

OCCASIONAL PAPER NO. 173

**RECORDS OF THE
ZOOLOGICAL SURVEY OF INDIA**

**Studies on Taxonomy, Biology and Ecology of
Grasshoppers Infesting Field Crops and
Vegetables with notes on Nymphal Taxonomy
of some Species in West Bengal**

**S. K. MONDAL
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S. K. MONDAL, A. K. HAZRA & S. K. TANDON
Zoological Survey of India, Calcutta

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INTRODUCTION

The short horned grasshoppers belong to superfamily Acridoidea under the Order Orthoptera. The acrididae and pyrgomorphidae are exclusively herbivorous occurring abundantly and are most injurious to agricultural crops, vegetables and pasture fields in India. They were associated with the destructive locust and have long been recognised as crop pest probably from the time when cultivations were first practised. In general, it is difficult to separate locust from grasshoppers particularly when we talk about this group of insects in relation to damage of crops. Damage by locust although pasmodic in both space and time may cause local famine (Tandon, 1986). In our country with the rapid expansion of agriculture, grasshoppers have become major pests of crops and vegetables. Their devastation may be less spectacular than those caused by locusts but they are more persistant so that the effect of agricultural production is much more serious. Many species of grasshoppers have already been recorded as occasional pest but the damage is usually local and is confined to native crops so that it does not attract much attention to the farmers and scientists. But recently various development schemes entail mechanised production of different crops in India and this has led to identification of 19 species of grasshoppers as major or minor pests on the basis of change of soil condition, rotation of crops, temperature and humidity etc. It is therefore obvious that these conditions are conducive to these 14 species of grasshoppers making them minor pests and 5 species as major pest on the basis of maximum visual infestations.

Keeping the above background in view, the present investigation have been carried out with the following main objectives.

- 1) To study the general morphology and systematics of economically common important grasshoppers.
- 2) To study the distribution and abundance of grasshoppers of different crops and vegetables.
- 3) To study the nymphal taxonomy of the different instars of pest grasshoppers.
- 4) To study the seasonal abundance of grasshoppers in relation of physical factors in some localities in West Bengal.

REVIEW OF LITERATURE

A. Taxonomy

In India, the taxonomy of grasshoppers was initiated probably by Stål (1860, '73). Thereafter

Walker (1870, '71), Saussure (1884, '88) and Bolivar (1902, '09, '14, '18) studied the order Orthoptera of Indian subcontinent. The most consolidated taxonomic work on Indian grasshoppers was made by Kirby (1914) in his notable work of "Fauna of British India" which is now completely out of date for practical utility (Tandon, 1976). Chopard (1920) first introduced the structure of internal genitalia and phallic complex for the purpose of systematics of Orthoptera. Uvarov (1921, '24, '42) studied the taxonomy of Indian Acridoidea in details which has resulted in profound change in systematic concept of this group. Jago (1963) studied the life history of *Eyprepocnemis plorans meridionalis* (Uvarov) and observed the growth rates, sex ratio, mortality and different nymphal instar. Dirsh (1968) gave a detailed account of nymphal development of the morphological aspects of Acridomorpha (previously known as Acridoidea). In recent years, Iqbal et al (1974) reported about the eggs and nymphal instars of *Spathosternum prasiniferum prasiniferum* (Walker). Keven and Lee (1974) observed the life history and various nymphal stages of *Atractomorpha sinesnsis sinensis* Bolivar. Tandon (1975) and Tandon and Shishodia (1969, '75, '76, '77) published a list of all the known species of grasshoppers from different States of India. Shishodia and Hazra (1985, 1986) recorded some grasshoppers from Namdhapa (Arunachal Pradesh) and Silent Valley (Kerala) Bhowmik (1986) and Hazra et al (1993) gave a consolidated faunal information of the family Acridoidea (Orthoptera) known to occur in the state of West Bengal, India. Hazra et al (1995) studied the 55 species of grasshoppers from state of Meghalaya.

B. On Biology and Ecology

Morse (1904, '07) studied the effects of local conditions on the distribution of Acrididae in north America. Lefroy (1907, '09) recognised some information fo life history of *Hieroglyphus banian* (Fabricius), Later, some scattered works on the ecology and population density of grasshoppers were done by Vestel (1913) and Grasse (1929). Rao (1921) studied the breeding habit and seasonal abundance of *Oxya velox* (Fabricius) of a locality in South India. Antonov (1922) observed the influence of some metrological factors on the distribution of Acrididae in Russia. The details of the oviposition of an Egyptain grasshopper, *Anacridium aegyptium* (Linnaeus) came from Fedrov (1927). The notable work on the ecology and biology of grasshoppers was contributed by Uvarov (1928, '66, '77). During this period he actually studied not only the ecology of grasshoppers but also various aspects like distribution, population structure and migration. The most interesting amongst them was the studies of phases in different taxa of Acridoidea particularly of *Locusta*. Comprehensive works of Faber (1929, '32, '36, '53) included a large number of data on the behaviour of Acridoidea before copulation and also on during and after copulation but these were based on obsevation of a limited number of European species. Bei-Bienko (1930) studied the geographical and ecological distribution of Acrididae in West Siberian and Zaisan plains of Russia. Ayyar et al (1953) gave some informations about the

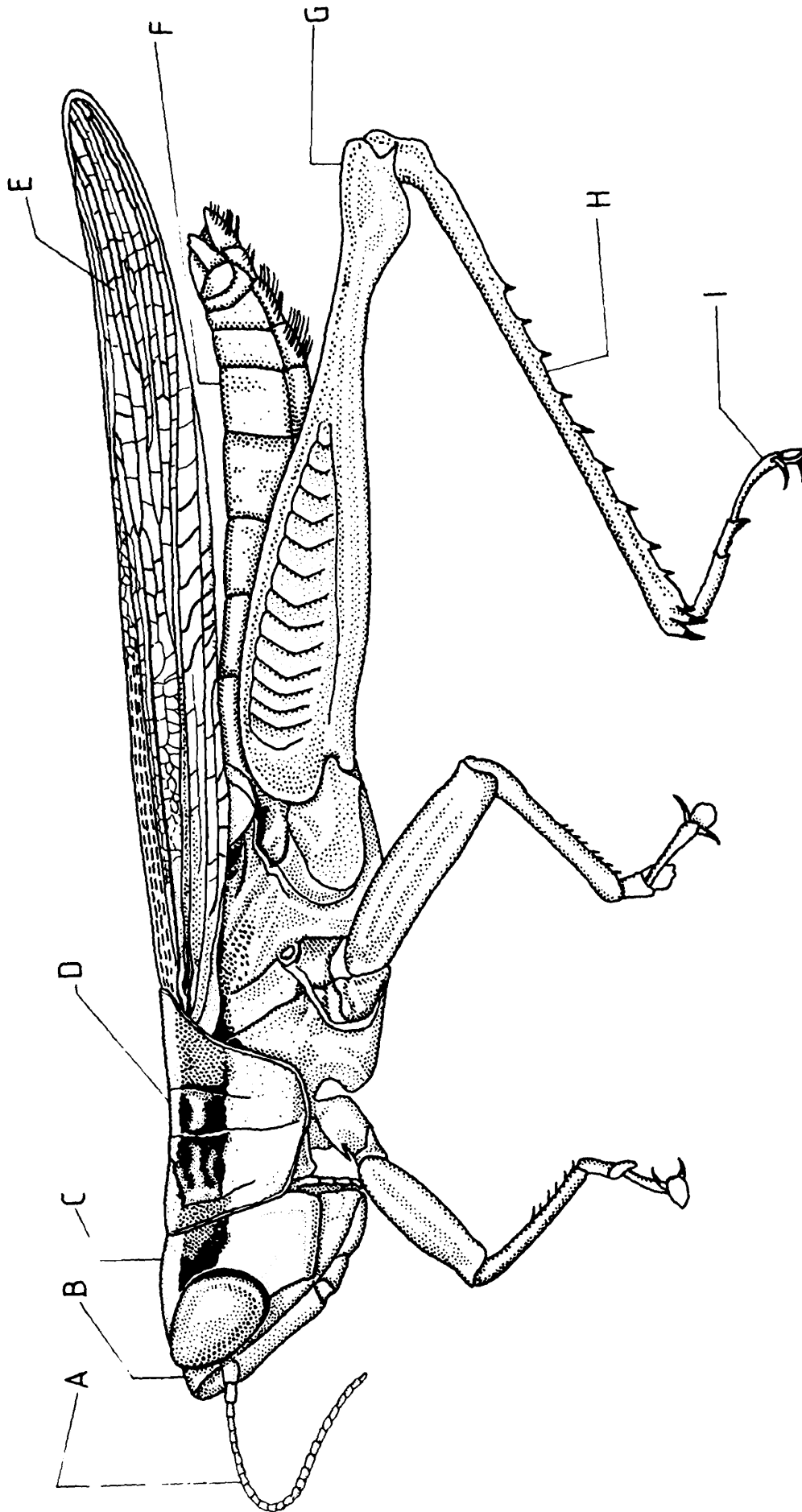
life history of *Gesonula punctifrons* (Stål). Diver and Diver (1933) have recorded the polyspecific grasshoppers population. Smith (1935) studied the role of biotic factors which play in the determination of population densities of grasshoppers. Isely (1937) presented a thorough account of the abundance of grasshoppers of different species in a particular grassland habitat. Chesler (1938) noted the biology of South African acridid such as oviposition, hatching and number of instars etc. In northern India, Pruthi and Nigam (1939) studied details of bionomics, life history and control of *Peukilocerus pictus* (Fabricius) Waloff (1940, '46) presented the distribution and the migratory behaviour of European species of *Locusta* and he also studied the population dynamics of some British grasshoppers, Hussain et al (1944) studied the development and general bionomics of *Schistocerca gregaria* (Forsk.) and observed the effect of Water and relative humidity on its development. Roonwal (1936, '45, '46, '58, '76, '76a) did the notable works on grasshoppers in respect to ecology and biology in different aspects such as bionomics, life history and population. Phipps (1949, '50, '59, '62) observed the habits, seasonal cycle and relation between copulation and sexual maturity of grasshoppers. Agarwal (1951) gave a detailed account of oviposition in *Locusta migratoria migratoriodes* (R. and F.) Richards et al (1954) studied the biology and population dynamics of British grasshoppers. Agarwal (1955) studied the bionomics of *Atractomorpha crenulata* (Fabricius) and also observed the precopulation period in various seasons. Katiyar (1955) briefly described the mode of copulation and oviposition of two Indian species, *Aularches punctatus* (Drury) and *Parahieroglyphus bilineatus* (Bolivar) and studied the development of egg pods and eggs in some Indian Acrididae. Hafez and Ibrahim (1958, '58a, '62, '62a) studied the ecology of adult of *Aecira pellucida* Clug, *Aiolopus thalassinus* Fabricius and has also observed the biology of the above two species. Pradhan and Paswani (1961) studied the population density of *Hieroglyphus nigrorepletus* Bolivar and the influence of the high and low temperature and rainfall on it. Ashall et al (1962) recorded the field population of *Schistocerca gregaria* (Forsk.) in number per unit area and showed the seasonal mortality by using the statistical approaches. Chapman (1962, '67) studied the ecological distribution, the breeding habit and nymphal instar of *Zonocerus variagatus* (Linnaeus). Chahal and Sohi (1965) studied the bionomics of *Chrotogonus tr. trachypterus* (Blanchard) and also observed the seasonal occurrence on vegetables like cow-pea and clusterbean. Bullen (1966) observed the nature of damage to crops and their effects upon yield and also studied the quantitative evaluation of locust damage and its relation to human economy. Grewal et al (1968) studied the life cycle and feeding habit of *Chrotogonus tr. trachypterus* (Blanchard) in relation to different levels of temperature and humidity. Gausz (1970) presented a thorough account of the ecological habits of 34 species of Orthoptera of the middle Tisza valley and Kiskore (Hungary). Suslik (1971) carried out the investigation to know the dispersal of grasshoppers in relation to the season and height of the grass and also observed the population density in different times of the year. Antonion (1973) studied the life history of *Ornithacris turbida* (Walker) under controlled laboratory conditions and also observed the variation between the crowded population

and isolated population in respect of colour, morphometrics, weight of the hatching of fledging. Khan et al (1974) discussed the effect of temperature and humidity on the development of eggs and hoppers and also the seasonal variation of the population of hoppers and adults of *Oedaleus abruptus* (Thunberg). Mukherjee and Raudell (1974) reported the effect of temperature increase in population. Parihar (1974) studied the breeding habit, development of eggs and hoppers of *Peokilocerus pictus* (Fabricius) in the laboratory as well as in the field at different temperature. Muraliragan and Ananthkrishnan (1974) studied the taxonomic significance of foregut armature of 31 of south Indian species. Mahato (1977) observed the bionomics of *Eyprepocnemis of Acredidae alacris impicata* Uvarov on variable temperature and humidity. Pfadt (1977) gave an account of grasshopper population over a period of 6 years in short grass of South Eastern Wyoming (USA). Tandon and Khera (1978) studied some interesting changes in the distribution, habits and other peculiarities of grasshoppers in Arunachal Pradesh. Hazra et al (1981) studied the population of grasshoppers in relation to the effect of temperature and relative humidity in two grass lands of West Bengal. John and McE. Keven (1981) observed the laboratory rearing of *Pyrgomorpha vignaudil vignaudil* (Guerin-Meneville) and *Pyrgonorpha bispinosa incognita* Hisung and Kevan and studied the development of eggs, egg pod, nymphs, and also reproductive capacity at different temperature. Shamshad Ali (1982) studied the seasonal variation in the population of *Acrida exaltata* (Walker) in optimum ecological condition particularly temperature, relative humidity and food and also observed the development, fertility-fecundity and biological activities of their various nymphal stages. Julka et al (1982) gave the information of the ecology of grasshoppers of Solan (Mimachal Pradesh) on three habitats such as cultivated field, orchard and an open grass land (altitude approx. 1500 m). Meera (1982) studied the bio-ecology of *Oxya nitidula*.

MATERIALS AND METHODS

The nymphs and adult grasshoppers were collected from the places in different districts of West Bengal. In order to have a comprehensive collection from agricultural crops and vegetables, several surveys were made in different seasons at different times. Grasshoppers were usually collected by sweeping insect net or from the leaves, stems etc. Some of the larger insects were picked up from bare ground directly by hand or with the help of fine forceps.

The grasshoppers after collections from the field were killed in potassium cyanide or chloroform in a killing bottle. For temporary storage in the field they were kept in insects envelopes. Sometimes the insects were placed directly in ethyl alcohol (70%) in the field. Before permanent storage in insect cabinets such collections were washed in ethyl alcohol in laboratory and then the specimens were pinned after proper orientation and ready for identification. Male



A= Antenna; B= Vertex; C= Head; D= Pronotum; E= Tegmen;
F= Abdomen; G= Femur; H= Tibia; I= Tarsus

Fig. 1. General morphology of a typical short horned grasshopper (*Oxya fuscovittata*)

genitalia were dissected out and kept in 10% KOH solution for 12 hours, rinsed in distilled water for several times and were then preserved in glycerol for further study.

The figures were drawn with the help of camera lucida. All measurements are in millimeters (mm.) and measured with the help of slide caliper.

The Study of Biology

The material comprised of the eggs, nymphs and adults of selected grasshoppers. Gravid females were collected from cultivated fields and were allowed to lay eggs in glass tubes containing sterilised moistend mixture of 50% clay and 50% sand, to get a separate stock in the laboratory. These eggs hatched to give the first laboratory generation and subsequent F2 generation were reared both singly or in pair. Laboratory rearing of grasshoppers were made after Hlunter and Jones (1966) with slight modifications as stated below. The nymphs were reared singly keeping in perforated cylindrical brass cages measuring 14 cm. × 5 cm. in diameter, the mouth of the cages were tied with fine silk cloth. The humidity of the cages were maintied by keeping bottom soil moistend.

