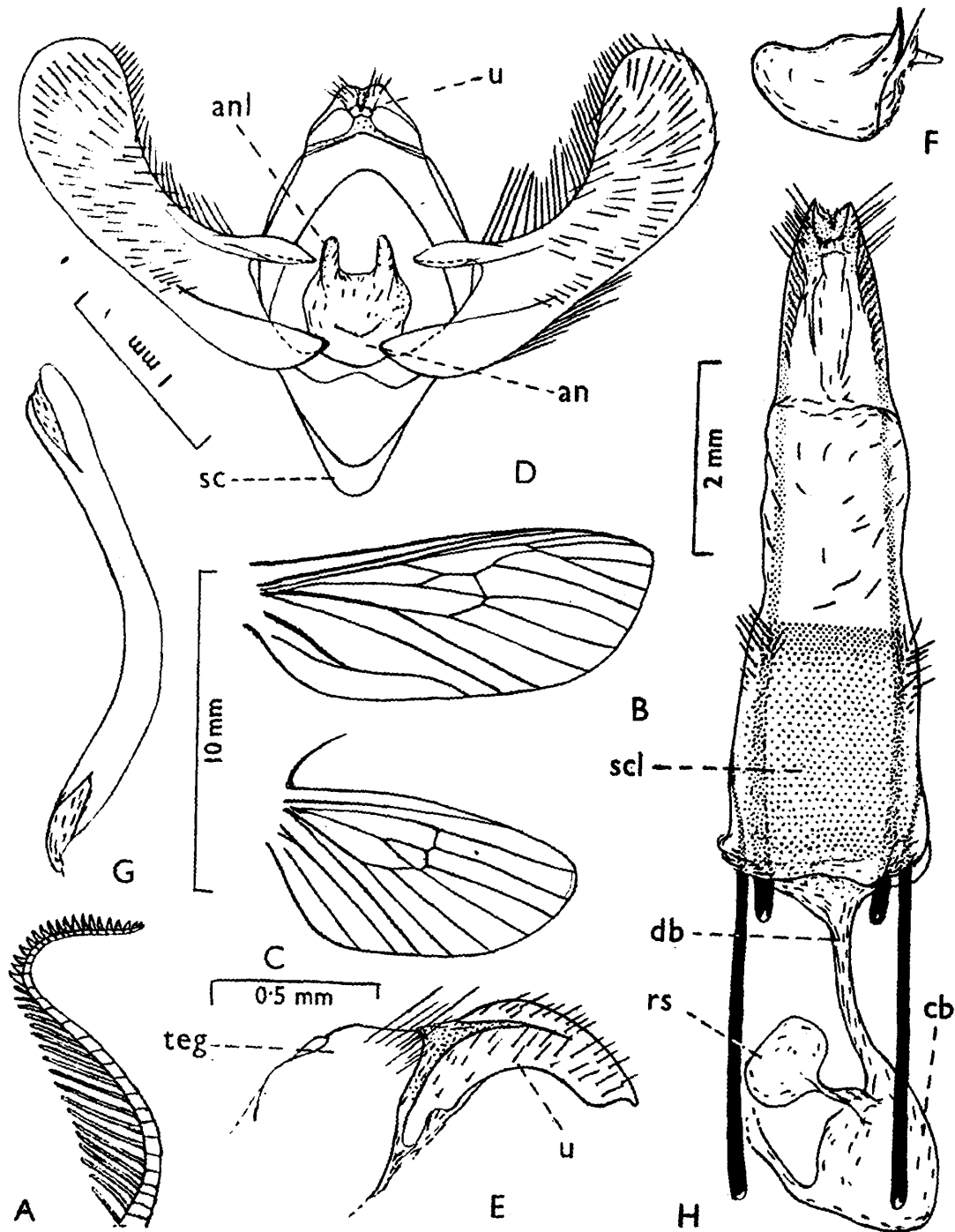
Type : In B.M

Head, thorax and fore wings dark smoky-black. Antennae and frontal tufts dark brown, the latter with some blackish scales; labial palpi dark brown. Hind wing pale fuscous. Underside pale fuscous throughout, the area near the head irrorated with dark scales.

Antennae (Text-fig. 14A) with 36 shaft-segments; bipectinate in both sexes; pectination longer and up to 22 basal segments in male, shorter and up to 19 segments in female; the longest rami as long as four segments in male, and three in female; the distal part minutely, but distinctly serrate; the tip simple. Labial palpi short, nearly porrect. Wings with a single frenulum spine in male and four spines in female; retinaculum in male reduced to a small elongate lobe. Legs with a single pair of short spurs on hind tibiae; tarsi without spines; claws with well developed arolium. Abdomen longer than hind wings.

Venation.—Fore wing (Text-fig. 14B) : Areole distorted by the union of upper branch of median with chorda and projecting outside the cell angle by a little less than half the length; vein R_1 near the origin of areole and arising in line with the origin of median cell; R_2 from near the tip of areole; R_3 free and connate in male, shortly stalked with $R_4 + R_5$ in female; M_1 from angle, or from above the angle if areole distorted; median cell with the upper branch ending at chorda and distorting the shape of areole, the lower branch ending at

vein M_2 in male, and M_2 or M_3 in female ; M_2-M_3 close but separate. Hind wing (Text-fig. 14C) : Vein M_1 arises from well below the cell angle ; median cell with the upper and lower branches ending, respectively, between M_1-M_2 and $Cu_{1a}-M_3$.



Text-fig. 14. *Phragmataecia impura* Hampson : (A) Male antenna showing pectination of one side. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in inner view, with claspers and juxta. (E) Uncus and a portion of tegumen. (F) Saccus. (G) Aedeagus. (H) Female genitalia in a dorsal view. (A & H ; B-C ; D & G ; and E-F of the same magnifications).

Genitalia.—Male (Text-fig. 14D-G) : Uncus about two-and-a-half to three times as long as its width in middle ; distal end hooked and produced into a fine, downwardly directed tip. Tegumen broadly triangular. Saccus short and conical. Claspers simple and undifferentiated ; costal margin produced inwardly. Juxta short, almost semicircular and with short lobes, the latter with fine setae. Aedeagus simple, weakly curved and undifferentiated. Female (Text-fig. 14H) : Short. Genital plates and the tube rather heavily sclerotised, the former sclerotised both dorsally and ventrally, the latter short ; ostium bursae simple and unsclerotised ; ductus bursae short and slender ; corpus bursae irregularly shaped and with a fine duct ; receptaculum seminalis present.

Measurements.—Expanse : Fore wing ; male, 28.5 mm. ; female, 34-39 mm. Length : Fore wing : male, 12.5 mm. (approx.) ; female, 17 mm. Hind wing : male, 9.5 mm. ; female, 13-14 mm. Abdomen : male, 11 mm. ; female, 15-19 mm. Body : male, 15 mm. ; female, 21-23 mm.

Material examined.—Two examples as follows : India : Kerala ; Trivandrum, 1 ♂, (no other data) (ex. colln. B.M.). Bihar ; Pusa, 1 ♀, 7.vii.1926 (G. P. Pillai coll.) (ex. colln. I.A.R.I.) (no. L41/23 ; det W.H.T. Tams).

Distribution.—India (Bihar ; Pusa ; Tamil Nadu ; Nilgiris ; Kerala, Trivandrum) and Java.

Remarks.—*P. impura* is characterised by dark smoky-black wings in both the sexes and by the uncus, in male genitalia, which is of uniform width beyond the middle and has a downwardly pointing hook-like tip. It resembles, in respect of the latter character, with the other species of the genus *Phragmataecia*, viz. *castaneae*, *pallidulae* and *purpureus*, but differs from these all in having smoky black wings and a short uncus in the male genitalia.

19. *Phragmataecia purpureus* Fletcher

(Pl. II, fig. 19 , Text-fig. 15)

1920. *Phragmataecia* sp. Fletcher and Ghosh, *Rep. 3rd. Ent. Mtg.*, 1 : 374.
 1928. *Phragmataecia purpureus* Fletcher, *Scient. Rep. agric. Res. Inst. Pusa*, 1926—27 : 58, pl. I, figs. 1a-c (Type loc.—Pusa, Bihar, India).
 1930. *Phragmataecia purpureus* Fletcher, *Scient. Rep. agric. Res. Inst. Pusa*, 1928—29 : 68.

Type : In I. A. R. I.

Hosts : *Andropogon sorghum*, *Saccharum arundinaceum* roots, *Saccharum spontaneum*, Maize and Jowar (Fletcher, 1928).

Fletcher (1928) described the species from larvae and pupae. Although he figured the adult he did not give any description of it. The following description is based on the type specimens present in the I. A. R. I., New Delhi. The specimens were extremely oily in appearance and had probably lost their natural coloration.

Head, thorax and abdomen appear brown to blackish brown. Frontal tufts and labial palpi blackish. Antennae brown. Wings blackish brown; fore wings darker than hind wings. Legs brown to blackish brown. Male generally somewhat paler than female.

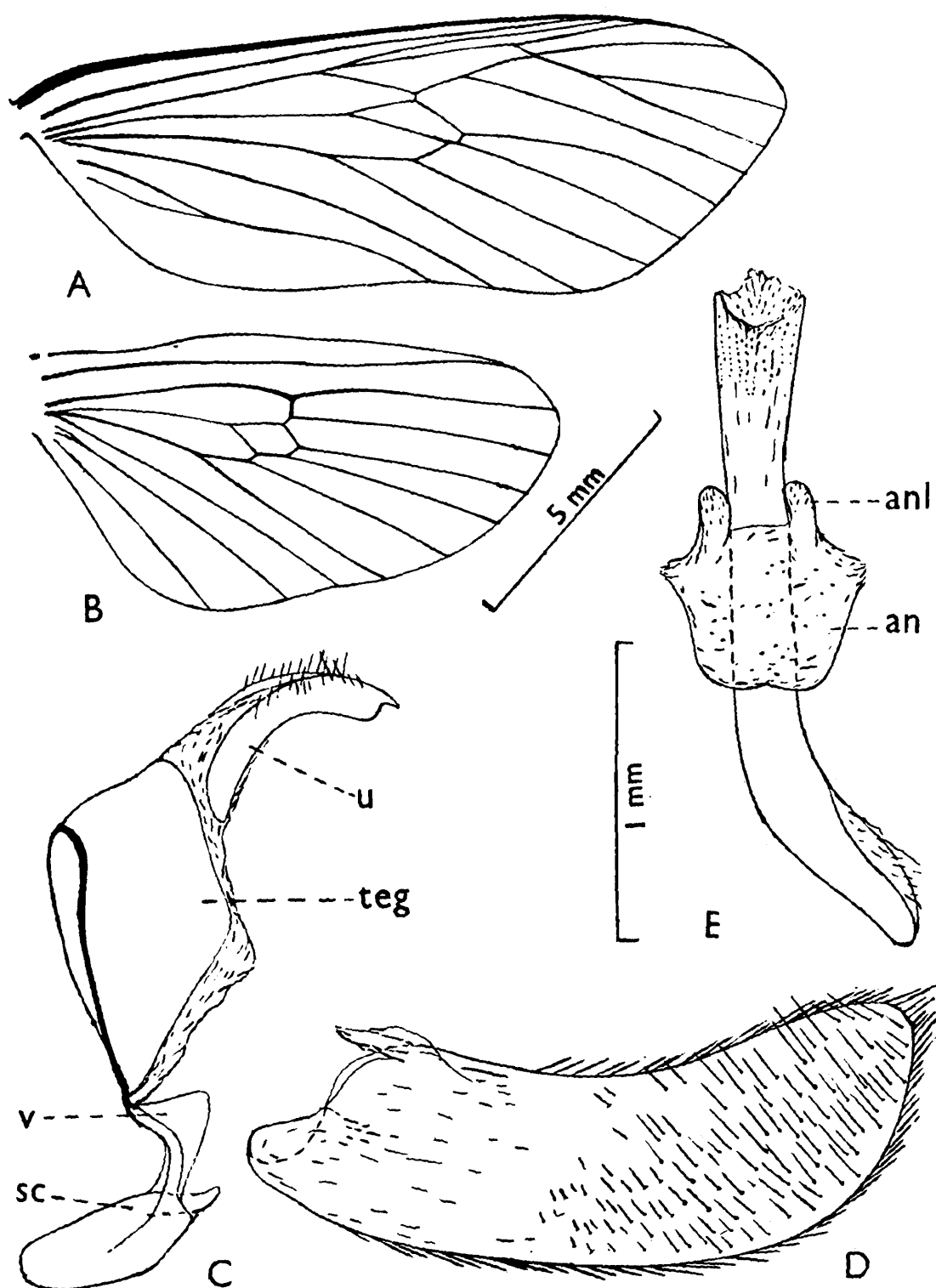
Antennae with 43 shaft-segments; bipectinate up to basal half or roughly 19-21 basal segments; rami short, the longest ones as long as two middle segments of shaft in female and four segments in male, the outer ones shorter than the inner ones; the distal segments serrate; tip simple. Labial palpi extremely short and nearly porrect. Frenulum spine single in male and four in female. Legs with a single pair of minute spurs on hind tibiae; arolium well developed. Abdomen longer than hind wings.

Venation.—Fore wing (Text-fig. 15A) : Areole moderately large, normal and projecting outside the cell angle by about half its length or a little more; veins R_1 and R_2 arise from areole; R_3 connate with R_4+5 ; M_1 from above the angle; median cell with the upper branch ending at upper angle of cell and not distorting the areole, lower branch ending at M_3 or between Cu_{1a} — M_3 . Hind wing (Text-fig. 15B) : Vein M_1 arises from well below the angle; median cell with upper and lower branches ending, respectively, between veins M_1 — M_2 and Cu_{1a} — M_3 .

Genitalia.—Male (Text-fig. 15C-E) : Uncus about three-and-a-half to four times as long as its width in middle, sclerotised on the dorsal and the lateral sides, leaving some weakly sclerotised area in the centre above the tegumen; the tip hooked, pointed and with fine setae. Tegumen broadly quadrangular. Saccus short and broadly cylindrical. Claspers about thrice as long as the width in middle, simple; uniformly wide throughout but somewhat narrower distally. Juxta broadly quadrangular and with extremely short lobes, the latter beset with fine setae. Aedeagus long, narrow and without striations, not differentiated into basal and apical portions. Female : Not studied.

Measurements.—Expanse: Male, 25-37 mm.; female, 34 mm. length: Fore wing : male, 11-14 mm; female, 14 mm. Hind wing : male, 8-10 mm.; female, 10 mm. Abdomen : male, 9-10 mm.; female, 14 mm. Whole body : male, 13-15 mm.; female, 19 mm.

Material examined.—Three examples (types) as follows : India : Bihar : Pusa, 1 ♂, 15.vi.1918 (no.L41/3), 1 ♂, 27.vi.1918



Text-fig. 15. *Phragmataecia purpureus* Fletcher : (A) and (B) Fore and hind wing venation, respectively. (C) male genitalia in a lateral view (D) A clasper in a inner view. (E) Aedeagus, with the juxta attached. (A & B ; C to E of the same magnifications).

(no.L41/5) [Both Paralectotype] ; and 1 ♀ , 10.vii.1918 (no.L41/4, "Figured") [Lectotype]. All (Boy coll.) from Kanra root (*Saccharum arundinaceum*) and reared in laboratory (C. S. 1805) (ex. colln. I.A.R.I.).

Distribution.—India, Bihar (Pusa).

Remarks.—Fletcher (1928) described this species on the basis of larval characters only and gave no account of its adult, except that he figured a female specimen. He (*loc. cit.*) also did not designate any type category to these specimens, except that he labelled one specimen, a female, as 'Figured', which resembled with the one published by him. This specimen has been designated by the present author as 'Lectotype' and the remaining as 'Paralectotypes'. The adults have been described here for the first time.

This species is characterised by the presence of a normal areole unlike in *P. castaneae* and *P. impura*, where it is distorted.

20. *Phragmataecia pallidalae* (Hampson) comb. nov.

(Pl. II, fig. 20 ; Text-fig. 16)

- 1892b. *Cossus pallidalae* Hampson, *Fauna Brit. India, Moths*, 1 : 306 (Type loc.—Sikkim).
 1899. *Cossus pallidalae*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 645.
 1923. *Cossus pallidalae*, Dalla-Torre, *Lepid. Cat.*, 29 : 12.
 1933. *Cossus pallidalae*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 809.
 1961. *Catopta* (?) *pallidalae* (Hampson) : Daniel, *Mitt. münch. ent. Ges.*, 51 : 209.

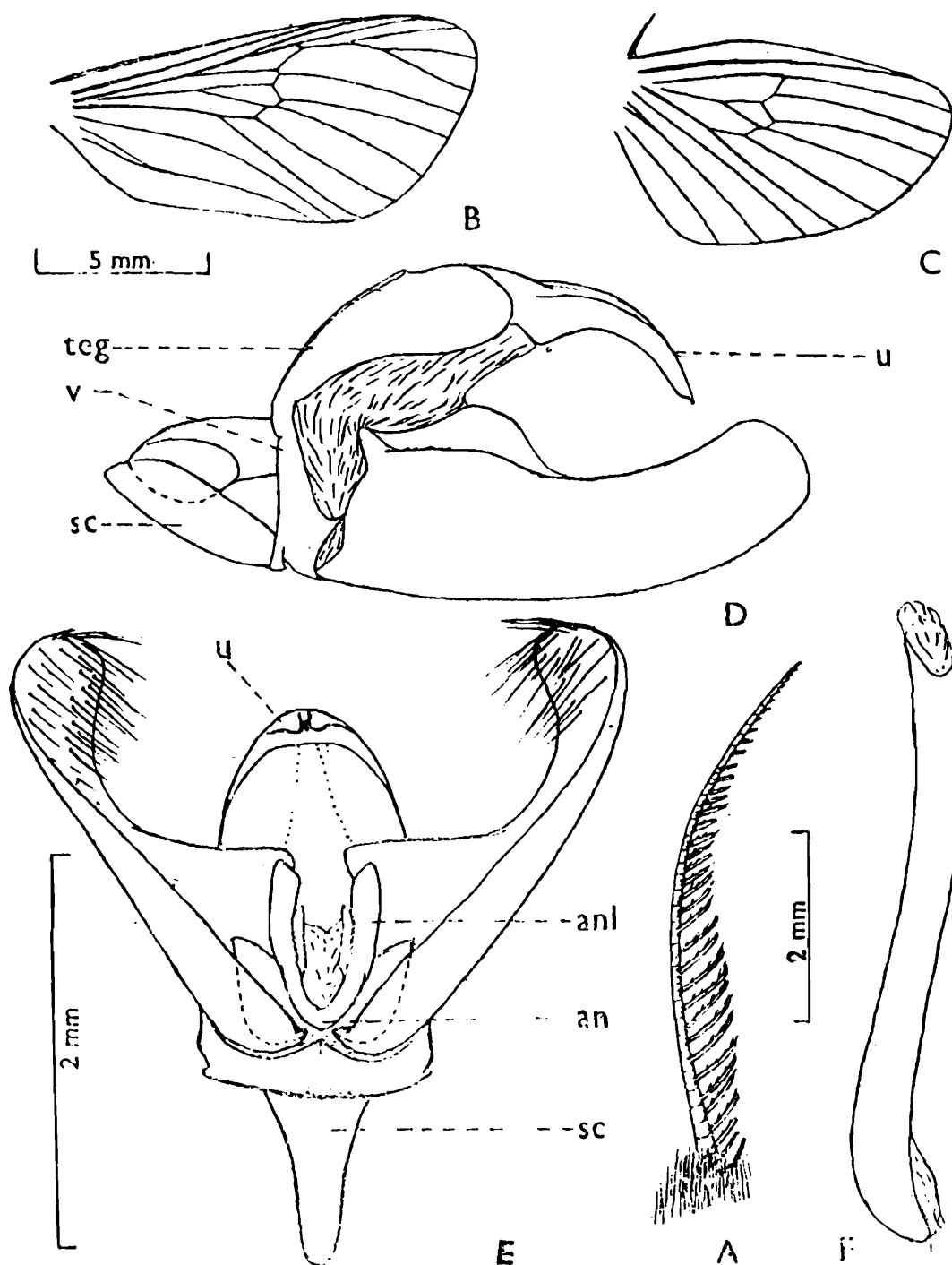
Type : In B. M.

Head, thorax and abdomen ochreous white. Fore wing, especially the cell, slightly suffused with rufous ; with numerous wavy rufous striae in the cell, between vein Cu_{1b} and the inner margin and a few in the outer area ; marginal line rufous. Hind wing white.

Frontal tufts short. Antennae (Text-fig. 16A) with 40 shaft-segments ; bipectinate up to nearly three-fourths of the length from base ; the distal one-fourth minutely serrate ; the longest rami about the length of three middle segments. Labial palpi minute, porrect. Frenulum, retinaculum, tibial spurs and spines as for the genus.

Venation.—Fore wing (Text-fig. 16B) : Areole normal, projecting outside the cell angle by about one-third its length ; vein R_1 arises from near the middle of areole ; R_2 from near the tip of areole ; veins R_3 to R_5 stalked, R_3 from middle of the common stalk of $R_4 + R_5$; M_1 from well below the cell angle ; origin of median cell not in line with the origin of veins R_1 and Cu_{1b} ; upper and lower branches of median cell ending between veins $M_1 - M_2$ and

$Cu_{1a}-M_3$, respectively; veins M_2 and M_3 separate. Hind wing (Text-fig. 16C) : Venation as given in generic characters.



Text-fig. 16. *Phragmataecia pallidulae* (Hampson) : (A) Male antenna showing pectinations of one side. (B) and (C) Fore and hind wing venation, respectively. (D) and (E) Male genitalia in lateral and inner views, respectively. (F) Aedeagus. (B-C; and D to F of the same magnifications).

Genitalia.—Male (Text-fig. 16D-F) : Uncus triangular, slightly sclerotised; with a fine distal point and having setae on dorsal surface.

Tegumen broader at the latero-dorsal than at the lateral side. Saccus cylindrical, about one-third as wide as its length. Claspers simple and weakly sclerotised ; costa produced inwards, on the mesal side, into a short fold, and coming close to that of other side ; with a few setae mesally, near the distal end. Juxta reduced, horse-shoe shaped, anellus lobes thicker. Aedeagus simple, slender and poorly differentiated into a base and an apical portion.

Measurements.—Expanse : fore wing, 29 mm. Length : fore wing, 13 mm. ; hind wing, 10 mm. ; abdomen, 10 mm. ; whole body, 15 mm.

Material examined.—Bhutan : 1 ♂, 20.iii.1892 (G. G. Dudgeon coll.) (ex. colln. B.M.).

Distribution.—Sikkim and Bhutan.

Remarks.—Hampson (1892b) described *pallidulae* as a species of the genus *Cossus* and placed it under the category "Male with the antennae serrated at tip, the branches of the proximal half longer. Fore wing with the areole much larger." Hitherto it was considered as a *Cossus* species until Daniel (1961) placed it in the genus *Catopta*, with some doubt, on the basis of the study of the male holotype. The male before me, from Bhutan, received from B.M., has all the distinctive characters of the genus *Phragmataecia*, e.g., the antennae having pectination in basal three-fourths part, a large areole in fore wing, a single pair of hind tibial spurs, absence of tarsal spines, and presence of arolium in between the claws. Moreover, Hampson's placing of the species in the category as mentioned above, and these characters of the species suggest that it actually belongs to the genus *Phragmataecia* and not to *Cossus* or *Catopta*.

It is close to other three species, viz., *castaneae*, *purpureus* and *impura* in the character of uncus, but differs from the latter by longer uncus and saccus. From the former two species it differs in the structure of juxta which is reduced and horse-shoe shaped.

21. *Phragmataecia terebrifer* Fletcher

(Pl. II, fig. 21 ; Text-fig. 17)

1920. *Phragmataecia* sp. Fletcher and Ghosh, *Rep. 3rd. Ent. Mtg.*, 1 : 374 (pl. 35, fig. 1).
 1928. *Phragmataecia terebrifer* Fletcher, *Scient. Rep. agric. Res. Inst. Pusa*, 1926—27 : 58, pl. I, fig. 2a-d (Type loc.—Pusa, Bihar, India).

Type : In I. A. R. I.

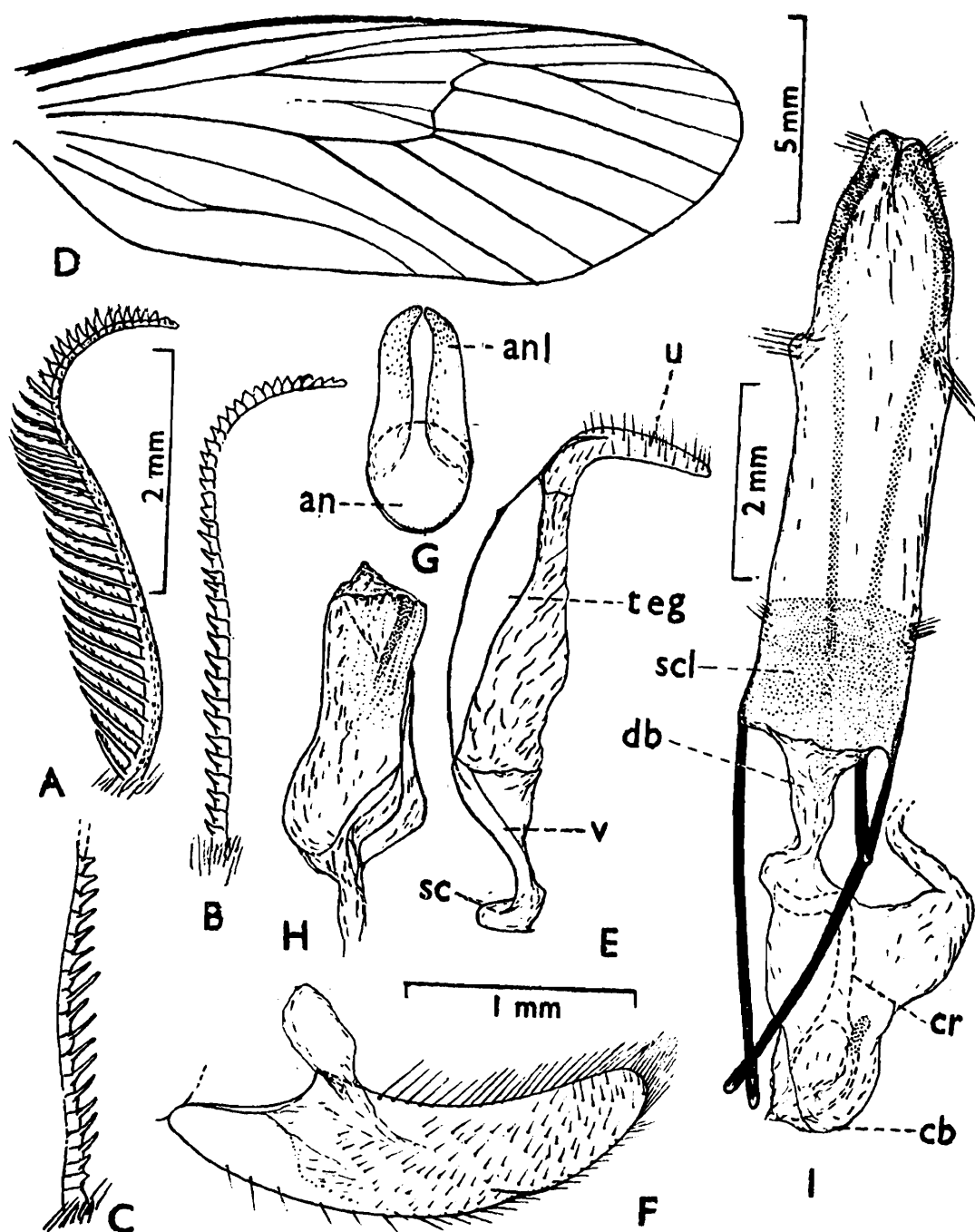
Hosts : *Saccharum spontaneum* stem, *Saccharum arundinaceum* and *Andropogon sorghum*.

Head, thorax and abdomen dark brown. Frontal tufts brown, blackish on sides. Antennae brown. Labial palpi dark brown. Fore wings dull brown and grizzled with scales, numerous short striae all along the costa, median and the inner areas, thus giving an apparent look of three longitudinal fascia in female. These fascia are more prominent before the discocellular in male. Hind wings pale brown to brown and almost without markings. Legs blackish on upperside, paler beneath. Underside of body and wings paler than above, that of the latter with darker markings.

Head with the labial palpi short, nearly porrect, not projecting beyond frons. Antennae (Text-fig. 17 A-C) with 36-43 segments in the shaft ; minutely bipectinate up to a little more than basal half of the length ; the longest rami as long as four segments of the shaft in male and two in the female ; the rami of the inner and outer sides equal in length in male and unequal in female, *i.e.*, in the latter the rami are longer on the inner side than those on the outer side ; the distal segments serrate ; the tip simple. Frenulum spines single in male and four in female. Legs without tarsal spines ; arolium well developed. Abdomen as long as hind wings or slightly longer.

Venation.—Fore wing (Text-fig. 17D) : Areole long, projecting outside the cell only by about one-fifth of its length ; veins R_1 and R_2 arise from areole, R_2 as far from the tip of areole as R_1 from the origin of areole ; R_3 to R_5 stalked, R_3 arising from middle of the common stalk ; M_1 from well below the angle of cell ; median cell present, with the upper and lower branches ending between M_1 — M_2 and at M_2 , respectively. Hind wing : Vein M_1 from well below the cell angle ; median cell present, with its branches ending between M_1 — M_2 and Cu_{1a} — M_3 .

Genitalia.—Male (Text-fig. 17E-H) : Uncus about twice as long as its width in middle, the tip blunt and rounded, not produced into a point. Tegumen triangular, broadest at the dorso-lateral side. Saccus short. Clasper simple, narrowed distally, about three times as long as its width in middle. Juxta subrounded ; anellus lobes from near the apical area, broader at base, slightly incurved and narrowing apically. Aedeagus small ; vesica with some striation on one side and beset with short spines. Female (Text-fig. 17 I) : Short and broad ; genital tube short ; ostium bursae simple, without any sclerotisation ; ductus bursae membranous, short and enters into a lobe of corpus bursae, the latter membranous ; signum either elongate or rounded ; genital plate sclerotised on both dorsal and ventral sides.



Text-fig. 17. *Phragmataecia terebrifer* Fletcher : (A) Male antenna showing pectinations of one side. (B) and (C) Outer and Inner rows, respectively of pectination in a female antenna. (D) Fore wing venation. (E) Male genitalia in a lateral view, without claspers. (F) A clasper in a inner view. (G) Juxta. (H) Aedeagus. (I) Female genitalia in a dorsal view. (A-C ; E-H of the same magnifications).

Measurements.—Expanse : Male, 25-28 mm. ; female, 30-42 mm. length : Fore wing : Male, 10-13 mm. ; female, 13-18 mm. Hind wing : Male, 8-10 mm. ; female, 9-14 mm. Abdomen : Male, 8-10 mm. ; female, 10-16 mm. Body : Male, 12-25 mm. ; female, 18-23 mm.

Material examined.—47 ♂♂, 17 ♀♀, as follows : India : Bihar : Pusa, 1 ♀, 1.x.1917 (Regd. no. L42/8) ; 2 ♀♀, 15.x.1917 (Regd. nos. L41/7 ; L41/14, the latter labelled “FIGURED” and designated as ‘Lectotype’) ; 1 ♂, 4.x.1918 (Regd. no. L41/18) ; 1 ♀, 6.x.1919 (Regd. no. L42/13) ; 1 ♂, 11.x.1919 (Regd. no. L42/9) ; 1 ♀, 6.xi.1919 (Regd. no. L42/16) (all coll. *Boy*) ; 1 ♀, 25.ix.1923 (Regd. no. L41/25) (all labelled “Boring *Saccharum spontaneum*, Batri”) ; 1 ♂, at light, 6.x.1923 (*Paries* coll.). Assam, Sarbhog, 1 ♀, 4.x.1917 (*Fletcher* coll.) (Regd. no. L42/17). (all, except L41/14 designated as ‘Paralectotypes’ ex colln. I.A.R.I.) ; Lekhabali, 44 ♂♂, 10 ♀♀ at light, 6—8.x.1966 (*S. K. Tandon* and *G. S. Arora* coll.). Bengal : Jalpaiguri Dist., Rydak forest, 1 ♀, 10.ix.1975 (*H. K. Bhoumik* coll.).

Distribution.—India, Bihar (Pusa), Assam.

Remarks.—Fletcher (1928) described this species too, like *P. purpureus*, on the basis of larval characters. He (*loc. cit.*) neither described the adult nor designated any type category, but only labelled one specimen, a female, as ‘Figured’, which resembled with the one published by him (*loc. cit.*). These specimens, in I. A. R. I., have been examined by the present author and the one labelled as ‘Figured’ has been designated as ‘Lectotype’ and the remaining as ‘Paralectotypes’

This species is close to *P. parvipunctus* (Hampson) and *P. dudgeoni* Arora in the shape of uncus which is broad and rounded distally. It, however, differs from both the species by the areole which projects about one-fifth its length (about half or more its length in the other two species) outside the cell angle and by the aedeagus which is smaller than in the other two species.

Hitherto known from Bihar, the species is being recorded from Assam and Bengal for the first time.

22. *Phragmataecia parvipunctus* (Hampson)

(Text-fig. 18)

- 1892b. *Cossus parvipunctus* Hampson, *Fauna Brit. India, Moths*, 1 : 306 (Type loc.—Naga Hills, India).
- 1918. *Phragmataecia parvipunctus*, Turner, *Trans. ent. Soc. Lond.*, 66 : 160, 161.
- 1923. *Cossus parvipunctus*, Dalla-Torre, *Lepid. Cat.*, 29 : 12.
- 1933. *Cossus parvipunctus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 809.

Type : A male in B. M

Hosts : *Saccharum officinarum*.

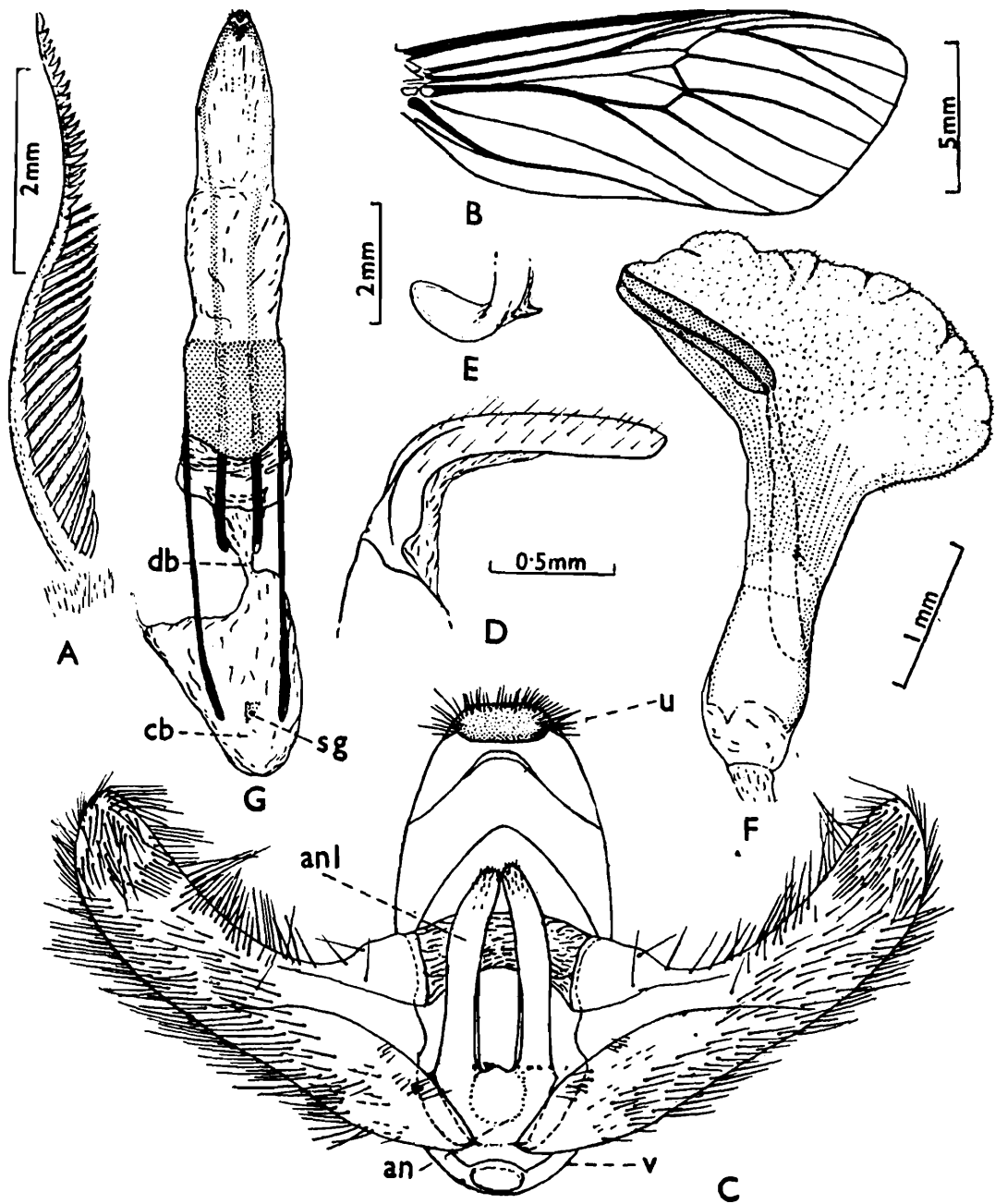
The material before me, for the present study, consists of three examples from Ceylon. The coloration of the specimens seem to have got damaged in the flood at Varanasi when some of the Z.S.I. collections were submerged.

Frontal tufts brown. Antennae brown, the branches whitish at their tips. Labial palpi dark brown. Thorax, wings and abdomen brown. Underside of thorax, near the base of fore legs, dark brown, otherwise as on upper side. Legs generally brown; tarsi black, with narrow, pale brown to whitish bands at joints.

Antennae (Text-fig. 18A) bipectinate up to two-thirds from base, distal one-third serrate; the branches shorter at base and at apical part of the pectinate portion, the longest rami as long as four to five middle segments of shaft, the terminal segment long; antennae in female simple and without pectination (incomplete and with only 21 segments in an example available for study). Labial palpi short and porrect. Frenulum spines single in male and three in female. Tarsal spines wanting; arolium in between the claws well developed. Abdomen as long as wings.

Venation (Text-fig. 18B).—Venation in both the wings mainly as in the genus. Fore wings with a large areole, the latter projecting beyond the cell angle by about half its length; vein R_1 arises from basal one-third of areole; R_2 from near the tip of areole; R_3 shortly stalked with R_4 and R_5 ; M_1 from well below the angle; median cell large, with upper and lower branches ending between M_1 — M_2 and M_2 — M_3 or at M_3 , respectively.

Genitalia.—Male (Text-fig. 18C-F) : Highly sclerotised as a whole. Uncus uniformly broad from base to near the distal end; about three times as long as its width in middle; distal end slightly narrowed, rounded, slightly depressed in the middle and more or less duck-beak shaped. Tegumen broad dorso-laterally, narrower laterally. Vinculum narrow and ending into a short upturned saccus. Claspers simple, without sclerotisation and about four times as long as the width in middle; broader in the middle than at the distal end, the latter narrowly rounded. Juxta narrow at base; lateral margins oblique and continuous with anellus lobes, the latter broad up to basal half but narrowing distally. Aedeagus well built, indistinctly differentiated into base and vesica, the latter striated and with a narrow sclerotised portion on one side. Female (Text-fig. 18G) : Ostium bursae simple, without any sclerotisation; ductus bursae short, membranous and broad at base; corpus bursae large, broadly triangular; with a large lobe on one side, into which opens the ductus bursae, and a fine duct on the other side opening into genital tube; signum triangular, with a shallow depression and beset with fine setae;



Text-fig. 18. *Phragmataecia parvipunctus* (Hampson): (A) Male antenna showing pectinations of one side. (B) Fore wing venation. (C) Male genitalia in inner view, with claspers. (D) and (E) Uncus and saccus, respectively in a lateral view. (F) Aedeagus. (G) Female genitalia in a dorsal view. (C & F; D & E of the same magnifications).

genital plates strongly sclerotised both dorsally and ventrally; posterior apodemes extending far beyond the genital plates and reaching as far as the corpus bursae.

Measurements.—Expanse; Male and female, 40 mm. Length: Fore wing: male, 17 mm.; female, 18 mm. Hind wing: male

and female, 14 mm. Abdomen : male and female, 14 mm. Body : male and female, 19 mm.

Material examined.—Three specimens as follows : Ceylon : Maskeliya, 1 ♂, —.ii.— ; 1 ♂, —.iii.—, 1 ♀, —.iv.— (*E. E. Green* coll.) (no further data).

Distribution.—India (Nilgiris and Naga Hills), Ceylon.

Remarks.—Referable to the genus *Phragmataecia*, it was placed by Hampson (1892b) originally in the third category of the genus *Cossus* Fabricius, i.e., "Male with the antennae serrated at tip; the branches of the proximal half longer. Fore wing with the areole much larger." Turner (1918) figured the wing venation of this species and placed it under the genus *Phragmataecia*. Dalla-Torre (1923), however, catalogued it under the genus *Cossus*, followed by Gaede (1933).

The present study of the external and genitalic characters clearly indicates that the species belongs to the genus *Phragmataecia* and to the category of those species viz., *terebrifer* Fletcher and *dudgeoni* Arora, in which the uncus is rounded at the tip. It, however, differs from both *terebrifer* and *dudgeoni* for its areole being projected outside the cell angle by half its length vs. one-fifth in *terebrifer* and one-third in *dudgeoni*, and in the juxta having oblique lateral margin unlike in the other two species where the margins are curved.

Hitherto known from India, the species is being reported from Ceylon for the first time.

23. *Phragmataecia dudgeoni* Arora

(Pl.II, fig. 22 ; Text-fig. 19)

1974. *Phragmataecia dudgeoni* Arora, *Oriental. Ins.*, 8 (2) : 157-159. (Type loc.—Bhutan).

Type : In Z. S. I.

Head brown ; frontal tufts brown to fuscous brown ; antennae pale brown to whitish above, brown below ; labial palpi fuscous brown, pale on the inner side. Thorax and abdomen fuscous brown, the latter with tufts of brown scales on each segment. Fore wings brown ; the area along the costa, up to the basal two-thirds and along the cubital area, little beyond the discocellulars, distinctly fuscous, with numerous short, chocolate brown striae ; a short chocolate brown triangular stigma formed by the confluence of the striae, may be present on the upper angle of the cell, the stigma being faint or absent in some of the specimens ; the area below and beyond the

cell marked by numerous striae, some of which join and end up into five spots in an oblique row, the striation being uniform and without the above-mentioned confluence in some of the specimens. Hind wings brown, unmarked ; costa not shining. Underside of both the wings striated, the striation on the fore wings as on the upper side. Legs pale brown, with some fuscous scales.

Antennae (Text-fig. 19B) bipectinate up to two-thirds from the base, the distal segments serrate except the last which is short and simple ; the rami longest in the middle, being about the length of five segments of the shaft. Labial palpi short and porrect. Legs fringed with hairy scales up to tibiae ; hind tibiae with a pair of short unequal spurs ; tarsi without spines, with first segment longer than the rest ; arolium (Text-fig. 19C) well developed. Frenulum single and stout ; retinaculum well developed and curved at tip.

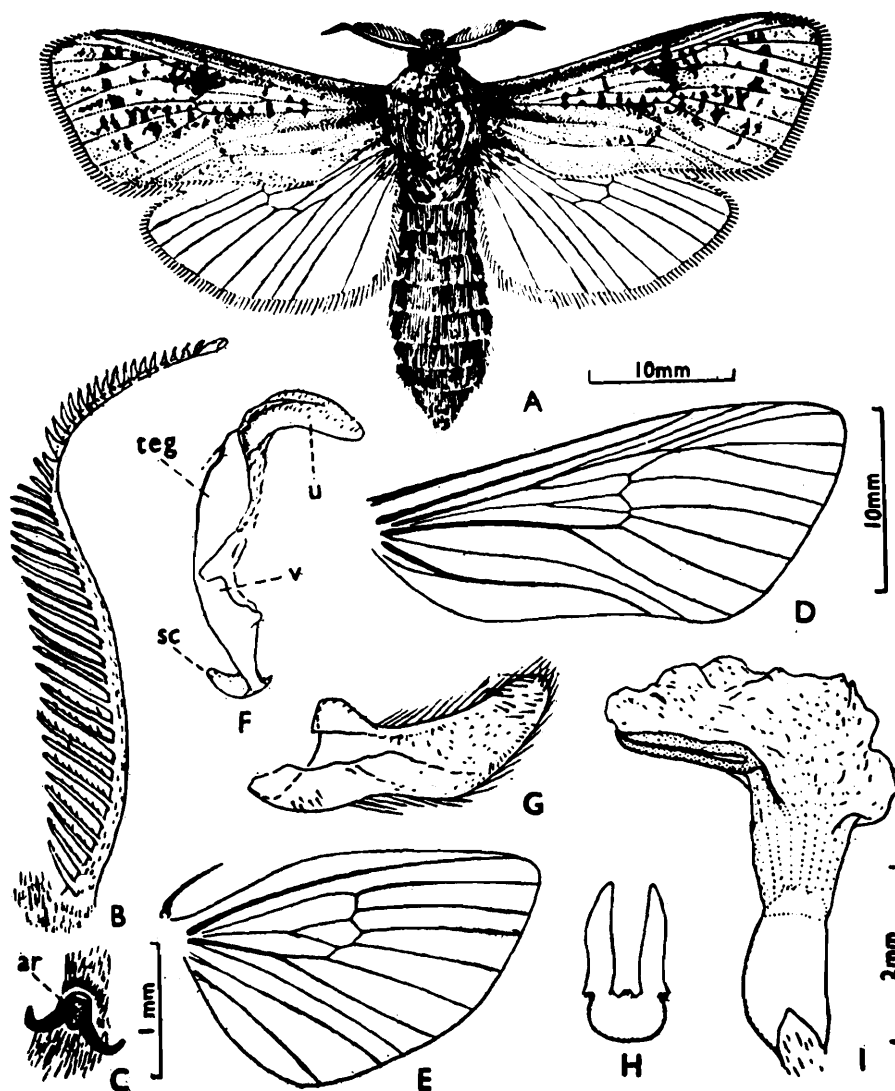
Venation.—Fore wing (Text-fig. 19D) : Areole long, projecting by about one-third its length outside the cell angle ; vein R_1 arises from basal one-third of areole ; R_2 from near the tip of areole ; R_3 shortly stalked or anastomosed with the base of $R_4 + R_5$; M_1 from well below the angle of cell ; median cell large, with its upper and lower branches ending between veins M_1-M_2 and M_2-M_3 or at M_3 , respectively ; M_2 and M_3 close at base but distinctly separate ; Cu_{1a} and Cu_{1b} from before the lower angle of cell. Hind wing (Text-fig. 19E) : Without any cross bar between vein Sc and Rs, *i.e.*, the latter two veins free ; M_1 well below Rs ; median cell large, with its branches ending between M_1-M_2 and $Cu_{1a}-M_3$; veins M_2 and M_3 wide apart.

Genitalia.—Male (Text-fig. 19F-I) : Uncus curved from near the base and highly sclerotised ; about one-and-a-half times as long as its width in middle, the distal end narrow, rounded and blunt, and half the width of the middle portion. Tegumen broadly triangular ; vinculum broadest in the middle. Saccus short and narrow, with its tip slightly upturned. Clasper broad near the middle and at base, about four times as long as its width in middle. Juxta almost rounded and without distinct median lobes ; the lateral lobes long and narrow. Aedeagus well developed, with an indistinct base and a large vesica, the latter sclerotised on one side.

Female : Not known.

Measurements.—Expanse, 41–55 mm. Length : Fore wing, 19–25 mm. ; hind wing, 15–19 mm. ; abdomen, 12–17 mm. whole body, 19–25 mm.

Material examined.—Seven examples : Bhutan : 1 ♂, (holotype, No. 1469/H10), and 6 ♂♂, (paratypes, Nos. 1470–1475/H10) —.iii.1895, G. C. Dudgeon coll.) (All deposited in Z.S.I.).



Text-fig. 19. *Phragmataecia dudgeoni* Arora : (A) An outline drawing of the male holotype. (B) Male antenna showing pectination of one side. (C) A portion of the hind leg, with arolium. (D) and (E) Fore and hind wing venation, respectively. (F) Male genitalia in a lateral view, without claspers. (G) A clasper in a inner view. (H) Juxta. (I) Aedeagus (D & E ; B, F to I of the same magnifications).

Distribution.—Bhutan

Remarks.—*Phragmataecia dudgeoni* comes very close to *P. parvipunctus* (Hampson) in respect of the bipectinate antennae, certain characters of wing venation and the genitalia. It can, however, be differentiated from *parvipunctus* by the following characters : In the fore wing the areole is long, arising from much before the point of origin of veins Cu_{1b} and R_1 , unlike in *parvipunctus* where the areole is short and its origin is nearly in the line with that of vein Cu_{1b} ; the fore wing with an oblique row of striae beyond the cell and a patch on the upper angle of the cell (prominent in certain

examples or faint or absent in others) whereas in *parvipunctus* there is a row of spots on the vein 1A. In respect of the male genitalia it differs from *parvipunctus* by the shape of uncus which is short and stout; about one-and-a-half times as long as its width at the middle, the distal part narrow, with its tip about half as wide as the width at the middle, whereas in the latter species the uncus is somewhat long and narrow; and nearly uniformly broad throughout.

24. *Phragmataecia clara* (Bryk) comb. nov.

(Pl. II, fig. 23 ; Text-figs. 20, 21)

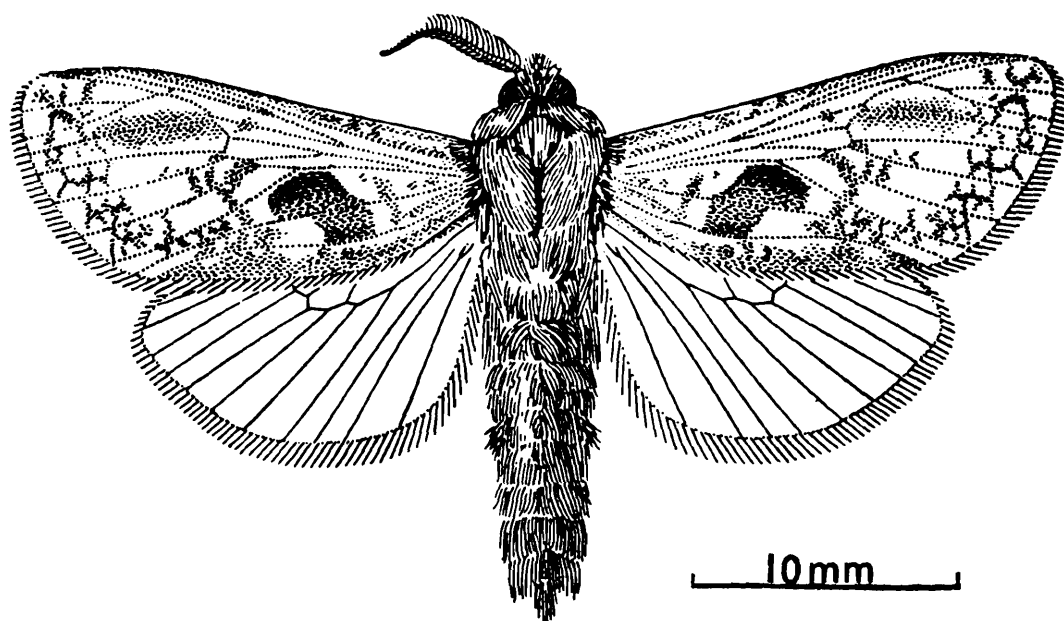
1950. *Xyleutes clara* Bryk, *Ark. Zool.* 42A (19) : 47, pl.iii, fig. 1 (Type loc.-Mekane, 90 km. E. of Moulmein, Tenasserim, Burma).

Type : In Rm.

Head, thorax and abdomen ochreous white. Frontal tufts ochreous brown in front, blackish below and laterally. Antennae brown, covered with white scales above throughout. Eyes black. Labial palpi blackish. Fore wings ochreous white throughout, with brown striae along costa and in between veins in the postmedial area ; a large, prominently curved geminate spot present below the cell, the larger one blackish in the upper half and reddish brown in the lower half ; the smaller one reddish brown all over : a small prominent and light-blackish spot present in sub-median fold ; black striae near the apical margin between veins R_3 and R_5 either present or absent. Hind wings ochreous white, without markings. Legs ochreous brown, intermixed with blackish scales ; tarsi somewhat darker and with an indistinct band of paler scales. Abdomen on both upper and lower sides ochreous white, covered with woolly hair. Underside of both wings without markings.

Antennae (Text-fig. 21A) bipectinate up to basal two-thirds ; the longest rami about the length of five segments in the middle ; remaining ones serrate ; the terminal joint simple. Labial palpi short. Hind wing with a well developed frenulum spine ; retinaculum elongate, and weakly curved. Legs without tarsal spines ; hind tibiae with a single pair of minute spurs ; claws with well developed arolium. Abdomen shorter than, or as long as, hind wings.

Venation.—Fore wings (Text-fig. 21B) : Areole long, projecting outside the cell angle by about one-third its length ; vein R_1 arises from areole and in line with the origin of median cell ; R_2 from near the distal end of areole ; R_3 shortly stalked with $R_4 + R_5$, nearer to base than to R_5 ; M_1 generally from the upper angle of cell (from below the angle in type), rarely from above ; median cell with



Text-fig. 20. *Phragmataecia clara* (Bryk) : An outline drawing of the male holotype.

its upper and lower branches ending between veins M_1-M_2 and $Cu_{1a}-M_3$, respectively ; M_2 and M_3 separate. Hind wing venation mainly as for the genus.

Genitalia.—Male (Text-fig. 21C-F) : Uncus triangular and sclerotised ; narrowing gradually into a narrow rounded tip. Saccus short and rounded. Clasper weakly sclerotised, with only a few setae on the inner side ; about four-and-a-half times as long as its width in middle ; the distal end narrow. Juxta horse-shoe shaped ; anellus lobes long, about four times as long as the width. Aedeagus weakly differentiated into a short base and a large striated and sclerotised apical part, the latter with membranous vesica.

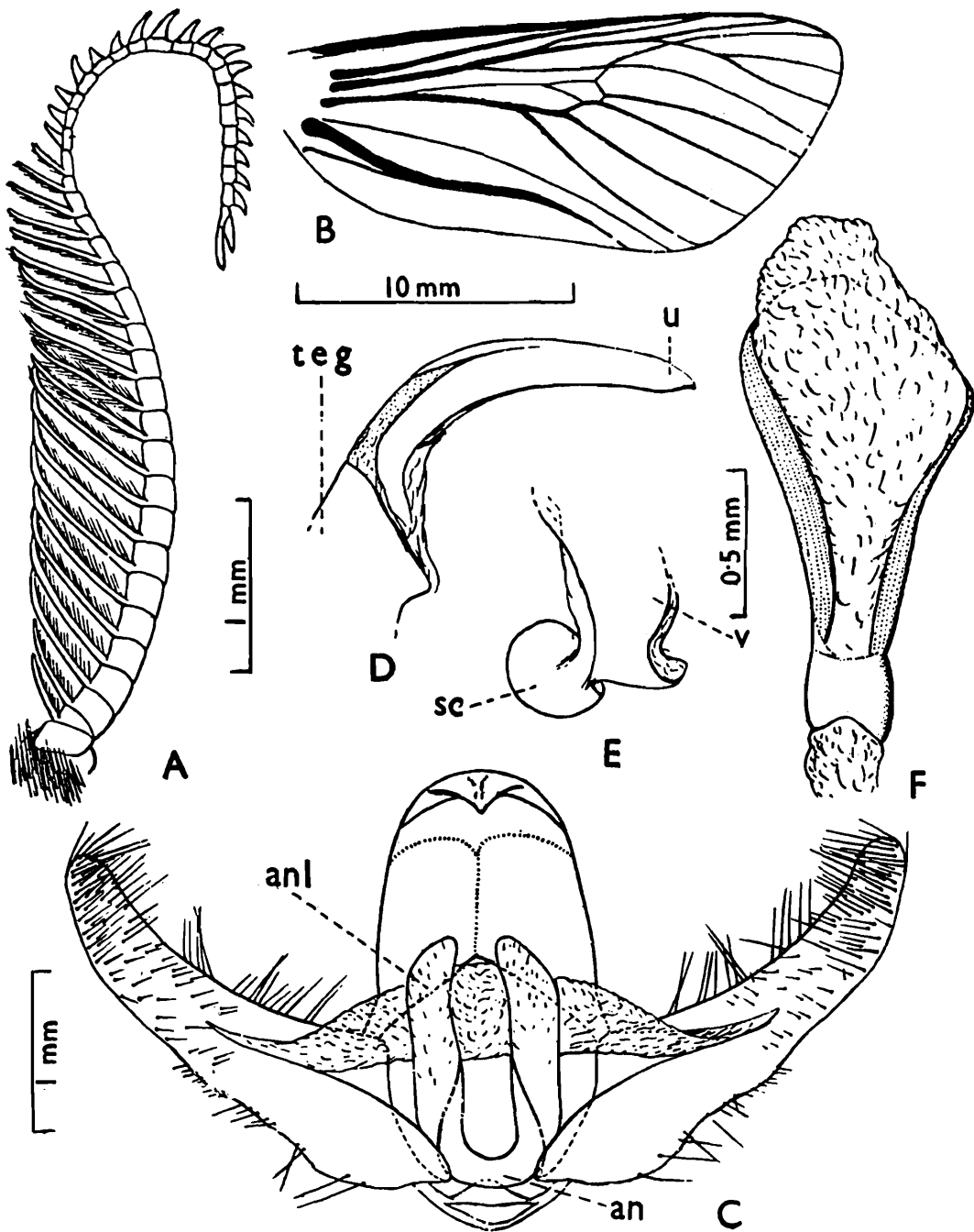
Female : Not known.

Measurements.—Type material : Expanse : Fore wing, 38.5 mm. Length : Fore wing, 18 mm. ; hind wing, 13 mm. ; abdomen, 11 mm. ; body, 18 mm.

Other material.—Expanse : Fore wing, 35–40 mm. Length : Fore wing, 16–19 mm. ; hind wing, 12–15 mm. ; abdomen, 11–15 mm ; whole body, 18–22 mm.

Material examined.—Six examples as follows : Sikkim : 548.63 m., 2♂♂, —.ix and .x. 1897 (G. C. Dudgeon coll.).

Bhutan : 3♂♂, 6.ix.1894 (G. C. Dudgeon coll.)



Text-fig. 21. *Phragmataecia clara* (Bryk) : (A) Male antenna showing pectinations of one side. (B) Fore wing venation. (C) Male genitalia in inner view, with claspers. (D) Uncus and a portion of tegumen in a lateral view. (E) A portion of vinculum and saccus in a lateral view. (F) Aedeagus. (C & F; D & E of the same magnifications).

Burma : Tenasserim, Mekane, 90 Km. east of Moulmein, 'Typus' 1 ♂, 2—8.xi.1934 (*Malaise* coll.) (ex. colln. Rm., Stockholm).

Distribution.—India (Sikkim), Bhutan and Burma.

Remarks.—Referable to the genus *Phragmataecia*, it was described as a species of the genus *Xyleutes* Hübner (*vide* Bryk, 1950). The type (male), on examination, was found to have the antennae bipectination up to basal two-thirds, the reduced labial palpi, arolium in between the claws, and no tarsal spines and gnathos. These are the characteristic features of the genus *Phragmataecia* and leave no doubt in the species belonging to this genus.

Phragmataecia clara is close to *stigmaticus* and infact the above-mentioned specimens from Sikkim and Bhutan, present in Z.S.I, were confused for *stigmaticus*. It, however, differs from the latter in the absence of an oblique series of striae on the fore wing (present in *stigmaticus*); in having a rounded saccus and horse-shoe shaped juxta, whereas in *stigmaticus* the saccus is short and narrow and the juxta rounded.

It is also close to *obliquifascia* but can be separated by the absence of oblique band on the fore wing (present in *obliquifascia*) and by the underside coloration of abdomen which is ochreous white in this species *vs.* black in *obliquifascia*.

Phragmataecia clara, hitherto known from Burma, is being reported from India (Sikkim) and Bhutan, for the first time.

25. *Phragmataecia stigmaticus* (Moore) comb. nov.

(Pl. II, figs. 24-25 ; Text-fig. 22)

- 1879b. *Zenzera stigmatica* Moore, *Descr. Indian Lep. Atk.* : 86 (Type loc.-Darjeeling, India).
- 1887. *Zeuzera stigmatica*, Cotes and Swinhoe, *Cat. Moths of India* : 234.
- 1892. *Zeuzera stigmaticus*, Kirby, *Cat. Lep. Het.* : 872.
- 1892b. *Cossus stigmaticus* (Moore) : Hampson, *Fauna Brit. India, Moths*, 1 : 306.
- 1923. *Cossus stigmaticus* Dalla-Torre, *Lepid. Cat.*, 29 : 13.
- 1896a. *Azygophelps stigmaticus*, Hampson, *Fauna Brit. India, Moths*, 4 : 473.
- 1899. *Duomitus stigmaticus*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
- 1933. *Xyleutes stigmaticus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 819
- 1950. *Zeuzera stigmaticus*, Bryk, *Ark. Zool.*, 42 (A) 19 : 46 (Sikkim and Bhutan).

Type : In Ber. Mus.

Frontal tufts and the labial palpi black, intermixed with white-scales. Antennae brown. Upperside of wings pale golden-yellow. Fore wings with a prominent, curved geminate spot, which is blackish above and reddish below ; some confluent, brownish striae along costa, a clouded series of striae obliquely from the apex to the spot

and a paler series on the outer margin, also present. Hind wings pale golden yellow, glossy at the base and without markings. Underside of wings dull golden-yellow; reticulations and the upper spot on fore wing fuliginous brown; the lower reddish portion of the large spot and the spot below the cell obsolete. Legs with brownish bands at the joints and tarsi. Legs and the abdomen covered with woolly, golden-yellow hair.

Frontal tufts small. Antennae (Text-fig. 22B) bipectinate up to nearly three-fourths from the base, the distal part serrate, the teeth small; the longest rami about the length of 5 shaft-segments; the shaft with about 36 segments. Labial palpi extremely minute, porrect. Frenulum, retinaculum, tibial spurs and arolium (Text-fig. 22C-D) as for the genus; tarsal spines absent. Abdomen as long as hind wings.

Venation.—Fore wing : Areole long and normal, projecting outside the cell by about one-third its length; vein R_1 arises from areole and almost in between vein Cu_{1a} — Cu_{1b} ; R_2 from near the tip; vein R_3 shortly stalked with $R_4 + R_5$; M_1 well below the angle; median cell short, with the upper and lower branches ending between M_1 — M_2 and Cu_{1a} — M_3 , respectively; veins M_2 — M_3 separate but close. Hind wing : Venation as for the genus.

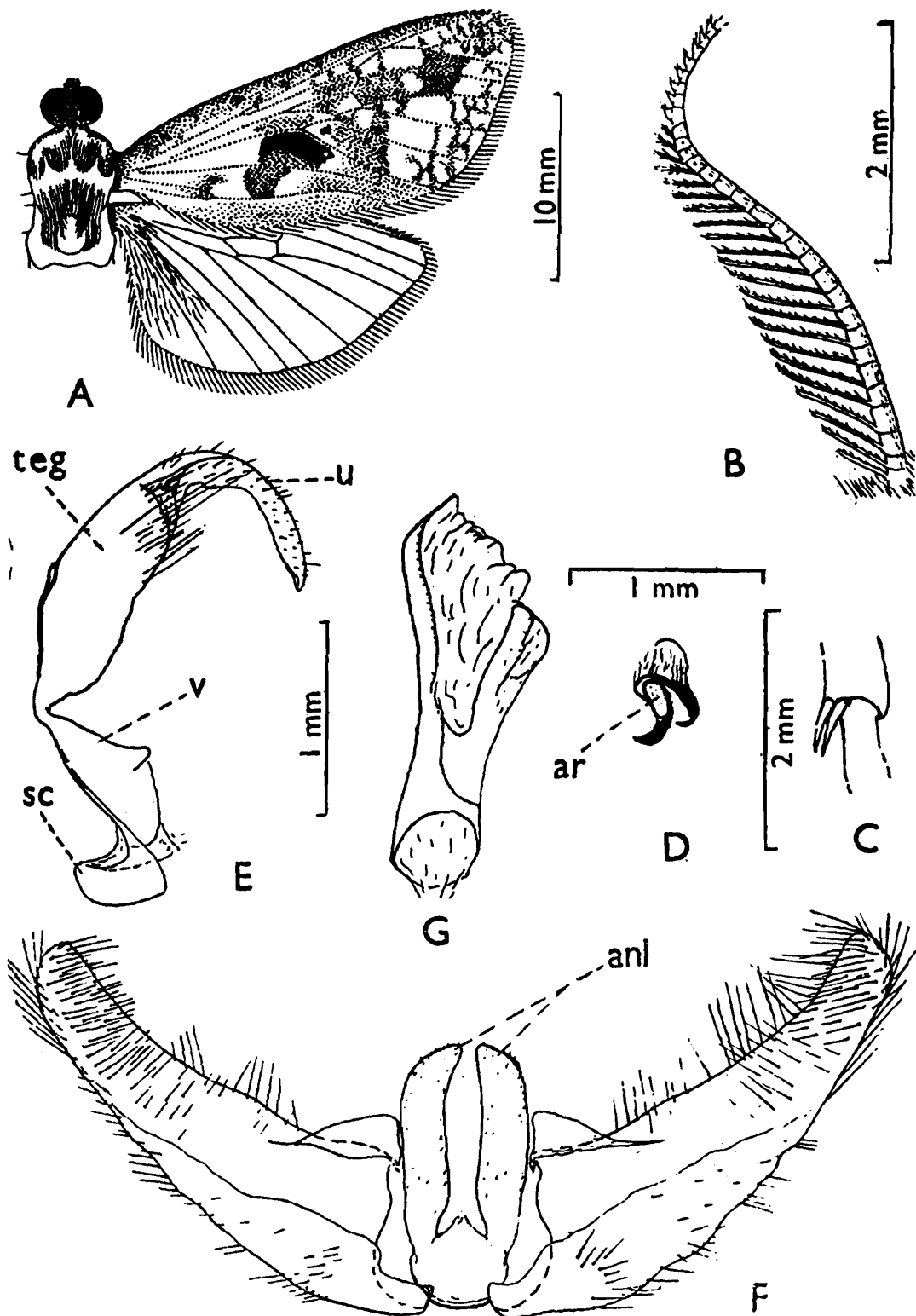
Genitalia.—Male (Text-fig. 22E-G) : Uncus triangular and sclerotised, gradually narrowing towards the distal end and ending in a narrow point. Saccus short. Clasper weakly sclerotised and with numerous setae on mesal side; narrowing gradually towards the distal end and about four times as long as its width in middle; distal end narrow and about half the width in middle. Juxta rounded; anellus lobes about five times as long as the width in middle and narrowing distally. Aedeagus with weak differentiation into a short basal and a large striated and sclerotised apical portion, the latter with membranous vesica.

Female : Not known.

Measurements.—Type ♂ : Expanse, 48.5 mm. Length : Fore wing, 22 mm.; hind wing, 17 mm. (Abdomen broken).

Other material : Expanse : 41 mm. Length : Fore wing, 18 mm.; hind wings, 13.5 mm.; abdomen, 13.5 mm., body, 19 mm.

Material examined : Two examples as follows : India : West Bengal : Darjeeling, 1 ♂ 'Type' (colln. Atkinson, Staudinger coll.) (ex. colln. Ber. Mus.) (type labelled "*Zenzera bistigma*"). Arunachal Pradesh : Kameng; Rahung, 1830 m., 1 ♂, 14.ix.1961 (*S. Biswas* coll.)



Text-fig. 22: *Phragmataecia stigmaticus* (Moore) : (A) An outline drawing of the male holotype, showing one side only (specimen badly damaged). (B) A portion of the male antenna with pectinate branches of one side. (C) A portion of the hind leg with a single pair of tibial spurs. (D) Tarsal claws with arolium. (E) Male genitalia in a lateral view, without claspers. (F) Claspers in a inner view, with juxta. (G) Aedeagus. (E to G of the same magnifications).

Distribution.—India (West Bengal, Arunachal Pradesh, Sikkim), Bhutan.

Remarks.—Referable to the genus *Phragmataecia*, this species has been hitherto transferred several times, from one genus to another. Hampson (1892b) transferred it from *Zeuzera* to his third category of the genus *Cossus*, i.e., "Male with the antennae serrate at tip, the branches of the proximal half longer. Fore wing with the areole much larger", but later (1896) transferred it to the genus *Azygophelps*. Later, Dudgeon (1899) placed it in the genus *Duomitus* followed by Gaede (1933), who placed it under the genus *Xyleutes*, obviously because of the *Duomitus* having been synonymised with the former genus. The present study of the type shows that the species belongs to the genus *Phragmataecia* as it has all the characters of this genus.

This species along with *P. clara* (Bryk) can be separated from all the other species of the genus *Phragmataecia*, known from the Indian subregion, by the presence of golden yellow woolly hair on abdomen and legs. For differences from *P. clara* see under that species.

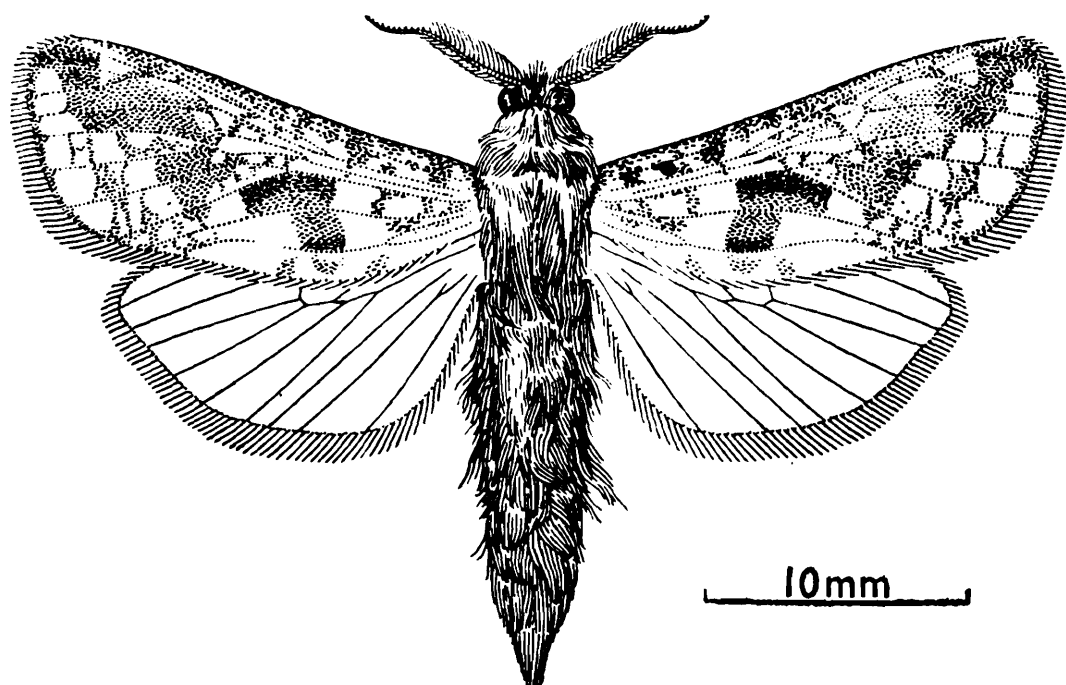
26. *Phragmataecia obliquifascia* (Bryk) comb. nov.

(Pl. II, figs. 26-27 ; Text-figs. 23, 24).

1950. *Xyleutes obliquifascia* Bryk, *Ark. Zool.*, 42A (19) : 46, pl. III, fig. 3 (♂). (Type loc.—Kambaiti 2000 m., Burma).

Type : In Rm.

Frontal tufts and the base of antennae covered with black and white scales. Antennae brown, darker at tips. Labial palpi black. Thorax and abdomen golden yellow ; tegulae black anteriorly, mixed with whitish scales, and with golden yellow ones posteriorly. Fore wings silky white ; veins umber brown ; costa marked with several dark brown close striae ; an oblique well-defined dark brown band from apex to vein Cu_2 , and a curved geminate spot, below the cell between the base of vein Cu_2 and 1A, present ; the upper half of the larger part of geminate spot dark, rather blackish ; the lower half of the larger spot and whole of the smaller part of the geminate spot golden orange ; inner margin almost devoid of markings ; the area between oblique band and the outer margin marked by short brown striae from M_2 -1A. Hind wings pale ochreous white, with pale golden-yellowish cilia. Underside of both the wings whitish ; fore wings with the markings as on the upper side, spots not as brightly coloured as above ; hind wings with a few striae on the costa near the apical one-third. Underside of abdomen blackish throughout, and mixed with woolly-white hair. Legs greyish yellow, femora covered with woolly-white hair, mixed with blackish grey ones ; tarsi blackish, with white segmental bands.



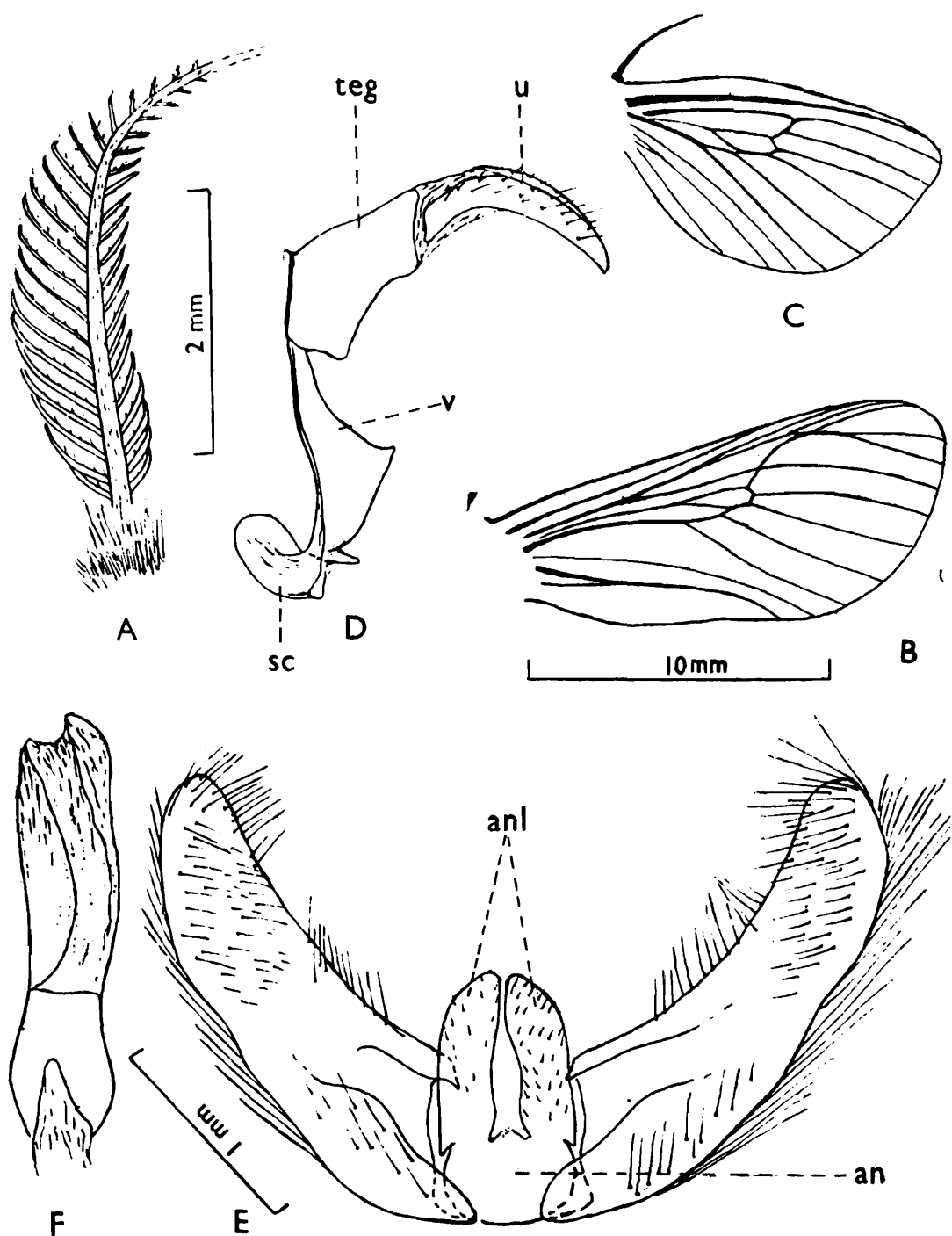
Text-fig. 23. *Phragmataecia obliquifascia* (Bryk) : An outline drawing of the male holotype.

Antennae (Text-fig. 24A) with 35 shaft-segments ; bipectinate up to the basal two-thirds ; the distal one-third serrate ; the longest rami about the length of four middle segments of shaft. Labial palpi minute. Frenulum, retinaculum, legs, spines and spurs as given for the genus.

Venation.—Fore wing (Text-fig. 24B) : Areole normal, long, projecting about one-fourth outside the cell ; vein R_1 arises from near the middle of areole, almost in line with origin of Cu_{1a} , or between origin of Cu_{1a} and Cu_{1b} ; R_2 from near the tip of areole ; R_3 stalked with $R_4 + R_5$; M_1 from well below the angle of cell ; median cell large, with the upper and lower branches ending between $M_1 - M_2$, and $Cu_{1a} - M_3$, respectively ; M_2 and M_3 separate but close. Hind wing (Text-fig. 24C) : Venation as for the genus.

Genitalia.—Male (Text-fig. 24D-F) : Uncus weakly sclerotised, triangular, broad basally, gradually narrowing distally into a narrow and rounded tip ; vinculum broad in the upper part. Saccus short. Clasper long, broader at the base, about four times as long as its width in the middle, and narrow distally. Juxta rounded ; anellus lobes long and narrow, about thrice as long as wide and narrower apically. Aedeagus short and slender, vesica not much enlarged.

Measurements.—Type material : Expanse : Fore wing, 39 mm. Length : Fore wing, 18 mm. ; hind wing, 14 mm. ; abdomen, 12 mm. ; whole body, 20 mm.



Text-fig. 24. *Phragmataecia obliquifascia* (Bryk) : (A) A portion of the male antenna showing pectinations. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers (E) Claspers in an inner view, with juxta. (F) Aedeagus. (B & C ; D to F of the same magnifications).

Other material.—Expanse : Fore wing, 37 mm. Length : Fore wing, 17 mm. ; hind wing, 12 mm. ; abdomen, 12 mm. , body, 18 mm.

Material examined.—Two examples as follows : India : Assam ; Lekhabali, 1 ♂, 7.x.1966 (S. K. Tandon and G. S. Arora coll.).

Burma : NE.Burma, Kambaiti, 2000 m., 'Types' 1♂, 12-17. vi. 1934 (*Malaise*).

Distribution.—India (Assam), Burma.

Remarks.—Referable to the genus *Phragmataecia*, the species was hitherto known under the genus *Xyleutes* (*vide* Bryk, 1950). It is very close to the other species *viz.*, *clara* and *stigmaticus*. (For detailed differences see under these species). On the basis of study of the type and other material present, the species has been transferred to the genus *Phragmataecia*, as done in *clara* and *stigmaticus*.

Hitherto known only from Burma (Type locality), this species is being recorded from India (Assam, Lekhabali) for the first time.

Genus *Xyleutes* Hübner

1822. *Xyleutes* Hübner, *Verz. bek. Schmett.* : 195 (Type *crassa* Drury from Africa).
1822. *Morpheis* Hübner, *Verz. bek. Schmett.* : 196 (Type *pyracmon* Cramer from Surinam) (*syn.* Dalla-Torre, 1923).
1822. *Chalcidica* Hübner, *Verz. bek. Schmett.* : 197 (Type *mineus* Cramer from Java) (*syn.* Hampson, 1892b ; Turner, 1918).
1844. *Strigoides* Guérin, *Icon. Reg. Anim. Ins.* : 505 (Type *leucolophus* Guér. from Amboina) (*syn.* Dalla-Torre, 1923).
1854. *Endoxyla* Herrich-Schäffer, *Samml. Ausser. Schmett.*, 1 : 7 (Type *d'Urvillei* from Australia (*syn.* Turner, 1918).
1880. *Duomitus* Butler, *Ann. Mag. nat. Hist.*, (5) 6 : 68 (Type *ligneus* Butler from Darjeeling) (*syn.* Piepers & Snellen, 1900).
1883. *Hinnaeya* Moore, *Lep. Ceylon*, 2 : 153 (Type *leuconota* Walker from Ceylon) (*syn.* Hampson, 1892 b ; Turner, 1918).
1887. *Duomitus*, Cotes and Swinhoe, *Cat. Moths of India* : 234.
1892. *Strigoides*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.*, 1 : 280.
1892. *Chalcidica*, Kirby, *Cat. Lep. Het.* : 872.
1892. *Xyleutes*, Kirby, *Cat. Lep. Het.* : 873.
1892. *Duomitus*, Kirby, *Cat. Lep. Het.* : 877.
- 1892b. *Duomitus*, Hampson, *Fauna Brit. India, Moths*, 1 : 307.
1900. *Endoxyla*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 38.
1905. *Xyleutes*, Schaus, *Proc. U.S. Nat. Mus.*, 29 : 339.
1912. *Duomitus*, Seitz, in *Seitz Macrolepidoptera of the World*, 2 : 418.
1917. *Xyleutes*, Chapman, *Entomologist's Rec.*, 29 (3) : 5.
1918. *Xyleutes*, Turner, *Trans. ent. Soc. Lond.*, 66 : 162, 163, 174.
1923. *Xyleutes*, Dalla-Torre, *Lepid. Cat.*, 29 : 49.
1929. *Xyleutes*, Gaede, in *Seitz Macrolepidoptera of the World*, 14 : 546.
1933. *Xyleutes*, Gaede, in *Seitz Macrolepidoptera of the World*, 10 : 813.
1950. *Xyleutes*, Bryk, *Ark. Zool.*, 42A (19) : 46.
- 1951b. *Chalcidica*, Viette, *Lambillionea*, 51 (5-8) : 40.
- 1951b. *Duomitus*, Viette, *Lambillionea*, 51 (5-8) : 42.
- 1951b. *Endoxyla*, Viette, *Lambillionea*, 51 (5-8) : 42.

- 1951b. *Hinnaeya*, Viette, *Lambillionea*, **51** (5-8) : 43.
 1951b. *Strigoides*, Viette, *Lambillionea*, **51** (11-12) : 71.
 1951b. *Xyleutes*, Viette, *Lambillionea*, **51** (11-12) : 72.
 1957. *Xyleutes*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nat.*, (2) **52** (1) : 18.
 1965. *Xyleutes*, Müller, *Dt. Z. Ent.*, **12** (3) : 245.

Type species : *Noctua crassa* Drury.

(a) *General*

Hübner (1822) while erecting the genus *Xyleutes* listed four species, viz., *crassa* Drury, *strix* Linn., *cossus* Linn., and *terebra* Schiffermüller, but did not designate any type of the genus. Gaede (1929) cited *crassa* Drury as the type, and has been followed by Viette (1951b) and Roepke (1957).

The earliest record of a *Xyleutes* species from India is by Donovan (1800) who recorded '*Mineus*' from Bengal. Walker (1856) described *leuconota* and *signata*; Butler (1800) described *ligneus*; and Moore (1877, 1879b) added two species, viz., *nigra* and *pardicolor*, from the Indian region. Hampson (1892b) in his 'Fauna of British India', synonymised *ligneus* and *signata* with *ceramicus* and *strix*, respectively, both belonging to the family Cossidae, and *pardicolor* to *Arbela quadrinotata* Walker, belonging to the family Arbelidae. He (*loc. cit.*) also described a new species, viz., *Duomitus fuscipars* from Sikkim, thus bringing the number of species from India to six. Dudgeon (1899) added a species from Sikkim, viz., *Duomitus pardalis*, which was later synonymised by Gaede (1933) with *pardicolor* Moore. Bryk (1950) referred two more species, *obliquifascia* and *clara*, to *Xyleutes*. These have, however, been transferred to the genus *Phragmataecia* in the present revisionary study.

Thus, in all seven species are hitherto known from the Indian subregion. Except *Xyleutes fuscipars* (Hampson), of which no material was available, all other species have been redescribed from the actual material. In case of *X. pardicolor* (Moore), the type was examined. A new species from Andamans has been described here.

(b) *Characters of the Genus Xyleutes Hübner*

Antennae in male bipectinate from base up to nearly the middle, the distal part minutely serrate; in female simple throughout, with the shaft cylindrical from base up to the middle, but laterally flattened beyond the middle. Labial palpi either short or long, nearly always porrect, the third segment shortest. Wings long and narrow in male, broader in female, the expanse reaching sometimes up to 180 mm. in females. Abdomen shorter or longer than the hind wings. Frenulum spine single in male, as many as 20-30 in female; retinaculum

in male forming an elongated lobe. Hind tibiae with a single pair of minute spurs. Tarsal spines sparse from first to the fourth joint and absent or indistinct on the fifth. Arolium absent.

Venation.—Fore wings : Areole either large and projecting by one-third its length outside the cell angle, or short and projecting by half its length ; vein R_1 usually arises from near the distal end of areole, rarely from cell, in the latter case the areole reduced in size ; vein R_3 close to or shortly stalked with $R_4 + R_5$; M_1 from well below the upper angle of cell (except in *pardicolor* and *kapuri* where it is either from angle or above) ; median cell with the upper branch ending between M_1-M_2 , and the lower branch between veins $Cu_{1a}-M_3$; M_2 and M_3 close, M_2 arises from above the angle and M_3 from the angle. Hind wings : With vein Sc free ; veins Rs and M_1 wide apart at base ; median cell with the branches ending as in the fore wing : veins M_2 and M_3 wide apart at base, M_2 arises from above the angle, M_3 from the angle.

Male genitalia well developed. Claspers broad in middle. Uncus sclerotised, broad at the base and narrower distally. Gnathos present, free and not united with each other mid-ventrally. Juxta generally reduced. Aedeagus well built and differentiated into a short base and a large vesica, the latter always with a well developed and strong cornutal process. Female genitalia with large corpus bursae ; signum and the receptaculum seminalis present ; genital tube long ; genital plate without much sclerotisation.

(c) Relationships of the Genus *Xyleutes* with the other allied Genera

A true Zeuzerine genus, it consists of some of the largest Indian species (*viz. mineus, persona* and *strix*) of the family Cossidae. On account of antennae, which are bipectinate up to the basal half in male, the genus *Xyleutes* is close to *Azygophelps*, but differs from it by the widely separate veins M_2 and M_3 in hind wings and absence of arolium in between the claws ; the antennae simple in female, whereas in *Azygophelps* these are pectinate in both the sexes. From the genus *Zeuzera*, it can be separated by the absence of a cross bar between veins Sc and Rs in hind wings and by having a larger areole in the fore wings. From *Phragmataecia*, it differs by the antennae which are bipectinate up to basal half in male and simple in female unlike in the latter where these are bipectinate up to nearly two-thirds in both sexes ; by the absence of arolium ; and by the presence of tarsal spines.

(d) Geographical Distribution of the Genus *Xyleutes*

The genus *Xyleutes* is known from all the zoogeographical regions except the Palaearctic. Most of the species occur in the Indo-Austra-

lian regions. In the Oriental region the genus is represented in India (Kashmir, Himachal Pradesh, West Bengal, Orissa, Assam, Arunachal Pradesh, Sikkim), Bhutan, Bangladesh, Burma, Ceylon, Indochina, Indonesia and Philippines.

(e) *Key to Indian Species of the Genus Xyleutes*

1. Areole in the fore wing moderately large ; vein R_1 arising from cell 2
 Areole in the fore wing very large ; R_1 arising from areole 3
2. Fore wing with rounded or sub-rounded spots all over Hind wing with coloured patches in between veins from the outer margin to a little inside the cell ; the cell marked in the distal half *pardicolor* (Moore)
 Fore wings with striae all over, striae denser in distal half. Hind wings with striae in between veins from the outer margin up to discocellular and 1A and 2A ; the cell unmarked completely *kapuri* sp.n.
3. Head, thorax and abdomen with metallic shine (bluish-green). Fore wing with large spots *mineus* (Cramer)
 Head, thorax and abdomen without metallic shine. Fore wing without large spots 4
4. Smaller species. Wings blackish, irrorated with greyish scales *nigra* (Moore)
 Larger species. Wings dark brown, and irrorated with whitish scale 5
5. Abdomen with a dark longitudinal line on dorsal and ventral sides. Fore wing with ringed-patches on inner margin *ceramicus* (Walker)
 Abdomen without any longitudinal line on dorsal and ventral sides. Fore wing without ringed-patches, but with numerous striae forming a net work 6

6. Thorax and the last abdominal segment covered with white scales. Fore wing with a prominent dark streak beyond the cell. Corpus bursae with a rounded signum *persona* (Le Guillou)

Thorax and the last abdominal segment without white scales. Fore wing with a weak streak beyond the cell. Corpus bursae with a triangular signum *strix* (Linn.)

(f) *Descriptions of Species*

27. *Xyleutes pardicolor* (Moore)

(Pl. III, fig. 28 ; Text-fig. 25)

- 1879b. *Zenzera pardicolor* Moore, *Descr. Indian Lep. Atk.* : 86 (Type loc.—Darjeeling).
 1887. *Zeuzera pardicolor*, Cotes and Swinhoe, *Cat. Moths of India* : 234.
 1892b. *Zenzera pardicolor*, Hampson, *Fauna Brit. India, Moths*, 1 : 315 (treated as a syn. of *Arbela quadrinotata* Walker—family 'Arbelidae').
 1892. *Zeuzera pardicolor*, Kirby, *Cat. Lep. Het.* : 872.
 1899. *Duomitus pardalis* Dudgeon, *J. Bombay. nat. Hist. Soc.*, 12 (4) : 645 (Type loc.—Sikkim) [*syn.* Gaede, 1933].
 1900. *Duomitus pardalis*, Hampson, *J. Bombay nat. Hist. Soc.*, 13 : 228.
 1923. *Zeuzera pardicolor*, Dalla-Torre, *Lepid. Cat.*, 29 : 39.
 1923. *Xyleutes pardalis*, Dalla-Torre, *Lepid. Cat.*, 29 : 52.
 1933. *Xyleutes pardicolor*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 819.
 1957. *Xyleutes pardicolor*, Roepke, *Verh. K. ned. Akad. Wet. Afd. nat.*, (2) 52 (1) : 34.

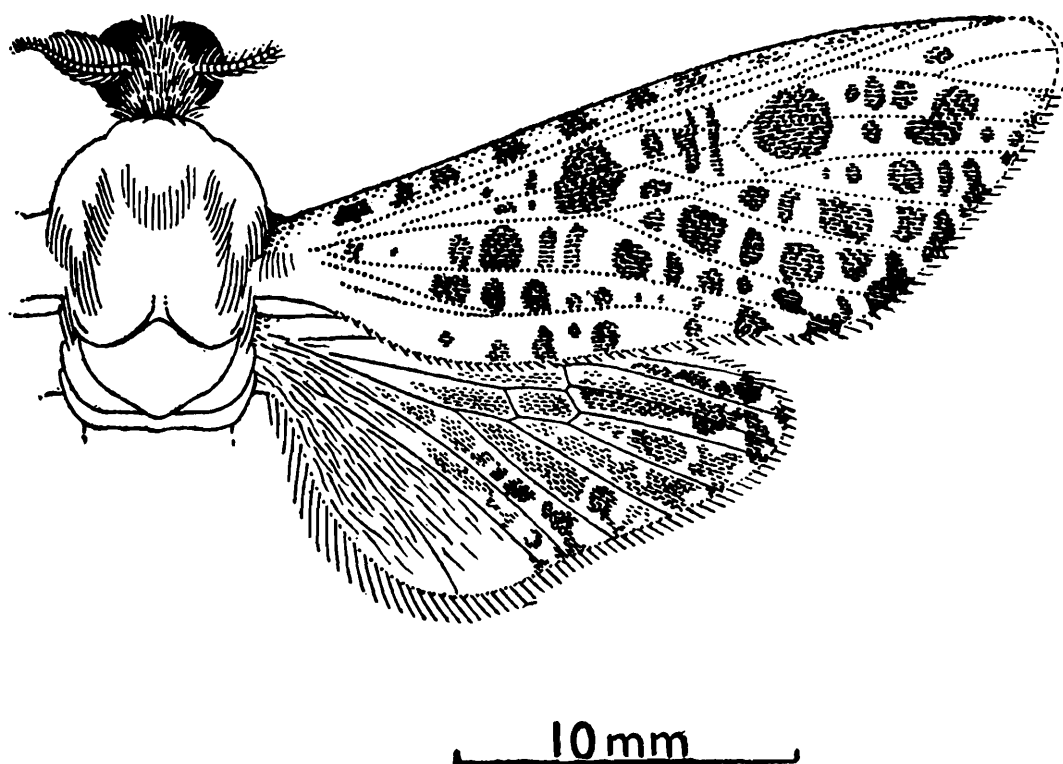
Types : *pardicolor* Moore—a male in Ber. Mus.

pardalis Dudgeon—a male in B. M.

The only material of this species, available for the present study, was that of the type (♂), received from the Berlin Museum, Berlin, and was found to be in a damaged condition. The following description is based on this type.

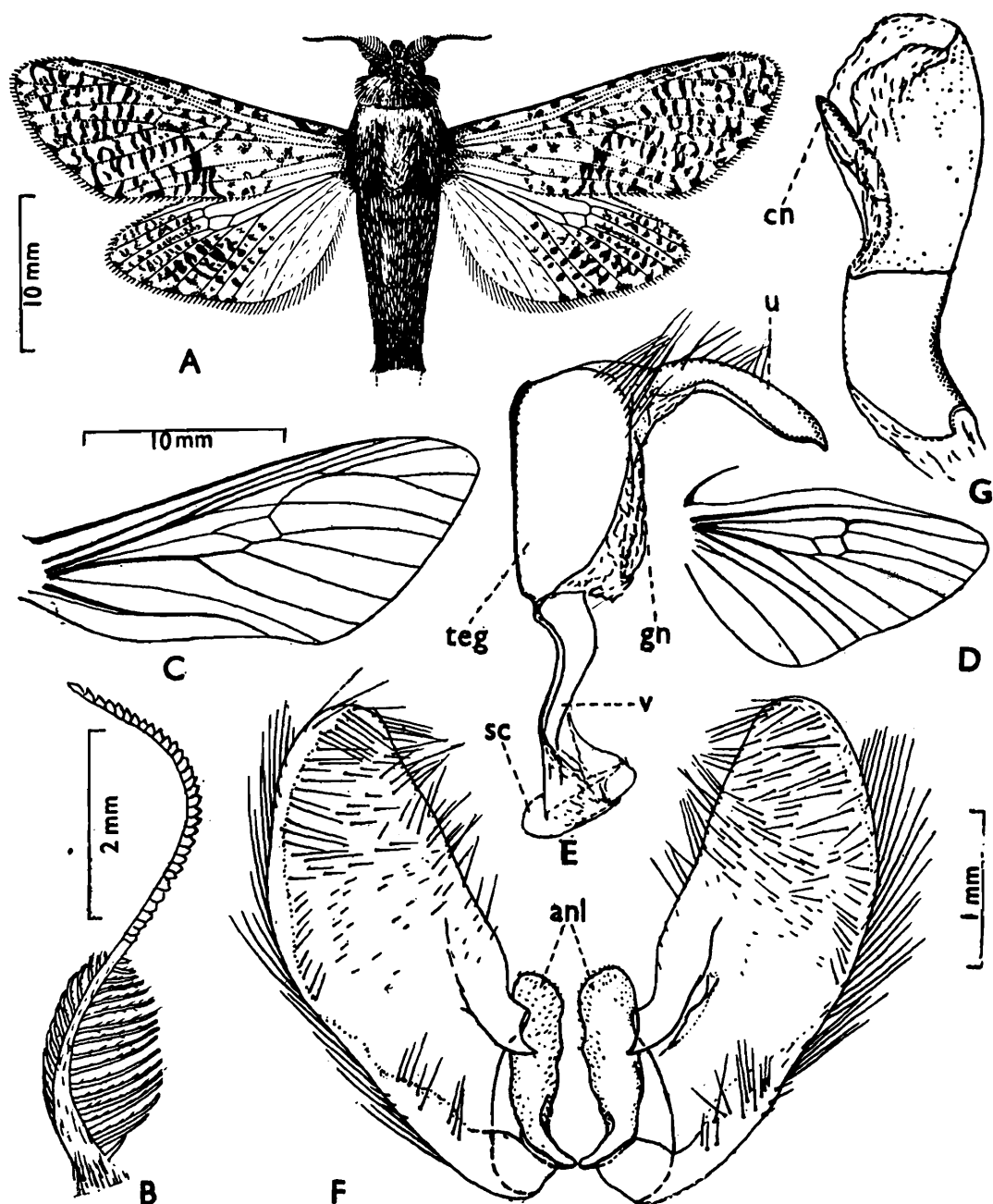
Head with the frontal tufts and the vertex light brown above, blackish in the front and intermixed with light brown scales below. Antennae and eyes brown. Labial palpi blackish brown. Thorax brownish-white, with a row of three black spots on each side ; tegulae

brownish-white, each with a black spot. Fore wings brownish white, with dark brown rounded spots; a prominent series of small spots in between the veins, and a large spot each in the cell and beyond it, present, the latter being the largest; a few spots having a weak reddish tinge, also present in the inner and the marginal areas; veins pale brown to brown. Hind wings also brownish white and with a series of confluent dark brown markings in between the veins and in the distal half of the cell; anterior margin and some area in the cell whitish; inner area pale brown and covered with long hairy scales of the colour of wing. Underside of both wings marked as on the upperside, the area below Cu_2 without any spots; hind wings with a small whitish area at the base of the cell. Legs whitish, with broad black bands.



Text-fig. 25. *Xyleutes pardicolor* (Moore) : An outline drawing of the male type (Specimen badly damaged).

Frontal tufts small. Antennae (incomplete) bipectinate up to basal 16 segments; the rami longest in the middle and as long as about five segments of the shaft; the distal part serrate. Labial palpi short, closely appressed to face and not reaching up to the frontal tufts. Frenulum in the form of a single stout spine; retinaculum short and slightly excurved. Legs with a pair of minute spurs on the hind tibiae; basal four tarsal joints with rows of small spines, the last one without spines, claws without arolium.



Text-fig. 26. *Xyleutes kapuri* sp.n. : (A) An outline drawing of the male holotype (Abdomen partly shown). (B) Male antenna. (C) and (D) Fore and hind wing venation, respectively. (E) Male genitalia in a lateral view, without claspers. (F) Claspers in a inner view with anellus. (G) Aedeagus (C-D ; E to G of the same magnifications).

Venation.—Fore wing (Text-fig. 25) : Areole small, projecting outside the cell angle by half its length and lying almost in line with origin of median cell ; vein R_1 arises from the cell and in line with the origin of vein Cu_{1b} ; vein R_2 from near the distal end of areole ; R_3 stalked with $R_4 + R_5$ and nearer to areole than to R_4 ; M_1 from above the cell angle ; median vein with its branches ending between $M_1—M_2$ and $Cu_{1a}—M_3$, the lower one nearer vein Cu_{1a} than M_3 ; veins

M₂—M₃ close but separate ; vein M₃ from the angle. Hind wing with the venation mainly as for the genus.

Genitalia.—Not studied.

Measurements.—Type : Expanse, 51 mm. Length : Fore wing, 22.5 mm. ; hind wing, 15 mm. ; abdomen, incomplete in the specimen.

Material examined.—India : West Bengal ; Darjeeling, 1 ♂, 1869 (Staudinger coll.), labelled as "*Zenzera pardicolor* ♂ type Moore" (colln. Atkinson) (ex. colln. Ber. Mus.).

Distribution.—India (West Bengal, Sikkim).

Remarks.—The species differs from all the species of this genus, except *X. kapuri* sp. n., in respect of the origin of vein R₁, which arises from cell in both of these species, whereas it arises from areole in the other species. From *kapuri* sp.n., it differs by the presence of several rounded or subrounded spots on the fore wing whereas in *kapuri* there are short striae, and by the presence of markings in distal half of the cell in the hind wing whereas in *kapuri* the cell is completely without any markings.

28. *Xyleutes kapuri* sp. n.

(Pl. III, fig. 29 ; Text-fig. 26)

Head with the frontal tufts and labial palpi dark brown, the former brown above. Antennae brown. Collar with a short, black cross streak. Thorax dark greyish brown, upperside marked with two longitudinal, black stripes. Tegulae with a spot each, of the same colour as the stripes on thorax. Abdomen dark-greyish brown. Wings semihyaline ; fore wings marked with numerous, dark brown striae in between veins, those beyond the cell forming lines and those inside and below the cell, fainter ; marginal series of spots from base to vein 1A distinct. Hind wings with the striae present between the cell and the outer margin ; inner area, the cell and the area above it, unmarked. Underside from head up to base of fore legs black. Legs pale reddish brown ; fore and mid tibiae marked on the upper-side with two large black spots, hind tibiae without spots ; 1st to 3rd tarsal joints with black bands, 4th and 5th completely black ; claws reddish brown.

Head with the labial palpi short and porrect. Antennae (Text-fig. 26B) bipectinate to nearly one-third its length, the distal part serrate ; shaft with 42 segments, of which 17 pectinate, the last segment simple and elongate ; the rami longest in the middle, as long as about six middle segments. Hind tibiae with a single pair

of short spurs ; tarsi with minute spines from the first to fourth segment ; claws without arolium. Frenulum single, extending far beyond the retinaculum, the latter broad at the base and not curved, about four times as long as its width in middle.

Venation.—Fore wings (Text-fig. 26C) : Areole in fore wing moderately large, with its origin in line with the origin of median cell ; vein R_1 arises from cell and in line with the origin of Cu_{1b} ; R_2 from near the tip of areole ; R_3 shortly stalked with R_4+R_5 ; the latter two forming a long stalk ; M_1 from upper angle of cell ; M_2 and M_3 close at base ; the lower branch of median cell ending between Cu_{1a} and M_3 ; Hind wings (Text-fig. 26D) : Broadly as for the genus.

Genitalia.—Male (Text-fig. 26E-G) : Uncus short, about twice as long as its width in middle and highly sclerotised ; strongly bent from the base and ending into a pointed hooked tip. Gnathos rather weak. Tegumen broadly oval, gradually narrowing towards base ; vinculum narrow, ending into a short saccus. Clasper broadest in the middle, about twice as long as its width in middle ; slightly depressed at the base dorsally and ending in a fold ; simple mesally. Juxta absent ; anellus lobes distinct, narrow at the base and broadly elongate in the distal part. Aedeagus rather short, stout and clearly differentiated into sclerotised base and vesica, the latter with a few striation and a hard cornutal process. Female : Not known.

Measurements.—Holotype : Expanse : Fore wing, 48 mm. Length : Fore wing, 21.5 mm. ; hind wing, 15 mm. ; abdomen, 14 mm. ; whole body, 21 mm. Paratypes : Expanse : Fore wing, 35-52mm. Length : Fore wing, 15-23 mm. ; hind wing, 11-15 mm. ; Abdomen, 11-15 mm. ; whole body, 16-23 mm.

Holotype : A male : India : S. Andaman ; Humphrygunj, 106.68 m. 3.iii.1964 (B. S. Lamba coll.) Paratypes : 8♂♂ ; India : Middle Andaman ; Rangat Rest House, at light, 1♂, 4.i.1973, 1♂, 6.i.1973, 1♂, 7.i.1973, 2♂♂, 8.i.1973 (all G. S. Arora coll.). S. Andaman ; Humphrygunj Rest House, at light, 1♂, 13.iii.1975, 2♂♂, 14.iii.1975 (all G. K. Srivastava coll.). Deposited in Zoological Survey of India.

Remarks.—It is remarkably different from the other Indian species for its wing pattern which is more like *Zeuzera* species.

It is close to *X. pardicolor* (Moore) especially in respect of the origin of the vein R_1 which is from the cell. For differences see under *pardicolor*.

It is also close to a Malayan species, *X. malayica* Roepke, in respect of the wing pattern but, however, can be separated by the pre-

sence of two longitudinal, black stripes on thorax and for the longer stalk of the veins R_4+R_5 in the fore wing. The uncus in male genitalia is short and bent unlike in *malayica* where it is broad, short and straight.

29. *Xyleutes mineus* (Cramer)

(Pl. III, fig. 30 ; Text-fig. 27)

- 1779. *Phalaena mineus* Cramer, *Papill. Exot.*, 2 : 5, pl. 131, fig. D (Type loc.-Batavia).
- 1800. *Phalaena bombyx mineus*, Donovan, *Ins. India* : 82 (Bengal).
- 1821. *Zeuzera viridicans* Eschscholtz, in Kotzebue *Ent. Reise*, 3 : 219, pl. 11, fig. 29 (Type loc.- Ganjam) (*syn.* Kirby, 1892).
- 1822. *Chalcidica mineus*, Hübner, *Verz. bek. Schmett.* : 197.
- 1838. *Zeuzera mineus*, Westwood, *Nat. Hist. Ins. India* : 83.
- 1856. *Zeuzera mineus*, Walker, *List Lep. Het. Brit. Mus.*, 7 : 1535. (Sylhet).
- 1865. *Zeuzera mineus*, Moore, *Proc. zool. Soc. Lond.* : 822.
- 1887. *Zeuzera mineus*, Cotes and Swinhoe, *Cat. Moths of India* : 233.
- 1892. *Chalcidica mineus*, Kirby, *Cat. Lep. Het.* : 872 (Indonesia).
- 1892. *Zeuzera mineus*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 283.
- 1892b. *Duomitus mineus*, Hampson, *Fauna Brit. India, Moths*, 1 : 309. (Bangladesh, India (Calcutta, Sikkim, Ganjam), Java and Manilla).
- 1899. *Duomitus mineus*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 645 (Bengal).
- 1900. *Endoxyla mineus*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 39 (Java).
- 1909. *Duomitus mineus*, Lefroy, *Indian Insect Life.* : 495.
- 1923. *Xyleutes mineus*, Dalla-Torre, *Lepid. Cat.*, 29 : 52 (Batavia, Bangladesh, India, Manilla, Java, Cambodia, Siam, Philippines and New Guinea).
- 1933. *Xyleutes mineus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 818 (India, Indo-china, Sunda Is., Philippines and New Guinea).
- 1951b. *Chalcidica mineus*, Viette, *Lambillionea*, 51 (5-12) : 40 (Batavia).
- 1955. *Xyleutes mineus*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 284.
- 1957. *Xyleutes mineus*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 25, 57. (India to Philippines and New Guinea).
- 1965. *Xyleutes mineus*, Müller, *D. ent. Z.*, 12 (3) : 251.

Type : Lost (*vide* Roepke, 1957).

Antennae, thorax and abdomen dark metallic bluish-green. Fore wings yellowish, with a pinkish tinge, the base bluish green ; spots of the same colour also present along the costa ; the largest ones being one beyond cell, and another just before the apex, smaller spots at the centre near the end of cell ; with a large oval, transverse spot from median nervure to inner margin and another large, longitudinal spot extending from below the end of cell at vein 1A nearly up to the apex at vein R_5 . Hind wing yellowish, with some blackish brown on inner area and bluish black streaks in the inter-spaces

beyond cell ; two spots on costa near apex and a series of marginal spots present. Underside of palpi and thorax, up to fore legs, tinged with metallic blue green.

Head with the labial palpi large, porrect and reaching as far as the frontal tufts. Antennae shaft (Text-fig. 27A) with 60-62 short segments ; bipectinate in male from base to nearly middle of shaft, or up to some 22 segments ; the distal part with about 40 short segments, minutely serrate, the last segment simple, rami very long in the middle, about as long as ten middle segments of shaft ; antennae in female simple, laterally flattened in distal part.

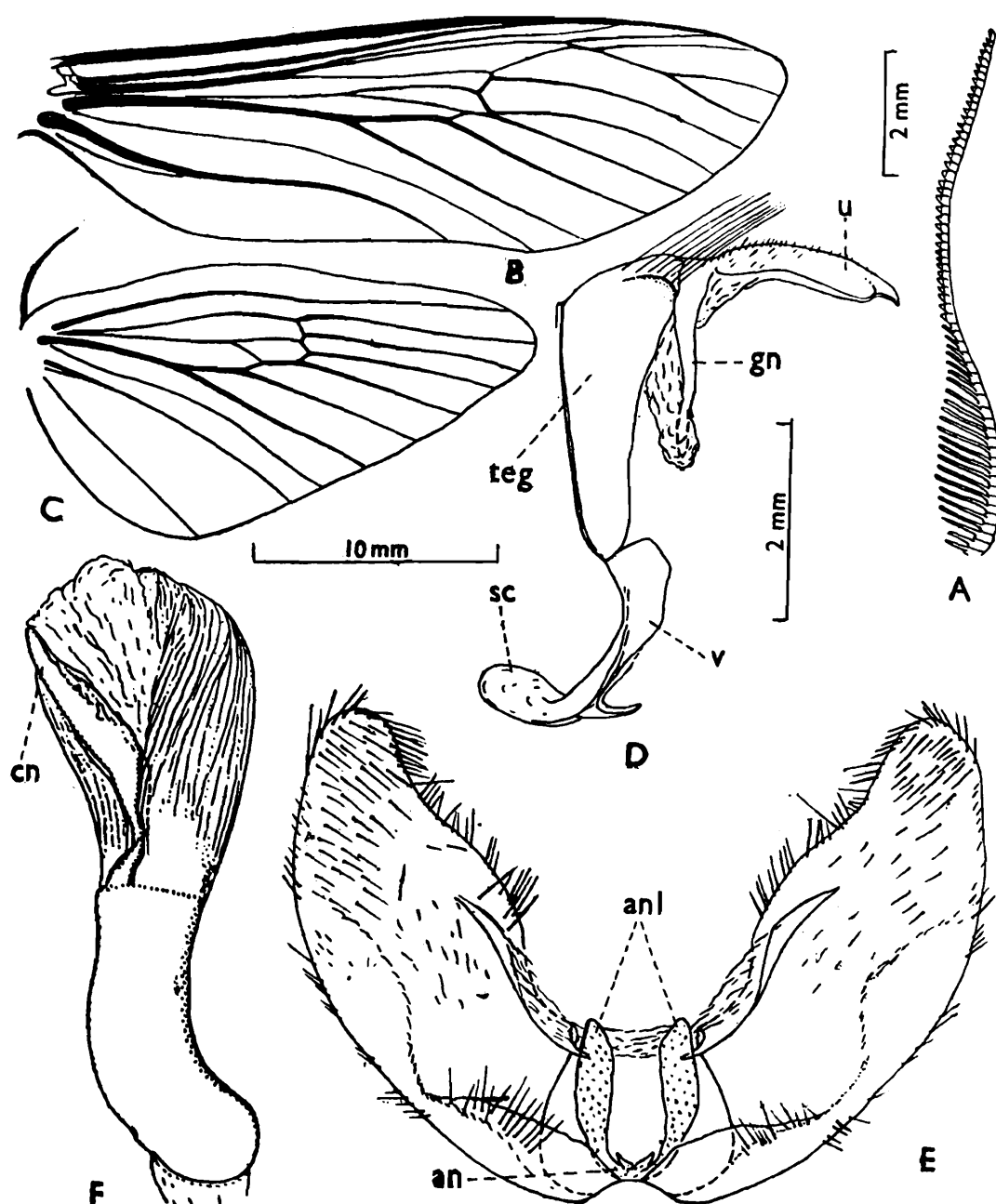
Venation (Text-fig. 27B-C) : Broadly as for the genus.

Genitalia.—Male (Text-fig. 27D-F) : Uncus broadly triangular, sclerotised and sharply pointed downwards in the form of a hook ; about twice as long as its width in middle. Tegumen broadly triangular, narrow at base. Saccus more or less globular. Gnathos long, the ends incurved and coming close to each other but not uniting. Clasper about two-and-a-half times as long as its width in middle ; broader in the middle than at base or apex, the latter almost rounded at the tip and beset with long hair on outer side ; ventral margin wavy. Juxta small and reduced ; anellus lobes long, broader distally. Aedeagus well built ; markedly differentiated into a short base and a large sclerotised and striated vesica, the latter with a hard, sclerotised cornutal process. Female : Ostium bursae and ductus bursae sclerotised ; corpus bursae large, nearly quadrangular, with a signum, the latter slightly depressed and beset with short spinose protuberances ; receptaculum seminalis large and nearly globular, with a fine duct entering into ductus bursae.

Measurements.—Expanse : Fore wing : male, 65 mm. ; female, 110-126 mm. Length : Fore wing : male, 28 mm. ; female, 55-59 mm. Hind wing : male, 22 mm. ; female, 38-40 mm. Abdomen : male, 22 mm. ; female, damaged. Whole body : male, 38 mm. ; female, Damaged.

Material examined.—India : W. Bengal : Darjeeling, 3 ♂♂, 28.ii.1880 (no further data) ; Calcutta, 1 ♀, -x-1870 (no further data). Bihar : Pusa, 1 ♂, 1 ♀, 29.viii.08 (*C.M.E.* coll.) (wild bush) (ex. colln. *I.A.R.I.*). Orissa : Puri, 1 ♂, (no date) (*D. Walsch* coll.). Arunachal Pradesh : Kameng Division, Kimin, 1 ♂, 9.v.1966 (*A.N.T. Joseph* coll.). Sikkim : 548.63 m., 1 ♀, -.viii.1897, 1 ♀, -.ix.1897, 2 ♂♂ (no date) (All *G. C. Dudgeon* coll.).

Bangladesh : Sylhet, 1 ♂, 1 ♀, 28.ii.1880 (no other data).



Text-fig. 27. *Xyleutes mineus* (Cramer) : (A) Male antenna showing pectinations of one side. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers. (E) Claspers in inner view, with anellus. (F) Aedeagus., (B & C ; D to F of the same magnifications).

Distribution.—This is a very widely distributed species in the Oriental region and is recorded from India (W. Bengal, Sikkim, Assam, Arunachal Pradesh, Bihar and Orissa), Bangladesh (Sylhet), Indonesia, Thailand, Indo-china (Cambodia) and the Philippines. It is also known from New Guinea in the Australian region.

Remarks.—Cramer (1779) while describing the species from Batavia, illustrated a male with the antennae filiform, though he mentions

them as "plumose" Later, Donovan (1800) figured a male from Bengal and characterised it as "Antennae gradually tapering from base" As also stated by Roepke (1957), the antenna in the male figured by Cramer (1779) is erroneous and does not represent the true structure of male antenna.

This species is readily distinguishable from all the other species of the genus by its metallic bluish-green tinge on the body and by the large conspicuous spots on both wings which are also tinged with metallic bluish-green. In male genitalia, it is characterised by reduced juxta which is without a median lobe ; and the corpus bursae, in the female genitalia, having a quadrangular signum.

30. *Xyleutes nigra* (Moore)

(Pl. III, fig. 31)

1877. *Zeuzera nigra* Moore, *Ann. Mag. nat. Hist.*, (4) 20 : 348. (Type loc.- Ceylon).
 1883. *Zeuzera nigra*, Moore, *Lep. Ceylon*, 2 : 155.
 1887. *Zeuzera nigra*, Cotes and Swinhoe, *Cat. Moths of India* : 233.
 1892. *Zeuzera nigra*, Kirby, *Cat. Lep. Het.* : 872.
 1892b. *Duomitus nigra*, Hampson, *Fauna Brit. India, Moths*, 1 : 307. (Nilgiris, Ceylon).
 1923. *Xyleutes nigra*, Dalla-Torre, *Lepid. Cat.*, 29 : 52. (Nilgiris, Ceylon).
 1933. *Xyleutes nigra*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 816 (Nilgiris, Ceylon).

Type : In B.M.

Host : Coffee.

Head, thorax and abdomen blackish. Frontal tufts blackish, irrorated with grey scales. Antennae and labial palpi blackish. Fore wings blackish, densely irrorated with greyish scales ; a large area beyond the cell angle without greyish scales. Hind wings blackish, densely irrorated with grey scales in the lower half of wings ; the area between costa and cell golden yellow to pale ochreous. Underside of fore wings with the coloration as on upperside ; hind wings without pale ochreous colour above the cell, otherwise as on upper-side. Legs black.

Antennae simple (incomplete and damaged apically). Labial palpi short and slender. Frenulum spines several. Legs with the spurs and spines, as for the genus.

Venation.—Mainly as for the genus.

Genitalia.—Not studied (abdomen damaged in the specimens available for this study).

Male : Not known.

Measurements.—Expanse : Fore wing, 48-72 mm. Length : fore wing, 23-34 mm. ; hind wing, 14-21 mm. ; abdomen, 15-30 mm. ; whole body, 21-44 mm.

Material examined.—2 examples as follows : Ceylon ; Kandy, 1 ♀, 16.x.1903 ; 1 ♀, -.v.1905 (Both *E.E. Green* coll.).

Distribution.—India (Nilgiris), Sri Lanka

Remarks.—Referable to the genus *Xyleutes*, it can very well be differentiated from the other species by the colour of its body and wings which are irrorated with grey scales.

31. *Xyleutes ceramicus* (Walker)

(Pl. III, fig. 32 ; Text-fig. 28)

- 1865. *Zeuzera ceramica* Walker, *List Lep. Brit. Mus.*, 32 : 587 (Type loc.-Ceram, Amboina, Indonesia).
- 1880. *Duomitus ligneus* Butler, *Ann. Mag. nat. Hist.*, (5) 6 : 68. (Type loc.-Darjeeling) (syn. Hampson, 1892(b)).
- 1886. *Duomitus ligneus* Butler, *Ill. Typ. Lep. Het.*, 6 : 29.
- 1887. *Duomitus ligneus*, Cotes and Swinhoe, *Cat. Moths of India* : 234.
- 1892. *Endoxyla bosschae* Heylaerts, *Annls. Soc. ent. Belg.*, 36 : 45 (Type loc.-Borneo) (syn. Roepke, 1957).
- 1892. *Strigoides ceramica*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 280.
- 1892b. *Duomitus ceramicus*, Hampson, *Fauna Brit. India, Moths*, 1 : 307 (Sikkim, Indonesia and New Zealand).
- 1892. *Xyleutes ceramicus*, Kirby, *Cat. Lep. Het.* : 875 (Nias and Indonesia).
- 1892. *Duomitus' ligneus*, Kirby, *Cat. Lep. Het.* : 877. (Darjeeling).
- 1899. *Duomitus ceramicus*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 645 (Sikkim).
- 1916. *Strigomorphus ceramicus*, Houlbert, in Oberthur *Etud. Lep. Comp.*, 11 : 113.
- 1916. *Endoxyla bosschae*, Houlbert, in Oberthur *Etud. Lep. Comp.*, 11 : 113.
- 1916. *Duomitus ceramicus*, Beeson, *Rep. Bd. scient. Advice India*, 1914-15 : 167.
- 1917. *Duomitus ceramicus*, Chatterjee, *Rep. Bd. scient. Advice India*, 1915-16 : 174.
- 1918. *Duomitus ceramicus*, Beeson, *Rep. Bd. scient. Advice India*, 1915-16 : 96.
- 1923. *Endoxyla bosschae*, Dalla Torre, *Lepid. Cat.*, 29 : 49 (Panama).
- 1923. *Xyleutes ceramicus*, Dalla Torre, *Lepid. Cat.*, 29 : 50 (Ceram, Nias, New Zealand and Darjeeling (India).
- 1933. *Xyleutes ceramicus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 818 (Ceram, Nias, New Zealand).

1936. *Xyleutes ceramicus*, Atkinson, *Indian For. Res. (N. S.) Ent.*, 2 (1) : 98 (Rangoon).
1941. *Xyleutes ceramicus*, Beeson, *The Ecology and the Control of Forest Insects of India and the Neighbouring Countries* : 573, 953.
- 1951b. *Xyleutes ceramicus*, Viette, *Lambillionea*, 51 (5-12) : 42.
1955. *Xyleutes ceramicus*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 284 (New Guinea).
1957. *Xyleutes ceramicus*, Roepke, *Verh. K. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 34-35 (Burma, Malaya Peninsula).
1958. *Xyleutes ceramicus*, Kaput, in *Problems of Humid Tropical Regions* : 63.
1959. *Xyleutes ceramicus*, Insects : In *Wealth of India*, 5 : 205 (C.S.I.R., New Delhi).
1959. *Xyleutes ceramicus*, Mathur and Singh, *Forest. Bull. Dehra Dun*, 171 (4) : 61.
- 1961a. *Xyleutes ceramicus*, Mathur and Singh, *Forest Bull. Dehra Dun*, 171 (8) : 36.
1965. *Xyleutes ceramicus*, Müller, *Dt. ent. Z.*, 12 (3) : 248-250.

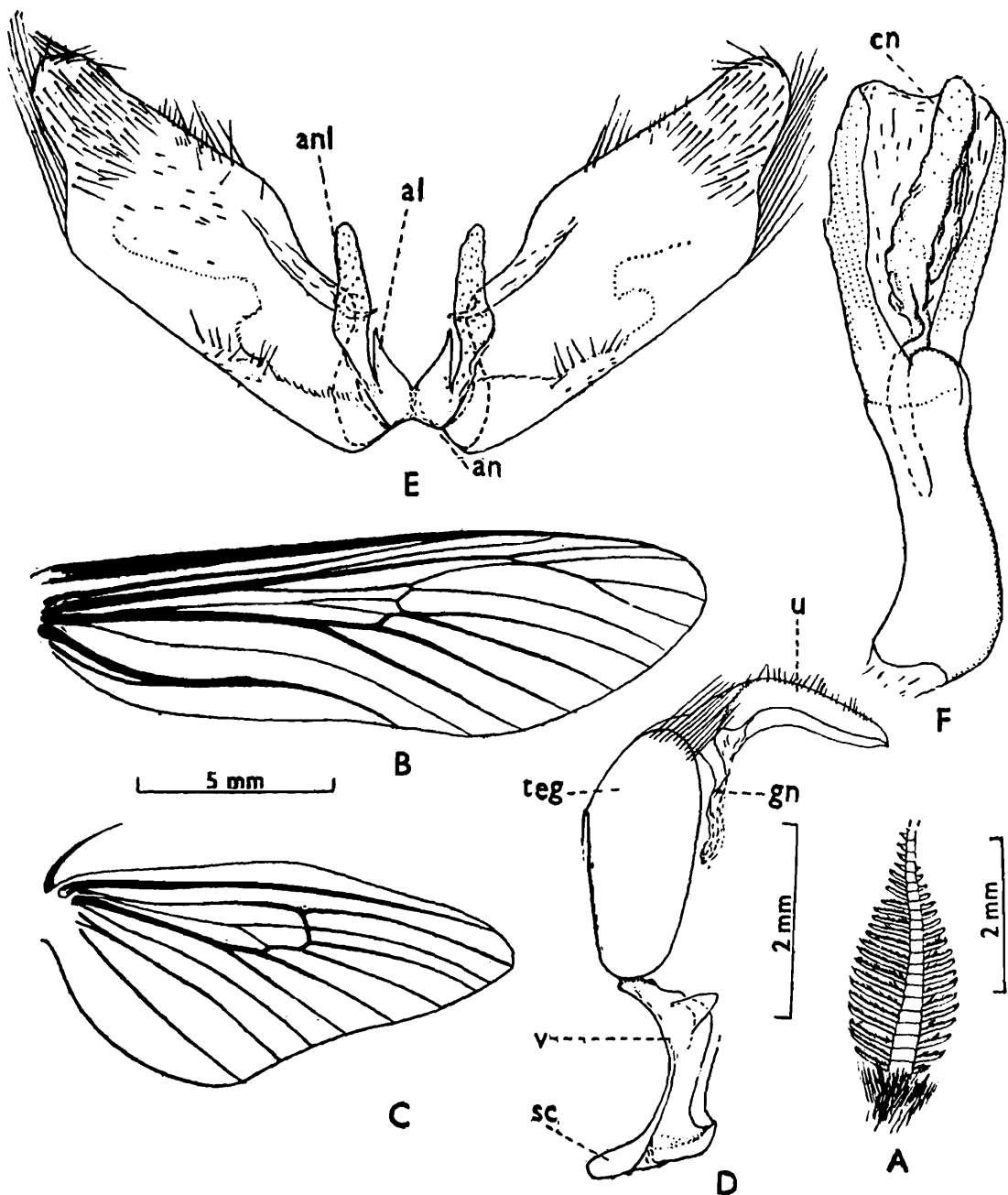
Types : *ceramica* (Walker). In colln. Wallace, Ox. Univ. Mus.
ligneus Butler—In B.M.
bosschae Heylaerts—In Leiden Museum.

Hosts : *Callicarpa arborea* Roxb. ; *Clerodendron infortunatum* Linn. ; *Duabanga sonneratioides* ; *Sesbania grandiflora* ; *Spathodes companulata* ; *Tectona grandis*.

Body cinereous. Antennae and labial palpi brown. Thorax yellowish brown ; marked with two longitudinal brownish-black stripes. Fore wings with the ground colour yellowish brown ; with several black costal dots from base to apex and lines in between veins and in & around cell, the lines beyond the cell prominent ; a large white-ringed patch, tessellated with black around tornus, extending along outer and inner margins. Hind wings brownish, tessellated with black ; a few indistinct submarginal white spots, similar to those on the fore wing, also present. Abdomen yellowish brown at base, with blackish bands on the sides from near the base to 4th segment but brownish in the distal half ; a longitudinal blackish line present both dorsally and ventrally. Underside of wings yellowish brown, markings brownish black and more prominent than on the dorsal side ; thorax and legs brownish black ; tarsi yellowish brown at or near the base, the lateral sides brownish black.

Head with the antennae (incomplete in all the examples available for study) bipectinate (Text-fig. 28A) up to 22-26 segments, the rami longest in the middle, about as long as four segments. Labial palpi well developed, slender, nearly porrect and reaching the frontal tufts. Legs with the spurs and spines, and frenulum and retinaculum, as for the genus.

Venation. —Fore wing (Text-fig. 28B) : Areole very large, extending beyond the cell ; vein R_1 arises from the areole and in line with the origin of median cell and vein Cu_{1b} , rarely the median cell arising before the origin of areole ; R_2 from near the tip of areole ; R_3 shortly stalked with R_4+R_5 ; M_1 from well below the angle (except in one example where M_1 is obsolete in the left wing, and arises from angle of cell in the right) ; M_2-M_3 generally close, rarely stalked. Hind wing (Text-fig. 28C) : Broadly as given in generic characters.



Text-fig. 28. *Xyleutes ceramicus* (Walker) : (A) A portion of the male antenna showing pectinations. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers. (E) Claspers in inner view, with juxta. (F) Aedeagus. (B & C ; D to F of the same magnifications).

Genitalia.—Male (Text-fig. 28D-F) : Uncus sclerotised ; a little less than twice as long as its width in middle ; broader at base than in distal portion, the latter narrow and blunt, not pointed. Tegumen broadly, oval, sclerotised. Gnathos extending laterally inwards but not meeting with each other ; vinculum broad above, with a short conical process. Saccus short, flattened, more or less broadly quadrangular. Claspers simple, about three times as long as the width in middle ; costa produced inwards into a short, blunt prolongation ; deeply incurved ventrally near distal margin, the apex narrow and about half the width of middle. Juxta reduced, with two short median lobes ; anellus lobes longer than juxta lobes and rounded at tips. Aedeagus well developed, markedly differentiated into a short base and a large vesica, the latter sclerotised, striated and with a hard cornutal process on one side.

Measurements.—Expanse : Fore wing, 65-120 mm. Length : fore wing, 31-55 mm. ; hind wing, 20-40 mm. ; abdomen, 26-38 mm. ; body, 23-55 mm.

Material examined.—Five examples as follows : India : West Bengal : Darjeeling, 1 ♂, (no date) (W.D. coll.). Sikkim : 548.63 m., 2 ♂♂, -vii.1898 (G. C. Dudgeon coll.)

Burma : N. Shan States, 1 ♂, 1 ♀, 16. v. 1914 (C.F.C. Beeson) (ex. *Tectona grandis*) (ex. colln. F.R.I.).

Distribution.—It is a widely distributed species in the Orient and is known from India (W. Bengal, Sikkim), Burma, Malaya Archipelago, Indonesia (Ceram, Nias, Borneo, Java, Sumatra, New Guinea) and Indo-china.

Remarks.—Referable to the genus *Xyleutes*, it is widely distributed in the Orient region. From India (Darjeeling) it was described under the name *Duomitus ligneus* by Butler (1880). and was treated *vide* Hampson, 1892b) as a synonym of *ceramica*. Beeson (1941), however, mentioned that the species does not occur in India and Ceylon. Recently Roepke (1957), although mentions that it is not known from India and Ceylon and records its western limit as Burma and Malaya Peninsula, cites *ligneus* Butler, from Darjeeling, under the synonymy of *Xyleutes ceramica ceramica* (Walker). Evidently the distribution of *ligneus* escaped the notice of both Beeson (1941) and Roepke (1957) and if *ligneus* Butler is to be considered as synonym of *ceramica*, the later has to be accepted as occurring in India.

It is characterised by the presence of a whitish ringed-patch around the tornus in the fore wing and a well marked median longitudinal line each on dorsal and ventral surfaces of abdomen (which are absent in the other Indian species).

32. *Xyleutes persona* (Le Guillou)

(Pl. III, fig. 33 ; Text-fig. 29, 30)

1841. *Cossus persona* Le Guillou, *Revue zool.*, 4 : 257. (Type loc.-Samarang, Java, Indonesia).
1844. *Strigoides leucolophus* Guérin, *Icon. Regne Animal* : 505 (Type loc.-Amboina, New Guinea) (*syn.* Gaede, 1933 ; Roepke, 1957).
1856. *Zeuzera leuconota* Walker, *List Lep. Brit. Mus.*, 7 : 1538. (Type loc.-Ceylon) (*Syn.* Dalla-Torre, 1923).
1859. *Zeuzera leuconotus*, Horsfield and Moore, *Cat. Lep. Mus. E.I.C.*, 2 : 437.
1867. *Zeuzera leuconotus*, Moore, *Proc. zool. Soc. Lond.* : 686 (Calcutta, Dum Dum).
1883. *Hinnaeya leuconota*, Moore, *Lep. Ceylon*, 2 : 153 (Ceylon).
1886. *Zeuzera leuconotus*, Butler, *Ill. Typ. Lep. Het.*, 6 : 28. (Ceylon, Darjeeling (India) and Silhet (Bangladesh)).
1887. *Zeuzera leuconota*, Cotes and Swinhoe, *Cat. Moths of India* : 233.
1892. *Zeuzera leuconota*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 283.
1892. *Xyleutes leucolophus*, Kirby, *Cat. Lep. Het.* : 874.
1892. *Xyleutes leuconotus*, Kirby, *Cat. Lep. Het.* : 874.
- 1892b. *Duomitus leuconotus*, Hampson, *Fauna Brit. India, Moths*, 1 : 307 (Ceylon, Calcutta, Simla, Sikkim).
1895. *Duomitus leuconotus*, Swinhoe, *Trans. ent. Soc. Lond.* : 29.
1899. *Duomitus leuconotus*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 645.
1900. *Cossus persona*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 39 (Treated as synonym of *Endoxyla strix* (Linn.)).
1903. *Cossus persona*, Poujade, *Bull. Soc. ent. Fr.* : 122 (S. India, Ceylon and Java).
1904. *Duomitus leuconotus*, Stebbing, *J. Asiat. Soc. Beng.*, 73 (2) : 25.
1909. *Duomitus leuconotus*, Lefroy, *Indian Insect Life* : 495.
1912. *Duomitus leuconotus*, Seitz, in Seitz *Macrolepidoptera of the World*, 2 : 418 (Kashmir).
1916. *Xyleutes persona*, Houlbert, in Oberthur, *Etud. Lep. Comp.*, 11 : 79.
1923. *Strigoides leucolophus*, Dalla-Torre, *Lepid. Cat.*, 29 : 51 (Amboina, Papua).
1923. *Xyleutes persona*, Dalla-Torre, *Lepid. Cat.*, 29 : 53 (India (Simla, Calcutta, Sikkim), Ceylon and China).
1933. *Xyleutes leuconotus*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 817.
1937. *Xyleutes leuconotus*, Dupont, *Ent. Meded. Ned. India*, 3 : 12 (Java).
1941. *Xyleutes persona*, Beeson, *The Ecology and the Control of Forest Insects of India and Neighbouring Countries* : 580.
1945. *Xyleutes leucolophus*, Sevastopulo, *J. Beng. nat. Hist. Soc.*, 19 : 115.
1955. *Xyleutes leucolophus*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 283 (New Guinea).
1957. *Xyleutes persona*, Roepke, *Verh. k. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 22 (India, Ceylon, S. Asia, New Guinea, Greater Sunda Is.).
1958. *Xyleutes leuconotus*, Bhasin, Roonwal and Singh, *Forest Bull. Dehra Dun*, 171 (2) : 84, 80, 90.

1959. *Xyleutes leuconotus*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (4) : 62.
 1965. *Xyleutes persona*, Müller, *Dt. ent. Z.*, **12** (3) : 253.

Types : *persona* Le Guillou, in Paris Mus.; *leuconotus* Walker, in B.M.

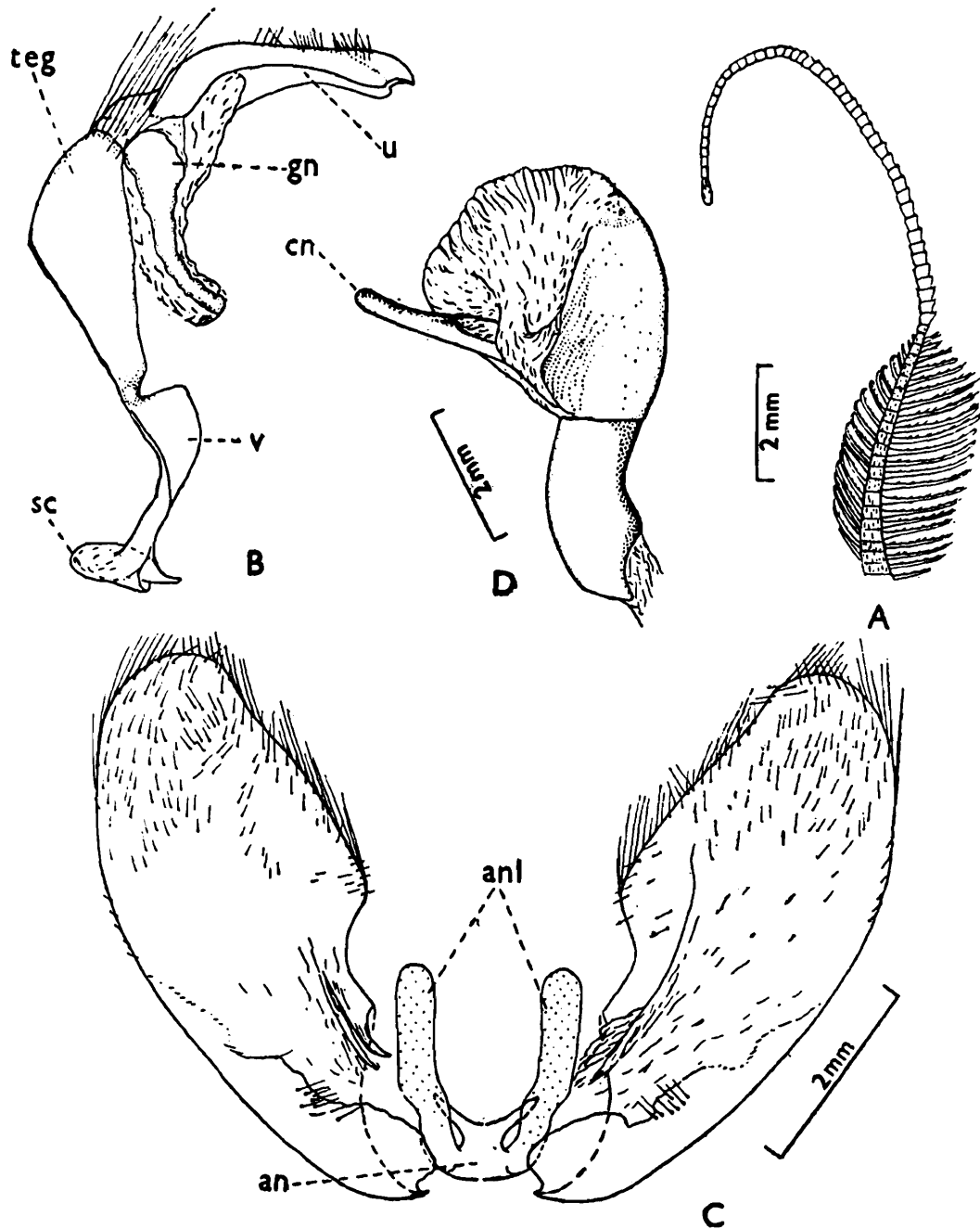
Hosts : *Cassia fistula*, *Cassia multijuga*, *Cassia nodosa*, *Cassia renigera*, *Cassia siamea*, *Durio zibethinus* and *Premna* sp.

Head with the antennae, labial palpi and frontal tufts dark brown. Thorax whitish throughout. Wings dark brown. Abdomen dark brown, except the base and the last segment which have whitish scales dorsally. Legs dark to blackish brown. Fore wings with the base covered with white scales, which are continuous with the white patch of scales along the inner margin up to the tornal angle ; a white patch also present at the apex ; the remaining portion of wing dull blackish-brown and marked with numerous blackish striae in between veins, forming short and long streaks, the prominent one being beyond the discocellular in the space between veins M_1-M_2 . Hind wings smoky brown, with a white patch on inner area near the anal angle ; outer area marked with blackish brown striae ; the area along costa and the base unmarked but with some shine. Underside of both wings smoky brown and of abdomen pale yellowish brown, the latter with segmental lateral white spots.

Antennae (Text-fig. 29A) long, the shaft with about 75 segments ; in male, bipectinate up to basal half, or a little less (up to basal 25 segments), the distal part serrate, the tip simple ; rami very long, about as long as ten middle segments of shaft ; antennae in female simple. Labial palpi well developed, long and nearly porrect or slightly ascending, and closely appressed to face, reaching as far as the frontal tufts. Legs with the spurs, spines, frenulum and retinaculum as given for the genus.

Venation.—Fore wing : vein R_1 arises in line with the origin of median cell and vein Cu_{1b} ; vein R_3 connate or stalked with veins R_4+R_5 ; other features as for the genus. Hind wing : Broadly as for the genus.

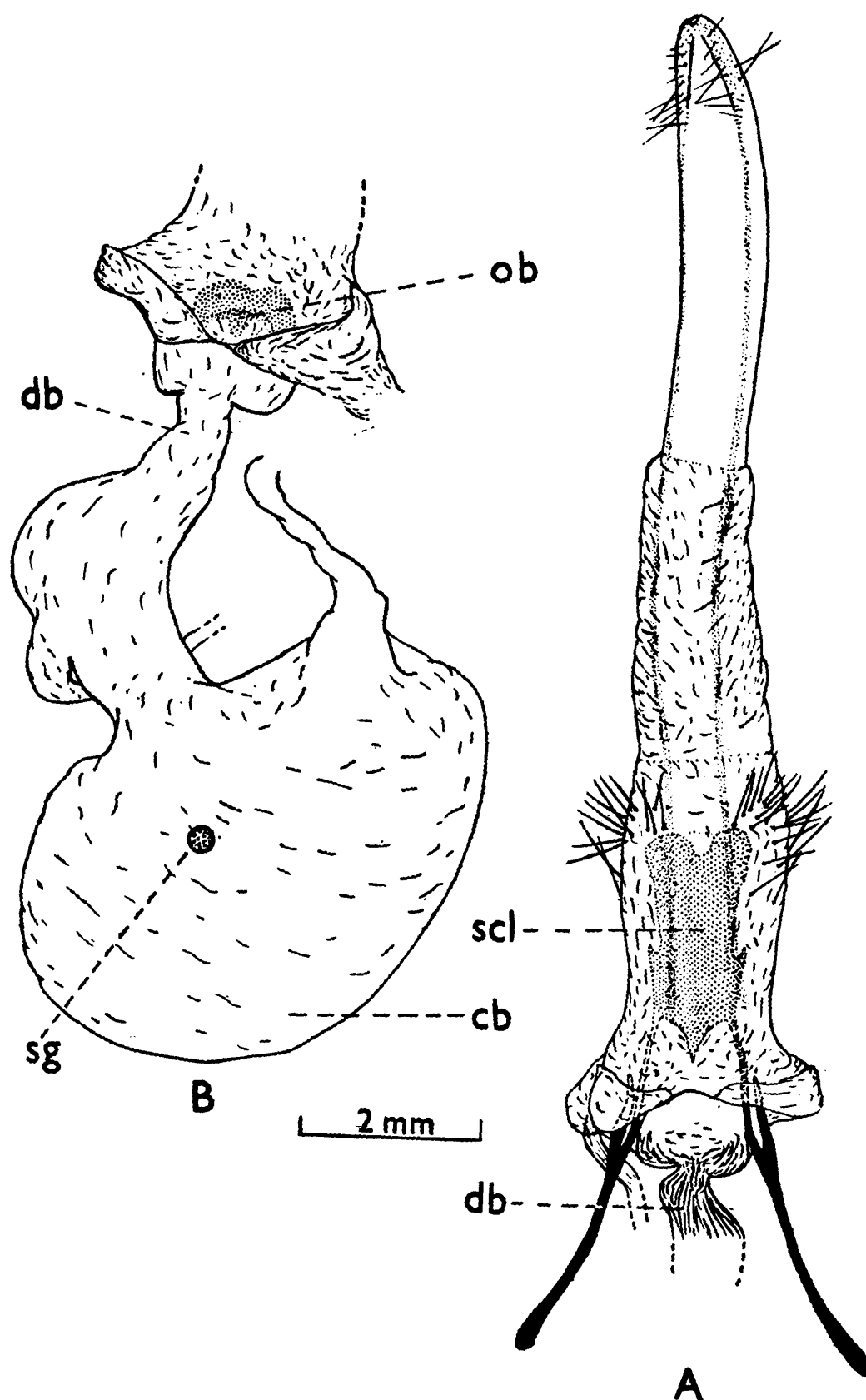
Genitalia.—Male (Text-fig. 29B-D): Uncus about two-and-a-half times as long as its width in middle ; broad at the base, the distal portion narrow, raised into a ridge distally and ending in a fine hooked-point. Gnathos as in *ceramicus*. Tegumen and vinculum not much different from *ceramicus*. Saccus short. Claspers a little less than three times as long as the width in middle ; with generally long and clubbed hair on the outside and fine setae on the mesal side along the dorsal and on ventral margins. Juxta short



Text-fig. 29. *Xyleutes persona* (Le Guillou) : (A) A portion of male antenna showing pectinations. (B) Male genitalia in a lateral view, without claspers. (C) Claspers in inner view, with juxta. (D) Aedeagus. (B & C of the same magnifications).

and reduced ; with a short median lobe and two lateral anellus lobes, the latter rounded at apex. Aedeagus well built and clearly differentiated into a short base and a large vesica, the latter slightly sclerotised and striated ; cornutal process present, not extending beyond veisca. Female (Text-fig. 30) : Ostium bursae sclerotised, the sclerotisation horse-shoe shaped ; ductus bursae short and sclerotised ; corpus bursae irregular, slightly striated, with rounded signum which is depressed into a slight cavity and beset with fine black spines ; ductus bursae connected by a duct with a globular, translucent sac-the recep-

taculum seminalis ; another fine duct arises from the corpus bursae and enters into the genital tube ; genital plate sclerotised only dorsally.



Text-fig. 30. *Xyleutes persona* (Le Guillou) : (A) and (B) Dorsal and ventral views, respectively of the parts of female genitalia.

Measurements.—Expanse : Fore wing : Male, 65-133 mm. ; female, 80-194 mm. Length : Fore wing : Male, 28-61 mm ; female, 37-88 mm. Hind wing : Male, 19-39 mm. ; female, 25-57 mm. Abdomen : Male, 21-39 mm. ; female, 21-50 mm. Whole body : Male, 32-62 mm. ; female, 30-73 mm.

Material examined.—43 examples as follows : India : Bengal : Calcutta, 2 ♀ ♀, 2 ♂ ♂, -ix-1903 (ex. colln. F.R.I.) 1 ♂, 1 ♀, -iii.1885 (S. Thomas coll.); 8 ♂ ♂, 9 ♀ ♀, 22.ix.1903-10.x.1903 (Reared in Indian Museum) ; 1 ♀, 4.viii.1909 (B. L. Chowdhury coll.) ; 1 ♀, -x.1949 (A. P. Kapur coll.). Uttar Pradesh ; Chakrata Range ; Haldwani, 1 ♀, 14.vii.1930 (S. N. Chatterjee coll.) ; Dehra Dun, Guchhupani, 1 ♀, 19.ix.1925 (S. Bahadur coll.), F.R.I. Compound, 1 ♀, 21.ix.1914, 1 ♂, 18.viii.1925 (C. F. C. Beeson coll.), 1 ♂, 20.x.1917, 1 ♂, 15.viii.1923 (Student coll.), New Forest, 1 ♂, 15.ix.1939 (J. C. M. Gardner coll.) (all. ex. colln. F R. I.) Himachal Pradesh : Simla, 1 ♀, 25.vi.1902 (No further data). Sikkim : 2 ♀ ♀ (no date) (W. D. coll.) ; Naga, 1575 m., 1 ♂, 4.viii.1959 (A. G. K. Menon coll.).

Ceylon : Peradeniya, 1 ♂, -ix.1900 ; 3 ♂ ♂ (no further data). Kandy, 1 ♀, -vi.1909 ; 2 ♀ ♀ (no further data) (E. E. Green coll.).

Distribution.—It is known from India (Kashmir, S. India, Himachal Pradesh, West Bengal, Sikkim), Bangladesh (Sylhet), Burma, Sri Lanka, Indonesia and China.

Remarks.—There had been a lot of confusion in the literature, regarding the validity of this species. Walker (1856) described *Zeuzera leuconota* from Ceylon and since then the species has been referred to by this name by Horsfield and Moore (1954), Moore (1867, 1883), Butler (1886), Cotes and Swinhoe (1887), Swinhoe (1892, 1895), Hampson (1892b), Kirby (1892), Seitz (1912) and so on. Although Dalla-Torre (1923) synonymised *leuconotus* to *persona*, Gaede (1933), Dupont (1937), Sevastopulo (1945), etc., still referred it as *leuconotus*. Recently Roepke (1957) has rightly set aside the controversy by treating it as a synonym of *persona persona*.

Referred to the genus *Xyleutes*, it is one of the largest species of the Indian Cossidae and is close to *Xyleutes strix* (Linn.). It, however, differs from it for having a well marked streak beyond the cell in the fore wing (absent in *strix*) ; thorax and the tip of abdomen whitish (brownish in *strix*) ; and signum in the female genitalia rounded (triangular in *strix*).

33. *Xyleutes strix* (Linnaeus)

(Text-fig. 31)

1758. *Phalaena Noctua Strix* Linnaeus, *Syst. Nat. Regnum Anim.*, 10th ed : 508 (Type loc.-America Merid*).

* see remarks.

1764. *Phalaena Noctua strix* Linnaeus, *Mus. Lud. Ulricae* : 377.
 1767. *Phalaena Noctua strix* Linnaeus, *Syst. Nat. Regnum Anim.*, 12 : 833.
 1779. *Phalaena Noctua strix*, Cramer, *Papil. Exot.*, 77 (Ambon, Java).
 1822. *Xyleutes strix*, Hübner, *Verz. bek. Schmett.* : 195.
 1856. *Cossus strix*, Walker, *List Lep. Brit. Mus.*, 7 : 1521 (Asia).
 1856. *Zeuzera signata* Walker, *List Lep. Brit. Mus.*, 7 : 1537 (Type loc.-N. India) (Syn. Hampson, 1892 (b)).
 1859. *Cossus strix*, Horsfield and Moore, *Cat. Lep. Mus. E.I.C.*, 2 : 437 (Java).
 1865. *Cossus strix*, Walker, *List Lep. Brit. Mus.*, 32 : 583 (Java).
 1877. *Cossus strix*, Piepers and Snellen, *Tijdschr. Ent.*, 20 : 22.
 1882. *Xyleutes strix*, Aurivillius, *Sveńska Ak. Handl.*, 19 (5) : 154 (Java).
 1887. *Zeuzera signata*, Cotes and Swinhoe, *Cat. Moths of India* : 234 (North India).
 1892. *Strigoides strix*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 281. (Makian, Celebes).
 1892. *Zeuzera signata*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 283 (N. India).
 1892. *Xyleutes signata*, Kirby, *Cat. Lep. Het.* : 874 (N. India).
 1892. *Xyleutes strix*, Kirby, *Cat. Lep. Het.* : 874 (Amboina, Java).
 1892b. *Duomitus strix*, Hampson, *Fauna Brit. India, Moths*, 1 : 307 (Sikkim, Sylhet, Java, Nias, New Ireland, New Britain).
 1895. *Duomitus strix*, Swinhoe, *Trans. ent. Soc. Lond.* : 29 (Khasis).
 1899. *Duomitus strix*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 645 (Sikkim and Bhutan).
 1900. *Endoxyla strix*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 39 (Java).
 1916. *Strigomorphus strix*, Houlbert, in Oberthur *Etud. Lep. Comp.*, 11 : 78, 114 (Sikkim, Borneo, Java Celebes, Ternate and Rooh Isl.)
 1923. *Xyleutes strix*, Dalla-Torre, *Lepid. Cat.*, 29 : 54 (New Britain, Nias, New Ireland, Celebes, Ternate, Buru, Formosa, Moluccas, Sikkim and Sylhet).
 1927. *Duomitus strix*, Candeze, *Encycl. Ent.*, (B) III Lep., 2 : 122 (Indo-China).
 1932. *Xyleutes strix*, Jordan, *Mem. Mus. R.d' Hist. nat. Belg.*, 6 : 23.
 1933. *Xyleutes strix*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 817 (Sikkim, Tonkin, Borneo, Celebes, Philippines, Moluccas and New Guinea).
 1955. *Xyleutes strix*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 283.
 1957. *Xyleutes strix*, Roepke, *Verh. k. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 19.
 1965. *Xyleutes strix*, Müller, *Dt. ent. Z.*, 12 (3) : 245.

Type : strix Linnaeus—? In Ox.Univ.Mus. ; *signata* Walker—In B.M.

Head, thorax and abdomen brown to dark brown. Eyes, labial palpi and antennae brown. Fore wings whitish to yellowish-brown; brownish at the base and with brownish patches along the costa ; a few patches and also minute striae present on the outer margin ; the

latter forming a fine net work of lines, some of which coalescing into prominent ones in the postmedial area. Hind wings brown, densely striated with minute lines forming a net work in the area below the cell; anal area unmarked; some dark brown spots present on the outer margin at tips of veins. Abdomen brown or dark brown, with narrow white segmental bands. Underside of wings yellowish brown, with a net work of lines which are prominent and dense beyond the cell in the postmedial area.

Antennae simple (present only in single specimen, damaged in others); the shaft with about 60 segments; basal segments cylindrical but the distal ones laterally flattened. Labial palpi long and slender, nearly upturned. Legs with the spurs (Text-fig. 31A) and spines, and the frenulum and retinaculum as for the genus.

Venation.—Broadly as given in the generic characters.

Genitalia.—Female (Text-fig. 31B-D) : Ostium bursae well marked and sclerotised, the sclerotisation being horse-shoe shaped; corpus bursae and receptaculum seminalis smaller than in *X. persona*; signum triangular and not much depressed on the general surface. Male : As no male specimens were available, the description of the genitalia as given by Roepke (1957) is reproduced here : “..... the genitalia very large and heavily chitinized. Uncus triangular, lora rather short. Valve about as long as broad, ligulae rather large, aedeagus strong, curved, apical portion bulbus, densely striate.”

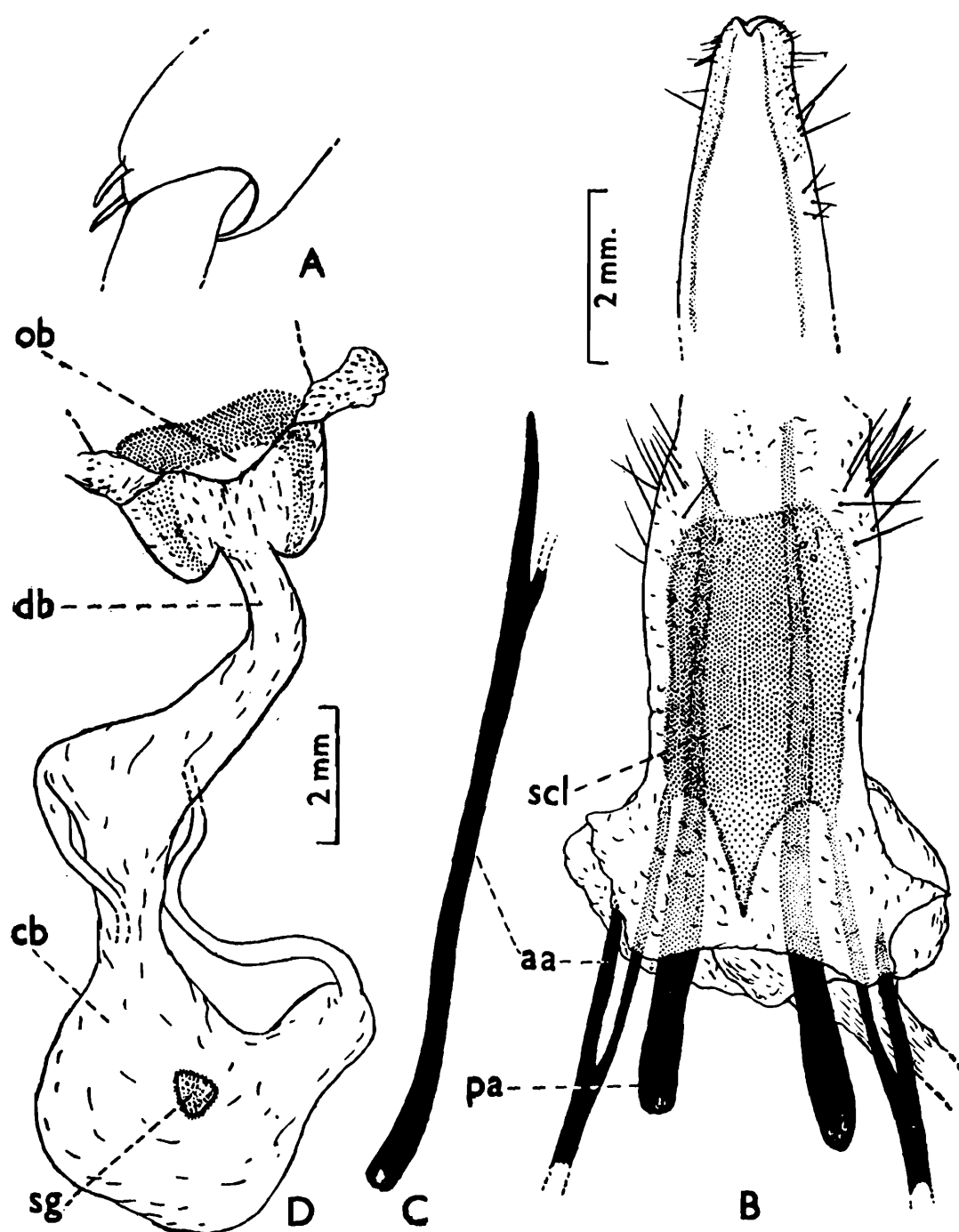
Measurements.—Expanse : Fore wing : Female, 79-188 mm. Length : Female : fore wing, 37-87 mm.; hind wing, 25-61 mm.; abdomen, 23-48 mm.; whole body, 38-65 mm.

Material examined.—Seven examples as follows : India : Assam ; Naga Hills, 1676 m., 1 ♀, 5.v.1927 (*O. C. Ollenbach* coll.), Dehra Dun, 1 ♀, 27.vii.1934 (*C. F. C. Beeson* coll.), 1 ♀, 19.vii.1923 (*Student* coll.) (ex. colln. F.R.I.) W Bengal : Calcutta, 1 ♀, 10.x.1903 (Reared in Indian Mus.). Manipur : 1 ♀, -vi.1901 (*Anderson* coll.).

Bhutan : 2 ♀ ♀, 26.v.1895 (*G.C.Dudgeon* coll.).

Distribution.—*X. strix* (Linn.) is also a widely distributed species in the Orient and is known to occur in India (W. Bengal, Manipur, N. India, Sikkim), Bhutan, Bangladesh, Malaya, Indonesia, Indochina, Taiwan and the Philippines. It is also recorded from New Britain and New Ireland in the Australian region.

Remarks.—Linnaeus (1758) while describing this species gave the habitat as “America Meridonali” Swinhoe (1892), however,



Text-fig. 31. *Xyleutes strix* (Linn.) : (A) A portion of the hind leg, with a pair of tibial spurs. (B) Portions of the female genitalia in a dorsal view. (C) An anterior apodeme. (D) A portion of the female genitalia in a ventral view. (A-C of the same magnifications).

cites 'Makian Celebes' as the locality of the 'type' Roepke (1957) states (p.29) "Linnaeus (1758) mixed up two quite different insects, viz., the large South American *Noctua Erebus* (*Thysania*) *agrippina* and the Eastern Cossid under consideration. It is, however, now generally agreed that the name *strix* must be attributed to the last name. The type locality is also uncertain." I am also unable

to give a definite opinion about it, but through citations of Swinhoe (1892) and Roepke (1957) it is certain that the type locality is in the East and possibly Indonesia.

It is the largest and heaviest insect in the Indian Cossidae and is close to *X. persona* (Le Guillou) externally to a great extent. For differences see under that species.

34. *Xyleutes fuscipars* (Hampson)

- 1892b. *Duomitus fuscipars* Hampson, *Fauna Brit. India, Moths*, 1 : 309 (Type loc.—Sikkim).
 1899. *Duomitus fuscipars*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12(4) : 645.
 1923. *Xyleutes fuscipars*, Dalla-Torre, *Lepid. Cat.*, 29 : 51.
 1933. *Xyleutes fuscipars*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 817.

Type : In B. M.

“♂ Head and thorax dark brown, grizzled with grey; abdomen fuscous. Fore wing with the costal half very deep red-brown; the inner area more or less thickly suffused with white scales, the inner margin being white tessellated with black marks. Hind wing pale red-brown; a large white triangular patch tessellated with black on the outer margin between veins 1b and 4.

Hab. Sikkim (Möller). Exp. 44 millim. Type in coll. Elwes.”

Remarks.—As no material of this species was available, the original description has been reproduced above. The photograph of the type, which is present in the British Museum (Nat. Hist.), London, clearly shows that the antennae are bipectinate up to about the basal half and serrate in the distal half; the lower branch of the median cell in the fore wing ends near Cu_{1a} ; the veins M_2 and M_3 arise from a point, but in the hind wing these veins are separate. From the description of the adult, as given by Hampson (1892b) it can be differentiated from the other Indian *Xyleutes* species by the fore wing in having deep red-brown costal half, and whitish suffusion in the inner area.

Genus *Zeuzera* Latreille

1804. *Zeuzera* Latreille, *Nouv. Dict. Hist. Nat.*, 24 : 186 (Type—*pyrina* Linn. from Europe).
 1822. *Zeuzera*, Hübner, *Verz. bek. Schmett.* : 196.
 1822. *Latagia* Hübner, *Verz. bek. Schmett.* : 196 (Type—*aesculi* L.) [Syn. Hampson, 1892b].
 1834. *Zeuzera*, Boisduval, *Icon. Hist. Lep. Nouv.*, 2 : 181.

1840. *Zeuzera*, Boisduval, *Gen. et Index-Meth. Eur. Lep.* : 75.
 1854. *Zeuzera*, Herrich-Schäffer, *Samml. Ausser. Schmett.* : 7, 58.
 1856. *Zeuzera*, Walker, *List Lep. Brit. Mus.*, 7 : 1528.
 1858. *Zeuzera*, Westwood, *Nat. Hist. Ins. India* : 83.
 1859. *Zeuzera*, Horsefield and Moore, *Cat. Lep. Mus. E. I. C.*, 2 : 437.
 1883. *Zeuzera*, Moore, *Lep. Ceylon.*, 2 : 153.
 1886. *Zeuzera*, Butler, *Ill. Typ. Lep. Het.*, 6 : 28.
 1887. *Zeuzera*, Cotes and Swinhoe, *Cat. Moths of India* : 232.
 1892. *Zeuzera*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 281.
 1892b. *Zeuzera*, Hampson, *Fauna Brit. India, Moths*, 1 : 310 (quotes *Z. aesculi* Latr. as the type of genus).
 1892. *Zeuzera*, Kirby, *Cat. Lep. Het.* : 870.
 1900. *Zeuzera*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 37, 41, 43.
 1905. *Zeuzera*, Schaus, *Proc. U. S. Nat. Mus.*, 29 : 339.
 1912. *Zeuzera*, Seitz, in *Seitz Macrolepidoptera of the World*, 2 : 428.
 1917. *Zeuzera*, Chapman, *Ent. Rec.*, 29 (3) : 5.
 1918. *Zeuzera*, Turner, *Trans. ent. Soc. Lond.*, 66 : 163.
 1923. *Zeuzera*, Dalla-Torre, *Lepid. Cat.*, 29 : 37.
 1933. *Zeuzera*, Gaede, in *Seitz Macrolepidoptera of the World*, 10 : 811.
 1945. *Zeuzera*, Turner, *Proc. R. Soc. Qd.*, 56 (6) : 47, 63.
 1950. *Zeuzera*, Bryk, *Ark. Zool.*, 42A (19) : 48 (quotes *Z. aesculi* Latr. as the type of genus).
 1951. *Zeuzera*, Viette, *Lambillionea*, 51 (11-12) : 72.
 1955. *Zeuzera*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 281.
 1957. *Zeuzera*, Roepke, *Verh. k. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 12.
 1962. *Zeuzera*, Daniel, *Z. Arb. Gem. Öst. Ent.*, 14 (1) : 6.
 1965. *Zeuzera*, Müller, *Dt. ent. Z.*, 12 (3) : 238.

Type species : *Phalaena Noctua pyrina* Linnaeus

(a) General

The species of the genus *Zeuzera* Latreille are of great agricultural and forestry importance, some of them being serious pests of coffee plantations, small sapplings in the forestry nurseries and several species of forest plants. From the Indian subregion, only five species of this genus are known, viz., *Zeuzera coffeae* Neitner — the red borer, *Z. indica* Herrich-Schäffer, *Z. multistrigata* Moore, *Z. conferta* Hampson and *Z. postexcisa* Hampson.

After Latreille (1804), Walker (1856) gave the characteristic features of the genus, which though certainly better than those given by several subsequent workers such as Hampson (1892b), Seitz (1912), Turner (1918) and Gaede (1933), still lacked certain important characters of the labial palpi and the legs which have some bearing on the phylogenetic position of the genus. The descriptions, etc., of the Indian forms are also very sketchy and not adequately figured.

In the present study the generic characters are given in detail and three Indian species, viz. *coffeae*, *multistrigata* and *postexcisa*,

of which the material was available, are redescribed in detail and figured adequately from the actual specimens. The genitalia, both male and female, wherever available, have also been studied. A new subspecies of *Z. coffeae* Neitner is described from India.

(b) *Characters of the Genus Zeuzera Latreille*

Antennae in male bipectinate up to basal half, the distal part minutely serrate, the pectination large except at both the ends; antennae in female wholly simple. Labial palpi rudimentary to moderately well developed. Hind legs with a pair of extremely short tibial spur; tarsi with spines on all the segments; arolium absent. Frenulum spine single in male, several in female. Abdomen in male generally longer than hind wing; in female either shorter or longer than hind wing.

Fore wing with a moderately long areole, projecting outside the cell angle by one-fourth to one-third of its length; vein R_1 arises from near the tip of areole; R_3 shortly stalked with $R_4 + R_5$; vein M_1 variable, either from above, or from below the angle of cell; median cell always present, short, with its upper and lower branches ending between $M_1 - M_2$ and $Cu_{1a} - M_3$, respectively; veins M_2 and M_3 separate, M_2 arises from above, and M_3 from angle. Hind wing with a cross bar between veins Sc and R_s ; $R_s - M_1$ veins wide apart at origin; median cell with its branches ending as in fore wing.

Gnathos in male genitalia present, either well developed or reduced to mere rudiments; aedeagus either simple or with a well developed cornutal process; juxta well developed and with large anellus lobes.

In female genitalia, signum on corpus bursae present; genital plate generally with sclerotisation both on the dorsal and ventral sides.

(c) *Relationships of the Genus Zeuzera with the Other Allied Genera*

Typically a *Zeuzerinae* genus, it is very important, both economically and phylogenetically. Economically, since it includes one of the well known species, viz. *Zeuzera coffeae* Nietner, which attacks the coffee plants and a variety of other plants. Phylogenetically, it is important since it has bipectinate antennae in male, a moderately long areole in fore wing, ending of the lower branch of median in both wings between veins Cu_{1a} and M_3 , a character found only in the primitive moths, and by the presence of cross vein between veins Sc and R_s in the hind wing, a character not generally present in any

other Indian cossid. The male genitalia, however, show great variation, *i.e.*, gnathos are either very well developed as in *Xylentes* or reduced.

The genus *Zeuzera* is close to the genus *Xylentes* Hübner in respect of the antennae which are bipectinate up to about the basal half and in the absence of arolium between the claws, but differs by the presence of a short cross bar, in the hind wing, between veins Sc and Rs (absent in *Xylentes*), and by the ending of the lower branch of the median between the veins Cu_{1a} and M_3 , in both the wings (variable in *Xylentes*, but mostly between M_2 and M_3). From the genus *Phragmataecia* it differs in respect of the antennae in the male, which are bipectinate up to basal half (up to two-thirds in *Phragmataecia*) and for the absence of arolium (present in *Phragmataecia*). *Azygophelps* Hampson can be differentiated from *Zeuzera* in having bipectinate antennae in both sexes (bipectinate in basal half in male and simple in female in *Zeuzera*), and for presence of arolium (absent in *Zeuzera*).

(d) Geographical Distribution of the Genus *Zeuzera*

It is cosmopolitan in distribution and in the Oriental region it is fairly widely distributed.

(e) Key to Indian Species of the Genus *Zeuzera*

The following key is based on four Indian species and subspecies of which the material was available for study.

1. Vein M_1 , in the fore wing, arises from angle of cell or above. Gnathos in the male genitalia, reduced ; median lobes absent ; aedeagus slender, without cornuti. Female genitalia with two sclerotised patches on genital plate on ventral surface 2

Vein M_1 , in the fore wing, arises from below the angle of cell. Gnathos well developed ; median lobes present ; aedeagus well developed, with cornuti. Female genitalia without sclerotised patches on genital plate 3

2. Outer margin of fore wing evenly curved. Corpus bursae in the female with signum ; receptaculum seminalis present and well developed

coffae coffae Nietner

Outer margin of fore wing sharply angled at tornus. Corpus bursae without signum ; receptaculum seminalis reduced and indistinct *coffae angulata* ssp. n.

3. Hind wing with the anal angle not incised. Metathorax without medial spot. Abdomen with transverse bands on seven basal segments. Cornutal process, in the male genitalia, extending beyond the apex of aedeagus *multistrigata* Moore

Hind wing with the anal angle deeply incised. Metathorax with a medial spot. Abdomen with a transverse band only on the basal third segment. Cornutal process not extending beyond the apex of aedeagus *postexcisa* Hampson

(f) *Descriptions of Species*

35. *Zeuzera coffae* Nietner

1861. *Zeuzera coffae* Nietner, *Observations on enemies of the Coffee trees in Ceylon* : 21 (Type loc.—Ceylon).
 1883. *Zeuzera coffae*, Moore, *Lep. Ceylon*, 2 : 154.
 1887. *Zeuzera coffae*, Cotes and Swinhoe, *Cat. Moths of India* : 232.
 1891. *Zeuzera coffae*, Hampson, *Ill. Typ. Lep. Het. Brit. Mus.*, 8 : 11.
 1892b. *Zeuzera coffae*, Hampson, *Fauna Brit. India, Moths*, 1 : 312.
 1892. *Zeuzera coffae*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 281.
 1892. *Zeuzera coffae*, Kirby, *Cat. Lep. Het.* : 871.
 1899. *Zeuzera coffae*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
 1900. *Zeuzera coffae*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 37, 42.
 1909. *Zeuzera coffae*, Lefroy, *Indian Insect Life* : 495.
 1914. *Zeuzera coffae*, Fletcher, *Some South Indian Insects and Other Animals of Importance* : 446.
 1917. *Zeuzera coffae*, Fletcher, *Rep. Proc. 2nd. Ent. Mtg.*, 1917 : 21, 34, 121.
 1917. *Zeuzera coffae*, Chatterjee, *Rep. Bd. scient. Advice India, 1915-1916* : 1.
 1918. *Zeuzera coffae*, Turner, *Trans. ent. Soc. Lond.*, 66 : 163.
 1919a. *Zeuzera coffae*, Kalshoven, *Meded. Procfsn. Bosch. Batavia*, 4 : 57.
 1923. *Zeuzera coffae*, Dalla-Torre, *Lepid. Cat.*, 29 : 38.
 1933. *Zeuzera coffae*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 812.
 1940. *Zeuzera coffae*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1016.
 1940. *Zeuzera coffae*, Kalshoven, *Ent. Meded. Ned. India*, 6 (3-4) : 50.
 1940. *Zeuzera coffae*, Ayyar, *Handbook of Economic Entomology for South India* : 307, 360, 362, 472, 3 figs.
 1941. *Zeuzera coffae*, Beeson, *The Ecology and the Control of Forest Insects of India and the Neighbouring Countries* : 581-583, 956.