The adults were reared in wooden cages 25 cm. × 15 cm. top of which were fitted with sliding doors, and the front and two sides were covered with wire mesh, and the back of the cages were fitted with glass for frequent observations from outside. The bottom of the cages were covered with 10 cm. sterilised loamy soil to facilitate the female for laying of egg pods. The grasses and sedges were provided as food separately in small sterilised tubes. During night the rearing cages

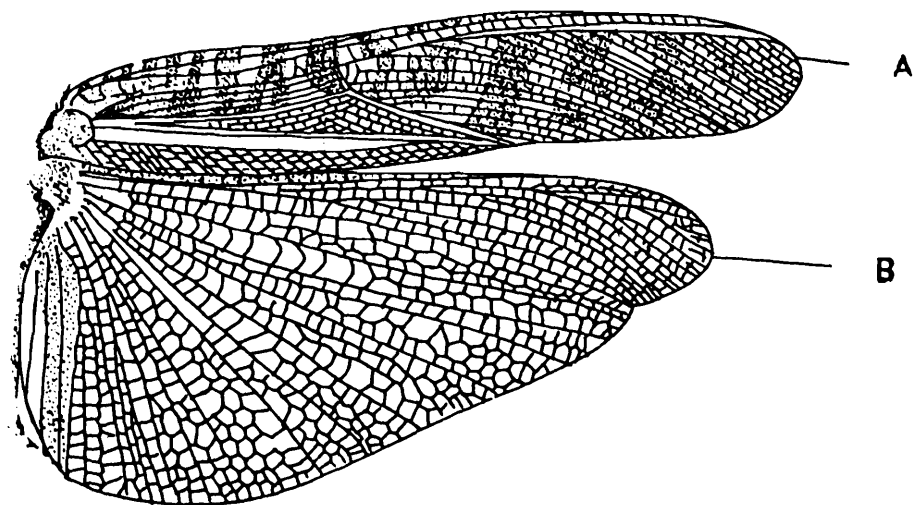


Fig. 2. Fore wing (A) and hind wing (B) of a typical grasshopper

were kept in B. O. D. incubator under controlled temperature ($33^{\circ} \pm 2^{\circ}\text{C}$). and 70% to 90% humidity and during day time, the cages were kept in the laboratory in ambient conditions. The fresh food of grasses and sedges like *Helianthus* Sp. and *Enhydra fluctuens* were provided every day.

The sexes of all the selected species can easily be differentiated by observing the external genitalia of the vermiform larvae as well as the first instar nymphs. The number of instars could easily be determined by examining the exuviae of the moulting hoppers. The nymphs of each instars were preserved in 'Sweet pickle' fluid (Keven and Lee, 1974) for further studies.

The measurements of structural parts of egg pods, eggs and nymphs have been given in mm. The figures in parentheses indicate the ranges, those outside the parentheses being the mean value and 'N' denoting number of specimens measured.

Characteristics of the locality for Ecological Studies

For all practical purposes, the sites were chosen in four different places of West Bengal (namely Narendrapur and Garia South 24 Parganas, Botanical gardens in Howrah. Bethuadahari in Nadia districts). All the collections were mixed and average was taken. The areas of the each sites measured about 220 m \times 150 m. All the sites were sampled at a time by four persons. The grasshoppers were collected by catch count method (Andrewartha, 1970) by using standard net of conventional size of 36 cm. and were estimated per man hour. Field temperatures were recorded at different times by using a mercury thermometer and relative humidity by a dial hygrometer. The sites includes pasture land, cultivated land and orchards. Other than paddy, almost all the vegetables mentioned in the present study were cultivated. The grass fields comprising the grasses like *Cynodon dactylon*, *Panicum* sp., *Arundinella* Sp., *Dichanthium annulatum*, *Digitaria marginata*, etc. were common in all the four sites. The soil of these sites are gangetic alluvium, brownish grey in colour and clay-loam in texture.

OBSERVATIONS

Grasshoppers in different crops and vegetables

It is rather difficult to assess the amount of damage caused by grasshoppers to the economy. It is evident from tables, 1,2, and 3 that the grasshoppers attacked almost all the crops, cereals, vegetables and cash crops. The Paddy crops were infested by 19 species of grasshoppers, maize by 10 species, wheat by 6 species of grasshoppers. The cereals like Peas and grams were infested

respectively by 6 species each of grasshoppers. And their infestations in vegetables and cash crops are shown in table 3. A survey on the occurrence of different grasshopper species from those crops. Cereals and vegetables have been made per month in different areas of West Bengal are shown in table 4.

Paddy : (*Oryza sativa*) : Economically most important crop, widely cultivated throughout the country. Both the adults and nymphs of all the 19 species of grasshopper were observed to cause serious damage to the paddy plants. Maximum infestations of grasshopper were recorded in September - October (Table 4).

Maize : (*Zea mays*) Another important crop in India, usually sowed during June to September. Maize leaves are infested by the species like *Atractomorpha crenulata*, *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Oxya hyla hyla*, *Choroedocus robustus*, *Eyprepocnemis alacris alacris*, *Aiolopus thalassinus tamulus*, *Acrida exaltata*, *Phlaeoba infumata*, *Eupreponotus inflatus*. The maximum infestations were recorded in the month of July-August (Table 4).

Wheat (*Triticum sativum*) This is a most common rabi crop in West Bengal usually sowing in December in North and East India. Only six species of grasshoppers like *Atractomorpha crenulata*, *Chrotogonus trachypterus trachypterus*, *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Aiolopus tamulus*, and *Phlaeoba infumata* were found to cause damage this crop. The maximum infestations were found in the month of January-February (Tab. 4).

Sugar cane : (*Saccharum officinarum*) It is a common cash crop and cultivated more or less in major states of India from December to March. The species like *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Oxya hyla hyla*, *Eyprepocnemis alacris alacris*, and *Acrida exaltata* have been recorded from Sugar cane. These species were found to occur maximum in the month of April (Tab. 4).

Pea : (*Pisum sativum*) It is one of the most common cereal crops and cultivated throughout the North and East India during December to March. Grasshoppers like *Atractomorpha crenulata*, *Chrotogonus trachypterus trachypterus*, *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Aiolopus th. tamulus*, *Trilophidia annulata*, *Acrida exaltata*, *Oedaleus abruptus* are causing damage to these plants. These species were found to occur in January and February (Tab. 4).

Gram : (*Cicer esculentus*) Most common cereal and widely cultivated in North, East and Western part of the country from December to March. The plants are damaged by the species like *Atractomorpha crenulata*, *Spathosternum prasiniferum prasiniferum*, *Aiolopus th. tamulus*, *Trilophidia annulata*, *Acrida exaltata* and *Oedaleus abruptus*. Maximum occurrence were recorded during January-February (Tab. 4).

Ladies finger : (*Hibiscus esculentus*) A common Vegetable plants grows maximum in monsoon. Leaves of young plants are eaten up by the species like *Oxya fuscovittata*, *Aiolopus th. tamulus*, *Acrida exaltata*. Maximum occurrences were found during April-July (Table 4).

Chilly : (*Capsium spp.*) Seasonal sometimes pernnial economically important bushy plant largely grown all over India.

Atractomorpha crenulata is a major pest of chilly. These plants are also infested by *Spathosternum pr. prasiniferum*, *Oxya fuscovittata*, *O. hyla hyla*, *Aiolopus th. tamulus* and *Acrida exaltata*. In the month of July-August showed maximum infestation (Tab. 4).

Brinjal : (*Solanum molangona*) a widely cultivated vegetable plant in the Eastern states and during winter in the Southern states. In absence of prepered food plants the leaves of these plants are occassionally damaged by *Spathosternum pr. prasiniferum*, *Oxya fuscovittata*, *O. hyla hyla*, *O. nitidula* and *Acrida exaltata*. Maximum infestation were recorded during May-July (Tab. 4) in Eastèrn India.

Cucumber : (*Cucumis sativum*) An important vegetable plant extensively cultivated throughout East and North India. It is one of the most prepered vegetable plant of two species of grasshoppers like *Aiolopus th. tamulus* and *Eyreprocnemis al. alacris* (Tab. 4).

Arum : (*Colocasia antiquorum*) A seasonal edible herb with smooth extended petiole terminated by a flattened lamina. The plants are grown in moist places of the country particularly in the eastern states and southern states. It is used as vegetable. Only lamina portion of leaves were found to be preffered by the species like *Gesonula punctifrons*, Occasionally, *Atractomorpha crenulata*, *Oxya fuscovittata*, *O. hyla hyla* and *O. nitidula* (Table 4).

Cauliflower : (*Brasica oleracea var. botrytis*) the vegetable is extensively cultivated throughout the country from October to March. Only leaves of these plants are consumed by the species like *Oxya fuscovittata* *O. hyla hyla*, and *Aiolopus th. tamulus* (Table 4).

Table 1 : List of grasshoppers and their occurrence on some major crops

Name of the species	Paddy	Maize	Wheat
1. <i>Atractomorpha crenulata</i>	+	+	+
2. <i>Chotogenus ts. trachypterus</i>	+	-	+
3. <i>Gesunula punctifrons</i>	+	-	-
4. <i>Sapthosternum pr. prasiniferum</i>	+	+	+
5. <i>Hieroglyphus banian</i>	+	-	-
6. <i>Oxya fuscovittata</i>	+	+	+
7. <i>O. hyla hyla</i>	+	+	-

Name of the species	Paddy	Maize	Wheat
8. <i>O. nitidula</i>	+	-	-
9. <i>Tristria pulvinata</i>	+	-	-
10. <i>Choreodocus robustus</i>	+	+	-
11. <i>Eyprepocnemis al. alacris</i>	+	+	-
12. <i>Catantops pinguis innotabilis</i>	+	-	-
13. <i>Cyrtacanthacris tatarica</i>	+	-	-
14. <i>Aiolopus th. tamulus</i>	+	+	+
15. <i>Trilophidia annulata</i>	+	-	-
16. <i>Acrida exaltata</i>	+	+	-
17. <i>Oedaleus abruptus</i>	+	-	-
18. <i>Phlaeoba infumata</i>	+	+	+
19. <i>Eupreponotus inflatus</i>	+	+	-

Table 2 : List of grasshoppers and their occurrence on cereals

Name of the species	Pea	Gram
<i>A. crenulata</i>	+	+
<i>Ch. tr. trachypterus</i>	+	-
<i>G. punctifrons</i>	-	-
<i>S. pr. prasiniferum</i>	+	+
<i>H. banian</i>	-	-
<i>O. fuscovittata</i>	+	-
<i>O. hyla hyla</i>	-	-
<i>O. nitidula</i>	-	-
<i>Tr. pulvinata</i>	-	-
<i>C. robustus</i>	-	-
<i>Ey. alacris alacris</i>	-	-
<i>C. pinguis innotabilis</i>	-	-
<i>Cy. tatarica</i>	-	-
<i>A. th. tamulus</i>	+	+
<i>T. annulata</i>	+	+
<i>A. exaltata</i>	+	+
<i>O. abruptus</i>	+	+
<i>Ph. infumata</i>	-	-
<i>Eu. inflatus</i>	-	-

Table 3 : List of grasshoppers and their occurrence on major vegetables, spices and sugarcane.

Name of the species	Colo- casia sp.	Cauli flower	Sugar cane	Ladies finger	Chili	Bri- njaj	Cucum- ber
<i>A. crenulata</i>	+	-	-	-	+	-	-
<i>Ch. tr. trachypterus</i>	-	-	-	-	-	-	-
<i>G. punctifrons</i>	+	-	-	-	-	-	-
<i>S. pr. prasiniferum</i>	-	-	+	-	+	+	-
<i>H. banian</i>	-	-	-	-	-	-	-
<i>O. fuscovittata</i>	+	+	+	+	+	+	-
<i>O. hyla hyla</i>	+	+	+	-	+	+	-
<i>O. nitidula</i>	+	-	-	-	-	+	-
<i>Tr. pulvinata</i>	-	-	-	-	-	-	-
<i>C. robustus</i>	-	-	-	-	-	-	-
<i>Ey. alacris alacris</i>	-	-	+	-	-	-	+
<i>C. pinguis innotabilis</i>	-	-	-	-	-	-	-
<i>Cy. tatarica</i>	-	-	-	-	-	-	-
<i>A. th. tamulus</i>	-	+	-	+	+	-	+
<i>T. annulata</i>	-	-	-	-	-	-	-
<i>A. exaltata</i>	-	-	+	+	+	+	-
<i>O. abruptus</i>	-	-	-	-	-	-	-
<i>Ph. infumata</i>	-	-	-	-	-	-	-
<i>Eu. inflatus</i>	-	-	-	-	-	-	-

Table 4 : Showing monthwise occurrence of Grasshoppers from different crops, and vegetable, grain, spices and sugar cane.**Paddy**

Name of the species	J	F	M	A	M	J	J	A	S	O	N	D
<i>A. cruenlata</i>	-	+	+	+	-	-	-	+	+	+	+	-
<i>Ch. tr. trachypterus</i>	-	-	+	-	-	-	-	+	-	+	+	-
<i>G. punctifrons</i>	-	-	+	+	+	-	-	-	+	+	+	-
<i>S. pr. prasiniferum</i>	-	-	+	+	-	-	-	+	+	+	+	+
<i>H. banian</i>	-	-	-	-	-	-	-	+	+	+	+	-
<i>O. fuscovittata</i>	-	-	+	+	-	-	-	+	+	+	+	+
<i>O. hyla hyla</i>	-	-	+	+	-	-	-	+	+	+	+	+

Sugarcane

Name of the species	J	F	M	A	M	J	J	A	S	O	N	D
<i>S. Pr. Prasiniferum</i>	-	-	+	+	+	-	-	-	-	-	-	-
<i>O. fuscovittata</i>	-	-	-	+	+	+	+	-	-	-	-	-
<i>O. hyla hyla</i>	-	-	-	+	-	-	-	-	-	-	-	-
<i>Ey. al. alacris</i>	-	-	-	-	-	-	-	-	-	+	+	-
<i>A. exaltata</i>	-	-	+	+	+	+	-	-	-	-	-	-

Pea

Name of the species	J	F	M	A	M	J	J	A	S	O	N	D
<i>A. crenulata</i>	+	+	-	-	-	-	-	-	-	-	-	+
<i>Ch. tr. trachypterus</i>	+	+	-	-	-	-	-	-	-	-	-	-
<i>S. pr. prasiniferum</i>	+	+	+	-	-	-	-	-	-	-	-	+
<i>O. fuscovittata</i>	+	+	-	-	-	-	-	-	-	-	-	-
<i>A. th. tamulus</i>	+	+	+	-	-	-	-	-	-	-	-	-
<i>T. annulata</i>	-	+	+	-	-	-	-	-	-	-	-	-
<i>A. exaltata</i>	+	-	-	-	-	-	-	-	-	-	-	-
<i>O. abruptus</i>	-	+	-	-	-	-	-	-	-	-	-	-

Gram

Name of the species	J	F	M	A	M	J	J	A	S	O	N	D
<i>A. crenulata</i>	+	+	-	-	-	-	-	-	-	-	-	+
<i>S. pr. prasiniferum</i>	+	+	+	-	-	-	-	-	-	-	-	+
<i>A. th. tamulus</i>	+	+	-	-	-	-	-	-	-	-	-	-
<i>T. annulata</i>	+	+	-	-	-	-	-	-	-	-	-	-
<i>A. exaltata</i>	+	+	+	-	-	-	-	-	-	-	-	-
<i>O. abruptus</i>	-	+	+	-	-	-	-	-	-	-	-	-