1941. *Zeuzera coffeae*, Miller, *Bull. ent. Res.*, **32**(1) : 3.
 1945. *Zeuzera coffeae*, Sevastopulo, *J. Beng. nat. Hist. Soc.*, **19** : 115.
 1948. *Zeuzera coffeae*, Toxopeus, *Treubia*, **19** : 167.
 1954. *Zeuzera coffeae*, Bhasini and Roonwal, *Forest Bull. Dehra Dun*, **171** (1) : 2, 29, 65, 76.
 1955. *Zeuzera coffeae*, Roepke, *Trans. R. ent. Soc. Lond.*, **107** : 282.
 1957. *Zeuzera coffeae*, Roepke, *Verh. k. ned. Akad. Wet. Afd. Nat.*, (2) **52** (1) : 16.
 1958. *Zeuzera coffeae*, Bhasini, Roonwal and Singh, *Forest Bull. Dehra Dun*, **171** (2) : 60, 80, 85, 88, 96, 99, 105, 107, 113, 117, 121, 125.
 1959. *Zeuzera coffeae*, Insects, in *Wealth of India*, **5** : 205.
 1959. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (4) : 79, 151.
 1960a. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (3) : 6, 13, 16, 27, 36.
 1960b. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (5) : 21, 25, 49, 60.
 1960c. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (6) : 21, 84.
 1960d. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (7) : 12, 13, 17, 23, 75.
 1961a. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (8) : 18, 30, 79, 80.
 1961b. *Zeuzera coffeae*, Mathur and Singh, *Forest Bull. Dehra Dun*, **171** (9) : 16, 47, 49, 81, 97.

Hosts : *Aberia gardneri*, *Acalypha* sp., *Amherstia nobilis*, *Anona muricata*, *Anona squamosa*, *Camellia sinensis*, *Camellia theifera*, *Cassia fistula*, *Casuarina equisetifolia*, *Cedrela toona*, *Cestrum nocturnum*, *Chickrassia tabularis*, *Cinnamomum zeylanicum*, *Citrus aurantium*, *Citrus medica*, *Clerodendrum infortunatum*, *Coffea arabica*, *Coffea robusta*, *Crataegus oxyacantha*, *Cryptomeria japonica*, *Eriobotrya japonica*, *Erythroxylon cocoa*, *Filicum decipiens*, *Gossypium* sp., *Grevillia robusta*, *Hibiscus rosa-sinensis*, *Hydnocarpus kurzii*, *Hydnocarpus wightiana*, *Lantana indica*, *Litchi chinensis*, *Melia azedarach*, *Pericopsis moonians*, *Perses gratissima*, *Persea gratissima*, *Phoebe hainesiana*, *Phyllanthus emblica*, *Psidium guajava*, *Santalum album*, *Schleichera oleosa*, *Swietenia macrophylla*, *Swietenia mahagoni*, *Tectona grandis*, *Thea sinensis*, *Theobroma cocoa*, *Vitex pubescens*, *Xylia xylocarpa*.

Zeuzera coffeae Nietner is widely distributed in almost whole of the Oriental region and is also known from New Guinea in the Australian region.

It differs from the other Indian species of the genus *Zeuzera*, as follows :

From *Z. multistrigata* and *Z. postexcisa*, in having vein M_1 in the fore wing arising either from the angle of cell or from above it (from below the angle of cell in the other two species) ; in respect of male genitalia by the reduced gnathos and median lobe of juxta (present in the other two). From *Z. indica* Herr-Schäffer, it differs in having spots on the thorax (absent in *indica*) and from *Z. conferta* Walker, by the absence of lateral spots and ventral bands on the abdomen (present in *conferta*).

Toxopeus (1948) separated the Javanese *coffae* as the subspecies *virens*, and opines about *Z. oblita* Swinhoe (1890) from Rangoon, which was treated as a synonym of *Z. coffae* by Hampson (1892b), that it is more likely to be conceived as a subspecies of *coffae*. He (*loc. cit.*) provisionally included *oblita* in the list of subspecies, for he was doubtful of its status and mentioned that further examination of type of *oblita* was required. Roepke (1957), however, is of the opinion that the question of the subspecies *virens* deserves re-investigation based on fresh and topotypical material of *coffae*, which Toxopeus did not have at the time of describing the subspecies.

I have not included *oblita* in my present work because I had no access to the types and since I feel the question of subspecies *oblita* needs further examination.

I have five examples, both males and females, all from Sri Lanka and I refer them to the typical species. I also have a few examples from different parts of India : These, I find, are very different from the material from Sri Lanka, and require a different and distinct subspecies status. I, therefore, have referred the Indian specimens to a new subspecies, *viz.*, *Zeuzera coffae angulata* ssp.n., which is described below. This new subspecies differs from typical *coffae* in respect of the fore wings which are sharply angled at the tornus, where as in the typical species these are evenly curved at the tornus ; by the marginal spots, on the wings, which are round (triangular in the typical *coffae* from Sri Lanka). In respect of female genitalia the new subspecies differs in the absence of signum on corpus bursae, which is present in the ceylonese material of *coffae*. The differences from the other subspecies have been dealt with under the description given for the subspecies.

35a. *Zeuzera coffae coffae* Nietner

(Pl. III, Fig. 34 ; Text-fig. 32)

For synonymy see under *Zeuzera coffae* Nietner above.

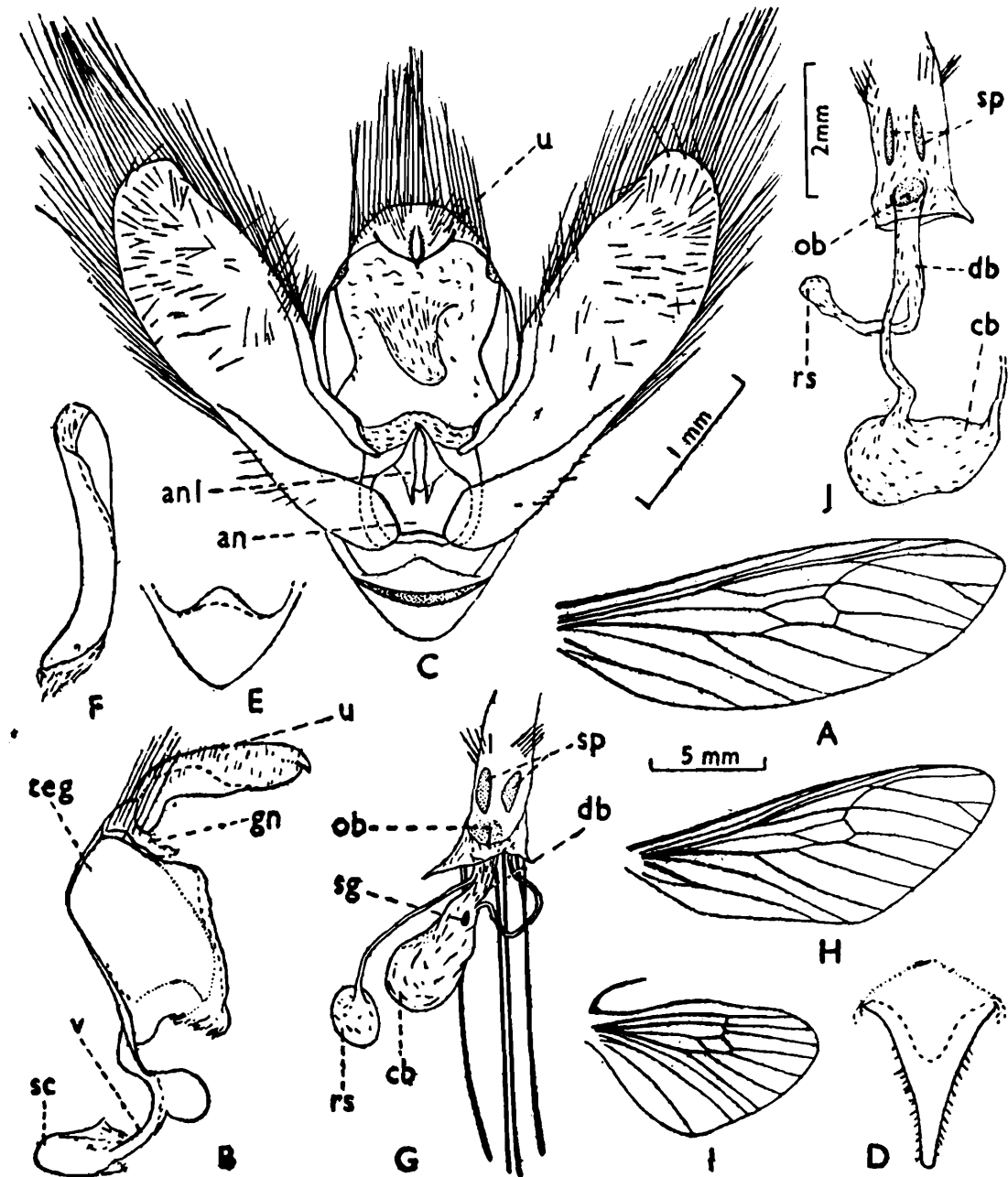
Types : Repository not known.

Frontal tufts whitish above, dark brown below. Antennae brown to dark brown in both sexes, covered with woolly scales above, especially in female. Labial palpi dark brown on sides, and covered with woolly white scales beneath. Thorax whitish, with two steel-blue spots on either side. Fore wings either pale brownish or whitish, with one large spot in the cell and series of spots in and outside the cell, those on the outerside arranged in rows in between the veins ; marginal row of triangular spots prominent. Hind wings paler, with fewer rows of spots in between the veins and on the margin, those at the tornal angle large and confluent ; the area below the cell unspotted. Legs bluish ; femora of fore legs white on underside, dark tan-brown above ; middle legs with the femora white ; hind legs with the femora and tibiae white. Abdomen brown to dark brown ; with a row of spots present dorsally. Underside of abdomen unspotted.

Antennae wholly simple in female ; bipectinate up to basal half in male, the distal part serrate ; the rami long, the longest ones as long as six middle segments of shaft. Labial palpi extremely minute. Fore wings smoothly curved from the apex to the inner margin, without any angle at the tornus. Abdomen longer than hind wings. Tibial spurs, tarsal spines, frenulum, and retinaculum, as for the genus.

Venation.—Fore wing (Text-fig. 32A) : Areole of moderate size, projecting beyond the cell angle by about one-fourth its length ; vein R_1 generally arises from near the origin of areole, rarely from the subcostal nervure ; R_2 from near the tip of areole ; R_3 from areole and either shortly stalked or connate with the stalk of veins R_4+R_5 ; M_1 either from angle or from above the angle ; median with the upper and lower branches ending between veins M_1-M_2 and $Cu_{1a}-M_3$, respectively, the lower nearer Cu_{1a} than M_3 ; veins M_2-M_3 separate ; M_2 from above the lower angle and M_3 from angle. Hind wings with a cross bar between veins Sc-Rs ; vein Rs and M_1 separate ; the median with its branches ending as in fore wing.

Genitalia.—Male (Text-fig. 32B-F) : Uncus triangular, short and narrow ; about thrice as long as its width in middle ; broader at base than in distal part ; tip produced into a downwardly directed fine point. Tegumen broad, curved laterally ; posteriorly produced into thin membranous folds for attachment of membranes inside ; ventral portion depressed into a short shallow cavity ; vinculum V-shaped, evaginated at the upper end. Saccus short, triangular. Gnathos short, rudimentary and forming a short protuberance. Claspers broadest beyond the middle ; costa produced into long and blunt costal prolongations ; inner side beset with inwardly directed setae, those on the costal margin are outwardly directed. Juxta cup-shaped and sclerotised ; lateral margins extending into narrowly pointed



Text-fig. 32. *Zeuzera coffeae* Nietner : *Zeuzera coffeae coffeae* Nietner. (A) Fore wing venation. (B) Male genitalia in a lateral view, without claspers. (C) Male genitalia in a inner view, with claspers. (D) Uncus in a dorsal view. (E) and (F) Saccus and Aedeagus, respectively. (G) A portion of the female genitalia in a ventral view. *Zeuzera coffeae angulata* ssp.n. (H) and (I) Fore and hind wings venation, respectively. (J) A portion of the female genitalia in a ventral view. (A, H & I; B to F; and G & J of the same magnifications).

anellus lobes. Aedeagus simple; weakly sclerotised throughout, slightly differentiated into a base and the apex, the latter with the vesica reduced. Female (Text-fig. 32G): Ostium bursae weakly sclerotised at base, leading into a bag like corpus bursae through membranous ductus bursae; corpus bursae broad at base, with a

short nearly oval signum ; a fine duct arises from the corpus bursae and enters into the genital tube ; receptaculum seminalis rounded and membranous ; genital tube long and slender, with its posterior apodemes very long, reaching as far as the end of the anterior apodemes ; genital plate wholly sclerotised dorsally but ventrally with two small sclerotised patches.

Measurements.—Expanse : Fore wing : Male, 34-44 mm. ; female, 39-42 mm. Length : Fore wing : Male, 17-20 mm. ; female, 12-15 mm. Abdomen : Male, 13-16 mm. ; female, 15-18 mm. Whole body : Male, 20-23 mm. ; female, 22-25 mm.

Material examined.—Five examples from Sri Lanka as follows : Peradeniya, 1 ♀, —.xii.1902, 1 ♀, —.ix.1907 ; Watagoda, 1 ♂, —.i.1904 ; Kandy, 1 ♂, —.v.1911 ; Madulsima, 1 ♀, —.ii.1906 (all *E. Green* coll.).

Distribution.—Sri Lanka India (?).

Remarks.—Referable to the genus *Zeuzera*, the nominotypical species probably occurs only in Sri Lanka, but its occurrence elsewhere, specially in India, is not completely ruled out. The differences from *coffae angulata* and other subspecies have been given above.

35b. *Zeuzera coffae angulata* ssp. n.

(Pl. III, fig. 35 ; Text-fig. 32)

Head and thorax slightly paler, abdomen somewhat darker than in the typical form. The spots on the wings almost as in *coffae coffae* except that the larger spot in the cell, on the fore wing, is absent, and that the marginal spots on wing are not triangular. The wings are semihyaline and with a sharp angle at the tornus in the fore wing of both sexes. The labial palpi more reduced. Other features as in *coffae coffae*.

Venation (Text-fig. 32H-I) : Almost as in *coffae coffae*.

Genitalia.—Male : As in *coffae coffae*. Female (Text-fig. 32 J) : It differs from *coffae coffae* in the ductus bursae being long and narrow and enters into the corpus bursae at its broader end unlike the case in the latter where it is short and enters into the corpus bursae straight at its narrower end ; the corpus bursae without signum unlike in *coffae coffae* where it is present ; receptaculum seminalis short and narrow as compared to that in *coffae coffae* where it is large and rounded.

Measurements.—Expanse : Fore wing : Male, 36-42 mm. ; female, 34-42. Length : Fore wing : Male, 16-19 mm. ; female, 15-19 mm.

Hind wing : Male, 9-12 mm. ; female, 8-12 mm. Abdomen : Male, 10-13 mm. ; female, 9-12 mm. Whole body : Male, 17-21 mm. ; female, 16-21 mm.

Holotype : A male : India : West Bengal ; Singur, 28.xi.1967 (S.S. & S.R. Coll.), at light. *Paratypes* : India : Arunachal Pradesh : Siang Dist., Kambang, 200 m., 1 ♂, at light, 14.x.1966 (S. K. Tandon & G. S. Arora coll.). Mysore : S. Coorg, Tithimatti, 1 ♂, 13.x.1942. Tamil Nadu : S. Coimbatore, Karian shola, 1 ♀, 2.vii.1938 (R. O. coll.). (All deposited in Z. S. I.).

Distribution.—The new subspecies is recorded from the Indian main-land, viz., Arunachal Pradesh, West Bengal, Mysore and Tamil Nadu. Several other records of the species, occurrence in India possibly refer to this subspecies.

Remarks.—Besides the differences from *coffae coffae*, as given above, *coffae angulata* differs from the other two subspecies as follows :

From *oblita* Swinhoe it differs by the sharply angled fore wing at the tornus (evenly curved in *oblita*) and for bluish green spots on the wings (bluish in *oblita*).

From *virens* Toxopeus it differs in having a series of marginal spots on both the wings (marginal spots not in series in *virens*) and bluish green spots on wings and abdomen (greenish in *virens*).

36. *Zeuzera multistrigata* Moore

(Pl. III, fig. 36 ; Text-fig. 33)

- 1856. *Zeuzera indica* Walker (nec. Herrich-Schäffer), *List Lep. Brit. Mus.*, 7 : 1536 (*Syn. Cotes* and Swinhoe, 1887).
- 1881. *Zeuzera multistrigata* Moore, *Proc. zool. Soc. Lond.* : 327 (Type loc.—Darjeeling, India).
- 1887. *Zeuzera multistrigata*, Cotes and Swinhoe, *Cat. Moths of India* : 233.
- 1892. *Zeuzera multistrigata*, Kirby, *Cat. Lep. Het.* : 871 (Darjeeling).
- 1892b. *Zeuzera multistrigata*, Hampson, *Fauna Brit. India, Moths*, 1 : 311 (Dharamshala, Nagas, Sikkim).
- 1892. *Zeuzera multistrigata*, Swinhoe, *Cat. East. & Aust. Lep. Het. Ox. Univ. Mus.* : 282 (Sylhet (Bangladesh), India).
- 1895. *Zeuzera multistrigata*, Swinhoe, *Trans. ent. Soc. Lond.* : 29.
- 1899. *Zeuzera multistrigata*, Dudgeon, *J. Bombay nat. Hist. Soc.*, 12 (4) : 646.
- 1912. *Zeuzera multistrigata*, Seitz, in Seitz *Macrolepidoptera of the World*, 2 : 429.
- 1923. *Zeuzera multistrigata*, Dalla-Torre, *Lepid. Cat.*, 29 : 39. (Darjeeling, Sylhet, Kashmir, Indian Himalayas to Sikkim, Naga Hills).

1933. *Zeuzera multistrigata*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 812 (N. India).
 1940. *Zeuzera multistrigata*, Daniel, *Mitt. münch. ent. Ges.*, 30 : 1016.
 1941. *Zeuzera multistrigata*, Beeson, *The Ecology and the Control of Forest Insects of India and Neighbouring Countries* : 583, 956.
 1950. *Zeuzera multistrigata*, Bryk, *Ark. Zool.*, 42A (19) : 48 (Kambaiti, Burma).
 1960b. *Zeuzera multistrigata*, Mathur and Singh, *Forest Bull. Dehra Dun*, 171 (5) : 64.
 1960c. *Zeuzera multistrigata*, Mathur and Singh, *Forest Bull. Dehra Dun*, 171 (6) : 120.
 1960d. *Zeuzera multistrigata*, Mathur and Singh, *Forest Bull. Dehra Dun*, 171 (7) : 91, 101.
 1961a. *Zeuzera multistrigata*, Mathur and Singh, *Forest Bull. Dehra Dun*, 171 (8) : 18.
 1962. *Zeuzera multistrigata*, Daniel, *Z. Arb. Gem. öst. Ent.*, 14 (1) : 6.

Type ; In B. M.

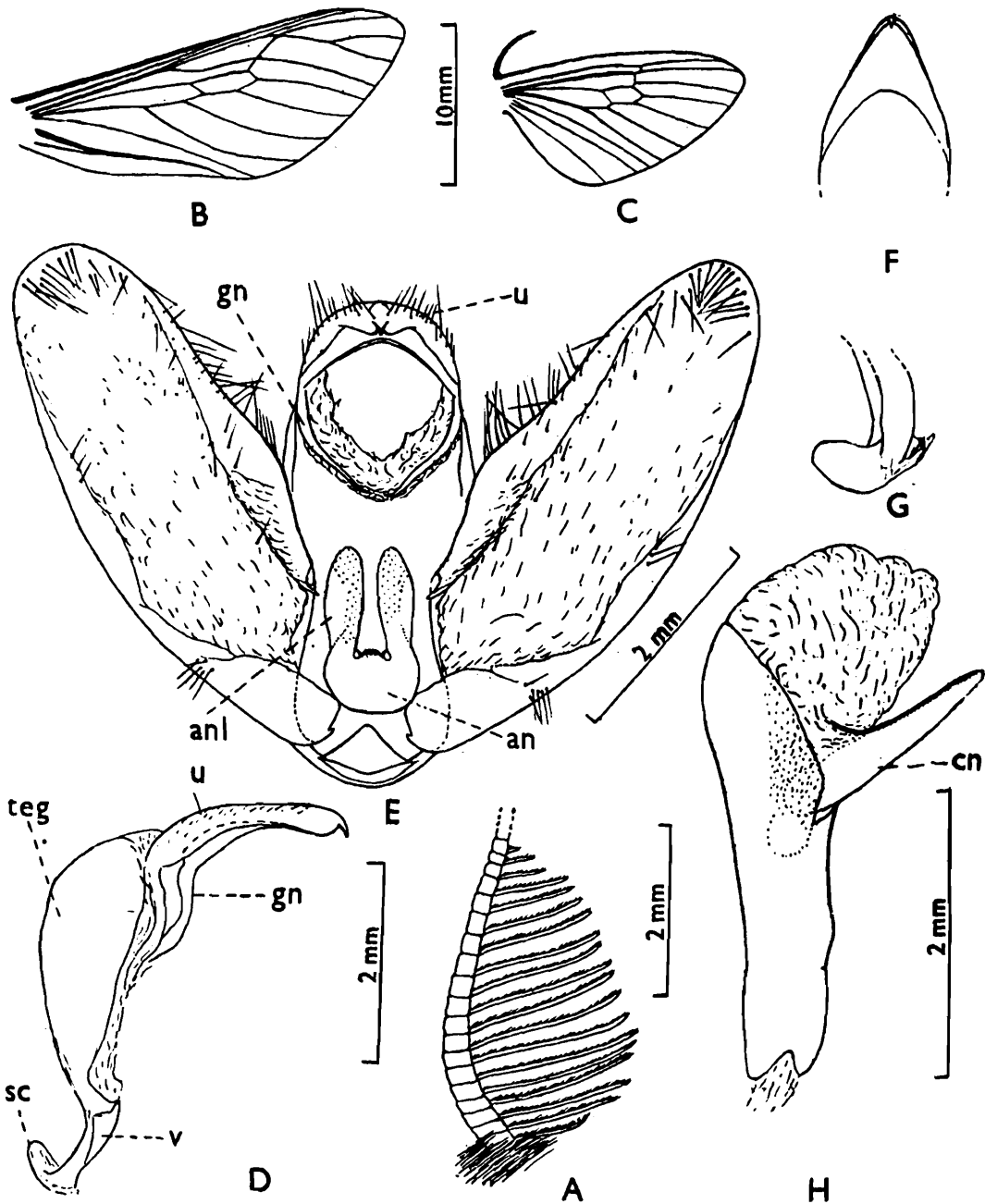
Hosts : *Cryptomeria japonica*, *Ilex* sp., *Mahonia nepaulensis*, *Mussaenda frondosa*, *Pyrus malus*, *Quercus lineata*, *Santalum album*.

Frontal tufts, antennae and labial palpi dark brown to black. Vertex and thorax white, covered with white, woolly hair-scales ; six bluish spots, three on each side of thorax, present. Fore wings whitish ; marked with steel blue spots, in a series of rows, between the veins and in the cell ; those in the cell and on the margins rounded and those in between the veins elongate. Hind wings whitish ; a few small, elongate spots of steel blue colour present in and beyond the cell ; marginal spots only up to vein Cu_2 ; the area below the cell unspotted from base to vein Cu_2 . Abdomen brown, marked with black transverse bands up to seven segments ; with tufts of hair ; the last two segments without any bands, but with only tufts of brownish or whitish scales. Underside of wings as on upperside and that of abdomen without any spots. Legs steel blue, femora whitish beneath.

Antennae, in male (Text-fig. 33A), strongly bipectinate nearly up to basal half, the distal half minutely serrate ; the shaft with 41-49 segments, of which basal 18-23 segments bipectinate, the rami longer in middle, the longest being as long as 7-8 middle segments of shaft ; the last segment simple ; antennae, in female, simple. Labial palpi minute. Legs, hind-tibial spurs, tarsal spines, frenulum and retinaculum, as for the genus.

Venation.—Fore wing (Text-fig. 33B) : Mainly as given in generic characters. Areole projecting a little beyond the cell angle ; vein R_1 generally arises from cell, rarely from the origin of or from the

areole ; R_2 from near the distal end of areole ; R_3 generally shortly anastomosed with $R_4 + R_5$, rarely connate or free ; M_1 from below the cell ; lower branch of median cell ending nearer Cu_{1a} than M_3 . Hind wing (Text-fig. 33C) : As for the genus.



Text-fig. 33. *Zeuzera multistrigata* Moore : (A) A portion of the male antenna. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers. (E) Male genitalia in inner view, with claspers. (F) and (G) Uncus and saccus, respectively. (H) Aedeagus. (B & C ; E to G of the same magnifications).

Genitalia.—Male (Text-fig. 33D-H) : Uncus more or less triangular, broad at base and in middle ; length about twice the width

in middle, narrowed distally to a fine, downwardly pointed tip. Gnathos long and incurved, not meeting each other but connected by only a thin membrane. Tegumen weakly sclerotised, and without invagination at base. Saccus short, broadly triangular and slightly upturned at tip. Claspers broadest in middle; costal prolongation short and reduced. Juxta sclerotised, nearly rounded, with short median lobes and long and blunt anellus lobes. Aedeagus poorly differentiated into a base and a large vesica, the latter membranous and with a hard cornutal process arising from near the base. Female (incomplete and damaged): Ostium bursae simple, without chitinisation; ductus bursae simple; genital plate sclerotised dorsally but without any sclerotisation ventrally; the posterior apodemes extending a little beyond genital plate; ovipositor simple.

Measurements.—Expanse: Fore wing: Male, 42-74 mm.; female, 66-117 mm. Length: Fore wing: Male, 19-32 mm.; female, 30-48 mm.; Hind wing: Male, 13-20 mm.; female, 20-33 mm. Abdomen: Male, 13-23 mm.; female, 33 mm. Whole body: Male, 20-32 mm.; female, 44 mm.

Material examined.—30 examples as follows: India: Uttar Pradesh: Mussoorie, 4 ♂♂, -vii-viii.1927, 1 ♂, 1 ♀, ix-x.1928 (*C.F.C. Beeson* coll.); Dehra Dun, 1 ♂, -.-.1931 (*S.A.A. Anvery* coll.) (ex. colln. F R.I.); Lata, Garhwal Dist., 2428.40 m., 6 ♂♂, 6.vii. 1958; Gadera, 2896 m. 1 ♂, 8.viii. 1958 (*B.S. Lamba* coll.). W. Bengal: Darjeeling, 1 ♂, -.-.1860 (no further data); 1 ♀, 30. xii.1881; 1 ♀, -vii.1912 (no further data); Sanchal range, 1 ♂, 6. iii.1923, Tista range, 1 ♂, 19.viii.1923 (both *J. C. M. Gardner* coll. ex. coll. F.R.I.). Sikkim: 1676.38 m., 1 ♀, 1-5.iv.1888, 1 ♂, -.-.1891; 1 ♀, 10.ix. 1898 (all *G. C. Dudgeon* coll.); 2133 m., 1 ♂, 1 ♀, -viii.1895 (*J. G. Pilcher* coll.); 1 ♂, 2.viii.1888, 2 ♂♂, 1 ♀ (no date) (*O. Möller* coll.); 2 ♂♂ (no date) (*Jordon* coll.).

Distribution.—India (Kashmir, Himachal Pradesh, Uttar Pradesh, Naga Hills, West Bengal, Sikkim), Bangladesh (Sylhet) and Burma (Kambaiti).

Remarks.—A good species of *Zeuzera*, it can be separated from the other species by the wing spots which are not only prominent on the upper side but also on the under side; by the unspotted inner area of hind wings; by the transverse bands and tufts of hair on the abdominal segments; and by the absence of medial spot on metathorax. In male genitalia, it differs from *Z. coffeae* by the presence of gnathos (absent in *coffeae*), and from *postexcisa* in having weakly developed median lobe of juxta (well developed in *postexcisa*).

Phylogenetically this species serves a very good example to show a close link between the two subfamilies *Cossinae* and *Zeuzerinae*, on one hand, because of the origin of vein R_1 from subcostal nervure, which is a cossinae character and on the other hand, by the presence of single pair of tibial spurs in hing legs, and free gnathos.

37. *Zeuzera postexcisa* Hampson

(Pl. III, figs. 37, 38 ; Text-figs. 34, 35)

- 1892a. *Zeuzera postexcisa* Hampson, *Ill. Typ. Lep. Het. Brit. Mus.*, 9 : 68 (Type loc.—Ceylon).
 1892b. *Zeuzera postexcisa* Hampson, *Fauna Brit. India, Moths*, 1 : 311 (Ceylon).
 1900. *Zeuzera postexcisa*, Piepers and Snellen, *Tijdschr. Ent.*, 43 : 41 (Java).
 1919b. *Zeuzera postexcisa*, Kalshoven, *Meded. Profstn. Boschw. Batavia*, 4 : 69.
 1923. *Zeuzera postexcisa*, Dalla-Torre, *Lepid. Cat.*, 29 : 39 (Ceylon).
 1933. *Zeuzera postexcisa*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 812 (Ceylon).
 1941. *Zeuzera postexcisa*, Beeson, *The Ecology and Control of Forest Insects of India and the Neighbouring Countries* : 583.

Type ; In B. M.

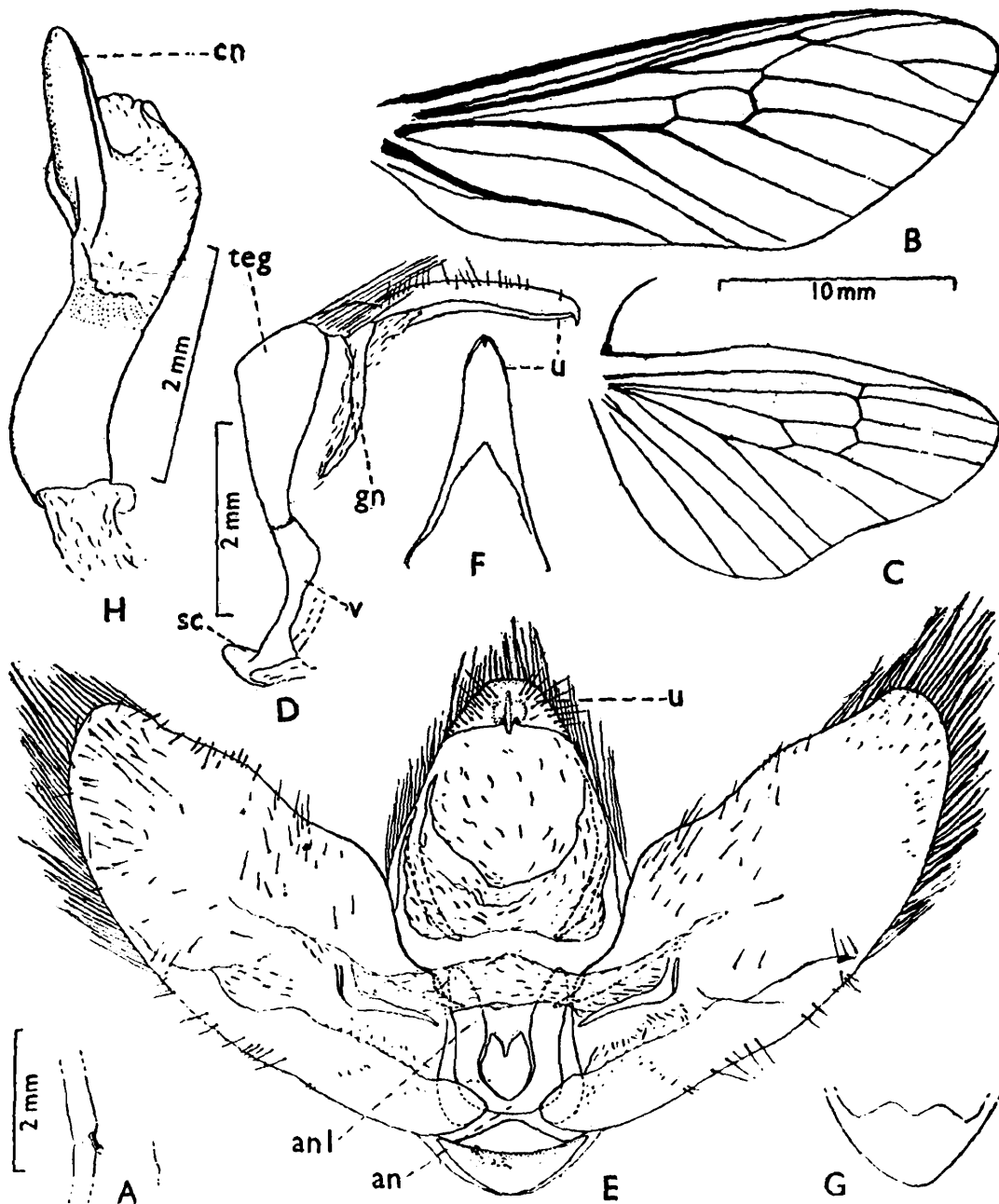
Host ; *Phoeba excelsa*.

Frontal tufts and labial palpi dark brown. Vertex covered with white woolly hair-scales. Antennae dark brown, mixed with whitish scales, some of which giving metallic-blue shine. Thorax pale brown, with three lateral, shining bluish-black spots and a median one on metathorax. Fore wings whitish to pale brown, with rows of shining, bluish-black spots in between the veins ; those on the costa, along the outer margin and on the inner margin, prominent. Hind wings deeply incised at the tornal angle, generally with fewer spots ; sometimes with indistinct ones and with marginal row of blue-black spots on the outer margin, the one at the tornal angle large and prominent. Legs (damaged in the specimens available), appear to have whitish to pale brown femora ; the remaining portion with bluish tinge. Abdomen white to pale brown ; a series of large or small spots present on the dorsal and lateral sides, except the third segment which has a transverse band, and the last which has three elongate spots, which are broad basally but narrow distally. Underside of wings as on the upperside but that of abdomen without any spots.

Antennae, in male, bipectinate nearly up to the basal half, the distal part minutely serrate ; the shaft with about 50 segments, of which about 23 bipectinate ; the rami longer in the middle, the longest ones as long as 7 middle segments of shaft ; the antennae in female, wholly

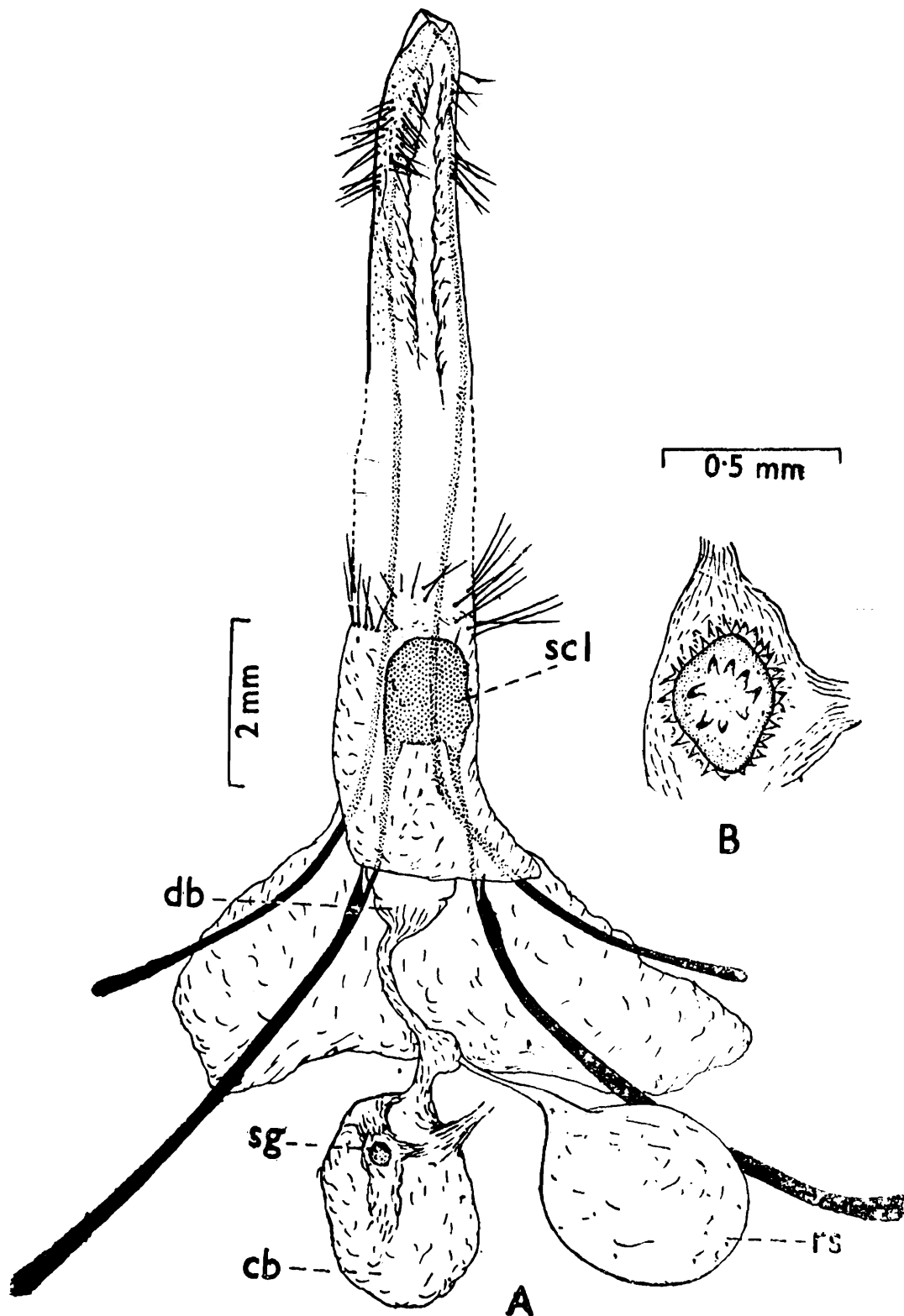
simple, with a few flattened distal segments. Labial palpi minute. Hind tibial spurs (Text-fig. 34A) tarsal spines, frenulum and retinaculum, as for the genus.

Venation.—Fore wings (Text-fig. 34B) : Areole in fore wing slightly more produced outside the cell angle than in the preceding species ; vein R_1 arises generally from the cell, rarely from areole ;



Text-fig. 34. *Zeuzera postexcisa* Hampson : (A) A portion of the hind leg with a single pair of tibial spurs. (B) and (C) Fore and hind wing venation, respectively. (D) Male genitalia in a lateral view, without claspers. (E) Male genitalia in inner view. (F) and (G) Uncus and saccus, respectively. (H) Aedeagus. (B & C ; D, F-G and E & H of the same magnifications).

R_3 shortly stalked with $R_4 + R_5$; M_1 from below the cell angle; the median cell with the lower branch ending between veins $Cu_{1a} - M_3$, nearer Cu_{1a} than M_3 . Hind wing (Text-fig. 34C) : As for the genus.



Text-fig. 35. *Zeuzera postexcisa* Hampson : (A) and (B) Portions of the female genitalia.

Genitalia.—Male (Text-fig. 34D-G) : Uncus broadly triangular, long, narrow and pointed distally ; strongly sclerotised ; about thrice as long as its width in middle. Gnathos long, incurved and not meeting with each other. Tegumen without membranous folds and invagination at its base. Saccus small, blunt and upturned. Claspers simple, broader in the middle ; costal process short. Juxta well developed, sclerotised ; median lobes thick and blunt apically ; anellus lobes long, narrow and pointed distally. Aedeagus well developed, with the short base differentiated from the large vesica, the latter sclerotised and striated at base and membranous distally ; the cornutal process extending far beyond the vesica. Female (Text-fig. 35) : Ostium bursae simple, weakly sclerotised ; ductus bursae short ; corpus bursae nearly rounded ; signum on the corpus bursae semicircular and blackish, due to the presence of short tubercles ; receptaculum seminalis also rounded and membranous ; genital plate sclerotised only on the dorsal side.

Measurements.—Expanse : Fore wing : Male, 52-75 mm. ; female, 68-97 mm. Length : Fore wing : male, 25-34 mm. ; female, 32-46 mm. Hind wing : Male, 15-21 mm. ; female, 26-30 mm. Abdomen : Male, 19-25 mm. ; female, 22-28 mm. Whole body : Male, 27-36 mm. ; female, 34-40 mm.

Material examined.—Fourteen examples as follows : India : Uttar Pradesh : New Forest, Dehra Dun, 1 ♀, 4.viii. 1928, 1 ♂, 6.viii. 1928, 1 ♂, 1 ♀, 9. viii. 1928, 2 ♀ ♀, 12-13. viii. 1928, 1 ♂, 14.viii. 1928, 1 ♀, 16. viii. 1928. (*G. D. Bhasin*. coll.) ; 1 ♂, 11.vii. 1948 (*K. M. Subhaya* coll.) ; 1 ♂ (no date) (All ex. colln. F. R. I.). Sikkim, 1 ♂ (no data).

Ceylon : Diyatalawa, 2 ♂ ♂, 1 ♀, 1.xii.1900 (*E. E. Green* coll.).

Distribution.—India, Sri Lanka and Java.

Remarks.—Referable to the genus *Zeuzera*, it is characterised by its stout body, with an additional spot on the collar, tegulae and the metathorax ; a dorsal and lateral series of markings on the abdomen ; and a well-developed free gnathos. The specimens from Uttar Pradesh with somewhat semihyaline wings.

It is close to *multistrigata* Moore, for differences see under that species.

38. *Zeuzera indica* Herrich-Schäffer

1854. *Zeuzera indica* Herrich-Schäffer, *Samml. Ausser. Schmett.* : 58, fig. 166 (Type loc.—not given).

1856. *Zeuzera paucipunctata* Walker, *List Lep. Brit. Mus.*, 7 : 1537 (Type loc.—Silhet, Bangladesh) (*Syn.* Cotes and Swinhoe, 1887).
 1859. *Zeuzera indica*, Horsfield and Moore, *Cat. Lep. Mus. E. I. C.*, 2 : 437.
 1865. *Zeuzera indica*, Moore, *Proc. zool. Soc. Lond.* : 822.
 1867. *Zeuzera paucipunctata*, Moore, *Proc. zool. Soc. Lond.* : 686.
 1881. *Zeuzera paucipunctata*, Moore, *Proc. zool. Soc. Lond.* : 327.
 1887. *Zeuzera indica*, Cotes and Swinhoe, *Cat. Moths of India.* : 233 (Sikkim, Simla, Sylhet).
 1892. *Chalcidica indica*, Kirby, *Cat. Lep. Het.* : 873 (N. India).
 1892b. *Zeuzera indica*, Hampson, *Fauna Brit. India, Moths*, 1 : 311 (Simla, Sikkim and Sylhet).
 1895. *Zeuzera indica*, Swinhoe, *Trans. ent. Soc. Lond.*, 29.
 1923. *Zeuzera indica*, Dalla-Torre, *Lepid. Cat.*, 29 : 38.
 1933. *Zeuzera indica*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 812 (Java, New Guinea, Simla and Sikkim).
 1955. *Zeuzera indica*, Roepke, *Trans. R. ent. Soc. Lond.*, 107 : 281.
 1957. *Zeuzera indica*, Roepke, *Verh. k. ned. Akad. Wet. Afd. Nat.*, (2) 52 (1) : 13 (from Himalayas through S. E. Asia the Archipelago, the Philippines, New Guinea and Australia).

Types ; *indica* in Paris Mus.

paucipunctata in B. M.

As no specimens of this species were available for study, a revised description of the species, given by Hampson (1892b), is given below. The description of male genitalia is quoted from Roepke (1957).

Thorax unmarked. The basal and terminal segments of abdomen each with three dorsal blue-black streaks ; each of the other segments with one dorsal streak, those on the second and third segments triangular. Fore wings with the spots fewer and large, the most conspicuous being a spot at centre of the cell, one near the apex, and those on each side of vein 1A. Hind wing with three large spots below the end of cell ; one between vein 1A and Cu_2 , the largest between Cu_2 and Cu_{1b} , the smallest between Cu_{1a} and Cu_{1b} ; with a marginal series of spots, the one nearest to the anal angle large.

Genitalia.—Male : “Uncus straight and long, the lora [gnathos] elongate and narrow, about as long as uncus. Valvae [claspers] of normal shape, about thrice as long as broad. Aedeagus short and thick, with some complicated structure projecting from its orifice.”

Measurements.—Expanse : 96-114 mm.

Distribution.—This species is known from India (Simla, Sikkim), Bangladesh (Sylhet), throughout South-Eastern Asia, the Archipelago, the Philippines in the Oriental region, and New Guinea and Australia in the Australian region.

Remarks.—The largest of Indian *Zeuzeras*, it is characterised by the absence of spots on thorax. Hampson (1892) placed this species along with *Z. conferta*, under his first category, *i.e.*, vein M_1 in the fore wing arising from the angle, and the hind wing with the outer margin evenly curved. It can, however, be differentiated from *conferta* by the thorax being unmarked.

39. *Zeuzera conferta* Walker

1856. *Zeuzera conferta* Walker, *List Lep. Brit. Mus.*, 7 : 1536 (Type loc.—Sylhet, Bangladesh).
 1867. *Zeuzera conferta*, Moore, *Proc. zool. Soc. Lond.* : 686.
 1886. *Zeuzera conferta*, Butler, *Ill. Typ. Lep. Het. Brit. Mus.*, 6 : 28.
 1887. *Zeuzera conferta*, Cotes and Swinhoe, *Cat. Moths of India* : 233.
 1892b. *Zeuzera conferta*, Hampson, *Fauna Brit. India, Moths*, 1 : 311.
 1892. *Zeuzera conferta*, Kirby, *Cat. Lep. Het.* : 872.
 1923. *Zeuzera conferta*, Dalla-Torre, *Lepid. Cat.*, 29 : 38 (Sylhet, Bangladesh, and Luzon, Philippines).
 1933. *Zeuzera conferta*, Gaede, in Seitz *Macrolepidoptera of the World*, 10 : 811 (Sylhet, and Labuan).

Type : In B. M.

As no material of this species was available, the original description by Walker (1856) is reproduced here : "Female. Whitish. Antennae black. Thorax with two interrupted green stripes. Abdomen with three rows of green spots. Legs mostly green. Wings with very numerous minute transverse green or aeneous streaks, and with green dots along the border ; parts of the disk of the fore wings without streaks. Length of body 13 lines ; of wings 28 lines. a. Silhet."

Distribution.—The species is known from Bangladesh (Sylhet) and the Philippines (Labuan and Luzon), in the Oriental region.

Remarks.—It is close to *Z. indica* Herr.-Sch., in respects of the origin of vein M_1 in the fore wing and in the evenly-rounded outer margin in the hind wing. It is separable by the presence of spots on thorax, as mentioned by Hampson (1892b).

V. DISCUSSION

(a) *Some Important Taxonomic Characters*

The taxonomic study of the Indian species of the family Cossidae is based on certain important characters like the pectination of antennae, the size and shape of labial palpi, the hind tibiae & tibial spurs, tarsal spines and the wing venation. In respect of the male genitalia the important characters are the gnathos-whether meeting

in the middle below the uncus or free, if present, or absent completely; the structure of claspers—whether simple or with some well-defined areas; the shape of juxta; and the aedeagus—whether simple and without cornuti or highly sclerotised and with cornuti.

The family Cossidae has been divided into two subfamilies, viz. Cossinae and Zeuzerinae, as proposed by Neumoegen & Dyer (1894). The basis of division has, however, been modified by taking into account several characters, as mentioned above, instead of taking any single character as done by Neumoegen & Dyer himself and several others. While Neumoegen & Dyer (1894) based his classification on the basis of presence or absence of a cross bar between veins Sc and Rs in the hind wing (This character among the Indian fauna is present only in the genus *Zeuzera* Latreille of Zeuzerinae, with the result that all the other genera, viz., *Azygophelps* Hampson, *Phragmataecia* Newman and *Xyleutes* Hübner, are excluded from Zeuzerinae). Barnes & McDunnough (1911) and Dyar (1937) proposed the origin of vein R_1 in the fore wing as the basis of division between the two subfamilies (This is quite a good character and generally helpful, except in certain species of Zeuzerinae, viz., *Xyleutes pardicolor* (Moore) and *Xyleutes kapuri* sp. n., where the vein R_1 does not arise from the areole—a characteristic feature of the subfamily, but from the cell), and Essig (1951) proposed the origin of veins Rs and M_1 in the hind wing, as being connate or stalked in Cossinae unlike in Zeuzerinae where it is free (This again is generally helpful, except in the genus *Paracossus* Hampson and in some specimens of Cossinae where these veins are either wide separate or tend to separate). Thus, it is evident that no single character is sufficient to divide the family. By taking into account the characters proposed by Barnes & McDunnough, Dyar, and Essig along with a few more characters as that of antennae, hind tibiae and the gnathos in male genitalia, it would not be difficult to separate the Cossinae from Zeuzerinae, e.g., the genus *Cossus* is typically characterised by the presence of antennae which are pectinate up to tip, the dilated hind tibiae and two pairs of hind-tibial spurs, the origin of vein R_1 from the cell, veins Rs and M_1 connate in the hind wing and the gnathos meeting below the uncus, unlike the typical genus *Zeuzera* of the latter subfamily, wherein the antennae are pectinate up to the basal half, the hind tibiae are not dilated and with single pair of spurs, the vein R_1 arises from the areole, veins Rs and M_1 in the hind wing are wide separated and the gnathos, if present, either rudimentary or free. A few more characters of taxonomic importance have also been used here for this study, e.g., the presence or absence of ocelli, the tarsal spines and arolium, etc, which hitherto have not been used among the Cossidae. A brief resume of these characters, with their bearing on the taxonomy, is as follows :

Although Seitz (1937) was of the opinion that antennae were not good characters for separation of various genera in the two

subfamilies, which may be true as far as the world fauna is concerned, the present study of the Indian fauna shows that the antennae generally constitute a fairly constant character and can be profitably used in classification, e.g., the antennae are generally pectinate up to the tip in Cossinae (except in the genus *Holcocerus* where these are simple) and not up to tip in Zeuzerinae. While in other genera of Cossinae the antennae are bipectinate, in the genus *Cossus* these are unipectinate, probably leading to a stage found in the genus *Holcocerus*. The ocelli had been unknown in the Cossidae till Clench (1959 a) recorded these from a Madagascan genus *Pseudocossus*. Ocelli have also been recorded among the Indian Cossidae, especially in the two species, viz. *Catopta cashmirensis* (Moore) and *Catopta sikkimensis* (Arora), which differ distinctly from the other Cossids.

The legs have proved to be quite useful in the study. The hind-tibial spurs are present in all the cossids, though varying in length and number. There are two pairs of tibial spurs in the subfamily Cossinae, and a single pair in Zeuzerinae. While the hind tibiae are dilated distinctly in the former, in the latter these are simple. The tarsal spines have also been found useful in the study, as these are present on all the tarsal segments in Cossinae, unlike in Zeuzerinae where these are either not present on all the segments in any of the genera studied, or not present at all as in the genus *Phragmataecia* Newman. The arolium is generally present in Cossinae, either weak or strong, but in Zeuzerinae it may be either present, as in *Azygophelps* Hampson and *Phragmataecia* Newman, or absent in *Xyleutes* Hübner and *Zeuzera* Latreille. The species of *Azygophelps* and *Xyleutes* were often confused because of the male antennae pectination and the wing venation. The study of the legs, however, distinctly separates these two genera.

In the male genitalia the gnathos is always present in Cossinae and meeting below the uncus, but in Zeuzerinae it is either completely absent as in the genus *Phragmataecia* Newman, or free if present, either weak or strong, as in *Azygophelps*, *Xyleutes* and *Zeuzera*. Besides, other characters as that of clasper, juxta, aedeagus, etc., have also been described in detail.

(b) Phylogeny

Some generic characters which have been noted also seem to have a bearing on the phylogeny of the family Cossidae. Turner (1918) traced the phylogeny on the basis of wing-venation. According to him the family Cossidae has retained the primitive-type of neurulation and claimed that all the other families of Lepidoptera could be derived from this subfamily in so far as the venation was concerned. He used the origin and location of various veins in the evolution of different genera.

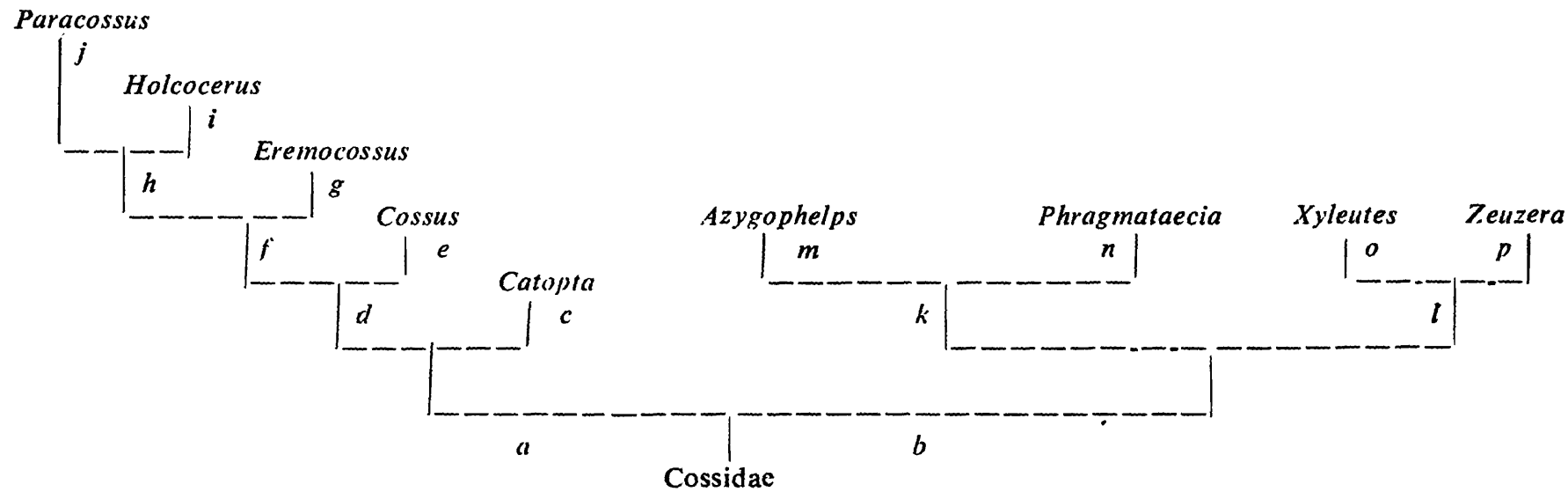
As pointed out by him the most primitive genera are the *Cossodes* and *Dudgeonea*, which have the long and well developed tibial spurs and rather long palpi. Their neururation, according to him, also confirms this conclusion. The genus *Dudgeonea*, however, has recently been separated into a distinct family Dudgeonidae by Berger (1957) on the basis of the presence of tympanum.

The Indian group of Cossids seem to have diverged into two lines : one having the characters of Cossinae, *i.e.*, antennal pectination up to the tip, dilated hind tibiae, and the gnathos which are fused, and the other having the characters of Zeuzerinae, *i.e.*, antennae partly pectinate, the hind tibiae normal, and the gnathos free. In the Cossinae group of genera the genus *Catopta*, appears to have got separated into an independent line which retains the primitive characters, *i.e.*, presence of ocelli and pectination of antennae up to the tips. The other group of genera got diverged on the line, with the antennae which are either pectinate or simple and where the ocelli are obsolete. From the latter the genus *Cossus* seems to have evolved and is characterized by unipectinate antennae in the male. The other line of development leads to bipectinate or simple antennae. The genus *Eremocossus* seems to have diverged further on account of the presence of stalked veins Rs-M₁; the other two genera, *viz.*, *Holcocerus* and *Paracossus* have free or connate veins. The genus *Holcocerus* is easily separated by the characters of simple antennae in the male and by the forked median vein in both the wings. The genus *Paracossus* is characterised by bipectinate antennae and unforked median vein and constitutes a group by itself.

The Zeuzerine group of genera appears to have evolved in two lines, *i.e.* one with the pectination in antennae up to more than the basal half and having distinct arolium, as in the two genera *Azygophelps* and *Phragmataecia*, which again are separated into two different lines of development, one having well developed gnathos in the male genitalia and well developed palpi as in the genus *Azygophelps*, as compared to the other being without gnathos and with reduced or obsolete palpi as in *Phragmataecia*. The genera *Xyleutes* and *Zeuzera* appear to diverge from the common stalk, with the pectination of antennae only up to basal half and without arolium. The genus *Xyleutes* constitute the line of development, which is characterized by the hypertrophied areole in the fore wings and the absence of cross bar between Sc-Rs in hind wings, as compared to the moderately large areole and a cross bar between the veins Sc-Rs in the hind wing in the genus *Zeuzera* which constitutes the other line of development.

Thus, it will be seen that the family Cossidae has evolved from the taxa related to the genus *Dudgeonea* which is perhaps the most primitive among the superfamily Cossoidea. As pointed out by Turner (1918), the genus *Dudgeonea* possessed certain characters

Scheme of evolution in the Indian Cossidae



a, antennal pectination up to the tips, dilated hind-tibiae, fused gnathos; *b*, antennae pectination in part, normal hind tibiae, free gnathos; *c*, ocelli present, antennae bipectinate up to tips; *d*, ocelli absent, antennae bipectinate, or unipectinate or simple; *e*, antennae unipectinate; *f*, antennae bipectinate or simple; *g*, veins R_s and M_1 stalked; *h*, R_s and M_1 either connate or free; *i*, antennae simple, median forked in both wings; *j*, antennae bipectinate, median unforked; *k*, antennal pectination for more than basal half, arolium present; *l*, antennae pectination up to basal half, arolium absent; *m*, labial palpi and gnathos well developed; *n*, labial palpi reduced or obsolete, gnathos absent; *o*, areole hypertrophied, cross bar between Sc and R_s in hind wing absent; *p*, areole moderately large, cross bar between Sc and R_s in hind wing present.

which were typical of his hypothetical family, Protocossidae, *i.e.* the long and well developed palpi, the bipectinate antennae up to tips, the veins R_2 - R_5 arising separately from the areole and the well developed tibial spurs. The genus *Catopta* possesses most of these characters, and appears to be the primitive genus among the Indian Cossids whereas the genera *Paracossus* and *Zeuzera* are at the specialised stage of development, especially the genus *Paracossus*, which although peculiar due to the unbranched median vein in both the wings and in the absence of areole, has still retained the Cossid characters, and has led to the origin of higher group of moths, especially those having no areole and median cell.

(c) Zoogeography

The Cossidae in the Indian subregion (India, Bangladesh, Pakistan, Burma, Sri Lanka, and Bhutan) is represented by 40 species and subspecies belonging to nine genera, *viz.*, *Catopta* Staudinger (2 species), *Cossus* Fabricius (5 species), *Eremocossus* Hampson (one species), *Holcocerus* Staudinger (2 species), *Paracossus* Hampson (2 species), *Azygophelps* Hampson (4 species), *Phragmataecia* Newman (10 species), *Xyleutes* Hübner (8 species) and *Zeuzera* Latreille (5 species and one subspecies).

The genus *Catopta* is known only from the Palaearctic and the Oriental regions, but is mainly Palaearctic. Out of 16 species known so far 14 occur in that region and two in the Oriental region (India; Kashmir and Sikkim). Out of the two Oriental ones, one is common with the Palaearctic region. This distribution shows that the origin of the genus was probably in the Palaearctic region.

The genus *Cossus* is cosmopolitan and is mainly either Palaearctic or Ethiopian. Out of a total number of 87 species, eighteen are represented in the Oriental region, of which five are Indian.

Only two species of the genus *Eremocossus* are known, out of which one is from Pakistan (Karachi) and the other from Aden.

Holcocerus is again a Palaearctic genus, and 36 of the 37 species occur in that region. Two species are known from India (Gt. Nicobar, Assam and Sikkim), out of which one is common with the Palaearctic region.

The genus *Paracossus* Hampson is endemic to the oriental region and is represented by only two species, which come from Sri Lanka and Burma.

The genus *Azygophelps* Hampson is represented in the Oriental region by four species which occur in India and one of these also

occurs in China. Twenty of the 27 species are known from Ethiopian and 3 from the Australian regions. The origin of this genus seems to be Ethiopian and its distribution seems to have extended to the Oriental and the Australian regions.

Of the thirty known species of the genus *Phragmataecia*, 13 occur in the Oriental region, of which 10 are known from the Indian subregion. This genus is mainly Oriental, but has an almost world-wide distribution except in the Nearctic region.

The genus *Xyleutes* is represented by 29 species from the Oriental region, 8 of which are occurring in the Indian region. The genus is mainly Australian and out of the total of 154 species about 84 are known from this region. It is also known from all the other Zoogeographical regions except Palaearctic. The origin of the genus is possibly in Australia from where it has spread to India and other Oriental regions, probably the ancient Papuan connections.

The genus *Zeuzera* is represented by 14 species in the Oriental region. Out of the total number of 52 species from the world, only 5 occur in the Indian region.

Thus, out of the total of 407 species of nine genera, which are present in the Indian region, only 85 occur in the Oriental region, with only 40 species from the Indian region. While some of these species are endemic, several other species are well represented in the oriental as well as other regions.

VI. SUMMARY

The present study deals with taxonomic revision of forty species & subspecies, belonging to nine genera, viz. *Catopta*, *Cossus*, *Eremocossus*, *Holcocerus*, *Paracossus*, *Azygophelps*, *Phragmataecia*, *Xyleutes* and *Zeuzera*.

Two species and a subspecies are described as new to science : *Cossus greeni* from Sri Lanka ; *Xyleutes kapuri* from Andaman Is ; and *Zeuzera coffeae angulata* from W. Bengal.

Five new combinations have been proposed : *Catopta sikkimensis* (Arora) ; *Phragmataecia pallidulae* (Hampson) ; *Phragmataecia clara* (Bryk) ; *Phragmataecia obliquifascia* (Bryk) ; and *Phragmataecia stigmaticus* (Moore). The latter has been referred to various genera by different workers but the present study reveals that it belongs to the genus *Phragmataecia* Newman.

The following new distributional records, including those from India, are being reported :

<i>Cossus</i> Fabricius	From Sri Lanka
<i>Cossus cadambae</i> Moore	From Sri Lanka
<i>C. acronyctoides</i> (Moore)	From Delhi
<i>Holcocerus arenicola</i> (Staudinger)	From India (Great Nicobar)
<i>H. rufidorsia</i> (Hampson)	From Assam
<i>Phragmataecia terebrifer</i> Fletcher	From Assam and Bengal
<i>P. parvipunctus</i> (Hampson)	From Sri Lanka
<i>P. clara</i> (Bryk)	From India (Sikkim) and Bhutan
<i>P. obliquifascia</i> (Bryk)	From India (Assam)

Types of the following species (the repositories given in the square brackets) were examined : *Catopta cashmirensis* (Moore) [Ber. Mus.]; *Azygophelps albofasciata* (Moore) [Ber. Mus.]; *Phragmataecia saccharum* Moore and *P. minor* Moore [Ber. Mus.]; *Phragmataecia clara* (Bryk) and *P. obliquifascia* (Bryk) (Rm. Stockholm); *Phragmataecia purpureus* Fletcher and *P. terebrifer* Fletcher [N. P. C., New Delhi]; and *Xyleutes pardicolor* [Ber. Mus.]. The types of *P. purpureus* and *P. terebrifer*, examined at N. P. C. have been described for the first time, as these were only figured by the original author who gave only the characters of their larvae and did not designate any type. Accordingly, the present author has selected the Lectotypes and Paralectotypes from the original series.

Some characters such as pectination of antennae, presence or absence of tibial spurs, tarsal spines and arolium, have been found to be of considerable taxonomic importance, specially in the classification of subfamilies of Cossidae and in the identity of different genera.

Some of the species, viz. *Xyleutes persona*, *X. ceramicus* and *Zeuzera coffeae*, etc., are of economic importance as these are serious pests of agriculture and forestry.

The relationships of the Indian genera and their allies, their taxonomic status, phylogeny and zoogeography have been discussed.

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PLATE I

- Fig. 1. *Catopta cashmirensis* (Moore) — ♂ (Type) : 'Tawi Kashmir', ex. colln. Ber. Mus.
2. *C. sikkimensis* (Arora) — ♂ (holotype) : Dambung, N. Sikkim, (A. G. K. Menon coll.).
3. *Cossus acronyctoides* (Moore) — ♂ : Poona, (B. S. Lamba coll.).
4. *C. acronyctoides* Moore — Delhi, ex. colla. I. A. R. I. (Gullamullah coll.), ex. collan. I. A. R. I.
5. *C. greeni* sp. n. — ♂ : Kandy, (E. E. Green coll.).
6. *Holcocerus arenicola* (Staudinger) — ♂ : Bellabay, Great Nicobar Islands, (Daniel & Bhowmik coll.).
7. *H. rufidorsia* (Hampson) — ♂ : N. Lakhimpur, (S. K. Tandon & G. S. Arora coll.).
8. *Paracossus parva* Hampson — ♂ : Mirigama, ex. colln. B. M.
9. *Azygophelps scalaris* (Fabricius) — ♂ : Baratla, on Sunnhemp.
10. *A. albofasciata* (Moore) — ♂ (Type) : Darjilling, ex. colln. Ber. Mus.
11. *A. pusilla* (Walker) — ♂ : Bangalore, ex. colln. I. A. R. I.
12. *A. pusilla* (Walker) — ♂ : Bangalore,
(Magnification scale of 3, 4, 6, 7. 9-12 same as of 1)

Records of the Zoological Survey of India

ARORA

PLATE I

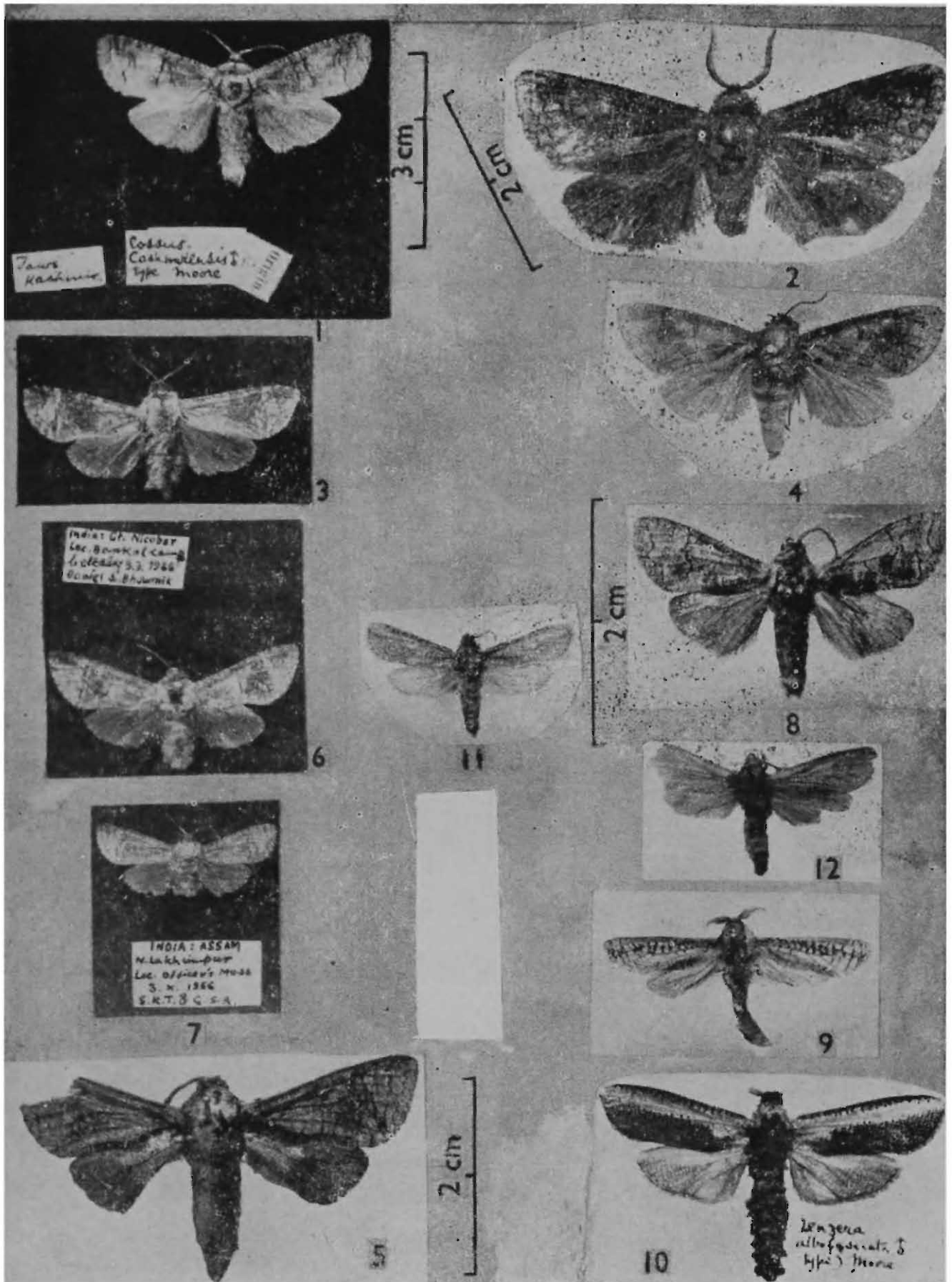


PLATE II

- Fig. 13. *A. scalaris* (Fabricius) — ♀ : Bhiun, Punjab, ex. colln. F. R. I., Dehra Dun.
14. *Phragmataecia castaneae* (Hübner) — ♂ (Type of *saccharum*) : Darjiling, ex. colln. Ber. Mus.
15. *P. castaneae* (Hübner) — ♂ (Type of *minor*) : 'Silhet Jheels', (Sylhet Lakes), Bangladesh, ex. colln. Ber Mus.
16. *P. castaneae* (Hübner) — ♂ : Sikkim.
17. *P. impura* Hampson — ♂, Trivandrum, ex. colln. B. M.
18. *P. impura* Hampson — ♀ : Pusa, Bihar, ex. colln. I. A. R. I.
19. *P. purpureus* Fletcher — ♂ : Pusa, Bihar on *Saccharum arundinaceum*, ex. colln. I. A. R. I.
20. *P. pallidulae* (Hampson) — ♂ : Bhutan, ex. colln. B. M.
21. *P. terebrifer* Fletcher — ♂ : Pusa, Bihar, on *Saccharum spontaneum*, ex. colln. I. A. R. I.
22. *P. dudgeoni* Arora — ♂ : Bhutan.
23. *P. clara* (Bryk) — ♂ (Type) : Mekane, Tenasserim, Burma, ex. colln. Riksmuseum, Stockholm.
24. *P. stigmaticus* (Moore) (after Moore, 1879) — ♂ : (Type). Darjiling, ex. colln. Ber. Mus. (The original label, however, reads *Zenzera bistigma*).
25. *P. stigmaticus* (Moore) — ♂, Rahung, 1830 m., Kameng Div., Arunachal Pradesh, (S. Biswas coll.).
26. *P. obliquifascia* (Bryk) — ♂ (Type), Kambaiti, 2000 m., N. E. Burma, ex. colln., Riksmuseum, Stockholm.
27. *P. obliquifascia* (Bryk) — ♂, Lekhabali, Assam, (S. K. Tandon & G. S. Arora coll.).
- (Magnifications scale of 14, 15, 18, 19, 21, 24, 25 same as of 13 ; 22 as of 16 ; 17 as of 20 ; and 23 as of 26).

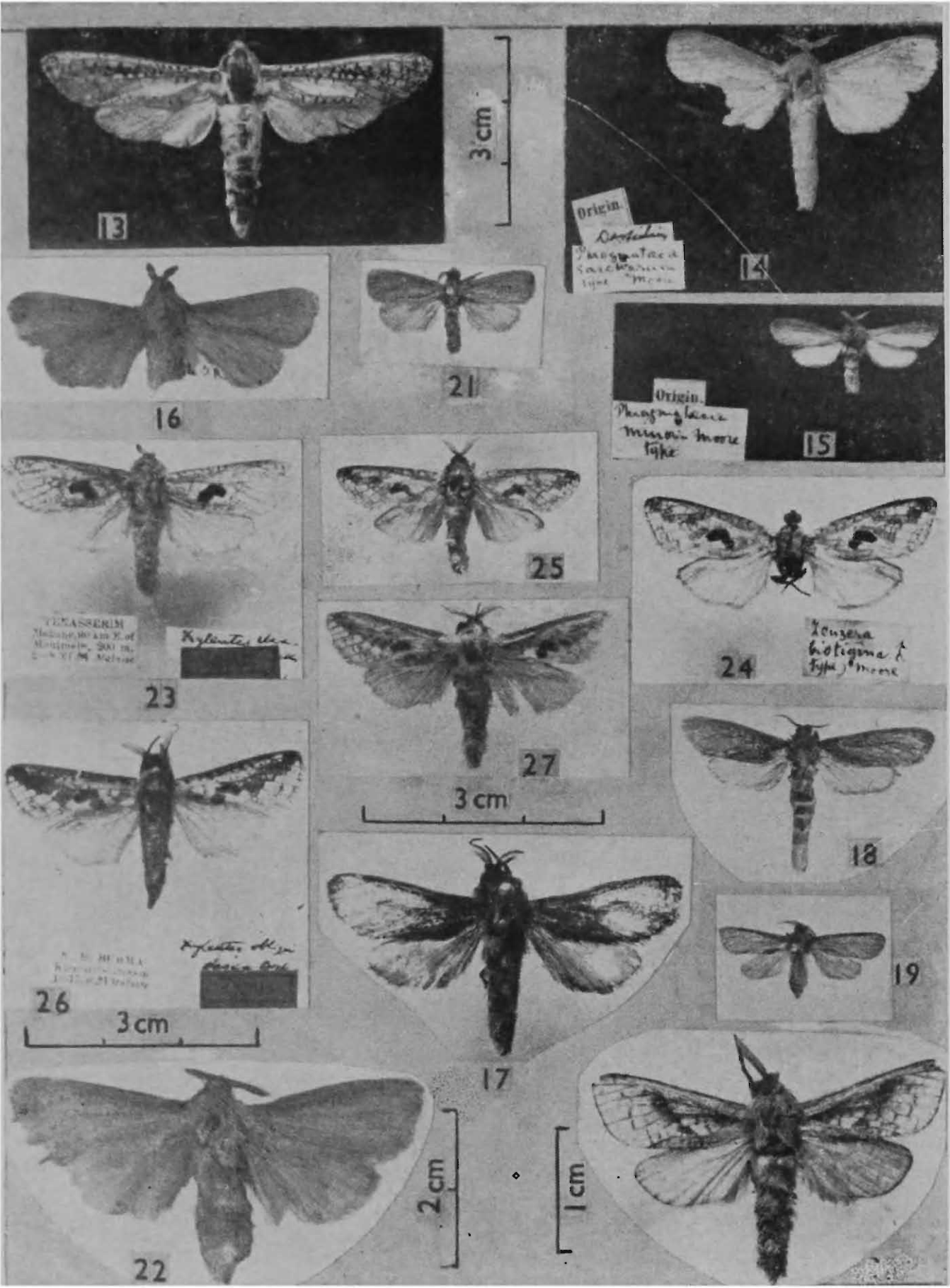
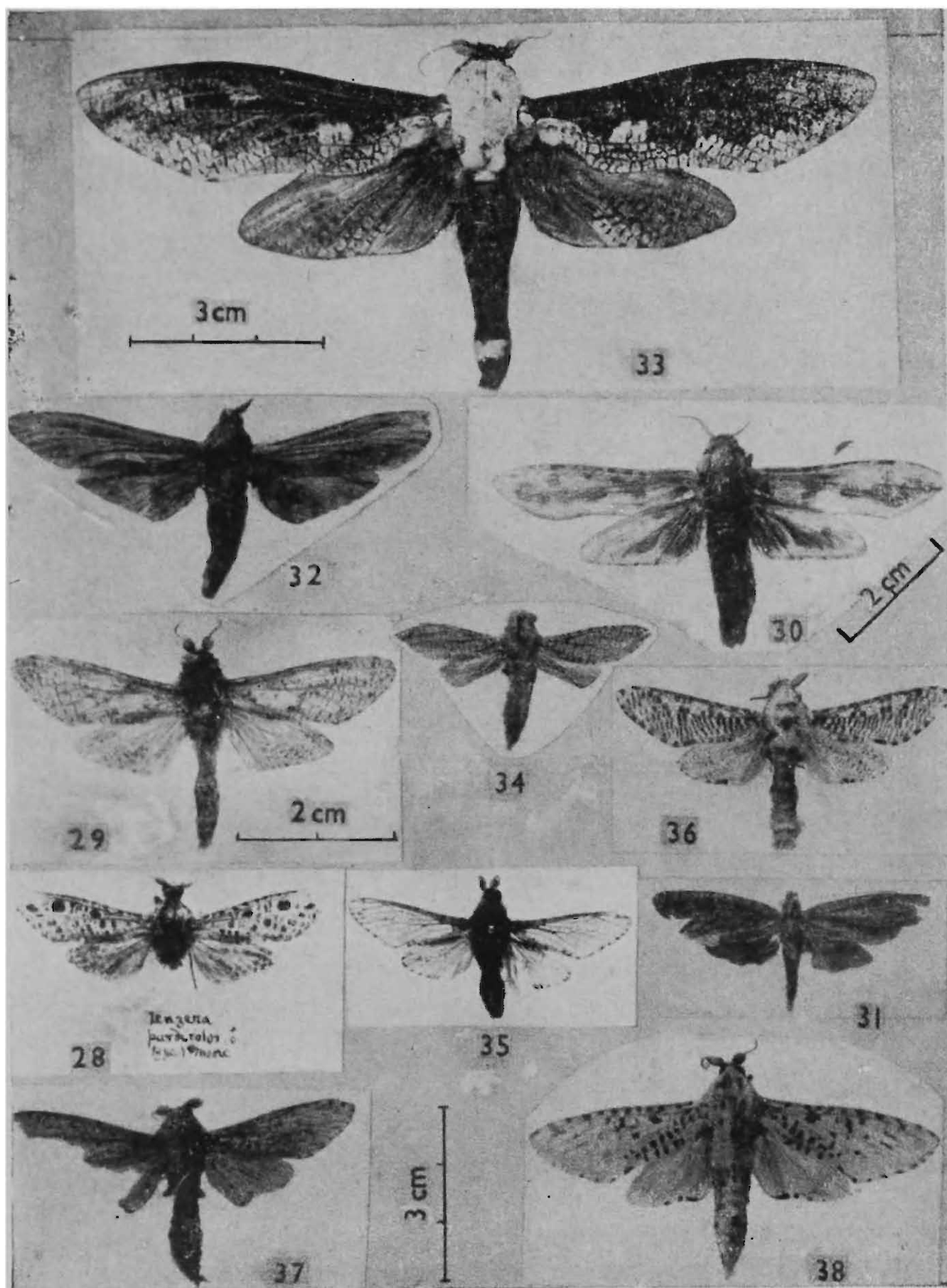


PLATE III

- Fig. 28. *Xyleutes pardicolor* (Moore) — ♂ (Type) : Darjiling, ex. colln. Ber. Mus.
29. *X. kapuri* sp. n. — ♂ (holotype) : Humphrygunj, S. Andaman, (B. S. Lamba coll.).
30. *X. mineus* (Cramer) — ♂ : Kimin, Kameng Div., Arunachal Pradesh (A. N. T. Joseph coll.).
31. *X. nigra* (Moore) — ♀ : Kandy, Ceylon, (E. E. Green coll.).
32. *X. ceramicus* (Walker) — ♂ : Sikkim, (G. C. Dudgeon. coll.).
33. *X. persona* (Le Guillou) — ♂ : Naga : Sikkim, (A. G. K. Menon coll.).
34. *Zeuzera coffeae* Nietner — ♂ : Watagoda, Ceylon, (E. E. Green coll.).
35. *Z. coffeae angulata* ssp. n. — ♂ (paratype) : Kambang, Arunachal Pradesh, (S. K. Tandon & G. S. Arora coll.).
36. *Z. multistrigata* Moore — ♂ : Sikkim.
37. *Z. postexcisa* Hampson — ♂ : Diyatalawa, Ceylon, (E. E. Green coll.).
38. *Z. postexcisa* Hampson — ♂ : New Forest, Dehra Dun, ex. colln. F. R. I., Dehra Dun,
(Magnification scale of 28 same as of 33 ; 31, 32, 34-38 as of 29).

ERRATA

- p. 27 under species no. 3 read (Pl. I, figs. 3 & 4, Text-fig. 3).
- p. 30 under species no. 4 read only (Text-fig. 4).
- p. 36 Foot note read p. 25 instead of p. 23.



TERMITES FROM THE AMAZON BASIN, BRAZIL, WITH
NEW RECORDS AND TWO NEW *NASUTITERMES*
(INSECTA : ISOPTERA)

By

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Desert Regional Station
Zoological Survey of India, Paota, Jodhpur
(With 6 Text-figures and 5 Tables)

INTRODUCTION

(Text-fig. 1 ; and Table 1)

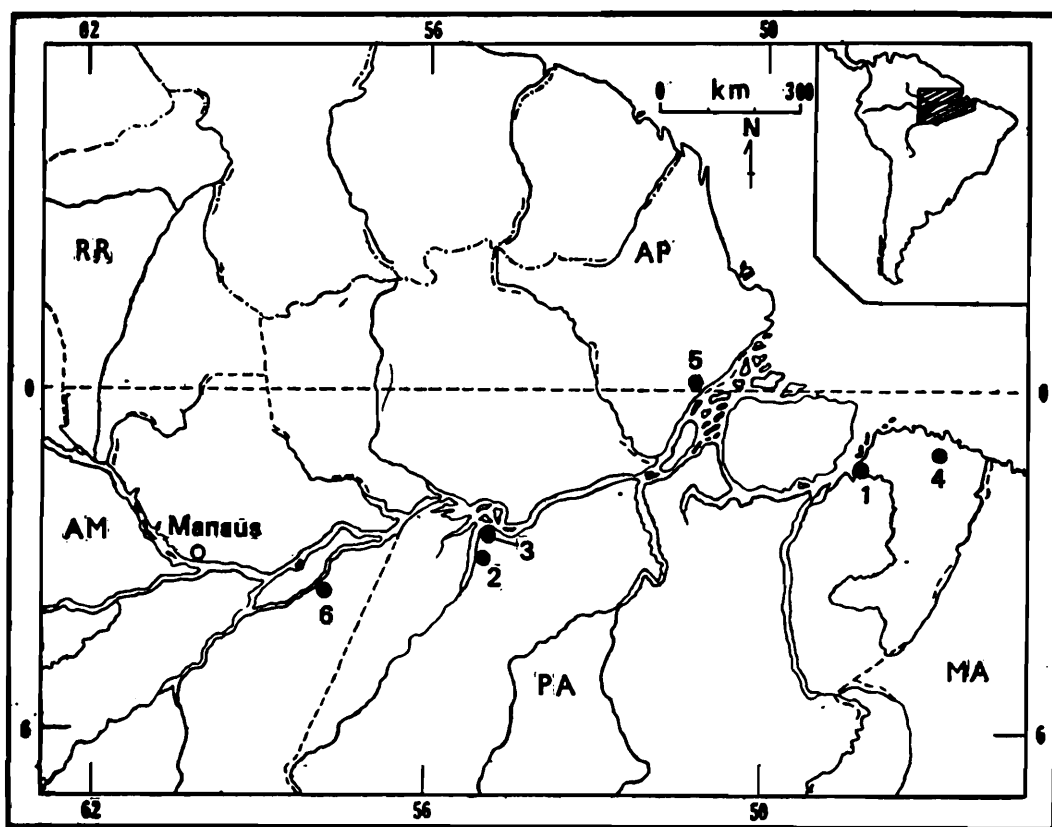
In the year 1957, one of us (M. L. R.), through the good offices of the UNESCO, paid a short visit to the Amazon Basin, Brazil (South America), during which a modest collection of termites (Isoptera) was made. During that same visit were obtained, through the courtesy of a number of Brazilian institutions, especially the Instituto Agronomico do Norte, Belém, some termite collections. The small but interesting collection so assembled from the north-eastern States (Amapá, Amazonas and Pará, *vide* Table 1) is here reported upon. The termite fauna of this vast and rich tract, the Amazon Basin, is very meagrely known, and it is not surprising that the present collection, though modest, has yielded new and valuable information.

The geographical range of a number species is greatly extended by several new locality records, and two new species of the genus *Nasutitermes* (Termitidae : Nasutitermitinae) are described.

The major part of the collection, together with the holotypes of the new species, has been deposited with the Zoological Survey of India, Calcutta ; some of it in Brazil at the Museu de Zoologia da Universidade de São Paulo, São Paulo, and Instituto Agronomico do Norte, Belém ; and at the Forest Research Institute, Dehra Dun.

The taxonomic measurements of termites have been taken in accordance with the limits prescribed in Roonwal (1970).

The Amazon Basin, except near the coast, is a heavily wooded, sparsely inhabited, hot, humid tropical belt with innumerable water-courses, both large and small. The rainfall is heavy, about 140 cm. per annum (Manaus), and is usually received throughout the year but mostly in the southern summer and autumn (January-May). The temperature is high (average over 27°C) the year round. The



Text-fig. 1.—Map of the Amazon Basin, north-eastern Brazil, showing the collecting localities for termites (solid circles). [*Inset* : South America, showing the approximate area covered by the termite collection. (shaded in diagonal lines)].

1. Belém ; 2. Belterra ; 3. Santarem ; 4. Região Bragantina ; 5. Mazagão ; 6. Maués.

States : AM, Amazonas ; AP, Amapá ; MA, Maranhão ; PA, Pará ; RR, Roraima.

vegetation consists mostly of the equatorial, broad-leaved, evergreen rain-forests, and in places there are plantations of rubber (*Hevea* spp.) and Brazilian nut (*Bertholletia* sp.).

Abbreviations used

The following abbreviations have been used :—

Coll.,	Collection ; collected by.	S,	Soldier.
Fd.,	Field.	Sev.,	Several.
Ex.,	From ; out of ; <i>also</i>	W,	Worker.
	Example (s) (exs.).	WM,	Worker Major.
Im,	Imago.	Wm,	Worker minor.
Max.,	Maximum	Z. S. I.,	Zoological Survey of
Ny,	Nymph.		India, Calcutta.

Table 1.—Details of collecting stations for termites in the Amazon Basin, Brazil. (Also see Text-fig. 1.)

Collecting Station	State	Approx. coordinates		Approx. altitude (above M. S. L.)	Remarks
		Latitude	Longitude		
1. Belém	Pará	1°28' S	48°29' W	14 m.	—
2. Belterra	Pará	2°38' S	54°57' W	36 m.	—
3. Santarem (near Airport)	Pará	2°24' S	54°39' W	36 m.	—
4. *Regiao Bragantina (Area between Belém and Braganca)	Pará	1°10' S	46°48' W	—	Approximate
5. Mazagao	Amapá	0°07' N	51°17' W	10 m.	—
6. Maués	Amazonas	3°33' S	57°41' W	18 m.	—

* This is a general denomination for the region between Braganca (lat. 1°04' S, long. 46°46' W) and Belém, the region being named after a railroad, now discontinued (R. L. Araujo, *in litt.*).

ACKNOWLEDGEMENTS

For assistance in various ways we are indebted to the following to whom we would like to express our gratitude :

To the United Nations Educational, Scientific and Cultural Organisation, Paris, for making possible the visit of one of us (M. L. R.) to the Amazon Basin. To Dr. Rubens Lima (Director) and Dr. Elias Sefer (Chief of Entomological Section) at the Instituto Agronomico do Norte, Belém (Brazil), for the donation of a collection of termites (now deposited with the Zoological Survey of India, Calcutta). To Dr. Aristoteles d'Araujo e Silva, Defesa Sanitaria Vegetal, Rio de Janeiro, for assistance in examining collections. To Dr. R. L. Araujo, Museu de Zoologia, Universidade de São Paulo, São Paulo, for valuable taxonomic and other assistance. To Dr. O. B. Chhotani, Zoological Survey of India, Calcutta, for considerable help with measurements and literature. To Mr. S. C. Verma, Jodhpur, for assistance with some measurements. Finally, to the Council of Scientific and Industrial Research, New Delhi, for financial assistance during the later part of this work.

TAXONOMIC ACCOUNT

The following is a short taxonomic account (together with field notes of one of the authors, M. L. R., given here in the first person), and includes 9 species belonging to 2 families (Rhinotermitidae and Termitidae) and 5 genera. Two species of *Nasutitermes* are new to science, while considerable extension of geographical range, north and north-east has been recorded in others. *Nasutitermes guayanae* Holmgren is recorded for the first time from Brazil.

Early works on South American termites, by naturalists in the 16th to 19th centuries, has been summarised by Hagen (1858a, pp. 269-287), noteworthy among these being the account of H. W. Bates on the termites of Santarem (the area also included in the present collection) in the Amazon Basin (pp. 270-280). Later important works are those of Silvestri (1901, 1903), Holmgren (1906-1912), Strelnikov (1920), John (1920), Snyder (1926, 1933), and Emerson (1938, 1945). Some recent accounts are those of Snyder (1949), Grassé (1949, 1958), Emerson (1952-1955), Araujo (1958a, b, 1970a, b), Roonwal (1962) and Weidner (1970). In spite of these, our knowledge of Brazilian termites is still extremely meagre.

The following species are dealt with in the present account :—

Family I. **Rhinotermitidae**

1. *Heterotermes tenuis* (Hagen)
2. *Coptotermes testaceus* (Linnaeus)

Family II. **Termitidae**

3. *Syntermes molestus* (Burmeister)
4. *Cornitermes ovatus* Emerson
5. *Cornitermes silvestrii* Emerson
6. *Nasutitermes araujo* n. sp.
7. *Nasutitermes bragantinus* n. sp.
8. *Nasutitermes costalis* (Holmgren)
9. *Nasutitermes guayanae* (Holmgren)

Genus (1) **Heterotermes** Froggatt

This genus is almost world-wide in distribution, and a few species also occur in South America.

1. **Heterotermes tenuis** (Hagen 1858)

(Synonyms : *Termes corticola* Bates 1854 ; and *Leucotermes flavipes* subsp. *paraensis* Wasmann 1902).

1858. *Termes tenuis* Hagen, *Linn. Entom.*, Berlin, 12 (2) : 231 (Im), Fig. 35. Type-localities : St. Domingo near Port au Prince, Colombia ; and Brazil.
1925. *Leucotermes tenuis* (Hag.), Emerson, *Zoologica*, New York, 6 (4) : 340-341.
1949. *Heterotermes tenuis* (Hag.), Snyder, *Smiths. misc. Coll.*, Washington, 112 : 70.

Material : One tube, as follows :—Tube No. 5 (Fd. Coll. No. R4/2.8.57), sev. S and W, Belterra (Pará), M. L. Roonwal coll., 2 August 1957, ex piece of dry pine plank in a house.

Measurements (mm.), etc.

	<i>Soldiers Major</i> (4 exs.)	<i>Soldiers Minor</i> (1 ex.)
1. Head-length to mandible-base	1.80-2.00	1.50
2. Maximum head-width	1.05-1.08	0.90
3. Length of mandibles :		
Right	1.12-1.13	1.05
Left	1.12-1.13	1.05
4. No. of antennal segments	15	15

Distribution : The species is widespread in Central and South America, and also occurs in the West Indies.

Field notes and remarks : I found several soldiers and workers in a piece of dry pine plank inside a house in a rubber plantation at Belterra. The soldiers are of two types—large (major) and small (minor).

The species is known from imagoes (alates) soldiers and workers. For a summary of its biology, see Araujo (1970a).

Genus (2) *Coptotermes* Wasmann

2. *Coptotermes testaceus* (Linnaeus 1758)

1758. *Hemirobeus testaceus* Linnaeus, *Systema Naturae* (10th Ed.), 1 : 550. Im. Type-locality : America.
1911. *Coptotermes testaceus* (L.), Holmgren, *K. Svenska Vetensk. Akad. Handl.*, Stockholm, 46 (6) : 73.
1949. *Coptotermes testaceus* (L.), Snyder, *Smiths. misc. Coll.*, Washington, 112 : 83. Synonymy.

Material : Three tubes, as follows :—(i) Tube No. 10 (Fd. Coll. No. 3), sev. S and W, Mazagao (Amapá), Inacio coll., 6 September

1955. (ii) Tube No. 14 (Fd. Coll. No. 7), 1 S, sev. W. (iii) Tube No. 18 (Fd. Coll. No. 6 or 9), 1 S, sev. W; both Tubes 14 and 18, Regiao Bragantina (Pará), E. Sefer coll., 1956.

Measurements (mm.), etc.

	<i>Soldiers</i>	
	Mazagao (Amapá) (2 exs.)	Regiao Bragantina (Pará) (2 exs.)
1. Total length, with mandibles	—	4.31 (1ex.)
2. Head-length to mandible-base	1.35-1.40	1.40-1.45
3. Max. head-width	1.13-1.18	1.15-1.20
4. Min. head-width	0.65-0.68	0.70-0.75
5. Height of head	0.80 (1 ex.)	—
6. Occipito-fontanelle distance	1.33	1.33-1.40
7. Length of mandibles :		
Right	0.95	0.95-0.98
Left	0.95	0.95-0.98
8. No. of antennal segments ..	14 (1 ex.)	15

Distribution : This neotropical species is widespread in the West Indies and northern parts of South America, including Brazil.

Remarks : The species is known from imagoes (alates), soldiers and workers. It is common in forests and also seriously damages wood-work in houses. For a summary of its biology, see Araujo (1970a).

Genus (3) *Syntermes* Holmgren

This neotropical genus has been revised by Emerson (1945 ; and 1952b, p. 488, extension of geographical range of some species).

3. *Syntermes molestus* (Burmeister 1839)

(Synonym : *Syntermes brasiliensis* Holmgren 1911).

- 1839. *Termes molestus* Burmeister, *Handb. d. Entomologie*, Berlin, 2 : 766 (Im.).
- 1911. *Syntermes molestus* (Burm.), Holmgren, *Zool. Anz.*, Leipzig, 37 (26) : 547-548. (Im, S).
- 1911. *Syntermes brasiliensis* Holmgren, *Zool. Anz.*, Leipzig, 37 (26) : 547-548. (Im, S).
- 1945. *Syntermes molestus* (Burm.), Emerson, *Bull. Amer. Mus. nat. Hist.*, New York, 57 : 467-470. Type-locality designated : Bahia (Brazil).
- 1949. *Syntermes molestus* (Burm.), Snyder, *Smiths. misc. Coll.*, Washington, 112 : 258.

Material : One tube, as follows :—Tube No. 2, Maués (Amazonas), *Flavio* coll., 6 June 1957, sev. S.

Measurements (mm.), etc.

	<i>Soldiers</i> (5 exs.)
1. Total length with mandibles	12-13
2. Head-length to mandible-base	3.8-4.2
3. Max. head-width	3.36-3.8
4. Head-width at base of mandibles	2.10-2.18
5. Length of mandibles :	
Right	2.2-2.4
Left	2.2-2.4
6. No. of antennal segments	19

Distribution : The species is found in the northern two-thirds of South America, viz., Venezuela, Colombia, Bolivia and almost all over Brazil (Emerson, 1945, 1952*b*, p. 488 ; Snyder, 1949).

Remarks : The measurements given above nearly agree with those of Emerson (1945) ; he gives, the number of antennal segments as 19-20. For a summary of its biology, see Araujo (1970*a*).

Genus (4) *Cornitermes* Wasmann

This neotropical genus has been revised by Emerson (1952*b*) according to whom it is "essentially a tropical and savanna genus" (p. 507). On the basis of the present account, the known geographical ranges of the two species dealt with below have been considerably extended north and north-east by about 1200-1400 km.

4. *Cornitermes ovatus* Emerson 1952

1952. *Cornitermes ovatus* Emerson, *Bull. Amer. Mus. nat. Hist.*, New York, 99 (8) : 506 (Fig. 16, distribution map) ; 511 (key) ; 534-535, S ; Fig. 31 (S, head and pronotum). Type-locality : Rio Autaz (Amazonas, Brazil).

Material : One tube (Tube No. 1) : 15 S, Belém (Pará), Inst. Agron. de Norte, *Cincinato* coll., 1956.

Measurements (mm.), etc.

	<i>Soldiers</i> (5 exs.)
1. Total length with mandibles	8.5-8.8
2. Head-length to mandible-base	3.4-3.7
3. Head-length to tip of frontal tube	3.2-3.5

	<i>Soldiers</i> (5 exs.)
4. Length of frontal tube	0.45-0.48
5. Max. head-width	2.8-3.0
6. Length of mandibles :	
Right	1.5-1.6
Left	1.5-1.6
7. No. of antennal segments	15

Distribution : NE Brazil (States of Amazonas and Pará) between approximate S. latitudes $1^{\circ}28'$ — $5^{\circ}00'$, and W. longitudes $48^{\circ}29'$ — $62^{\circ}00'$, as follows :—*Amazonas* : Cururuzinho, Rio Autaz (type-locality) (Emerson, 1952*b*). *Pará* : Belém (*new record*).

Remarks : In body-size, the present specimens nearly agree with those of Emerson (1952*b*), except that the frontal tube is longer (0.45—0.48 *vs.* 0.32—0.42 mm.), the head slightly narrower (2.8—3.0 *vs.* 2.98—3.20 mm.) and the mandibles a little shorter (length 1.5—1.6 *vs.* 1.68—1.86 mm.).

This collection considerably extends the known distribution east by about 1200 km., right upto the sea-coast. Only soldiers are hitherto known.

The species is confined to hot tropical rain-forest where the average daily temperature is always above 20°C (Emerson, 1952*b*; and Araujo, 1970*a*). Nothing else is known of its biology.

5. *Cornitermes silvestrii* Emerson 1949, 1952

(Synonym : *Cornitermes cumulans* Kollar, 1901, in part.

(Text-fig. 2)

- 1901. *Cornitermes cumulans* Koll. (in part), Silvestri *Bull. Mus. Zool. Anat. Comp. Torino*, Turin, 16 (389) : 4. Cuyaba (Brazil). Vide Emerson 1949. (in Snyder), 1952*b*.
- 1903. *Cornitermes cumulans* Koll. (in part), Silvestri, *Redia*, Portici, 1 : 56 (Im, S, W), p. 120 (biology), Figs. 40-41 (nest), Pl. 3, Figs. 96-98 (mI, S). Brazil : Examples from Coxipó and Cuyabá only (*vide* Snyder, 1949 : 263). (Biological observations may apply mainly to *Cornitermes cumulans* Kollar which too occurs here.)
- 1949. *Cornitermes silvestrii* Emerson (in Snyder), *Smiths. misc. coll.*, Washington, 112 : 263, Brazil : Coxipó and Cuyabá. *Nomen nudum*.
- 1952. *Cornitermes silvestrii* Emer., Emerson. *Bull. Amer. Mus. nat. Hist.*, New York, 99 (8) : 506 (Fig. 16, distribution map) ; 511 (key) ; and 523-524, S and W ; Fig. 25 (S, head and pronotum). Type-locality ; Coxipó, Cuiabá (= Cuyabá) (Mato Grosso, Brazil).

Material : Two tubes, Santarem (Pará), just outside airport, M. L. Roonwal coll., 2 August 1957, as follows :— (i) Tube No. 6, (Fd. Coll. No. R2/2.8.57), 3 S, sev. W, 1 Ny, *ex* mound of brown earth, c. 60 cm. high. (ii) Tube No. 8 (Fd. Coll. No. R1/2.8.57 (A), 9 S, sev. W, *ex* dome-shaped mound of black earth, c. 30 cm. high. (Mixed with *Nasutitermes costalis*, collected from same mound in field but later on separated into Tube No. 8A/Fd. Coll. No. R1/2.8.57(B), *vide infra*).

Measurements (mm.), etc.

	<i>Soldiers</i> (3 exs.)
1. Total length, with mandibles	5.5-6.0
2. Head-length to mandible-base	2.20-2.25
3. Head-length to tip of frontal tube	2.00-2.10
4. Length of frontal tube	0.33-0.38
5. Max. head-width	1.63-1.68
6. Length of mandibles :	
Right	1.00
Left	0.75-1.00
7. No. of antennal segments	15

Distribution : Central Brazil, in the States of Mato Grosso and Pará, between S. latitudes 2°55'—15°33' and W. longitudes 54°39'—56°00'.

Hitherto known only from the type-locality, Coxipó (15°30' S. lat., 56°00' W. long., Cuyabá, Mato Grosso). The present records (Santarem, Pará) extend the range north by about 1400 km.

Field notes and remarks : Emerson (in Snyder, 1949, p. 263 ; and 1952b, pp. 523-524) has clarified its synonymy and concluded that some examples from Coxipó, determined by Silvestri (1901, 1903) as *Cornitermes cumulans* Kollar, belong here.

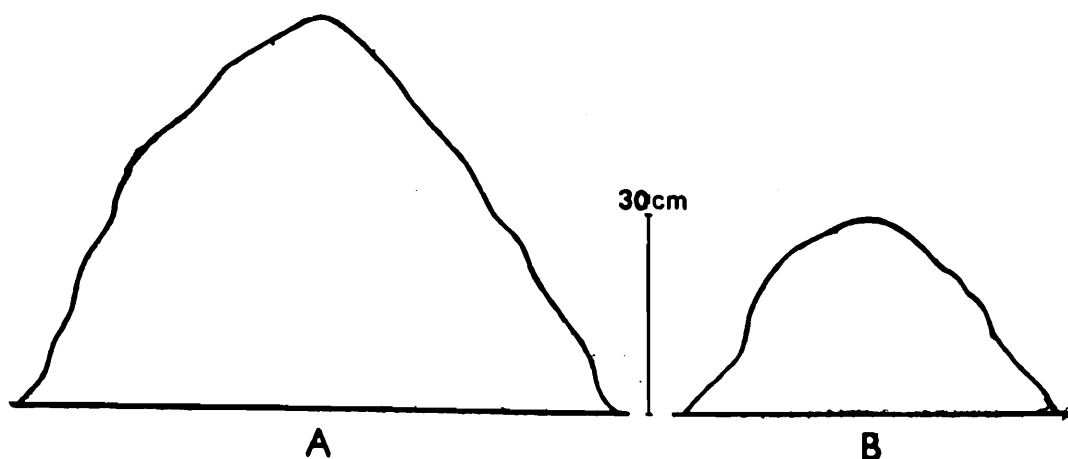
The species is known from imagoes (Silvestri), soldiers and workers. I collected soldiers, workers and a nymph from Santarem. These soldiers are slightly larger than those of Emerson (1952b) from further south, thus : Head-length to mandible-base 2.20-2.25 *vs.* 2.00-2.07 mm., and to tip of frontal tube 2.00-2.10 *vs.* 1.83-1.94 mm.; head-width 1.63-1.68 *vs.* 1.40-1.46 mm.

It is interesting to note that the species *Cornitermes cumulans* Kollar (middle part of South America, e.g., NE. Argentina, Paraguay and S. Brazil) with which *C. silvestrii* was formerly confused, is a

common southern species, and *C. silvestrii* a northern one, with Coxipó (Cuyabá) as the meeting place of the two.

From Coxipó, Silvestri (1903) described the earthen mounds (under *C. cumulans*, *vide* Emerson, 1952b, p. 509) as conical and about a metre high and with the same basal diameter; swarming occurs in August or a little later.

In Santarem, I found earthen mounds about 30–60 cm. high, the basal diameter being a little more than double the height. Their shape varied from dome-shaped to subconical and they were made of either brown or blackish earth, with a rugose outer surface (Text-fig. 2). In one case, several soldiers of *Nasutitermes costalis* (Holmgren) (*vide infra*) were also obtained from a mound along with soldiers and workers of *C. silvestrii*.



Text-fig. 2.—*Cornitermes silvestrii* Emerson. Outline of two earthen mounds, A, B. Santarem, Pará, Brazil. (From freehand field drawings by M.L.R.)

C. silvestrii is a species of the tropical savanna with many trees and with hot summers (average daily temperatures above 20° C) and mild winters (10°–20° C) (Emerson 1952b; Araujo, 1970a).

Genus (5) *Nasutitermes** Banks (*nec* Dudley)

This genus is richly represented in the neotropics by many species.

6. *Nasutitermes araujo* n. sp.†

(Text-figs. 3–5; and Tables 2 and 3)

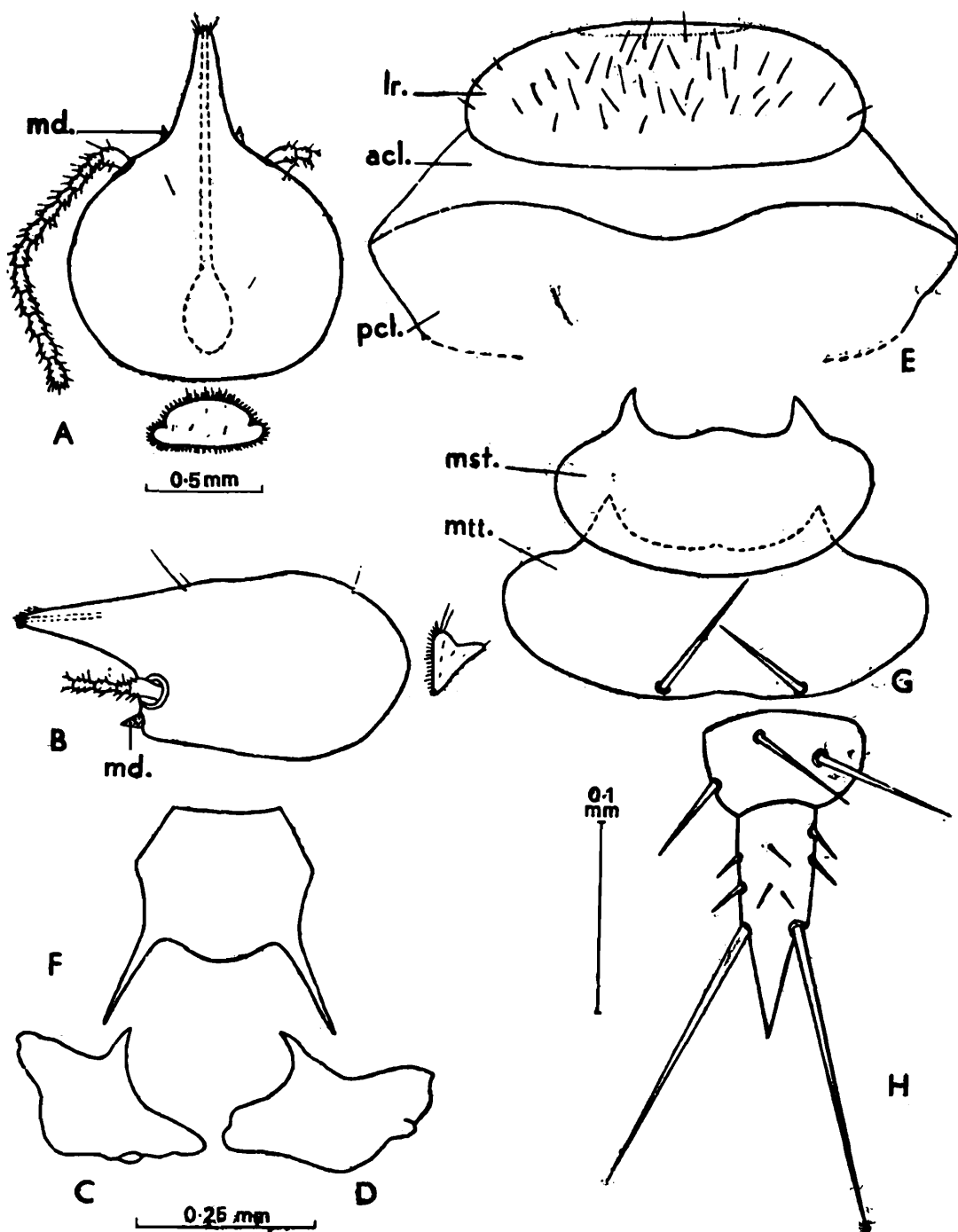
Material: One tube, as follows :- Tube No. 3 (Fd. Coll. No. R3/2.8.57), sev. S, a few W and Ny, Belterra (Pará), M. L. Roonwal coll., 2 August 1957, *ex* carton nest on rubber tree.

* For discussion on authorship of genus, *vide* Prashad and Sen-Sarma (1959).

† Named after the well known Brazilian termitologist, Dr. R. L. Araujo, in appreciation of his assistance.

Description

1. IMAGO.—Unknown.
2. SOLDIER (Text-fig. 3).—Head dark castaneous brown, rostrum paler ; antennae pale yellowish with brownish edges ; thoracic



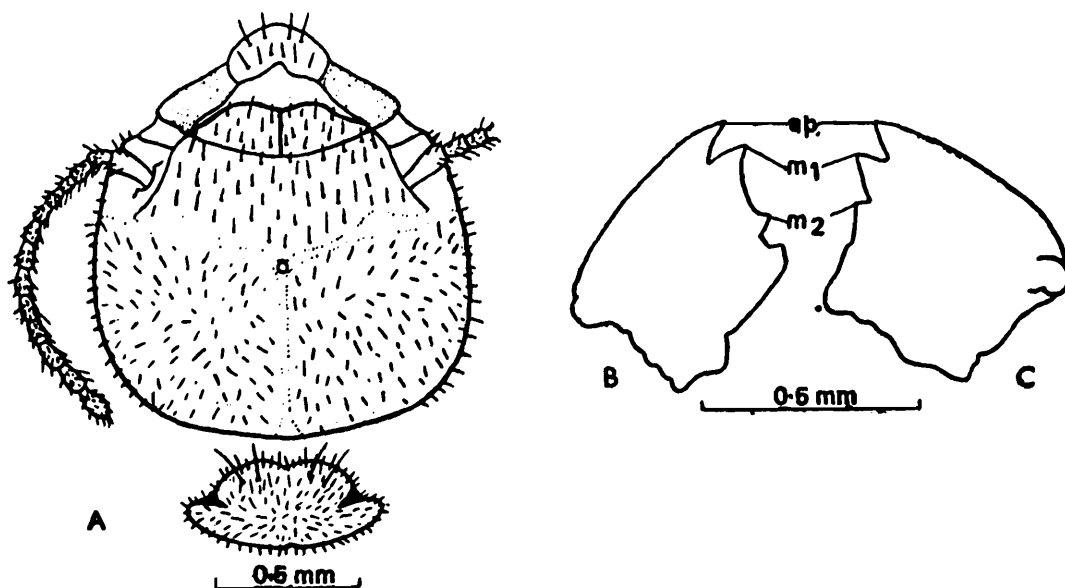
Text-fig. 3.—*Nasutitermes araujoi* n. sp. Brazil (Belterra, Pará). Soldier. (A) Head and pronotum (from holotype), in dorsal view. (B) Ditto, in side view. (C) Left mandible, in dorsal view. (D) Ditto, right mandible. (E) Labrum and clypeus, in dorsal view. (F) Postmentum, in ventral view. (G) Meso- and metanotum, in dorsal view. (H) Right cercus.

acl., anteclypeus ; *lr.*, labrum ; *md.*, mandible ; *mst.*, mesonotum ; *mtt.*, metanotum ; *pcl.*, postclypeus.

terga brownish, legs paler; abdomen pale brownish. Head very sparsely pilose, with 2 or 3 longish hairs; several short hairs present at tip of rostrum; abdomen moderately pilose, with several short and long hairs. Total length to tip of rostrum 3.7-5.1 mm. Head-capsule smooth, rounded, with posterior margin substraight; slightly wider than long. Rostrum short, stout and subconical, *c.* one-third the length of rest of head-capsule. Tips of mandibles visible from above. Fontanelle tube and gland visible. In lateral view, head-capsule with a slight depression in mid-dorsal area followed by a weak hump. Antennae with 13 segments, all fairly pilose; segment 1 longest; 2 slightly longer than 3, the latter smallest; 4 slightly longer than 2; 5 to the last gradually increasing in length. Labrum translucent, colourless, band-like, over twice as wide as long; with several small hairs all over. Anteclypeus band-like, apilose. Postclypeus wider than anteclypeus; with a few hairs. Mandibles reduced, each with a prominent, lateral, non-dentate, spinous process. Postmentum subsquarish, with angulate lateral margins; with two long, lateral processes at posterior end; anterior margin weakly concave, posterior margin prominently convex. Pronotum saddle-shaped, moderately hairy, with rounded anterior lobe; anterior margin convex, posterior substraight, both without median notch. Mesonotum somewhat narrower than pronotum, and with posterior margin without median notch. Metanotum wider than mesonotum; posterior margin weakly concave, and with two long setae. Legs long, slender, moderately hairy. Tibiae long, with numerous spines; apical tibial spur formula 2 : 2 : 2. Tarsi 4 segmented, the last with a pair of terminal claws; arolium absent. Abdomen moderately hairy, with short hairs. Cerci hairy and short (*c.* 0.14 mm. long) but prominent; terminal segment sharply pointed. Styli absent.

Measurements : See Table 2.

3. WORKER MAJOR (Text-fig. 4).—Head dark brown, with a narrow pale stripe along arms of Y-suture; thorax and abdomen light brown from above; antennae, legs and sternites pale. Head and body fairly densely hairy. Total length *c.* 5.8–6.1 mm. Head-capsule subsquarish. Fontanelle present at junction of Y-suture as a small rounded spot, *c.* 0.05 mm. in diameter. Eye and ocelli absent. Antennae fairly pilose, with 14 segments; segment 1 longest, stout and cylindrical; 2 almost half of 1; 3 subequal to 2; 4 smallest. 5 to the last gradually increasing in length and becoming pyriform. Anteclypeus hyaline, whitish and apilose; anterior margin projecting in front medially. Postclypeus swollen, pilose, light brown; much broader than long; divided into right and left halves by a median vertical suture. Labrum dome-shaped, with longish hairs; broader than long; anterior tip weakly pointed medially. Mandibles yellowish brown. Left mandible with an apical and 2 marginal teeth;



Text-fig. 4.—*Nasutitermes araujoï* n. sp. Worker Major. (A) Head and pronotum, in dorsal view. (B) Left mandible, in dorsal view. (C) Ditto, right mandible. *ap.*, apical tooth ; *m*₁, *m*₂, 1st and 2nd marginal teeth.

apical conial ; marginal 1 subequal to apical ; 2 small, widely separated from 1 by a concave margin. Right mandible similar to left ; but marginal 2 closer to 1. Pronotum strongly saddle-shaped ; broader than long, fairly pilose ; with numerous fine hairs, also with a pair of longish hairs on either side in anterior half ; anterior and posterior margins convex ; the former with a well-marked, and the latter with a weak, median depression. Legs long and slender, moderately pilose ; hind-femur not reaching tip of abdomen ; hind-tibiae longer than hind-femora. Tarsi 4-segmented. Apical tibial spur formula 2 : 2 : 2. Abdominal tergites and sternites fairly pilose, with small and long hairs. Cerci short, hairy, 2-segmented. Styli absent.

Measurements : See Table 3.

4. WORKER MINOR.—Resembles worker major, except in the following respects :—Smaller (total-length 4.4-5.1 mm.) ; head-capsule light brown ; fontanelle not clear ; pronotum weakly saddle-shaped.

Table 2.—*Nasutitermes araujoi* n. sp. and *Nasutitermes bragantinus* n. sp. from the Amazon Basin, Brazil.
Body-measurements (mm.), indices, etc. of *soldiers*.

Item (1)	<i>Nasutitermes araujoi</i> n. sp. (Tube No. 3)		<i>Nasutitermes bragantinus</i> n. sp. (Tube No. 20)	
	Holotype (2)	Range (10 exs.) (3)	Holotype (4)	Range (5 exs.) (5)
1. Total length	3.8	3.7-5.1	3.3	3.2-3.4
2. Length of head with rostrum	1.74	1.63-1.84	1.58	1.53-1.63
3. Length of head without rostrum	1.16	1.11-1.21	1.05	1.00-1.11
4. Length of rostrum	0.58	0.53-0.63	0.53	0.53-0.58
5. Maximum width of rostrum	0.37	0.37-0.47	0.26	0.21-0.26
6. Maximum width of head	1.37	1.26-1.37	1.00	0.95-1.00
7. Minimum width of head	0.68	0.63-0.74	0.58	0.53-0.58
8. Posterior bulge of head	0.37	0.31-0.47	0.37	0.37-0.47
9. Maximum height of head	0.89	0.84-1.00	0.63	0.63-0.68
10. Median length of labrum	—	0.09 (1 ex.)	—	0.07 (1 ex.)
11. Maximum width of labrum	—	0.21 (1 ex.)	—	0.23 (1 ex.)
12. Rostrum-Head Index I (Rostrum-length/Head-length without rostrum)	0.50	0.48-0.54	0.50	0.48-0.58

13. Rostrum-Head Index II (Max. rostrum-width /Max. head-width)	0.27	0.27-0.36	0.26	0.21-0.26
14. Head-bulge Index (Posterior head-bulge/Head-length without rostrum)	0.32	0.28-0.41	0.35	0.35-0.47
15. Head Contraction Index (Min. head-width/Max. head-width)	0.50	0.48-0.56	0.55	0.50-0.58
16. Head Index I (Max. width/Length without rostrum)	1.18	1.07-1.19	0.95	0.86-1.00
17. Head Index II (Max. height/Length without rostrum)	0.77	0.76-0.84	0.60	0.60-0.63
18. Head Index III (Max. height/Max. width)	0.65	0.64-0.76	0.63	0.63-0.72
19. Maximum (median) length of postmentum	0.36	0.34-0.38	0.19	0.19-0.20
20. Maximum width of postmentum	0.38	0.36-0.41	0.22	0.22-0.23
21. Length of pronotum	0.18	0.16-0.24	0.16	0.16-0.18
22. Maximum width of pronotum	0.54	0.49-0.59	0.47	0.47-0.49
23. Pronotum Index (Length/Max. width)	0.33	0.33-0.41	0.37	0.33-0.40
24. Length of hind-femur	0.72	0.67-0.90	0.79	0.74-0.79
25. Maximum width of hind-femur	0.18	0.18-0.20	0.14	0.12-0.14
26. Length of hind-tibia	1.16	1.00-1.26	1.11	1.05-1.11
27. No. of antennal segments	13	13	13	13

Table 3.—*Nasutitermes araujoi* n. sp. from the Amazon Basin, Brazil.
Body-measurements (mm.), etc. of *workers* (major and minor).
Tube No. 3, Belterra, Pará.

Item	Workers Major (3 exs.)	Workers Minor (3 exs.)
1. Total length	5.8 -6.1	4.4 -5.1
2. Length of head to lateral base of mandibles	1.16-1.26	0.83-0.86
3. Max. width of head	1.32	1.05-1.11
4. Max. height of head	0.81-0.86	0.68-0.77
5. Length of labrum	0.09-0.10	0.09
6. Max. width of labrum	0.43-0.54	0.36-0.45
7. Length of pronotum	0.32-0.36	0.18-0.20
8. Max. width of pronotum	0.74-0.81	0.56-0.59
9. No. of antennal segments	14	14

Measurements : See Table 3.

Type-specimens : Deposited as follows:—*Holotype* (a soldier), in a tube (Z. S. I. Reg. No. 14/H11) in the Zoological Survey of India, Calcutta. *Paratypes* (soldiers) and *morphotypes* (workers major and minor ; and nymphs) : (i) 5 S, 2 WM, 2 Wm, 3 Ny, in a tube, in Z. S. I., Calcutta. (ii) 2 S, 1 WM, 1 Ny, in a tube, in Forest Research Institute, Dehra Dun. (iii) 2 S, 2 WM, 1 Ny, in a tube, in the Zoology Museum, São Paulo University, São Paulo, Brazil. The remaining material, in Z. S. I., Calcutta, thus : In a tube, sev. S, a few WM, Wm and Ny. ; also 2 slides of mandibles (1 of S, 1 of WM).

Type-locality and distribution : Known only from the type-locality (Belterra, State of Pará, Brazil).

Comparison : *Nasutitermes araujoi* n. sp. is close to *N. maximus* (Holmgren) from Peru but differs as follows :—

SOLDIERS : Head with rostrum shorter (length with rostrum 1.63-1.84 *vs.* 1.90-2.05 mm.) but wider (maximum width 1.26-1.37 *vs.* 1.15-1.30 mm.). Antennae with 13 segments (*vs.* 14) ; segment 3 smaller than 2 (*vs.* longer), 5 longer than 4 (*vs.* smaller).

WORKERS : Dimorphic (with major and minor forms (*vs.* monomorphic). Head narrower (maximum width : major 1.32, minor 1.05-1.11 ; *vs.* 1.53 mm.). Antennae with 14 segments in both forms (*vs.* 15).

Field notes : In the well-stocked rubber plantation (*Hevea* sp.) where the collection was made, with trees about 5 metres or more high, nests of *Nasutitermes araujoi* n. sp. were very common, almost every twentieth tree having a nest in the forks at the upper end of the bole, usually about 2-3 metres above ground-level, but some were higher.

The nest (Text-fig. 5) is an irregularly roundish mass of black, polyporous wood-carton with a highly rugose surface. An average-sized nest measured about 45×60 cm. in diameter. Flat, broad (1-2 cm. wide) wavy strips of runways, composed of black earthy material, extend from the ground at the base of the tree along the surface of the trunk to the nest. Four or five, sometimes more, such runways were found on the trunks of trees which carried a nest, but they were also present on some trees where no nest was visible.

A nest was broken and examined. It was rather fragile and could be broken easily with the hands and a small knife. No termites were seen on the surface, but all over the porous, honey-combed interior, thousands of soldiers, and in the central part of the nest several nymphs, were found. Although the nest was completely broken open, there was no trace of a royal chamber or of the reproductive pair (king and queen). The workers are dimorphic as regards size, there being major (large) and minor (small) forms. They moved about sluggishly when disturbed. The soldiers too, curiously, did not exhibit any extraordinary activity or alertness and were as sluggish as the workers.

The runways on the tree trunks were full of soldiers but no workers were found in them.

7. *Nasutitermes bragantinus* n. sp.

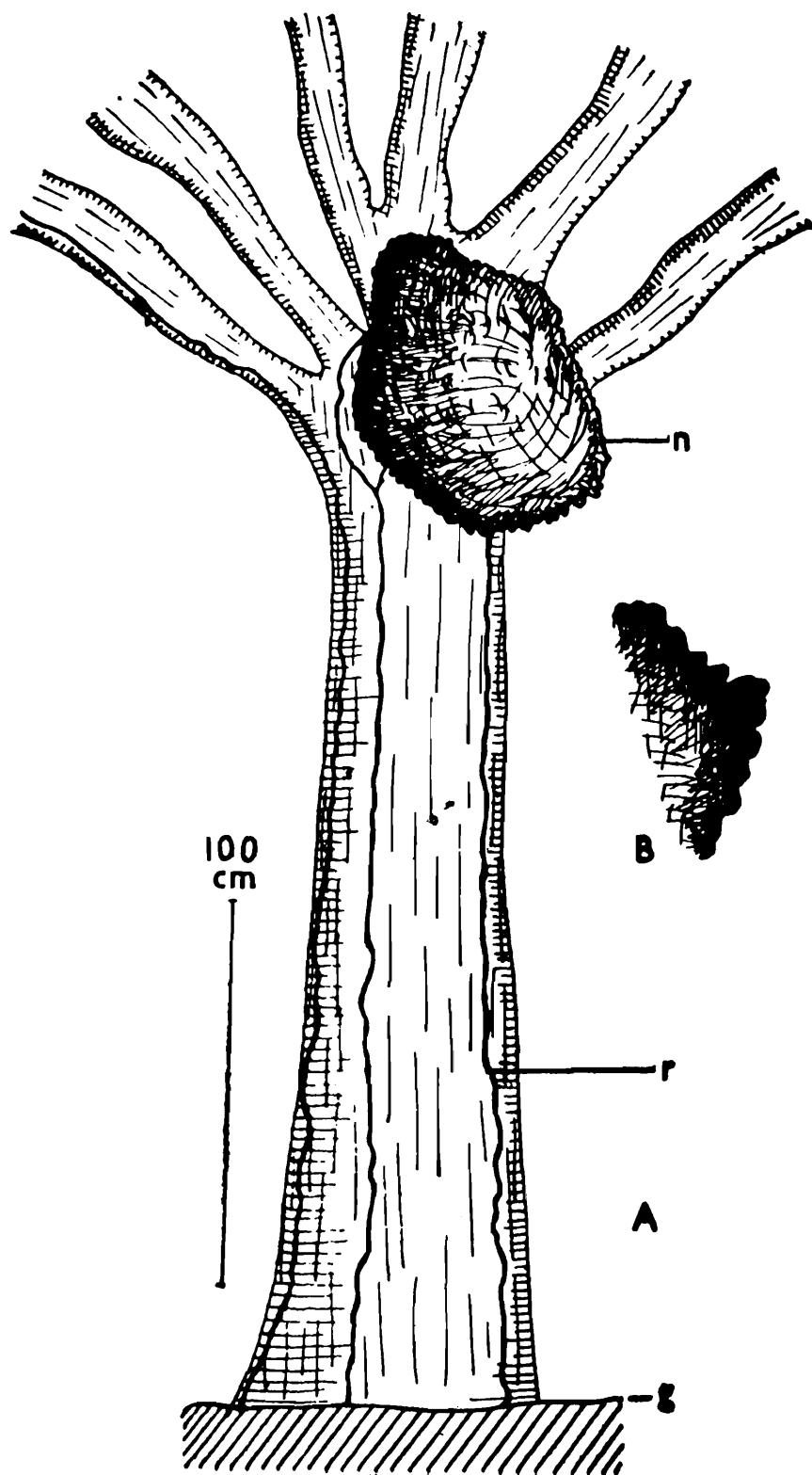
(Text-fig. 6 ; and Table 2)

Material : One tube, as follows :—Tube No. 20 (Fd. Coll. No. 8), 9 S, Região Bragantina (Pará), E. Sefer coll., 1956.

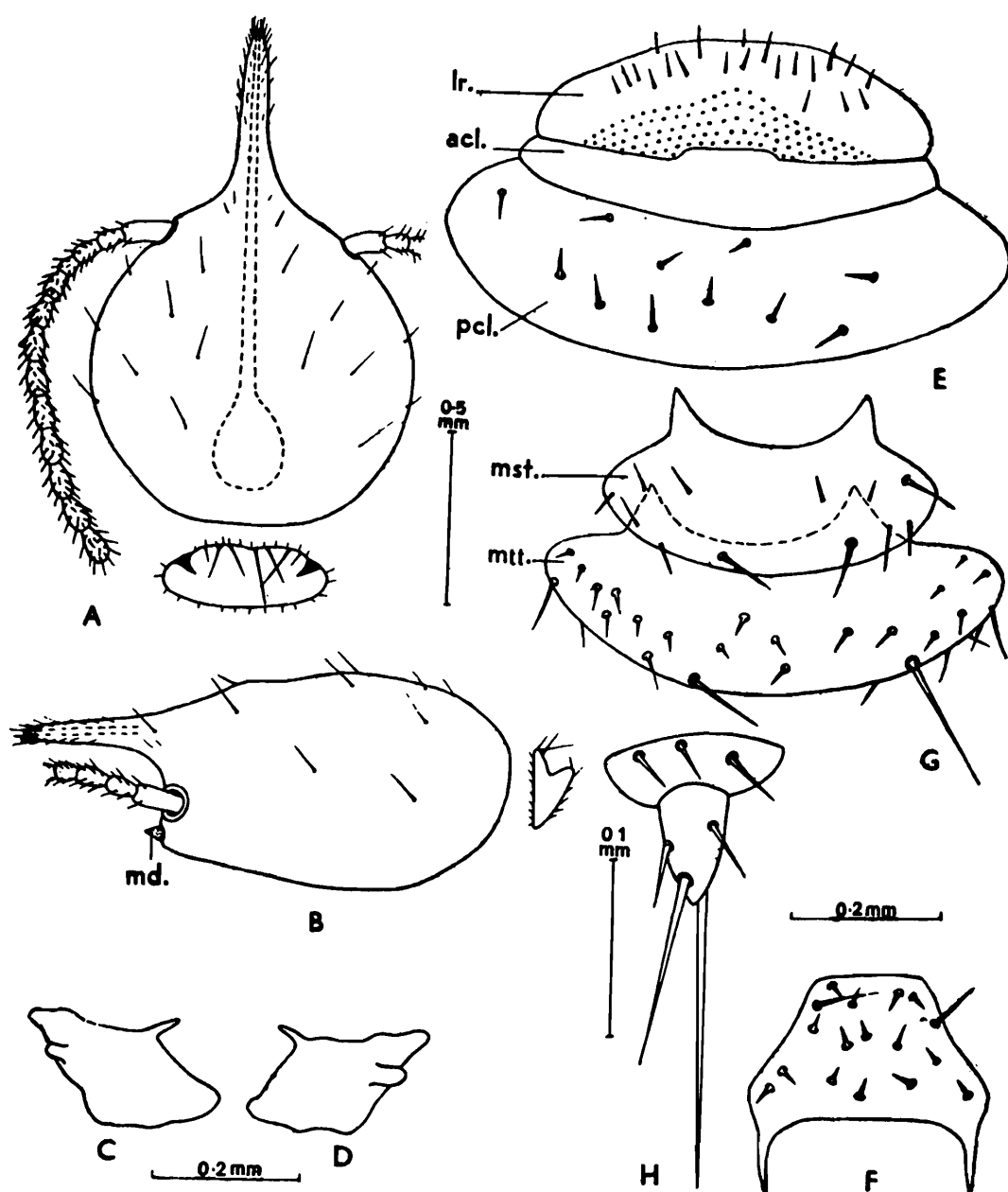
Description

1. IMAGO.—Unknown.

2. SOLDIER (Text-fig. 6).—Head pale brown ; rostrum darker, but paler at tip ; antennae yellowish brown ; thoracic terga, legs and abdomen brownish. Head with a few longish hairs all over ; tip of rostrum with several small hairs. Abdomen fairly pilose with



Text-fig. 5.—*Nasutitermes araujoi* n. sp. Carton nest on rubber tree. Belterra (Pará, Brazil). (From field drawings by M.L.R., 2 August 1957, Fd. Coll. No. R3/2.8.57). (A) Lower part of tree, showing entire nest. (B) Part of nest, enlarged to show surface rugosity. *g.*, ground-level; *n.*, nest; *r.*, runways.



Text-fig. 6.—*Nasutitermes bragantinus* n. sp. Brazil (Região Bragantina, Pará). Soldier. (A) Head and pronotum (from holotype), in dorsal view. (B) Ditto, in side view. (C) Left mandible, in dorsal view. (D) Ditto, right mandible. (E) Labrum and clypeus, in dorsal view. (F) Postmentum, in ventral view. (G) Meso- and metanotum, in dorsal view. (H) Left cercus. *acl.*, anteclypeus; *lr.*, labrum; *md.*, mandible; *mst.*, mesonotum; *mtt.*, metanotum; *pcl.*, postclypeus.

several short and longish hairs. Total length with rostrum 3.2-3.4 mm. Head-capsule almost rounded, posterior margin substraight; length (1.53-1.63 mm.) more than maximum width (0.95-1.00 mm.). Rostrum short, rather slender and subcylindrical, about half the length of rest of head-capsule. Tips of mandibles not visible from above. Fontanelle tube and gland visible. In lateral view, head-capsule with a slight hump in foredorsal area, followed

by a shallow depression. Antennae with 13 segments, fairly pilose ; segment 1 long, cylindrical and stout ; 2 about half of one ; 3 slightly longer than 2 ; 4 smallest ; 5 subequal to 3 and much longer than 4 ; 6 to the last gradually increasing in length. Labrum whitish, translucent, band-like, width about twice the length ; anterior margin convex ; anterolateral corners rounded. Anteclypeus hyaline, band-like, much broader than long ; anterior margin slightly protruded in middle. Postclypeus much broader than anteclypeus, with a few stout hairs ; anterior margin concave ; posterior margin rounded, convex. Mandibles small and reduced, each with a non-dental spine-like lateral process. Postmentum subtrapezoidal, slightly broader than long, with anterior end narrower ; fairly pilose ; both anterior and posterior margins substraight. Pronotum strongly saddle-shaped, broader than long ; with a few long and short hairs on both margins ; anterior margin substraight, with a weak median notch ; posterior margin slightly convex, without a median notch. Mesonotum narrower than, and metanotum subequal to, pronotum ; with a few hairs on body ; in both, the posterior margin convex and not medially notched. Legs long and slender ; moderately hairy except for the tarsi which have numerous hairs and stout spines. Apical tibial spur formula 2 : 2 : 2. Tarsi 4-segmented, with a pair of terminal claws ; arolium absent. Abdomen moderately hairy, with short and long hairs. Cerci short (length 0.09 mm.), 2-segmented, hairy. Styli absent.

Measurements : See Table 2.

3. WORKER.—Unknown.

Type-specimens : Deposited as follows :—*Holotype* (a soldier) in a tube (Z. S. I. Reg. No. 17/H11) in the Zoological Survey of India, Calcutta. *Paratypes* : (i) 2 S in a tube, in the Zoology Museum, São Paulo University, São Paulo, Brazil. (ii) 2 S (+ 3 broken) in a tube, and 5 slides of various body-parts of S, in Z. S. I., Calcutta.

Type-locality and distribution : Known only from the type-locality (Região Bragantina, State of Pará, Brazil).

Comparison : The soldiers of *Nasutitermes bragantinus* n. sp. are close to *N. rippertii* (Rambur) [synonyms *N. bahamensis* (Holmgren) and *N. cubanus* (Holmgren)] from the West Indies, but differ as follows :—Total length somewhat smaller (3.2-3.4 *vs.* 3.5-3.9 mm.) ; head-capsule more rounded (*vs.* pear-shaped) ; and antennal segment 4 much shorter than 2, and 5 much longer than 4 (*vs.* 4 subequal to 2, and 5 either subequal to or only slightly longer than 4).

8. *Nasutitermes costalis* (Holmgren 1910)

(Tables 4 and 5)

1910. *Eutermes costalis* Holmgren, *Mitteil. naturhist. Mus. Hamburg*, 27 (Jahrb. Hamburg. wissenschaft. Anstalt, Beih. 2), Hamburg : 293-294 (Im). Fig. 64. Type-locality : Trinidad (West Indies).
 1949. *Nasutitermes costalis* (Holmg.), Snyder, *Smiths. misc. Coll.*, Washington, 112 : 272-273. (Synonymy).

Material : Five tubes as follows :—(i) Tube No. 4 (Fd. Coll. No. R1/3.8.57), sev. S and W, Belém (Pará), *M. L. Roonwal* coll., 3 August 1957, *ex* narrow earthen gallery on trunk of large tree in garden. (ii) Tube No. 7 (Fd. Coll. No. R1/6.8.57), sev. S and W, Belém (Pará), *M. L. Roonwal* coll., 6 August, 1957, *ex* long earthen runways on tree trunk on roadside avenue. (iii) Tube No. 8A (Fd. Coll. No. R1/2.8.57(B), *M. L. Roonwal* coll., 2 August 1957, *ex* mound of *Cornitermes silvestrii*, *vide supra*. (iv) Tube No. 9 (Fd. Coll. No. R 2/3.8.57), sev. S and W, Belém (Pará), *M. L. Roonwal* coll., 3 August 1957, *ex* earthen runways on tree trunk in garden. (v) Tube No. 19 (Fd. Coll. No. 4), sev. S and W (major and minor), Região Bragantina (Pará), *E. Sefer* coll., 1956.

Measurements : See Tables 4 (soldiers) and 5 (workers).

Table 4.—*Nasutitermes costalis* and *N. guayanae* from the Amazon Basin, Brazil. Measurement (mm.), etc. of body-parts of *soldiers*.

Item	<i>Nasutitermes costalis</i> (3 exs.). (Belém, Pará) (Tube No. 4)	<i>Nasutitermes guayanae</i> (3 exs.). (Região Bragantina, Pará) (Tube No. 12)
1. Total length to tip of head-rostrum	3.16-4.05	3.26-3.47
2. Head-length with rostrum	1.32-1.58	1.42-1.68
3. Head-length without rostrum	0.95-1.05	0.89-1.05
4. Length of rostrum	0.37-0.53	0.47-0.63
5. Maximum head-width	1.00-1.05	1.00-1.05
6. Minimum head-width	0.53	0.47-0.53
7. Posterior bulge of head	0.26-0.37	0.26-0.32
8. Maximum length of pronotum	0.21-0.26	0.32
9. Maximum width of pronotum	0.47-0.53	0.63
10. Number of antennal segments	13	14

Table 5.—*Nasutitermes costalis* and *N. guayanae* from the Amazon Basin, Brazil. Measurements (mm.) etc. of body-parts of workers.

Item	<i>Nasutitermes</i> <i>costalis</i> (3 exs.). (Belém, Pará) (Tube No. 4)	<i>Nasutitermes</i> <i>guayanae</i> (3 exs.). (Região Bra- gantina (Pará) (Tube No. 12)
1. Total length	3.32-4.10	2.84-3.16
2. Head-length to lateral base of mandibles	0.68-0.89	0.79-1.05
3. Maximum head-width	1.00-1.16	1.05-1.42
4. Maximum head-height	0.47-0.53	0.68-0.74
5. Length of labrum	0.21	0.21-0.26
6. Maximum width of labrum	0.47	0.63
7. Length of pronotum	0.21-0.26	0.21
8. Maximum width of pronotum	0.47-0.58	0.58-0.63
9. Number of antennal segments	14	15

Distribution : Widespread in the neotropics. Hitherto known from the West Indies (Cuba, Haiti, Dominican Republic, Martinique, Grenada and Trinidad) and northern part of South America (Guyana, northern Brazil and Bolivia), *vide* Snyder, 1949, pp. 272-273 ; Araujo, 1970a, p. 562). As a rule not going above about 610 m. altitude. All present collections are from north-eastern Brazil (State of Pará).

Field notes and remarks : The species is known from alates, queens, soldiers and workers. I found *N. costalis* very common in Belém (Pará) and obtained it from beneath long, narrow (c. 1 cm. wide) earthen runways made of dark matter and running up the tree trunks in gardens and roadside avenues, sometimes going upto the top of the bole 15 m. or more in height, but no nests were seen on the trees. In some cases soldiers were very common (forming about 95 % of the population in the earthen runways) and in others less so (the workers being more numerous). In one lot (Tube 19) two types of workers, major and minor (large and small respectively), were met with. In Santarem the species was found in a mound of *Syntermes silvestrii* along with examples of the latter species, but the nature of their association is not clear.

For a summary of its biology, see Araujo (1970a).

9. *Nasutitermes guayanae* (Holmgren 1910)

(Synonym : *Eutermes* (E.) *grandis* Holmgren 1910.)

(Tables 4 and 5)

1910. *Eutermes* (*Eutermes*) *Guayanae* Holmgren, *Mitteil. naturhist. Mus. Hamburg*, 27 (*Jahrb. Hamburg. wissenschaft. Anstalt.*, Beih. 2), Hamburg : 254-256 (S, W), Fig. 36 (S, head). Type-locality : Upper Surinam (South America).
1910. *Eutermes* (*Eutermes*) *grandis* Holmgren, *Mitteil. naturhist. Mus. Hamburg*, 27 (*Jahrb. Hamburg wissenschaft. Anstalt.*, Beih. 2), Hamburg : 258-259 (S, W), Fig. 39 (S). Type-locality : Chaquimayo (Peru).
1949. *Nasutitermes guayanae* (Holmg.), Snyder, *Smiths. misc. Coll.*, Washington, 112 : 278-279.

Material : Four tubes, all from Região Bragantina (Pará), E. Sefer coll., 1956, as follows :— (i) Tube No. 12 (Fd. Coll. No. 2), sev. S, a few W. (ii) Tube No. 13 (Fd. Coll. No. 5), sev. S, a few W. (iii) Tube No. 15 (Fd. Coll. No. OT), sev. S, 1W. (iv) Tube No. 16 (Fd. Coll. No. 6 or 9), sev. S.

Measurements, etc. : See Tables 4 (soldiers) and 5 (workers).

Distribution : The species was hitherto known from the north-east (Guyana and Surinam) and the west (Peru) in South America. The present one is the first record from Brazil, and the species may be expected to occur in the intermediate area, *i.e.*, the Amazon Basin lying between north-east Brazil and Peru.

Remarks : These examples, especially the workers, are smaller than the type-specimens (Holmgren) from upper Surinam as follows :— *Soldiers* : Total length 3.26-3.47 mm. (*vs.* 3.67) ; head-length 1.42-1.68 mm. (*vs.* 1.65-1.85). *Workers* ; Total length 2.8-3.16 mm. (*vs.* 5.0).

The species is known from winged forms, soldiers and workers. Emerson (1938) has described the nest. For a summary of its biology, see Araujo (1970a).

SUMMARY

1. This paper deals with a collection of termites from the Amazon Basin, made in 1957 by one of the authors (M. L. R.). It includes 9 species belonging to 2 families and 5 genera, the number of species being given within brackets : Fam. Rhinotermitidae : *Heterotermes* (1) and *Coptotermes* (1). Fam. Termitidae : *Syntermes* (1), *Cornitermes* (2) and *Nasutitermes* (4).

2. Two new species are described : *Nasutitermes araujo* n. sp. (type-locality : Belterra, Pará ; soldiers, workers and nymphs) and *N. bragantinus* n. sp. (type-locality : Região Bragantina, Pará ; soldiers only).

3. *Nasutitermes guayanae* is recorded for the first time from Brazil.

4. The distribution range of *Cornitermes ovatus* and *C. silvestrii* in Brazil are considerably extended, by about 1200-1400 km. north and north-east.

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DESCRIPTIONS OF NEW SPECIES OF THE GENERA
SINOPHTHALMUS AND *SCAPTOMYZA* (INSECTA :
DIPTERA : DROSOPHILIDAE) FROM
CHANDIGARH, INDIA.

By

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(With 3 text-figures)

INTRODUCTION

Since Bezzi (Sturtevant, 1921) who was the first to report *Drosophila* species (*Drosophila repleta*) from Calcutta, India, there have been only occasional reports on the Indian Drosophilidae till 1964. In 1964, a project "Drosophilid Survey of India" was initiated by the Panjab University, Chandigarh consequently, Parshad and Paika (1964) gave the chronology of the recording of a few species of the Indian Drosophilidae described so far and also reported eleven species of the subgenus *Sophophora* Sturtevant. Besides the above, Parshad and Duggal (1966) reported twenty species ; Gupta (1969) reported one species ; Gupta and Ray-Chaudhury (1970) recorded eight species and Gupta (1970) recorded five species. Judging from the reports on the Indian Drosophilidae, it seems that the knowledge of the Indian species recorded so far is quite meagre. Therefore the present author started collecting the wild species of the Indian Drosophilidae and has published four papers viz., Parshad and Singh (1972) recorded nine species from South Andamans ; Singh (1972a) recorded eight species belonging to *Drosophila*, Singh (1972b) described five new species of the subgenus *Drosophila* and Singh (1972c) described six new species of the subgenus *Paradrosophila*. The present communication in the series contains the descriptions of three new species of the genera *Sinophthalmus* and *Scaptomyza*.

MATERIAL AND METHODS

All the three species, which constitute the material for the present investigations, were collected from Chandigarh (India).. The collection and the treatment of the flies for various taxonomical studies were carried out in the same way as described by Parshad and Paika (1964). The types of the new species have been placed in the Panjab University Zoology Museum, Chandigarh.

Genus *Sinophthalmus* Coquillett, 1904

Sinophthalmus Coquillett, 1904. *Proc. ent. Soc. Wash.*, 6 : 191 ; Sturtevant, 1921. *Carnegie. Inst. Publs.*, 301 : 54.

1. *Sinophthalmus creberii* n. sp.

(Text-fig. 1)

*Description of imago**Male imago*

External characters.—Arista plumose with numerous minute dorsal and ventral branches, terminal fork indiscernable; antenna brownish yellow, third segment brownish yellow, broad and large. Front over $1/4$ the greatest width of head, wider above, dark brown, periorbits yellow. Orb₁ equal to Orb₃, Orb₂ very well developed about $3/4$ of either, Orb₁ near to verticals than to Orb₃, Orb₂ posterior to Orb₃, Orb₃ outside Orb₂. Or₂ absent, vibrissa very prominent. Carina extremely short, only within the limits of antenna, narrow and slightly raised, yellow; face and clypeus yellow. Palpus club-shaped, pale with a large bristle at the tip and a few more bristles along the entire length. Cheeks pale, with two prominent bristles, one on the outer and the other on the inner side near the clypeus, their greatest width $1/9$ the greatest diameter of eye. Eyes deep red; ocelli brownish yellow, ocellars divergent.

Acrostichal hairs in ten irregular rows; prescutellars very well developed, more than $1/2$ the size of posterior dorsocentrals, anterior dorsocentrals small about $1/3$ the posterior dorsocentrals, anterior scutellars divergent arising from the mid-lateral side of the scutellum, not as usual from the anterior proximity, posterior scutellars crossed at the very apex. Mesonotum and scutellum dark brown, all the bristles on the mesonotum arise from a dark tan spot. Humeral one. Pleura brownish yellow, bare, with a broad light black stripe across it, middle sternopleurals absent. Sterno-index 1.0.

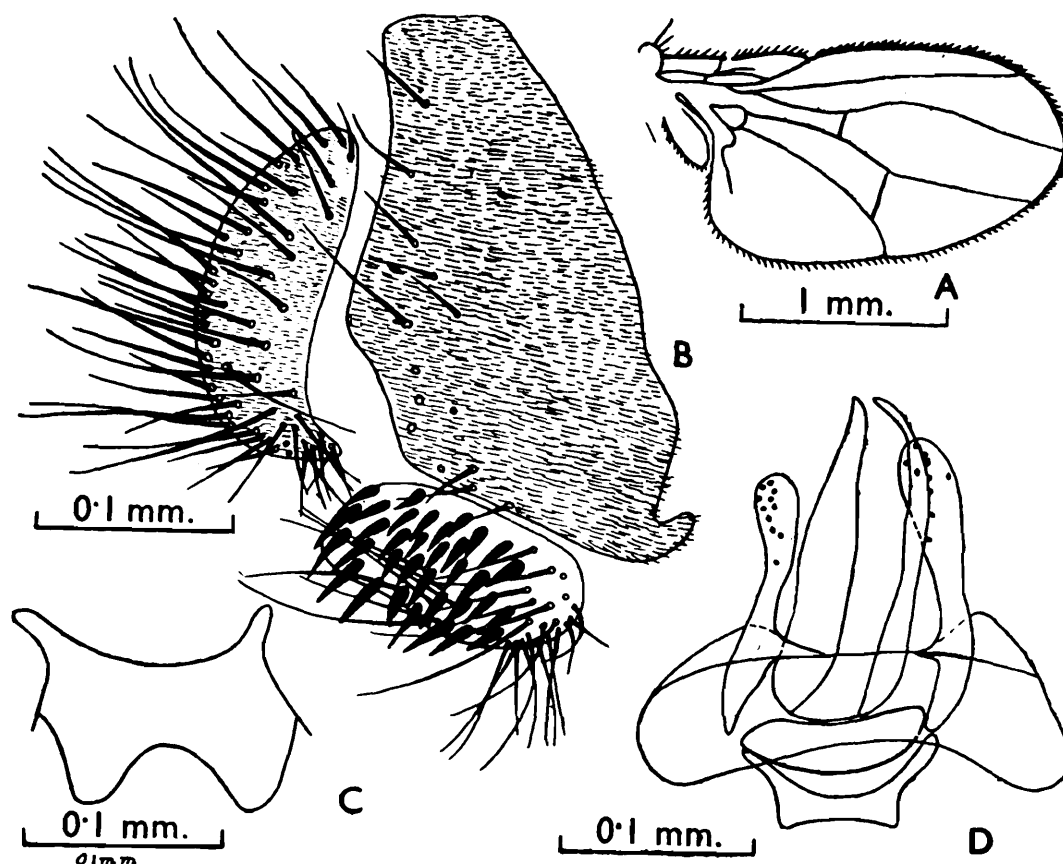
Legs pale. Preapicals on all the three tibiae, apicals only on the middle tibia. Abdomen yellow, each tergite with uninterrupted light black broad caudal band.

Wing (Text-fig. 1A): Clear, costa reaches up to the apex of third longitudinal vein; second basal cell and discal cell not confluent; C-1 bristle absent; C-3 bristles on the basal $2/3$ the third costal section; C-index about 2.25, 4 V-index about 2.0, 4C-index about 1.33 and 5X-index about 1.00. Halteres balloon-shaped, light pale.

Length of the wing. .2.04 mm.

Length of the body... .2.4 mm.

Periphallic organs (Text-fig. 1B).—Genital arch brown, narrow above, broader in the middle, tapers below, the pointed tapering end



Text-fig. 1.—*Sinophthalmus creberii* n. sp. A. wing ; B. periphallic organs ; C. decasternum ; D. phallic organs.

curves anteriorly and upwards forming a hook-like structure, medially and caudally concave with fourteen bristles on the caudal end from top to toe, out of these four are on the upper margin, pubescent. Heel and toe not observable. Anal plate roughly crescent-shaped, pubescent, separate from the genital arch and with about fifty three bristles. Clasper single, separate from the genital arch, rectangular, primary teeth large, peg or nail-like, about thirty five arranged irregularly on the entire clasper ; marginal bristles thirteen, long and flexible, arranged on the lower end, fifteen more long and flexible bristles arranged irregularly on the clasper.

Decasternum (Text-fig. 1C).—Roughly trapezoidal, with two anterior thin and posterior thick and round horns ; main body lightly and deeply concave at the anterior and posterior sides respectively, lateral sides with a medial projection.

Phallic organs (Text-fig. 1D).—Light brown ; aedeagus large, broad, bifid, pointed and curved at the apex. Anterior parameres absent. Posterior parameres roughly club-shaped with a pointed basal branch at $1/3$ distad of the base, about eleven sensillae at the apex. Ventral fragma broad laterally and very narrow and concave anteroposteriorly.

Novasternum and submedian spines not observable. Basal apodeme very small, bifid at the base and truncate at the apex. P. I. : 3.00.

Holotype.—One male from Chandigarh deposited in the Museum, Department of Zoology, Panjab University, Chandigarh, *vide* registration no. 109/73, dated 12.4.73.

Allotype.—One female collected along with the holotype.

Paratypes.—One male and one female deposited along with the holotype.

Other specimens examined.—Six males and seven females from Chandigarh.

Remarks.—Sturtevant (1921) remarked that *Sinophthalmus* Coquillett is somewhat similar to *Drosophila repleta* Wollaston in general appearance, and this may be due to each bristle of the body arising from a dark brown spot. The genus is so far represented by a single species *Sinophthalmus pictus* Coquillett collected from Mexico and California.

Coquillett (1904) established the genus *Sinophthalmus* under the subfamily Geomyzinae. Sturtevant (1921), on the other hand, placed this genus under the subfamily Drosophilinae. He further indicated that the subfamily Geomyzinae can be distinguished by the presence of following characters. Costa once broken, auxiliary vein usually ending in costa and arista seldom plumose. Consequently, *Sinophthalmus* is more close to Drosophilinae than to Geomyzinae.

The present species resembles *Sinophthalmus pictus* in the following diagnostic features :

1. Arista minutely pubescent ; 2. Three orbitals placed high up ; 3. The presence of prescutellars, anterior scutellars and posterior scutellars ; 4. Humeral one ; 5. Post-verticals small ; 6. Vibrissa present ; 7. Dorsocentrals two pairs ; 8. Auxiliary vein rudimentary (Sturtevant, 1921), distinct (Coquillett, 1904) ; 9. Discal and second basal cells separated ; 10. Two pairs of verticals, supra alars, notopleurals, sternopleurals and one pair of ocellars ; 11. Posterior cross vein present ; 12. Anal angle well developed.

It, however, differs from *S. pictus* (Coquillett, 1904) in the absence of the following characters :

1. Second joint of antenna with a rather long bristle on upper side, third segment truncate ; 2. Cheeks $1/5$; 3. Carina large ; 4. Acrostichals four rows ; 5. No preapicals on legs.

The present species does not resemble *Sinophthalmus pictus* except in having the brown spots on the body and the size of the body. The present species possesses ten rows of acrostichal hairs compared to four rows in *S. pictus*. The new species has been named as *Sinophthalmus creberii*.

Genus *Scaptomyza* Hardy, 1849

Scaptomyza Hardy, 1849. *Proc. Berwicksh. Nat. Club.*, 2 : 359 ; Sturtevant, 1921. *Carnegie. Inst. Publs.*, 301 : 63 ; Patterson, 1943. *Univ. Texas Publ.*, 4313 : 41 ; Wheeler, 1949. *Univ. Texas Publs.*, 4920 : 165 ; Wheeler, 1952. *Univ. Texas Publs.*, 5204 : 194 ; Okada, 1956. *Syst. St. Drosophilidae Allied Fam. Japan* : 67.

2. *Scaptomyza cristata* n. sp.

(Text-fig. 2)

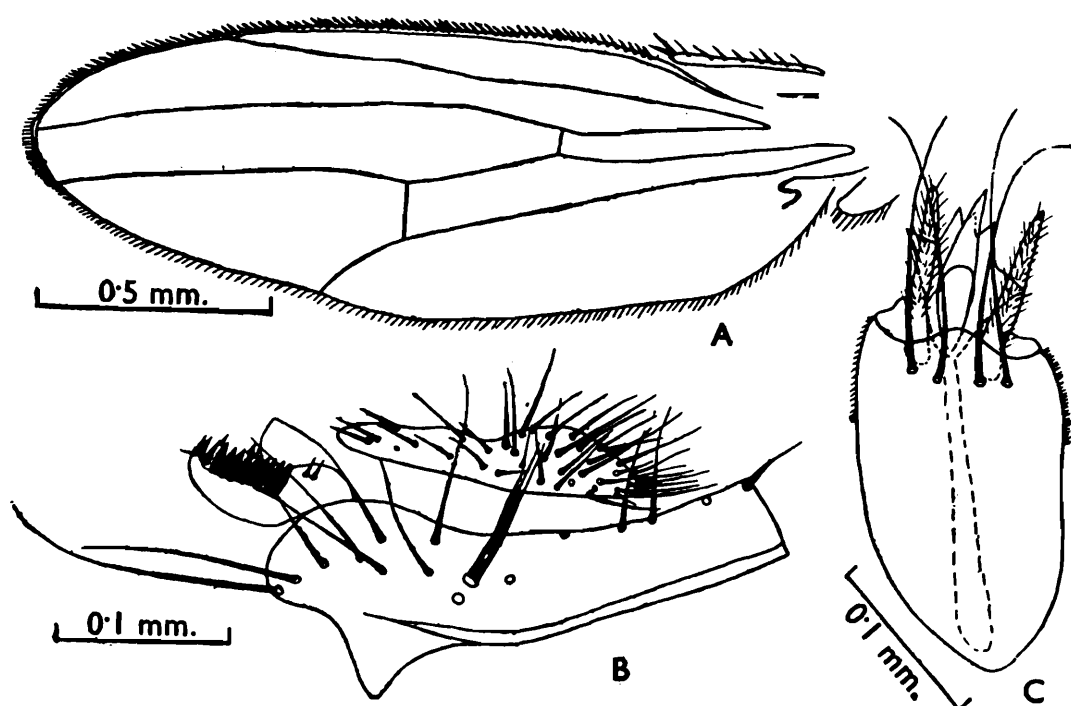
Description of imago

Male imago

External characters.—Arista with three branches above and one below, in addition to the terminal fork ; antenna black, with a white speck on the first and second segment. Front over $\frac{1}{3}$ the width of head, black with silvery white stripes, almost squarish. Orb₁ and Orb₃ almost equal, Orb₂ $\frac{1}{2}$ of either. Or₂ $\frac{1}{2}$ of vibrissa. Carina raised, narrow above broader below, a white streak running in the middle of it ; face black with two dorsomedian white specks ; clypeus black. Palpus grey, club-shaped, with a few short bristles. Cheeks dark brown, their greatest width about $\frac{1}{4}$ the greatest diameter of eye. Eyes maroon, a white streak runs along the orbit ; ocelli shining dark grey.

Acrostichal hairs in four regular rows ; prescutellars present, anterior scutellars divergent, posterior scutellars convergent and crossed in the middle. Mesonotum and scutellum black, mesonotum with five white stripes ; one dorsocentral continues behind on the scutellum, two dorso-medials running forward on the front and unite below the ocelli and traverse the carina as a single stripe and two dorso-laterals running anteriorly along the orbit and posteriorly along the lateral sides of scutellum. Three more stripes on each pleura. Humerals two, equal. Pleura light black, bare, with a muddy-white stripe across it. Sterno-index 0.85.

Legs black with yellow tinge. Preapicals on the first and third tibiae, apicals only on the second tibia. Sex-comb absent. Abdomen black.



Text-fig. 2.—*Scaptomyza cristata* n. sp. A. wing ; B. periphallic organs ; C. phallic organs.

Wing (Text-fig. 2A) : Clear ; C-1 bristles two, equal ; C-3 bristles on basal $\frac{2}{3}$ the third costal section ; C-index about 1.33, 4 V-index about 2.9, 4C-index about 2.18 and 5X-index about 1.6. Halteres light yellowish grey.

Length of the wing. .2.12 mm.

Length of the body. .2.35 mm.

Periphallic organs (Text-fig. 2B).—Genital arch wheatish brown, narrow above concave on the anterior lower margin with about twelve bristles, five arranged along the upper posterior margin. Heel distinct and pointed. Toe round, pointed downwards and inwards. Anal plate elliptical, notched in the middle and with about thirty six long bristles. Clasper single, comb-shaped, large, primary teeth twelve arranged concavely, four small marginal bristles, two small bristles on the clasper.

Phallic organs (Text-fig. 2C).—Wheatish brown in general. Aedeagus transparent rod-like, slender and pointed distally. Anterior parameres large and rod-like with numerous sensillae. Posterior parameres large, contiguous at the base, apparently fused distally, with two large lateral pointed projections at the meson and three small pointed projections at the distal end, lateral margins folded ventrally to form a sheath for the aedeagus. Ventral fragma almost rectangular, round anteriorly. Basal apodeme expands gradually from

base towards the distal end, about one and a half the size of aedeagus. Novasternum prominent, with a small round median projection, two pairs of exceedingly long submedian spines. P. I. : 0.6.

Holotype.—One male from Chandigarh deposited in the Museum, Department of Zoology, Panjab University, Chandigarh *vide* registration No. 111/73 dated 12.4.73.

Paratype.—Two males deposited along with the holotype.

Relationship.—This species belongs to the genus *Scaptomyza* because of the following characters :

Acrostichal hairs in four rows ; occiput more convex than in *Drosophila* ; thorax, abdomen and wings more slender ; prescutellars never present (Sturtevant, 1921 ; Patterson, 1943).

However, the present species differs from other species of the genus in having well developed prescutellars.

It resembles with *S. monticola* Okada in the following characters :

Body blackish grey ; arista with six branches ; ocellar triangle black ; Or_2 $1/2$ of vibrissa ; humerals two ; acrostichal hairs in four rows ; wings hyaline, cross vein clear ; C-1 bristles two ; abdominal tergites almost entirely black, with grey pollinosity ; anal plate separate from the genital arch ; anterior parameres large ; ventral fragma longer than broad.

However, the present species can be easily distinguished from *Scaptomyza monticola* on account of the following well defined differences :

<i>Scaptomyza cristata</i> n. sp.	<i>Scaptomyza monticola</i>
1. Antenna black ; third segment black	Antenna dark brown ; third segment yellow
2. Palpus grey with few short bristles	Palpus yellow with one prominent bristle at the tip
3. Periorbits silvery white	Periorbits black
4. Front black	Front orange brown
5. Carina rasied, a white streak running through the entire length of it	Carina low, short and black
6. Cheeks dark brown ; $1/4$ the greatest diameter of eye	Cheeks yellow ; $1/7$ the greatest diameter of eye

<i>Scaptomyza cristata</i> n. sp.	<i>Scaptomyza monticola</i>
7. Mesonotum grey ; five silvery white longitudinal stripes pass through it	Mesonotum silvery grey ; three longitudinal black stripes passing through it
8. Scutellum grey, with one median and two dorsolateral silvery white stripes	Scutellum grey, silvery, with a median longitudinal black stripe
9. Prescutellars present	Absent
10. Anterior scutellars divergent	Anterior scutellars convergent
11. Sterno-index 0.85	Sterno-index 0.6
12. Legs black with yellow ting preapicals on the first and third tibiae, apicals only on the second	Legs yellow ; preapicals on all the three tibiae, apicals on the middle
13. Wing indices : C —index 1.33 4V —index 2.9 4C —index 2.18 5X —index 1.6	3.3 1.5 0.7 1.8
C-3 bristles on the basal 2/3 the third costal section	1/4 the third costal section
14. Genital arch wheatish brown ; two hairs on the clasper	Genital arch brownish black ; no hairs on the clasper
15. Marginal bristles four on the clasper	No marginal bristles
16. Anal plate elliptical, with thirty six hairs	Anal plate elongate, with seventy hairs
17. Aedeagus pale, transparent ; no medioventral process	Aedeagus pale brown ; subapically there is a medioventral process
18. Anterior parameres with a pointed tip and numerous sensillae	Anterior parameres have round tip and have no sensillae
19. Posterior parameres well developed and have two lateral and three distal pointed projections	Posterior parameres absent
20. Novasternum with a small round median projection ; with two pairs of black, stout and exceedingly long Submedian spines	Novasternum without such projection ; with one pair of slender submedian spines

On the resemblance of the clasper to a comb the present species has been named *Scaptomyza cristata*.

3. *Scaptomyza plumata* n. sp.
(Text-fig. 3)

Description of imagines

Male imago

External characters.—Arista with four branches above and two below, in addition to the terminal fork ; antenna light brown, third segment and outside of second segment dull silvery white and transparent. Front over $\frac{4}{15}$ the width of head, front longer than broad, of equal width above and below and brownish yellow. Orb₁, and Orb₃ almost equal, Orb₂ much shorter than either Orb₁ or Orb₃. Or₂ much shorter or absent. Carina flat, narrow above broader below ; face silvery white with a brown dot in the middle ; clypeus whitish yellow. Palpus club-shaped, creamy white with few short bristles. Cheeks pale yellow, their greatest width about $\frac{1}{15}$ the greatest diameter of eye. Eyes brilliant red ; ocelli shining dark brown.

Acrostichal hairs in four regular rows ; prescutellars present, anterior scutellars convergent, posterior scutellars crossed at the distal end, not upright. Mesonotum and scutellum blackish brown. Mesonotum with one dorsomedian and two dorso-lateral silvery white stripes. Two dorso-lateral stripes anteriorly continue on the frons along the entire length of the orbit, posteriorly they run along the lateral side of the scutellum, a silvery white dot on the posterior extremity of the scutellum. Humerals two, equal. Pleura bare, brownish yellow with a faint black longitudinal stripe across it. Sterno-index 0.85.

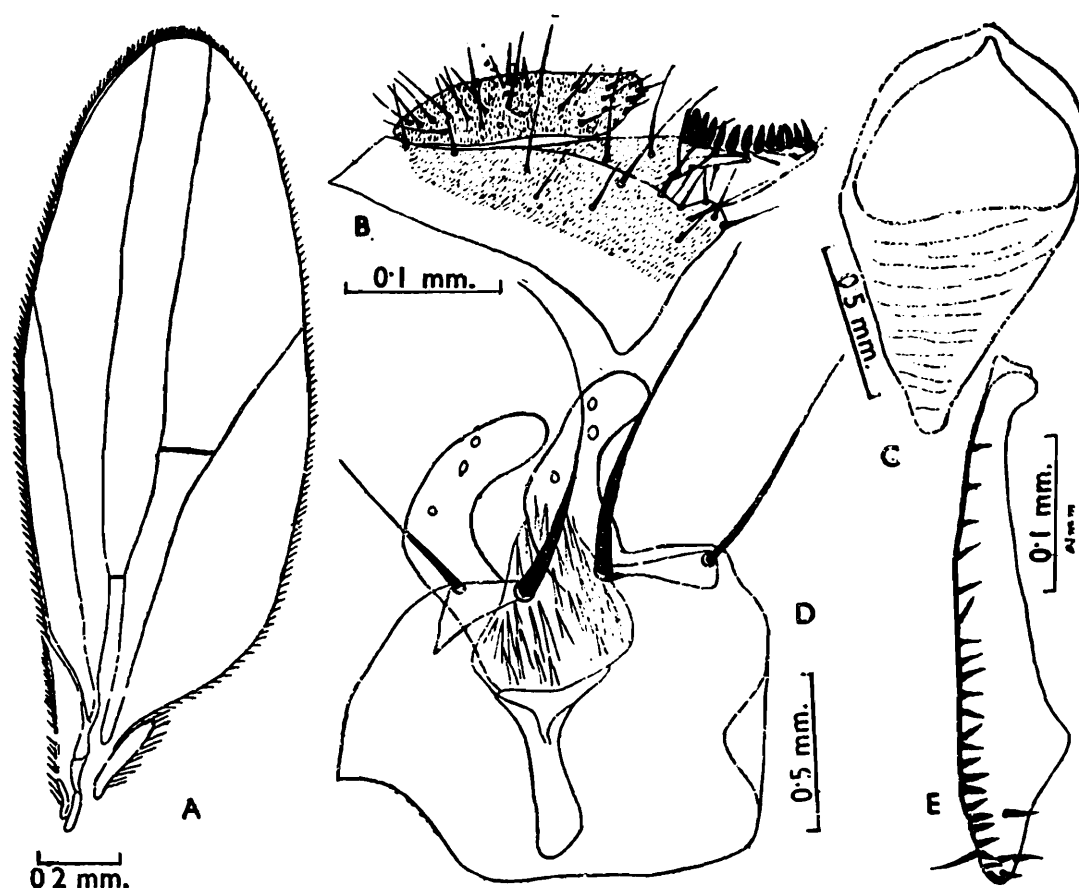
Legs pale. Preapicals on all the three tibiae, apicals on the first two. Sex-comb absent. Abdomen light black, sometimes black bands discernible.

Wing (Text-fig. 3A) : Clear ; C-1 bristle one ; C-3 bristles on basal $\frac{1}{2}$ the third costal section ; C-index about 1.75, 4V-index about 2.71, 4C-index about 1.71 and 5X-index about 2.0. Halteres pale.

Length of the wing 1.85 mm

Length of the body 2.00 mm

Periphallic organs (Text-fig. 3B).—Genital arch dark wheatish brown, narrow above with about thirteen bristles, two arranged along the upper posterior margin. Heel distinct and pointed. Toe round. Anal plate oblong, separate from the genital arch and with about twenty eight long bristles. Clasper single, large ; primary teeth thirteen arranged concavely on the clasper, marginal bristles eight.



Text-fig. 3.—*Scaptomyza plumata* n. sp. A. wing ; B. periphallallic organs ; C. deca sternum ; D. phallic organs ; E. egg-guides.

Deca sternum (Text-fig. 3C).—Triangular with two posterior lateral processes which bend forward and downwards to form a circular ring.

Phallic organs (Text-fig. 3D).—Pale in general. Aedeagus compact, plumose and pale. Anterior parameres pale, large, curved in the middle, tip round with three sensillae in a row. Posterior parameres absent. Novasternum indistinct, fused with the ventral fragma, with two pairs of submedian spines ; the inner pair large, black, exceedingly elongated ; the outer pair at the lateral margins comparatively smaller and slender than the inner pair. Ventral fragma quadrangular, antero-lateral margins concave and pale. Basal apodeme yellow shorter than the ventral fragma. P.I. : 1.22.

Female imago

External characters.—Resembles male in all its details except little lighter body colour.

Length of the wing 1.94 mm

Length of the body 2.07 mm

SINGH : *The Genera Sinophthalmus and Scaptomyza*

Egg-guides (Text-fig. 3E).—Lobe pale-yellow, narrow at the base, round at the apex, a bulge at $1/3$ distad of the apex, with twenty five stout pointed marginal and two discal teeth. The subterminal hair present between the fifth and sixth teeth. Fifteen teeth at the upper margin are pale, pointed and long, eight at the base are short and dark brown. There is a gap between the ultimate and the penultimate tooth.

Holotype.—One male from Chandigarh deposited in the Museum, Department of Zoology, Panjab University, Chandigarh *vide* Registration No. 110/73, dated 12.4.73.

Paratypes.—One male and one female deposited along with the holotype.

Other specimens examined.—One male and seven females collected along the holotype and paratype.

Relationship.—Like *Scaptomyza cristata* n. sp. the present species also differs from the other members of the genus described so far, in having well-developed prescutellar bristles.

The present species resembles *S. paravittata* of *vittata* species-group (Wheeler, 1952) only in possessing some longitudinal stripes. In general it compares favourably with *montana* species-group (Wheeler, 1952) in the following features : Blackish or yellowish species ; four acrostichal rows ; long apical scutellars ; two humerals ; no wing spot. However, it does not resemble with any of the species of the *montana* species-group.

Okada (1956) reported five species of *Scaptomyza*. *S. graminum* Fallen, *S. apicalis* Hardy, *S. unipunctum* Zetterstedt, *S. disticha* Duda and *S. monticola* Okada from South East Asia. Of all the species of the genus so far known the present species is more close to *S. monticola*. Superficially it resembles *S. monticola* in the following features :

Front brownish yellow ; carina flat and short ; cheeks pale yellow ; humerals two ; acrostichal hairs in four rows ; anterior scutellars convergent ; preapicals on all the three tibiae ; wings hyaline, cross vein clear ; halteres pale ; anal plate separate ; anterior parameres large, tip round ; posterior parameres absent.

It, however, differs from *S. monticola* as follows :

Scaptomyza plumata n. sp.