Ldies finger

Name of the species	J	F	M	A	M	J	J	A	S	O	N	D
<i>O. fuscovittata</i>	-	-	+	+	+	+	+	-	-	-	-	-
<i>A. th. tamulus</i>	-	-	-	+	+	-	-	-	-	-	-	-
<i>A. exaltata</i>	-	-	-	-	-	+	+	+	-	-	-	-

Systematic account of different Taxa

Family : PYRGOMORPHIDAE

Subfamily PYROGOMORPHINAE

1. *Atractomorpha crenulata* (Fabricius)

1793. *Truxalis crenulatus* Fabricius : 28

1914. *Atractomorpha crenulata* Kirby : 181

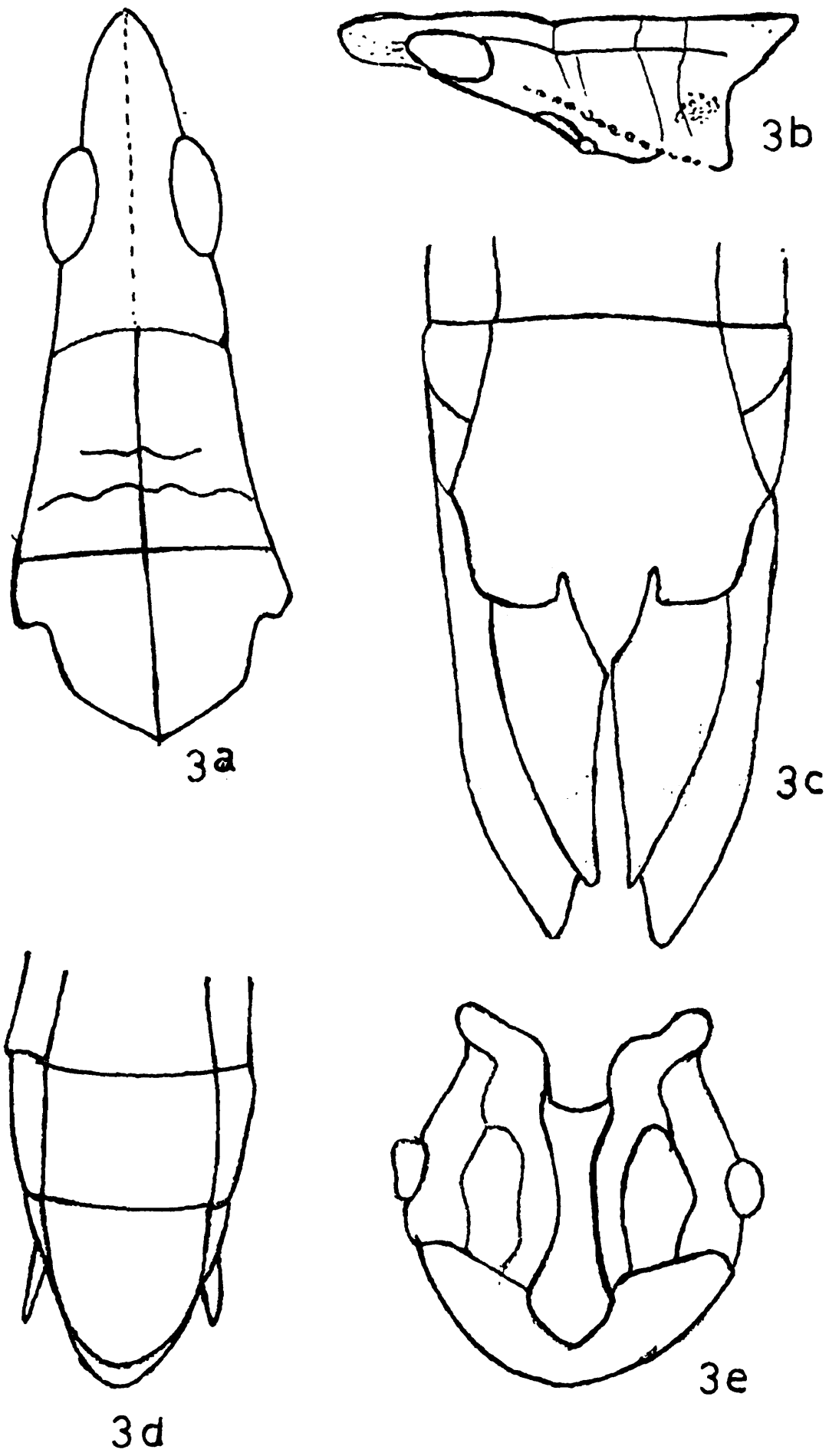
1969. Kevan and chen : 187

Diagnostic Features : Male : Medium size. Body long, slender and laterally compressed. Integument shiny and finely punctate. Head conical in shape, gradually broadend behind and shorter than pronotum ; face strongly bent downwards ; frontal ridge sulcated throughout and extend up to the clypeus; fastigium of vertex comparatively longer than broad. Antennae subfiliform and not longer than pronotum. Pronotum long ; prozona longer than metazona ; median carina feebly marked, crossed by three sulci ; first present, lateral carinae undulating ; a membranous area is present on the posteriolateral lobe of metazona, posterior margin of metazone obtusely pointed. Mesosternal lobe ellipsoidal in shape. Mesosternal interspace trapezoidal in shape. Supra-anal plate triangular and longer than breadth. Cercus small, narrow and conical ; Sub-genital plate obtusely rounded at apex. Epiphallus as in figure (Fig. 3e).

Female : More robust and longer than male ; Membranous area more prominent than male. Anterior ovipositor valves moderately broad and slightly crenulated. Subgenital plate as usual.

Colour : General body colour green, pale yellow or light brown and hind tibiae light bluish.

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	16.9	20.0	18.30	27.00	29.00	28.14
L. of the head	3.4	3.7	3.48	4.30	5.00	4.62
Br. of the head	5.1	6.0	5.43	7.00	7.50	7.34
L. of the pronotum	3.5	4.0	3.75	5.90	6.90	6.35
L. of the Tegmen	15.0	18.8	16.21	21.50	25.00	22.96
L. of the hind femur	8.2	10.0	9.00	13.00	14.00	13.24
Br. of the hind femur	1.5	1.6	1.56	2.20	2.30	2.25
L. of the tibiae	7.3	9.0	7.85	11.40	12.00	11.76



Figs. 3 a-e. *Atractomorpha crenulata* — 3a, head and pronotum ; 3b, head and pronotum (lateral view) ; 3c, external genitalia of female (ventral view) ; 3d, subgenital plate of male (ventral view) ; 3e, epiphallus.

Distribution : INDIA (Andhra Pradesh, Andaman Is., Assam and Arunachal Pradesh, Bihar, Goa, Jammu and Kashmir, Kerala, Laccadive and Maldiva Is., Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal) Elsewhere Bangladesh, Burma, Cambodia, Laos, Nepal, Sri Lanka, Thailand, Vietnam.

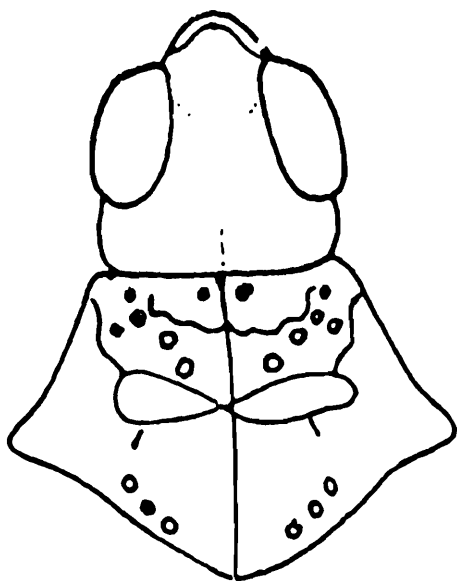
Remarks This common species can easily be recognised in having slender, compressed body with pointed elytra which is extended beyond the apex of abdomen and shape of male epiphallus.

2. *Chrotogonus (Chrotogonus) trachypterus trachypterus* (Blanchard)

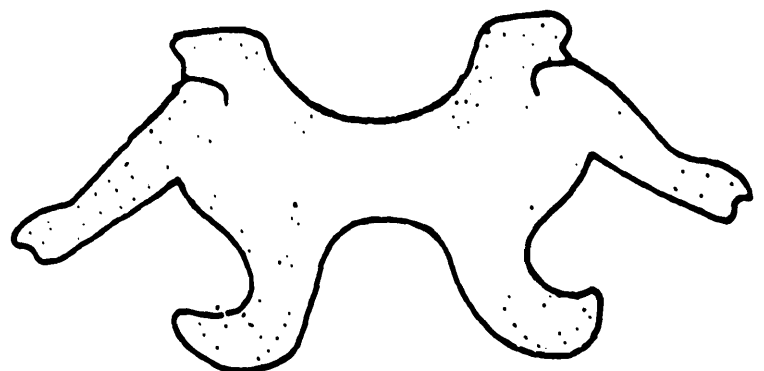
1836. *Ommexecha trachypterus* Blanchard : 618

1959. *Chrotogonus (Ch.) trachypterus trachypterus* Kevan : 147.

Diagnostic Features : Male : Medium size. Body robust and laterally depressed. Integument rugose, strongly tuberculate. Head short, broad and shorter than pronotum ; face bent downwards ; frontal ridge sulcated, slightly expanded towards the clypeus and not reaching up to the clypeus ; fastigium of vertex short, angular and comparatively shorter than breadth. Antennae filiform and not reaching beyond the pronotum. Pronotum short ; prozona shorter than metazona, median carina interrupted and it is crossed by three transverse sulci ; first sulcus present only in the dorsum, second and the third entirely present lateral carinae also interrupted by tubercles and diverging posteriorly, posterior margin obtusely rounded. Mesosternal lobes shorter than broad inner margin concave in shape. Mesosternal interspace longer than broad. Supra-anal plate small, angular in shape. Cercus short and obtusely conical. Subgenital plate obtusely subconical at apex. Epiphallus bridge shaped, undivided and sclerotised ; ancorae absent ; lophi large strongly upcurved and hook like (Fig. 4b).



4a



4b

Figs. 4 a-b. *Chrotogonus (Ch.) tr. trachypterus* — a, head and pronotum ; b, epiphallus.

Female : More robust and longer than male ; mesosternal interspace broader than long. Anterior ovipositor valves broad ; Subgenital plate simple.

Colour : Genral body colour brown or reddish brown ; sternum yellowish occasionally white and with black spots.

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	13.0	14.8	14.30	18.50	23.00	21.80
L. of the head	2.2	2.6	2.40	3.00	3.30	3.12
Br. of the head	4.0	4.3	4.10	5.40	5.60	5.48
L. of the pronotum	3.0	3.3	3.20	4.20	5.00	4.71
L. of the Tegmen	8.6	10.5	9.70	11.20	14.00	12.90
L. of the hind femur	6.5	7.6	7.10	9.00	11.00	12.20
Br. of the hind femur	2.0	2.2	2.15	3.00	3.20	3.12
L. of the hind tibiae	6.0	6.3	6.17	8.00	.87	8.44

Distribution : INDIA (Assam, Bihar, Delhi, Himachal Pradesh, Madhya Pradesh, Maharashtra, Punjab, Orissa, Uttar Pradesh) Elsewhere : BANGLADESH ; IRAN ; NEPAL ; PAKISTAN.

Family : ACRIDIDAE

Subfamily : HEMIACRIDINAE

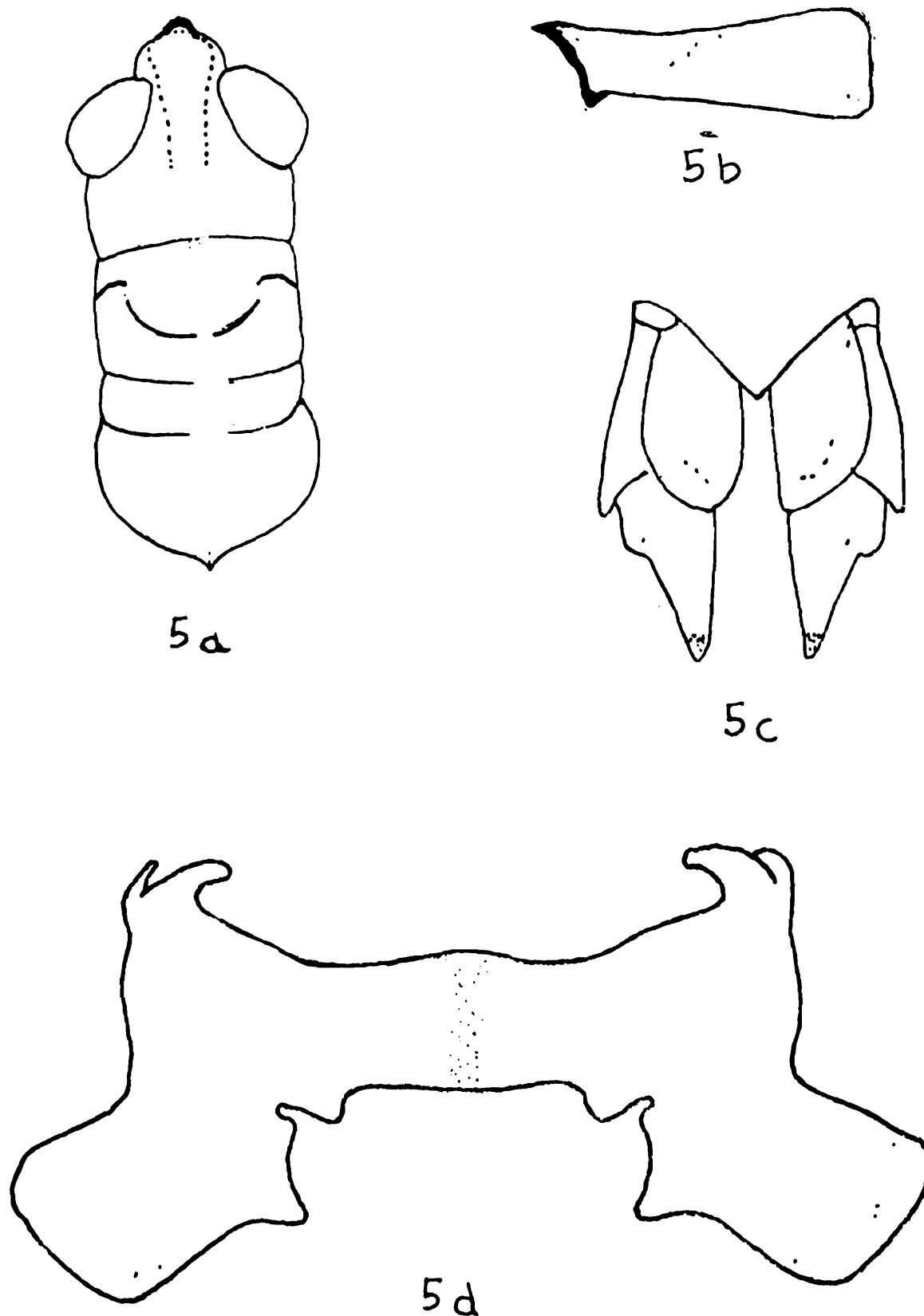
3. *Hieroglyphus banian* (Fabricius) (Figs. 5a-d)

1798. *Gryllus banian* Fabricius : 194

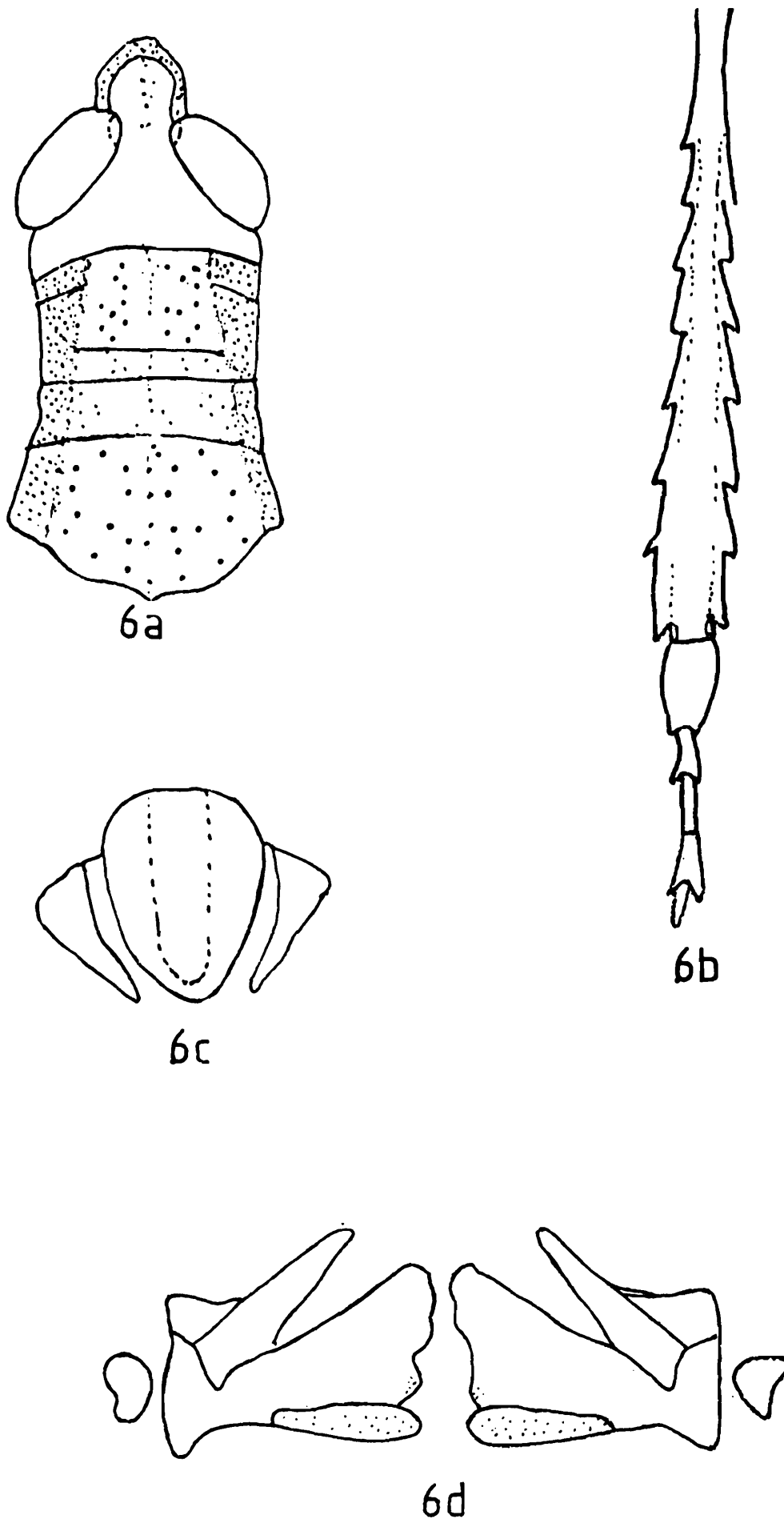
1906. *Hieroglyphus banian* Lefroy : 120.

1973. *Hieroglyphus banian* Mason : 540-541.

Disgnostic Features : Male : Medium size. Body more or less slender and laterally compressed. Integument shining, finely rugose and punctate. Head large, shorter than pronotum ; face somewhat bent down wards ; frontal ridge moderately broad and almost parallel, sulcated throughout and extended upto the clypeus ; fastigium of vertex with equal breadth and length, elongated depressed in the the middle and the apex rounded. Antennae long and filiform extended beyond the margin of pronotum. Pronotum smooth ; prozona longer than metazona



Figs. 5 a-d. *Heiroglyphus banian* — 5a, head with pronotum ; 5b, cerci ; 5c, posterior ovipositor valves (ventral view) ; 5d, epiphallus.



Figs. 6 a-d. *Gesonula punctifrons* — 6a, head and pronotum ; 6b, Tibiae ; 6c, supra-anal plate (ventral view) ; 6d ; epiphallus (male).

median carina faintly present in metazona and crossed by three culci ; first sulcus present only in lateral lobe second, third on dorsum and fourth present on dorsum as well as lateral lobe, lateral carinae absent, posterior margin of metazona rectangular. Prosternal tubercle conical, straight, pointed at apex. Mesosternal lobes slightly longer than broad, inner margin rounded ; mesosternal interspace longer than broad. Supra anal plate longer than broad, two ridges like elevation presents in the middle. Cerci slender, apex bifurcate, lower part of bifurcation long and acute. Epiphallus broad and large, bridge undivided, ancorae inwardly directed with acute apex, lophi large with two lobe outer edges sinuate.

Female : More robust and larger than male. Fastigium broader than long. Anterior ovipositor valves elongate with two prominent teeth on either side and three and half times as long as wide. Subgenital plate as usual.

Colour : General colour of the body almost green or yellowish-green, blackish brown at joints, transverse sulci of pronotum blackish, wings hyaline, tibiae bluish or orange.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	31.5	35.0	32.80	40.00	49.00	45.20
L. of the head	4.1	4.7	4.38	5.50	6.00	5.82
Br. of the head	7.5	8.0	7.80	10.00	11.50	10.70
L. of the pronotum	6.0	6.8	6.50	8.70	9.00	8.80
L. of the tegmen	22.5	28.0	24.50	34.00	36.00	35.00
L. of the hind femur	17.0	19.0	18.20	22.30	24.50	23.80
Br. of the hind femur	3.9	4.0	3.98	5.00	5.20	5.02
L. of the hind tibiae	16.0	17.5	16.42	20.00	13.50	21.60

Distribution : INDIA (Andhra Pradesh, Bihar, Karnataka, Maharashtra, Rajasthan, Orissa, Sikkim, Tamil Nadu, Uttar Pradesh. Elsewhere : AFGHANISTAN ; BHUTAN ; BURMA ; CHINA ; THAILAND AND VIETNAM.

Remarks The male can be easily recognised by its colour, size of the body, rounded fastigium of vertex and bifurcated cerci, while the female by presence of dental projection on either side of the ovipositor valves.

4. *Gesonula punctifrons* (Stål)1860. *Actidium (Oxya) punctifrons* Stal : 3361955. *Gesonula punctifrons* Willemese : 161

1963. Bei-Bienko and Mishchenko : 172

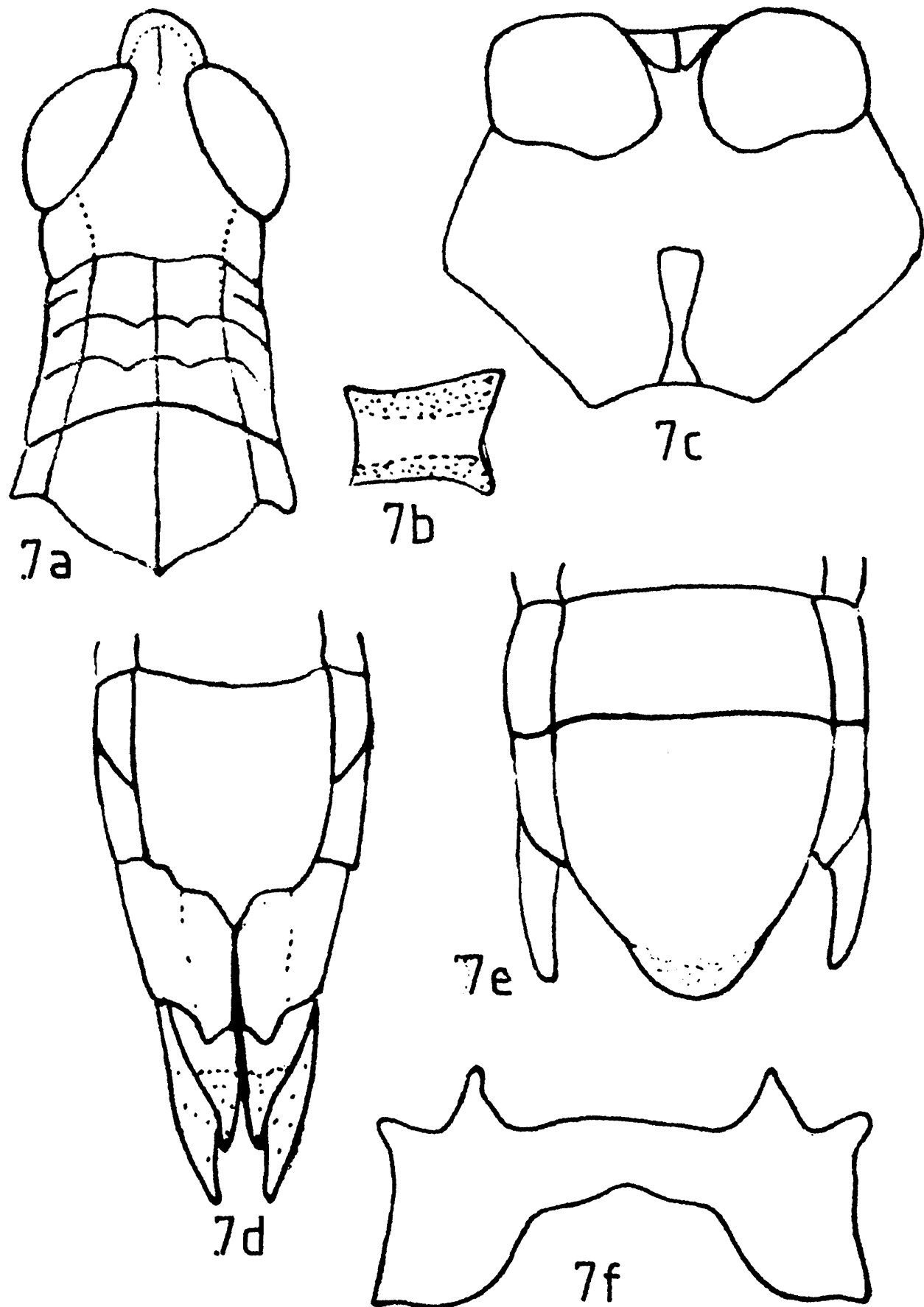
Diagnostic features : Male : Medium sized. Body slender and laterally compressed. Integument shiny, finely rugose and punctured. Head short not longer than pronotum ; face strongly bent downwards ; frontal ridge almost parallel, sulcated throughout and reaching upto the clypeus ; fastigium of vertex slightly longer than wide, forming a clear angle with the frontal ridge, apex rounded. Antennae filiform and extend beyond the pronotum. Pronotum finely punctate, cylindrical, slightly narrowed anteriorly ; prozona longer than metazona ; median carina feebly marked, lateral carinae absent ; first sulci present only in dorsum, second and the third present on the dorsum as well as on lateral lobe. Prosternal tubercle short, conical, Mesosternal lobes equal in length and breadth, inner margin rounded. Mesosternal interspace quadrat, slightly wider posteriorly. Supra-anal plate spoon like, triangular with a median sulcus. Cerci long narrow, apex pointed. Subgenital plate as usual. Epiphallus bridge shaped, divided, ancorae straight, inwardly directed with tapering at apex and broad at the base, lophi small with two lobes. (Fig : 6d)

Female : Larger than male. Anterior ovipositor valves narrow towards the apex and slightly longer than posterior valves. Subgenital plate longer than broad with a median spine.

Colour : General body lush green to yellow green black stripe run laterally behind the eye and extend upto the end of pronotum, hind femur yellowish brown to green, hind tibiae bluish in general, reddish at the base and back at apex.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	18.0	19.0	18.50	23.0	26.00	24.40
L. of the head	2.4	2.5	2.55	2.80	3.10	2.96
Br. of the head	4.9	5.0	4.85	5.80	6.00	5.85
L. of the pronotum	4.2	4.5	4.33	5.50	5.70	5.59
L. of the tegmen	16.0	19.0	17.71	21.00	23.50	22.10
L. of the hind femur	10.0	10.2	10.03	13.00	13.50	13.27
Br. of the hind femur	2.8	2.9	2.85	3.50	3.50	3.50
L. of the hind tibiae	8.0	8.6	8.30	10.50	10.70	10.60



Figs. 7 a-f. *Spathosternum pr. prasiniferum* — 7 a, head and pronotum ; 7 b, prosternal process ; 7 c, mesosternum ; 7 d, external genitalia of female (ventral view) ; 7 e, subgenital plate of male (ventral view) ; 7 f, epiphallus.

Distribution : INDIA (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Uttar Pradesh and West Bengal). Elsewhere : BANGLADESH, BORNEO, BURMA ; CHINA HAINAN ; JAVA ; MALACCA ; NEPAL ; NORTH VIETNAM ; TAIWAN AND U. S. S. R.

Remarks : The species is easily recognised by its green colour, medium size and broadly expanded hind tibiae and the posterior margin.

5. *Spathosternum prasiniferum prasiniferum* (Walker)

1871. *Heteracris* (?) *prasiniferum* Walker : 65

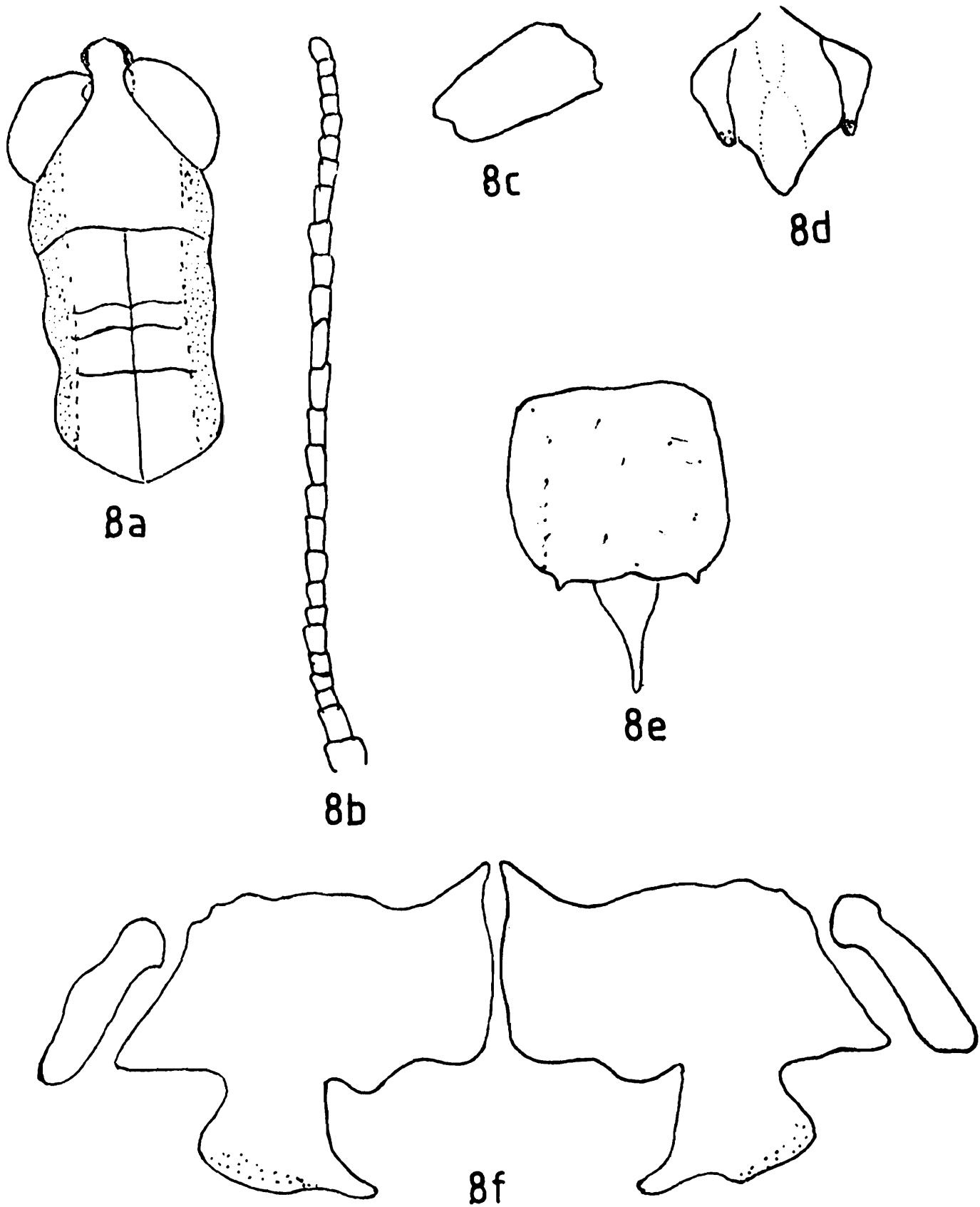
1936. *Spathosternum prasiniferum* Tinkham : 208

1963. *Bei-Bienko and Mishchenko* : 160.