Scaptomyza monticola

1. Body blackish yellow

Body blackish grey

<i>Scaptomyza plumata</i> n. sp.	<i>Scaptomyza monticola</i>
2. Third segment of antenna silvery white, transparent	Third segment yellow
3. Palpus creamy white, with few short bristles	Palpus yellow, with one bristle
4. Ocellar triangle brown	Ocellar triangle black
5. Periorbits silvery white	Periorbits black
6. Cheeks $\frac{1}{15}$ the greatest diameter of eye	$\frac{1}{7}$ the greatest diameter of eye
7. Orb_2 much shorter than either Orb_1 or Orb_3	Orb_2 $\frac{1}{3}$ the Orb_3
8. Or_2 much shorter	Or_2 $\frac{1}{2}$ of the vibrissa
9. Mesonotum with three silvery white stripes	Three black stripes
10. Scutellum with two silvery white stripes and a silvery white dot at the posterior tip.	Scutellum with a median black stripe
11. Prescutellars present	Prescutellars absent
12. Sterno-index 0.85	Sterno-index 0.6
13. Apicals on the first and second tibiae	Apical only on the middle tibia
14. Wing indices : C—index 1.75 4 V—index 2.71 4 C—index 1.71 5 X—index 2.00	3.3 1.5 0.7 1.8
15. C-1 bristle one	Two
16. C-3 bristles on the basal $\frac{1}{2}$ the third costal section	$\frac{1}{4}$ the third section
17. Abdomen light black	Abdomen exceedingly black
18. Genital arch dark wheatish brown, with eighteen bristles, two at the upper posterior margin, five on the clasper	Genital arch brownish black, upper posterior margin with five bristles, lower portion with five hairs
19. Clasper with thirteen concavely arranged teeth, no stout bristles	With twelve concavely arranged teeth, several stout bristles below

<i>Scaptomyza plumata</i> n. sp.	<i>Scaptomyza monticola</i>
20. Marginal bristles eight	No such bristles
21. Anal plate oblong, with about twenty eight bristles	Anal plate elongate, with seventy bristles
22. Aedeagus, compact, plumose and pale,	Aedeagus pale brown, subapically with a medioventral process
23. Anterior parameres with three sensillae	No sensillae
24. Ventral fragma quadrangular	Ventral fragma longer than broad
25. Novasternum not discernible, with two pairs of sub-median spines, inner pair dark and larger, outer comparatively lighter and small	Novasternum dark brown, with a pair of slender sub-median spines

Further, this species can be easily distinguished from *Scaptomyza cristata* because of the following differences :

<i>Scaptomyza plumata</i> n. sp.	<i>Scaptomyza cristata</i> n. sp.
1. Antenna light brown, third segment silvery white, transparent	Antenna black, third segment black
2. Arista with eight branches, four dorsal, two ventral, excluding the fork	Arista with six branches, three dorsal, one ventral, excluding the terminal fork
3. Palpus creamy white	Palpus grey
4. Ocellar triangle dark brown	Ocellar triangle black
5. Front brownish yellow	Front black
6. Carina flat, no white streak	Carina raised, a white streak running in the middle of it
7. Cheeks pale yellow, $1/15$ the greatest diameter of eye	Dark brown, $1/4$ the greatest diameter of eye
8. Orb_2 much shorter than Orb_1 and Orb_3	Orb_2 $1/2$ of Orb_3
9. Or_2 much shorter than vibrissa	Or_2 $1/2$ of the vibrissa
10. Mesonotum with three silvery white stripes	With five such stripes

Scaptomyza plumata n. sp.*Scaptomyza cristata* n. sp.

11. Scutellum blackish brown, with two lateral silvery white stripes and a silvery white speck at the tip	With three silvery white streaks, two lateral and one median
12. Anterior scutellars convergent	Divergent
13. Preapicals on all the three tibiae ; apicals on the first two	Preapicals only on the first and third tibiae ; apicals on the second tibia only
14. Wing indices :	
C—index 1.75	1.33
4 V—index 2.71	2.9
4 C—index 1.71	2.18
5 X—index 2.00	1.6
C-1 bristle one	C-1 bristles two
C-3 bristles on the basal 1/2 the third costal section	On 2/3 of the third costal section
15. Halteres pale	Halteres yellowish-grey
16. Abdomen light black	Abdomen exceedingly black
17. Genital arch with eighteen bristles, two at upper posterior margin, five on the clasper	With twelve bristles ; five at upper posterior margin, two on the clasper
18. Clasper with thirteen concavely arranged teeth with eight marginal bristles	Clasper with twelve concavely arranged teeth, with four small marginal bristles
19. Anal plate oblong, with about twenty eight bristles	Anal plate elliptical, with about thirty six bristles
20. Aedeagus pale, compact and plumose	Aedeagus light pale, slender, pointed at the tip, transparent
21. Anterior parameres with distal tip rounded, with three sensillae	With distal tip pointed, with numerous sensillae
22. Posterior parameres absent	Very well developed, contiguous at the base, apparently fused distally, with two lateral and three median pointed projections
23. Ventral fragma quadrangular	Longer than broad, rectangular

Scaptomyza plumata n. sp.*Scaptomyza cristata* n. sp.

24. Novasternum with two pairs of sub-median spines ; the inner pair large and stout, the outer pair slender and comparatively smaller	Novasternum with two pairs of large stout black sub-median spines

From the fact that the aedeagus in this is plumose, it has been named as *S. plumata*.

ACKNOWLEDGEMENTS

The author is very grateful to Prof. G. P. Sharma, Head of the Department of Zoology, Panjab University, Chandigarh, for very kindly providing the necessary laboratory facilities.

SUMMARY

A new oriental representative of the genus *Sinophthalmus* and two new species of the genus *Scaptomyza* are described from India.

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MORPHOLOGICAL STUDIES ON *HIRSCHMANNIELLA*
ORYZAE (SOLTWEDEL) (NEMATODA : TYLENCHIDA)

By

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(With 11 Text-figures)

INTRODUCTION

The genus *Hirschmanniella* Luc and Goodey, 1963 is cosmopolitan in its distribution and an established parasite of paddy, banana, etc. Sanwal (1957) gave a good account of the morphology of one of its widely known species, *H. gracilis* (de Man, 1880). Sher (1968) gave an excellent revision of the genus which to-date includes 16 species. The species, *H. oryzae* (Soltwedel, 1889) Luc and Goodey, 1963 is of common occurrence around paddy in this country and also in Japan, Formosa, Malaysia, Nigeria, Venezuela, San Salvador, Indonesia, Ghana etc. Taking into account the world wide distribution of the genus and its economic importance, it was proposed to undertake detailed morphological study of *H. oryzae* which is the most common species of the genus in India. The morphological studies are important because these provide pertinent information on a particular species and its intra-specific variations; this has a direct bearing on the taxonomy of the genus concerned and also on the related groups. The utility of a structure as taxonomic character can only be judged by adequate study of the morphology based on large number of specimens obtained from different populations.

The observations were made on fixed as well as on live specimens.

The authors are thankful to Professor S. Mashhood Alam, Head, Department of Zoology for providing laboratory facilities.

MATERIALS AND METHODS

Materials.—The specimens of *Hirschmanniella oryzae* for the present study were collected from the soil around roots as well as from within the roots of paddy, *Oryza sativa* L. from the following localities in the district Aligarh.

- (i) 73 ♀ ♀ and 27 ♂ ♂ from Jamalpur north on 1.1.1968
- (ii) 58 ♀ ♀ and 22 ♂ ♂ from Jamalpur east on 3.11.1967
- (iii) 55 ♀ ♀ and 22 ♂ ♂ from Bhambhola on 26.10.1967
- (iv) 56 ♀ ♀ and 21 ♂ ♂ from University Agriculture Farm (A) on 26. 10.1967
- (v) 48 ♀ ♀ and 18 ♂ ♂ from University Agriculture Farm (B) on 3.11.1967
- (vi) 45 ♀ ♀ and 20 ♂ ♂ from Qasimpur north on 4.3.1968
- (vii) 57 ♀ ♀ and 20 ♂ ♂ from Qasimpur south on 4.3.1968
- (viii) 56 ♀ ♀ and 21 ♂ ♂ from Zohra Bagh on 4.3.1968
- (ix) 56 ♀ ♀ and 19 ♂ ♂ from CDF road field (A) on 25.2.1968
- (x) 56 ♀ ♀ and 20 ♂ ♂ from CDF road field (B) on 18.3.1968

Methodology.—The specimens for the morphological study were stained with different techniques for obtaining various structural details. The gross morphology was studied on the specimens stained with the saturated solution of Picric acid. Intravital staining was done with different stains but the best results were obtained with Methylene blue. In particular, it was helpful in the study of excretory and digestive systems of the nematode. First, the specimens were kept for two hours in Methylene blue then fixed in Picro-carmine. Methyl red was also tried as intra-vital stain but it gave poor results.

Cuticle and associated structures.—For the study of Cuticle and its modifications, the method employed by Sanwal l.c. was followed except that the Silver nitrate was acidulated by adding a few drops of nitric acid. After the nematodes had assumed a dark brown appearance, they were transferred to a mixture of glycerine-alcohol (5 parts glycerine : 95 parts 30% alcohol) and then processed as usual. This method gives excellent details of cuticular structures including transverse striae, lateral fields, amphids, phasmids, oral aperture, anal opening, excretory pore, etc. It also stains the reproductive organs specially the nuclei of the oocytes, spermatocytes and that of the oesophageal glands. An attempt was made to study the nervous system by staining it with silver impregnation technique but poor results were obtained, more so, because the entire nervous system leaving aside the nerve ring and associated cells is very delicate and difficult to study in such a small nematode. For the study of sphincter muscles encircling the excretory bulb of the terminal excretory duct and outlet of the terminal duct some specimens were kept in a mixture of picric acid and A.F.A. for about two weeks.

For detailed study of the muscles the following method was found good :—First of all, living nematodes were stained with methylene blue and then fixed in picro-carmine. Later on, they were transferred to haematoxylin and finally to a mixture of aniline blue, orange red, and acetic acid (in equal proportions). After keeping the nematodes in this mixture for two weeks they were treated with

lactophenol. Specimens were then mounted in anhydrous glycerine by usual technique.

Chang's nerve stain (theonin 0.3 gm., formaldehyde 4% 10 cc and distilled water 90 cc) was found to be a good medium for the study of nervous system.

OBSERVATION

(For measurements and dimensions see Table 1 & 2)

General Body Shape

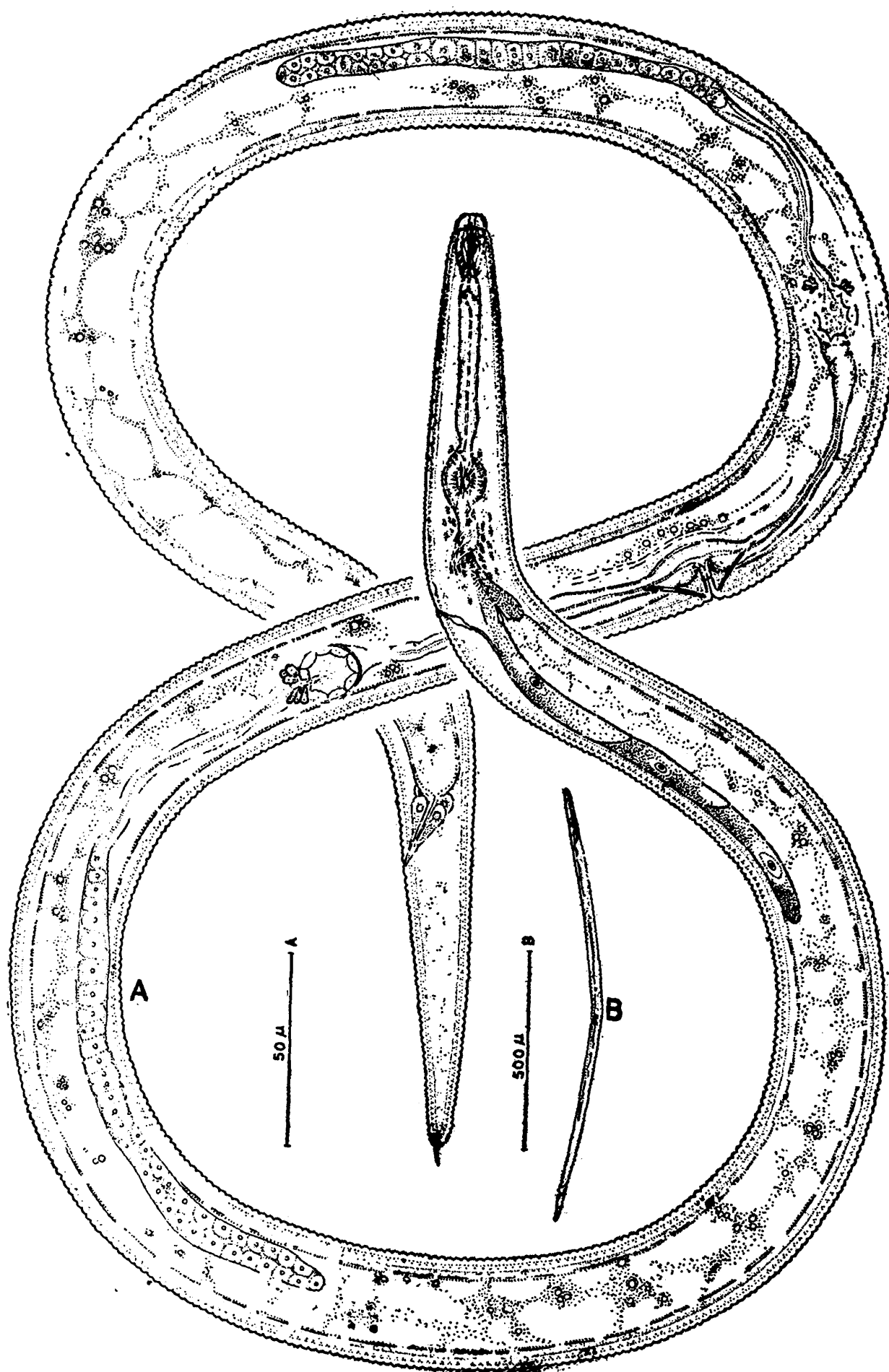
(Text-figs. 1 & 2)

The nematodes are irregularly coiled, whitish to bluishgreen in colour while alive. In water, the nematodes start swarming in a few hours time. Their characteristic movement helps in quick detection under the stereoscopic binocular microscope. The nematodes upon fixation assume ventrally arcuate posture, slightly narrowing anteriorly above the level of oesophago-intestinal junction and sharply behind the anus. The width of body in the middle third is nearly uniform, except at vulva where it is maximum.

Head.—The head is slightly marked off from the body by a faint constriction, slightly hemispheroid in shape, 3 μ high and 8-9 μ wide. It is supported by a well developed hexaradiate framework, formed by the fusion of six strong radially placed cuticularized ridges. The inner edges of these ridges at their extremities converge to form a tube-like structure which serves as a guide for the spear. The outer edges of these ridges form a disc-like basal plate (Text-fig. 5, D).

Lip region is rounded, flat at apex. *En face* view shows the usual six lips : two lateral, two dorso-lateral and two ventro-lateral. Each lip bears a minute papilla at its inner margin. In addition, there are four pairs of outer cephalic papillae, one pair on each dorso-lateral and ventro-lateral lips, the lateral lips having only one papilla on their outer margins but they also possess the amphidial apertures (Text-fig. 6, A).

Tail.—The tail is more or less cylindrical (Text-fig. 4, A-N) with blunt tip, usually with a distinct mucro. The dorsal surface of the tail is usually straight while the ventral side curves inward. Tail length varies from 70-120 μ (averaging 85 μ) or 4-6 anal body-widths (averaging 5 anal body-widths), possesses pore-like phasmids on the lateral sides in the posterior half of its length. The usual



Text-fig. 1. *Hirschmanniella oryzae* (Soltwedel), A. Entire female. B. Actual shape of female.

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Table 1.—Measurements and Dimensions of *Hirschmanniella oryzae* ♀♀

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Dimensions and Measurements

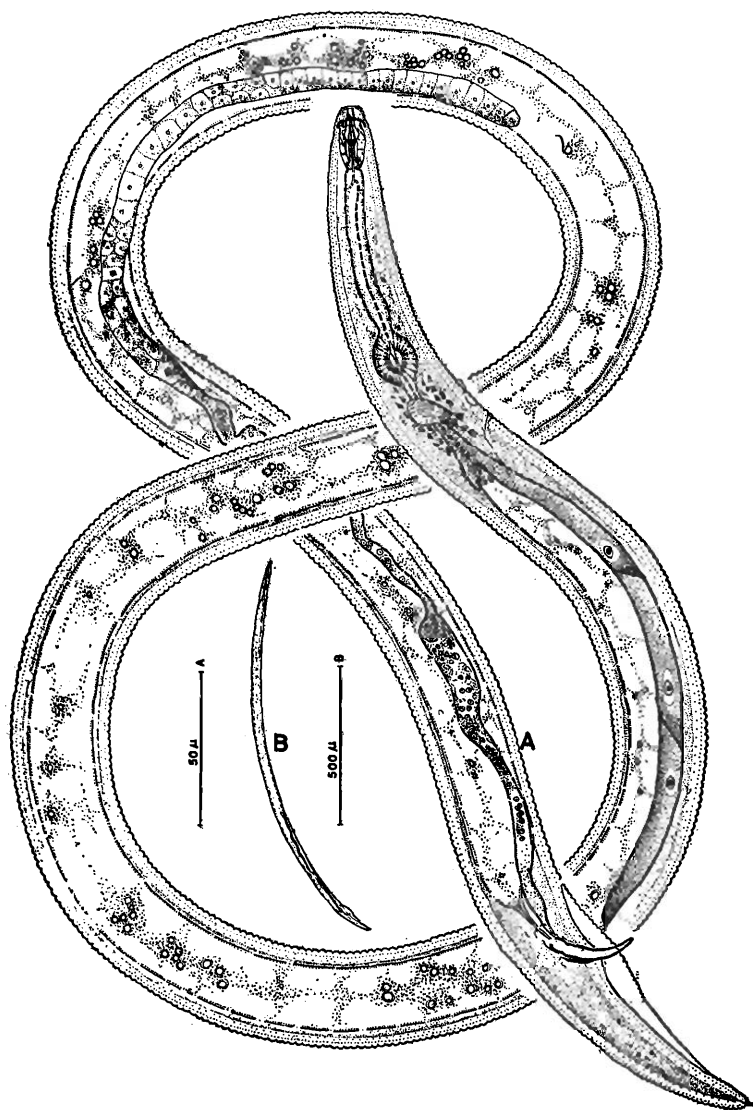
Measurements	Jamalpur North	Jamalpur East	Bhambhola	University Agriculture Farm A	University Agriculture Farm B	Qasimpur North	Qasimpur South	Zohra Bagh	Central Dairy Farm Road A	Central Dairy Farm Road B
LENGTH = 1.34 (1.00-1.59) (in mm.)	1.01-1.49	1.10-1.45	1.12-1.40	1.00-1.54	1.01-1.56	1.00-1.59	1.00-1.53	1.15-1.54	1.06-1.54	1.00-1.57
a = 52 (32-60)	46-53	43-60	39-56	39-58	32-60	40-60	37-56	40-59	41-58	43-57
b = 11.2 (7.6-13.1)	8.7-11.5	8.1-13.7	7.6-11.9	8.0-11.1	8.0-11.3	7.8-12.6	7.8-13.1	8.7-11.2	8.5-11.5	8.6-13.1
b' = 5.0 (3.2-6.7)	4.1-6.4	5.1-6.7	4.1-5.7	4.1-5.6	3.3-5.4	3.4-5.9	4.1-6.6	3.7-6.3	3.9-6.1	4.3-6.1
c = 19 (13-27)	15-22	14-20	17-23	16-26	15-27	16-23	15-22	19-27	15-25	16-23
V = ²⁴ 53 ²² (¹⁷⁻⁴⁸ 46-67 ¹⁷⁻⁴¹)	48-57	46-56	48-67	46-61	48-58	48-53	48-51	46-57	46-63	48-53
G ₁ = 24 (17-43)	19-22	17-23	19-43	18-23	19-38	17-29	19-27	18-32	18-29	19-24
G ₂ = 22 (17-41)	18-20	17-22	20-41	16-21	15-29	18-23	16-33	17-26	18-23	16-21
Spear length = 17 μ (15-19 μ)	16-18 μ	15-18 μ	16-19 μ	15-17 μ	15-18 μ	15-19 μ	16-19 μ	16-19 μ	17-18 μ	15-19 μ
Metacarpus = 68 μ (56-85 μ)	56-80 μ	59-81 μ	59-83 μ	58-73 μ	59-85 μ	60-82 μ	59-81 μ	58-82 μ	59-86 μ	59-83 μ
Excretory pore	80-120 μ	83-110 μ	83-95 μ	87-113 μ	82-115 μ	85-117 μ	91-199 μ	93-120 μ	80-120 μ	83-111 μ
Dorsal oesophageal gland overlap	212-350 μ	210-320 μ	215-291 μ	214-330 μ	230-310 μ	250-319 μ	220-293 μ	215-281 μ	214-273 μ	220-333 μ
Vulval slit = 9 μ (8-10 μ)	9-10 μ	8-9 μ	8-10 μ	9-10 μ	9-10 μ	9-10 μ	8-10 μ	9-10 μ	8-10 μ	8-10 μ
Vagina length = 10 μ (8-12 μ)	10-12 μ	8-12 μ	8-11 μ	9-12 μ	8-12 μ	9-10 μ	10-12 μ	9-12 μ	8-11 μ	8-10 μ
Tail length = 85 μ (70-120 μ)	73-80 μ	73-80 μ	71-82 μ	73-91 μ	73-80 μ	73-89 μ	71-89 μ	73-95 μ	73-85 μ	73-120 μ
Tail striae = 50 (50-80)	50	50	50	50	50	50	50	50	50	50-80
Rectum = 16 μ (15-18 μ)	16-17 μ	16-18 μ	15-17 μ	15-18 μ	15-18 μ	16-17 μ	16-18 μ	16-18 μ	16-18 μ	15-18 μ
Anal body-width = 17 μ (15-24 μ)	17-20 μ	17-19 μ	16-22 μ	17-24 μ	16-22 μ	17-22 μ	17-23 μ	15-19 μ	17-18 μ	15-19 μ
Phasmids	13-52 μ	14-23 μ	16-22 μ	23-24 μ	16-23 μ	17-29 μ	23-26 μ	16-39 μ	16-33 μ	22-52 μ

G₁ = Anterior gonad .. G₂ = Posterior gonad

Table 2.—Measurements and Dimensions of *Hirschmanniella oryzae* ♂ ♂

Dimensions and Measurements

Measurements	Jamalpur North	Jamalpur East	Bhambhola	University Agriculture Farm A	University Agriculture Farm B	Qasimpur North	Qasimpur South	Zohra Bagh	Central Dairy Farm Road A	Central Dairy Farm Road B
LENGTH = 1.45 (1.04-1.94) (in mm),	1.10-1.56	1.04-1.46	1.24-1.76	1.16-1.80	1.23-1.46	1.37-1.56	1.20-1.70	1.11-1.80	1.32-1.92	1.46-1.94
a = 54 (37-62)	37-48	37-53	39-54	39-62	41-56	53-59	52-56	43-58	43-60	43-62
b = 10.5 (7.0-12.8)	7.6-11.3	7.4-11.2	7.6-11.5	7.6-11.6	7.6-12.0	8.2-12.6	8.1-12.0	7.3-11.9	7.6-12.2	8.7-12.8
b' = 4.9 (3.6-6.1)	3.9-5.4	4.1-5.3	3.9-4.9	3.8-5.3	3.9-5.6	4.1-6.0	3.9-5.9	4.3-5.0	4.1-5.3	4.3-6.1
c = 18 (15-22)	17-21	16-22	15-19	15-17	17-21	16-18	15-17	16-21	15-21	17-22
T = 33 (24-42)	26-36	28-39	27-41	28-33	29-38	27-42	29-38	30-42	24-36	29-39
Spicules = 25 μ (22-29 μ)	23-29 μ	22-29 μ	22-28 μ	24-29 μ	24-29 μ	22-29 μ	22-27 μ	22-26 μ	22-29 μ	22-29 μ
Gubernaculum = 8 μ (7-10 μ)	7-9 μ	7-10 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-9 μ	7-10 μ
Caudal alae = 73 μ (58-80 μ)	58-73 μ	58-80 μ	58-80 μ	58-75 μ	58-79 μ	58-76 μ	58-80 μ	58-73 μ	58-80 μ	58-80 μ
Rectum = 22 μ (19-24 μ)	19-22 μ	19-23 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ	19-24 μ
Phasmids	16-22 μ	17-25 μ	18-32 μ	16-35 μ	16-42 μ	16-43 μ	10-46 μ	15-43 μ	15-46 μ	15-48 μ



Text-fig. 2. *H. oryzae*. A. Entire male. B. Actual shape of male.

number of tail striae is 50, but in few specimens it may have as many as 80 striae.

Cuticle and its Modifications

(Text-fig. 3)

The cuticle is almost uniformly thick throughout the body except at vulva, anus and at tail tip. It is about $1\ \mu$ thick on the general body surface, about $2\ \mu$ at vulva and anus while $2-3\ \mu$ at tail tip.

Transverse striations.—The head bears usually 6 fine, but distinct transverse striae placed at less than $1\ \mu$ apart. The number of head striae is constant, with the exception that rarely 5 striae may also be present. In the region of spear, the striae are of the same width as those on the head. Posterior to spear the striae become more and more distinct with the increase in the inter-strial width, becoming about $2\ \mu$ near the middle of the body. Posterior to middle this distance gradually decreases to about $1\ \mu$ near the tip of the tail. In few specimens, the inter-strial width remains uniform until the tail tip. In one specimen the inter-strial width was found to be of two different alternating thickness $1\ \&\ 2\ \mu$ on the body without any uniformity.

Mucro.—The cuticle at tail tip projects into a sharply pointed, peg-like 'mucro'. The length of the mucro varies from $1-3\ \mu$. In some specimens, the mucro is inconspicuously developed or even absent; this might have occurred due to some mechanical injury to the nematode.

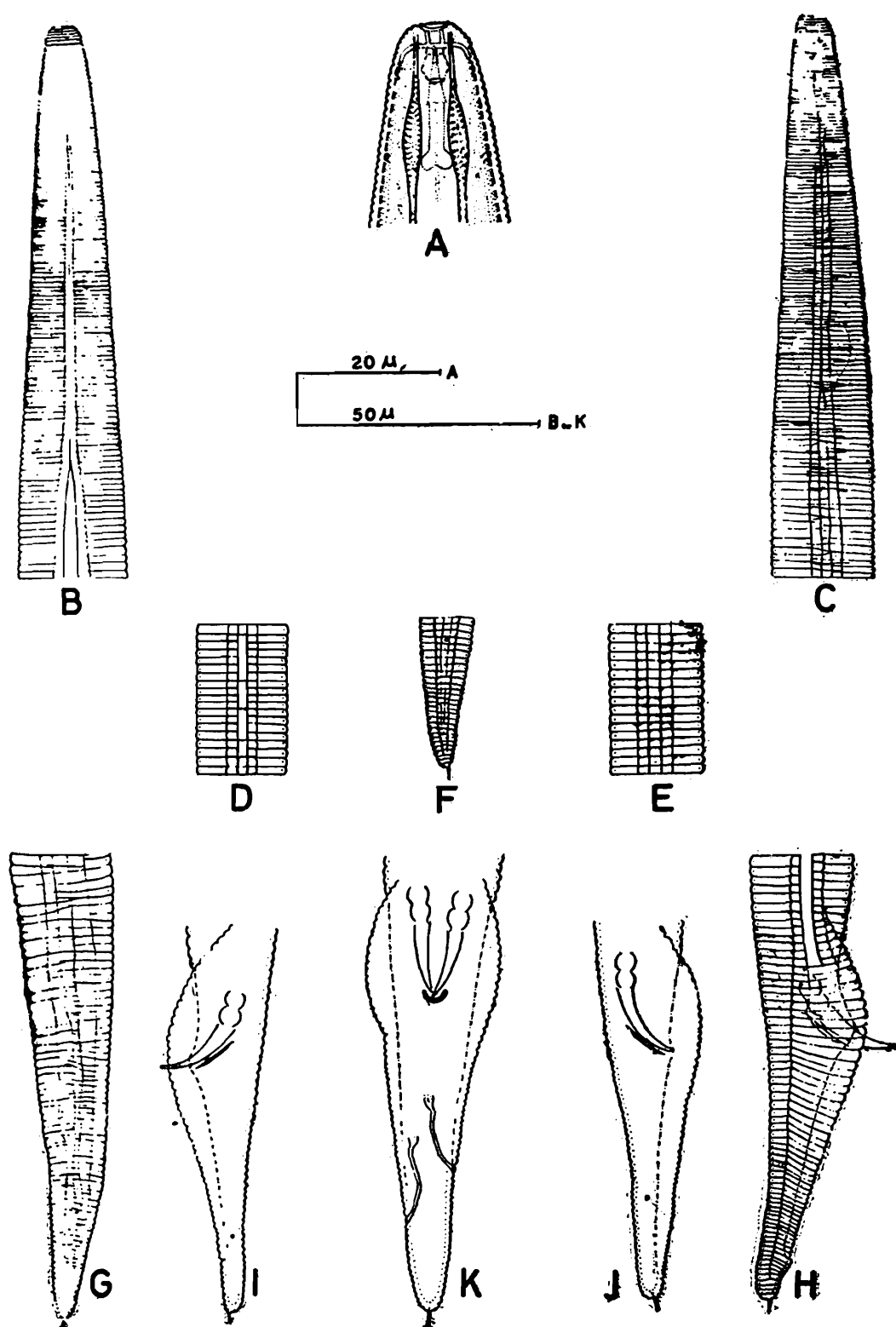
Lateral fields.—The lateral sides of the body are marked with four longitudinal incisures (lateral lines) overlying the lateral hypodermal chords. These markings are more prominent in the middle part of the body. They originate just behind the level of spear base as a single depression in the cuticle, run as single line until the middle of procarpus and then are joined by the second incisure, the third one originates slightly posterior to the second incisure. These three incisures follow a parallel course up to the median bulb. Afterwards, the middle one (first incisure) splits up into two at the level of nerve ring, and the number of incisures become four. In a cross section (Text-fig. 4, D) at the level of metacarpus, the lateral sides show two strong ridges and three grooves formed by the three incisures. In the region of nerve ring and posteriorly across section (Text-fig. 6, G-K) shows three strong ridges with four depressions formed by the four incisures. The width of the lateral fields in the region of metacarpus is $4-5\ \mu$, at nerve ring $5-6\ \mu$ and near the middle of the body about $8\ \mu$ ($6-10\ \mu$) or $1/3$ rd the corresponding body-width. The width of lateral fields is maximum at vulva. In the post-vulval region the lateral fields begin to narrow, in tail region the incisures run close to each other and start converging,

In males, the width of the lateral fields is almost uniform from the oesophago-intestinal junction to the beginning of the caudal alae, about 15-20 μ above the cloaca.

The termination of lateral fields is quite different in the two sexes. In females (Text-fig. 3, F), the incisures terminate 15-20 μ above the tip of tail. The width of lateral fields decreases due to convergence of incisures in the postvulval region, but the narrowing becomes conspicuous only in the anal region. Usually, the inner two (median incisures) disappear at about 10-20 μ above the tip of the tail followed by the ventral and dorsal ones which terminate at about 5-15 μ above the tip of tail. In males (Text-fig. 3, H), posterior to the origin of caudal alae, the ventral and the inner two incisures run a short distance on the two wings of the alae where they expand and gradually disappear, usually above or occasionally slightly below the cloacal aperture. The ventral incisure disappears first, followed by the inner ones. The dorsal incisure runs along the dorsal margin of the caudal alae and finishes at 5-15 μ above the tip of the tail.

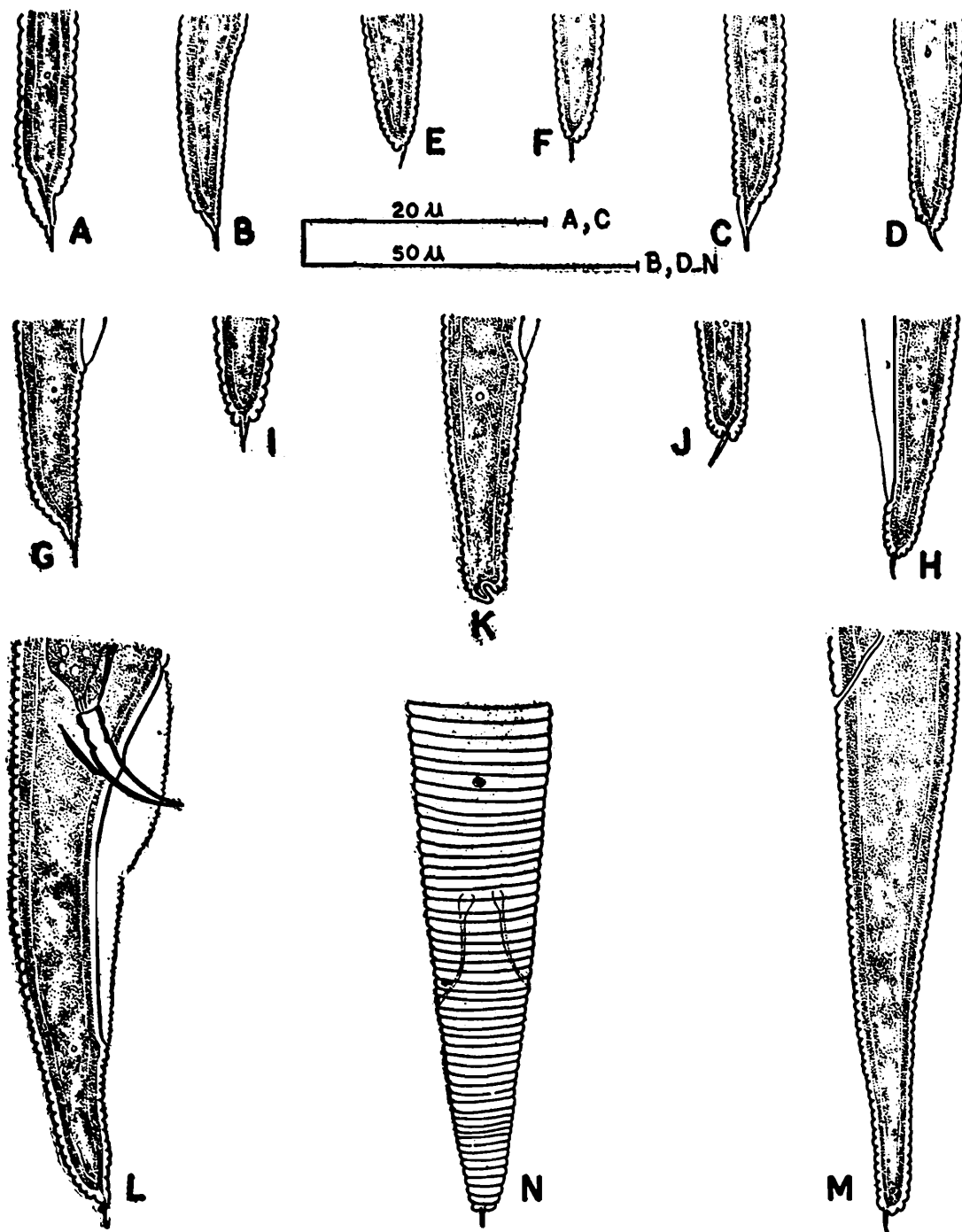
Areolation (Text-fig. 3, D-F).—The lateral fields are usually incompletely areolated. The areolation is caused by intrusion of transverse striae into the lateral fields. In the anterior half of the body, the areolation usually does not extend through the entire width of the lateral fields (incomplete areolation), but sometimes it may be almost complete. However, irregularities are very common in the occurrence of complete and incomplete areolation. It has been observed that in the pre-vulval region, the areolation is mostly confined to the outer bands of the lateral fields, the middle band is rarely crossed. However, in vulval and post-vulval regions, the outer as well as median bands of incisures are all interrupted by the transverse striae which may make complete rings around the body of the worm. In a number of specimens the areolation was complete throughout the length of the lateral fields. The areolation in the pre-vulval region is generally incomplete, but in post-vulval region it is mostly complete.

Anastomosis (Text-fig. 3, C and G).—The phenomenon of anastomosis is rarely observed in nematodes, except in Criconematids. However, here it was observed in several specimens. Striations from head to tail are adversely affected in some of the specimens studied. The anastomosis may cause difficulties in the study of lateral fields because both the transverse and longitudinal striae show anomalies in their normal pattern. In specimens showing anastomosis, the lateral fields follow a random course, they do not run parallel to each other and show interruption at several places with the result that they do not look as incisures but as uneven lines made up of several small units. The overlapping of transverse striae was seen on any region of the body and they also do not form complete rings,



Text-fig. 3. Cuticular modifications of *H. oryzae*, A. Head end of female showing Amphids and Cephalids, B. Anterior region of female showing origin of lateral fields, C. Anterior region of female showing anastomosis, D. Lateral fields with incomplete areolation in the pre-vulval region, E. Lateral fields with complete areolation in the post-vulval region, F. Lateral fields with complete areolation in tail region, G. Lateral fields on tail showing anastomosis, H. Lateral fields on male tail, I. & J. Male tails showing origin and termination of caudal alae, K. Male tail in dorso-ventral position.

Caudal alae (Text-fig. 3, I--K).—The males of the species have a pair of wing-like structure known as caudal alae which are sometimes referred to as 'bursa'. The term bursa is incorrect as this structure is neither supported by rays nor by ribs as in the strongylid nematodes.



Text-fig. 4. Tail shapes of *H. oryzae*. A-D. Leaf-shaped tails of females, E & F. Tail tips with additional striae, G & H. Posterior halves of male tails, I. Female tail tip dorso-ventral, J. Female tail tip with curved mucro, K. Male tail notched, L. Male tail lateral, M. Female tail lateral, N. Female tail dorso-ventral.

The caudal alae are formed due to the lateral extensions of the body cuticle. They originate about 15-20 μ above the cloacal aperture on the lateral sides of the body and terminate before the tip of the

tail and thus do not envelop the tail completely. The alae in the anterior half of their length are distinctly convex, but gradually narrowing on the rest. The outer edges of the alae are crenate due to the continuation of the transverse striae of the body. The alae normally neither originate at the same level on the body nor do they terminate.

The relation of caudal alae with the phasmids is variable. In most of the specimens, it was found that while one ala reaches beyond phasmids, the other one stops slightly short; in few specimens, both the alae reach beyond the level of phasmids. However, it was never found to end before the phasmidial level.

Amphids (Text-fig. 6, A).—The amphids are situated on the lateral sides of the body in the head region. The amphidial slits $2-3\ \mu$ wide are crescentic in shape, situated on the lateral lips. The amphidial ducts have ellipsoidal pouch-like structure which are known as sensillar pouches, the latter being innervated by minute fibres from the cephalic sensory nerves (Text-fig. 9, A).

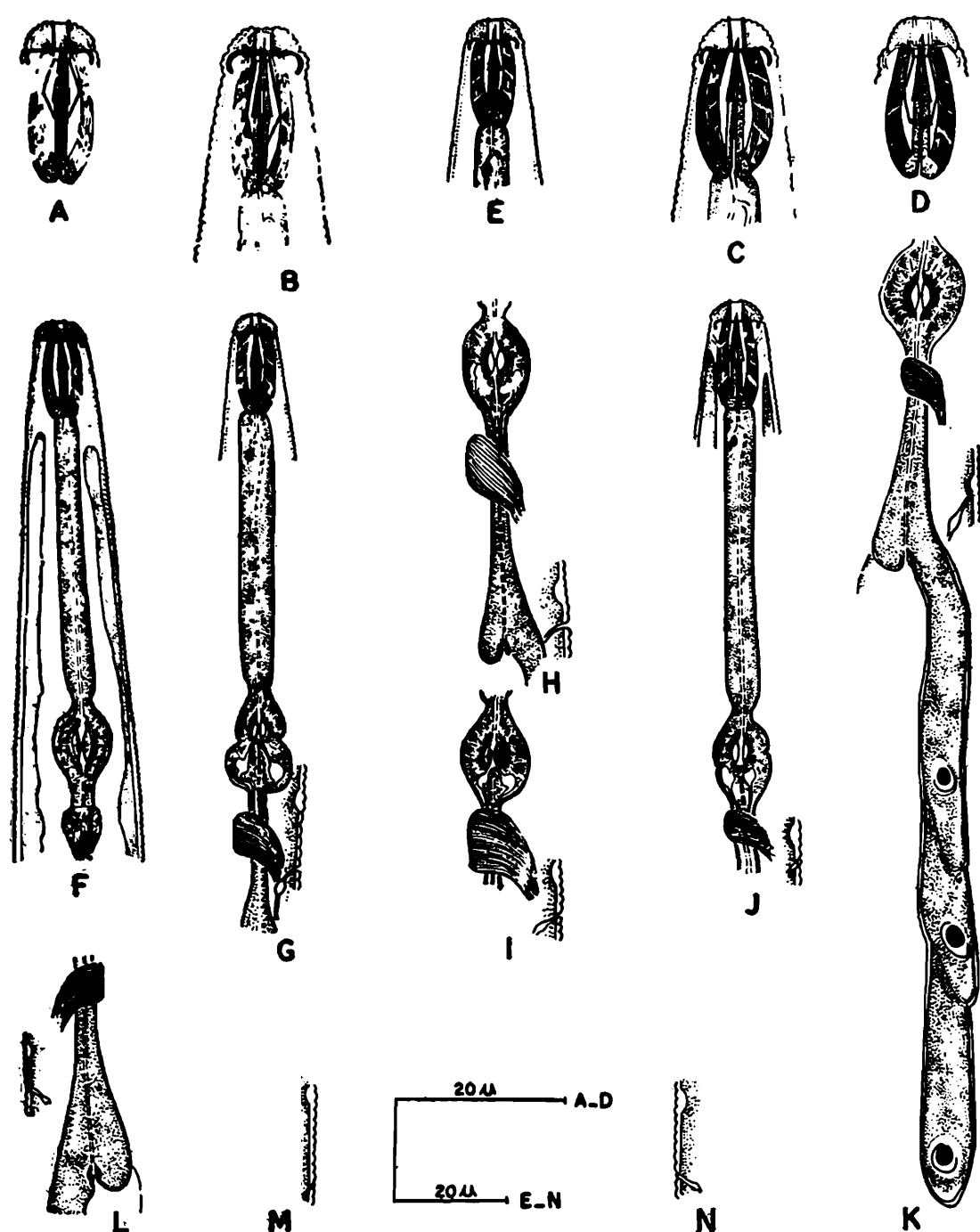
Cephalids (Text-fig. 3, A).—The cephalids are present in the stomal region. The first or the anterior cephalid is situated 2-4 striae behind the basal plate. The second cephalid can be seen at about the level of spear knobs. The cephalids form complete rings around the body of the worm.

Hemizonid.—The hemizonid appears laterally as a cup-shaped structure, highly refractive in nature. It is situated in the vicinity of the excretory pore, usually 2-8 body striae above the former, 2-3 body striae long. The hemizonid is supplied with prominent nerve fibres arising from the nerve ring (Text-fig. 9, A).

Phasmids (Text-fig. 3, F-K).—The phasmids are located on the posterior half of the tail on the lateral sides as refractive pore-like structures. The position of the phasmids is variable and in the same specimens they are not situated at one level. The phasmids are situated in between the median incisures. Sometimes abnormally they are situated below the termination of the incisures but in the centre of the lateral fields.

Hypodermis (Text-fig. 5, F)

The hypodermis is a rather thin, syncytial layer which is thickened at four points to form the longitudinal chords. These thickenings are dorsal, ventral and lateral in position. Towards the anterior



Text-fig. 5. Head ends and oesophageal regions of *H. oryzae*. A. Head end of female, B & C. Head ends of male, D. Head end of female showing head skeleton, E. Head end of female showing opening of dorsal-oesophageal gland in the lumen of procorpus, F. Anterior region of female in dorsoventral view showing lateral hypodermal chords, G-K. Different regions of oesophagus showing oesophageal lumen, valvular apparatus, oesophageal gland lobes, their ampullae and orifices. H-N. Relative positions of Hemizonid and Excretory pore.

and posterior ends of the body these chords are rather poorly defined. Anteriorly they originate just behind the spear base, becoming prominent in the region of median bulb and continue as such up to the

level of anus where these chords become less prominent and finally disappear at the hinder end of the tail. In cross sections of the body (Text-fig. 6, D-L) at different levels, these chords can be clearly seen bulging out in the body cavity (pseudocoel) in the dorsal, ventral and lateral positions of the body. However, the dorsal and ventral chords appear to be slightly different in shape and comparatively more prominent than the laterals. The lateral hypodermal chords posterior to level of excretory pore enclose the lateral excretory canals. These four hypodermal chords divide the visceral cavity though incompletely into four quadrants in which sets of somatic muscles are arranged.

Musculature

(Text-fig. 8, A-G)

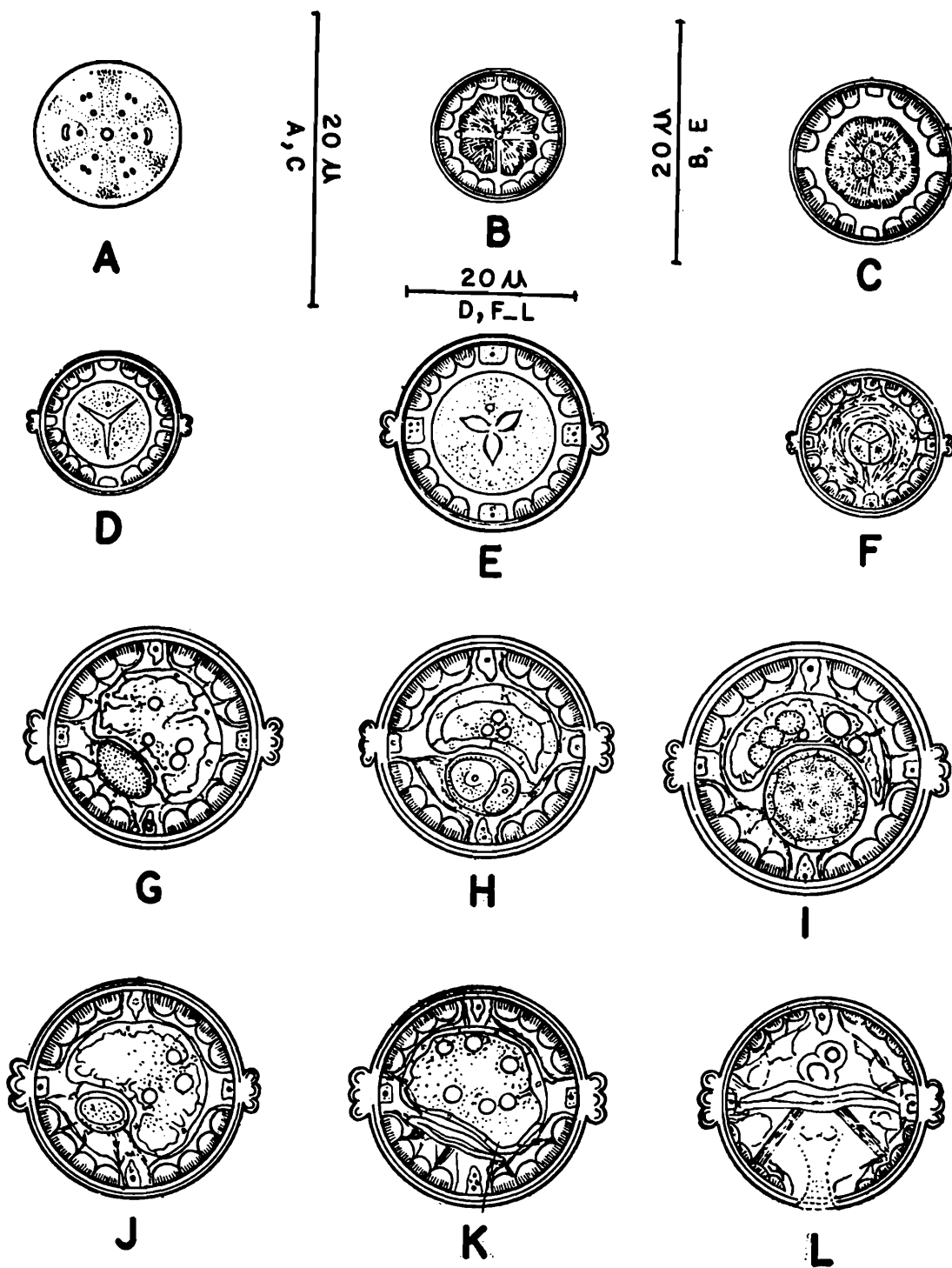
The muscles in the body of the nematodes were studied under two headings : 'Somatic or unspecialised musculature' and 'Specialised musculature'

Somatic or unspecialised musculature (Text-fig. 8, A-C).—Each quadrant of the hypodermis is provided with 4 cells which are flat at the point of their attachment with the hypodermis. Thus the nematodes are typical meromyarian with platymyarian type of somatic musculature. The number of muscle cell was found to be always constant, i.e. 4 cells per quadrant from the region of spear to anus, but normally they are more prominent towards the middle of the body and less towards extremities depending upon the width of the body. The 'thorneian cells' of Sher (1968) could not be detected in this species.

Specialised musculature.—In addition to the somatic muscles there are 'specialised muscles' associated with the various organs of the body to help them in their activities. The various body parts such as spear, oesophagus, intestine spicules, gubernaculum, etc., each having muscles attached to them. In addition, all the openings to the exterior are guarded by specialized type of muscles known as sphincters.

(i) *Spear muscles* (Text-fig. 5, A-D and 6, B and C).—There are four primary sets of muscle bands associated with the spear, but each set is ultimately subdivided. Thus there appear to be 8 muscle bands. They are attached to the base of spear knobs at one end and to the basal plate of the lip region at the other. These muscles serve for the forward and backward movement of the spear. When the nematodes are relaxed by gentle heat these muscles keep the spear in its natural position.

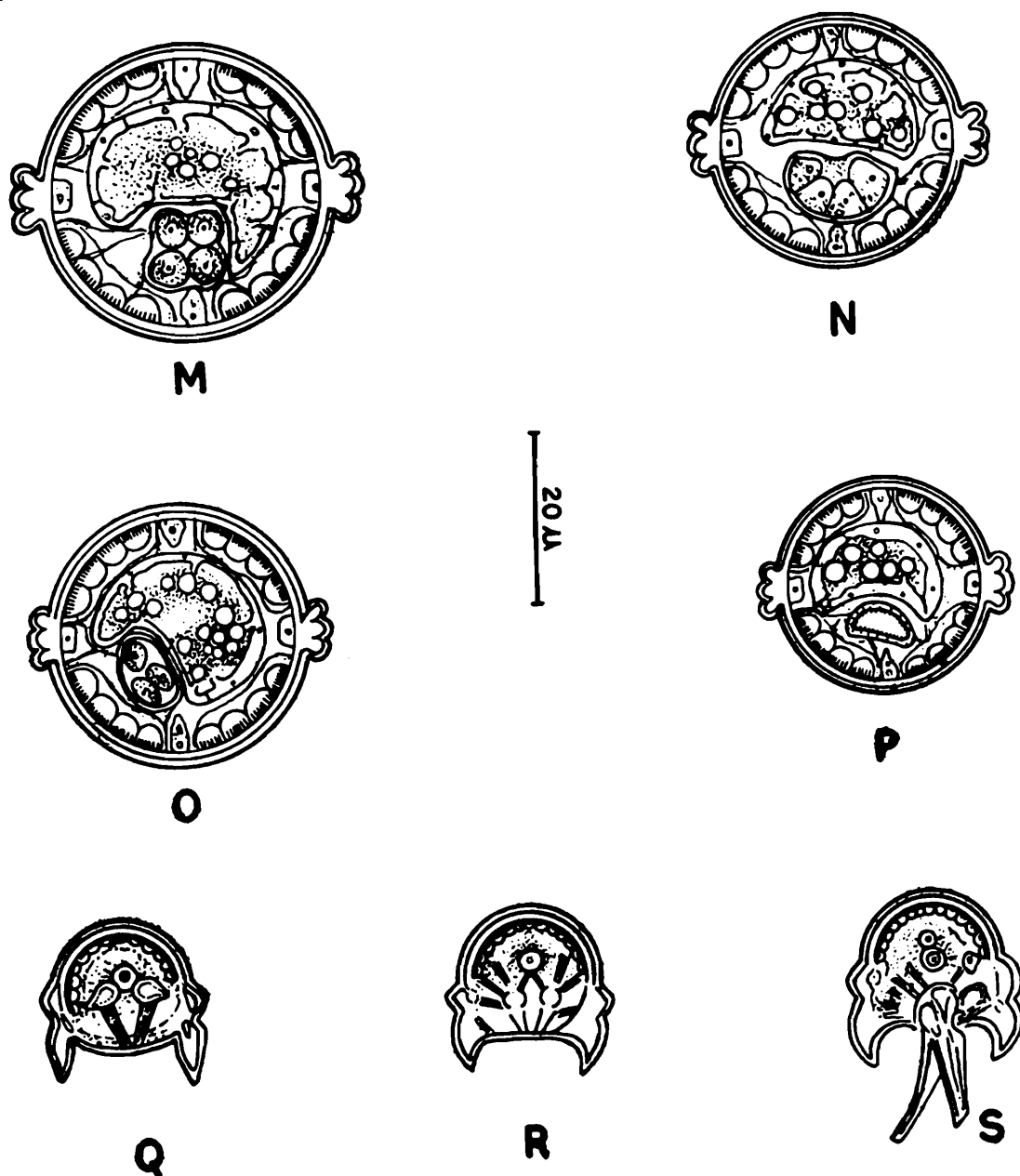
(ii) *Somato-oesophageal muscles*.—Associated with oesophagus. Not very prominent.



Text-fig. 6. Cross-sections of *H. oryzae* at different levels, A. *En face* view, B. Below the basal plate showing spear muscles, C. At level of spear knobs, D. At level of the anterior region of median bulb, E. At level of middle of median bulb, F. Through the isthmus, G. Through dorsal-oesophageal gland lobe, H. Through the ovary, I. Through spermatheca, J. Through the proximal part of the uterus, K. Through the distal part of the uterus, L. At level of anus.

(iii) *Somato-intestinal muscles*.—Associated with intestine. Not very prominent.

(iv) *Vulval muscles*.—There are several sets of muscles associated with the vulva that help in the dilation and contraction of the vulval opening. These are primarily of two types :



Text-fig. 7. Cross-sections of *H. oryzae*, ♂ ♂ at different levels M-O. Through testis, P. Through vas deferens, Q. Through the head of spicules, R. & S. Through the middle of spicules.

(a) *Dilator vulvae* (Text-fig. 8, D-G : 2).—They consist of eight muscle bands, 4 anterior to vulva and 4 posterior. These sets are arranged in 4 pairs — 2 anterior and 2 posterior to vulva. They originate from vulva and run ventro-laterally. These vulval muscles in association with the sphincter muscles control the dilation of vulva.

(b) *Constrictor vulvae* (Text-fig. 8, D-G : 1).—The *constrictor vulvae* consist of four muscle bands. They are attached to the base

of the vagina at one end and to the latero-ventral body wall at the other end.

(v) *Anal muscles* (Text-fig. 8, H : 3).—A single muscle band in the anal region of female extends from the lower margin of the anus to the subdorsal wall of the body. This muscle band is also present in males, but is inconspicuous.

(vi) *Spicular muscles* (Text-fig. 8, I).—There are several sets of muscle bands associated with the spicules of the males to bring about its movements. These muscles are *retractor spiculi* and *protractor spiculi*.

Retractor spiculi ;

(a) *Latero-ventral retractor spiculi* (Text-fig. 8, I : 4).—A pair of muscle bands on each side extends from the head of spicules to the body wall in between the lateroventral somatic muscles.

(b) *Latero-dorsal retractor spiculi* (Text-fig. 8, I : 5).—A pair of muscle bands on each side extends from the head of the spicules to the body wall in between the laterodorsal somatic muscles.

Protractor spiculi ;

(a) *Right and left external protractor spiculi* (Text-fig. 8, I : 6-7).—They extend from the lower margin of the head of spicules, and are inserted in the anterior region on the latero-ventral wall of the tail region.

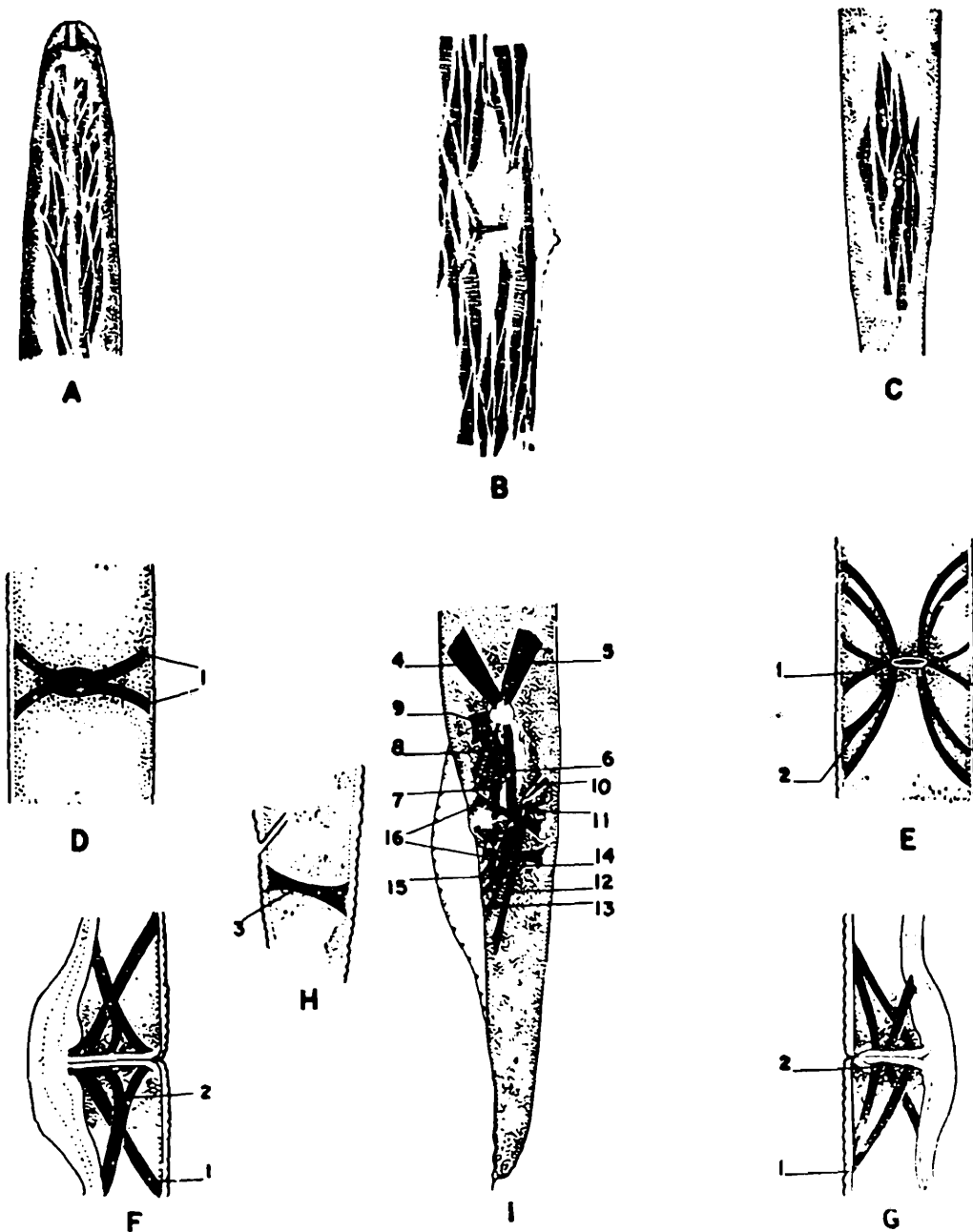
(b) *Internal protractor spiculi* (Text-fig. 8, I : 8).—They are less prominent, extending from the lower part of the head of spicules to ventro-lateral wall of the body.

(c) *Anterior protractor spiculi* (Text-fig. 8, I : 9).—They extend from the posterior side of the head of spicules, and are inserted straight on the lateroventral wall.

(vii) *Gubernacular muscles*.—The muscles associated with the gubernaculum are of following three types :

Retractor gubernaculi (Text-fig. 8, I : 10 and 11).—A set of muscles extending from the distal part of the gubernaculum to the latero-dorsal wall of the body.

Protractor gubernaculi (Text-fig. 8, I : 12 and 13).—They are strongly developed as compared to other muscles associated with the gubernaculum. They extend from the proximal end of the



Text-fig. 8. Musculature of *H. oryzae*, Somatic muscles : A. In the anterior part of body, B. In the vulval region, C. In the anal region ; *Specialized muscles* : D-G. Vulval muscles, H. Anal muscles, I. Male copulatory muscles ; 1. *Constrictor vulvae* ; 2. *Dilator vulvae* ; 3. *Anal muscles* ; 4. *Latero-ventral retractor spiculi* ; 5. *Latero-dorsal retractor spiculi* ; 6. *Right external protractor spiculi* ; 7. *Left external protractor spiculi* ; 8. *Internal protractor spiculi* ; 9. *Anterior protractor spiculi* ; 10. *Right retractor gubernaculi* ; 11. *Left retractor gubernaculi* ; 12. *Right protractor gubernaculi* ; 13. *Left protractor gubernaculi* ; 14. *Right seductor gubernaculi* ; 15. *Left seductor gubernaculi* ; 16. *Copulatory muscles*.

gubernaculum to the subventral body wall and are known as right and left protractor gubernaculi depending upon their position in the body.

Seductor gubernaculi (Text-fig. 8, I : 14 and 15).—These muscles are clearly visible only in the ventro dorsal view, laterally they are obscure. They extend from the proximal end of the gubernaculum to the latero-ventral body wall of the nematode and are known as right and left seductor gubernaculi depending upon their position in the body.

(viii) *Copulatory muscles* (Text-fig. 8, I : 16).—The paired copulatory muscles described by Coomans (1963) in *Rotylenchus goodey* are not distinct in this nematode. However, a band of muscles in the pre-anal region, extending from latero-ventral position of the body wall to laterodorsal body wall is distinct in some of the specimens in addition to post-anal muscle bands. These muscles may be copulatory in function.

Digestive System

The digestive system of the nematode is made up of the following parts :

(i) Stoma, (ii) Procorpus, (iii) Metacarpus, (iv) Basal glandular part of oesophagus, (v) Intestine, (vi) Rectum and (vii) Anus.

Stoma.—The region between the oral aperture and the spear base is termed pharynx, oral cavity, buccal cavity or stoma. This part of the digestive system is connected to the oral aperture which is guarded by six lips and is supported by sclerotized ridges along the six radii which form the head framework. The oral aperture leads into a narrow cavity formed by the union of the inner extremities of the six ridges which provide a passage for the forward and backward movement of the spear. The spear measure 15-19 μ (average 17 μ) in length and is divisible into anterior conical part (metenchium) and posterior cylindrical part (telenchium); the latter is provided with three well developed knobs at its base. The movement of spear is brought about by means of the four paired muscle bands discussed earlier.

Oesophagus.—The oesophagus of the nematode is divisible into an anterior procorpus or precorpus, metacarpus or median bulb, the isthmus, and the glandular lobe overlapping the intestine. The procorpus or the proximal part of the oesophagus is a slender tube narrowing at both the extremities. The lumen of the procorpus is uniform throughout its length. In the anterior part of the lumen of procorpus opens the duct from the dorsal oesophageal gland at 2-3 μ behind the base of the spear. The distal end of procorpus is connected to the median bulb through a narrowing. The median bulb is an ovate muscular organ which has well developed crescentic valvular apparatus. It is situated at 56-85 μ from anterior end of body.

In the specimens stained by modified Cajal's method (Sanwal, 1957), the median bulb shapes differently (Text-fig. 5, F-J). In some specimens, it is pyriform, with a slight constriction in the middle. This shape was evident in the lateral as well as in the dorsoventral position. In all such specimens crescentic valvular plates remain in the anterior half while the ampullae of the two subventral glands occupy the available space (1/3rd of the total space) posteriorly. The ampullae of the subventral glands open just at the base of the crescentic valves.

The isthmus connects the median bulb with the glandular lobe. It is a very narrow tube enveloped at its middle by the nerve ring.

The posterior glandular part of the oesophagus which may also be called as end bulb, is narrow and refractive, forms a long ventral overlap over the intestine, measures 210-350 μ (average 295 μ) in length. It is made up of three oesophageal glands one dorsal, and two subventral in positions. All the three glands are enclosed in a bag of epithelial cells as evident from the cross sections of body in the oesophageal region (Text-fig. 6, G). The glands have a prominent nucleus situated at their hinder end or the lobular part of the oesophageal glands. The dorsal gland is situated in anterior part of the lobe followed by the subventral which occupy the middle and the posterior position. The duct from the dorsal oesophageal gland passes through the isthmus and median bulb into the procorpus where it opens at the base of spear. Before opening into the lumen of the procorpus it forms a prominent ampulla. The two subventral oesophageal glands also form distinct and prominent ampullae before opening in the median bulb at the base of valvular apparatus (Text-fig. 5, G-J).

Intestine.—The oesophago-intestinal junction is guarded by small cells which are refractive in nature. These cells were distinctly visible in those specimens which were specially stained for the study of muscles. The intestinal tube is narrow in the region where it is overlapped by the glandular part of the oesophagus but posteriorly it occupies nearly all the available space. The intestine is supported by somatointestinal muscles in the body cavity. It is pushed to dorsal side in mature specimens in order to accommodate the developing genital organs (Text-fig. 1, A). In the posterior region it gradually narrows to join the rectum.

Rectum.—The rectum is a dorso-ventrally bent tube lined by the cuticle, measuring 16 μ (15-18 μ) in females and 22 μ (19-24 μ) in males, slightly shorter than one anal body-width in females and slightly longer than one anal body-width or cloacal-body-width in males. In males, the rectum opens along with the genital duct into cloaca. The cloaca is also lined by cuticle. The latter communicate outside through cloacal aperture.

Anus.—A circular opening (Text-fig. 4, N) in the posterior region of the body, midventral in position. Through this the alimentary canal communicates with the outside.

Excretory System

(Text-fig. 9, H)

The excretory system comprises the longitudinal excretory ducts, terminal duct and excretory pore. The excretory pore lies on the midventral position of the body at or below the level of nerve ring. The excretory pore is guarded by a sphincter. It leads into a terminal duct, which has a swelling in the anterior region giving it a beak-like appearance. The anterior and posterior extremities of this swelling are also provided with sphincters. The sphincters were seen in the specimens treated with A.F.A. The terminal duct runs posteriorly, after a distance of about 50-60 μ it ends into an ampulla-like structure. The latter also receives the anterior and posterior longitudinal excretory ducts. The presence of a renette cell could not be confirmed with certainty. Sanwal (l.c.) also failed to locate it in *Hirschmanniella gracilis*. The lining of excretory ducts shows refractive spots which may be protoplasmic projections of the epithelial cells lining these ducts.

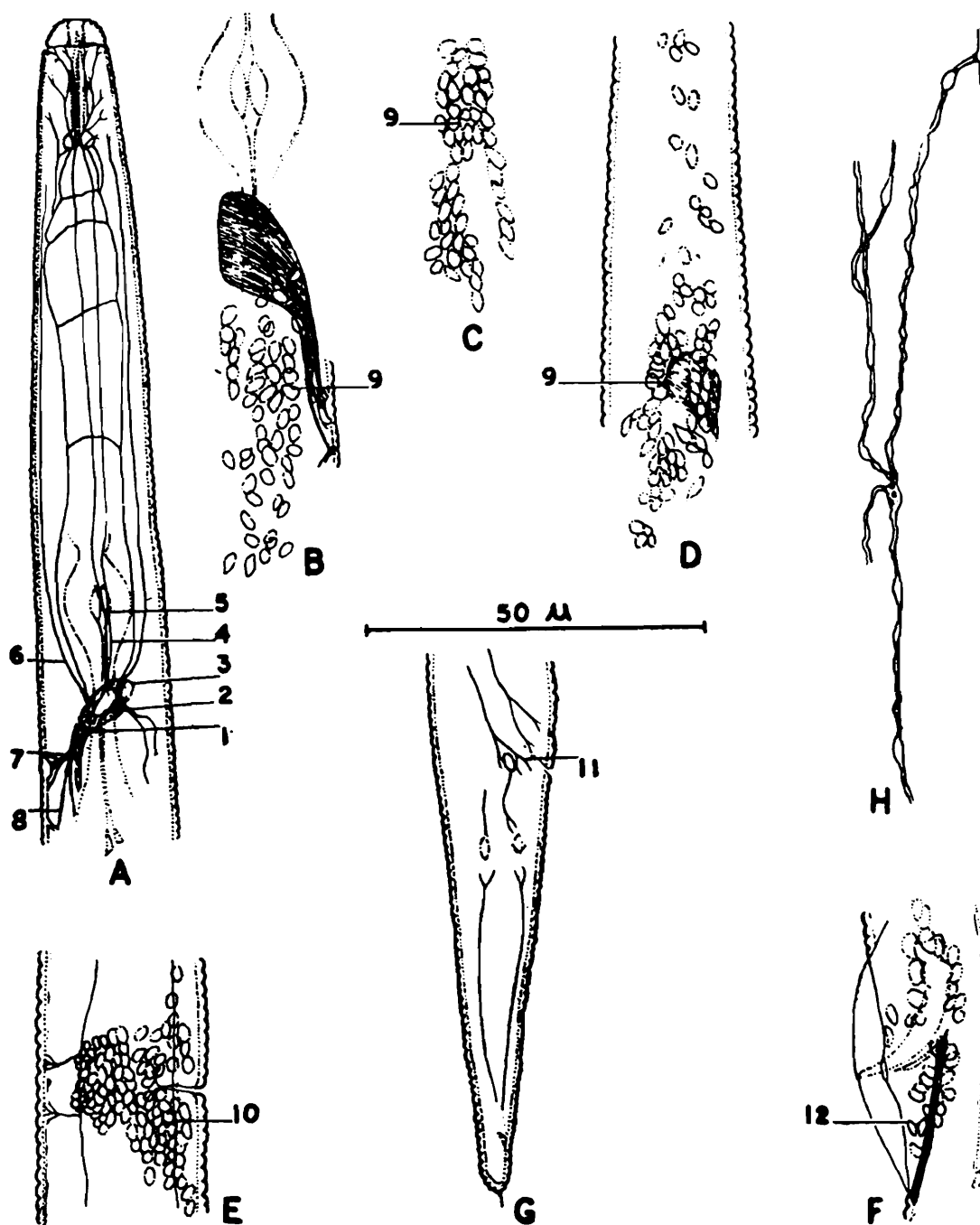
Sanwal (l.c.) was doubtful about the connection of ampulla with the excretory ducts. The present study which is based on a larger number of specimens clearly shows that there is definite connection between the two. The tubular longitudinal excretory canals extend from the ampulla-like structure anteriorly and posteriorly (Text-fig. 9, H). A transverse duct arising out of the ampulla is clearly visible. The anterior canal breaks up into two at about 25-30 μ from the excretory ampulla. These two branches cover up the anterior part of the body running laterally. In some specimens, they could be traced up to the base of spear. On the other hand the posterior duct is visible with distinction only in the pre-vulval region of the freshly stained specimens. The two canals are dilated, at several places throughout their lengths into ampulla-like structures. At these places, they are supposed to receive smaller excretory tubules from different parts of the body. The excretory ducts were also observed in living specimens where they appear smooth.

Nervous System

(Text-fig. 9, A-G)

The nervous system consists of a nerve ring, the ganglia and the nerves. In addition, there are scattered nerve cells which are also associated with this system and are perhaps sensory in function. The nerve ring which is the centre of nervous system is fibrous in

nature. The ganglia (one ventral, one dorsal and two laterals) were visible only in some of the specimens. The nerves arising out of the nerve ring and the associated ganglia are delicate. Two nerves known as cephalic sensory nerves arise out of the dorsal and



Text-fig. 9. Nervous and excretory system of *H. oryzae*, A. Nerve ring complex, B. Nerve ring and associated neuro-sensory cells. C. & D. Nerve ring and associated neuro-sensory cells at different levels, E. Neuro-sensory cells in the vulval region, F. Neuro-sensory cells in the cloacal region, G. Neuro-sensory cells and nerves in the anal region, 1. Nerve ring ; 2. Lateral cephalic ganglion ; 3. Dorsal ganglion ; 4. Lateral cephalic-sensory nerve ; 5. Lateral cephalic-sensory nerve ; 6. Ventral cephalic sensory ; 7. Nerve to hemizonid ; 8. Nerve to excretory pore ; 9-12. Neuro-sensory cells, H. Excretory system.

two ventral ganglia. Two more nerves one to each amphids, originate from the lateral ganglia, the branches of which also supply to the submedian lips. Branches from the nerve ring also supply the hemizonid, and cephalids. The nerve supply to other parts of the body such as excretory pore, digestive and reproductive systems, was observed in some of the specimens, but on the whole they are very faint.

Nerve cells.—A number of nerve cells were found scattered in the body, but they accumulate in the vicinity of nerve ring, vulva and cloaca. According to Sanwal (1957) the number of these cells in *H. gracilis* is definite but in the present material their number as well as distribution is variable.

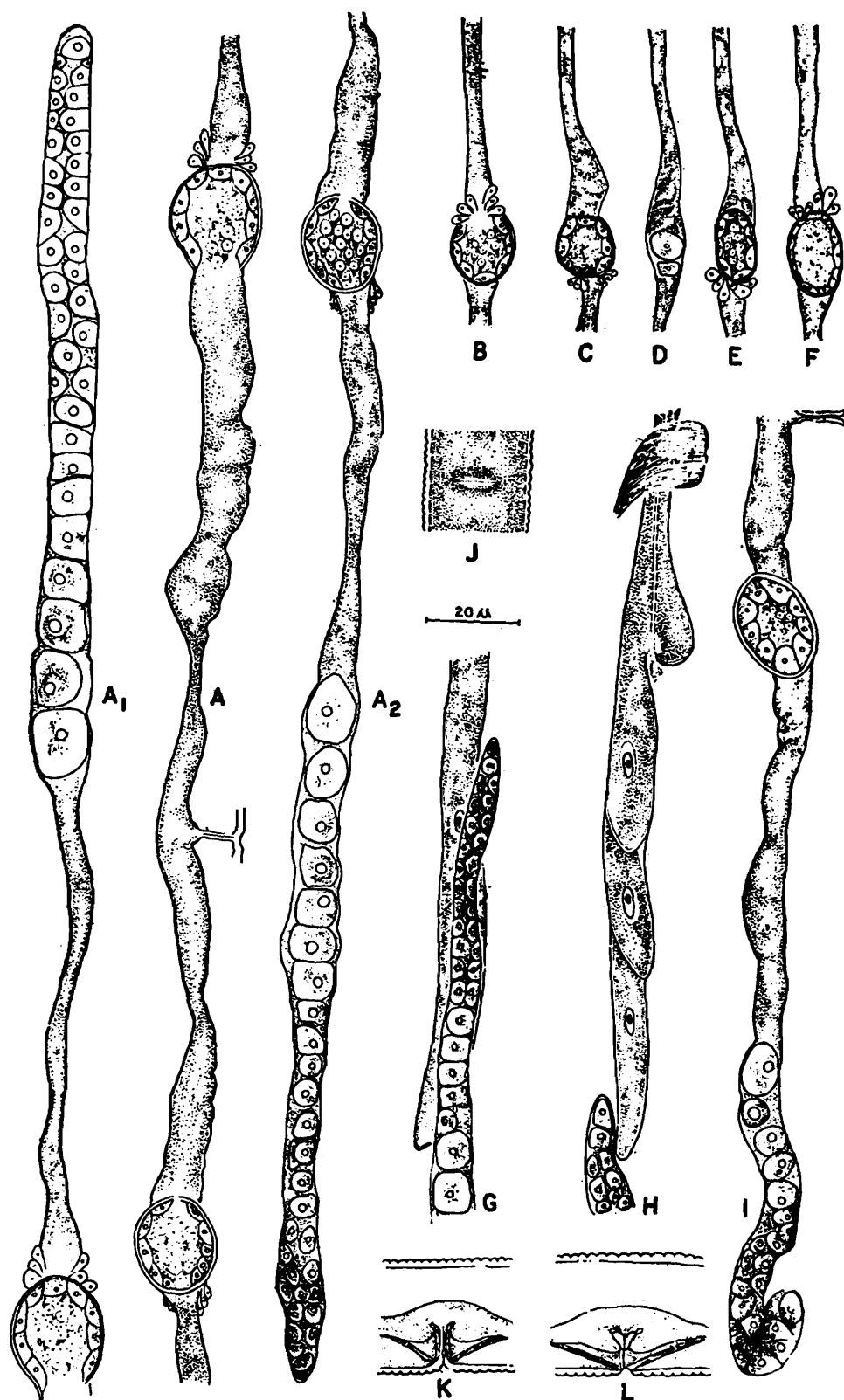
Reproductive System

Sexes are separate, but there is no sexual dimorphism except for the differences in gonads and their associated structures. The males and females are found in ratio of 3 : 7 in the soil as well as in the roots of paddy.

Female reproductive organs.—The female (Text-fig. 10, A-L) gonads are amphidelphic with outstretched ovaries. Each sexual branch consists of an ovary, an oviduct, a spermatheca and a uterus. The total space occupied by the gonads is 46% (40-75%) of the total body length. The anterior and posterior branches measure 285 μ (231-440 μ) and 268 μ (234-416 μ) or 24% (17-43 μ) and 22% (17-41%) respectively of the total body length.

Each sexual branch consists of an ovary which is a long tubular structure lying ventral to the intestine. The oöcytes are arranged in a single row, except in the region of the multiplication. In few specimens, the oöcytes were found arranged uniformly in a single row. The nuclei of the oöcytes are very prominent. The number of oöcytes in each ovary varies from 37-43 (average 39). In some older females there were only 17-18 oöcytes in one ovary.

The ovary leads into an oviduct which is a narrow muscular tube having almost a uniform width throughout its length. The oviducts of anterior and posterior sexual branches measure 87 μ (28-153 μ) and 91 μ (28-191 μ) respectively. The oviduct terminates into a round spermatheca which measures 14-22 $\mu \times$ 7-10 μ . At the junction of oviduct and spermatheca, three pairs of unicellular structure are present. They may be glandular in nature. Their function could not be determined. The shape of spermatheca varies from a simple pouch to a more or less spherical structure (Text-fig. 10, B-F). In some females, it assumes somewhat oval or elongate shape. In the younger



Text-fig. 10. Gonads of *H. oryzae*, ♀ ♀ A. Uterine part ; A₁. Anterior sexual branch ; A₂. Posterior sexual branch ; B. Anterior spermatheca ; C. Posterior spermatheca ; D-F. Developing spermatheca ; G. Abnormally developed ovary reaching the glandular part of oesophagus ; H. Ovary touching the tip of the glandular overlap ; I. Posterior gonad showing a part of ovary reflexed ; J. Vulva (surface view) ; K & L. Vulva (lateral) showing structure of the vagina at two different levels,

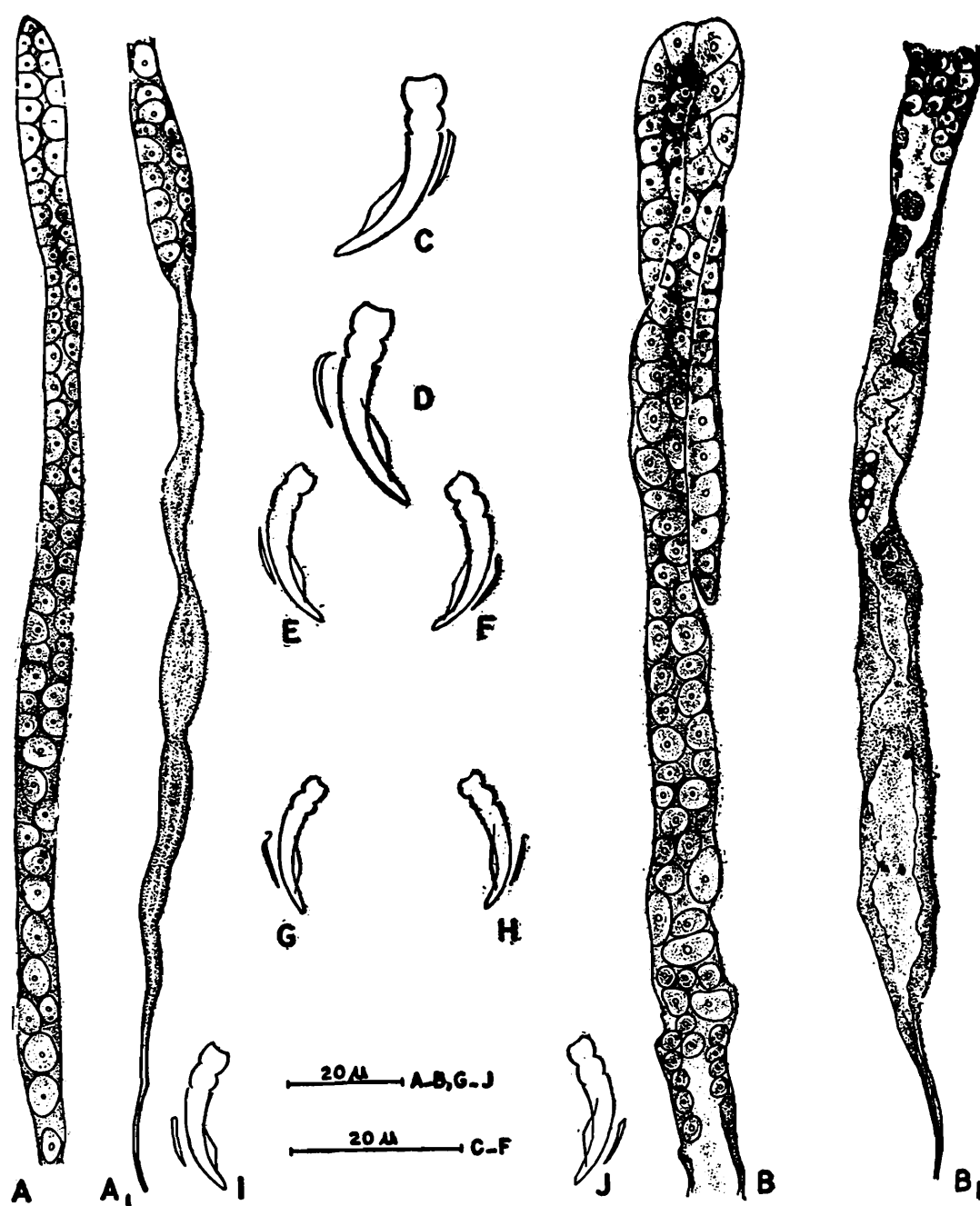
females the spermatheca is inconspicuous in the form of a swelling (Text-fig. 10, D) and assumes a definite shape upon the maturity of the worm. They are usually filled with oval to spherical sperms. The spermatheca lies at the oviduct-uterus junction. The proximal part of the uterus is muscular, while the distal is glandular. The distal part is also known as quadricolumella or 'shell-gland' part. The uterine or proximal part is more conspicuous in appearance than the quadricolumella region due to its having strong muscles which are used for the ejection of the eggs. The total length of the anterior uterus is $90\ \mu$ ($58-197\ \mu$) and of the posterior uterus is $80\ \mu$ ($58-105\ \mu$).

The uteri jointly open into the vagina. The vagina is $10\ \mu$ ($8-12\ \mu$), its walls are lined with cuticle. In lateral view, the vaginal walls show two distinct parts which have been regarded as rods by Sanwal (l.c.). The anterior part is smaller than the posterior one. There are some cells conspicuously visible in lateral view which lie at the vaginauteri junction. The vagina opens outside through a depressed transverse slit-like vulva $7\ \mu$ ($6-8\ \mu$) wide. In some of the specimens, the body wall is slightly raised (protruded) in the region of vulva. The position of the vulva is 53% ($46-67$) of the body length from the anterior end.

In one female, the anterior sexual branch was normal, but the posterior branch had a reflexed ovary (Text-fig. 10, I). In some females (Text-fig. 10, G and H) whose gonads were parasitized by a species of Sporozoa, the sexual branches were extensively developed. Usually the anterior sexual branch ends well below the ventral oesophageal gland lobe but in these specimens it reaches up to the middle of the subventral gland lobe of oesophagus.

Male reproductive organs.—The male gonad (Text-fig. 11, A-J) consists of a testis, a vas deferens, an ejaculatory duct and the copulatory apparatus, and occupies 33% ($30-43$) of the total body length confining itself to the posterior half of the body. The testis is outstretched rarely reflexed (Text-fig. 11, Band B1). The germ cells are arranged in a single file except in the zone of multiplication. The number of germ cells in the testis varies from 49-69 (averaging 59). The testis leads to the vas deferens, which is thin and tubular at the anterior end, and thick and glandular towards the posterior end. The vas deferens (Text-fig. 11, A₁) measures $230\ \mu$ ($156-310\ \mu$) and terminates into a narrow muscular ejaculatory duct which opens to the outside through the cloaca.

The associated copulatory structures are paired spicules, a gubernaculum and the caudal alae. Spicules are identical, each measures $25\ \mu$ ($22-29\ \mu$) medially and consists of a well developed head, a short neck, and a long concave tapering blade with blunt



Text-fig. 11. Gonads of *H. oryzae*, ♂♂ A. Testis ; A₁. Vas deferens and ejaculatory duct ; B. Abnormally reflexed testis ; B₁. Posterior part of the same ; C-J. Spicules and gubernaculum.

tips. There is a distinct membranous structure along the concave margin or the ventral side of the spicules. The gubernaculum is generally trough-shaped, measures 8 μ (7-10 μ) but it shows polymorphism (Text-fig. 11, C-J).