Diagnostic features : Male : Size small. Body more or less slender, laterally compressed. Integument finely punctate. Head considerably shorter than the pronotum ; face very sloping ; frontal ridge almost parallel, slightly sulcated in the middle and reaching upto the clypeus ; fastigium of vertex short, almost flat, apex obtusely rounded. Antennae filiform, shorter than pronotum. Pronotum finely punctate, tricarinated, crossed indistinctly by all the three sulci ; first sulci present only on disc ; prozona longer than metazona and posterior end of the metazona obtusely angulated. Prosternal tubercle broad, apex transverse and depressed in the middle (Fig. 7b). Mesosternal lobes equal in length and breadth, inner margin rounded. Mesosternal inter space longer than broad. Supra-anal plate triangular, apex obtusely rounded with a longitudinal depression in the middle. Cerci short, conical. Subgenital plate as usual. Epiphallus bridge shaped, undivided, ancorae short slightly inwardly directed, lophi lobiform.

Female : Larger and more robust than male. Anterior ovipositor valves long, hook like. Subgenital plate longer than broad with a projection at the apex medially.

Colour : Green to brownish green, some times a dark brown stripe extends along the lateral side of the head, behind the eyes a broad stripe extends upto the apex of pronotum along the lateral carinae, tegmina brown or green, middle area with black or brown patches and with yellow markings, wings hyaline, hind femur green or brown and tibiae pale green with black tip spines.



Figs. 8 a-f. *Oxya fuscovittata* — 8 a, head and pronotum ; 8 b, antennae, 8 c, supra anal plate ; 8 d, cerc ; 8 e, subgenital plate (Ventral plate) female ; 8 f, epiphallus (male).

Measurement (mm.) :

	Male			Female		
	Range			Range		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	15.0	15.8	15.40	17.00	20.00	19.20
L. of the head	2.2	2.5	2.32	2.7	3.10	2.94
Br. of the head	4.5	4.7	4.61	5.00	5.80	5.62
L. of the tegmen	12.5	13.0	12.70	13.30	17.00	15.30
L. of the pronotum	3.6	3.7	3.63	4.20	4.50	4.35
L. of the hind femur	9.0	9.2	9.03	9.50	11.50	10.50
Br. of the hind femur	2.7	2.8	2.76	3.00	3.05	3.02
L. of the hind tibiae	6.5	6.6	6.48	7.50	8.50	8.10

Distribution : INDIA (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Karnataka, Kashmir, Manipur, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh) ; Elsewhere : Sri Lanka.

Remarks : This species is easily recognised by its small size, greenish colouration in live, characteristic post ocular-band on head and pronotum, tegmina with nervures, prosternal process transverse at apex.

Subfamily OXYINAE

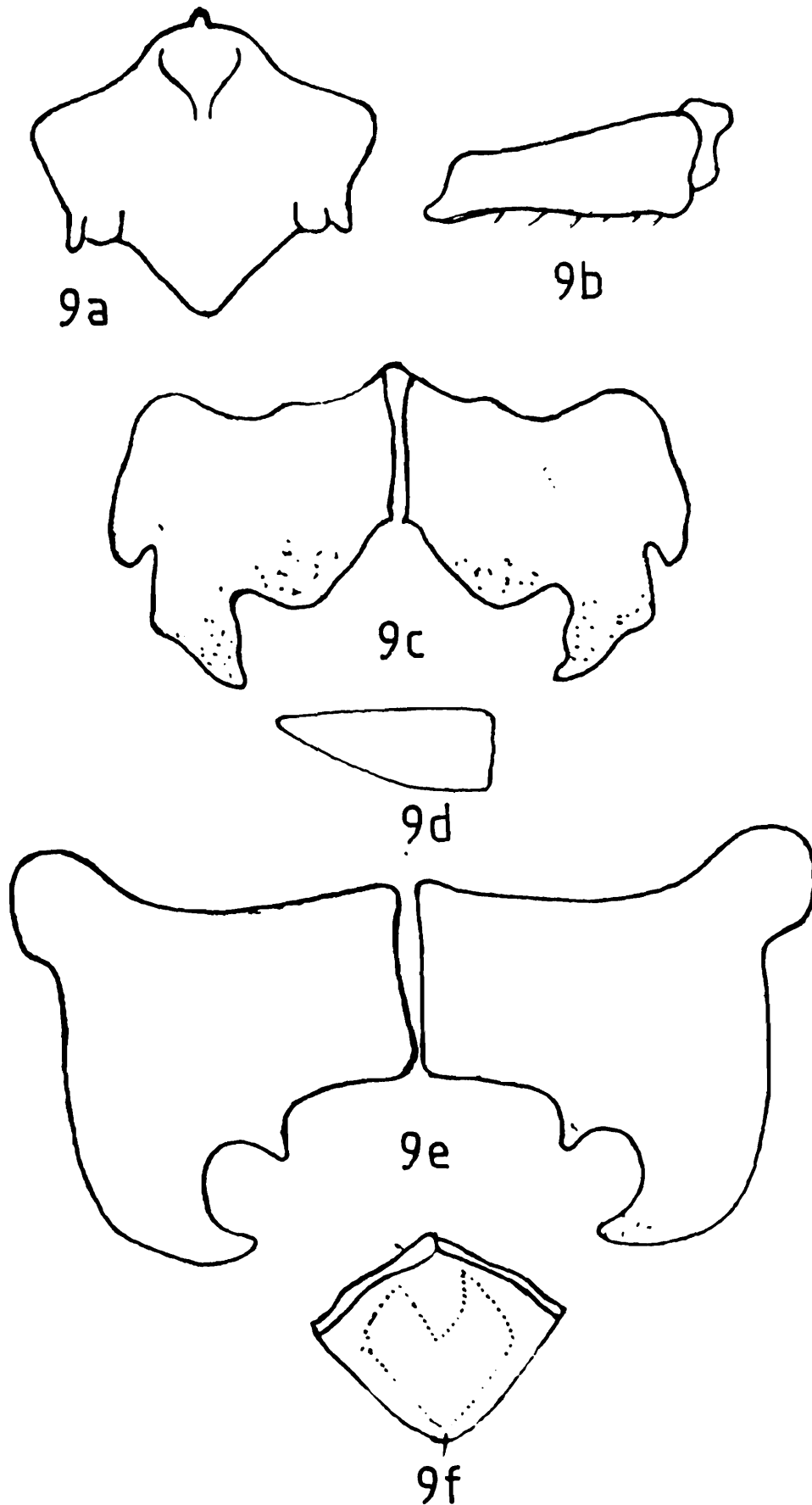
6. *Oxya fuscovittata* (Marschall)

1836. *Gryllus fuscovittata* Marchall : 211

1926. *Oxya fuscovittata* Uvarov : 46

1971. Hollis : 289

Diagnostic features : Male : Medium in size. Body slender, laterally compressed. Integument finely pitted. Head shorter than pronotum. Face strongly bent downwards. Frontal ridge almost parallel, sulcated and reaching up to the clypeus. Fastigium of vertex slightly sloping forwards, apex obtusely rounded. Antennae filiform (Fig. 8b) as long as head and pronotum together. Pronotum rugose and pitted ; prozona longer than metazona, median carina faintly present and crossed by all the three sulci ; lateral carinae absent ; posterior margin of metazona broadly rounded. Prosternal tubercle conical with obtuse apex. Mesosternal lobe almost equal in length and breadth, inner margin more or less straight. Mesosternal interspace narrow. Supra-anal plate



Figs. 9 a-c. *Oxya hyla hyla* — 9a, supra anal plate; 9b, cerci; 9c, epiphallus; *Oxya nitidula* 9d, cerci, 9e, supra anal plate; 9f, epiphallus.

triangular at apex, lateral tubercle distinct (Fig. 8c). Cerci wide, highly compressed laterally, slightly narrowed and bifurcated at apex (Fig. 8d). Epiphallus moderate in size with narrow bridge, ancorae absent. Outer lophi boat shaped in inner lophi tooth-like (8b).

Female : Larger than male and more robust. Antennae not reaching upto the posterior end of pronotum. Anterior ovipositor valves hook like. Subgenital plate smooth with a few hairs, ps straight. Mesosternal interspace narrow. Supra-anal plate triangular at apex, lateral tubercle distinct (Fig. 8c).

Colour : General colour of the body green and shiny. A blackish longitudinal stripe runs behind the eye and reach upto the posterior margin of pronotum along its lateral carinae. Wings hyaline. Hind femur green. Hind tibiae bluish or grey with black tip spines.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	22.0	25.0	22.5	25.5	32.5	28.8
L. of the head	3.1	3.5	3.32	3.9	4.2	4.05
Br. of the head	5.5	6.0	5.76	7.0	7.8	7.4
L. of the pronotum	4.5	5.5	4.82	5.6	6.5	6.05
L. of the tegmen	14.0	16.0	15.4	17.0	22.5	20.5
L. of the hind femur	12.0	13.0	12.2	14.5	18.0	15.5
L. of the hind tibiae	10.0	11.0	10.75	13.0	15.0	13.85
Br. of the hind femur	2.85	2.92	2.88	3.5	4.0	3.8

Distribution : INDIA (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Goa, Himachal Pradesh, Jammu and Kashmir). Elsewhere : AFGHANISTAN ; NEPAL ; PAKISTAN ; U.S.S.R. (South West).

Remarks It is easily recognised by its medium size, green colour with a blackish longitudinal stripe runs behind the eye and reaches upto the posterior margin of pronotum and almost flat pronotum and flat subgenital plate.

7. *Oxya hyla hyla* (Serville)

1831. *Oxya hyla* Aninet Serville : 287.

1971. *Oxya hyla hyla* Hollis : 282.

Diagnostic features : Male : Medium sized. Body slender and laterally compressed. Integument finely pitted. Head considerably shorter than pronotum face strongly bent downwards, slightly convex ; frontal ridge almost parallel and extend upto the clypeus ; fastigium of vertex short, obtusely rounded at apex. Antennae as long as head and pronotum together or slightly smaller. Pronotum similar as in the preceding species. Prosternal tubercle conical and subacute at apex. Mesosternal lobe almost equal in length and breadth, inner margin rounded, Mesosternal interspace much narrower. Supra-anal plate with a tubercle on each side of a median apical process. Cercus conical, apex obtusely pointed and slightly compressed laterally. Epiphallus as in (Fig. 9c).

Female : More robust and larger than the body of a male. Anterior ovipositor valves with long teeth. Subgenital plate with a pair of median spines on its posterior margin, a median longitudinal concavity present on the ventral surface, which is bordered on each side by a longitudinal ridge bearing short spines.

Colour : Body green and shiney, hind femur green, hind tibiae bluish or grey.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	23.0	26.5	25.2	26.5	31.0	28.7
L. of the head	3.0	3.5	3.3	4.1	4.3	4.25
Br. of the head	6.0	7.0	6.5	7.6	8.0	7.75
L. of the pronotum	4.9	6.0	5.54	6.0	7.2	6.61
L. of the tegmen	18.5	25.0	21.4	26.0	31.0	29.0
L. of the hind femur	12.0	15.0	14.2	15.5	17.5	16.4
Br. of the hind femur	3.4	3.45	3.32	3.5	3.8	3.7
L. of the hind tibiae	10.5	11.0	12.5	12.5	14.2	13.5

Distribution : INDIA (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Karnataka, Meghalaya, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal). Elsewhere AFGHANISTAN ; ANGALO ; BANGLADESH ; CAMERON ; CENTRAL AFRICA REPUBLIC ; CLAD ; CONGO ; BRAZILIAM ; DAHOMEY ; ETHIOPIA ; GHANA ; GUINEA ; IVORY COAST ; KENYA ; LIBEYIA ; MADAGASCAR ; MALAWI ; MALI MOZAMBQUE ; NEPAL ; NIGER ; NIGERIA ; PAKISTAN ; IRAN ; ZIMBAWE ; SENEGAL ; SIERALEONE ; SRI LANKA ; SOUTH AFRICA SUDAN ; TANZANIA ; UGANDA ; ZAMBIA.

Remarks : This species is easily recognised by laterally compressed conical cercus in male and ventral surface of subgenital plate with a pair of median spines on posterior margin in female.

8. *Oxya nitidula* (Walker)

(Figs. 9d-f)

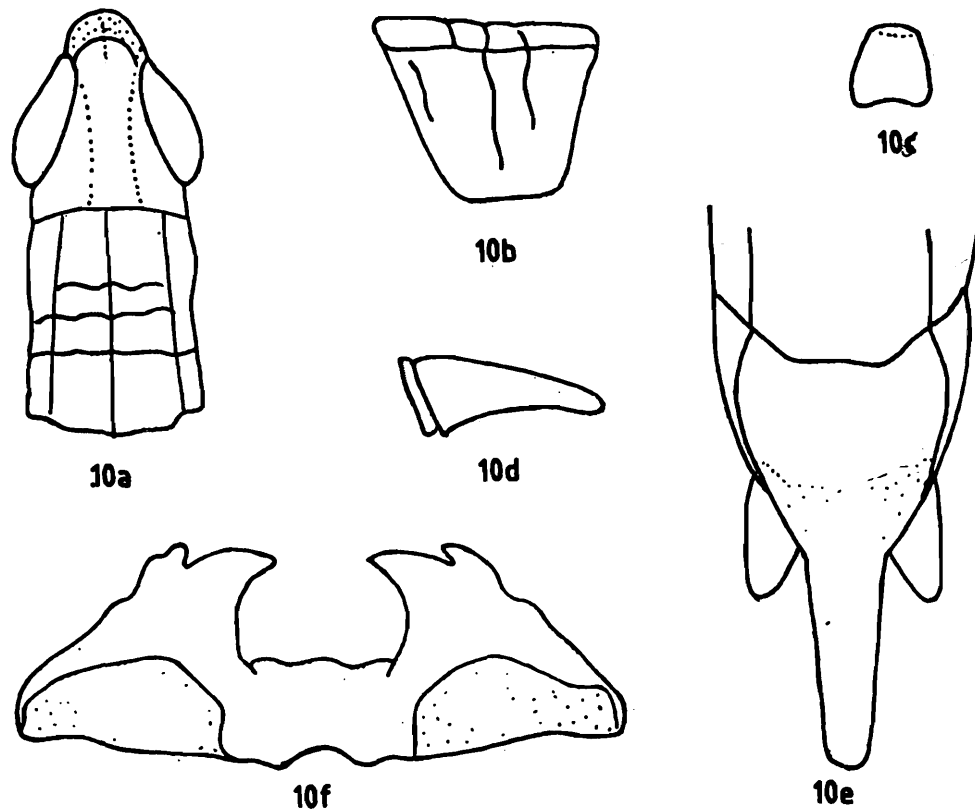
1870. *Acridium nitidulum* Walker : 631.