DISCUSSION

The observations on the morphology of *Hirschmanniella oryzae* show many intra-specific variations which are important for the

taxonomic study of the genus *Hirschmanniella* and also have a bearing on the related groups. An evaluation of the diagnostic characters studied in *H. oryzae* is given below :—

The body shape upon fixation in the two sexes varies from an open "C" to almost straight. The body size ranges significantly. This variation may be as much as 0.45 mm from the mean. However, worms with considerable slender or stout bodies are of frequent occurrence thereby altering the value of 'a'

The transverse striae may vary in nature and on any particular part of body may be fine or coarse, but extreme variations are rare. Normally the midbody has striae with greatest inter-strial width. They usually form complete rings on the head region before the appearance of the lateral incisures. The lateral fields interrupt the striae. Areolations are also present. The phenomenon of anastomosis of striae was seen in some specimens.

The number of incisures in the lateral fields was found to be constant, variations occur only in the manner of its termination. They may terminate 5-20 μ from the tip of tail, either above or below the level of phasmids. This is correlated with the fact that the position of phasmids is also variable. Therefore, the relation of phasmids with the termination of lateral incisures is no longer a dependable character for taxonomic purposes and should be used with caution after studying a large number of specimens.

The height and the width of the lip region ('head') are constant features and should be given importance. The shape of head is hemispheroid with or without a flat apex. In the specimens not fixed properly the actual shape of head may change to considerable extent. In order to determine the exact shape of head the specimens should be excellently preserved and neatly mounted. The number of head annules varies little, in the present specimens from 5 to 6 and is a good taxonomic character.

The average length of spear is 17 μ ranging from 15 to 19 μ . The deviations from the average length should be noted carefully. As recently pointed out by Taylor (1969), the spear, being a cuticularised structure, shows very little variations. Sometimes, it becomes rather difficult to see the tip of the spear and thus measure it accurately. This may result in error if proper care is not taken. In poorly fixed specimens, the head becomes a bit twisted and this results in faulty observations on the spear. Usually spear is slender in *H. oryzae* but abnormally it may be thicker in some specimens. The spear knobs are always rounded and slightly sloping. There was hardly any variation in the shape of the spear knobs. Spear,

therefore, should be given considerable importance in the separation of species of *Hirschmanniella* or any other Tylenchida.

The orifice of dorsal oesophageal gland is also quite constant. It varies 1 μ anterior or posterior to its usual position which is negligible. Therefore, the distance, of dorsal oesophageal gland opening from spear base stands out as a dependable character.

The median bulb is always located posterior to middle of oesophagus. The change in position, if considerable, may be important. This could not be found in the present species. The length and width of the median bulb has little value.

The relation of hemizonid with excretory pore is not very significant because the former is found 1-8 striae above the latter. Sometimes, the hemizonid appears double. Therefore, much importance to these two structures cannot be given. The excretory pore is always situated anterior to oesophago-intestinal valve. This relation is very constant and should be given due consideration in the description of the nematode species.

SUMMARY

Morphological studies have been made on *Hirschmanniella oryzae* (Soltwedel). Intra-specific variations, important for the taxonomic study of the genus *Hirschmanniella* and also having a bearing on the related groups, have been observed. Number of incisures, height and width of the lip region, number of head annules, structure and length of spear, distance of the orifice of dorsal oesophageal gland from spear base, situation of the excretory pore in relation to oesophago-intestinal valve are considered constant characters whereas the body shape and diameter, transverse striae, termination of incisures from the tip of the tail and in relation to phasmids, length and width of the median bulb and the relationship of hemizonid with excretory pore are of little significance.

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STUDIES ON THE EARTHWORMS COLLECTED DURING
THE DAPHABUM EXPEDITION IN ARUNACHAL
PRADESH, INDIA

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INTRODUCTION

The Daphabum Scientific Expedition was organised by the Geological Survey of India in November, 1969 — January, 1970 to explore the Lohit District of Arunachal Pradesh. The general topography of the area is of mighty mountains, intersected by large river beds and water courses. The vegetation at lower altitudes consists of tall trees, shrubs, bamboo, cane, wild banana and various kinds of creepers. At higher altitudes, the forest is mostly composed of ferns and rhododendrons. The average annual rainfall is over 300 cm., mainly occurring from April to October. The climate is quite hot in summer with the temperature reaching upto 30°C, and very cold in winter with the temperature varying from 8°C to 17°C and falling below the freezing point at higher elevations during night.

The earthworm fauna of Arunachal Pradesh is not much known, but for a contribution by Stephenson (1914), although the earthworms of neighbouring areas of Burma and Assam have been studied to certain extent by Stephenson (1914, 1923) and Gates (1930, 1931, 1932, 1933, 1936, 1945, 1962). The present article deals with the studies on a part of earthworm fauna collected by the author during the expedition. As a result, twelve species are recorded, of which three species, *Drawida tihunensis*, *Tonoscolex michaelsoni* and *Plutellus mishmiensis* are new to science.

SYSTEMATIC ACCOUNT

Family MONILIGASTRIDAE

*Drawida kemp*i Stephenson

1914. *Drawida kemp*i Stephenson, *Rec. Indian Mus.*, 8 : 376.
1923. *Drawida kemp*i : Stephenson, *Fauna Brit. India, Oligochaeta* : 144.
1934. *Drawida kemp*i : Gates, *Rec. Indian Mus.*, 36 : 238.

Material.—2 ex; Chowkham, alt. 242 m., under the bark of a decaying wooden log; 24.xi.1969. 4 ex; Wakro, alt. 515 m., under

stones on the bank of a stream in the North-West of Dak Bungalow; 3.xii.1969. 3 ex; Tihun, alt. 1260 m; 12.xii.1969.

Remarks.—Ectal end of spermathecal duct enlarged into a spindle-shaped thickening.

***Drawida nepalensis* Michaelsen**

1907. *Drawida nepalensis* Michaelsen, *Mitt. naturh. Mus. Hamb.*, 24 : 146.
 1909. *Drawida burchardi* Michaelsen, *Mem. Indian Mus.*, 1 : 149.
 1916. *Drawida jalpaigurensis* Stephenson, *Rec. Indian Mus.*, 12 : 307.
 1923. *Drawida nepalensis* : Stephenson, *Fauna Brit. India, Oligochaeta* : 146.
 1962. *Drawida nepalensis* : Gates, *Bull. Mus. comp. Zool. Harv.*, 127 : 331.

Material.—3 ex; Chowkham, alt. 242 m., under bark of a decaying wooden log; 24.xi.1969. 4 ex; Chowkham, alt. 242 m., under stones on the bank of Berang river. 2 ex; Gogoi Camp (near Chowkham); 29.xi.1969. 28 ex; Wakro, alt. 515 m., rocky soil in the forest east of Dak Bungalow; 2.xii.1969. 1 ex; Wakro, under stones on the bank of a stream in north-west of Dak Bungalow; 3.xii.1969. 1 ex; Wakro, under stones near hutments, 4.xii.1969.

***Drawida tihunensis* n. sp.**

External characteristics.—Length, 87-135 mm. Diameter, 4-5 mm. Segments 130-134, 85 (Juvenile). Prostomium, prolobous. Pigmentation, unrecognizable (alcoholic preservation). Setae, begin on II, closely paired; on XX, $AA > BC$, $AB = CD$, $DD = 1/2 C$. Nephropores, first present on III, are dorsal to *D* lines in III-VI, but are irregularly located on the posterior segments; in one specimen, they are on *B* lines in X(L), XI, XIII (R), XIV (L), XVI, XIX, XXII, XXV, XXVIII, XXXI, on *D* lines in VII (L), VIII, XII (L), XIV (R), XVII, XX, XXIII, XXVI, XXIX, XXXII, near mD in VII (R), IX, X (R), XII (R), XIII (L), XV, XVIII, XXI, XXIV, XXVII, XXX; in second specimen, they are on *B* lines in X, XI, XIV, XVII, XX, XXIII, XXVI, XXIX, XXXII, on *D* lines in XII, XV, XVIII, XXI, XXIV, XXVII, XXX, near mD in XIII, XVI, XIX, XXII, XXV, XXVIII, XXXI; in the third specimen, on *B* lines in XI, XIII (L), XV (R), XVI (L), XVIII (R), XIX (L), XXI (R), XXII (L), XXIV (R), XXV (L), XXVII (R), XXVIII (L), XXX (R), on *D* lines in VII, VIII, XII, XIII (R), XIV (L), XVI (R), XVII (L), XIX (R), XX (L), XXII (R), XXIII (L), XXV (R), XXVI (L), XXVIII (R), XXIX (L), near mD on IX, X, XIV (R), XV (L), XVII (R), XVIII (L), XX (R), XXI (L), XXIII (R), XXIV (L), XXVI (R), XXVII (L), XXIX (R), XXX (L), Clitellum, not developed.

Spermathecal apertures (secondary) large, transverse slits, at 7/8, near *CD*, pores (primary) minute, on small elliptical papillae

in *C*. Secondary male pores (apertures of copulatory chambers), large, elliptical slits, at 10/11, in *mBC*. An antero-posteriorly compressed papilla slightly protrudes through the secondary male pore. There is a deep depression on the posterior face of the papilla and within this depression is a thin-walled, translucent, tubular penial body, at the tip of which is located a minute male pore. Female pores. minute, on 11/12, close to *B* lines.

Genital markings, median, unpaired, small, circular in outline, presetal on VI-XII or VI-X, XI or IX-XII.

Internal anatomy.—Gizzards, in XIV-XVIII or XV-XIX. Intestinal origin, in XXV. A pair of sac-like structures open into gut in segments XXII and XXIII, each sac-like structure is laterally placed and supplied with a well-developed commissure from the dorsal blood vessel.

Dorsal blood vessel, traceable anteriorly upto IV. Subneural, adherent to parieties, traceable upto VI. Commissures from extra-oesophageals, on the posterior face of 8/9.

Testis sacs, almost entirely in X, with only a slight protuberance in IX, and slightly constricted by 9/10. Vas deferens, slender, closely coiled into a small mass, which is smaller than the testis sac. Vas enters into the parieties at *B* levels and runs a little posterior below the longitudinal muscle layer to open at the anterior end of the prostate. Prostates, muscular, circular in outline, dome-shaped, partially embedded in the parieties.

Spermathecal ampulla, ovoid; duct, muscular, thick, shining and loosely coiled on the posterior face of 7/8, slightly enlarged at its ectal end, which is embedded in the parieties.

Genital marking glands, pear-shaped, muscular, embedded in the parieties, below the nerve cord.

Holotype.—1 ex; Tihun, alt. 1260 m., under stones near a stream; 12.xii.1969; coll. *J M Julka*; Z. S. I. Regd. No. An. 110/1.

Paratypes.—2 ex; Tihun, alt. 1260 m., 13.xii.1969; coll. *J M Julka*; Z. S. I. Regd. No. An. 111/1.

Remarks.—Spermathecal ampullae are distended with white material and ovisacs are empty, extending upto 12/13.

Relationship.—*Drawida tihunensis* is closely related to the *beddardi*-complex, but can be distinguished by the median, unpaired location of the genital markings and the location of the primary male pore.

Desmogaster ferina Gates

1943. *Desmogaster ferina* Gates, *Ohio J. Sci.*, **43** : 91.

Material.—4 ex; Gogoi Camp (near Chowkham), alt. 242 m. under wooden logs; 29.xi.1969.

External characteristics.—Length, 145 mm. 117-120 mm. (amputee posteriorly). Diameter, 7-8 mm. Segments, 342 (218 and 295 in amputees). A deep, presetal secondary furrow present on each of segments V-XI or V-XII or V-XXV. Nephropores of III-X, a little dorsal to *D* lines.

Spermathecal pores, minute, circular, on 8/9, on *C* lines; each pore located in the middle of an eye-like demarcated area. Male pores, small, in 11/12 and 12/13, a little ventral to *C* lines.

Internal anatomy.—Gizzards, in XX-XXV (3 specimens). Dorsal blood vessel, double in front of 5/6. Last pair of hearts, in XI.

Vas deferens, drops ventrally, median to heart and after making a long hair-pin loop upto the base of testis sac, passes under the extra-oesophagael trunk, entering the parieties at *AB* muscular gap. After the removal of a thin muscular layer, the vas has been traced running to the base of antero-posteriorly compressed, erect prostate. It runs upwards along the inner margin of prostate to open at the ental end of the latter. The vas deferens is enclosed in a common sheath of the prostate.

Spermathecal duct, muscular, thick, drops down into 3 or 4 loose coils before entering the posterior face of 8/9 septum, then running diagonally in the muscular layer of the septum, enters the parieties at *CD*.

Remarks.—In one specimen, there is an extra eye-like demarcated area with a minute pore, a little dorsal to the right spermathecal pore. The ovisacs are without any trace of ova.

This species has been recorded earlier only from Burma,

Family MEGASCOLECIDAE

Tonoscolex oneilli (Stephenson)

1914. *Megascolides oneilli* Stephenson, *Rec. Indian Mus.*, **8** : 377.
 1923. *Notoscolex oneilli* : Stephenson, *Fauna Brit. India, Oligochaeta* : 212.
 1934. *Tonoscolex oneilli* : Gates, *Rec. Indian Mus.*, **36** : 254.
 1936. *Tonoscolex oneilli* : Gates, *Rec. Indian Mus.*, **38** : 383.

Materials.—2 ex; Chikrung, alt. 1120 m., under stones; 18.xii.1969.

Remarks.—Length, 185-250 mm. Diameter, 5-7 mm. Segments, 238-306. Setal interval, $AB < CD < BC < AA$, posteriorly, $BC = CD$.

Seminal vesicles of X smaller than those of XI. Prostates, extend through XVII-XVIII. Prostatic duct, muscular, arises from near the anterior end of prostate and after forming two zig-zag loops, runs straight into the parietes under an ovoidal thickening, below the nerve cord. The removal of the muscular layer of the ovoidal body reveals a pear-shaped, sac-like structure, near the ectal end of which, the prostatic duct opens.

Spermathecal ampulla, much shorter than the duct, which is looped, the limbs of the loops are bound together by a tissue.

Abnormality.—The left seminal groove in one specimen is only partially developed.

***Tonoscolex michaelsoni* n. sp.**

External characteristics.—Length, 390 mm., 125 mm. (amputee posteriorly), 158-295 mm. (a clitellate). Diameter, 5-8 mm., 3-6 mm. (a clitellate). Segments, 339, 176 (amputee), 280-390 (a clitellate). Unpigmented, very light-greyish white except on clitellum which is brownish red. Prostomium, proepilobous. First dorsal pore, in 10/11. Segments V-XII, with a deep secondary postsetal furrow, VI-XII, in addition with a deep presetal furrow. Setae, lumbricine throughout the body, begin on II, AB missing on XVII. Setal interval, on pre- and post-clitellar segments, $AB < CD < BC < AA$. Clitellum, XIII—2/3 XVI, inter-segmental furrows distinct, dorsal pores occluded, setae present.

Male genital shield, extends across XVII and posterior part of XVI. Male pores, large, in setal zone, on XVII, in AB , connected by a deep transverse groove, which continues outwards, on either side, a little beyond B and then turns forwards as seminal grooves, extending upto the middle of posterior half of XVI. Seminal grooves, straight, deep. Two transverse furrows, a deep and a shallow, are present anterior to male pores in the space between the seminal grooves.

Spermathecal pores, paired, slit-like, in 6/7, 7/8, just ventral to A lines.

Internal anatomy.—Septa, 6/7—9/10, thickened, 10/11—11/12, slightly thickened. Gizzard, well-developed, elongate, in VI.

Paired calciferous glands, in IX — XII. Intestinal origin, in XIV. Typhlosole, lamelliform, mD, from XV — CCLXXVII, CCIVC.

Meronephric, exonephric, in posterior segments there are in addition enteronephric nephridia on the dorsal side of intestine, a cluster of micronephridia in VI near 5/6.

Dorsal blood vessel, continued anteriorly onto pharyngeal bulb. Supra-oesophageal, unrecognisable anterior to 10/11, in XI turning off laterally to pass into the calciferous glands. Extra-oesophageals, pass posteriorly into calciferous glands of XII. Latero-parietals, recognisable from XVI anteriorly to 12/13, where they move up to pass into calciferous glands of XII. No subneural. Last hearts, in XII.

Holandric. Seminal vesicles, in X, XI, on the posterior faces of 9/10 and 10/11. Prostates, strap-shaped, extending through XVI-XVIII. Prostatic duct, white, muscular with a little shine, forms a loop near its origin, and then runs straight underneath a well-developed, muscular, ovoidal body, in XVII, below the nerve cord.

Spermathecal ampulla, round ; duct, clearly marked off, narrows towards the ectal end, three times as long as ampulla, forming a loop, two limbs of the loop connected by tissue; diverticulum, smaller than ampulla, stalked, club-shaped, on the anterior face at the ectal end of duct.

Holotype.—1 ex; Wakro, alt. 515 m., rocky soil in a forest east of Dak Bunglow; 2.xii.1969; coll. *J M Julka*; Z.S.I. Regd. No. An. 112/1.

Paratypes.—2 ex; Wakro, alt. 515 m., rocky soil in a forest east of Dak Bunglow; 2.xii.1969; coll. *J M Julka*; Z.S.I. Regd. No. An. 113/1. 1 ex; Tihun, alt. 1260 m.; 10.xii.1969 ; coll. *J M. Julka*; Z.S.I. Regd. No. An. 114/1.

Relationship.—*Tonoscolex michaelsoni* is closely related to *Tonoscolex conversus* (Gates) and *Tonoscolex parvus* Gates but can be distinguished by the shape of the genital shield and seminal grooves.

Pheretima diffringens (Baird)

- 1869. *Megascolex diffringens* Baird, *Proc. zool. Soc. Lond.* : 40.
- 1887. *Perichaeta mirabilis* Bourne, *Proc. zool. Soc. Lond.* : 668.
- 1900. *Pheretima mirabilis* : Michaelson, *Das Tierreich*, 10 : 284.
- 1900. *Amyntas heterochaetus* (part) Beddard, *Proc. zool. Soc. Lond.* : 622.
- 1909. *Pheretima heterochaeta* : Michaelson, *Mem. Indian Mus.*, 1 : 110, 189.

1923. *Pheretima heterochaeta* (part) : Stephenson, *Fauna Brit. India, Oligochaeta* : 302.

1937 *Pheretima diffringens* : Gates, *Rec. Indian Mus.*, 39 : 198.

Material.—17 ex; Chowkham, alt. 242 m., under stones; 23.xi.1969. 9 ex; Chowkham, under stones on the bank of Berang river ; 27.xi.1969. 2 ex; Alubari, alt. 242 m., cultivated field; 23.xi.1969. 15 ex; Chakama village, alt. 242 m., under stones on the bank of Berang river; 25.xi.1969. 6 ex; Wakro, alt. 515 m., under stones; 2.xii.1969. 2 ex; Wakro; 3.xii.1969. 26 ex; Wakro; 4.xii.1969. 1 ex; near Chamba village, under stones on the bank of Kamalang river; 6.xii.1969. 23 ex; Hawaii; 9.i.1970. 25 ex; Kharang, under stones; 11.i.1970. 20 ex; Hayuliang; 16.i.1970. 1 ex; Tezu, alt. 275 m.; 20.i.1970.

Remarks.—The variations in the location of the genital markings are recorded in Table 1.

Abnormality.—In a specimen from Chakama village, left heart in XIII, missing ; left spermetheca in IX, absent; an extra male pore on the left side in XVII.

Perionyx excavatus Perrier

1872. *Perionyx excavatus* Perrier, *Nouv. Archs Mus. Hist. nat., Paris*, 8 : 126.

1892. *Perionyx intermedius* Beddard, *Proc. zool. Soc. Lond.* : 689.

1900. *Perionyx excavatus* : Michaelsen, *Das Tierreich*, 10 : 208.

1900. *Perionyx intermedius* : Michaelsen, *Das Tierreich*, 10 : 209.

1916. *Perionyx fulvus* Stephenson, *Rec. Indian Mus.*, 12 : 322.

1916. *Perionyx parvulus* Stephenson, *Rec. Indian Mus.*, 12 : 321.

1923. *Perionyx excavatus* : Stephenson, *Fauna Brit. India, Oligochaeta* : 329.

1923. *Perionyx fulvus* : Stephenson, *Fauna Brit. India, Oligochaeta* : 333.

Material.—14 ex; Chowkham, alt. 242 m., decaying wooden log; 23.xi.1969.

Abnormality.—In one specimen, spermathecal pores are in 8/9, 9/10, and there is an additional pair of male pores in XVII.

Perionyx modestus Stephenson

1922. *Perionyx modestus* Stephenson, *Rec. Indian Mus.*, 24 : 435.

1923. *Perionyx modestus* : Stephenson, *Fauna Brit. India, Oligochaeta* : 344.

1960. *Perionyx modestus* : Gates, *Bull. Mus. comp. Zool. Harv.*, 123 : 231.

Material.—1 ex; Chowkham, alt. 242 m.; 23.xi. 1969.

TABLE 1.—Location of genital markings in *Pheretima diffringens*.

Segment No. on which genital marking is present	No. of specimens
VII	1
VIII	5
VII-VIII	29
VII-VIII. absent on right side of VII	3
VII-VIII. absent on left side of VII	3
VII-VIII. absent on left side of VII, VIII	1
VII-VIII. absent on left side of VIII	1
VIII-IX. absent on right side of VIII	1
VIII-IX. absent on right side of IX	1
VII-IX. absent on right side of VII, left side of IX	1
VII-IX. absent on left side of VII, right side of IX.	1
VII-IX. absent on left side of IX.	6
VII-IX. absent on right side of IX	7
VII-IX. absent on right side of VIII. left side of IX.	1
VII-IX	42
VI-IX.	1
VII-X. absent on right side of X	1
Total :	105

Family ACANTHODRILIDAE¹*Plutellus mishmiensis* n. sp.

External characteristics.—Length, 90-180 mm. Diameter, 3-3.5 mm. Segments, 110-302. Unpigmented (alcoholic preservation). Prostomium, prolobous. Segments, IV-V, with a postsetal secondary furrow, VI-X, with a presetal and a postsetal secondary furrows, VIII-X, in addition with a tertiary furrow in the presetal area. Setae, present from II, on XX, $AB < CD < AA < BC$, $DD = \frac{1}{2} C$, AB missing on XVIII. First dorsal pore, in 9/10, Clitellum, not developed.

Spermathecal pores, minute, unpaired, on mid-ventral line, in 5/6, 6/7, 7/8, 8/9. Male pores, apparently unrecognizable, probably minute, located in a transverse groove, on XVIII, near mid-ventral line. Female pores, minute, transverse, slits, paired, presetal, on A lines.

Internal anatomy.—Septa, 5/6, thin, 6/7—9/10, slightly muscular. Gizzard, well-developed, in V. Oesophagus, in X-XIII, enlarged, much vascular and has slightly lamelliform, interrupted, longitudinal

ridges on its inner wall, in XIV-XVI, narrow tube-like. Intestinal origin, in XVII. An apparent typhlosome, lacking, but there is a slightly raised, wrinkled, ridge in mD. On the ventral wall of intestine, there are high, lamelliform, transverse ridges.

Dorsal blood vessel, continuing anteriorly onto the pharyngeal bulb. Supra-oesophageal and extra-oesophageals, unrecognizable. Subneural, absent. Last hearts, in XIII.

Holonephric; nephridia in anterior segments, on the anterior faces of septa, appear to be astomate.

Holandric. Seminal vesicles, in XI, XII, on posterior faces on 10/11, 11/12, lobulated; lobules small. Vas deferens, almost straight, superficial, opening at the enlarged portion of prostatic duct, in line with muscular gap of *B*. Prostates, long, straight, tubular, extending from XIX-XXX (5 specimens), XXXI (2 specimens), XXXIV (2 specimens), XXXVI (1 specimen), in *CD*. The prostatic duct, not clearly demarcated from prostate, probably in XVIII, running diagonally inwards from 18/19, enlarged and thickened before entering parietes, below nerve cord.

Spermathecae, small in mid-ventral line, below the nerve cord; ampulla, a little elongated; duct, indistinct; diverticulum, club-shaped, slightly stalked, opening at the ectal end of duct, on its anterior face. Penial setae, small, smooth, slightly curved towards the tapering end; tip, bluntly rounded to pointed.

Holotype.—1 ex; Tihun, alt. 1260 m.; 12.xii.1969; coll. *J. M. Julka*; Z.S.I. Regd. No. An. 115/1.

Paratypes.—1 ex; Tihun, alt. 1260 m.; 8.xii.1969; coll. *J. M. Julka*; Z. S. I. Regd. No. An. 116/1. 8 ex; Tihun, alt. 1260 m.; 12.xii.1969; coll. *J. M. Julka*; Z.S.I. Regd. No. An. 117/1. 6 ex; Chikrung, alt. 1120 m.; 18.xii.1969; coll. *J. M. Julka*; Z.S.I. Regd. No. An. 118/1. 2 ex; Tihun, alt. 1260 m.; 10.xii. 1969; coll. *J. M. Julka*; Z.S.I. Regd. No. An. 119/1.

Relationship.—*Plutellus mishmiensis* is closely related to *Plutellus affinis* Stephenson, *Plutellus palniensis* Michaelsen and *Plutellus unicus* (Fletcher), but can be distinguished by the presence of median spermathecal pores in 5/6-8/9 and long prostates.

Family OCTOCHAETIDAE

Dichogaster bolau (Michaelsen)

1891. *Benhamia bolau* Michaelsen. *Mitt. Mus. naturh. Hamb.*, 8 : 307.

1900. *Dichogaster bolaui* : Michaelsen, *Das Tierreich*, **10** : 340.
 1923. *Dichogaster bolaui* : Stephenson, *Fauna Brit. India, Oligochaeta* : 472.

Material.—1 ex; Wakro, alt. 515 m., from a drain and rocky soil; 4.xii.1969.

Dichogaster saliens (Beddard)

1893. *Microdrilus saliens*. Beddard, *Proc. zool. Soc. Lond.* : 683.
 1900. *Dichogaster saliens* : Michaelsen, *Das Tierreich*, **10** : 343.
 1923. *Dichogaster saliens* : Stephenson, *Fauna Brit. India, Oligochaeta* : 478.
 1942. *Dichogaster saliens* : Gates, *Bull. Mus. comp. Zool. Harv.*, **89** : 134.

Material.—3 ex; Chowkham, alt. 242 m.; 23.xi.1969. 57 ex; Wakro, alt. 515 m., from a drain and under stones; 3.xii.1969. 30 ex; Wakro, elephant dung; 4.xii.1970.

Remarks.—A genital marking is present on twenty one specimens, on 15/16. A tail regenerate, in one specimen, at level of segment LXXXVII.

ACKNOWLEDGEMENT

The author is grateful to Dr. A. P. Kapur, Director, Zoological Survey of India for providing an opportunity to participate in the Expedition and facilities for this research. Sincerest thanks are due to Dr. S. Khera, Deputy Director, Zoological Survey of India for his valuable suggestions in the preparation of this paper.

SUMMARY

The present article deals with the systematic studies on the earthworms collected during the Daphabum Expedition in Arunachal Pradesh (formerly North East Frontier Agency). As a result, twelve species are reported, of which three species, *Drawida tihunensis*, *Tonoscolex michaelseni*, and *Plutellus mishmiensis* are new to science. Some interesting morphological variations in *Desmogaster ferina* Gates, *Tonoscolex oneilli* (Stephenson), *Pheretima diffringens* (Baird) and *Dichogaster saliens* (Beddard) are brought to light.

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IMAGO OF THE WOOD-TERMITE *HETEROTERMES GERTRUDAE* ROONWAL (RHINOTERMITIDAE : HETEROTERMITINAE) FROM NORTH-WEST HIMALAYAS

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(with 3 Text-figures and 2 Tables)

INTRODUCTION

The termite *Heterotermes gertrudae* Roonwal (Rhinotermitidae, Heterotermitinae) was described from the North-Western Himalayas (Almora, Almora District, Uttar Pradesh) on the basis of soldiers and workers only (Roonwal, 1953). Nothing further is known about it (*vide* Roonwal, 1970a).

Recently a valuable collection of imagoes, with associated soldiers and workers, became available to us, and the hitherto unknown imago is described here. The body-measurements, etc. were taken as defined in Roonwal (1970b). The affinities of the species are also discussed.

ACKNOWLEDGEMENTS

Our thanks are due to the collector, Dr. Ganpat S. Roonwal of the Department of Geology, Delhi University, for placing the material at our disposal; and to the Council of Scientific and Industrial Research, New Delhi, for financial assistance.

IMAGO OF *HETEROTERMES*
GERTRUDAE ROONWAL

(Text-figs. 1 and 2; and Table 1)

1953. *Heterotermes gertrudae* Roonwal, *Indian J. Ent.* New Delhi, **15** (2) : 115-118. Soldier and worker. *Type-locality* : Almora (Uttar Pradesh, India). 5500 ft.

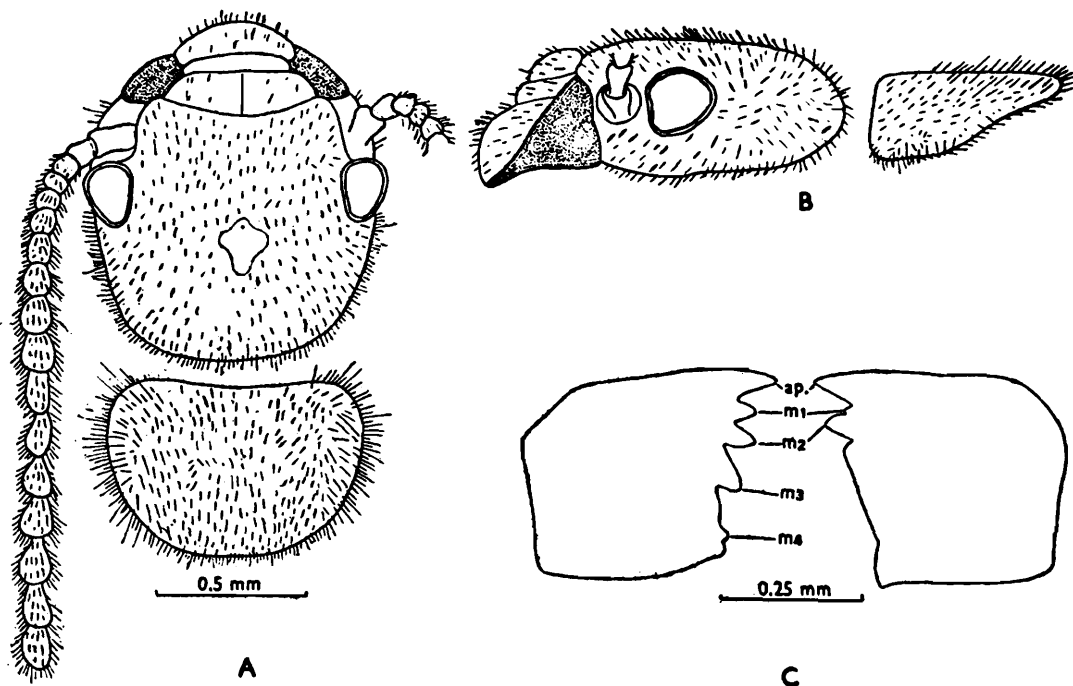
* Emeritus Scientist (C.S.I.R.).

⁺ Junior Research Fellow (C.S.I.R.).

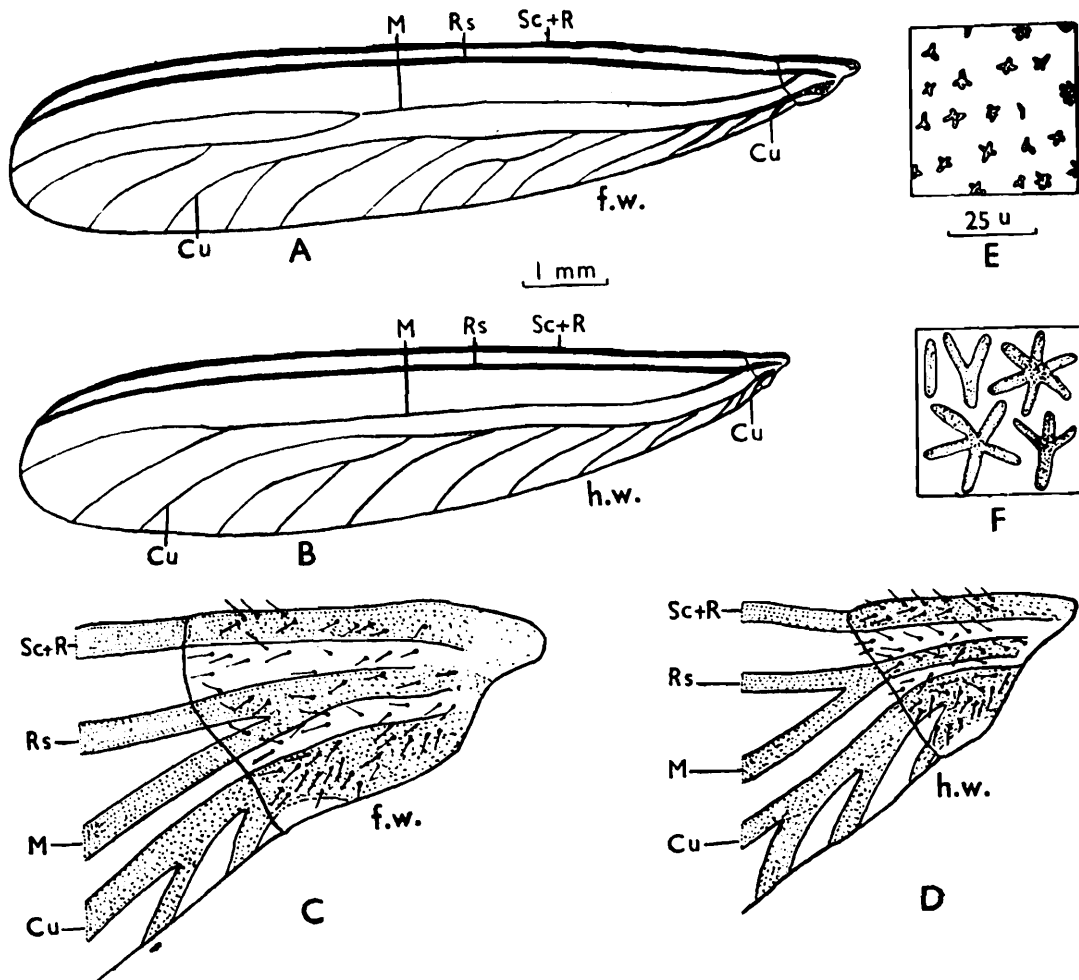
Material.—One tube, with several imagoes (alates) and associated soldiers, workers and nymphs, Melha (alt. ca. 1500 m. above M. S. L., approximate lat. $32^{\circ}40'$ N., long. $76^{\circ}05'$ E) on bank of R. Ravi (Chamba District, Himachal Pradesh, India), G. S. Roonwal coll., 26 May 1970, ex wooden beam in roof of a house. (Deposited with the Zoological Survey of India, Calcutta.)

IMAGO : Hitherto unknown, and is described below.

Head and body yellowish brown dorsally, paler ventrally; antennae and legs paler; fairly thickly pilose, with short to longish hairs. Total length with wings 10.0-11.5, without wings 5.5-5.8 mm. Head-capsule subround, slightly narrowing posteriorly; sides straight, posterior margin convex. Y-suture not visible. Fontenelle minute, rounded, situated in middle of head-dorsum. Eyes blackish, rather small, subround, slightly elongated ventrally; not greatly projecting from head; situated close to antennal base; minimum eye-antennal distance 0.027 mm. Ocelli absent. Antennae 17-segmented, moderately pilose; segment 1 longest; 2 about half of 1; 3 slightly smaller than 2; 4 smallest; 5 to the penultimate one gradually increasing in length in that order. Labrum subrectangular, almost twice as wide as long, and with a few short hairs distally. Anteclypeus band-like, hyaline, apilose. Postclypeus swollen, with a few hairs; divided into right and left halves by a faint median line. Mandibles pale yellowish



Text-fig. 1. *Heterotermes gertrudae* Roonwal. Imago (♀). Melha (Chamba District, Himachal Pradesh). (A) Head and pronotum, in dorsal view. (B) Ditto, in side view. (C) Mandibles, in dorsal view. ap. apical tooth; $m_1 - m_4$, first to fourth marginal teeth,



Text-fig. 2. *Heterotermes gertrudae* Roonwal. Imago (♀). Melha (Chamba District, Himachal Pradesh). (A) Left fore-wing. (B) Left hind-wing. (C) Base of left fore-wing, enlarged. (D) Ditto, hind-wing, enlarged. (E) Some micrasters on fore-wing membrane, in natural position. (F) Ditto, enlarged and re-arranged.

Cu 1-11, cubitus veins 1-11; *f.w.*, fore-wing; *h.w.*, hind-wing; *M*, media; *R*, radius; *Rs*, radial sector; *Sc*, subcosta.

with blackish margins. Left mandible with an apical and 4 marginal teeth; apical large and prominent; marginal 1 smaller than apical; 2 larger than and close to 1; 3 somewhat smaller than 2, separated from the latter by a wide margin; 4 very small, blunt and widely separated from 3. Right mandible with an apical and two marginal teeth; apical large and pointed; marginal 1 very small, and just above 2, the latter large and prominent. Pronotum shield-like, wider than long, with anterior corners rounded and sides convex; anterior margin concave, posterior margin convex, both margins without median notch. Meso- and metanota subequal, smaller than pronotum; both with posterior margins convex and without median notch. Legs rather short, moderately hairy. Tarsi with 4 segments, the last one terminating in a pair of claws; arolium absent. Apical tibial spur formula 3 : 2 : 2.

Wings almost colourless and translucent; membrane with a few small hairs all over, specially on the veins; entire membrane sculptured with numerous tiny 'micrasters', each with one to six arms. Length (without scale) of forewing *ca.* 8.0-9.0, of hindwing *ca.* 7.5-8.5 mm.; veins, specially the anterior ones, pale brown. Forewing with a well chitinised vein (subcosta + radius) running all along anterior margin;

TABLE 1.—*Heterotermes gertrudae* Roonwal. Body-measurements (in mm.). etc. of imagoes (Melha, Chamba District, Himachal Pradesh)

Body-parts	Range (mm.) (5 exs.)
1. Total length (with wings)	10.0 -11.5
2. Total length (without wings)	5.5 - 5.8
3. Length of head with mandibles	1.16 - 1.21
4. Length of head to lateral base of mandibles	0.89 - 0.95
5. Max. width of head (with eyes)	0.89 - 0.95
6. Max. height of head	0.53 - 0.58
7. Max. length of labrum	0.16
8. Max. width of labrum	0.32 - 0.37
9. Max. diameter of eyes	0.23
10. Min. diameter of eyes	0.18 - 0.20
11. Max. length of pronotum	0.47 - 0.53
12. Max. width of pronotum	0.84 - 0.89
13. Max. length of mesonotum	0.42
14. Max. width of mesonotum	0.79
15. Max. length of metanotum	0.42
16. Max. width of metanotum	0.79
17. Length of fore-wing without scale	8.0 - 9.0
18. Length of hind-wing without scale	7.5 - 8.5

radial sector running parallel to the previous one to the tip of wing. Remaining veins rather faintly marked; media arising from radial sector inside wing-scale, with 3 branches in distal half. Cubitus arising independently inside wing-scale, with about 11 branches to posterior margin of wing. Hindwing veins as in forewing, but media arising from radial sector just outside wing-scale, running across wing and giving 2 branches distally. Abdomen thickly hairy with moderately long hairs all over. Cerci short, 2-segmented, *ca.* 0.14 mm. long. Styli very small, 2-segmented, *ca.* 0.09 mm. long.

DISCUSSION

1. Affinities

The soldiers from the Chamba District agree well with the type material from Almora, U.P., in all respects (Table 2). The workers of the two lots also agree except that the Chamba ones are slightly

smaller (total length 4.5-5.2 *vs.* 5-6 mm.; and head-length to tip of labrum 1.16-1.26 *vs.* 1.25-1.35 mm.).

Like the soldier, the imago also is close to *H. philippinensis* (Light) of the Philippines but is distinctly larger, as follows :—Total length, with wings 10.0-11.5 mm. (*vs.* 9-10 in *philippinensis*), without wings

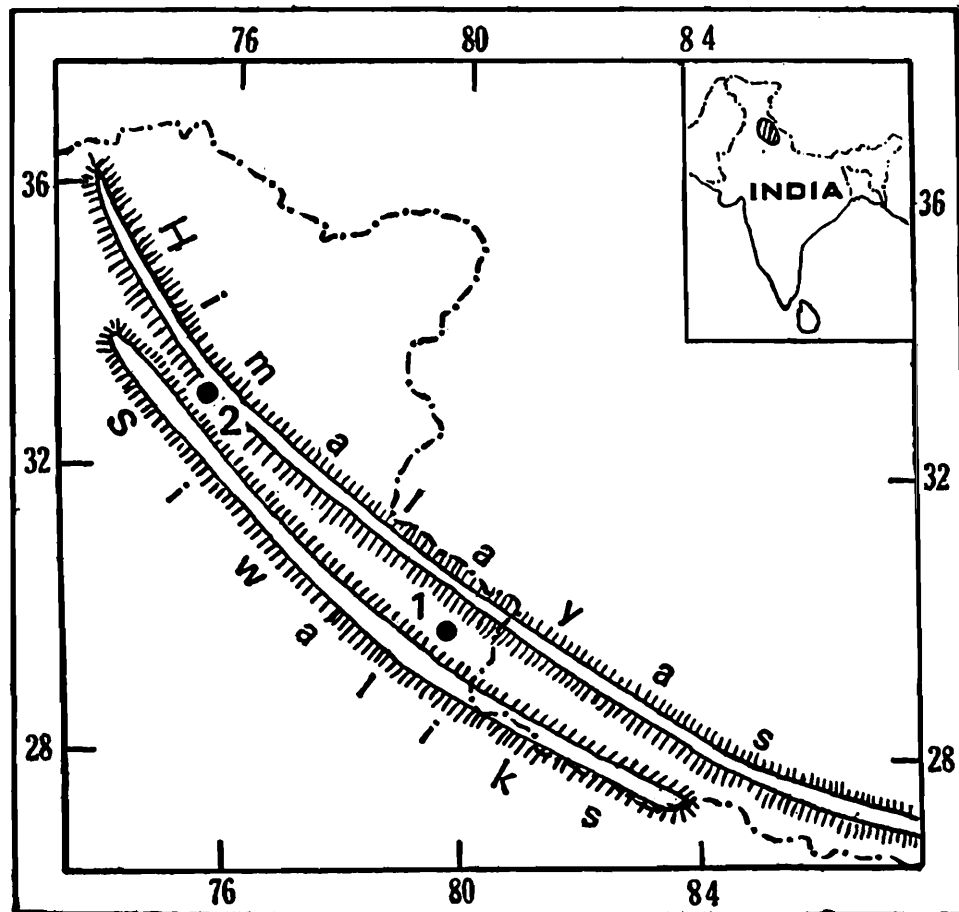
TABLE 2.—*Heterotermes gertrudae* Roonwal. Body-measurements (in mm.), etc. of soldiers.

Body-parts	Melha, (Chamba Dist., Himachal Pradesh) (3 exs.)	Almora (Uttar Pradesh) (From Roonwal, 1953, (6-8 exs.)	Range for species
1. Total length, with mandibles	4.9-5.2	—	4.9-5.2
2. Length of head with mandibles	2.47-2.63	2.18-2.70	2.18-2.70
3. Length of head to lateral base of mandibles	1.63-1.74	1.50-1.78	1.50-1.78
4. Max. width of head	1.00-1.05	0.98-1.05	0.98-1.05
5. Max. height of head	0.84	0.83-0.98	0.83-0.98
6. Max. width of labrum	0.21	—	0.21
7. Max. length of labrum	0.42-0.47	—	0.42-0.47
8. Max. length of right mandible	1.00	0.90-1.00	0.90-1.00
9. Max. length of left mandible	1.00	0.90-1.05	0.90-1.05
10. Min. (median) length of postmentum	1.26-1.32	1.13-1.50	1.13-1.50
11. Min. width of postmentum	0.16	0.13-0.19	0.13-0.19
12. Max. width of postmentum	0.42-0.47	0.30-0.38	0.30-0.47
13. No. of antennal segments	15	12-17 (mostly 14-16)	12-17 (mostly 15)
14. Max. length of pronotum	0.47-0.53	0.53-0.75	0.47-0.75
15. Max. width of pronotum	0.79-0.84	0.83-0.90	0.79-0.90

5.5-5.8 mm. (*vs.* 3.5-4.0); maximum head-width 0.89-0.95 mm. (*vs.* 0.86); length of forewing without scale 8.0-9.0 mm. (*vs.* 7.8 mm). The pronotum also differs in the anterior margin having no median depression (*vs.* with a depression).

2. Distribution

The species is confined to the North-West Himalayas (Text-fig. 3) at about 1500-1600 m. altitude, having been found so far in Uttar Pradesh (Almora District) and Himachal Pradesh (Chamba District). It attacks wood-work in houses.



Text-fig. 3. Map of NW India, showing the distribution of *Heterotermes gertrudae* Roonwal. (Inset : India ; shaded area is range of *H. gertrudae*). 1, Almora (Almora District, Uttar Pradesh). 2, Melha (Chamba District, Himachal Pradesh).

SUMMARY

The hitherto unknown imago of *Heterotermes gertrudae* Roonwal, originally described from soldiers and workers only (Roonwal, 1953), is described here, from material consisting of winged imagoes with associated soldiers and workers from the Chamba District, Himachal Pradesh.

The affinities, as determined on the basis of all the castes, place the species close to *Heterotermes philippinensis* (Light), of the Philippines, from which, however, it differs in being larger (*gertrudae* is, in fact, the largest among the oriental species), and in some other respects.

The species is confined to the North-West Himalayas (Chamba District, Himachal Pradesh, and Almora District, Uttar Pradesh) at ca. 1400-1500 m. altitude. It attacks wood-work in houses.

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THE COPULATORY COMPLEX OF *MEGALESTES MAJOR*
SELYS (COENAGRIIDAE : ZYGOPTERA)

By

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(With 2 Text-figures)

The present paper deals with the structure of the copulatory complex of *Megalestes major* Selys.

Like other Zygoptera, *Megalestes major* Selys bears two sets of copulatory or mating apparatuses, the first set, which is primary in nature, is situated on the venter of the ninth and tenth abdominal segments, while the second set, regarded as secondary complex, is located ventrally on the entire second and the apical part of the third abdominal segments.

The first set of the copulatory complex is used for holding the female during copulation, while the second set is used in actual coition.

Primary Copulatory complex

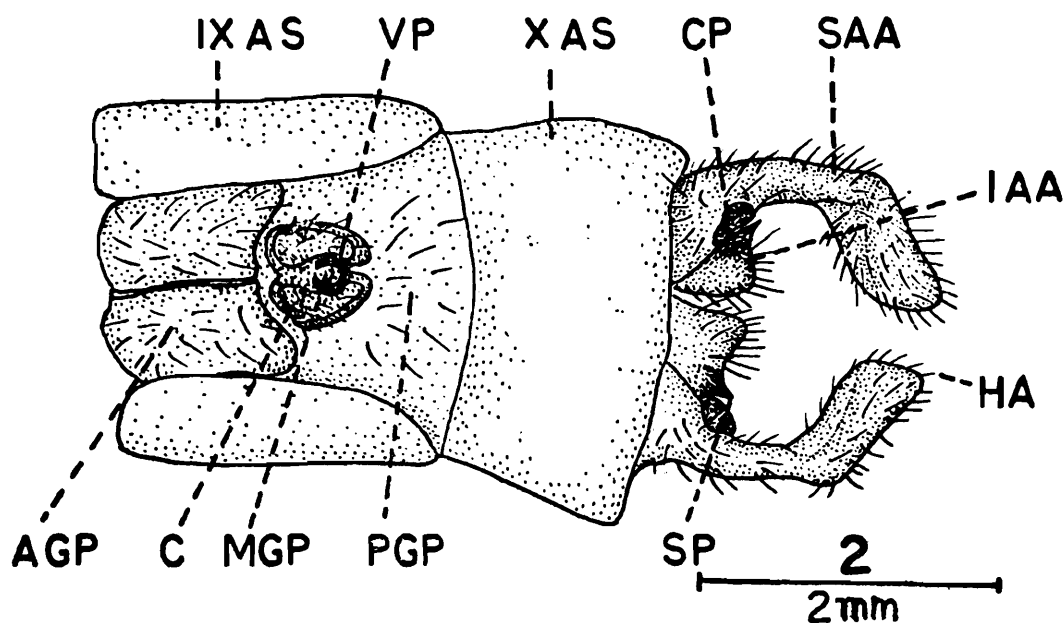
(Text-fig. 2)

The primary copulatory complex consists of a median vestigial or primitive penis (VP), a pair of reduced appendages or gonocoxites (C) (= gonapophyses, Fraser, 1956 in Tuxen's glossary of genitalia in insects; gonopods, Snodgrass, 1935; coxites, George, 1928; valvules, Whedon, 1918), a pair of infra-anal appendages (IAA) (= cerci, Fraser, 1956 in Tuxen's glossary of genitalia in insects; epiproct, Snodgrass, 1935), and a pair of Supra-anal appendages (SAA) (= cerci, Snodgrass, 1935).

(i) *The vestigial penis* (VP).—The vestigial penis is represented by a reduced sclerite situated almost in the middle of the ventral surface of ninth abdominal segment (IX AS). The vestigial penis has an elongated opening, the male gonopore (MGP) (= genital meatus, Fraser, 1956 in Tuxen's glossary of genitalia in insects).

(ii) *The coxites* (C).—The male gonopore (MGP) and the vestigial penis (VP) are guarded laterally by a pair of reduced, oval appendages

or gonocoxites. The portions of the ninth sternum lying anterior and posterior to the male gonopore are modified to form the anterior and posterior genital plates (AGP), (PGP), respectively. The anterior genital plate (AGP) is comparatively longer than the posterior genital plate. Both the genital plates are furnished with hairs.



Text-fig. 2. Ventral view of the primary copulatory complex of *M. major* Selys.

AGP — Anterior genital plate ; AH — Anterior hamule ; AL — Anterior lamina ; APSF — Anterior portion of supporting framework ; AR — Arm ; AS — Abdominal segment ; C — Coxite ; CP — Conical process ; FL — Flagellum ; GLA — Glans ; GR — Groove ; HA — Hair ; HB — Horizontal bar ; IAA — Infra-anal appendage ; IB — Inner border ; IP — Inner plate ; LAB — Lamina-batilliformis ; LB — Lateral bar ; LI — Lip ; LP — Laminar process ; MGP — Male gonopore ; N — Notch ; OB — Outer border ; OP — Outer plate ; PGP — Posterior genital plate ; PH — Posterior hamule ; PPSF — Posterior portion of supporting framework ; PV — Penis vesicle ; SAA — Supra-anal appendage ; SP — Spine ; ST — Sternum ; STI — Stigma ; VP — Vestigial penis.

(iii) *The supra-anal appendages (SAA).*—The supra-anal appendages arise from the terminal end of the tenth abdominal segment (X AS). They are well demarcated, forcepate, with broad, rounded, incurved apices. Each supra-anal appendage bears a short conical process (CP) on the inner and lateral side near the base, and is heavily covered with hairs.

(iv) *The infra-anal appendages (IAA).*—The infra-anal appendages (IAA) also arise from the terminal end of the tenth abdominal segment, lying ventral to supra-anal appendages and lateral to the anus. They are very much reduced and somewhat conical structures, with broad bases, and bear spines (SP) on the outer and lateral sides.

Secondary Copulatory complex

(Text-fig. 1)

The secondary copulatory complex consists of the genital fossa (= fenestra, Fraser, 1956 in Tuxen's glossary of genitalia in insects), the anterior lamina (AL), the lamina-batilliformis (LAB), the posterior lamina, the chitinous supporting framework, the hamules, the penis Vesicle (PV) (=vesicula spermalis, Fraser, 1956 in Tuxen's glossary of genitalia in insects ; sperm receptacle, Snodgrass, 1935), the penis (= prophallus, Fraser, 1956 in Tuxen's glossary of genitalia in insects ; intromittent organ, Snodgrass, 1935).

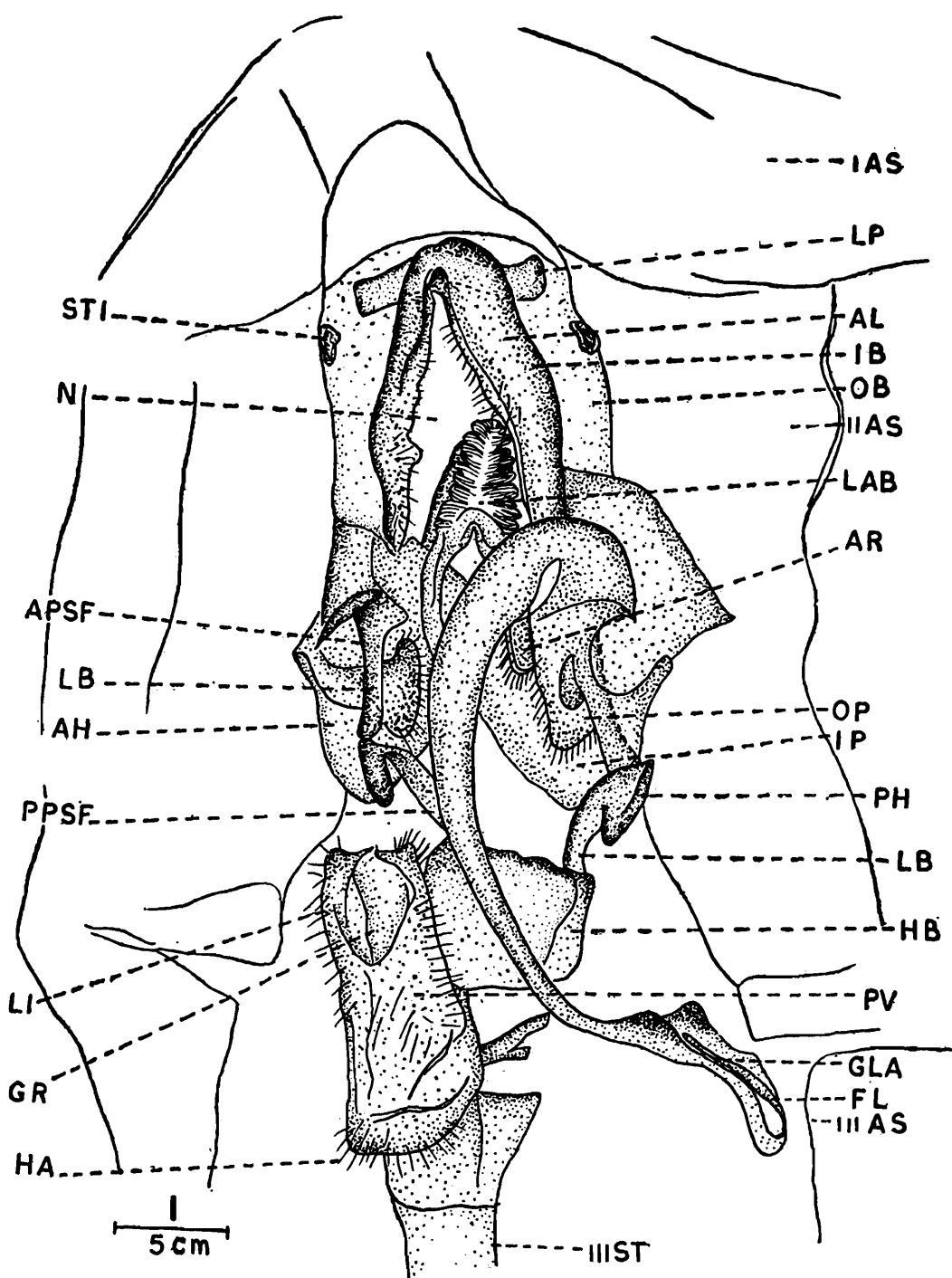
(i) *The genital fossa*.—The genital fossa is a median, shallow and membranous depression on the entire second and apical part of third sternum. It is supported by three sclerites. Anteriorly it is supported by the anterior lamina (AL) and lamina-batilliformis (LAB), posteriorly by a posterior lamina and laterally by a chitinous framework of sclerites. All the structures of the secondary complex are placed inside the fossa.

(ii) *The anterior lamina (AL)*.—The anterior lamina is a chitinous, hood-like sclerite occupying the front part of the second venter and extending between the two ventral margins of the second tergum.

The anterior lamina is somewhat inverted V-shaped, plate, with a convex anterior margin having thick laminar processes (LP). At its posterior margin it is deeply cleft to form a prominent notch. The notch encloses the proximal portion of the penis. The anterior lamina has two prominent borders, the inner border (IB) and the outer border (OB). The outer border is broader than the inner border.

(iii) *The lamina-batilliformis (LAB)*.—It is forceps-like chitinous structure, lying inside the notch, between the two arms of the anterior lamina. According to Thompson (1908), the lamina-batilliformis may be regarded as penis sheath in *Zygoptera*, because it lies exactly in the same position as the penis sheath in *Anisoptera*, and it also covers the proximal portion of the penis. The lamina-batilliformis (LAB) bears a spiny apex, and short, thick and slightly curved arms (AR).

(iv) *The supporting framework (APSF, PPSF)*.—The genital fossa is strengthened and supported by a number of chitinous rods, which together make the complicated net-work of chitinous rods, the supporting framework. The supporting framework supports the various parts of the copulatory complex and also provides the various surfaces or facets for the articulation of the copulatory organs with each other.



Text-fig. 1. Ventral view of the secondary copulatory complex with penis of *Megalestes major* Selys.

(For explanation of legend see page 250)

It is divisible into two portions, the anterior portion (APSF) and the posterior portion (PPSF). The anterior portion of the supporting framework is an inverted V-shaped structure with two long rod-like lateral bars (LB). The posterior portion of the supporting framework is comparatively well developed and U-shaped structure, with short and curved lateral bars (LB), and broad, flat, rectangular horizontal bar (HB).

(v) *The hamules* (AII, PH).—The hamules are chitinous and robust structures. Behind the anterior lamina (AL) and articulated with the framework, there are two pairs of hamules.

The anterior pair of hamules are enormously developed, having four prominent plates ; out of the four plates, the two are inner plates (IP) and two are outer plates (OP). The outer plates of the anterior hamules are shorter than the inner plates. The posterior pair of hamules (PH) are reduced to papillae, and located at the junction of the anterior and posterior portions of the supporting framework.

(vi) *The penis vesicle* (PV).—Penis vesicle is situated on the anterior part of the third sternum (ST), and projects forwards underneath the second sternum. It is elongated sacciform, with broad body. At the apical end the penis vesicle bears a prominent groove (GR) guarded by two lips (LI) in which the glans of the penis is placed during rest.

(vii) *The penis*.—The penis is located on the second segment and it does not arise from the penis vesicle as in Anisoptera. It lies on the ventral surface of second abdominal segment in an exactly homologous position as the penis sheath in Anisoptera. It is well developed, much elongated, unsegmented, slightly curved and chitinous structure, broader proximally while narrower distally. It bears a membranous elongated glans (GLA), having a long flagellum (FL) and some lobes.

SUMMARY

Like Anisoptera, *Megalestes major* Selys bears two sets of copulatory apparatuses, the primary copulatory complex and the secondary copulatory complex. The primary copulatory complex consists of a vestigial penis, a pair of supra-anal appendages and a pair of infra-anal appendages. But unlike Anisoptera, there are two infra-anal appendages. The secondary copulatory complex is located on the ventral surface of second and third abdominal segments. The anterior pair of hamules are well developed, while the posterior pair of hamules are very much reduced. The penis sheath is absent, but in place of penis sheath there is a well developed lamina-batilliformis. The penis is unsegmented and does not arise from penis vesicle but from the floor of the second segment.

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LEECHES OF SIMLA HILLS, HIMACHAL PRADESH

By

* M. CHANDRA and K. K. MAHAJAN

INTRODUCTION

Harding and Moore (1927)¹ have reported five species of leeches, viz. *Paraclepsis praedatrix* Harding, *Barbronia weberi* (Blanchard), *Herpobdelloidea indica* (Kaburaki), *Hirudinaria granulosa* (Savigny), *Haemadipsa zeylanica* (Moquin-Tandon), from Simla Hills, apart from which there is no other reference to any of the forms described in the present communication from this area, though Bhatia (1939)², Soota (1959)³ and Chandra (1970)⁴ have recorded some of the forms included here from other mountain areas of Kashmir, Arunachal Pradesh and plains of Uttar Pradesh respectively.

The present paper is a report on a collection of leeches made mostly from temporary ponds and hill streams by the staff of High Altitude Zoology Field Station, Solan (H. P.), during January, 1969 to August, 1972. The authors collected the major part of the material which contains nine species and one subspecies, out of which five are new records, from the area. The region of Simla Hills comprises of districts of Simla, Solan, Sirmour and Bilaspur of Himachal Pradesh.

ACKNOWLEDGEMENTS

We are thankful to the staff of the High Altitude Zoology Field Station, Solan for assistance in the field as well as in the laboratory. We are also indebted to Dr. A. P. Kapur, Director, Zoological Survey of India, for his kind suggestions and guidance.

SYSTEMATIC ACCOUNT

Order RHYNCHOBDELLAE

Family GLOSSIPHONIDAE

Genus *Glossiphonia* Johnson, 1816

1. *Glossiphonia reticulata* Kaburaki, 1921

1921. *Glossiphonia reticulata* Kaburaki, *Rec. Indian Mus.*, 22 (5) : 65.

* High Altitude Zoology Field Station, Zoological Survey of India, Solan.

1. Harding, W. A. and Moore, J. P. 1927. *Fauna of British India* (Hirudinea).

2. Bhatia, M. L. 1939. *Bull. Punj. Univ. Zool.* 2 : 1-16.

3. Soota, T. D. 1959. *Rec. Indian Mus.*, 54 (1 & 2) : 2 (1956).

4. Chandra, M. 1970. *Rec. zool. Surv. India*, 64 (1-4), : 107-109. (1966.)

Material.—(1) 1 ex., North of Renuka lake, Renuka, District Sirmour, (attached to stones). 7.iv.70. Coll. *M. Chandra*. (ii) 8 exs., Dukali, Bilaspur, 25.viii. 72, Coll. *K. K. Mahajan*

Distribution.—Simla Hills (H. P.) (first record) as above. Elsewhere : India -Jullundhur, Maharashtra.

2. *Glossiphonia weberi* Blanchard, 1897

1897. *Glossiphonia weberi* Blanchard, *Zool. Ergeb. einer Reise*, Max Weber, 4 : 332, fig. 1.

1959. *G. weberi* : Soota, *Rec. Indian Mus.*, 54 (1 & 2) : 2. (1956).

Material.—(i) 25 exs., Parshuram Tank, Renuka, District Sirmour, (attached to stones), 6.iv.70, Coll. *M. Chandra*. (ii) 16 exs., Tank at Arki, 50 km. from Solan, 23-24.x.71, Coll. *M. Chandra*. (iii) 2 exs., Kanala Ambi, near Bilaspur, 21.iv.72, Coll. *M. Chandra*. (iv) 6 exs., Meiri, Ghumarwin, Bilaspur, 7.iv.72, Coll. *M. Chandra*. (v) 10 exs., Changar Khud, Bilaspur, 11.viii.72, Coll. *K. K. Mahajan*. (vi) 2 exs., Gohal Village, Bilaspur, 16.viii.72, Coll. *K. K. Mahajan*. (vii) 33 exs., Maigpur, Bhakra Nangal, 27.viii.72, Coll. *K. K. Mahajan*.

Distribution.—Simla Hills (H. P.) as above (first record). Elsewhere : India-widely distributed.

Genus *Hemiclepsis* Vejdovsky, 1882

3. *Hemiclepsis marginata asiatica* Moore, 1924

1924. *Hemiclepsis marginata asiatica* Moore, *Proc. Acad. Nat. Sci. Philadelphia*, 81 : 343-388, Pls. xix-xxi.

1959. *H. marginata asiatica* : Soota, *Rec. Indian Mus.*, 54 (1 & 2) : 2 (1956).

Material.—(i) 1 ex., Parshuram Tank, Renuka, District Sirmour, 6.iv.70, Coll. *M. Chandra* (attached to submerged stones). (ii) 5 exs., South bank of Renuka lake, Renuka, District Sirmour, 5.iv.70, Coll. *M. Chandra*.

Distribution.—Simla Hills (H.P.) as above (first record). Elsewhere : India-Kashmir.

Genus *Helobdella* Blanchard, 1896

4. *Helobdella stagnalis* (Linnaeus), 1758

1758. *Hirudo stagnalis* Linnaeus, *Systema Naturae*, 10th Ed. : 649

1939. *Helobdella stagnalis* : Bhatia, *Bull. Punj. Univ. Zool.*, 2 : 1-16.

Material.—(i) 10 exs., Yamuna River, Paonta, District Sirmour, (Attached to submerged stones). 12.iv.70, Coll. *M. Chandra*. (ii) 5 exs., Rajgarh, district Sirmour, 42 km. from Solan, 1.iii.71, Coll. *H. P. Agrawal*. (iii) 4 exs., Giripul, 20 km. from Solan, 23.xii.70, Coll. *M. Chandra*.

Distribution.—Simla Hills (H. P.) as above (first record). Elsewhere : India-Kashmir.

Genus *Paraclepsis* Harding, 1924

5. *Paraclepsis praedatrix* Harding, 1924

1924. *Paraclepsis praedatrix* Harding, *Ann. Mag. nat. Hist. Ser. (9) 14* : 489, pls. ix-xv.
 1927. *P. praedatrix* : Harding, *Fauna of British India-Hirudinea*. : 88-90, Fig. 36, pl. II, figs 11 & 12.

Material.—(i) 20 exs., tank near Arki, 50 km. from Solan, District Solan. 23-24.x.71, Coll. *M. Chandra*. (ii) 2 exs., Kanella Ambi, near Bilaspur, 21.iv.72, Coll. *M. Chandra*.

Distribution.—Simla Hills, (H. P.) as above. Elsewhere : India-South India, Maharashtra, West Bengal, Assam.

6. *Paraclepsis vulnifera* Harding, 1924

1924. *Paraclepsis vulnifera* Harding, *Ann. Mag. nat. Hist. Ser. (9) 14* : 489, pls. ix-xv.
 1927. *P. vulnifera* : Harding, *Fauna of British India-Hirudinea*. : 91-92, Fig. 37.

Material.—(i) 13 exs., Meiri, Ghumarwin, Bilaspur, 7.iv.72, Coll. *M. Chandra*.

Distribution.—Simla Hills (H.P.) as above (first record). Elsewhere : India-South India.

Order ARHYNCHOBDELLAE

Family ERPOBDELLIDAE

Genus *Barbronia* Johnson, 1918

7 *Barbronia weberi* (Blanchard), 1897

1897. *Dina weberi* Blanchard, *Zool. Ergeb. Reise, iv*, : 332-335, 11 text-figs.
 1939. *Barbronia weberi* : Bhatia, *Bull. Punj. Univ. Zool. 2* : 1-16.

Material.—(i) 2 exs., Yamuna river, (attached to submerged stones), Paonta, District Sirmour, 12.iv.70, Coll. *M. Chandra*. (ii) 12 exs.,

Parwanu, near Kalka (attached to submerged stones), 16.i.72, Coll. *M. Chandra*. (iii) 1 ex. Parwanu near Kalka, 14.iv.71, Coll. *K. K. Mahajan*. (iv) 4 exs. Sadhupul, 30 km. from Solan, Chail road, 18.v.71, Coll. *K. K. Mahajan*. (v) 6 exs., Kuthar, 36 km. from Solan, 19.ii.71, Coll. *M. Chandra*. (vi) 22 exs., Ochhghat, 10 km. from Solan, (attached to stones). 23.xii.70, Coll. *M. Chandra*. (vii) 3 exs., Ashwani Khud, 10 km. from Solan, 19.vi.70. Coll. *M. Chandra*. (viii) 2 exs., Nihal Village, Bilaspur, 13.iv.72, Coll. *M. Chandra*. (ix) 11 exs., Meiri, Ghumarwin, Bilaspur, 15.iv.72, Coll. *M. Chandra*. (x) 13 exs., Changar Khud, Bilaspur 11.viii.72, Coll. *K. K. Mahajan*. (xi) 2 exs., Oyal Village, Bilaspur, 15.viii.72, Coll. *K. K. Mahajan*. (xii) 8 exs., Ali Khud, Ghaghas, Bilaspur, 13.viii.72, Coll. *K. K. Mahajan*. (xiii) 8 exs., Nangal, Forest Rest House, Bhakra, 22.viii.72. Coll. *K. K. Mahajan*. (xiv) 16 exs., Nangal, Forest Rest House, Bhakra, 22.viii.72, Coll. *K. K. Mahajan*.

Distribution.—Simla Hills (H. P.) as above. Elsewhere : India-Kashmir and widely distributed throughout North India.

Genus *Herpobdelloidea* Kaburaki, 1921

8. *Herpobdelloidea indica* (Kaburaki), 1921

1921. *Nematobdella indica* Kaburaki, *Rec. Indian Mus.*, **18** : 706-707.

1927. *Herpobdelloidea indica* : Moore, *Fauna of British India -Hirudinea* : 144-148, pl. III, fig. 3, VI, figs. 15, 16.

Material.—(i) 6 exs., Parshu Ram Tank, Renuka, District Sirmour (attached to stones), 6.iv.70, Coll. *M. Chandra*. (ii) 2 exs., South bank of Renuka lake, Renuka, District Sirmour, 5.iv.70, Coll. *M. Chandra*. (iii) 10 exs., Taradevi near Simla, 3.ii.71. Coll. *H. P. Agrawal*. (iv) 4 exs., Ashwani Khud, 10 km. from Solan, 18.vi.70, Coll. *M. Chandra*. (v) 15 exs., Sarkaghat, Mandi, 1.iv.72, Coll. *M. Chandra*. (vi) 5 exs., Meiri, Ghumarwin, Bilaspur, 7.iv.72, Coll. *M. Chandra*. (vii) 1 ex., Nainadevi, Bilaspur, 24.iv.72, Coll. *M. Chandra*. (viii) 6 exs., Old Bilaspur, 16.iv.72, Coll. *M. Chandra*. (ix) 3 exs., Maigpur, Bhakra, 27.viii.72, Coll. *K. K. Mahajan*. (x) 3 exs., Dukali, Bhakra, 25.viii.72, Coll. *K. K. Mahajan*.

Distribution.—Simla Hills (H. P.) as above, Elsewhere ; India-Punjab, Madhya Pradesh and Maharashtra.

Family HIRUDIDAE

Genus *Hirudinaria* Whitman, 1866

9. *Hirudinaria granulosa* (Savigny)

1820. *Sanquisuga granulosa* Savigny, *Système des Annelides*, Paris : 115

1970. *Hirudinaria granulosa* : Chandra, *Rec. zool. Surv. India*, **64** (1-4): 107-109 (1966).

Material.—(i) 1 ex., Kuthar, 36 km. from Solan on Solan Patta road, 19.ii.71, Coll. *M. Chandra*. (ii) 2 exs., Ghaghas, Bilaspur, 14.viii.72. Coll. *K. K. Mahajan*. (iii) 1 ex., Oyal Village, Bilaspur, 15.viii.72, Coll. *K. K. Mahajan*. (iv) 8 exs., Gohal, Bilaspur, 16.viii.72, Coll. *K. K. Mahajan*.

Distribution.—Simla Hills (H. P.) as above. Elsewhere : India-widely distributed throughout India.

Genus *Haemadipsa* Tennent, 1859

10. *Haemadipsa zeylanica* (Moquin-Tandon)

1826. *Sanguisuga zeylanica* Moquin-Tandon, *Monographie de la famille Hirudinees*, Montpellier : 126
1970. *Haemadipsa zeylanica* : Chandra, *Rec. zool. Surv. India*, **64** (1-4) : 107-109 (1966).

Material.—25 exs., Nohra, Sirmour, 1.vii.72, Coll. *M. Chandra*.

Distribution.—Simla Hills (H. P.) as above. Elsewhere : India-Arunachal Pradesh.

SUMMARY

Nine species and one sub-species belonging to eight genera and three families are reported from Simla Hills of which four species and one subspecies are reported for the first time from Simla Hills.

ON A NEW SPECIES OF LEAF PIT-GALL FORMING ALEY-
RODID AND *ALEUROTUBERCULATUS HEXCANTA*
(SINGH) COMB. NOV, (ALEYRODIDAE : HOMOPTERA)

By

B. VASANTHARAJ DAVID*

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(With 2 Text-figures)

Dialeurodes (Rhabdostigma) saklaspurensis n. sp.

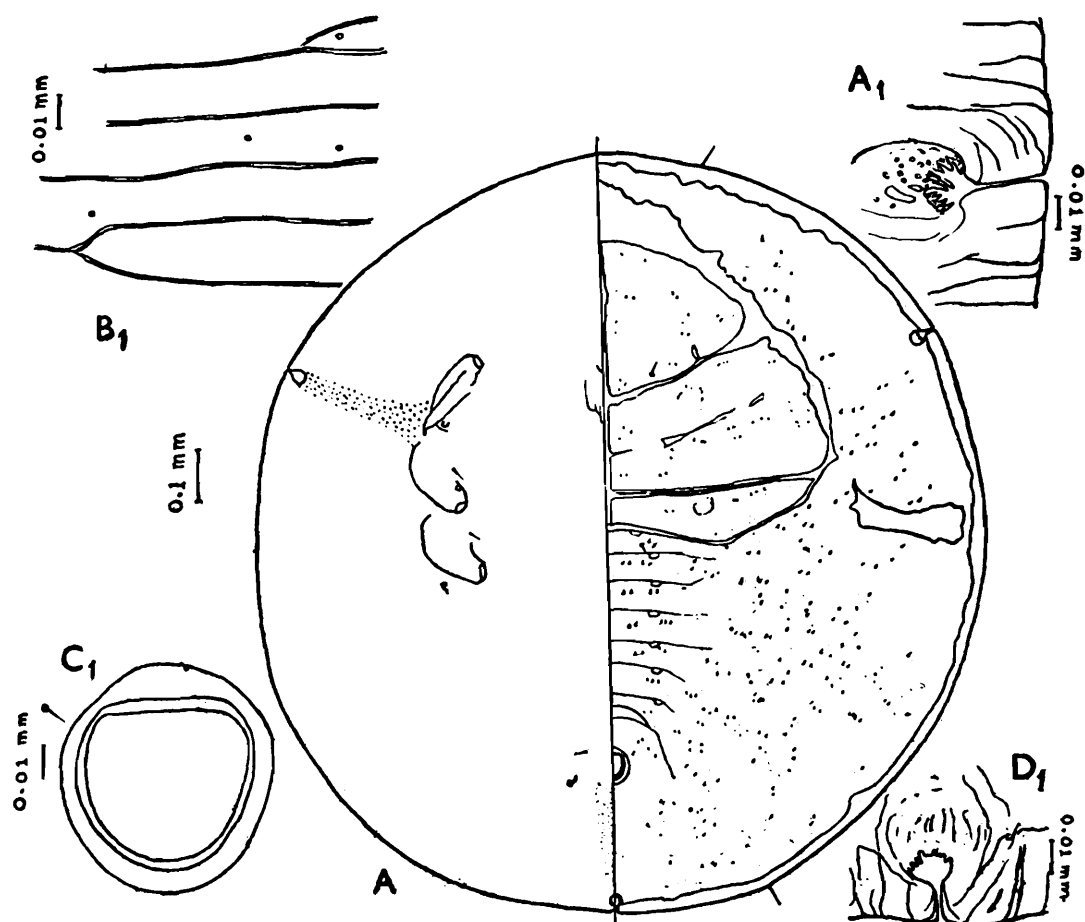
(Text-fig. 1)

Pupal case.—Brown without any waxy secretion: found in pits on the undersurface of leaf in large numbers, sometimes occurs on the upper surface of leaf in stray numbers; more or less circular in shape, 1.41—1.43 mm long, 1.28—1.31 mm wide.

Margin.—Entire with a series of sutures extending mesad. Paired anterior and posterior marginal setae 39-49 μ long. Thoracic and caudal tracheal ends invaginated.

Dorsal surface.—Dorsum light brown, a narrow area mesad of margin all round transparent. The suture separating the thorax and the abdomen is transparent and distinct, sublaterally it bends to anterior joining the outer margin of the transparent suture between the meso- and metathorax and that between the cephalic region and prothorax and finally curves cephalad, slightly widened and meets the similar transparent area from the other half. The transparent suture between the pro- and mesothorax very narrow and broken; the longitudinal moulting suture is narrow and transparent. A distinct transparent more or less rectangular area opposite metathoracic segment on part of subdorsum and submargin quite characteristic. All the three pairs of dorsal setae evident—a pair on cephalic region 14 μ long, a pair on basal abdominal segment 17 μ long, and a pair laterad of base of vasiform orifice 10 μ long; depressed markings seen on metathorax and on the first seven abdominal segments; pockets distinct and contiguous. Dorsum all over with papillae, abdominal rhachis absent. Thoracic tracheal furrows not discernible but pores invaginated with series of fine longitudinal ridges.

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Text-fig. 1. *Dialeurodes (Rhabdostigma) saklaspurensis* n. sp.

A. Pupal case showing ventral and dorsal surfaces ; A₁ Thoracic tracheal pore ; B₁ Tessellation and bases of papillae on dorsum ; C₁ Vasiform orifice ; D₁ Caudal tracheal pore.

Vasiform orifice more or less circular with thickened or chitinated rim, 56-59 μ long, 63 μ wide; operculum 43-46 μ long, 46-50 μ wide, subcordate, cephalic margin straight, almost covering the orifice with the setose lingula concealed or its tip slightly exposed ; lingula included not extending beyond orifice. Caudal furrow and caudal setae not present, pore invaginated with fine ridges.

Ventral surface.—Ventral abdominal setae 37 μ long, 69 μ apart. All the spiracles evident. Antenna slender and long with a finger-like tip extending beyond base of fore leg. A seta at base of each of meso- and metathoracic legs and a pair at base of rostrum evident. Thoracic and caudal tracheal folds tuberculate.

Material examined.—Holotype—pupal case from an unidentified tree, Saklaspur (Karnataka), 28.3.1969, B. V David. Paratypes—Two pupal cases on a slide in the collection of the Entomology Research Division, U.S.D.A., Washington, two pupal cases mounted in the collection of the Zoological Survey of India, Calcutta; ten pupal

cases mounted and numerous specimens on leaves in the collection of the author.

This species closely resembles *Dialeurodes* (*Rhabdostigma*) *radii-linearis* Q. & B. but differs distinctly in the distribution of the transparent pattern on dorsal disc and in the details of submarginal tessellation, distribution of papillae and structural details of thoracic and caudal tracheal pores.

***Aleurotuberculatus hexcantha* (Singh) Comb. nov.**

(Text-fig. 2)

1940. *Taiwanaleyrodes hexcantha* Singh, *Rec. Indian Mus.* **42** : 453-56.

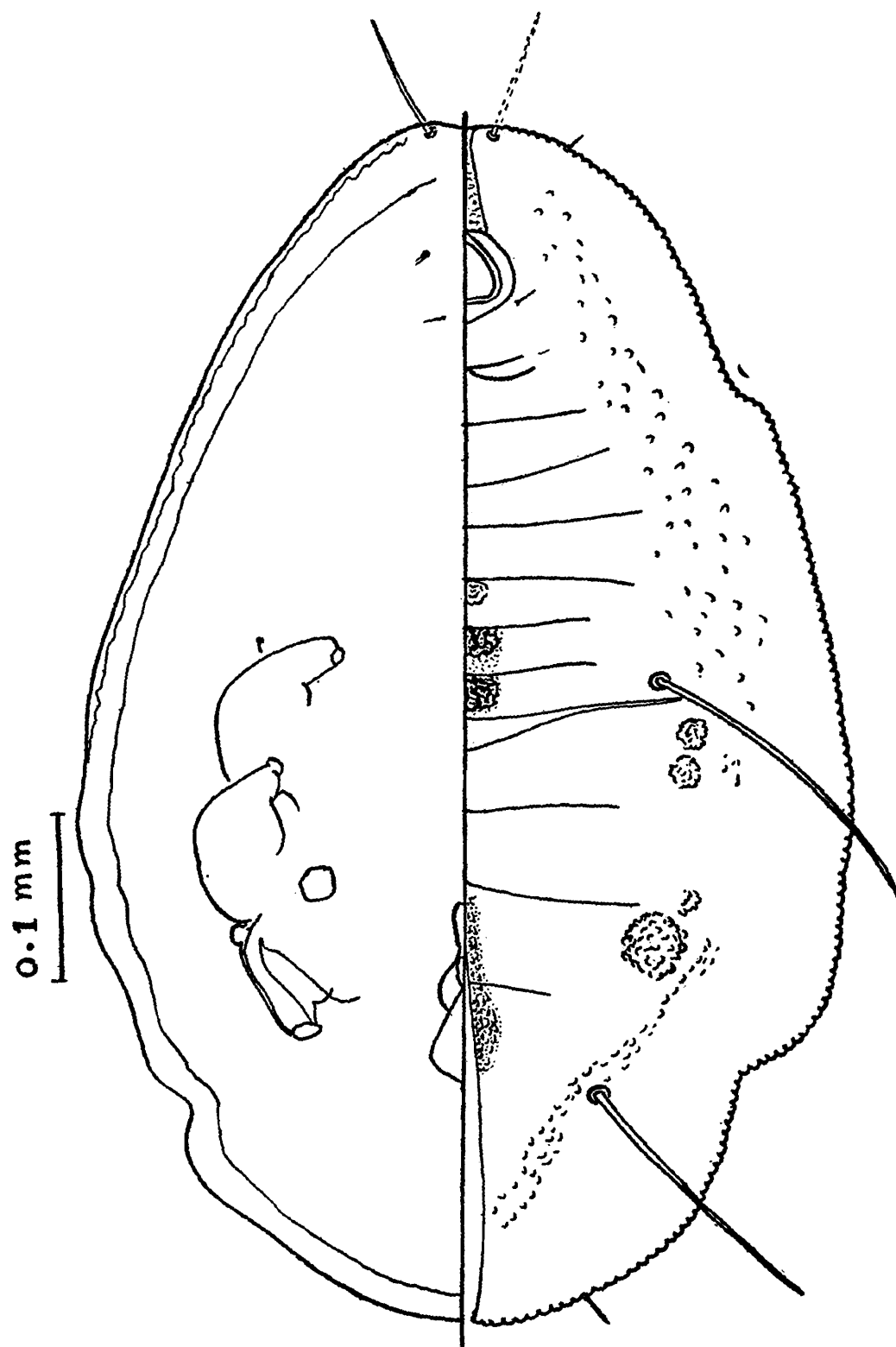
1958. *Taiwanaleyrodes hexcantha* : Rao, *Proc. 10th int. Congr. Ent.* 1956, **1** : 331-36.

Pupal case.—Colourless with a narrow fringe of white powdery wax and small brownish patches on the cephalic and prothoracic regions and on the first two abdominal segments; shape subelliptical, broader anteriorly and narrowing posteriorly ; 0.70 mm long, 0.46 mm wide.

Margin.—Finely crenulate, 26 crenulations in 0.1 mm ; slightly indented at caudal end, thoracic tracheal pore endings not indicated; paired anterior and posterior marginal setae evident, 13-17 μ long.

Dorsal surface.—Dorsum with distinct brownish tubercles along the longitudinal moulting suture on the proximal end of the cephalic region and prothorax and medially on the first two abdominal segments, also a rounded tubercle discernible medially on abdominal segment 3; sublaterally a pair of distinct rounded tubercles—one large and one small—present on prothorax and a pair of smaller rounded tubercles on metathorax ; in addition sparsely distributed tubercles evident on cephalothorax and abdominal region sublaterally. The longitudinal moulting suture reaches the margin, the transverse moulting suture extends upto the margin of dorsal disc. The thoracic and abdominal sutures distinctly evident ; pockets distinct but not contiguous. Paired cephalic and basal abdominal setae arise from rounded bases, long and pointed, 96 μ and 91 μ long respectively ; eighth abdominal setae short, 10 μ long on either side of base of vasiform orifice. Submarginal area not defined from dorsal disc by faint line. Thoracic tracheal furrows not discernible.

Vasiform orifice sub semicircular, 42 μ long, 33 μ wide with a thickened rim, caudal end not notched. Operculum almost fills the orifice concealing the lingula. Caudal furrow distinct, 63 μ long, wider at base (16 μ) and narrowing towards caudal end (7 μ), with irregular wavy transverse markings,



Text-fig. 2. *Aleurotuberculatus hexcantha* (Singh) — Dorsal and ventral surfaces of pupal case.

Ventral surface.—Ventral abdominal setae $17\ \mu$ long, $26\ \mu$ apart. Prothoracic and abdominal spiracles evident. Antenna short, does not extend beyond base of fore leg; setae at base of legs and rostrum wanting; adhesive sacs present; thoracic tracheal folds not evident;

caudal fold discernible, smooth. A distinct linear line running all round but broken in the region of caudal tracheal folds seen.

Hosts.—*Bauhinia* sp. (Singh 1940), *Ficus* sp. (Rao 1958).