1971. *Oxya nitidula* Hollis : 315.

Diagnostic features : Male : Size medium. The remaining characters are more or less similar to *Oxya hyla hyla* except the supra-anal plate which is triangulated with tubercle on lateral sides and with a longitudinal depression. Cercus conical, with obliquely truncate apex. Epiphallus as in (Fig. 9f).

Female : Ovipositor valves with tooth like spine. Ventral surface of subgenital plate with a single median spine and a pair of lateral spines on the posterior margin.

Colour : Same as *Oxya hyla hyla*.



Figs. 10 a-f. *Tristria pulvinata* — 10 a, head and pronotum; 10 b, pronotum (lateral view); 10 c, prosternal tubercle; 10 d, cerci; 10 e, subgenital plate; 10 f, epiphallus.

Measurement (mm.) :

	Male			Female		
	Range			Range		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	20.0	21.5	20.06	21.5	27.0	23.5
L. of the head						
Br. of the head	5.0	5.2	5.1	6.0	6.6	6.26
L. of the pronotum	4.0	4.6	4.45	5.1	6.0	5.46
L. of the tegmen	15.0	19.0	16.4	17.0	22.0	19.2
L. of the hind femur	10.5	11.5	11.1	13.5	15.2	14.1
Br. of the hind femur	2.8	2.9	2.84	3.2	3.5	3.34

Distribution : INDIA (Andhra Pradesh, Rajasthan, Tamil Nadu). Elsewhere : SRI LANKA.

Remarks : The male species can be recognised in the field by its triangulated supra anal plate, with tubercles on later sides and a longitudinal depression in the middle.

Subfamily : TROPIDOPOLINAE

9. *Tristria pulvinata* (Uvarov)

(Figs. 10a-f)

1921 *Tapinophyma pulvinata* Uvarov : 497

1929. *Tapinophyma pulvinata* Uvarov : 559

1970 Hollis : 465

Diagnostic features : Male : Medium in size. Body slender, elongate and laterally compressed. Integument finely rugulose. Head shorter than pronotum ; face strongly bend downwards and slightly convex ; frontal ridge flat, parallel and extend up to the clypeus ; fastigium of vertex parabolic and roundly conical at apex. Antennae filiform thick, shorter than head and pronotum together. Dorsum of pronotum finely punctate, almost flat ; prozona longer than metazona ; median carina crossed by all the three sulci ; lateral carinae almost parallel ; posterior margin of metazona excurved and rounded. Prosternal tubercle broad, flat, bent backwards and touches the mesosternum. Mesosternal lobes somewhat equal in length and breadth, inner margin rounded and forming triangular space in between. Mesosternal interspace narrower, 'X' shape, slightly widened posteriorly. Supra-anal plate elongate and triangular, apex obtuse. Cerci simple short, acute at apex. Subgenital plate obtusely conical at apex. Epiphallus as in (Fig. 10f).

Female : Larger and robust than male. Anterior ovipositor valves more or less long, straight and curved at apex. Subgenital plate longer than broad with a triangular projection at the apex medially.

Colour : General body colour straw yellow, brown of pale brown.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	24.0	25.5	24.82	31.0	39.0	34.60
L. of the head	3.8	4.0	3.9	5.1	5.3	5.25
Br. of the head	6.48	6.53	6.50	8.2	9.0	8.50
L. of the pronotum	5.2	6.0	5.6	7.0	7.5	7.20
L. of the tegmen	21.0	26.0	22.0	29.1	32.0	30.30
L. of the hind femur	15.0	17.0	16.1	20.5	22.0	21.50
Br. of the hind femur	4.20	4.70	4.40	5.50	6.0	5.65
L. of the hind tibiae	11.8	12.2	11.95	15.0	15.4	15.2

Distribution : INDIA (Bihar, Karnataka, Punjab and Tamil Nadu). Elsewhere : SRI LANKA.

Remarks : This species can be identified by the shape of fastigium which is roundly conical at apex and the shape of prosternal tubercle.

Subfamily : EYPREPOCNEMIDINAE

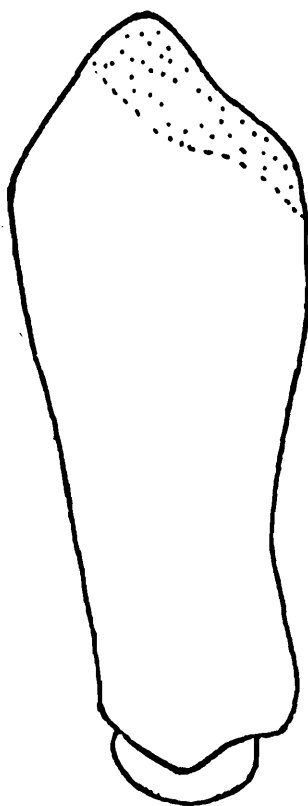
10. *Choroedocus robustus* (Serville)

(Figs. 11-b)

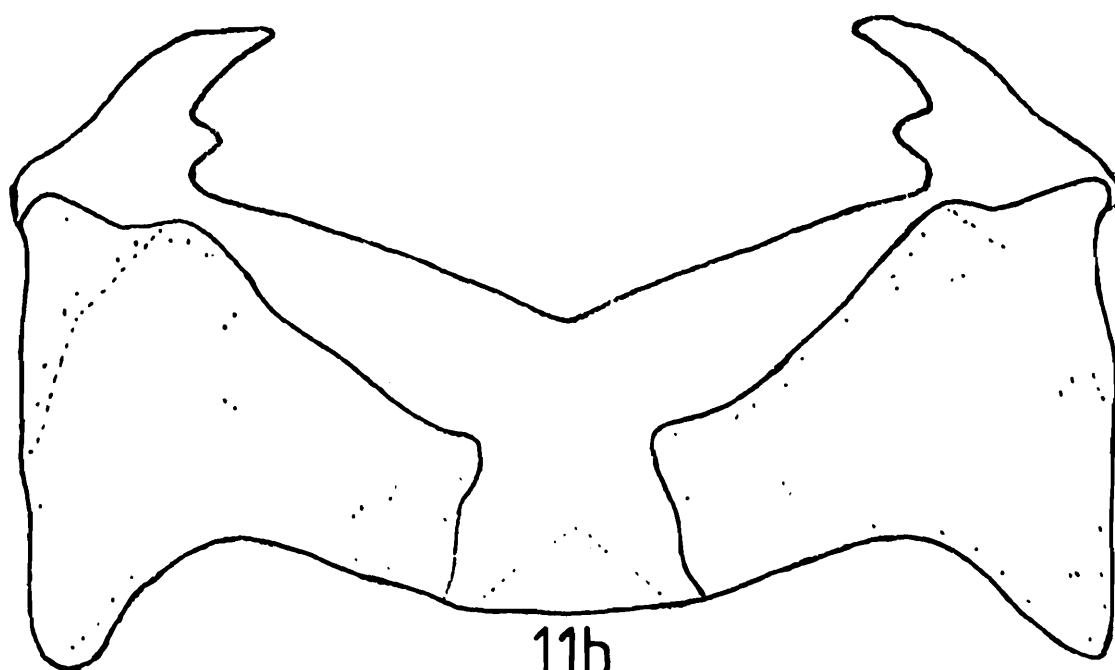
1839. *Acridium robustum* Serville : 647.

1921. *Choroedocus robustus* Uvarov : 109.

Diagnostic features : Male : Large in size. Body slender and laterally compressed. Integument finely wrinkled and punctate. Head narrow, much shorter than pronotum ; face vertically directed downwards ; frontal ridge flat, surface finely pitted and gradually expanded towards the clypeus, narrow between the antennae ; fastigium of vertex short, angulated, and obtusely rounded at apex. Antennae filiform as long as head and pronotum together or slightly

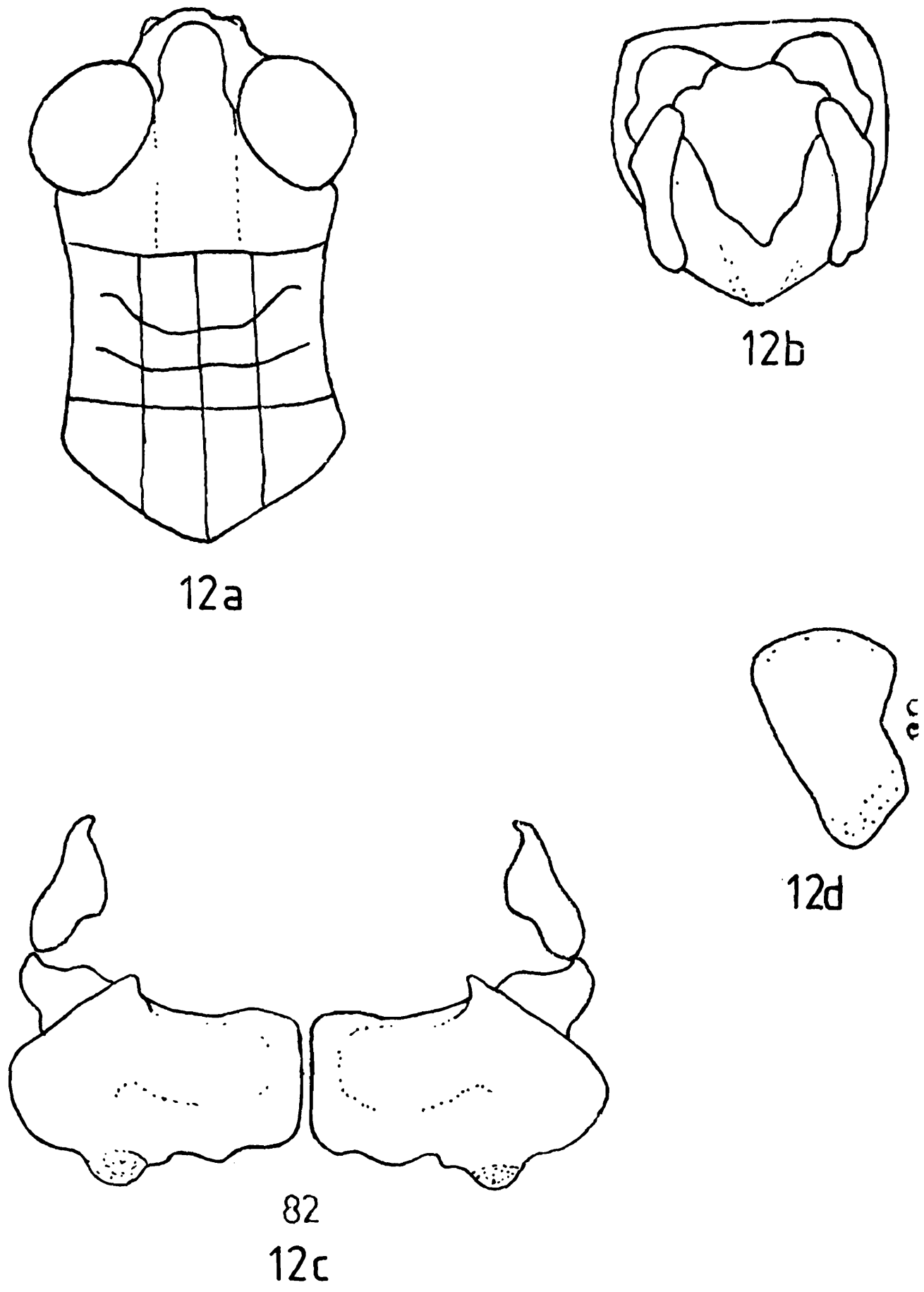


11a



11b

Figs. 11 a-b. *Choroedocus robustus* — 11 a, cerci ; 11 b, epiphallus.



Figs. 12 a-d. *Eupreponotus inflatus* — 12 a, head and pronotum ; 12 b, external genitalia of male (dorsal view) ; 12 c, epiphallus ; 12 d, cerci.

longer. Pronotum tectiform, and finely pitted ; prozona slightly less than twice as long as metazona ; median carina prominent and cut by three sulci, first present only in the dorsum, second and the third present on the dorsum as well as on lateral lobe ; lateral carinae more or less parallel ; posterior margin of metazona excurved and obtusely rounded. Prosternal tubercle large, cylindrical and the apex obtusely rounded and strongly curved backward. Mesosternal lobes shorter in length than breadth and the inner margin rounded. Mesosternal interspace more or less one third of width than length. Supra-anal plate large, triangular, apex broadly rounded ; cerci large, broad, apex obtusely rounded. Subgenital plate upwardly directed. Epiphallus bridge shaped, ancorae large, strongly curved inwardly and articulated with disc, lophi large and lobiform ; lateral plate prominent (Fig. 11b).

Female : Large and robust than male, anterior ovipositor valves robust and apex upwardly curved and highly sclerotized ; subgenital plate broad.

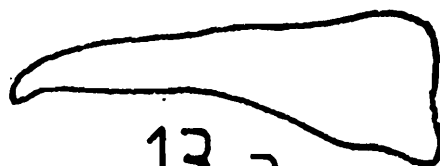
Colour : Olive green ; antennae reddish, a broad yellow band extends from vertex to the posterior margin of pronotum along the lateral side ; abdomen greenish yellow ; tegmen yellowish, subhyaline ; hind femora greenish yellow, hind tibiae and tarsi red.

Measurement (mm.) :

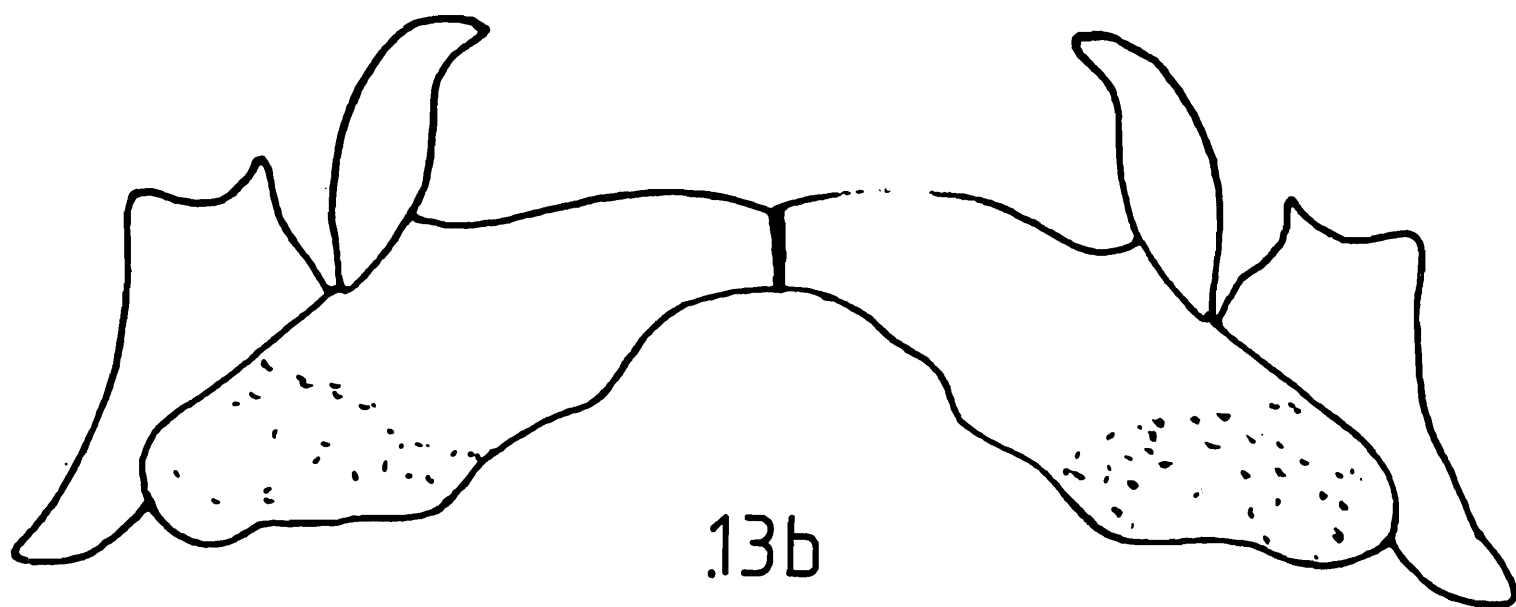
	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	43.0	45.0	46.6	58.0	63.0	61.5
L. of the head	4.70	4.90	4.82	6.35	6.5	6.43
Br. of the head	10.0	10.05	10.03	14.0	14.5	14.25
L. of the pronotum	8.0	8.8	8.47	14.0	14.5	14.3
L. of the tegmen	35.0	37.0	36.2	45.0	56.0	54.5
L. of the hind femur	26.0	27.5	26.8	40.0	40.5	40.2
Br. of the hind femur	6.0	6.0	6.0	7.06	8.0	7.6
L. of the hind tibiae	23.5	24.5	24.2	34.2	37.2	35.65

Distribution : INDIA (Arunachal Pradesh, Assam and is widely distributed in West Bengal).
Elsewhere : BANGLADESH.

Remarks : This species can be recognised by its large size and yellow stripe on the head and pronotum, red colouration of tibiae and hyaline wings in young, light blue on old.

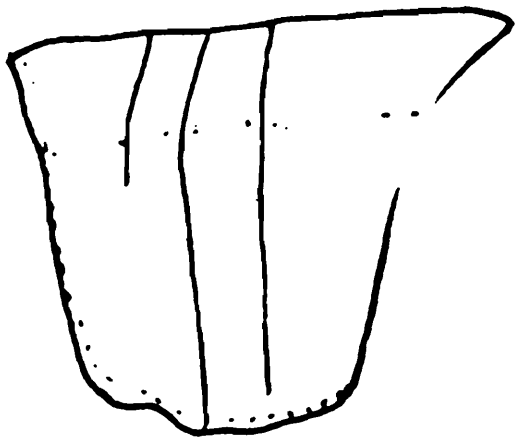


13 a

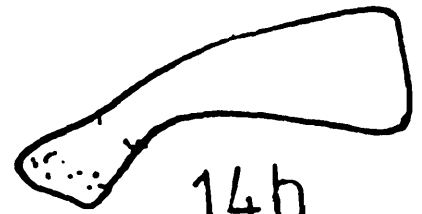


13 b

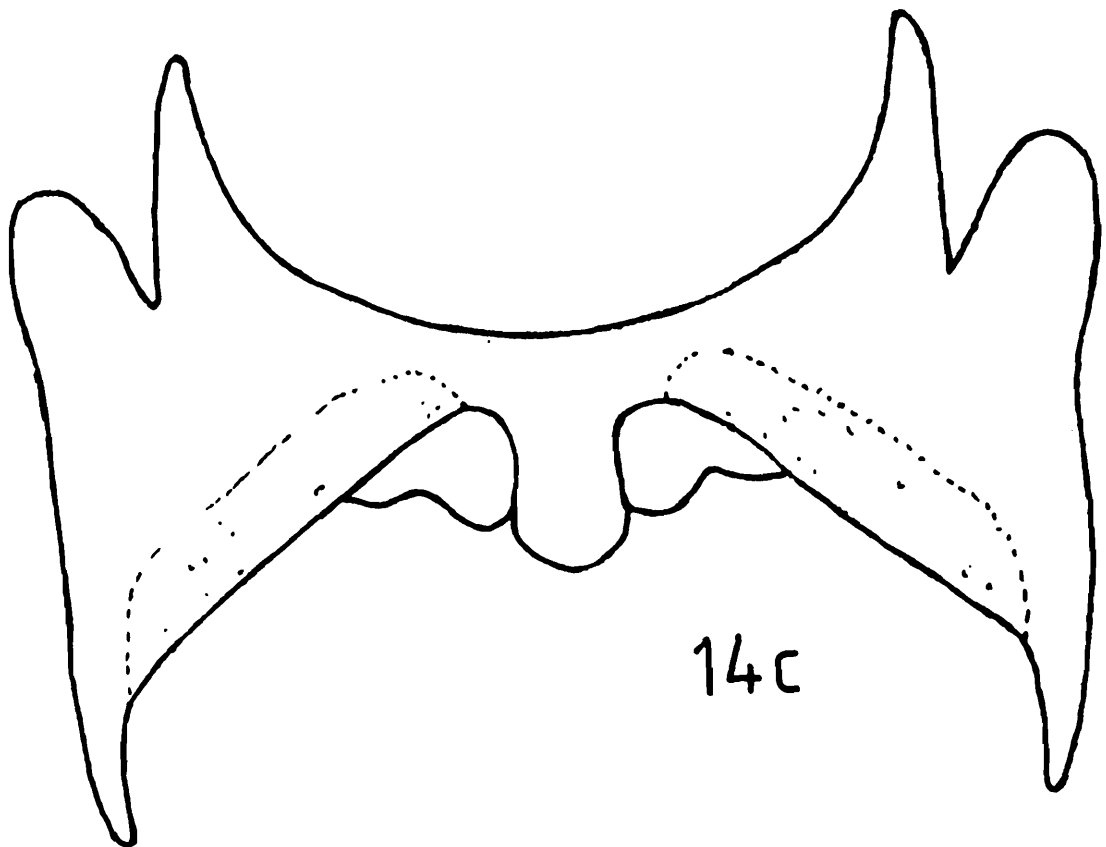
Figs. 13 a-b. *Eyprepocnemis al. alacris* — 13 a, cerci of male ; 13 b, epiphallus.



14a

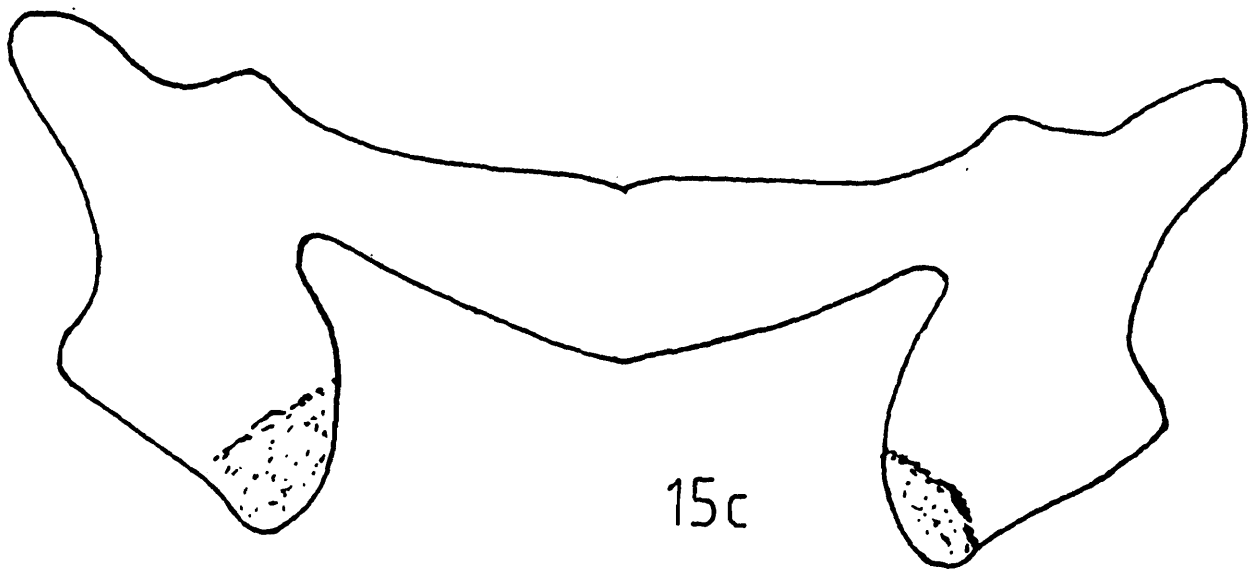
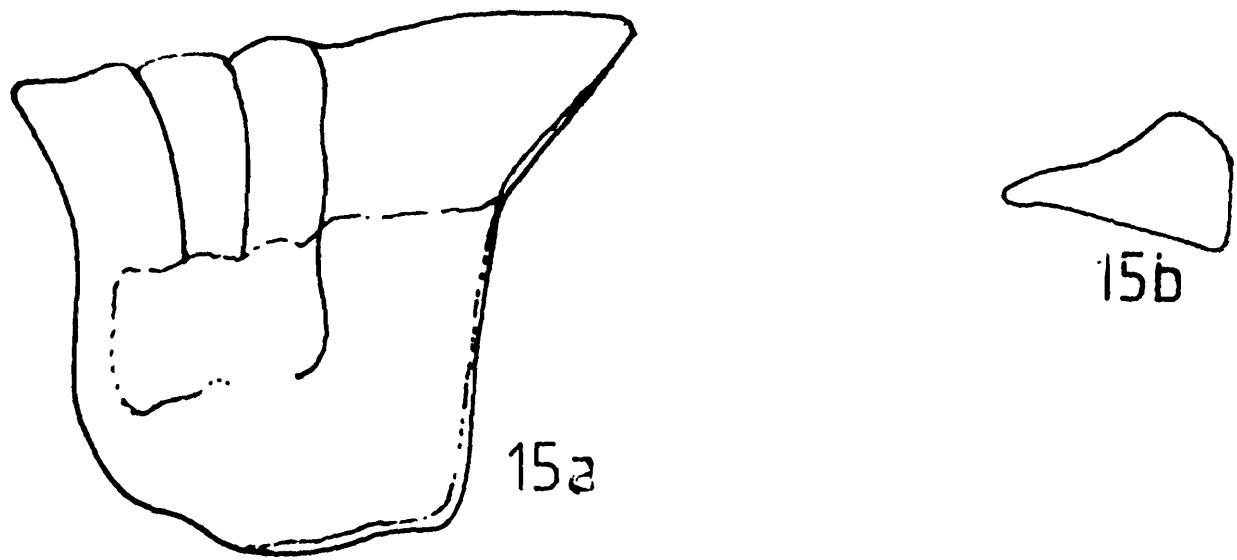


14b



14c

Figs. 14 a-c. *Catantops pinguis innotabilis* — 14 a, pronotum (lateral view); 14 b, cerci of male; 14 c, epiphallus.



Figs. 15 a-c. *Crytanthacris tatarica* — 15 a, pronotum of male (lateral view); 15 c, epiphallus.

11. *Eupreponotus inflatus* Uvarov

(Figs. 12a-d)

1921. *Eupreponotus inflatus* Uvarov : 508

1984. Bhowmik : 161, 162.

Diagnostic features : Male : Medium in size. Body moderately robust, laterally compressed and finely punctate. Head small, not longer than pronotum, face bent downwards ; frontal ridge flat, margin smooth and gradually expanded towards the clypeus ; fastigium short, concave, apex parabolic. antennae extended upto the posterior margin of pronotum. Pronotal disc flat ; prozona slightly longer than metazona ; median carina prominent, crossed by three sulci ; lateral carinae prominent on prozona and weak in metazona ; posterior margin of metazona obtusely rounded. Prosternal tubercle cylindrical, slightly curved backwards with obtusely rounded apex. Mesosternal lobes more or less broader than long, inner margin rounded. Mesosternal interspace longer than broad. Supra-anal plate triangular and elongate (Fig. 12b). Cerci large, folia-ceaus apex widely rounded and apically bent downwards (Fig. 12d.). Subgenital plate as usual. Epiphallus as in figure (Fig. 12c).

Female : Larger and more robust than male. Anterior ovipositor valves simple and apex moderately curved upwardly. Subgenital plate flat with three lobes.

Colour : Yellowish or pale brown in general, a velvety longitudinal stripe on vertex, more or less paralld on pronotum, tegmen deep brown with black spots ; hind tibiae bluish grey with two white rings at the base and red at the apex.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	25.0	26.5	25.8	36.3	38.0	33.8
L. of the head	3.85	4.0	3.88	4.9	5.0	4.95
Br. of the head	6.3	6.5	6.42	8.8	9.0	8.94
L. of the pronotum	5.0	5.2	5.16	7.0	7.3	7.22
L. of the tegmen	23.5	24.0	23.7	34.7	34.0	34.6
Br. of the hind femur	4.2	4.3	4.16	5.0	5.2	5.10
L. of the hind femur	13.8	15.0	14.2	19.5	20.0	19.65

Distribution : INDIA (Orissa and Bengal).

Remarks : This species is recognised by a deep blackish velvet like colour of the head and pronotum, very large last abdominal tergite and characteristic shape of cerci.

12. *Eyrepocnemis alacris alacris* (Serville)

(Figs. 13a-b)

1839. *Acridium alacre* Serville : 682.

1958. *Eyrepocnemis alacris alacris* Dirsh : 40.

Diagnostic features : Male : Slightly longer than the other species described here. Body moderately robust, laterally compressed, Integument finely punctate. Head small not longer than pronotum ; face bent downwards ; frontal ridge flat, margin smooth and gradually expanded towards the clypeus ; fastigium of vertex short, concave, apex parabolic. Antennae filiform extended upto the posterior margin of pronotum. Pronotal disc flat, prozona slightly longer than metazona ; median carina prominent on prozona and weak in metazona ; lateral carinae prominent on prozona and weak in metazona ; posterior margin of metazona excurved, obtusely rounded, Prosternal tubercle cylindrical, slightly curved backwards with obtusely rounded at apex. Mesosternal lobes more or less broader than long, inner margin rounded. Mesosternal interspace longer than broad. Supra-anal plate triangular and elongate. Cerci more or less broad at the base and curved inwardly. Subgenital plate short and conical at apex. Epiphallus as in figure (Fig. 13b).

Female : Larger and more robust than male. Anterior ovipositor valves simple and apex moderately curved upwardly. Subgenital plate flat with three lobes.

Colour : Yellowish or pale brown, a velvety longitudinal stripe present on vertex, tegmen with deep brown with black spots, hind tibiae bluish grey with two white rings at the base and red at the apex.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	24.0	25.5	24.8	31.0	39.0	34.6
L. of the head	3.2	3.4	3.3	4.3	4.8	4.46
Br. of the head	8.2	9.0	8.43	11.0	12.2	12.12
L. of the pronotum	5.2	6.0	5.6	7.0	7.5	7.2
L. of the hind femur	15.0	17.0	16.1	20.5	22.0	21.5
Br. of the hind femur	4.7	4.4	5.5	5.5	6.0	5.56
L. of the hind tibiae	11.1	13.2	12.42	17.0	18.5	17.65

Distribution : INDIA (Andhra Pradesh, Assam, Goa, Kerala, Madhya Pradesh and West Bengal). Elsewhere : AFGANISTAN ; IRAN ; IRAQ ; NEPAL ; PAKISTAN ; SRI LANKA.