Distribution.—Chanda, Nagpur (Singh 1940), Himayatnagar (Andhra Pradesh) (Rao 1958).

Material.—Holotype No. 5837/H7, one pupal case, *Bauhinia* sp., Chanda (Nagpur), December 1937, *Karam Singh*.

SUMMARY

In this paper a new aleyrodid *Dialeurodes* (*Rhabdostigma*) *saklaspurensis* n. sp. found in large numbers on the undersurface of leaves of an unidentified tree is described. The aleyrodid *Taiwanaleyrodes hexcantha* Singh is assigned to the genus *Aleurotuberculatus* suggesting a new name combination based on a study of the holotype and a detailed revised description as also available information on the hosts and distribution are provided for the species.

ACKNOWLEDGEMENT

I wish to express my sincere thanks to Dr. A. P. Kapur, Director, Zoological Survey of India, Calcutta for permission to study the material and to Mr. K. S. Pradhan, Superintending Zoologist and Mr. Kuldip Rai of the Zoological Survey of India for the cooperation extended in examining the material. Thanks are due to Dr. T. N. Ananthakrishnan, Director, Entomology Research Unit, Loyola College, Madras for the facilities provided.

REVISION OF THE SUBSPECIES OF THE LESSER BANDICOOT RAT *BANDICOTA BENGALENSIS* (GRAY)
(RODENTIA : MURIDAE)

By

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Zoological Survey of India, Calcutta

(With 2 Tables and 5 Text-figures)

INTRODUCTION

Gray (1835, 1837) erected the species *Arvicola bengalensis* and *Mus kok* from India, and Nehring (1902) described *Nesokia gracilis* from Ceylon, but none of them compared these with each other. Thomas (1907) accommodated these species under a new genus *Gunomys* and added another species *Gunomys varius* from Penang, Malaysia, to it. Wroughton (1908) described three more species, *Gunomys wardi*, *Gunomys lordi* and *Gunomys sindicus* from Kashmir, Maharashtra and Sind respectively, on the basis of the texture of fur. Later, he (1919) gave a key for the identification of all the above mentioned species. Ellerman (1941) considered these as mere subspecies of *Bandicota bengalensis* (Gray). Subsequently he (1947, 1963) distinguished *varius* from all other subspecies by its larger size (Occipito-nasal length over 44 mm.), and *wardi* in having longer and softer fur. Further, he synonymized *lordi* and *sindicus* with *kok* and differentiated the latter from *bengalensis* and *gracilis* on the length of tooth-row (over 7 mm. *vs.* under 7 mm.), and *bengalensis* from *gracilis* on the relative length of the tail (more than 80% *vs.* less than 80% of Head and Body length).

While cataloguing the collections of rodents in the Zoological Survey of India, we have come across several specimens of *Bandicota bengalensis* from different accepted subspecific zones, which according to the extant literature, cannot be distinguished from one another. An assessment of their taxonomic status was, therefore, felt necessary.

All measurements are in millimetres and have been taken after Ellerman (1963). For statistical analysis, the external and cranial measurements given by him have also been incorporated. Population-range diagrams (Text-figs. 1-5) for different external and cranial measurements have been prepared according to the methods of Dice and Leraas (1936) and Hubbs and Perlmutter (1942). The length of each ordinate represents the extremes of each set of measurements

and a central crossbar the mean ; a narrow shaded rectangle represents a distance equal to one standard deviation from the mean on each side of the mean, while the broad rectangle represents a distance equal to twice the standard error of the mean on each side of the mean.

ACKNOWLEDGEMENTS

We are thankful to Dr. A. P. Kapur, Director, Zoological Survey of India, for providing facilities and to Dr. B. Biswas, Deputy Director for kindly going through the manuscript.

OBSERVATION AND DISCUSSION

Colour.—The colour in *Bandicota bengalensis* ranges dorsally from dark brown to blackish, occasionally with pale brown or reddish hue and ventrally from dark gray to whitish. Tail in most of the specimens is dark throughout but sometimes paler below.

A detailed study of coloration of specimens of this species from different areas reveals that there is no significant difference in colour as it varies much individually, irrespective of localities.

Nature of fur.—The fur in specimens of *wardi* from Kashmir and Himachal Pradesh is long, thick and soft and with a silky lustre as against short and harsh in other subspecies. However, in one male specimen collected in October from Chamba, Himachal Pradesh

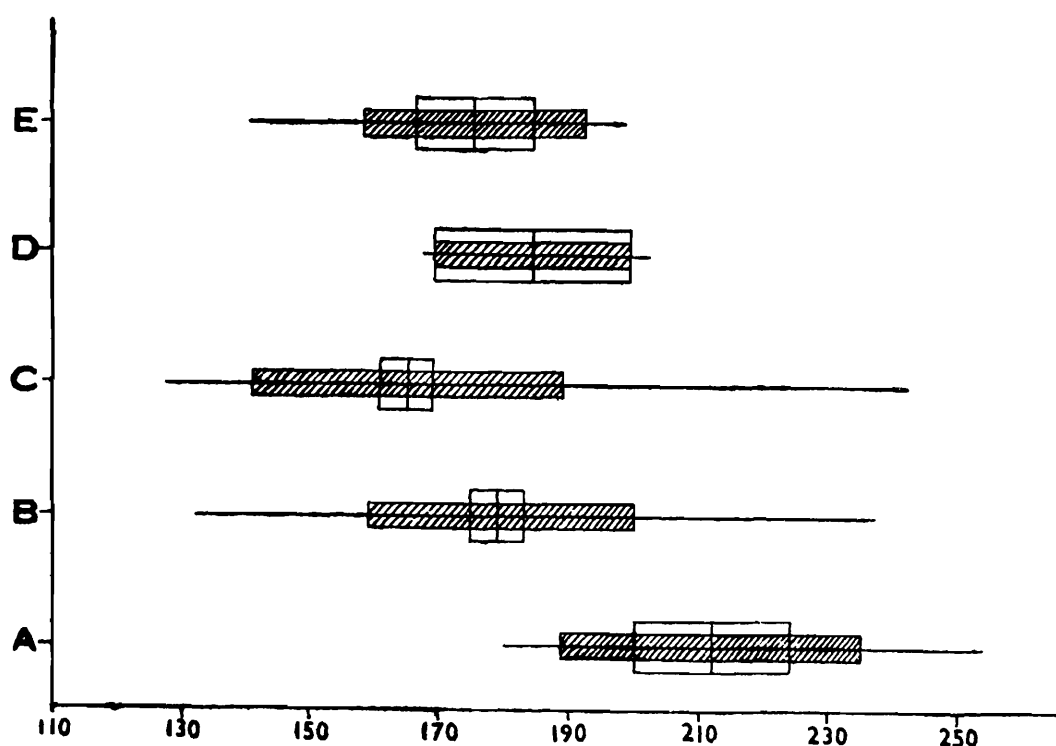
Table 1.—External measurements of different subspecies of *Bandicota bengalensis* (Gray).

Name of Subspecies	No. of ex.	Head & Body	Tail	Tail as % of HB	Hind foot	Ear
<i>Bandicota b. bengalensis</i>	115	132—237 (179)*	99—202 (148)	68—98 % (82 %)	29—39 (33.0)	18—25 (21.7))
<i>Bandicota b. kok</i>	106	128—243 (165)	100—217 (149)	62—103 % (85 %)	27—44 (33.5)	18—25 (22)
<i>Bandicota b. wardi</i>	14	140—198 (175)	108—162 (141)	67—93 % (81 %)	32—37 (35)	18—25 (22)
<i>Bandicota b. gracilis</i>	5	167—202 (184)	121—170 (140)	72—84 % (78 %)	28—35 (32)	19—23 (21)
<i>Bandicota b. varius</i>	14	180—255 (212)	135—205 (172)	65—96 % (80 %)	34—43 (39)	20—25 (23)

* Figures in parentheses indicate mean values

(alt 610 metres) it is coarse and not very dense. It appears to be in moulting stage. On the other hand, in a few winter specimens of *bengalensis* and *kok*, the fur is soft but can easily be distinguished from that of *wardi* in being shorter, less dense and lacking the silky lustre.

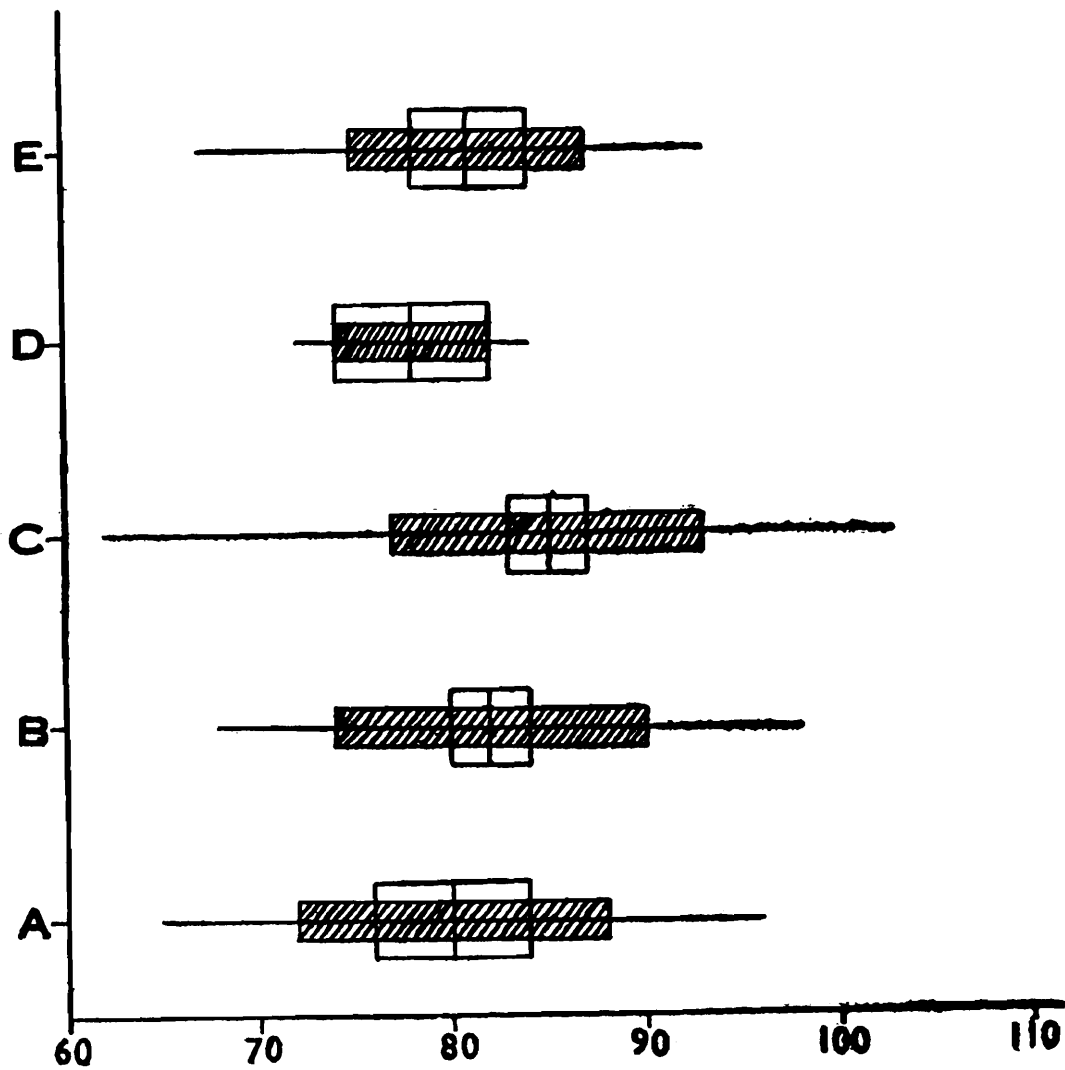
Size.—An analysis of the various measurements of the body and skull from different subspecific zones reveals that there is no significant difference between them either in the length of Head and Body or in the length of tail in relation to Head and Body (Text-figs. 1



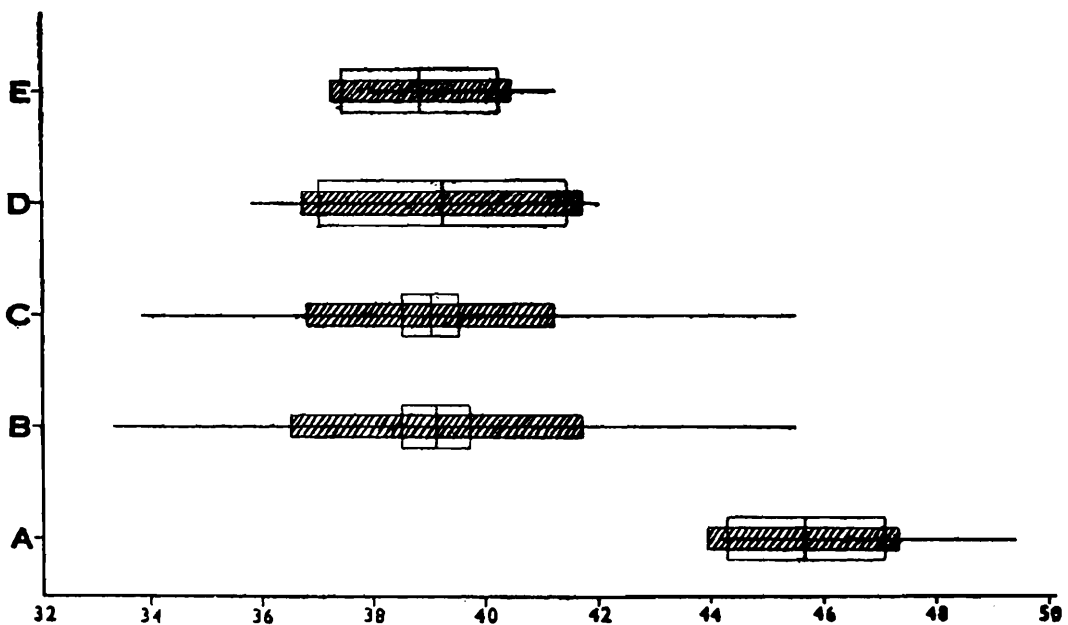
Text-fig. 1.—Graphic representation of Head and Body length in five subspecies of *Bandicota bengalensis* (Gray). A, *B. b. varius*; B, *B. b. bengalensis*; C, *B. b. kok*; D, *B. b. gracilis*; and E, *B. h. wardi*.

and 2, table 1), contrary to that mentioned by Wroughton (1919) and Ellerman (1963). However, the specimens of *varius* have a tendency of being larger in the Head and Body length. This tendency is clearly reflected in the length of its skull. The occipito-nasal length (Text-fig. 3, table 2) in this subspecies ranges from 44.2 to 49.4 mm. as against less than this in other subspecies (exceptions being three out of 156 skulls, where it reaches 45 mm.).

Tooth-row.—Ellerman (1963) separated *kok* from *bengalensis* and *gracilis* on the basis of its longer tooth-row (over 7 mm *vs.* below 7 mm). An analysis of the length of tooth-row in all the subspecies

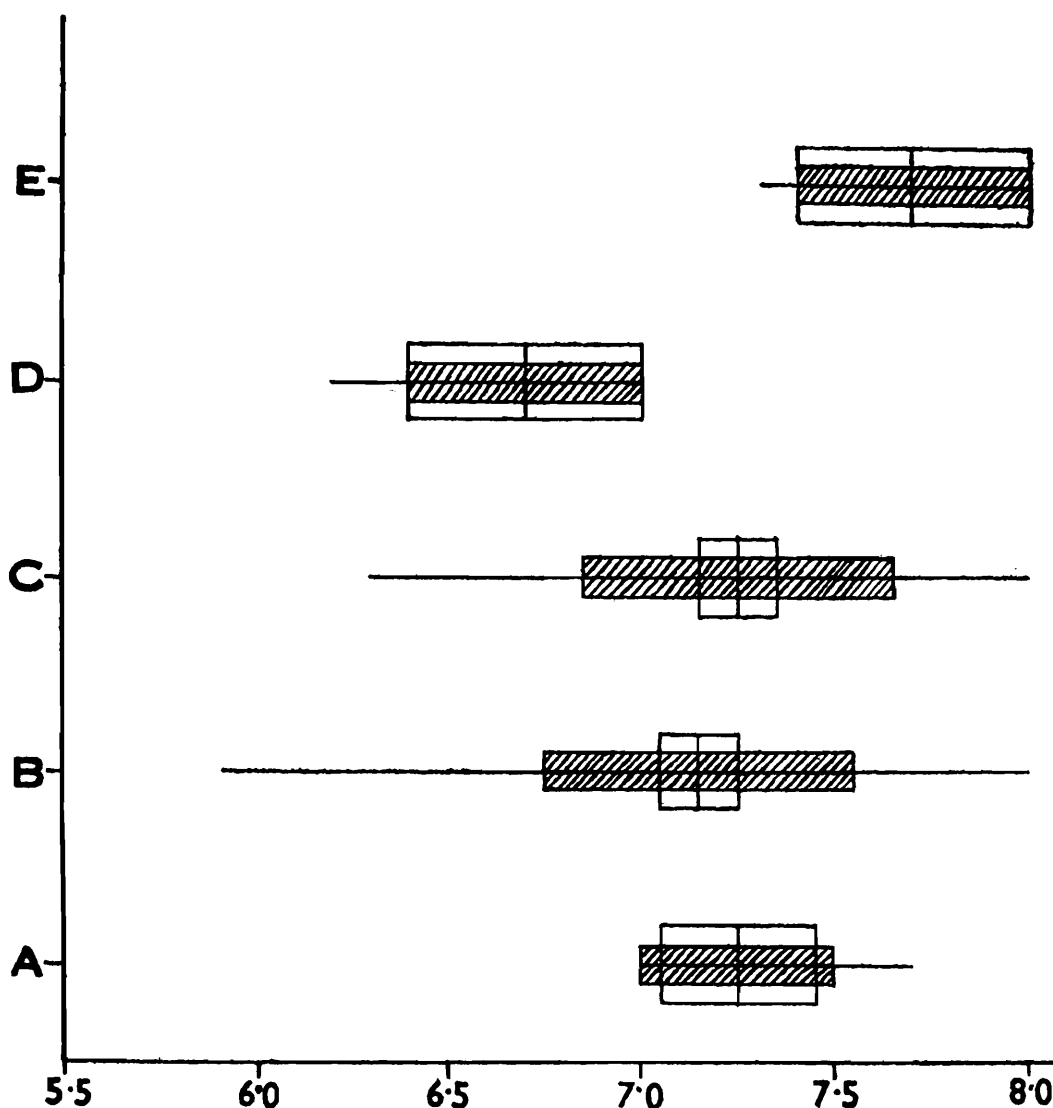


Text-fig. 2.—Graphic representation of the length of tail as percentage of Head and Body length in five subspecies of *Bandicota bengalensis* (Gray). A, *B. b. varius*; B, *B. b. bengalensis*; C, *B. b. kok*. D, *B. b. gracilis*; and E, *B. b. wardi*.



Text-fig. 3.—Graphic representation of occipitonasal length of skull in five subspecies of *Bandicota bengalensis* (Gray). A, *B. b. varius*; B, *B. b. bengalensis*; C, *B. b. kok*; D, *B. b. gracilis*; and E, *B. b. wardi*.

(Text-fig.4) shows that there is no significant difference between them in absolute measurements. However, when considered in relation

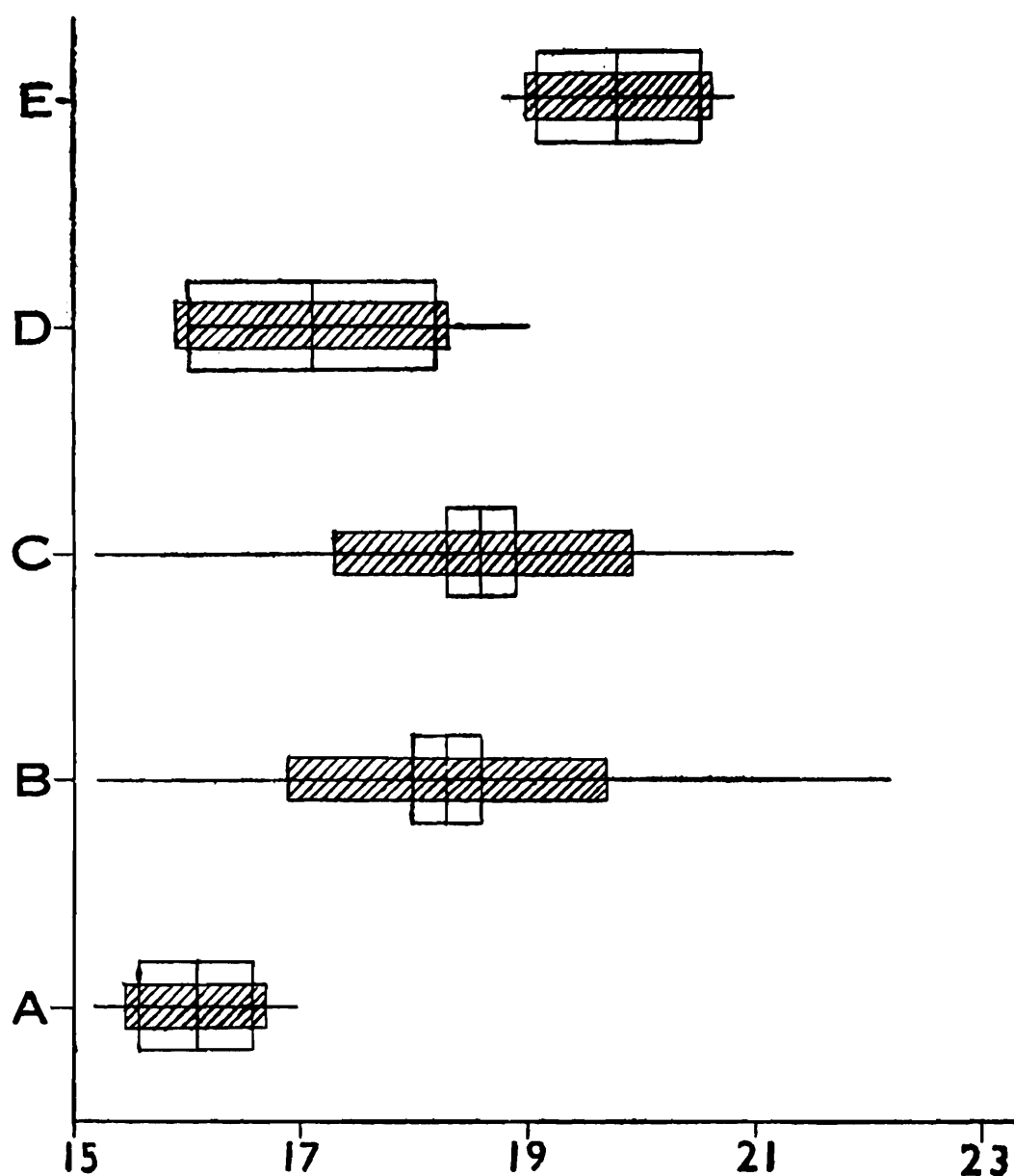


Text-fig. 4.—Graphic representation of the length of tooth-row in five subspecies of *Bandicota bengalensis* (Gray). A, *B. b. varius* ; B, *B. b. bengalensis* ; C, *B. b. kok* ; D, *B. b. gracilis* ; and E, *B. b. wardi*.

to occipitonasal length of the skull, it is slightly smaller in *varius* than in *bengalensis*, *kok* and *wardi*, but intermediate between the two in *gracilis* (Text-fig. 5, Table 2).

Thus, the separation of *bengalensis* from *kok* on the basis of the length of tooth-row, and from *gracilis* on the relative length of tail, is not justified.

We would, therefore, treat *Bandicota bengalensis kok* (Gray) and *Bandicota bengalensis gracilis* (Nehring) as synonyms of *Bandicota bengalensis bengalensis* (Gray).



Text-fig. 5.—Graphic representation of the length of tooth-row as percentage of occipitonasal length of skull in five subspecies of *Bandicota bengalensis* (Gray). A, *B.b. varius* ; B, *B.b. bengalensis* ; C, *B.b. kok* ; D, *B. b. gracilis* ; and E, *B. b. wardi*.

A key to the subspecies of *Bandicota bengalensis*, as recognized by us, is given below.

1(2). Fur long, dense with a silky lustre	<i>B. b. wardi</i>
2(1). Fur short, less dense and lacking silky lustre	3
3(4). Occipitonasal length more than 44 mm.	<i>B. b. varius</i>
4(3). Occipitonasal length less than 44 mm.	<i>B. b. bengalensis</i>

Table 2.—Some cranial measurements of different subspecies of *Bandicota bengalensis* (Gray).

Name of subspecies	No. of ex.	Occipito-nasal	Tooth-row	Tooth-row as % of ONL
<i>Bandicota b. bengalensis</i>	73	33.3—45.5 (39.1)*	5.9—8.0 (7.15)	15.2—22.2 % (18.3 %)
<i>Bandicota b. kok</i>	73	33.8—45.5 (39.0)	6.3—8.0 (7.25)	15.2—21.3 % (18.6 %)
<i>Bandicota b. wardi</i>	5	37.9—41.2 (38.8)	7.3—8.0 (7.7)	18.8—20.8 % (19.8 %)
<i>Bandicota b. gracilis</i>	5	35.8—42.0 (39.2)	6.2—7.0 (6.7)	16.2—19 % (17.1 %)
<i>Bandicota b. varius</i>	6	44.2—49.4 (45.65)	7.0—7.7 (7.25)	15.2—17 % (16.1 %)

* Figures in parentheses indicate mean values.

SUMMARY

The paper deals with the taxonomic revision of the subspecies of the Lesser Bandicoot Rat, *Bandicota bengalensis* (Gray).

From a detailed study of coloration, nature of fur and external and cranial measurements of all the five subspecies of *B. bengalensis*, it appears that *B. b. kok* and *B. b. gracilis* are nothing but synonyms of *B. b. bengalensis*. However, *B. b. wardi* and *B. b. varius* stand valid. Former can be differentiated from the nominate subspecies on the texture of fur, and the latter by its larger skull.

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DIPTERA FROM ARUNACHAL PRADESH* AND ASSAM
FOOT HILLS, PART IV, LOHIT DISTRICT, LAKHIMPUR
DISTRICT AND SIBSAGAR DISTRICT

By

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INTRODUCTION

This is the fourth part of the series and it deals with the material of Diptera collected during February-March, 1969 from the Lohit District, Arunachal Pradesh* and Lakhimpur and Sibsagar Districts, Assam, by Dr. S. K. Tandon, Zoologist, Zoological Survey of India, Calcutta. As in Part III, the distributional records are given only for those species which have not been reported in the earlier papers of the series (Joseph & Parui, 1973).

The families dealt with are Tipulidae, Culicidae, Bibionidae, Stratiomyidae, Tabanidae, Bombyliidae, Syrphidae, Tephritidae, Sepsidae, Chloropidae, Muscidae, Calliphoridae and Hippoboscidae.

SYSTEMATIC ACCOUNT

Family TIPULIDAE

1. *Nephrotoma concolorithorax* (Brunetti)

1912. *Pachyrhina concolorithorax* Brunetti, *Fauna Brit. India*, Diptera, Nematocera, 2 : 346.
1961. *Nephrotoma concolorithorax* (Brunetti) : Alexander, *Rec. Indian Mus.*, 59 : 21.

Material.—(I) 1 ex., Sta. No. 6, Lohit District, Bolung, 300 m., 4. iii. 1969. (II) 2 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 11. iii. 1969.

2. *Nephrotoma dorsopunctata* (Brunetti)

1911. *Pachyrhina dorsopunctata* Brunetti, *Rec. Indian Mus.*, 6 : 265-266.
1961. *Nephrotoma dorsopunctata* (Brunetti) : Alexander, *Rec. Indian Mus.*, 59 : 21.

*Formerly N. E. F. A.

Material.—(I) 3 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (II) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (III) 1 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 11. iii. 1969. (IV) 2 ex., Sta. No. 16, Lohit District, Sitpani, 100 m., 16. iii. 1969.

3. *Conosia irrorata* (Wiedemann)

1828. *Limnobia irrorata* Wiedemann, *Ausser. Zweifl.*, 1 : 574.
 1912. *Conosia irrorata* (Wiedemann) : Brunetti, *Fauna Brit. India*, Diptera, Nematocera, 2 : 497-499, fig. 43.

Material.—1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

Remarks.—Specimen damaged ; legs lost.

Family CULICIDAE

4. *Mansonia (Mansonioides) indiana* Edwards

1930. *Mansonia (Mansonioides) indiana* Edwards, *Bull. ent. Res.* 21 : 541.
 1934. *Mansonia (Mansonioides) indiana* Edwards : Barraud, *Fauna Brit. India*, Diptera, 5 : 130-131. figs. 29, d, e, 30b, 31a-c.

Material.—8 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 14. iii. 1969.

Remarks.—Mesonotum with uniform brown scales.

Recorded from Calcutta ; Gauhati and Dimapur, Assam ; Nongpoh, Meghalaya, Trivandrum, Kerala ; Coonoor, Tamil Nadu ; also from Burma ; Java.

5. *Culex (Culex) bitaeniorhynchus* Giles

1901. *Culex (Culex) bitaeniorhynchus* Giles, *J. Bombay nat. Hist. Soc.*, 13 : 107.
 1934. *Culex (Culex) bitaeniorhynchus* Giles : Barraud, *Fauna Brit. India*, 5 : 391-394, figs. 90b, 91e-h.

Material.—7 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 14. iii. 1969.

Remarks.—Wings with fewer and narrower pale wing scales. Abdomen with the yellow tergite bands complete.

Widely distributed in India ; recorded also from Japan ; Africa ; Australia.

Family BIBIONIDAE

6. *Plecia aterrima* Brunetti

1925. *Plecia aterrima* Brunetti, *Rec. Indian Mus.*, 27 : 446.

Material.— (I) 1 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (II) 2 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969. (III) 1 ex., Sta. No. 14, Lohit District, Tezu, Lohitpur Road, 150 m., 13. iii. 1969. (IV) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 14. iv. 1969.

Remarks.— Reported from Kalimpong, W. Bengal ; also from Langbian Peaks and Dalat, Vietnam.

7. *Plecia fulvicollis* (Fabricius)

1805. *Hirtea fulvicollis* Fabricius, *Syst. Antl.* : 53.

1912. *Plecia fulvicollis* (Fabricius) : Brunetti, *Fauna Brit. India*, Diptera, Nematocera, 2 : 163-164, Pl. 12, figs. 12, 15.

Material.— (I) 2 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (II) 1 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (III) 3 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 11. iii. 1969. (IV) 2 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 14. iii. 1969. (V) 1 ex., Sta. No. 16, Lohit District, Sitpani, 100 m., 16. iii. 1969. (VI) 1 ex., Sta. No. 17, Lohit District, Chowkham Road, 100 m., 16. iii. 1969.

8. *Plecia impostor* Brunetti

1912. *Plecia impostor* Brunetti, *Rec. Indian Mus.*, 7 : 446.

1952. *Plecia impostor* Brunetti : Hardy, *Rec. Indian Mus.*, 50(1) : 94-95, fig. 3.

Material.— 1 ex., Sta. No. 14, Lohit District, Tezu, Lohitpur Road, 150 m., 13. iv. 1969.

Remarks.— Recorded from Airadeo and Bhowali, Kumaon, Uttar Pradesh.

Family STRATIOMYIDAE

9. *Microchrysa flaviventris* (Wiedemann)

1824. *Sargus flaviventris* Wiedemann, *Anal. Ent.* : 31.

1920. *Microchrysa flaviventris* (Wiedemann) : Bruentti, *Fauna Brit. India*, Brachycera, 1 : 88.

Material.— (I) 1 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (II) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969.

Remarks.— Widely distributed in India ; also reported from Sri Lanka ; Java ; Sarawak ; Papua.

10. *Ampsalis longispinus* Brunetti

1913. *Ampsalis longispinus* Brunetti, *Rec. Indian Mus.*, 9 : 264, Pl. 14, figs. 2, 4, 16.

1920. *Ampsalis longispinus* Brunetti : Brunetti, *Fauna Brit. India*, Diptera, Brachycera, 1 : 44-45, figs. 18-19.

Material.— 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969.

Remarks.— Recorded from Darjeeling and Singla, W. Bengal ; Shillong, Meghalaya.

Family TABANIDAE

11. *Tabanus jucundus* Walker

1848. *Tabanus jucundus* Walker, *List. Dipt.*, 1 : 187.

1911. *Tabanus jucundus* Walker : Ricardo, *Rec. Indian Mus.*, 4, pp. 164-165, pl. 13, fig. 10.

Material.— 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969.

12. *Haematopota assamensis* Ricardo

1911. *Haematopota assamensis* Ricardo, *Rec. Indian Mus.*, 4 : 343-344, pl. 18, fig. 19.

Material.— 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969.

Remarks.— The median spots of the abdomen also present in segments 4 and 5.

Family BOMBYLIIDAE

13. *Aphoebantus ceylonicus* (Brunetti)

1909. *Argyramoeba ceylonica* Brunetti, *Rec. Indian Mus.*, 2 : 471, pl. 12, fig. 24.

1920. *Aphoebantus ceylonicus* (Brunetti) : Brunetti, *Fauna Brit. India*, Diptera, Brachycera, 1 : 257-258.

Material.— 1 ex., Sta. No. 1, Assam, Kaziranga, 100 m., 25. ii. 1969.

Remarks.— Known to occur in Calcutta and Kalimpong, W. Bengal ; Allahabad, Uttar Pradesh ; Pusa and Chapra, Bihar ; also in Sri Lanka.

Family SYRPHIDAE

14. *Paragus indicus* (Brunetti)

1908. *Pipizella indica* Brunetti, *Rec. Indian Mus.*, 2 : 52.
1923. *Paragus indicus* (Brunetti) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 33, pl. 1, fig. 8.

Material.— 1 ex., Sta. No. 2, Assam, Dibrugarh, Dinjan, 100 m., 27. ii. 1969.

Remarks.— The distinction between *Paragus indicus* and *P. atratus* de Meijere is arbitrary (Brunetti, 1923) ; only a detailed genitalic study of the types can determine their exact systematic position. Since the type of *P. atratus* is not available, it is not possible to conduct this study at present.

15. *Paragus atratus* de Meijere

1906. *Paragus atratus* de Meijere, *Nov. Guin. Res. V. Zool.*, 1 : 85.
1923. *Paragus atratus* de Meijere : Brunetti, *Fauna Brit. India*, Diptera, 3 : 33-34.

Material.— 1 ex., Sta. No. 2, Assam, Dibrugarh, Dinjan, 100 m., 27. ii. 1969.

Remarks.— Previously recorded from Bijrani, Nainital, Uttar Pradesh ; also from Java.

16. *Melanostoma orientale* (Wiedemann)

1824. *Syrphus orientalis* Wiedemann, *Analec. Ent.* : 36.
1923. *Melanostoma orientale* (Wiedemann) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 48-50, pl. 1, fig. 14.

Material.— (I) 1 ex., Sta. No. 2, Assam, Dibrugarh, Dinjan, 100 m., 27. ii. 1969. (II) 3 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (III) 5 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969, (IV) 1 ex., Sta. No. 9, Lohit District, Kanduk Roing,

300 m., 7. iii. 1969. (V) 1 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (VI) 4 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (VII) 2 ex., Sta. No. 13, Lohit District, Tezu, Hayliaung Road 700 m., 12. iii. 1969. (VIII) 2 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (IX) 1 ex., Sta. No. 18, Lohit District, M. T. Forest, 100 m., 17. iii. 1969.

17. *Melanostoma univittatum* (Wiedemann)

1824. *Syrphus univittatus* Wiedemann, *Analec. Ent.* : 36.
 1923. *Melanostoma univittatum* (Wiedemann) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 50-51, fig. 14.

Material.— (I) 2 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (II) 1 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (III) 1 ex., Sta. No. 13, Lohit District, Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (IV) 2 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (V) 2 ex., Sta. No. 18, Lohit District M. T. Forest, 100 m., 17. iii. 1969.

18. *Asarcina ericetorum* (Fabricius)

1781. *Syrphus ericetorum* Fabricius, *Spec. Ins.*, 2 : 245.
 1923. *Asarcina ericetorum* (Fabricius) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 63-64, pl. 1, fig. 18, pl. 2, fig. 1.

Material.— (I) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (II) 2 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iv. 1969. (III) 3 ex., Sta. No. 13, Lohit District, Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (IV) 1 ex., Sta. No. 14, Lohit District, Tezu, Lohitpur Road, 150 m., 13. iii. 1969. (V) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (VI) 2 ex., Sta. No. 17, Lohit District, Namsai, Chowkham Road, 100 m., 16. iii. 1969.

19. *Asarcina aegrota* (Fabricius)

1805. *Eristalis aegrota* Fabricius, *Syst. Antl.* : 243.
 1923. *Asarcina aegrota* (Fabricius) : Brunetti, *Fauna Brit. India*, Diptera, : 3, 64-65.

Material.— 2 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969.

20. *Syrphus serarius* Wiedemann

1830. *Syrphus serarius* Wiedemann, *Auss. Zweifl.*, 2 : 128.
 1923. *Syrphus serarius* Wiedemann : Brunetti, *Fauna Brit. India*, Diptera, 3 : 73-75, pl. 2, fig. 11-14.

Material.— (I) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (II) 2 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (III) 1 ex., Sta. No. 17, Lohit District, Namsai, Chowkham Road, 100 m., 16. iii. 1969.

21. *Syrphus balteatus* (de Geer)

1776. *Musca balteata* de Geer, *Mem. Insectes*, 6 : 116.

1923. *Syrphus balteatus* (de Geer) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 82-84, pl. 1, figs. 19, 20.

Material.— (I) 1 ex., Sta. No. 1, Assam, Kaziranga, 24. ii. 1969. (II) 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (III) 2 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (IV) 2 ex., Sta. No. 6, Lohit District, Bolung, 300 m., 4. iii. 1969. (V) 5 ex., Sta. No. 7, Lohit District, Dambuk, 5. iii. 1969. (VI) 1 ex., Sta. No. 8, Lohit District, Deopani Roing, 350 m., 6. iii. 1969. (VII) 1 ex., Sta. No. 9, Lohit District, Kandu Roing, 300 m., 7. iii. 1969. (VIII) 4 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (IX) 3 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (X) 5 ex. Sta. No. 13, Lohit District, Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (XI) 2 ex., Sta. No. 14, Lohit District, Tezu, Lohitpur Road, 150 m., 13. iii. 1969. (XII) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (XIII) 1 ex., Sta. No. 17, Lohit District, Namsai, Chowkham Road, 100 m., 16. iii. 1969.

22. *Sphaerophoria nigratarsis* Brunetti

1915. *Sphaerophoria* "Form 3 *nigratarsis*" Brunetti, *Rec. Indian Mus.*, 11 : 216.

1923. *Sphaerophoria indiana* Bigot : Brunetti, *Fauna Brit. India*, Diptera 3 : 102-103, pl. 3, figs. 1-6.

1967. *Sphaerophoria nigratarsis* Brunetti : Joseph, *Oriental Insects*, 1 (3 & 4) : 244-247, figs. 3, 4.

Material.— (I) 1 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (II) 2 ex., Sta. No. 13, Lohit District, Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (III) 2 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (IV) 1 ex., Sta. No. 17, Lohit District, Namsai, Chowkham Road, 100 m., 16. iii. 1969.

23. *Sphaerophoria vockerothi* Joseph

Sphaerophoria vockerothi Joseph, *EOS.*, 55 : 165.

Material.— (I) 2 ex., Sta. No. 7, Lohit District, Dambuk, 5. iii. 1969. (II) 2 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (III) 1 ex., Sta. No. 14, Lohit District, Tezu,

Lohitpur Road, 150 m., 13. iii. 1969. (IV) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969.

Remarks.—Originally described from Kameng Frontier and Subansiri Frontier Divisions, and Taichung, Taiwan.

24. *Baccha amphithoe* Walker

1849. *Baccha amphithoe* Walker, *List. Dipt. British Mus.*, 3 : 549.

1923. *Baccha amphithoe* Walker : Brunetti, *Fauna Brit. India*, Diptera, 3 : 126-127, pl. 3, fig. 12, text-figs. 25, 26.

Material.— 1 ex., Sta. No. 11, Lohit District, Teju, 150 m., 10. iii. 1969.

25. *Eristalis solitus* Walker

1849. *Eristalis solitus* Walker, *List. Dipt. Brit. Mus.*, 3 : 619.

1923. *Eristalis solitus* Walker, Brunetti, *Fauna Brit. India*, Diptera, 3 : 172-173.

Material.— 1 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969.

Remarks.— Common in Himalaya ; also occurring in Burma ; W. China ; Japan.

26. *Eristalis tenax* (Linnaeus)

1758. *Musca tenax* Linnaeus, *Syst. Nat.* ed. 10 : 591.

1923. *Eristalis tenax* (Linnaeus) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 173-174.

Material.— (I) 2 ex., Sta. No. 6, Lohit District, Bolung, 300 m., 4. iii. 1969. (II) 10 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969. (III) 6 ex., Sta. No. Lohit District, Namsai, Chowkam Road, 100 m., 16. iii. 1969.

27. *Megaspis zonatus* (Fabricius)

1787. *Syrphus zonatus* Fabricius, *Mant. Ins.*, 2 : 337.

1923. *Megaspis zonatus* (Fabricius) : Brunetti, *Fauna Brit. India*, Diptera, 3 : 203-204.

Material.— 1 ex., Sta. No. 7, Lohit District, Dambuk, 5. iii. 1969.

28. *Chrysotoxum baphyrus* Walker

1849. *Chrysotoxum baphyrus* Walker, *List. Dipt. British Mus.*, 3 : 542.

1923. *Chrysotoxum baphyrus* Walker : Brunetti, *Fauna Brit. India*, Diptera, 3 : 296-298, fig. 63.

Material.— (I) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (II) 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969. (III) 1 ex., Sta. No. 13, Lohit District Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (IV) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969.

Family TEPHRITIDAE

29. *Bactrocera caudata* (Fabricius)

1805. *Dacus caudata* Fabricius, *Syst. Antl.*, 16 : 276.
1913. *Bactrocera caudata* (Fabricius) : Bezzi, *Mem. Indian Mus.*, 3(3) : 97, pl. 8, fig. 8.

Material.— 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

30. *Rioxa quinquemaculata* Bezzi

1913. *Rioxa quinquemaculata* Bezzi, *Mem. Indian Mus.*, 3 : 115, pl. 9, fig. 27.
1970. *Rioxa quinquemaculata* Bezzi : Kapoor, *Oriental Insects*, 4(2) : 232.

Material.— 1 ex., Sta. No. 8, Lohit District, Deopani Roing, 350 m., 6. iii. 1969.

Remarks.—Thorax more yellowish ; hind tibiae black to a greater extent. Previously recorded from Darjeeling, W. Bengal ; also from Burma.

31. *Sphaeniscus sexmaculatus atilia* (Walker)

1849. *Trypeta atilia* Walker, *List. Dipt. Brit. Mus.*, 4 : 1021.
1970. *Sphaeniscus sexmaculatus atilia* (Walker) : Kapoor, *Oriental Insects*, 4(2) : 234.

Material.— 4 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969.

Remarks.— Widespread over the Orient including India.

Family SEPSIDAE

32. *Sepsis indica* Wiedemann

1830. *Sepsis indica* Wiedemann, *Ausseurop. Zweifl. Ins.*, 2 : 467.
1909. *Sepsis indica* (Wiedemann) : Brunetti, *Rec. Indian Mus.*, 3 : 357-359, pl. 13, figs. 9-13.

Material.— (I) 1 ex., Sta. No. 8, Lohit District, Deopani Roing, 350 m., 6. iii. 1969. (II) 1 ex., Sta. No. 9, Lohit District Kandu Roing, 300 m., 7. iii. 1969. (III) 2 ex., Sta. No. 10, Assam, Sadiya Road, 300 m., 8. iii. 1969. (IV) 1 ex., Sta. No. 13, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969.

Remarks.— The black dorsal band of thorax nearly covering the dorsum.

33. *Sepsis bicolor* Wiedemann

1830. *Sepsis bicolor* Wiedemann, *Ausseurop. Zweifl.*, 2 : 468.

1909. *Sepsis bicolor* Wiedemann : Brunetti, *Rec. Indian Mus.*, 3 : 364.

Material.— (I) 5 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969. (II) 3 ex., Sta. No. 13, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969.

Remarks.— Recorded from considerable regions of the Orient.

34. *Sepsis rufa* Macquart

1850. *Sepsis rufa* Macquart, *Dipt. Exot. Supp.*, 4 : 269.

1909. *Sepsis rufa* Macquart : Brunetti, *Rec. Indian Mus.*, 3 : 359.

Material.— 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

Family CHLOROPIDAE

35. *Rhodesiella scutellata* (Meijere)

1908. *Meroscinis scutellata* Meijere, *Tijd. Ent.*, 51 : 172.

1940. *Rhodesiella scutellata* (Meijere) : Sabrosky, *Ann. Mag. nat. Hist.*, (11) 6 : 425-426.

Material.— 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. ii. 1969.

Remarks.— Recorded from Calcutta, W. Bengal ; also from Java ; Singapore ; Formosa ; Malaysia.

Family MUSCIDAE

36. *Musca (Byomyia) ventrosa* Wiedemann

1830. *Musca ventrosa* Wiedemann, *Aussereurop. Zweifl. Ins.*, 2 : 656.

1965. *Musca (Byomyia) ventrosa* Wiedemann : Emden, *Fauna India*, Diptera, 7(1) : 60-61.

Material.— (I) 1 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (II) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969.

37. *Musca* (*Byomyia*) *sorbens* Wiedemann

1830. *Musca sorbens* Wiedemann, *Aussereurop. Zweifl. Ins.*, 2 : 418.
 1965. *Musca* (*Byomyia*) *sorbens* Wiedemann : Emden, *Fauna India*, Diptera, 7(1) : 61-63, fig. 14.

Material.— 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969.

38. *Musca* (*Byomyia*) *conducens* Walker

1860. *Musca conducens* Walker, *J. Proc. Linn. Soc.*, 4 : 138.
 1965. *Musca* (*Byomyia*) *conducens* Walker : Emden, *Fauna India*, Diptera, 7(1) : 68-69.

Material.— (I) 1 ex., Sta. No. 1, Assam., Kaziranga, 100 m., 24. ii. 1969. (II) 1 ex., Sta. No. 2, Dibrugarh, Dinjan, 100 m., 27. ii. 1969. (III) 3 ex., Sta. No. 3, Assam, Sadiya, 100 m., 28. ii. 1969 and 1. iii. 1969. (IV) 1 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (V) 2 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969.

Remarks.— Distributed throughout the Oriental and Ethiopian Regions.

39. *Musca* (*Philaematomyia*) *crassirostris* Stein

1903. *Musca crassirostris* Stein, *Mitt. Zool. Mus. Berlin*, 2 : 99.
 1965. *Musca* (*Philaematomyia*) *crassirostris* Stein : Emden, *Fauna India*, Diptera, 7(1) : 71-72, fig. 11b.

Material.— (I) 1 ex., Sta. No. 1, Assam, Kaziranga, 100 m., 24. ii. 1969. (II) 2 ex., Sta. No. 7A, Lohit District, Roing, 300 m., 5. iii. 1969 and 7. iii. 1969. (III) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969.

40. *Musca* (*Eumusca*) *lusoria* Wiedemann

1824. *Musca lusoria* Wiedemann, *Analecta ent.* : 47.
 1965. *Musca* (*Eumusca*) *lusoria* Wiedemann : Emden, *Fauna India*, Diptera, 7(1) : 79-80, pl. 1, fig. 2.

Material.— 1 ex., Sta. No. 3, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969.

41. *Musca* (*Viviparomusca*) *gibsoni* Patton and Cragg

1913. *Musca gibsoni* Patton and Cragg, *Ind. J. Med. Res.*, 1 : 14, pl. 1.
 1965. *Musca* (*Viviparomusca*) *gibsoni* Patton and Cragg : Emden, *Fauna India*, Diptera, 7(1) : 86-87. fig. 21.

Material.— (I) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (II) 1 ex., Sta. No. 9, Lohit District, Kandu Roing, 300 m., 7. iii. 1969.

42. *Musca* (*Setimusca*) *malaisei* Emden

1965. *Musca* (*Setimusca*) *malaisei* Emden, *Fauna India*, Diptera, 7(1) : 91-92.

Material.— (I) 1 ex., Sta. No. 13, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969. (II) 1 ex., Sta. No. 14, Lohit District, Tezu, Lohitpur Road, 150 m., 13. iii. 1969.

Remarks.— New to India. So far only reported from the type locality, i.e., N. E. Burma, Kambaiti.

43. *Orthellia* *fletcheri* Emden

1965. *Orthellia fletcheri* Emden, *Fauna India*, Diptera, 7(1) : 122-123, figs. 29, 30.

Material.— (I) 2 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (II) 2 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (III) 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969.

Remarks.— Some examples with 1+2 *stpl.*

44. *Orthellia* *coerulea* (Wiedemann)

1819. *Musca coerulea* Wiedemann, *Zool. Mag.*, 3 : 23.
 1965. *Orthellia coerulea* (Wiedemann) : Emden, *Fauna India*, Diptera, 7(1) : 124-125, pl. 1, fig. 4.

Material.— (I) 2 ex., Sta. No. 1, Assam, Kaziranga, 100 m., 24. ii. 1969. (II) 4 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (III) 15 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (IV) 3 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (V) 1 ex., Sta. No. 9, Lohit District, Kandu Roing, 300 m., 7. iii. 1969. (VI) 3 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (VII) 2 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969. (VIII) 5 ex., Sta. No. 13, Lohit District, Tezu, Hayliaung Road, 700 m., 12. iii. 1969. (IX) 2 ex., Sta. No. 17, Lohit District, Namsai, Chowkham Road, 100 m., 16. iii. 1969.

45. *Orthellia indica* (Robineau-Desvoidy)

1830. *Lucilia indica* Robineau-Desvoidy, *Myodairies* : 453.
1965. *Orthellia indica* (Robineau-Desvoidy) : Emden, *Fauna India*, Diptera, 7(1) : 126-127, pl. 1, fig. 3.

Material.— (I) 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (II) 1 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (III) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 14. iii. 1969.

46. *Orthellia claripennis* Malloch

1923. *Orthellia claripennis* Malloch, *Ann. Mag. nat. Hist.*, (9) 12 : 515.
1965. *Orthellia claripennis* Malloch : Emden, *Fauna India*, Diptera, 7(1) : 130-131.

Material.— (I) 3 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (II) 5 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (III) 2 ex., Sta. No. 6, Lohit District, Bolung Roing, 300 m., 4. iii. 1969. (IV) 1 ex., Sta. No. 8, Lohit District, Deopani Roing, 350 m., 6. iii. 1969. (V) 1 ex., Sta. No. 9, Lohit District, Kandur Roing, 300 m., 7. iii. 1969. (VI) 8 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969. (VII) 2 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969. (VIII) 1 ex., Sta. No. 13, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969.

47. *Orthellia chalybea faceta* (Enderlein)

1934. *Neomyia facetā* Enderlein, *Sitzber Ges. naturf. Fr.*, 1934 : 420.
1965. *Orthellia chalybea faceta* (Enderlein) : Emden, *Fauna India*, Diptera, 7(1) : 131-132, fig. 31.

Material.— (I) 12 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (II) 3 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969. (III) 3 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (IV) 1 ex., Sta. No. 8, Lohit District, Deopani Roing, 350 m., 6. iii. 1969. (V) 1 ex., Sta. No. 9, Lohit District, Kandur Roing, 300 m., 7. iii. 1969. (VI) 1 ex., Sta. No. 12, Lohit District, Digaru Road, 150 m., 11. iii. 1969.

48. *Stomoxys calcitrans* (Linnaeus)

1758. *Conops calcitrans* Linnaeus, *Syst. Nat.* ed. 10 : 604.
1965. *Stomoxys calcitrans* (Linnaeus) : Emden, *Fauna India*, Diptera, 7(1) : 160-161, figs. 35-37.

Material.— (I) 1 ex., Sta. No. 2, Assam, Dibrugarh, Dinjan, 100 m., 27. ii. 1969. (II) 6 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (III) 1 ex., Sta. No. 7, Lohit District, Dambuk, 5. iii. 1969. (IV) 1 ex., Sta. No. 15, Lohit District, Namsai, 100 m., 15. iii. 1969.

49. *Haematobia (Bdellolarynx) sanguinolenta* (Austen)

1909. *Bdellolarynx sanguinolentus* Austen, *Ann. Mag. nat. Hist.*, (8) 3 : 290.
1965. *Haematobia (Bdellolarynx) sanguinolenta* (Austen) : Emden, *Fauna India*, Diptera, 7(1) : 172-173, figs. 42, 43.

Material.— 1 ex., Sta. No. 4, Lohit District, Santipur, 100 m., 2. iii. 1969.

Remarks.— Femora dark except their apices. Widely distributed in India ; also recorded from Formosa ; China.

50. *Lyperosia (Lyperosia) exigua* de Meijere

1903. *Haematobia exigua* de Meijere, *Meded. Profest. Oost-Java*, (3) No. 44 : 17.
1965. *Lyperosia (Lyperosia) exigua* de Meijere : Emden, *Fauna India*, Diptera, 7(1) : 176-187, fig. 44, pl. 1, fig. 9.

Material.— 2 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

51. *Atherigona destructor* Malloch

1923. *Atherigona destructor* Malloch, *Ann. Mag. nat. Hist.*, (9) 12 : 185.

Material.— (I) 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969. (II) 2 ex., Sta. No. 5, Lohit District, Sunpura, 100 m., 3. iii. 1969. (III) 1 ex., Sta. No. 11, Lohit District, Tezu, 150 m., 10. iii. 1969. (IV) 1 ex., Sta. No. 13, Lohit District, Hayliaung Road, 700 m., 12. iii. 1969.

Remarks.— A common pest of cereal crops and grasses ; widely distributed in India.

52. *Atherigona bituberculata* Malloch

1925. *Atherigona bituberculata* Malloch. *Mem. Dept. Agri. India* (Ent. Ser.), 8 : 119, pl. 18, figs. 13a-d.

Material.— 1 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

Remarks.— Recorded from Pusa, Bihar ; Coimbatore, Saidapet and Tanjore, Tamil Nadu ; Wynaad, Kerala ; also from Java ; Philippines.

Family CALLIPHORIDAE

53. *Lucilia porphyria* (Walker)

1857. *Musca porphyria* Walker, *J. Proc. Linn. Soc. Lond.*, 1 : 24.
 1940. *Lucilia porphyria* (Walker) : Senior-White, Aubertin and Smart, *Fauna Brit. India*, Diptera, 6 : 53-54, fig. 25.

Material.— 1 ex., Sta. No. 10, Lohit District, Sadiya Road, 300 m., 8. iii. 1969.

Remarks.— Widely distributed in Himalaya ; also reported from Sri Lanka ; Malaya Peninsula ; China ; Hong Kong ; Sumatra ; Java ; Philippine Islands ; Japan ; Australia.

54. *Chrysomya pinguis* (Walker)

1858. *Lucilia pinguis* Walker, *Trans. Ent. Soc. London*, 4 : 213.
 1940. *Chrysomya pinguis* (Walker) : Senior-White, Aubertin and Smart, *Fauna Brit. India*, Diptera, 6 : 144-145, fig. 69.

Material.— 2 ex., Sta. No. 14, Tezu, Lohitpur Road, 150 m., 13. ii. 1969.

Remarks.— Recorded from Darjeeling, W. Bengal ; Simla, Himachal Pradesh ; Khasi Hills, Shillong and Mishmi Hills, Meghalaya ; Coonoor, Tamil Nadu ; also from Sri Lanka ; Burma ; Indonesia ; Malaysia ; China ; Hongkong.

Family HIPPOBOSCIDAE

55. *Hippobosca longipennis* Fabricius

1805. *Hippobosca longipennis* Fabricius, *Syst. Antliat.* : 338.
 1967. *Hippobosca longipennis* Fabricius, Maa, *Pacific Insects*, 9(4) : 743-744, fig. 7.

Material.— 3 ex., Sta. No. 3, Assam, Sadiya, 100 m., 1. iii. 1969.

SUMMARY

It includes 55 species of Diptera, of which one is new to India, i.e., *Musca* (*Setimusca*) *malaisei* Emden (Muscidae), belonging to 13 families. The total number of examples studied are 314.

ACKNOWLEDGEMENTS

We are grateful to Dr. A. P. Kapur, Director and Sri K. S. Pradhan, Superintending Zoologist, Zoological Survey of India, Calcutta, for placing the material at our disposal and for their encouragement during the course of this work.

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A CONTRIBUTION TO THE SYSTEMATICS OF *ARIUS*
TENUISPINIS DAY, 1877 (PISCES : ARIIDAE)

By

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(With 1 Text-figure)

INTRODUCTION

The marine cat-fish, *Arius tenuispinis* Day contributes an important commercial fishery along the Maharashtra and Andhra coast of India. The nomenclatural status of this species is, however, in need of clarification and revision.

Day (1877) described *Arius tenuispinis* on a badly preserved specimen, 350 mm in length, from Bombay and remarked "*Arius layardi* Günther, from Ceylon, were it not that it has two pear-shaped patches of granular teeth placed far back, agrees with the above, but a series of examples is necessary to prove whether they are identical or not" *Arius layardi* was described by Günther (1866) on a 280 mm long specimen; the type was stated to have come from Ceylon and is still preserved in the British Museum (Natural History) (Dr. G. Palmer — personal communication).

Chandy (1954) also considered *Arius tenuispinis* Day as probably identical with *Arius layardi* Günther and gave a detailed description of *A. tenuispinis* based on topotypes and on specimens from Puri (Orissa) and remarked "Since Day's account has been based on a badly preserved specimen, there is no type specimen of *T. tenuispinis* in his collection in the Indian Museum and, therefore, the author's recent collection of *Tachysurus tenuispinis* has been registered in the Indian Museum"

Munro (1955) did not list either *Arius layardi* Günther or *Arius tenuispinis* Day from Ceylon but remarked "*Arius tenuispinis* Day has been doubtfully listed from Ceylon"

In the course of preparation recently of a catalogue of the fishes figured in Day's (1875-1878) *Fishes of India* and deposited in the Zoological Survey of India, the unique holotype of *Arius tenuispinis* Day, 1877, has been discovered. The type registered as *Hemipimelodus enuispinis* agrees exactly with Day's (1877) description and the data

on the specimen label and in the Registration register are consistent.

Examination of the holotype of *Arius tenuispinis* Day surprisingly revealed the species to have two distinct pear-shaped patches of teeth on the palate (Text-fig. 1). The type agrees very well with the original description and figure of *Arius layardi* Günther in all the salient characters and in the absence of any differentiating character, these two species are considered identical. It is unfortunate that though *Arius layardi* Günther is a senior synonym of *Arius tenuispinis* Day, the former specific name cannot be used under provisions of Article 23(b) of the *International Code of Zoological Nomenclature* (1961) and should be considered a *nomen oblitum*.

SYSTEMATIC ACCOUNT

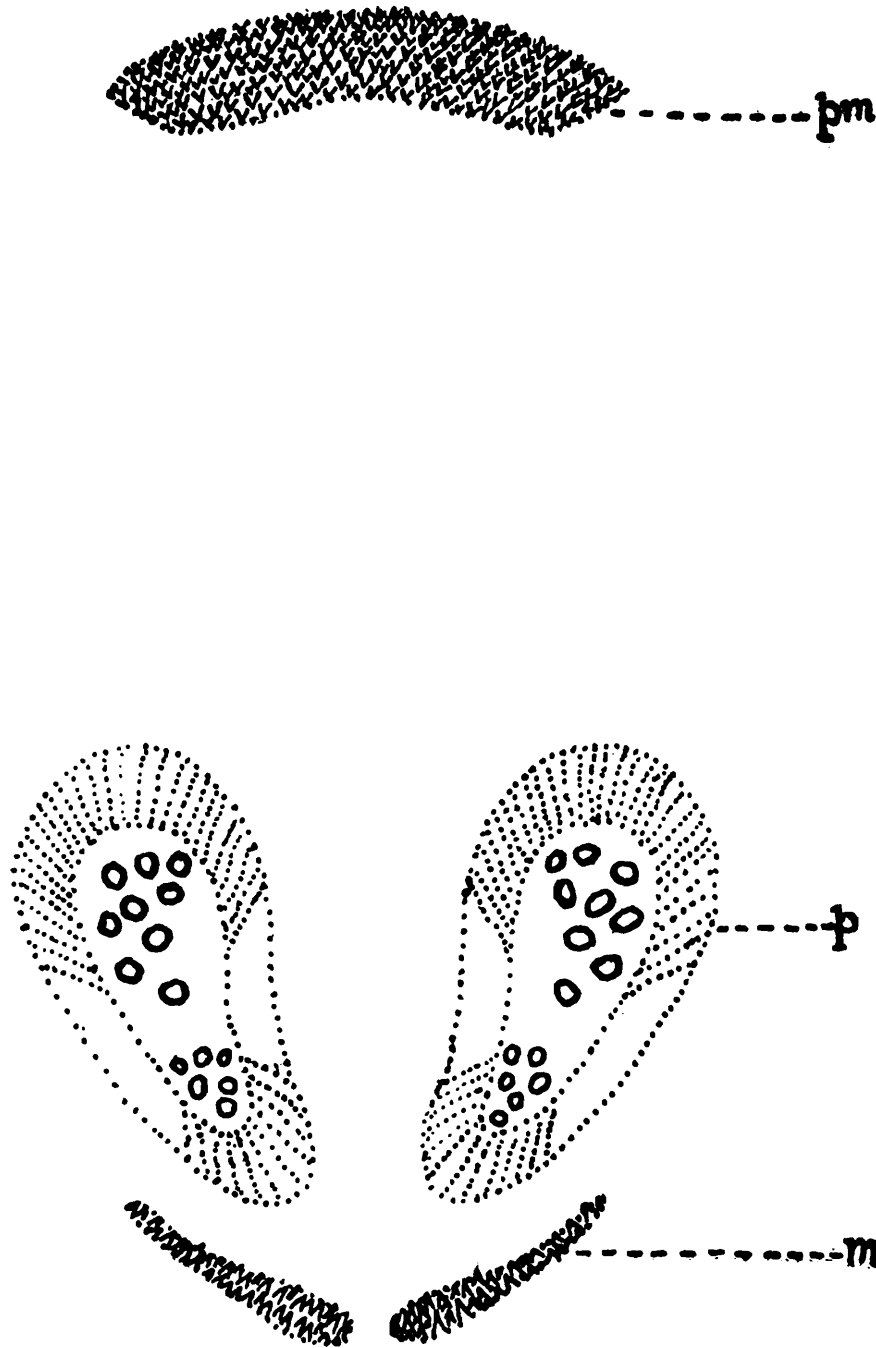
Tachysurus tenuispinis (Day, 1877)

1866. *Arius layardi* Günther, *Ann. Mag. nat. Hist.*, (3) 18 (108) : 473, pl. 15 (type loc. : Ceylon).
 1877. *Arius tenuispinis* Day, *Fishes of India* : 466, pl. 107, fig. 5 (type loc. : Bombay).
 1889. *Arius tenuispinis* : Day, *Fauna British India, Fish*, 1 : 187.
 1954. *Tachysurus tenuispinis* : Chandy, *Rec. Indian Mus.*, 51 : 13, pl. 2, fig. 8.

Diagnosis.—*Tachysurus* with palatal teeth in two pear-shaped patches (Text-fig. 1), much convergent behind and placed far back almost at the posterior extremity of the buccal cavity; palatine teeth globular. Vomerine teeth absent. Premaxillary teeth villiform, band four and a half times as long as broad; distance between premaxillary band and palatine patches roughly equal to the distance between anterior nares and anterior border of eye.

Head depressed, broader than high. Snout much depressed, angular; upper jaw somewhat prominent. Eye diameter 7.0 in head length. Median fontanelle commences at the level of the posterior nares as a narrow, well marked groove, almost reaching to occipital crest. Occipital process prominent with crenulated keel, posteriorly it reaches narrow V-shaped basal bone of dorsal fin. Skin of head on either side of fontanelle and behind eyes with few granulations. Three pairs of barbels; maxillary barbels extend to pectoral base or slightly shorter, outer and inner mandibulars do not reach gill opening. Dorsal spine slender, nearly as long as head excluding snout. Pectoral spine as long as dorsal spine but slightly stronger. Gill rakers 4 + 1 + 8 — 9, lanceolate.

The fullest description of the species remains that of Chandy (1954).



Text-fig. 1. Diagrammatic representation of dentition in the holotype of *Arius tenuispinis* Day showing premaxillary band (pm), palatal patches (p) and mandibular band (m).

Material examined.—(i) 1 ex., 280 mm in standard length (SL); Bombay; Dr. F. Day; Holotype of *Arius tenuispinis* Day, original of pl. 107, fig. 5; Zoological Survey of India Regd. No. 482. (ii) 1 ex., 96 mm SL; Puri (Orissa); ZSI Regd. No. F 3356/1; determined *Tachysurus tenuispinis* (Day) by Chandy (1954). (iii) 1 ex., 99 mm SL; Puri; Dec. 1908; ZSI Regd. No. F 5825/1; determined *T. tenuispinis* (Day) by Chandy (1954).

Distribution.—Sri Lanka and India. Contributes an important fishery along the Andhra and Maharashtra coast of India.

REMARKS

It is surprising how Day (1877), a very careful ichthyologist, failed to notice the two distinct pear-shaped patches of palatal teeth in his specimen from Bombay which compelled him, with much hesitation, to accommodate the badly preserved specimen in a new species. The present study of the type of *Arius tenuispinis* Day confirms Day's (1877) view that *Arius tenuispinis* is identical with *A. layardi* Günther. This study also confirms Chandy's (1954) contention of errors in the original description that the type of *Arius tenuispinis* has palatal teeth and hence does not belong to the genus *Hemipimelodus* Bleeker but to the genus *Tachysurus* Lacepede.

Tachysurus tenuispinis (Day) is a fairly large fish with the characteristic contours of the body of marine cat-fishes. The species is closely allied to *T. crossoccheilus* (Bleeker) and *T. argylopleuron* (Valenciennes), both Malayan species, from which it differs in the absence of vomerine teeth and in possessing longer maxillary barbels. Among the Indian species it is most closely related to *T. satpuranus* (Chaudhuri, 1916) from which it may be distinguished in the absence of dorsal tubercles and weak (*vs.* strong) dorsal and pectoral spines.

SUMMARY

Arius tenuispinis Day, 1877 has been shown to be conspecific with *Arius layardi* Günther, 1866 on study of the recently discovered holotype of the former species. The latter specific name, however, cannot be used for this important commercial cat-fish under provisions of Article 23(b) of the *International Code of Zoological Nomenclature* (1961) and Günther's *Arius layardi* should be considered a *nomen oblitum*.

ACKNOWLEDGEMENTS

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DISTRIBUTION OF THE GENUS *CYCLOCOELUM*
BRANDES, 1892 ON HOST ORDERS AND
ITS BEARING ON THEIR INTER-
RELATIONSHIPS

By

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(With 1 Table)

Digenetic trematodes are endoparasitic forms inhabiting in adult stages the vertebrates, and invertebrates and lower vertebrates in larval forms. The trematodes exhibit host-specificity of varying degrees. Host specificity is well marked in Monogenetic trematodes while in digenetic trematodes, it is more pronounced in larval condition. However, the fact that certain genera of these trematodes have not been recorded from some host orders inhabiting the same ecological niche as others harbouring these parasites suggests incipient host-specificity in adult trematodes also. To cite a concrete example, species of the genus *Cyclocoelum* Brandes, 1892, known to parasitise as adults, birds of the orders Anseriformes, Gruiformes, Charadriiformes etc. (*vide infra*), are not known from the Ciconiiformes which share the same habitat as the orders mentioned above (Table 1).

The intricate relationship between the host and its parasite has been utilized by parasitologists in the study of the phylogeny of hosts and their parasites, ancient migratory routes and palaeogeological land connections etc. An exhaustive review was published by Metcalf (1929) and the principle has been well taken advantage of by several entomologists in Phthiraptera (Hopkins, 1942, 1949, Clay, 1950 a,b; 1951, Eichler, 1949, Lakshminarayana, 1968, 1970 a,b). In recent years Baer (1951), Cameron (1952, 1964), Manter (1955, 1963, 1965), Sindermann (1937), Stunkard and Gandal (1965), Szidat (1961 a,b) have paid attention on zoogeography and phylogeny of the hosts on the basis of their trematode parasites.

A brief discussion on the distribution of the genus *Cyclocoelum* Brandes, 1892 on different avian host orders and its bearing on their inter-relationships are given here.

The genus *Cyclocoelum* Brandes, 1892 (Family Cyclocoelidae) has been thoroughly revised by Dubois (1959). In the course of

present work six species of this genus have been studied on five host species belonging to two orders.

The genus *Cyclocoelum* (*sensu* Dubois, op.cit.) contains three subgenera viz., *Cyclocoelum* (*sensu. str.*), *Haematotrephus* and *Hyptiasmus*. The genus chiefly occurs on Phoenicopteriformes, Anseriformes, Galliformes, Charadriiformes, Podicipitiformes, Piciformes and Passeriformes. Attention has been paid here on the distribution of the genus on different groups of these host orders in the light of Dubois' revisionary work and present records. It is interesting to find that some of the conclusions arrived at agree with those drawn from other parasitological, palaeontological, evolutionary and taxonomic contribution on these host orders. The distribution of the known species on the different host orders is given in Table 1. Since Charadriiformes comprise most of the host groups, the following discussion is chiefly based on it.

Table 1.— Showing the distribution of the genus *Cyclocoelum* on bird-hosts.

Species of genus <i>Cyclocoelum</i>	Bird-host orders and families
1. <i>Cyclocoelum</i> (<i>Cyclocoelum</i>) <i>mutabile</i>	Jacaniidae, Charadriidae (Charadriiformes), Rallidae (Gruiformes), Phasianidae (Galliformes)
2. <i>C. (C.) ovopunctatum</i>	Charadriiformes
3. <i>C. (C.) obscurum</i>	Charadriiformes, Rallidae, Passeriformes
4. <i>C. (C.) phasidi</i>	Galliformes
5. <i>C. (C.) erythropis</i>	Charadriiformes
6. <i>C. (C.) theophili</i>	<i>Phoenicopus</i> (Phoenicopteriformes)
7. <i>C. (C.) vogeli</i>	Galliformes
8. <i>C. (Haematotrephus) gendrei</i>	Jacaniidae (Charadriiformes)
9. <i>C. (H.) lanceolatum</i>	Recurvirostrinae, Charadriidae, Scolopacinae
10. <i>C. (H.) tringae</i>	Scolopacinae
11. <i>C. (H.) phaneropsolum</i>	Scolopacinae
12. <i>C. (H.) brazilianum</i>	Scolopacinae
13. <i>C. (H.) kossacki</i>	Scolopacinae, Recurvirostrinae
14. <i>C. (H.) jaenschi</i>	Podicipediformes
15. <i>C. (Hyptiasmus) arcuatum</i>	Anseriformes
16. <i>C. (Hy.) robustum</i>	Anseriformes
17. <i>C. (Hy.) magnum</i>	Anseriformes
18. <i>C. (Hy.) oculieum</i>	Rallidae
19. <i>C. (Hy.) magnipoles</i>	Charadriiformes
20. <i>C. (Hy.) skrjabini</i>	<i>Grus</i>
21. <i>C. (Hy.) antigonis</i>	<i>Grus</i>
22. <i>C. (Hy.) ominosum</i>	<i>Grus</i>
23. <i>C. (Hy.) elongatum</i>	Passeriformes, Piciformes, Galliformes
24. <i>C. (Hy.) vagum</i>	Galliformes

From the distribution point of view, the subgenus *Cyclocoelum* (*sensu. str.*) occurs chiefly on Phoenicopteriformes, Galliformes, Gruiformes, Charadriiformes, Passeriformes; the subgenus *Haematotrepheus* on Podicipitiformes, Charadriiformes and subgenus *Hyptiasmus* occurs on Anseriformes, Galliformes, Gruiformes, Pici-formes, Passeriformes and a single genus of Charadriiformes.

CHARADRIIFORMES

Mayr and Amadon (1951) included the families Jacanidae, Thinocoridae, Chionididae, Dromadidae, Burhinidae, Haematopodidae, Charadriidae (subfamily Charadriinae, Scolopacinae, Phalaropinae, Recurvirostrinae, Rostratulinae), Glareolidae, Laridae (subfamilies Stercorariinae, Larinae, Sterninae, Rhynchopinae) and Alcidae under the order Charadriiformes. Recurvirostrinae has, however, been raised to family rank by Ripley (1961). Of these families Jacanidae, Charadriidae and Recurvirostridae are known to have been infected by these parasites.

Charadriidae : The family Charadriidae is divided into three subfamilies, namely Charadriinae, Scolopacinae and Phalaropinae (*vide* Ripley, 1961).

Lakshminarayana (1970b) has proposed what he calls "Hopkins' Principle" which enunciates that one correspondence between the lice of two hosts, whose hypothetical relationship is under examination means very little; two such correspondences establish a probability that it may be genuine; and that three correspondences come very close to certainty. This principle may also hold good for other groups of parasites. Using this principle it appears that Scolopacinae and Charadriinae are closely related because they share atleast four species of the same parasites. Clay (1962) on the basis of the distribution of mallophagan genus *Actornithophilus* states that :

"all the genera of the Charadriidae form a related group with a gap between the Vanellinae *sensu* Peters and the Charadriinae ; and follows Rock's contention of the close relationship of the 'genera' comprising the Charadriinae on one side and the Vanellinae on the other, but differs in suggesting that *Vanellus* is somewhat distinct from the rest of the Vanellinae."

From the helminthological point of view it seems that the so called gap between *Vanellus* and the members of Scolopacinae is not much as compared to the other Charadriinae, in which *Vanellus* is also included. Among the members of the Scolopacinae, many genera share common parasitic fauna and it may be attributed either to the feeding habit and/or from a common descent. Peters (1934), Mayr and Amadon (1951) and Biswas (1953) consider Recurvirostrinae as a subfamily of Charadriidae while some authors like Ripley (*op.cit.*)

as a family. Three species of parasites are shared by the members of Recurvirostridae with Charadriinae and Scolopacinae. This shows that Recurvirostridae has closer relationship with Charadriidae. Even Clay (op.cit.) considers that species of the *Actornithophilus* parasitic on Recurvirostridae has similarities with those present on Charadriinae except *Ibidorhyncha* (Sf : Ibidorhynchinae, F. Recurvirostridae).

Jacanidae : Two species of the parasite, namely *Cyclocoelum* (*Cyclocoelum*) *mutabile* and *Cyclocoelum* (*Haematotrephus*) *gendrei** are known from Jacanidae. Of these the former is known extensively on Rallidae (Gruiformes) and two genera of Charadriidae (*Tringa*, Scolopacinae; *Vanellus*, Charadriinae) and *Gallus* (Galliformes). It is interesting to note that *Jacana*, the host of *C. (C.) mutabile*, shares the parasite with a number of genera of Rallidae, suggesting its relationship closer to Rallidae than Charadriiformes in which the family Jacanidae is normally placed. This fully endorses the evidences derived from the Mallophaga that Jacanidae is more closely related to Rallidae and perhaps the connecting family between the two host orders (Clay, 1950b; Lakshminarayana, 1970a). The single record of *C. (C.) mutabile* on *Gallus* may be accidental.

Recurvirostriidae : Two genera of this family, namely *Recurvirostra* and *Himantopus* are known to have trematode infestation. Restricting to the parasites of the genus *Cyclocoelum*, *C. (C.) obscurum* occurs on the former and *Cyclocoelum* (*Haematotrephus*) *kossacki* and *Cyclocoelum* (*Hyptiasmus*) *magniproles* on the latter. *Cyclocoelum* (*Cyclocoelum*) *obscurum* is very common on Scolopacinae as also *Cyclocoelum* (*Haematotrephus*) *kossacki* and this clearly suggests the probable relationship of *Himantopus* with Scolopacinae, though the latter has its own distinct parasite species also, supporting contention of Mayr and Amadon (1951) contrary to Ripley (1961).

GRUIFORMES

The following families are included under Gruiformes by Mayr and Amadon (1951) : Cariamidae, Psaphiidae, Gruidae, Aramidae, Eurypygidae, Heliornithidae, Rhynochetidae, Otididae, Rallidae, Mesoenatidae and Turnicidae.

Lowe (1931) considers that amongst Gruiformes the Gruidae is more closely related to Charadriiformes than Rallidae and hence suggested the division into Rallimorphae and Telmatomorphae.

*While describing *C. (H.) gendrei*, Dubois (1959) misspelt the host genus *Actophilornis* as *Arctophilornis*.

Clay (1950b) and Lakshminarayana (1970a) also agree with Lowe's opinion but with the addition of Jacanidae, (Clay, 1951), Jacanidae and Eurypygidae (Lakshminarayana, 1970a, b). So far only Rallidae and Gruidae have been reported as the hosts of the genus *Cyclocoelum*. Chandler (1916) states that :

"In general it seems best to consider the Gruidae, Aramidæ and Rallidæ as off-shots from a primitive stem leading to the Charadriiformes, while the Otididae, Phosphiidae and possibly Aramidæ, are more probably early off-shots from the stem leading to the Columbæ and Galli."

The distribution of *Cyclocoelum* among Gruidae, Rallidae, Charadriiformes and also Galliformes in a way supports Chandler's contention.

Rallidae : *Cyclocoelum* (*Cyclocoelum*) *mutabile* on *Fulica*, *Gallinula* and *Porphyrio* : *C. (C.) obscurum* on *Fulica* and *Cyclocoelum* (*Hyptiasmus*) *oculeum* on *Fulica*, *Porzana* and *Gallinula* are the known parasite records. None of these parasite species are shared by Gruidae though they occur on other Charadriidae. It indicates the distinctness of Gruidae from Rallidae and corroborates the evidences arrived at on the basis of Mallophaga studies (*vide supra*). *C. (C.) mutabile* has also been reported on Galliformes and *C. (C.) obscurum* on Muscipidae (Passeriformes). Members of the same generic complex of Mallophaga are also known from these two host orders (Clay, 1950b, 1953; Carriker, 1944, 1966; Lakshminarayana, 1968, 1970a,b). Carriker (1966) is of the opinion that the mallophagan genus *Furnaricola* (a member of *Rallicola-complex*) on Passeriformes should be separated into a distinct genus. Lakshminarayana (1970a) considers the similarity of *Rallicola* and *Furnaricola* may be either parallel evolution or secondary infestation and establishment.

Gruidae : Three species viz., *Cyclocoelum* (*Hyptiasmus*) *ominosum*, *C. (Hy.) skrjabini* and *C. (Hy.) antigonis* are known from *Grus*. Up till now these species are not known on any other host orders, although the subgenus *Hyptiasmus* is known mainly on Anseriformes, Rallidae, Charadriiformes, Piciformes, Passeriformes and Galliformes. The mallophaga of Gruidae are more closely related to Charadriiformes than to those of Rallidae (Clay, 1950b; Lakshminarayana, 1970a).

ANSERIFORMES

The following trematodes are recorded from Anseriformes : *Cyclocoelum* (*Hyptiasmus*) *arcuatum* on *Anser*, *Bucephala*, *Clangula*, *Melanitta*, *Somateria*, *Aythya*, *Anas*, *Mergus*; *Cyclocoelum* (*Hyptiasmus*) *robustum* on *Aythya*, *Anser* and *Cyclocoelum* (*Hyptiasmus*) *magnum* on *Chenopsis*. The occurrence of the same species of parasite on members of different host subfamilies within the order indicates that possibly these species have not yet attained host specificity and

the commonness of infection may be due to similar habits and habitat of the host genera.

PHOENICOPTERIFORMES

Cyclocoelum (*Cyclocoelum*) *theophili* is the only species reported on *Phoenicopterus*. The position of this host order is problematical. Many authors include this as a suborder under Ciconiiformes (Peters, 1931) and family (Ripley, 1961; Wetmore, 1951), others treat it as a separate order (*vide* Mayr and Amadon, 1951). The members of this order show characters of both Ciconiiformes and Anseriformes. It is generally argued that this similarity may be due to convergence. However, Hopkins (1942) and Clay (1950b, 1962) suggested Anseriformes affinities on the basis of the distribution of Mallophagan evidence. It is curious that the genus *Cyclocoelum* also occurs in Anseriformes and none of the Ciconiiform hosts have so far been reported.

GALLIFORMES

Five species viz., *Cyclocoelum* (*Cyclocoelum*) *mutabile* on *Gallus*; *Cyclocoelum* (*Cyclocoelum*) *phasidi* on *Guttera*; *Cyclocoelum* (*Cyclocoelum*) *vogeli* on *Francolinus*; *Cyclocoelum* (*Hyptiasmus*) *elongatum* on *Gallus*; *Cyclocoelum* (*Hyptiasmus*) *vagum* on *Chrysolophus* and *Syrnaticus* are known parasites in this host order. Of these *C* (*C.*) *mutabile* chiefly occurs on Rallidae, Jacanidae, Charadriidae; *C.* (*Hy.*) *elongatum* chiefly on Piciformes and Passeriformes. Isolated members of the same generic complex of mallophaga are known on Galliformes, Gruiformes and Passeriformes (*vide* Clay, 1950b; Lakshminarayana, 1970a) although the occurrence of *Furnaricola* (a member of *Rallicola*-complex) on Passeriformes may be due to parallel evolution.

PODICIPITIFORMES

Cyclocoelum (*Haematotrephus*) *jaenschi* is known on *Poliiocephalus* and *Podiceps*. Members of the subgenus *Haematotrephus* are also known from Charadriiformes. It is interesting to find similar mallophagan genera on this order, Gruiformes and Charadriiformes (Clay, 1950; Eichler, 1952; Lakshminarayan, 1970a). Chandler (1916) states that :

"In the structure of the breast feathers and down, loons come much nearer the Sphenisciformes than do grebes, and they are also more similar to the Procellariiformes. The grebes appears to represent a separate offshoot of the group, and have a condition of breast feathers which is different from that of any other birds except some of the Alcidae."

Lakshminarayana (1970a) attributed the occurrence of the same parasitic genera of mallophaga as secondary infestation due to similar feather structure between the former and some of the members of the Charadriiformes. In the present case also it may be likely that due to similar habitat a member of the subgenus parasitised a member of the host order in the by-gone days and has undergone sufficient degree of distinction.

PICIFORMES

Only one species, *Cyclocoelum (Hyptiasmus) elongatum* is known from *Megalaima*. It is not possible to draw any conclusion from this stray record.

PASSERIFORMES

Cyclocoelum (Cyclocoelum) obscurum in *Zoothera* (Muscicapidae); *Cyclocoelum (Hyptiasmus) elongatum* on *Cyanopica*, *Cissa*, *Pica*, *Dumetella* (Corvidae) are known in this order. The former is well known on many members of Charadriiformes and Rallidae, while the latter is known on a single genus each of Galliformes and Piciformes. It is not possible to assess the nature of infestation due to varied feeding habits of this host order.

SUMMARY

The distribution of the genus *Cyclocoelum* Brandes, 1892 in bird host orders has been discussed. The inter-relationships of the bird host orders have been discussed on the basis of the distribution of parasites.

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ON A COLLECTION OF FISH FROM THE MAHANADI

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(With 1 Text-figure)

INTRODUCTION

The collection of fish reported here was made by the senior author during October—November, 1954. The collections were made in the Mahanadi from its stretch at Cuttack to Seorinarayan in Madhya Pradesh, a distance of about 360 kilometres. The report is interesting in the fact that there are new records of some species from this drainage of which previous workers failed to obtain specimens. Hora (1949) published a list of 43 species from the headwaters of the Mahanadi based on a collection made by Dr. H. S. Rao in 1939, in the Raipur district. Some of the localities visited by Dr. Rao are now above the Hirakud Dam. Chauhan (1947) gave a list of 54 species from River Tel, a tributary of the Mahanadi. Job, David and Das (1955) surveyed the Mahanadi for a stretch of 65 miles and recorded 86 species from different localities both above and below the Hirakud Dam; however they did not collect from any locality beyond Mahadeopalli, which is about 50 kilometres above the dam. The present collection reports for the first time of species from Seorinarayan and Chandrapur, both in Madhya Pradesh, the farthest point, Seorinarayan, being 150 km. above the Hirakud Dam.

LIST OF LOCALITIES

Station 1. Anicut on the Mahanadi, Cuttack (Orissa State).

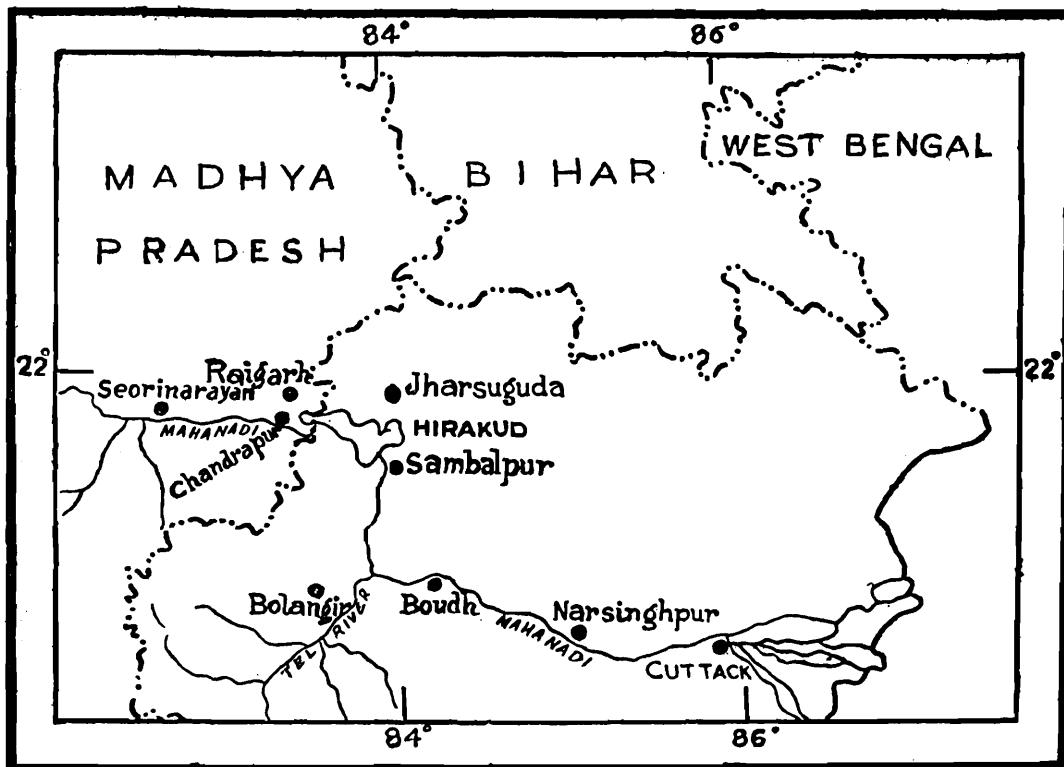
A strong masonry structure over which a fair-weather road is constructed during the dry season. Mahanadi at this place was about 0.6 km. wide and about 22 metres deep. Water was rapid, clear and bottom invisible. Temperature of water 30°C. Fishing was mainly done with line and rod, and cast-net. More prevalent was trap-netting. Large quantities of catfish were obtained by fishermen by placing strong nets, traps etc., across the rushing water at the sluice gates.

Station 2. Narsinghpur on the Mahanadi (Orissa State).

An elevated small town surrounded by hills, about 300 metres above sea level. It is situated about 122 km. north-west to Cuttack. The river was dry at the time of collection with a thin stream in the middle. Bank of the river was rocky, with sparse vegetation. Fishing was mainly done by bamboo-basket traps at suitable places in the meandering stream with weeds and shrubs placed in front of the traps to serve as bait and lure for the fish. In small puddles, and rock-pools only the weeds and shrubs were left overnight in which the fishes sought shelter and they were removed the next-day.

Station 3. A pond adjoining the fishery office at Narsinghpur.

A shallow pond with marginal vegetation mainly comprising of low shrubs and herbs. Water was muddy and warm at about 4 p.m.



Text-fig. 1. Map of the Mahanadi river with the localities where from the collections have been made.

Station 4. Mahanadi at Sambalpur near Kamli Bazar (Orissa State).

Water very clear and not very deep, hardly about 3 metres deep. Bank vegetation was sparse with boulders and rocks strewn all around. Bottom of the river was with shingles and pebbles. Fishing was mainly done by hooks and line. A long parachute wire was stretched across the river with 90 hooks of $\frac{1}{4}$ to $\frac{1}{2}$ inch size suspended from it at equal intervals. Three more such lines were placed at about 100 to 200 metres distance. These lines were never

taken out completely ; only the catch was removed from the hooks every day. Many catfishes were obtained on these lines. Occasionally, small baskets were attached to bamboo poles and left under water submerged overnight. Fishes caught were kept in the bamboo baskets with narrow mouth and kept submerged in water which also preserved the fish alive.

Station 5. Ramsagar tank, near the market and Bus stand, Sambalpur (Orissa State).

Water very clear, teeming with life. Fishing and bathing prohibited by the authorities. Fishing was done by special permission.

Station 6. Pension Para tank, near Circuit House, Sambalpur (Orissa State).

Water greenish, plenty of fishing with hook and line by local people prevalent. Said to be a good tank for *singi* fish.

Station 7. Burla, small tank opposite United Construction Company's quarry.

Water very shallow, muddy and with a clay bottom. Fishermen dam a portion of the pond and after emptying the water catch fish with hand.

Station 9. Mahanadi below the Hirakud Dam.

Current very rapid, running over boulders and rocks. No netting was possible, from the main stream, but a side channel running into a pool-like expanse was selected for fishing. Water current here was not very fast. Bottom was with weeds.

Station 10. Hirakud, a pond near the main road leading to the batching plant of the Dam.

Pond not very deep, with water only about a metre deep. Vegetation mainly aquatic plants such as Lily, Vallisneria, Hyacinths etc. Fishing was done with cast-net.

Station 11. Raigarh (Madhya Pradesh). Purchased from the fish market.

Station 12. Mahanadi at Chandrapur (Madhya Pradesh).

River smooth flowing with no rocks or boulders. Fishing was done mainly by long line and hooks.

Station 13. Mahanadi at Seorinarayan (Madhya Pradesh).

144 km. west to Raigarh, Mahanadi at Seorinarayan was not very broad at the time of collection and the stream was slow and shallow with water hardly above 2 meters. Fishing was done at Singol, a small village about two kilometres further west where the river was deep. *Benthua Jal* was used extensively for fishing.

The following species were collected from localities above the Hirakud Dam.—

1. *Bariulus barna* (Hamilton)
2. *Barilius bendelisis* (Hamilton)
3. *Barilius vagra* (Hamilton)
4. *Esomus danrica* (Hamilton)
5. *Labeo rohita* (Hamilton)
6. *Puntius gelius* (Hamilton)
7. *Ompok bimaculatus* (Bloch)
8. *Wallago attu* (Schenider)
9. *Xenentodon cancila* (Hamilton)
10. *Ambassis ranga* (Hamilton)
11. *Badis badis* (Hamilton)

The following species were collected from localities below the Hirakud Dam.—

1. *Goniolosa manmina* (Hamilton)
2. *Notopterus notopterus* (Pallas)
3. *Danio (Brachydanio) rerio* (Hamilton)
4. *Rasbora daniconius* (Hamilton)
5. *Amblypharyngodon mola* (Hamilton)
6. *Catla catla* (Hamilton)
7. *Puntius ticto* (Hamilton)
8. *Lepidocephalichthys guntea* (Hamilton)
9. *Mystus tengara* (Hamilton)
10. *Rita chrysea* Day
11. *Gagata cenia* (Hamilton)
12. *Ailia coila* (Hamilton)
13. *Ambassis nama* (Hamilton)
14. *Mastocembelus pancalus* (Hamilton)
15. *Osteobrama cotio peninsularis* (Silas)

The following species were collected from localities above and below the Hirakud Dam.—

1. *Oxygaster bacaila* (Hamilton)
2. *Labeo bata* (Hamilton)
3. *Aspidoparia morar* (Hamilton)

4. *Puntius sarana* (Hamilton)
5. *Puntius sophore* (Hamilton)
6. *Mystus cavasius* (Hamilton)
7. *Mystus seenghala* (Sykes)
8. *Mystus vittatus* (Bloch)
9. *Bagarius bagarius* (Hamilton)
10. *Clupisoma garua* (Hamilton)
11. *Channa punctatus* (Bloch)
12. *Channa striatus* (Bloch)
13. *Glossogobius giuris giuris* (Hamilton)
14. *Mastocembelus armatus armatus* (Lacépède)
15. *Macrornathus aculeatus* (Bloch)
16. *Rhinomugil corsula* (Hamilton)

SYSTEMATIC ACCOUNT

1. *Goniolosa manmina* (Hamilton)

1822. *Clupanodon manmina* Hamilton, *Fishes of Ganges* : 247, 383 (Type-locality, most of the freshwater branches of the Ganges).

Material.—4 exs., Mahanadi near Anicut at Cuttack (Orissa State), 19 Oct. 1954.

Distribution.—India : the rivulets and main streams of Ganga, Jamuna, Brahmaputra and Mahanadi and estuaries of the major Indian rivers except in the Deccan, southern and western India
Extra-Indian : Bangladesh; Pakistan.

2. *Notopterus notopterus* (Pallas)

1769. *Gymnotus notopterus* Pallas, *Spicil. Zool.*, 7 : 40, pl. 6, fig. 2 (Type-locality, Indian Ocean).

Material.—1 ex., Narsinghpur (Orissa State), from a pond adjoining the Fishery Office, 20 Oct. 1954.

Distribution.—India : Punjab, Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Maharashtra and Kerala. Extra-Indian : Bangladesh; Pakistan; Burma; Malaya Peninsula and Archipelago; Thailand.

3. *Oxygaster bacaila* (Hamilton)

1822. *Cyprinus bacaila* Hamilton, *Fishes of Ganges* : 265, 384, pl. 8, fig. 76 (Type-locality, freshwater rivers of all Gangetic Provinces).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954; 1 ex., inlet canal from Mahanadi at Cuttack (Orissa

State), 19 Oct. 1954 ; 9 exs., Mahanadi near Kamli Bazar at Sambalpur (Orissa State), 11 Nov. 1954 ; 4 exs., Raigarh (Madhya Pradesh), 16 Nov. 1954 ; 22 exs., Mahanadi at Seorinarayan (Madhya Pradesh), 21 Oct. 1954.

Distribution.—India : throughout except Kerala, Karnataka and Tamil Nadu. Extra-Indian : Bangladesh; Pakistan; Burma.

4. *Barilius barna* (Hamilton)

1822. *Cyprinus barna* Hamilton, *Fishes of Ganges* : 268, 384 (Type-locality, Yamuna and Brahmaputra rivers).

Material.—5 exs., Mahanadi at Seorinarayan (Madhya Pradesh), 18 Nov. 1954.

Distribution.—India : Assam, West Bengal, Bihar, Uttar Pradesh, and Orissa.

Remarks.—The five examples from Seorinarayan measure 20 to 28 mm. in standard length and have 8 to 10 vertical bars on their sides. Three examples have eight bars and the remaining two, have ten bars each.

5. *Barilius bendelisis* (Hamilton)

1822. *Cyprinus bendelisis* Hamilton, *Fishes of Ganges* : 270, 385 (Type-locality, Rivers of Mysore).

Material.—2 exs., Sambalpur, Mahanadi near Kamli bazar, (Orissa State), 11 Nov. 1954 ; 3 exs., Mahanadi at Seorinarayan (Madhya Pradesh), 18 Nov. 1954.

Distribution.—India : Punjab, Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Tamil Nadu and Karnataka. Extra-Indian Bangladesh; Pakistan; Sri Lanka.

Remarks.—The specimens from Seorinarayan measure 96, 101, 121 mm. in standard length and have 9 to 11 anal fin rays and 10 to 12 vertical bars on the sides.

6. *Barilius vagra* (Hamilton)

1822. *Cyprinus vagra* Hamilton, *Fishes of Ganges* : 269, 380 (Type-locality, Ganges at Patna).

Material.—2 ex., Sambalpur, Mahanadi near Kamli Bazar (Orissa State), 11 Nov. 1954 ; 32 exs., Mahanadi at Seorinarayan (Madhya Pradesh), 18 Nov. 1954.

Distribution.—India : throughout northern India. Extra-Indian : Pakistan; Sri Lanka.

Remarks.—Job, David and Das (1955) did not obtain any specimens of this species, though included by them in their list, on the strength of Chauhan's (1947) record. The occurrence of this species above and below the Hirakud Dam is noteworthy. The lot of 32 examples from Seorinarayan ranging 18 to 40 mm. in standard length have the following frequency distribution of the bars on their body sides. The smallest of them has no markings.

No. of bars	8	9	10	11	12	13	14	15	16
No. of exs.	6	5	6	—	3	2	6	2	1'

7 *Danio* (Brachydanio) *rerio* (Hamilton)

1822. *Cyprinus rerio* Hamilton, *Fishes of Ganges* : 323, 390 (Type-locality, Kosi River).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954.

Distribution.—India : throughout. Extra-Indian : Sri Lanka; Bangladesh; Pakistan; Burma; Thailand.

Remarks.—There are five longitudinal stripes along the sides of the body and four on the anal fin.

8. *Esomus danrica* (Hamilton)

1822. *Cyprinus danrica* Hamilton, *Fishes of Ganges* : 325, 327, pl. 16, fig. 88 (Type-locality, Ponds and ditches of Bengal).

Material.—1 ex., Ramsagar tank near the market and Bus stand at Sambalpur (Orissa State), 12 Nov. 1954; 2 exs., Pension Para tank near the Circuit House at Sambalpur (Orissa State), 12 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh; Pakistan; Burma, Sri Lanka; Malaya; Thailand.

Remarks.—It is remarkable that Job, David and Das (1955) were unable to procure an example of this otherwise common fish. However, it may be stated that it is more a tank fish than an inhabitant of the rivers.

9. *Rasbora daniconius* (Hamilton)

1822. *Cyrinus daniconius* Hamilton, *Fishes of Ganges* : 327, 329 (Type-locality, Rivers of southern Bengal).

Material.—2 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; 1 ex., a tank opposite United Construction Company's quarry at Burla (Orissa State), 14 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Burma; Malay Archipelago; Sri Lanka; Bangladesh; Pakistan.

10. *Labeo bata* (Hamilton)

1822. *Cyprinus bata* Hamilton, *Fishes of Ganges* : 283, 386 (Type locality, Rivers and ponds of Bengal).

Material.—1 ex., Mahanadi near the Anicut, Cuttack (Orissa State), 19 Oct. 1954 ; Mahanadi at Seorinarayan (Madhya Pradesh), 18 Nov. 1954.

Distribution.—India : Madhya Pradesh, Maharashtra, Tamil Nadu, Orissa, Bengal and Assam. Extra-Indian : Bangladesh; Pakistan.

11. *Labeo rohita* (Hamilton)

1822. *Cyprinus rohita*, Hamilton, *Fishes of Ganges* : 301, 388 (Type-locality, Freshwater rivers of Gangetic provinces).

Material.—1 ex., Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : Assam, West Bengal, Uttar Pradesh, Punjab, Madhya Pradesh, Orissa. Extra-Indian : Bangladesh; Pakistan; Burma.

Remarks.—Job, David and Das (1955) considered this important carp as infrequently obtained. The example recorded here was purchased from the fish market. The fishes were reported to come from the Mahanadi at Chandrapur and from Kelo river, an affluent stream of the Mahanadi flowing near Raigarh.

12. *Aspidoparia morar* (Hamilton)

1822. *Cyprinus morar* Hamilton, *Fishes of Ganges* : 264, 381 (Type locality, Rivers of Jamuna and Teesta).

Material.—4 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; 3 exs., Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout, except western coast and in localities south of Krishna river. Extra-Indian : Bangladesh; Pakistan ; Burma ; Thailand.

13. *Amblypharyngodon mola* (Hamilton)

1822. *Cyprinus mola* Hamilton, *Fishes of Ganges*, pp. 334, 392 pl. 38, fig. 92 (Type-locality, Ponds and freshwater rivers of Gangetic Provinces).

Material.—4 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; Pension Para tank near the Circuit House, Sambalpur (Orissa State), 12 Nov. 1954.

Distribution.—India : throughout except Kerala. Extra-Indian : Bangladesh ; Pakistan ; Burma.

14. *Catla catla* (Hamilton)

1822. *Cyprinus catla* Hamilton, *Fishes of Ganges* : 287, 318, 387, pl. 13, fig. 81 (Type-locality, Rivers and tanks of Bengal).

Material.—1 ex., a pond adjoining fishery office at Narsinghpur (Orissa State), 20 Oct. 1954.

Distribution.—India : throughout. Extra-Indian : Burma and Thailand.

15. *Puntius gelius* (Hamilton)

1822. *Cyprinus gelius* Hamilton, *Fishes of Ganges* : 320, 390 (Type-locality, Ponds and ditches of North-eastern Bengal).

Material.—1 ex., Ramsagar tank near the market and Bus stand, Sambalpur (Orissa State), 12 Nov. 1954.

Distribution.—India : Orissa, Bengal and Assam.

Remarks.—This species is generally confused with *Puntius phutunio* (Hamilton). It can be distinguished from it by its yellowish hue.

16. *Puntius sarana* (Hamilton)

1822. *Cyprinus sarana* Hamilton, *Fishes of Ganges* : 307, 388 (Type-locality, Ponds and rivers of India).

Material.—3 ex., Mahanadi at Narsinghpur (Orissa State) 21 Oct. 1954 ; 1 ex., Mahanadi near Kamli Bazar, Sambalpur

(Orissa State), 11 Nov. 1954 ; 2 exs., Raigarh (Madhya Pradesh), 16 Nov. 1954 ; 2 exs., Mahanadi at Seorinarayan (Madhya Pradesh), 18 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Malaya.

17. *Puntius sophore* (Hamilton)

1822. *Cyprinus sophore* Hamilton, *Fishes of Ganges* : 310, 389, pl. 19, fig. 86 (Type-locality, Ponds of Bengal).

Material.—36 exs., Mahanadi at Narsinghpur (Orissa State), 20 & 21 Oct. 1954 ; 7 exs., from a tank opposite United Construction Company's quarry at Burla (Orissa State), 14 Nov. 1954 ; 7 exs., Mahanadi near the Hirakud Dam (Orissa State), 15 Nov. 1954 ; 2 exs., Mahanadi below the Hirakud Dam (Orissa State), 15 Nov. 1954 ; 2 exs., Raigarh (Madhya Pradesh), 16 Nov. 1954 ; 3 exs., Mahanadi at Chandrapur (Madhya Pradesh), 17 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Burma ; Yunnan.

18. *Puntius ticto* (Hamilton)

1822. *Cyprinus ticto* Hamilton, *Fishes of Ganges* : 314, 389, pl. 8, fig. 87 (Type-locality, South-east part of Bengal).

Material.—1 ex., Mahanadi at Cuttack (Orissa State), 19 Oct. 1954 ; 3 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; 1 ex., a tank opposite United Construction Company's quarry at Burla (Orissa State), 14 Nov. 1954 ; 1 ex., Mahanadi at Chandrapur (Madhya Pradesh), 17 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Sri Lanka ; Burma ; Thailand.

19. *Osteobrama cotio peninsularis* Silas

1952. *Osteobrama cotio* var. *peninsularis* Silas, *Proc. natnl. Inst. Sci. India*, 18 (5) : 433 (Type-locality, Poona).

Material.—3 exs., a tank near the main road leading to the batching plant of the Hirakud Dam, Hirakud (Orissa State), 15 Nov. 1954.

Distribution.—India : South India.

Remarks.—Silas (1952) elucidated the systematic status of the species to be included under *Osteobrama* and differentiated the Peninsular form as a separate variety *peninsularis*. The three examples collected from Hirakud are referable to this taxa. They have lateral line scales 55 or 56, predorsal scales 21–23, and the number of anal fin rays 30 or 31. The specimens measure 36, 40 and 40 mm in standard length respectively. The head length is 4.00 times in standard length, body depth 2.38 (2.35–2.40). The diameter of eyes is 2.43 (2.26 to 2.57) in head length. Dorsal origin is nearer to tip of snout than to base of caudal fin. Pectoral fins reach pelvics and pelvics extend to anal fin. Fins are unmarked. This is the first record of this subspecies from this area.

20. *Lepidocephalichthys guntea* (Hamilton)

1822. *Cobitis guntea* Hamilton, *Fishes of Ganges* : 353, 394 (Type-locality, Ponds and freshwaters of Bengal).

Material.—6 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan.

21. *Mystus cavasius* (Hamilton)

1822. *Pimelodus cavasius* Hamilton, *Fishes of Ganges* : 203, 379, pl. 11, fig. 67, (Type-locality, Larger freshwater rivers of Gangetic Provinces).

Material.—3 exs., Mahanadi near Anicut, Cuttack (Orissa State), 19 Oct. 1954 ; 21 exs., Mahanadi at Narsinghpur (Orissa State), 20 & 21 Oct. 1954 ; 4 exs., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954 ; 3 exs., Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Burma ; Thailand ; Malay Archipelago.

Remarks.—The length of the maxillary barbels has been of diagnostic value in this species. 17 examples from Narsinghpur measuring 57 to 83 mm in standard length have their maxillary barbels extending upto the base of the caudal fin clearly, in all cases.

22. *Mystus seenghala* (Sykes)

1839. *Platystomus seenghala* Sykes, *Trans. zool. Soc. Lond.*, 2 : 371 (Type-locality, Mutha-Mula river, Poona).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 20 Oct. 1954; 1 ex., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : Andhra Pradesh, Punjab, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, West Bengal, Orissa and Deccan. Extra-Indian : Bangladesh ; Burma.

Remarks.—Fishermen differentiated *seenghala* from *aor* by the former having a more pronounced spatulate upper jaw and also a longer head. Locally called “*seenga*”, they do not attach credence to the length of the maxillary barbels in differentiating the two species.

23. *Mystus tengara* (Hamilton)

1822. *Himelodus tengara* Hamilton, *Fishes of Ganges* : 183, 377 (Type-locality, Northern parts of Bengal).

Material.—22 exs., Mahanadi at Narsinghpur (Orissa State), 20, 21 Oct. 1954; 2 exs., Mahanadi at Chandrapur (Madhya Pradesh), 17 Nov. 1954.

Distribution.—India : mostly confined to northern India, rare below the Krishna river system. Extra-Indian : Bangladesh ; Pakistan.

Remarks.—Job, David and Das (1955) did not obtain any specimens of this species though they indicated it in their list. Hora (1949) thought that this species is synonymous with *M. vittatus* (Bloch). Though apparently so, the two are different in their geographical range, external characters, and also in their osteological features (see Jayaram & Bhimachar, 1967). The median groove which represents the fontanelle on the skull does not reach the base of the occipital process in *tengara* unlike in *vittatus* where it reaches. The caudal fin is also longer in this species (Jayaram, 1954).

24. *Mystus vittatus* (Bloch)

1797. *Silurus vittatus* Bloch, *Ichth. Hist. nat.*, 11 : 40, pl. 371, fig. 2 (Type-locality, Tranquebar, S. India).

Material.—2 exs., Inlet canal from Mahanadi, Cuttack (Orissa State), 19 Oct. 1954; 23 exs., Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Sri Lanka ; Bangladesh ; Pakistan ; Burma ; Thailand.

25. *Rita chrysea* Day

1877. *Rita chrysea* Day. *Fish. India*: 455, pl. 104, fig. 1 (Type-locality, "Orissa"; subsequently revised as Anicut, Cuttack).

Material.—ZSI F 812/2, 126 exs., Mahanadi near the Anicut, Cuttack (Orissa State), topotypes, 18 to 20 Oct. 1954; ZSI F 813/2, 145 exs., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 nov. 1954; ZSI F 815/2, 22 exs., Sambalpur fish market (Orissa State), 11 Nov. 1954, ZSI F 814/2, 50 exs., Mahanadi, Chandrapur (Madhya Pradesh), 17 Nov. 1954.

Distribution.—Confined to the Mahanadi and its affluents. Not so far recorded from any other river systems.

Remarks.—Locally called "*Kokia*", "*Museri*", "*Kentia*", this species forms one of the chief economically important species of this area. A large quantity of this fish is generally caught. In fresh condition the body is of lead grey colour, with the ventral surface pale white with an yellowish tint over the iris. Some examples have a violet or bluish tint on and near the occiput. In fingerlings the fins are tipped black with the sides slightly golden coloured. Specimens from Sambalpur however, have a dark bluish tinge of patches over the dorsal surface and intermittant patches of same colour along sides upto the lateral line. Below the lateral line and all over the ventral surface, the colour is completely silvery white. Fins are tinged pale violet.

Day (1877) described this species from a single specimen from "Orissa". Subsequently, Southwell (unpublished) recorded this species from the Anicut at Cuttack. During October-November, 1954, one of us (K.C.J.) collected over 300 specimens of this species from the Mahanadi near the Anicut at Cuttack. Comparison of the single example of Day, present in the Zoological Survey of India (ZSI. Cat. 498) with those from Anicut, Cuttack and also from other localities indicates clearly that Anicut, Cuttack as the possible type-locality. Accordingly the type-locality was revised (Jayaram, 1966) from "Orissa" to Mahanadi, Anicut, Cuttack (Orissa State).

26. *Ompok bimaculatus* (Bloch)

1794. *Silurus bimaculatus* Bloch, *Auslandische Fische*, 8 : 24, pl. 364 (Type-locality, Tranquebar).

Material.—1 ex., Raigarh (Madhya Pradesh). 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Burma ; Malaya ; Thailand ; Yunnan ; Sri Lanka.

Remarks.—Job, David and Das (1955) noted that this species was rarely observed. The example reported here was purchased from the fish market. The catch was reported to be from the Mahanadi at Chandrapur and also from Kelo river, an affluent stream of the Mahanadi flowing near the town Raigarh.

27. *Wallago attu* (Schneider)

1801. *Silurus attu* Scheneider, *Syst. Ichth. Bloch.* : 338, pl. 75 (Type-locality, Malabar).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 20 Oct. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Sri Lanka ; Burma ; Malaya ; East Indies ; Thailand ; Indo-China ; Western Yunnan. A very widely distributed species.

28. *Ailia coila* (Hamilton)

1822. *Malapterurus coila* Hamilton, *Fishes of Ganges* : 158, 375 (Type-locality, freshwater rivers of Bengal).

Material.—1 ex., Mahanadi, Cuttack (Orissa State), 18 Oct. 1954.

Distribution.—India : Rivers of north India and Deccan, namely the Indus, Ganga, Yamuna, Brahmaputra, Mahanadi and Krishna. Extra-Indian : Bangladesh ; Pakistan ; Nepal.

29. *Clupisoma garua* (Hamilton)

1822. *Silurus garua* Hamilton, *Fishes of Ganges* : 156, 375, pl. 21, fig. 50 (type-locality, Freshwater rivers of the Gangetic provinces).

Material.—3 exs., Mahanadi, Cuttack (Orissa State), 18 Oct. 1954. ; 2 exs., Mahanadi near Anicut, Cuttack (Orissa State), 19 Oct. 1954 ; 1 ex., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; 1 ex., Sambalpur (Orissa State), 11 Nov. 1954 ; 3 exs., a pond near the main road leading to the batching plant of the dam, Hirakud (Orissa State), 25 Nov. 1954.

Distribution.—India : throughout North India. Extra-Indian : Bangladesh ; Pakistan ; Nepal ; Burma.

30. *Gagata cenia* (Hamilton)

1822. *Pimelodus cenia* Hamilton, *Fishes of Ganges* : 174, 376 pl. 21, fig. 57 (Type-locality, Northern parts of Bengal).

Material.—2 exs., Mahanadi near the Anicut, Cuttack (Orissa State), 18 Oct. 1954.

Distribution.—India : throughout North India. Extra-Indian : Bangladesh ; Pakistan ; Burma.

Remarks.—Job, David and Das (1955) synonymised *Gagata cenia* with *Gagata gagata* (Hamilton). The two species are distinguished by the relative lengths of the dorsal fin and also by the colouration (see Hora & Law, 1941).

31. *Bagarius bagarius* (Hamilton)

1822. *Bimelodus bagarius* Hamilton, *Fishes of Ganges* : 186, 378 pl. 7, fig. 62 (Type-locality, Ganges).

Material.—1 ex., Mahanadi, near the Anicut, Cuttack (Orissa State), 19 Oct. 1954 ; 1 ex., Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout North India. Extra-Indian : Bangladesh ; Pakistan ; Burma ; Malaya ; Thailand ; Indo-China.

32. *Xenentodon cancila* (Hamilton)

1822. *Belone cancila* Hamilton, *Fishes of Ganges* : 213, 380, pl. 27, fig. 70 (Type-locality, Ponds and smaller rivers of Gangetic Provinces).

Material.—1 ex., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Sri Lanka ; Burma.

33. *Channa punctatus* (Bloch)

1793. *Ophicephalus punctatus* Bloch. *Ausländischen Fische.*, 4 : 139, pl. 358 (Type-locality, Malabar).

Material.—3 exs., Mahanadi at Narsinghpur (Orissa State), 20, 21 Oct. 1954 ; 3 exs., Pension para tank near Circuit House, Sambalpur (Orissa State), 12 Nov. 1954 ; 1 ex., Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Sri Lanka ; Burma ; Malaya ; China ; Polynesia.

Remarks.—This is generally a tank fish, occurring infrequently in the rivers.

34. *Channa striatus* (Bloch)

1793. *Ophicephalus striatus* Bloch, *Ausländischen Fische.*, 4 : 141, pl. 359, (Type-locality, Malabar).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 20 Oct. 1954 ; 1 ex, Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Sri Lanka , Burma ; China ; Polynesia.

Remarks.—As *C. Punctatus*, this species is also mainly a tank fish.

35. *Ambassis nama* (Hamilton)

1822. *Chanda nama* Hamilton, *Fishes of Ganges* : 109, 371, pl. 39, fig. 37 (Type-locality, Ponds throughout Bengal).

Material.—1 ex., Mahanadi below the Hirakud Dam (Orissa State), 15 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Burma.

36. *Ambassis ranga* (Hamilton)

1822. *Chanda ranga* Hamilton, *Fishes of Ganges* : 113, 371, pl. 16, fig. 38 (Type-locality, Freshwater rivers of Gangetic Provinces).

Material.—1 ex., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954 ; 4 exs., Ramsagar tank near the market and Bus stand, Sambalpur (Orissa State), 12 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Burma ; Malaya ; Thailand.

37. *Badis badis* (Hamilton)

1822. *Labrus badis* Hamilton, *Fishes of Ganges* : 70, 368, pl. 25, fig. 23 (Type locality, not known).

Material.—1 ex., Ramsagar tank near the market and Bus stand, Sambalpur (Orissa State), 12 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh ; Pakistan ; Burma.

Remarks.—Job, David and Das (1955) reported this fish as rare.

38. *Rhinomugil corsula* (Hamilton)

1822. *Mugil corsula* Hamilton, *Fishes of Ganges* : 221, 381, pl. 9, fig. 97 (Type-locality, rivers of the Gangetic Provinces and in the southern parts of Bengal).

Material.—4 exs., Mahanadi, Cuttack (Orissa State), 19 Oct. 1954; 3 exs., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout North India. Extra-Indian : Bangladesh; Pakistan.

39. *Glossogobius giuris giuris* (Hamilton)

1822. *Gobius giuris* Hamilton, *Fishes of Ganges* : 51, 366, pl. 33, fig. 15 (Type-locality, ponds and freshwater rivers of Gangetic Provinces).

Material.—12 exs., Mahanadi at Narsinghpur (Orissa State), 20, 21 Oct. 1954; 2 exs., Mahanadi, near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954; 1 ex., near the dam, Hirakud (Orissa State), 15 Nov. 1954; 1 ex., Raigarh (Madhya Pradesh), 16 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh; Pakistan; whole of Asia; China; Japan; Philippines; Melanesia; Polynesia; Australia; East Africa.

40. *Mastocembelus armatus armatus* (Lacépède)

1800. *Macrognathus armatus* Lacépède, *Hist. Poissons*, 2: 286, (Type-locality, Bengal).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954; 2 exs., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh; Pakistan; Sri Lanka; Burma; Thailand.

Remarks.—This species is frequently caught in traps.

41. *Mastocembelus pancalus* (Hamilton)

1822. *Macrognathus pancalus* Hamilton, *Fishes of Ganges* : 30, 364 (Type-locality, Tanks of Gangetic Provinces).

Material.— 2 exs., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh; Pakistan.

42. *Macrogathus aculeatus* (Bloch)

1795. *Ophidium aculeatum* Bloch, *Naturg. Ausland. Fische*, pl. 159, fig. 2 (Type-locality, Not mentioned).

Material.—1 ex., Mahanadi at Narsinghpur (Orissa State), 21 Oct. 1954 ; 2 exs., Mahanadi near Kamli Bazar, Sambalpur (Orissa State), 11 Nov. 1954.

Distribution.—India : throughout. Extra-Indian : Bangladesh; Pakistan; Burma; Sri Lanka; Malaya; Malay Archipelago; Thailand; Indo-China; China.

Remarks.—Hora (1940) stated that this estuarine species is likely to be found in inland waters more widely. The record of this species in Mahanadi from Narsinghpur extends its inland distribution further than so far known in this river system.

SUMMARY

A report on the fish collection obtained from the Mahanadi drainage system in Orissa and Madhya Pradesh in a stretch extending from Cuttack to Seorinarayan, a distance of about 350 km., is presented in this paper. 42 species are recorded of which some continue to live above and below the Hirakud Dam. Taxonomic notes on a few interesting species are given. *Osteobrama cotio Peninsularis* Silas is recorded for the first time from this river system.

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ON A SMALL COLLECTION OF LEECHES FROM
MAHARASHTRA STATE, INDIA

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INTRODUCTION

Harding and Moore (1927) have reported only four species of leeches, viz. *Placobdella emydae* Harding, *Hemiclepsis marginata marginata* (Müller), *Paraclepsis praedatrix* Harding and *Hirudo birmanica* (Blanchard) from Maharashtra. I have not come across any subsequent reference to leeches from this area in published literature.

The present paper is a report on a small collection of leeches made by Dr. K. K. Tiwari of the Zoological Survey of India during August-September, 1964, mostly from temporary rain-water ponds and tanks, on the Deccan plateau fringing the Western Ghats in Maharashtra. The material contains eight species adding five new records to the known leech fauna of this area.

I am thankful to Dr. A. P. Kapur, Director, Zoological Survey of India for facilities to work out the collection and to Shri K. K. Mahajan, Superintending Zoologist and Officer-in-Charge for helpful suggestions in the course of the preparation of this report.

SYSTEMATIC ACCOUNT

Family GLOSSIPHONIDAE

Genus *Glossiphonia* Johnson, 1816

This genus is not so far reported from Maharashtra.

1. *Glossiphonia reticulata* Kaburaki, 1921

1921. *Glossiphonia reticulata* Kaburaki, *Rec. Indian Mus.* 22 (5) : 65.

Material. —(i) 1 ex. from rain-water pond at Wahgaon, ca. 8 km. North of Karad (Satara District). 6.ix.1964.

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Distribution. —Maharashtra (first record) ; Elsewhere ; India : Jullundhur.

2. *Glossiphonia annandalei* Oka, 1922

1922. *Glossiphonia annandalei* Oka, *Rec. Indian Mus.*, **24** (4) : 521.

Material. —(i) 12 exs. from a rain-water pond at Mahartara, Panhala Fort, ca. 19 km. West of Kolhapur. 9.ix.1964.

Distribution.—Maharashtra (first record) ; Elsewhere : India : Samal Island, (Chilka Lake—Orissa).

Genus *Hemiclepsis* Vejdovsky, 1883

The nominate subspecies is represented in the material from Maharashtra.

3. *Hemiclepsis marginata marginata* (Müller), 1774

1774. *Hirudo marginata* Müller, *Vermium terrestrium et fluviatilium*, i, pars 2.4° Havniae, Lipsie.

1921. *Hemiclepsis marginata*, Kaburaki, *Rec. Indian Mus.* **22** (5) : 689.

Material.—(i) 4 exs. from a pond in village Godoli, 2 km. South East of I. Bungalow, Satara. 6.ix.1964. (ii) 2 exs. from a rain-water pond at Wahgaon, ca. 8 km. North of Karad, Satara District. 6.ix.1964

Distribution.—Maharashtra : Elsewhere : India : Western Himalayas, Orissa and Bengal.

Genus *Paraclepsis* Harding, 1924

4. *Paraclepsis praedatrix* Harding, 1924

1924. *Paraclepsis praedatrix* Harding, *Ann. Mag. nat. Hist.* (9) **14** : 489, pls. ix-xiv.

Material.—(i) 3 exs. from a pond in village Godoli, 2 km. South-East of Inspection Bungalow, Satara District. 1.ix.1964. (ii) 1 ex. from a rain-water pond, Wai, (Satara District). 28.viii.1964. (iii) 4 exs. from a rain-water pond at Mahartara, Panhala Fort, Kolhapur District. 9.ix.1964.

Distribution.—Maharashtra : Elsewhere, Throughout India.

5. *Paraclepsis vulnifera* Harding, 1924

1924. *Paraclepsis vulnifera* Harding, *Ann. Mag. nat. Hist.*, (9) 14 : 489, pls. ix-xiv.

Material.—(i) 1 ex. from a rain-water pond at Wahgaon, ca. 8 km. North of Karad (Satara District). 9.ix.1964.

Distribution.—Maharashtra (first record) ; Elsewhere : India : Tanjore District, Madras.

Family ERPOBDELLIDAE

This family is not so far recorded from Maharashtra. The present collection contains two species of the genus *Herpobdelloidea*.

Genus *Herpobdelloidea* Kaburaki, 19216. *Herpobdelloidea indica* (Kaburaki), 1921

1921. *Nematobdella indica* Kaburaki, *Rec. Indian Mus.*, 18 : 707, text-fig. 7.

Material.—(i) 1 ex. from rain-water pond at Alibagh, (Colaba District), ca. 56 km. West of Khopoli. 27.ix.1964.

Distribution.—Maharashtra (first record) ; Elsewhere : India : Simla Hills, Punjab and Madhya Pradesh.

7 *Herpobdelloidea lateroculata* Kaburaki, 1921

1921. *Herpobdelloidea lateroculata* Kaburaki, *Rec. Indian Mus.* 18 : 705-706, fig. 4.

Material.—(i) 8 exs. from a pond in village Godoli, 2 km. South East of Inspection Bungalow, Satara. 1. ix.1964.

Distribution.—Maharashtra (first record) ; Elsewhere : India : Saugar (Madhya Pradesh) and Manipur.

Family HIRUDIDAE

Subfamily HIRUDINAE

Genus *Hirudo* Linnaeus, 17588. *Hirudo birmanica* (Blanchard, 1894)

1894. *Haemopsis birmanica* Blanchard, *Ann. Mus. civico di Storia Naturale*, Genova, 2 : 113-118.

1924. *Hirudo nipponica fuscolineata* : Moore, *Proc. Acad. Nat. Sci.*, Philadelphia, 51, 373-374, pl. xxi, figs. 27, 28.

Material.—(i) 9 exs. from a rain-water pond on Vetāl Hills, Poona. 17.ix.1964.

Distribution.—Maharashtra ; Elsewhere : India : Widely distributed.

SUMMARY

Eight species belonging to five genera and three families of leeches from Maharashtra are studied of which one family, two genera and five species are reported for the first time from Maharashtra.

REFERENCE

HARDING, W. A. and MOORE, J. P., 1927. *Fauna of British India, including Ceylon and Burma*—Hirudinea : XXXII+1-302, 9 pls., London (Taylor & Francis).

STUDIES ON FRESHWATER BRYOZOA. IV. THE
BRYOZOA OF RAJASTHAN, INDIA

By

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(With 2 Tables and 5 Text-figures)

INTRODUCTION

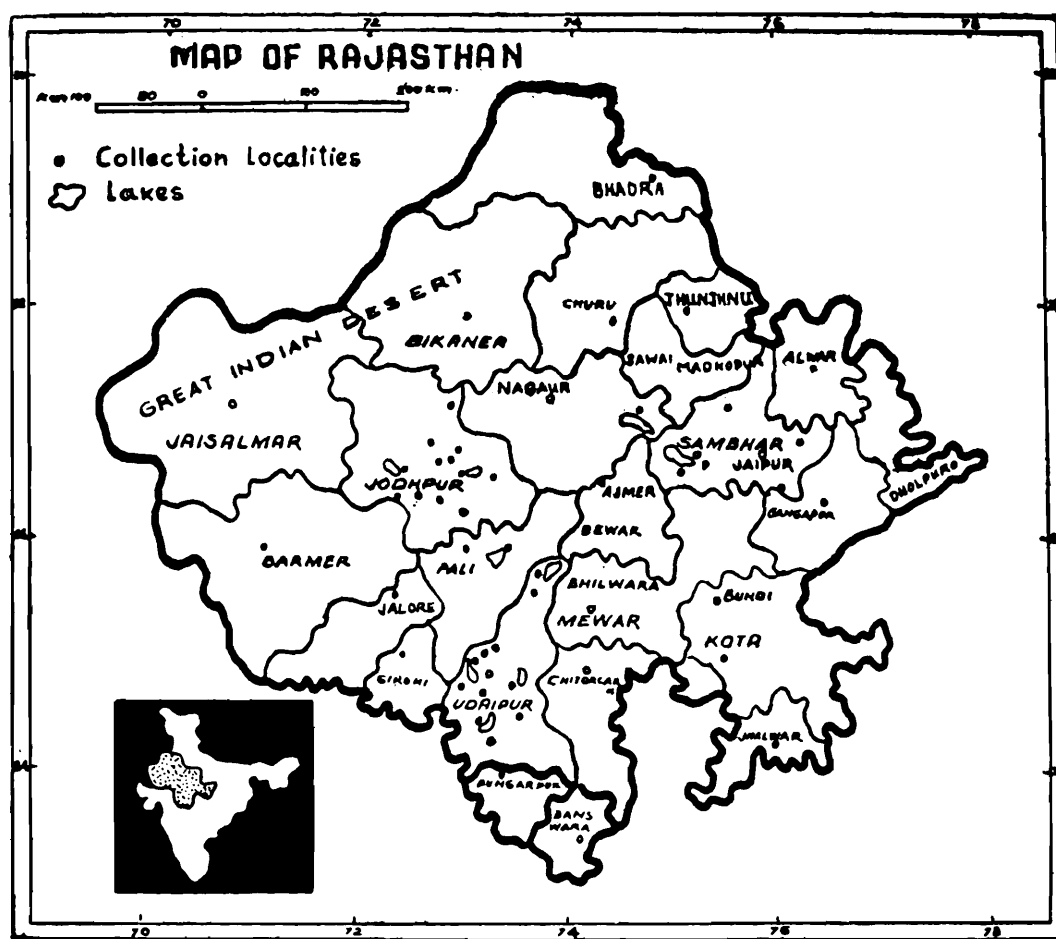
The purpose of the present study is to record the occurrence of the freshwater Bryozoa in Rajasthan, Western India. The collection work was undertaken by the survey party (February-April, 1962) of the Zoological Survey of India from two collection centres of Rajasthan one at Jodhpur and the other at Sambhar lake. Besides, the collections made by the author from Udaipur district (1970) were also included in the present report. Eleven species belonging to six genera were recorded from the localities the approximate situation of which is as pointed out in Text-fig. 1. All the species described hereunder are recorded from Rajasthan for the first time.

COLLECTION DATA

For a detailed account of topography, climate, vegetation, etc., of the collection localities see Part I of the Fauna of Rajasthan region (Roonwal, 1969). The list of the collection stations is as given under :

TABLE 1.—List of collecting stations for freshwater *Bryozoa* of Rajasthan (Coll. K. S. Rao)

Collecting station	Approx. Lat. (N)	Approx. Long. (E)
I. Jodhpur district		
1. Tank inside Zoological Garden, Jodhpur	26°18'	73°04'
2. Tank $\frac{1}{2}$ km. west of Jodhpur Fort	26°18'	73°48'
3. Mandore (12 km. N. of Jodhpur)	26°20'	73°00'
4. Nagkund (1 $\frac{1}{2}$ km. from Mandore)	26°19'	73°02'
5. Balsamund (near Jodhpur)	26°18'	73°04'



Text-fig. 1. A geographical map of Rajasthan showing the approximate situation of the collection localities for Bryozoa.

6. Takhat Sagar Lake (9 km. west of Jodhpur)	26°18'	73°00'
7. Pratap Sagar (8 km. west of Jodhpur)		
(Part of Kaylana Lake)	26°18'	73°09'
8. Agolai village (46 km. NW of Jodhpur)	26°19'	72°35'
9. Loridi village (16 km. NW of Jodhpur)	26°22'	72°55'
10. Umedsagar tank (10 km. west of Jodhpur)	26°15'	72°55'

II. Pali district

11. Sardarsamund Lake (55 km. SE of Jodhpur)	25°54'	73°25'

III. Nagaur district

12. Sambhar Salt Lake (Main lake)	26°55'	75°25'

IV. Jaipur district

13. New kyar (near Sambhar Lake)	26°54'	75°13'
14. Devdyani (near Sambhar Salt Lake)	26°55'	75°13'
15. A tank of Sambhar in Khyra village (75 km. S)	26°52'	75°13'
16. Erolai Dhani (village) (near Phulera)	26°52'	75°16'
17. A shallow well 50 metres west of tank in Erolai Dhani (village)	26°52'	75°16'

V. Udaipur district

18. Bhupalsagar (near Udaipur)	24°35'	73°40'
19. Dewari (near Udaipur)	24°36'	73°38'
20. Fatehsagar Lake (near Udaipur)	24°35'	73°35'
21. Jaisamund (53 km. N of Udaipur)	24°57'	73°35'
22. Madri (near Udaipur)	24°30'	73°40'
23. Kotra (near Udaipur)	24°22'	73°13'
24. Lake N of Udaipur near Game Sanctuary 53 km.	24°55'	73°35'
25. Kalaria Tank (7 km. W of Udaipur)	24°33'	73°40'
26. Pichola Lake (near Kalaria tank)	24°33'	73°42'
27. Udaisagar Lake (12 km. from Udaipur)	24°38'	73°30'

SPECIES RECORDED

The following species were recorded from Rajasthan Collections.

1. *Hislopia lacustris* Carter, 2. *Hislopia moniliformis* Annandale,
3. *Fredericella sultana* (Blumenbach), 4. *Plumatella emarginata* Allman,
5. *Plumatella casmiana* Oka, 6. *Plumatella frusticosa* Allman,
7. *Plumatella javanica* Kraepelin, 8. *Plumatella repens* (Linnaeus),
9. *Hyalinella punctata* (Hancock), 10. *Stolella indica* Annandale,
11. *Lophopodella carteri* (Hyatt).

SYSTEMATIC ACCOUNT

Class I. GYMNOLOEMATA

Order 1. CTENOSTOMATA

Family 1. HISLOPIIDAE

Genus 1. *Hislopia* Carter1. *Hislopia lacustris* Carter

(Text-fig. 2, D)

1858. *Hislopia lacustris* Carter, *Ann. Mag. nat. Hist.*, (3) 1 : 169.
 1880. *Norodonia combodgiensis* Jullien, *Bull. Soc. Zool. France*, 5 : 77.
 1885. *Norodonia combodgiensis* : Jullien, *Bull. Soc. Zool. France*, 10 : 181, 244, 245.
 1885. *Norodonia sinensis* Jullien, *Bull. Soc. Zool. France.*, 10 : 91.
 1907. *Hislopia lacustris* : Annandale, *Rect. Indian Mus.*, 1 : 145.
 1967. *Hislopia lacustris* : Wiebach, *Amazoniana*, 1 (2) : 173.

Material.—(i) 4 colonies, Mandore, Jodhpur Dist., on submerged rocks ; 2.iii.1962. (ii) 6 colonies ; Balsamund, Jodhpur Dist., on

Vallisneria leaves ; 3.iii. 1962. (iii) 12 colonies ; Partap Sagar, Jodhpur Dist., on weeds 3.iii.1962. (iv) 1 colony, submerged sticks from Umedsagar tank in Jodhpur Dist. ; 7.iii.1962. (v) 5 colonies Sardar-samund lake on submerged rocks in Pali Dist. ; 14.iii.1962. (vi) 2 colonies, Devdyani on *Vallisneria* leaves, in Jaipur Dist. ; 6.iv.1962. (vii) 3 colonies each, Jaisamund, Bhypalsagar, Dewali, and Fateh-sagar, on submerged rocks, in Udaipur Dist. ; 2 to 6.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Calcutta, Bulandshahr, Rewa, Indore, Bombay, Malwatal, Chilka lake, and Madras. Extra-Indian : America, West Germany, Japan, Africa, Russia, Europe and Burma.

Remarks.—The material conforms in general with the descriptions of this species given by Annandale (1911) and Wiebach (1967). Variations were, however, noticed. The Jaisamund material had larger zooecia with wider orifice, whereas the Balasamund material was marked by the invariable presence of spines around the orifice. The base of the spines is sometimes slightly raised. Overgrowth of colonies was rarely reported in *Hislopia*, but a number of such cases were found from the material collected on *Vallisneria* leaves from Devdyani. The observations of Stebbing (1972) on the phenomenon of recognition of the same species, during growth do not seem to hold good with freshwater ctenostomes.

2. *Hislopia moniliformis* Annandale

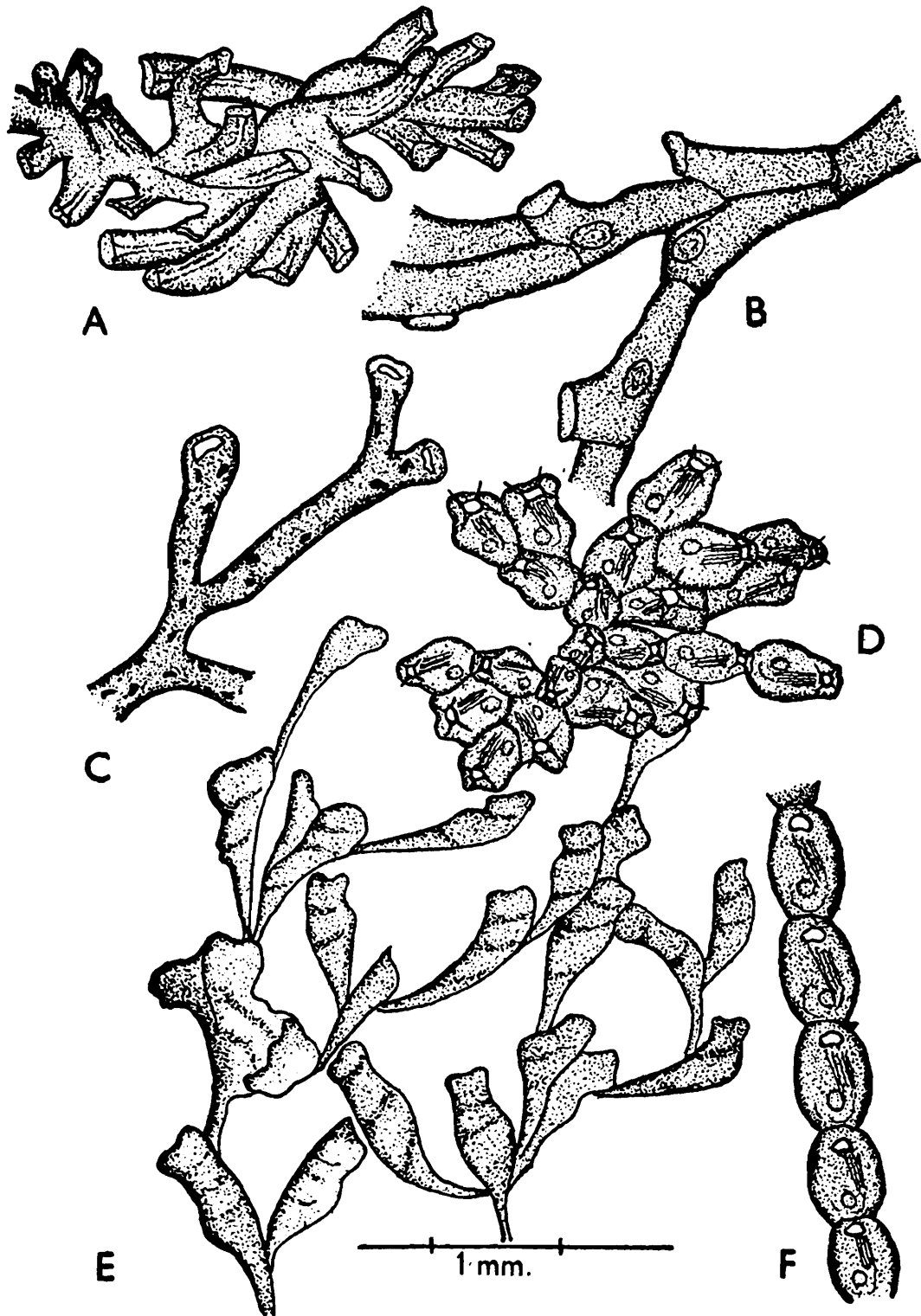
(Text-fig. 2, E)

1907. *Hislopia lacustris* subsp. *moniliformis* Annandale *J. Asiat., Soc. Beng.*, II (2) : 83-97.
 1962. *Hislopia lacustris* subsp. *moniliformis* : Rao, *J. Univ. Sauror.*, II (2B.) : 47.
 1967. *Hislopia moniliformis* Wiebach, *Amaxoniana.*, I (2) : 173.
 1972. *Hislopia moniliformis* : Rao, *Pro. Second, Int. Conj. Bryozoa. Durham.* (in press).

Material.—(i) 2 colonies on *Vallisneria* leaves, Agolai village pond in Jodhpur Dist., 4.iii.1962. (ii) 4 colonies on dead leaves, Madri in Udaipur Dist., 8.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Calcutta, Kashmir, Rewa, Extra-Indian : Germany, Burma.

Remarks.—*Hislopia moniliformis* occurs sparingly as compared with the cosmopolitan *H. lacustris*. The zooecia in the present material are more elongated than those described by Annandale (1911). The peculiarities of this species, as reported by Rao and Ghosh (1962)



Text-fig. 2. (A-F) Portions of Colony—A. *Plumatella casmiana* ; B. *Plumatella fruticosa* ; C. *Fredericella sultana* ; D. *Hislopia lacustris* ; E. *Hislopiu moniliformis* ; F. *Stolella indica*.

from Vindhyan material, are discernible in the Agolai material. The colonies are not profusely grown but very small.

Class II. PHYLACTOLAEMATA

Family 2. FREDERICELLIDAE

Genus 2. *Fredericella* Gervais3. *Fredericella sultana* (Blumenbach)

(Text-figs. 2, C & 4, A-C)

1779. *Tubularia sultana* Blumenbach, *Ann. Nat. Hist.*, **13** : 330.
 1844. *Fredericella dilatata* Allman, *Ann. Mag. nat. Hist. Ser.*, **1** (13) : 328.
 1851. *Fredericella regine* Leidy, *Proc. Acad. Nat. Sci. Phil.* **5** : 320.
 1866. *Fredericella pulcherrina* Hyatt, *Proc. Essx., Inst.*, **4** : 197.
 1909. *Fredericella indica* Annandale, *Rec. Indian. Mus.*, **3** : 373.
 1962. *Fredericella sultana* : Rao & Kulshrestha, *J. Univ. Saugor.*, **I I**, 2. B. : 50.

Material.—(i) 6 colonies from Pratapsagar on submerged rocks in Jodhpur Dist., 8.iii.1962. (ii) 2 colonies from Nagkund on submerged rocks in Jodhpur Dist., 7.iii.1962. (iii) a single colony from Dewali on submerged rocks in Udaipur Dist., 4.ii.1970. (iv) 4 colonies from Jaisamund lake on dead leaves in Udaipur Dist., 5.iii.1970. (v) 2 colonies from the lake near the game sanctuary on submerged weeds in Udaipur Dist., 8.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* ; India : M.P., U.P., Kashmir, Punjab and Orissa. Extra-Indian : Europe, America, Asia, and Africa.

Remarks.—*Fredericella* material seems to be comparatively sparing in Rajasthan than in other parts of the country. The paipoblasts are larger and often ornamented in the present material. The kidney-shaped paipoblasts described by Annandale (1911) could not be observed. The abnormal paipoblasts (Text-fig. 4, C) were observed from the material collected from Dewali, Udaipur Dist. Bushnell (1971) reports similar paipoblasts from *Fredericella australensis*, collected in Mexico. As rule the Rajasthan *Fredericella* material had a uniform encrustation which was never dense.

Family 3. PLUMATELLIDAE

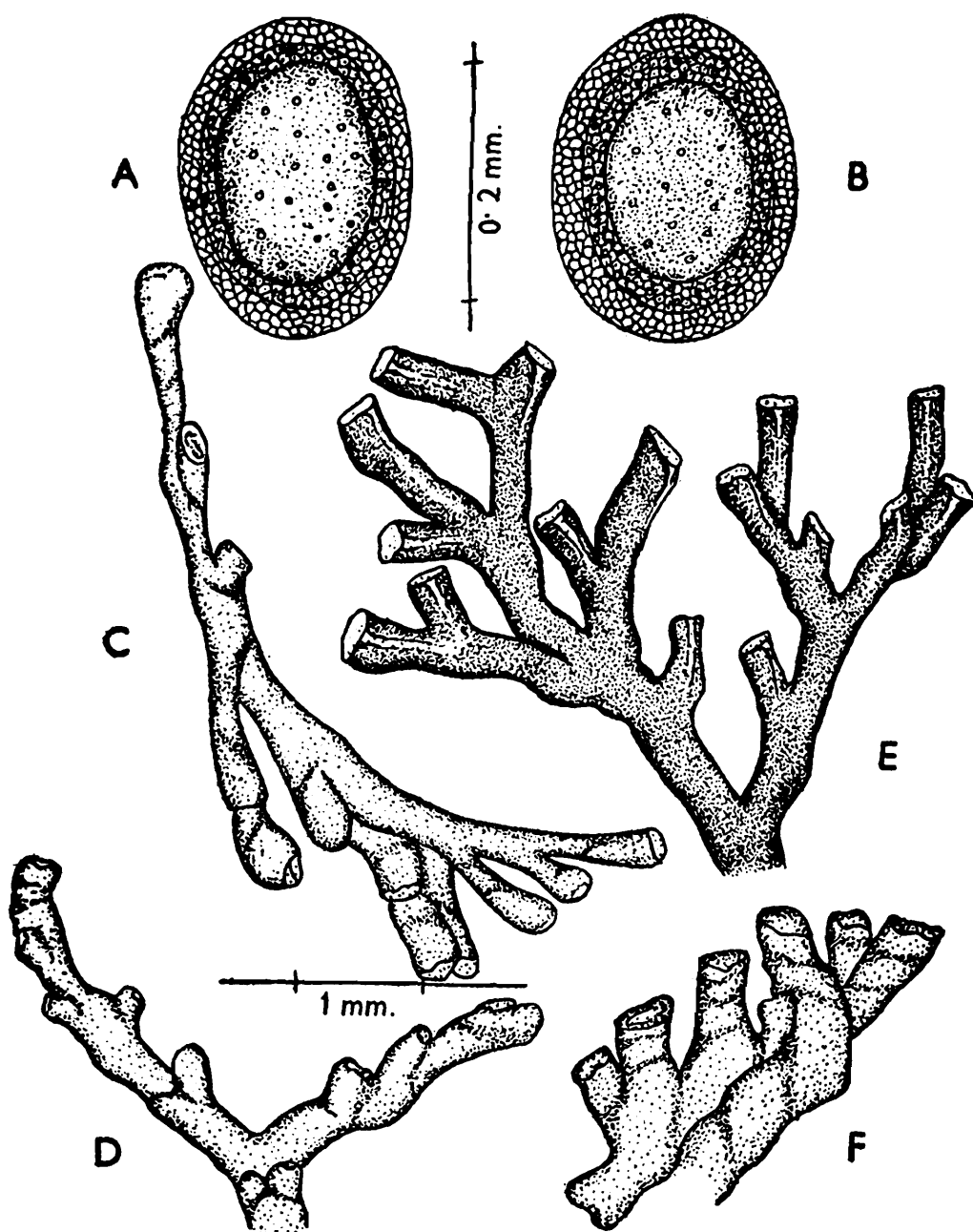
Genus 3. *Plumatella* Lamarck4. *Plumatella emarginata* Allman

(Text-figs. 3, E & 4D)

1844. *Plumatella emarginata* Allman, *Ann. Mag. nat. Hist. Ser.*, **I**, 13 : 320.
 1847. *Plumatella emarginata* : Johnston, *Brit. Zooph.*, (ed. 2) : 404.
 1850. *Plumatella allmani* Hancock, *Ann. Mag. nat. Hist. Ser.* **II**, 5 : 173.
 1851. *Plumatella diffusa* Leidy, *Proc. Acad. nat. Sci. Phil.* ; **5** : 320.
 1857. *Alcyonella benedeni* Allman, *Mon. Fresh-water Bryozoa*, : 89.

1885. *Plumatella lucifaga* Jullien, *Bull. Soc. Zool. France*, : 114.
 1887. *Plumatella princeps* var. *emarginata* (Partim) *Deutschen Susswasserbryoz.* : 120.
 1910. *Plumatella emarginata* : Annandale, *Rec. Indian Mus.* V : 47.
 1927. *Alcyonella benedini* : Abricossoff, *USSR. Compt. Rend. Acad. Sci. Urss. A.*, 19 : 307.
 1962. *Plumatella emarginata* : Rao and Kulshrestha, *J. Univ. Saugor.* II, 2 B : 50.

Material.—(i) 2 colonies from tank inside zoological gardens on submerged rocks in Jodhpur, 1.iii.1962. (ii) 6 colonies from



Text-fig. 3. (A-B) Floatoblasts—A. *Hyalinella punctata* ; B. *Stolella indica* ; (C-F) Portions of colony—C-D. *Plumatella repens* from Sardar samund, Pali Dist. & Jaisamund, Udaipur Dist. ; E. *Plumatella emarginata* ; F. *Hyalinella punctata*.

Mandore on submerged rocks in Jodhpur Dist., 3.iii.1962. (iii) 5 colonies from Balasamund on submerged rocks in Jodhpur Dist., 5.iii.1962. (iv) 2 colonies from Pratap Sagar on dead leaves in Jodhpur Dist., 8.iii.1962. (v) 2 colonies from Loridi village on submerged leaves in Jodhpur Dist. 27.ii.1962. (vi) 10 colonies from Umedsagar on submerged rocks in Jodhpur Dist., 7.iii.1962. (vii) 3 colonies from Sardarsamund on submerged rocks in Pali Dist., 14.iii.1962. (viii) 2 colonies from the tank in Khyra village on submerged sticks in Jaipur Dist., 8.iv.1962. (ix) 3 colonies from a tank in Erolai village on submerged sticks in Jaipur Dist., 10.iv.1962. (x) A single colony from a shallow well in Erolaidani village on dead leaves in Jaipur Dist., 7.iv.1962. (xi) 3 colonies from Bhupalsagar on submerged rocks, in Udaipur Dist., 3.ii.1970. (xii) 2 colonies each from Dewali, Fatehsagar, Madri, Kotra, and Kalari tanks on submerged rocks in Udaipur Dist., 7 to 10.ii.1970.

Distribution.—*Rajasthan* : Not reported. *Elsewhere* : India : Calcutta, Madras, Rewa, Indore, Mhow. Extra-Indian : Europe, N. America, Southern Asia, Africa, and Australia.

Remarks.—This seems to be the most abundant species in Rajasthan as it is in other regions. The high variability of the species is well known. The septa in between the zooecia is not a stable character in this species, but all the Rajasthan *Plumatella emarginata* material invariably showed a prominent septum. The floatoblasts and the sessoblasts conform with the earlier descriptions and lie within the variation range. The giant statoblasts of this species reported by Rao and Kulshrestha (1962) are not seen in the present material.

5. *Plumatella casmiana* Oka

(Text-figs. 2, A & 4, E, F)

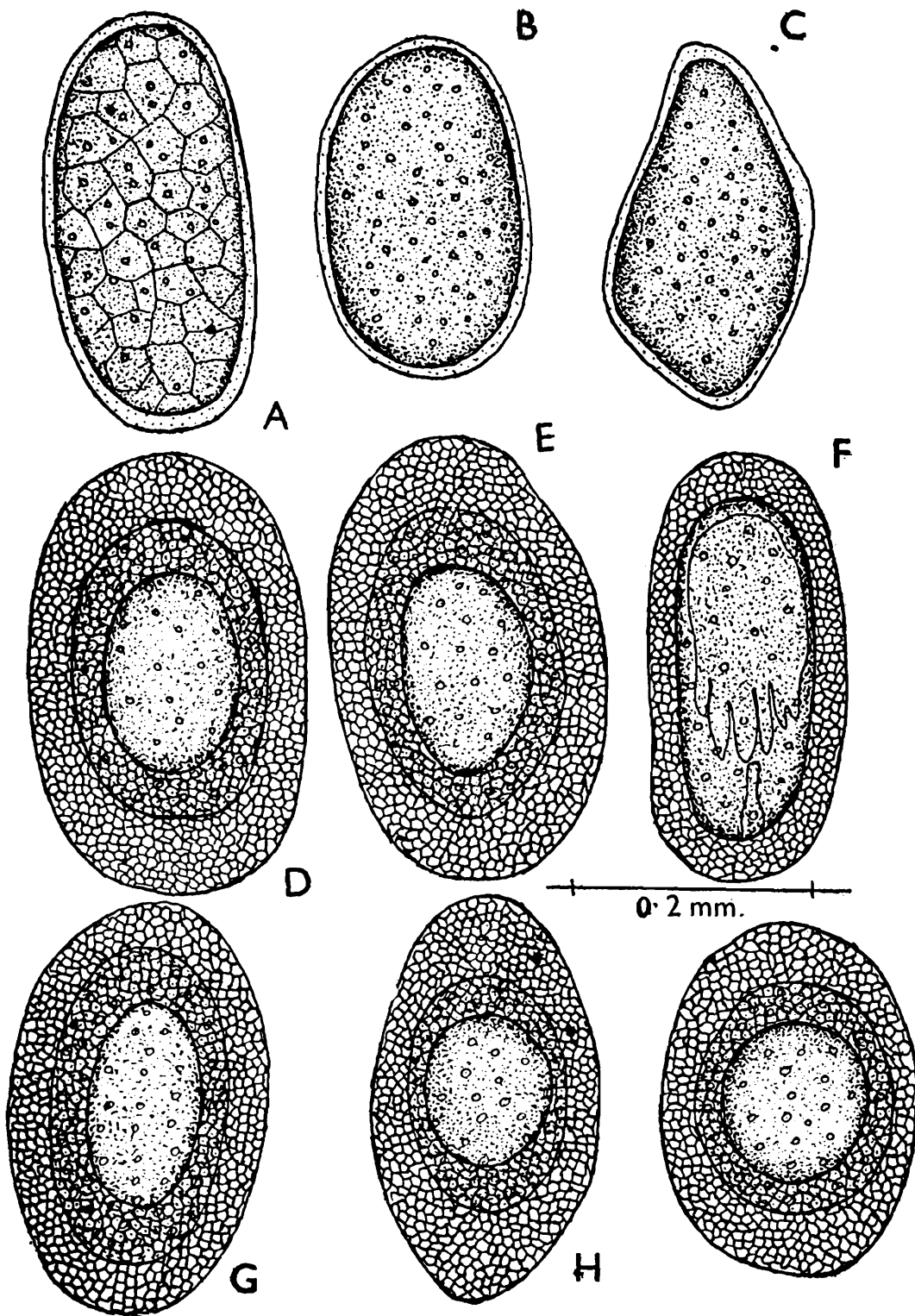
1907. *Plumatella casmiana* Oka, *Annot. Zool. Jap.*, 6 : 117.

1955. *Plumatella casmiana* : Toriumi, *Sci. Rep. Tohoku. Imp. Univ. Ser.*, 4 (21) : 67.

Material.—(i) 7 colonies from Jaisamund lake on submerged sticks in Udaipur Dist.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Govindhghadh, Patalpani fall area in Madhya Pradesh. Extra-Indian: N. America, Japan and Germany.

Remarks.—This species was recently reported from Madhya Pradesh (Rao, 1972, in press). It could be recorded from a single station in Rajasthan which represents the third locality of the species



Text-fig. 4. A-B Paipoblasts of *Fredericella sultana* ; C. Abnormal paipoblasts of *F. sultana* ; D. Floatoblasts of *Plumatella emarginata* ; E-F. Normal & thin floatoblasts of *Plumatella casmiana* ; (G-I) Floatoblasts G. *Plumatella fruticosa* ; H. *Plumatella javanica* ; I. *Plumatella repens*.

from India. The recent material resembles the one from Patalpani fall area. In external form it resembles *Plumatella emarginata*. The

two types of floatoblasts characteristic of *Plumatella casmiana*, were noticed. The measurement of the floatoblasts and sessoblasts recorded are as given under.

TABLE 2—Measurements of floatoblasts and sessoblasts of *Plumatella casmiana* : from Rajasthan.

Structure measured	Normal Type	Thin type
Length of entire statoblast	0.38 mm	0.36 mm
Width of entire floatoblast	0.29 mm	0.28 mm
Length of capsule	0.22 mm	0.26 mm
Width of capsule	0.07 mm	0.10 mm
Length of sessoblast	0.40 mm	0.35 mm

Plumatella casmiana from Rajasthan shows a comparative variation in the length of their floatoblasts and other measurements than that of the material reported from other Indian localities. The honeycomb colonies of the species reported by Bushnell (1971) could not be observed in Rajasthan.

6. *Plumatella fruticosa* Allman

(Text-figs. 2, B & 4, G)

1844. *Plumatella fruticosa* Allman, *Ann. Mag. nat. Hist. Ser. I*, 13 : 328.
 1847. *Plumatella repens* van Beneden, *Mem. Acad. Roy. Belg* : 21.
 1850. *Plumatella corolloides* Allman, *Rep. Brit. Assoc.* : 335.
 1856. *Plumatella stricta* Allman, *Mon. Freshwater Bryozoa. Ray. Soc. Lond.*
 1855. *Plumatella lucifuga* Jullian, *Bull. Soc. Zool. France.*, 10 : 9.
 1887. *Plumatella princeps* var. *fruticosa* Kraepelin, *Deutsch. Susswasser bryozoen*, i, : 120.
 1890. *Plumatella fruticosa* : Bran. *Bibl. zool.*, II : 9.
 1907. *Plumatella repens* Annandale, *J. Asiat. Soc. Bengal. NS.* iii, : 88.
 1954. *Plumatella repens* Toriumi, *Sci. Rep. Tohoku. Univ.*, 20 : 293.

Material.—(i) 2 colonies from the tank ½ km. west of Jodhpur fort on submerged weeds, 4.iii.1962. (ii) 4 colonies from Nagkund on submerged rocks in Jodhpur Dist., 7.iii.1962. (iii) 6 colonies from Takhat-sagar lake on submerged *Vallisneria* leaves in Jodhpur Dist., 10.iii.1962. (iv) 3 colonies from Erolaidani village tank on submerged rocks in Jaipur Dist., 7.iv.1962. (v) 6 colonies from Fatehsagar lake on submerged rocks in Udaipur Dist., 8.ii.1970. (vi) 2 colonies from Kotra tank on submerged rocks in Udaipur Dist., 10.ii.1970. (vii) 2 colonies from Pichola tank on submerged rocks in Udaipur Dist., 12.ii.1970.

Distribution.—*Rajasthan* not reported. *Elsewhere* : India : Calcutta, Chilka lake, Travancore, Bombay, Ganges delta, and the Himalayan region. Extra-Indian : Europe, N. America, Rajshahi, Africa, Lahore.

Remarks.—*Plumatella fruticosa* seems to be well distributed in Rajasthan. The colonies were observed profusely grown and shrubby. The floatoblasts are long and elliptical with a smooth capsule. The sessoblasts are large and elongated with markings on the surface.

7. *Plumatella javanica* Kraepelin

(Text-fig. 4, H)

1906. *Plumatella javanica* Kraepelin, *Mitt. Nat. Mus. Hamburg*. **23** : 123.
 1908. *Plumatella emarginata* var. *javanica* Loppens., *Ann. Biol. Lacustre.*, **3** : 162.
 1910. *Plumatella javanica* : Annandale, *Rec. Indian Mus.*, **5** : 37.
 1967. *Plumatella javanica* : Wiebach, *Amazoiana*, **I** (2) : 173.

Material.—(i) 2 colonies from Umedsagar on dead leaves in Jodhpur Dist., 7.iii.1962. (ii) 3 colonies from Sardarsumund lake on submerged sticks in Pali Dist., 14.iii.67 (iii) 2 colonies from Devdyani on submerged rocks, in Jaipur Dist., 1.iv.1962. (iv) 4 colonies from Udaisagar lake and Kalaria tank on weeds from Udaipur Dist., 13.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Calcutta, Berhampore, Murshidabad, Darjeeling, Tamil Nadu, Travancore, Indore and Mhow. Extra-Indian : Europe, N. America, Java, China and Japan.

Remarks.—This species is of a limited occurrence in Rajasthan. The zoarium is irregularly and sparingly branched and resembles the material of *Plumatella fruticosa* reported from Narmada (Rao, 1972, in press).

8. *Plumatella repens* (Linne)

(Text-figs. 3, C, D & 4, I)

1758. *Tubipora repens* Linne, *Ann. Nat. Ser.*, **15** : 15.
 1856. *Plumatella corolloids* Allman, *Mon. Fresh water Polyzoa*. Ray Soc. Lond.
 1866. *Plumatella limnas* Perfitt, *Ann. Mag. nat. Hist. Ser.*, **3** : 171.
 1890. *Plumatella fungosa* Braem, *Bibl. Zool.*, **II** : 1.
 1970. *Plumatella repens* : Toriumi, *Bull. Mar. Biol. Asamushi. Tohoku. Univ.*, **xiv** : 11.

Material.—(i) 2 colonies from Sardarsamund on submerged from Pali Dist., 14.iii.1962. (ii) 3 colonies from Jaisamund lake on bark in Udaipur Dist., 2.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : *India* : Recorded from few localities but under different names. *Extra-Indian* : Japan, N. America, Europe.

Remarks.—This cosmopolitan species seems to be of limited occurrence in Rajasthan. The *Plumatella repens* material described by Annandale earlier has been synonymised by the same author with *Plumatella fruticosa* (Annandale, 1911). The present record of the species can, hence be treated as the first from Indian waters. This highly variable polymorphic and polytypic species is most confusing and is closely related to *Plumatella fungosa*. The experimental rearing studies of Toriumi (1971) may in future prove the identity of both the species. The Rajasthan *Plumatella repens* conforms in general with its earlier descriptions and resembles *Plumatella fungosa* closely. The Sardarsamund and the Jaisamund material may vary to a large extent phenotypically (Text-fig. 3, C & D). The branching pattern of zoarium differs in both. The floatoblasts have a high variation range in their size and shape. The capsule length seems to be a constant character in all the lots. The species will however be dealt in detail elsewhere.

Genus 4. *Hyalinella* Jullien

9. *Hyalinella punctata* (Hancock)

(Text-fig. 3A & F)

- 1850. *Plumatella punctata* Hancock, *Ann. Mag. nat. Hist. Ser. II.*, **5** : 173.
- 1868. *Plumatella vitrea* Hyatt, *Proc. Essex. Inst.* **5** : 193.
- 1885. *Hyalinella vitrea* : Jullien, *Bull. Soc. Zool. France.* **x.** : 91.
- 1887. *Plumatella punctata* var. *donsa* Kraopelin, *Die Deutschen Süsswasser Bryozoen* : 11.
- 1908. *Hyalinella punctata* : Loppens, *Ann. Biol. Laoustre*, **3** : 141.
- 1910. *Plumatella punctata* : Annandale, *Rec. Indian Mus.*, **5** : 37.
- 1955. *Hyalinella punctata* : Toriumi, *Sci. Rep. Tohoku. Imp. Univ.*, **4** (16) : 193.

Material.—(i) 2 colonies from the tank inside Zoological gardens, Jodhpur, on submerged weeds. 1.iii.1962. (ii) one colony from Mandore, on submerged stones in Jodhpur Dist., 3.iii.1962. (iii) Four colonies from Umedsagar on submerged stones in Jodhpur Dist., 7.iii.1962. (iv) 3 colonies from a tank in Khyra village on dead leaves in Jaipur Dist., 8.iv.1962. (v) 3 colonies from Bhupalsagar on dead leaves in Udaipur Dist., 3.ii.1970. (vi) 6 colonies from Jaisamund on submerged *Vallisneria* leaves in Udaipur, 2.ii.1970. (vii) 2 colonies from Kotra on submerged rocks from Udaipur Dist., 9.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : *India* : Calcutta, Rewa, Indore. *Extra-Indian* : Europe, N. America.

Remarks.—The species is sufficiently represented in Rajasthan. It was previously recorded only from Calcutta. The present author recorded the species from Madhya Pradesh (Rewa and Indore). The record of this species from Rajasthan extends its distribution to the W. India. It is flat semitransparent with recumbent zooecia. The orifice of the zooecium is prominent with an agglutinated ectocyst. The latter is wrinkled in order zooecia with a faint emargination and furrow. A definite septum is absent. Floatoblasts are rounded or oval with a large capsule and agree in general with the earlier descriptions.

Genus 5. *Stolella* (Annandale)

10. *Stolella indica* Annandale

(Text-figs. 2, F & 3, B)

1909. *Stolella indica* Annandale, *Rec. Ind. Mus.*, 3 : 279.
 1910. *Stolella indica* : Annandale, *Rec. Indian Mus.*, 5 : 45.
 1943. *Stolella indica* : Rogick, *Ann. Newyork., Acad. Sci.*, 5 : 45.
 1962. *Stolella indica* : Rao and Kulshrestha, *J. Univ. Saugor.*, 112. B. : 50.

Material.—(i) 3 colonies from Takhsatsagar submerged rocks in Jodhpur Dist., 10.iii.1962. (ii) 5 colonies from Pratapsagar on submerged rocks from Jodhpur Dist., 8.iii.1962. (iii) A Single colony from Agolai village on submerged rocks in Jodhpur Dist., (iv) 6 colonies from Devdyani on dead leaves in Jaipur Dist., 1.iv.1962. (v) 2 colonies from a tank in Khyra village on submerged rocks in Jaipur Dist., 8.iv.1962. (vi) 6 colonies from a tank in Erloi village on Bark, in Jaipur Dist., 10.iv.1962. (vii) 2 colonies from a shallow well near Eolaidani village on submerged sticks in Jaipur Dist., 7.iv.1962. (viii) 12 colonies from Bhupalsagar on submerged rocks in Udaipur Dist., 3.ii.1970. (ix) 6 colonies from Madri on aquatic plants from Udaipur Dist., 9.ii.1970. (x) 6 colonies from Fatehsagar on submerged rocks in Udaipur Dist. (xi) 4 colonies from Pichola lake submerged rocks in Udaipur Dist., 12.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Calcutta and the Indogangetic plains, Rewa. Extra-Indian : N. America.

Remarks.—The *Stolella* material though observed earlier as a rare species strictly restricted to the Indogangetic plains by Annandale (1911), it could be recorded profusely by the author from different parts of India. The author agrees with Bogick (1943) that *Stolella himalayana* Annandale is no more than a synonym of *Stolella indica*. The Rajasthan *Stolella* material proves the fact further that the younger colonies from Erloidani village resemble *Stolella*

indica whereas the profusely grown older colonies from Jodhpur Dist. (Text-fig. 2, f), resemble *Stolella himalayana*. The floatoblasts and sessoblasts fully conform with the descriptions of Annandale (1911).

Family 4. LOPHOPODIDAE

Genus 6. *Lophopodella* Rousselet

11. *Lophopodella carteri* (Hyatt)

(Text-fig. 5, A-G)

1866. *Pectinatella carteri* Hyatt, *Proc. Essex. Inst.*, 4 : 197.
 1904. *Lophopodella carteri* : Rousselet, *Jour. Quckett. Micr. club.*, 2. 9 : 47.
 1908. *Lophopus carteri* : Annandale, *Rec. Indian Mus.*, 2 : 169.
 1910. *Lophopodella carteri* : Annandale, *Rec. Indian Mus.*, 5 : 37.
 1956. *Lophopodella carteri* : Toriumi, *Sci. Rep. Tohoku. Imp. Univ.*, 4. 22 : 57.

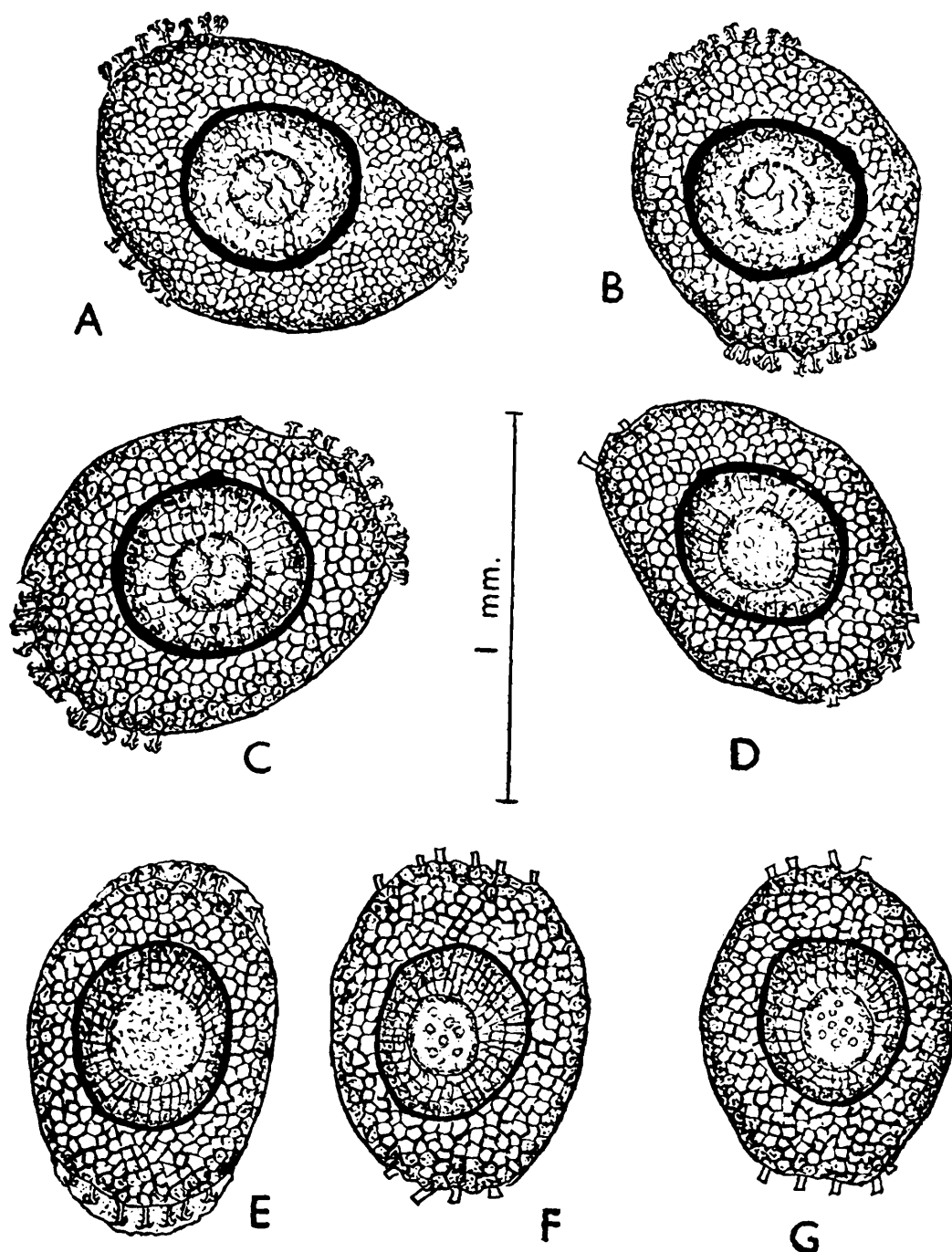
Material.—(i) 50 colonies from Balasamund lake on the stems of aquatic plants in Jodhpur Dist., 5.iii.1962. (ii) 12 colonies from Bhupalsagar on submerged stones in Udaipur Dist., 3.ii.1970. (iii) 12 colonies from Jaisamund and Kalaria lakes on aquatic plants from Udaipur Dist., 2.ii.1970.

Distribution.—*Rajasthan* : As above. *Elsewhere* : India : Bombay, Western Himalayas, Orissa and Madhya Pradesh. Extra-Indian : America, Japan and Europe.

Remarks.—This species was collected in abundance from Balasamund lake. After the recent records of this species from Madhya Pradesh and Rajasthan, from many localities the species seems to be well represented in India. It was hitherto considered a rare species. The spinoblasts in the Rajasthan material present extreme variations, firmly suggesting that *Lophopodella carteri* var *himalayana* Annandale is no else than its synonym. Rogick (1935) and Toriumi (1956) commented on the variations in the spinoblasts of the species. Further variations could be observed in the Rajasthan material, (Text-fig. 5, A-G) in the structure and number of spines.

DISTRIBUTIONAL PATTERN

The distributional pattern of various freshwater Bryozoan species in Rajasthan is interesting. The record of *Plumatella emarginata*, *P. javanica*, *P. repens*, *Hislopia lacustris* and *Fredericella sultana*, which are cosmopolitan in their distribution, can be easily explained. The occurrence of *Plumatella casmiana* in Rajasthan is noteworthy and shows the range of adaptability of the species which was hitherto known from areas of optimum environment. *Plumatella fruticosa*,



Text-fig. 5. A-G Spinoblasts of *Lophopodella carteri* showing extreme variations in the structure of spines.

which prefers colder temperatures, has now been recorded from this region. *Lophopodella carteri* is a temperate species and was supposed earlier to have a limited distribution. Its recent abundant records from Madhya Pradesh and Rajasthan make the view untenable. Annandale's contention that *Stolella indica* is restricted to the Indo-gangetic plains no more holds good by its recent records from Rajasthan. The wide occurrence of *Hyalinella punctata* in an arid environment is yet to be explained.