Remarks : It is easily recognised by the fully developed tegmen, wings, velvet brown spots on the disc of pronotum, black spot on the tegmen, bluish grey posterior tibiae with two basal and apical ring.

Subfamily : CATANTOPINAE

13. *Catantops pinguis innotabilis* (Walker)

(Figs. 14a-c)

1870. *Acridium innotabile* Walker : 629

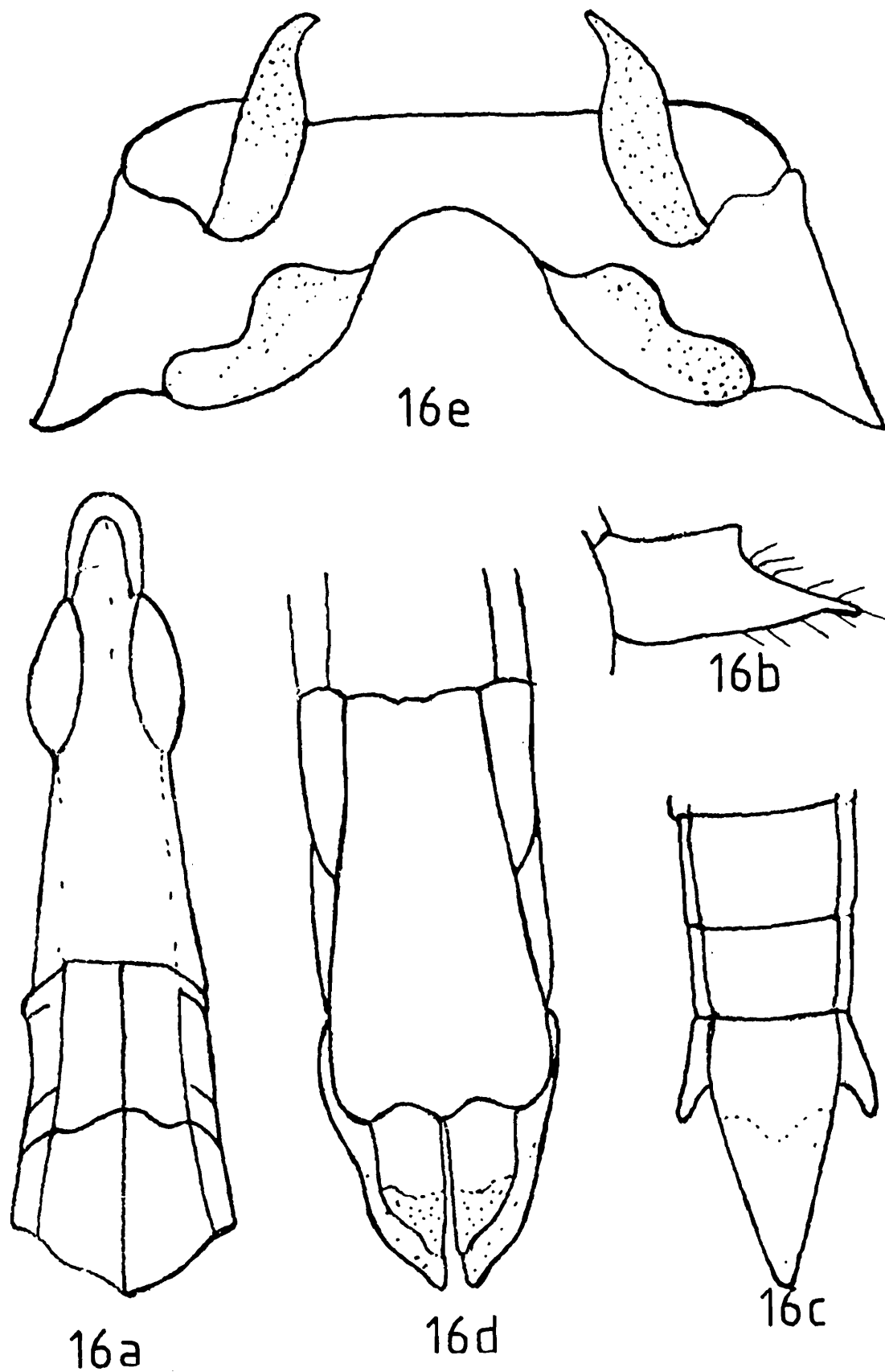
1953. *Catantops pinguis innotabilis* Dirsh and Uvarov : 233

1956. Dirsh : 105

Diagnostic features : Male : Size medium. Body slender, elongate and laterally compressed. Integument moderately wrinkled. Head moderately short, not longer than pronotum ; face bent downwards ; frontal ridge slightly depressed below the median ocelli, finely punctate and forming rounded angle with the fastigium of vertex ; fastigium trapezoid at the anterior and slopping downwards. Antennae filiform, reaching upto the end of pronotum. Prosternal tubercle thick, cylindrical, straight and apex obtusely rounded. Pronotum subcylindrical, feebly narrowed towards the proximal end ; prozona slightly shorter than metazona ; median carina weakly marked, continuous and crossed by three sulci ; lateral carinae absent ; posterior margin of metazona obtusely angular. Mesosternal lobe with equal length and breadth, inner margin rounded. Mesosternal intespace more or less 'X' shaped and longer than broad in length. Supra-anal plate triangular with a median longitudinal groove. Cerci short, strongly expanded at apex with less erecting upper apical angle. Apex of subgenital plate upcurved. Epiphallus bridge shaped ; ancorae large, finger shaped ; and lophi lobiform (Fig. 14C).

Female : Larger and more robust than male, more elongate. Anterior ovipositor valves short moderately curved. subgenital plate elongated, posterior margin angulated with a process medially.

Colour : Buff to dark brown; head and pronotum pale brown to deep brown, tegmen straw yellow to brown; a black median spot present on hind femur; hind tibiae orange red with black tip spines.



Figs. 16 a-e. *Acrida exaltata* — 16 a, head and pronotum; 16 b, cerci; 16 c, subgenital plate of male (dorsal view); 16 d, external genitalia of male (ventral view); 16 e, epiphallus.

Measurement (mm.) :

	Male			Female		
	Range			Range		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	22.0	28.0	25.2	33.0	34.5	34.0
L. of the head	2.10	2.4	2.27	2.6	3.1	2.92
Br. of the head	4.7	5.5	5.15	6.4	7.0	6.69
L. of the pronotum	4.8	5.25	5.25	6.5	7.7	7.2
L. of the tegmen	20.4	25.2	23.5	27.0	33.3	29.0
L. of the hind femur	12.5	14.8	14.0	16.5	18.8	17.7
Br. of the hind femur	4.0	4.2	4.1	4.6	5.1	4.96
L. of the hind femur	11.3	13.0	12.6	14.5	15.8	14.97

Distribution : INDIA : (Andhra Pradesh, Orissa, Bihar, Karnataka, Kerala, Laccadive Island, Madhya Pradesh, Rajasthan and is found commonly in West Bengal); Elsewhere : AFGANISTAN : CHINA.

Remarks : This species can easily be identified by shape of its fastigium, metazona and male cerci.

Subfamily : CYRTACANTHACRIDINAE

14. *Cyrtacanthacris tatarica* (Linnaeus)

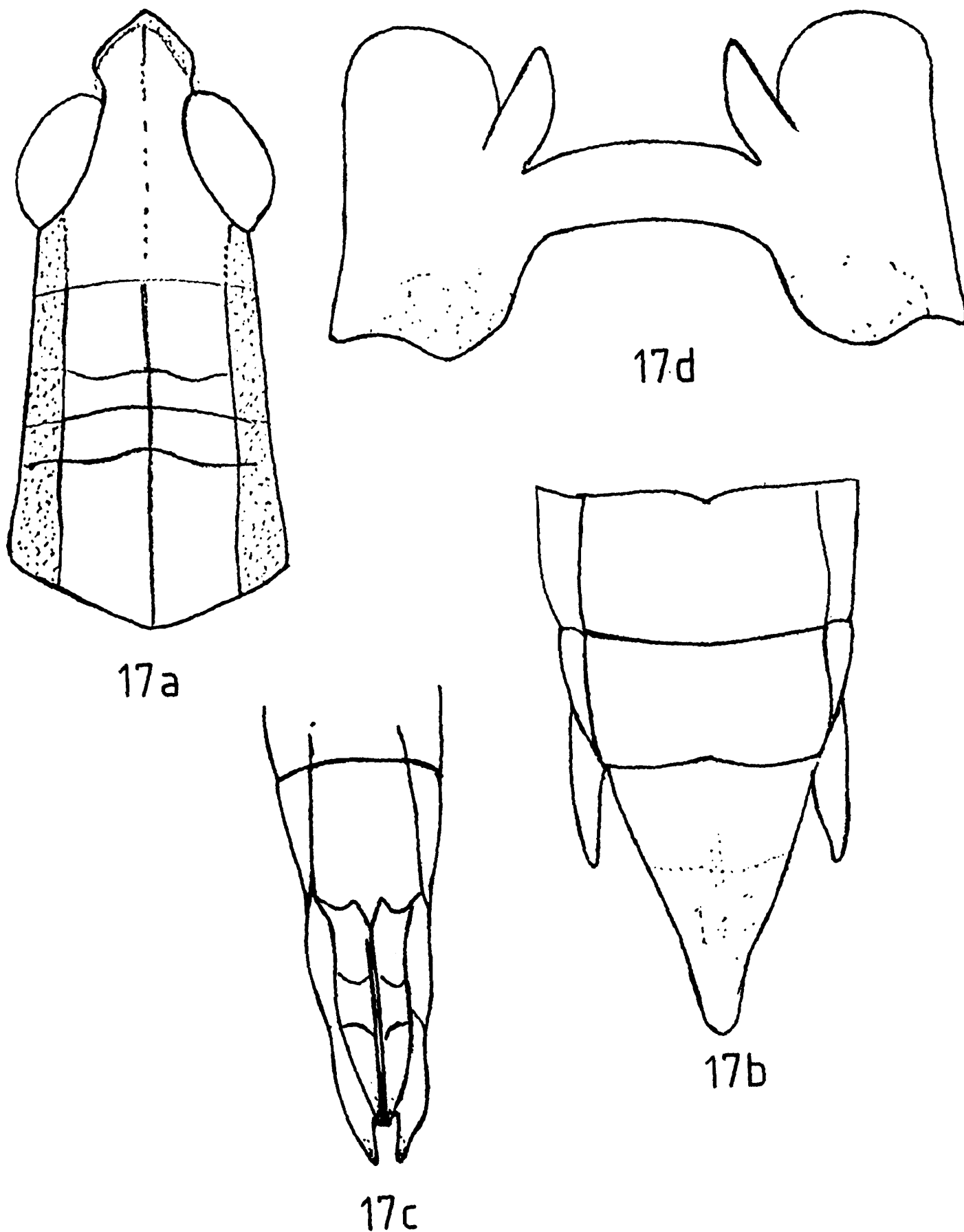
(Figs. 15a-c)

1758. *Gryllus locusta tataricus* Linnaeus : 432.

1870. *Cyrtacanthacris conicisa* Walker : 560.

1923. *Cyrtacanthacris tatarica* Uvarov : 39.

Diagnostic features : Male : Size large. Body robust, laterally compressed and finely punctate. Head much shorter than pronotum; face subvertical; frontal ridge almost parallel and extends upto the margin of clypeus; fastigium of vertex short, depressed in the middle, apex angularly rounded. Antennae filiform, reaching upto the end of pronotum. Pronotum moderately tectiform; prozona and metazona more or less equal in length; median carina a little raised on prozona and crossed by three transverse sulci; lateral carinae absent in prozona but irregularly present in the metazona; metazona expanded backwardly and its posterior margin angulated and obtusely pointed. Prosternal tubercle large, anterior part thick and strongly bend backwards and



Figs. 17 a-d. *Phlaeoba infumata* — 17 a, head and pronotum; 17 b, subgenital plate of male (ventral view); 17 d, epiphallus.

almost touching the mesosternum. Mesosternal lobes longer than broad inner margin irregularly straight or slightly curved. Mesosternal inter-space longer than broad. Supra-anal plate triangulate. Cerci short, conical, at the tip pointed, base more or less broad. Subgenital plate as usual. Epiphallus bridge shaped, undivided. Ancorae small and slightly distinct, tip of the lophi slightly bent outwards (Figs. 15a-c).

Female : Larger and more robust than male. Anterior valves of ovipositor more or less hook like. Subgenital plate smooth, as long as broad, on posterior margin forms triangular projection medially.

Colour : Reddish brown, or brown mixed with yellow patch; a broad velvety stripe extends from upper end to lower end on either side of median carina of pronotum; abdomen yellowish; tibial spines white at the base, red in the middle and black at the apex.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	35.0	40.5	38.1	48.0	63.0	53.09
L. of the head	3.4	3.9	3.7	4.4	4.9	4.55
Br. of the head	7.85	8.25	8.0	10.5	13.0	11.2
L. of the pronotum	9.0	10.0	9.5	12.0	14.0	13.2
L. of the tegmen	32.0	37.0	34.7	43.0	50.8	48.8
L. of the hind femur	19.5	21.0	20.2			
Br. of the hind femur	4.9	5.12	5.0	6.5	7.4	6.98
L. of the hind femur	17.5	22.0	19.5	25.0	28.0	26.41

Distribution : INDIA : (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Kerala, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal); Elsewhere : AFRICA; BANGLADESH; HAINAN; MADAGASCAR; PHILIPPINES; SRI LANKA; SUMATRA and THAILAND.

Remarks : It is easily recognised by the specific colour of the species, its large size, a little raised median carina of prozona and almost touching prosternal tubercle to mesosternum.

Subfamily : ACRIDINAE

15. *Acrida exaltata* (Walker)

(Figs. 16a-e)

1859. *Truxalis exaltata* Walker : 222

1914. *Acrida exaltata* Kirby : 99

1954. Dirsh : 149

Diagnostic features : Male : Moderate in size. Body slender, strongly elongate and laterally compressed. Integument finely punctate. Head elongate, conical and equal in length with pronotum; face strongly bent downwards; frontal ridge sulcated throughout and gradually divergent forwards and extend just above the clypeus; fastigium of vertex longer than broad, its apex obtuse, and broadly rounded. Antennae shorter than head and pronotum together. Pronotal disc weakly tectiform; prozona longer than metazona; median carina of prozona crossed by only posterior sulci; lateral carinae almost straight in prozona slightly undulating; in metazona lateral carinae slightly divergent towards the posterior end; posterior margin of metazona acutely angular. Mesosternal lobes longer than its breadth, inner margin rounded. Mesosternal interspace narrow, length longer than breadth. Supra-anal plate triangular. Cerci simple (Fig. 16b) apex obtusely rounded and not reaching up to the end of supra-anal plate. Sub-genital plate acutely conical at apex (Fig. 16c). Epiphallus bridge shaped; ancorae large, apex slight inwardly curved; lophi lobiform and bilobate; lateral plate large; anterior lateral projection prominent (Fig. 16e).

Female : Body much longer and robust than male; posterior margin of metazona less acute. Anterior ovipositor valves short. subgenital plate short and broad.

Colour : General colour yellowish green, some time yellowish brown, wings hyaline at base in young and pink in old specimens.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	33.0	37.0	34.5	47.0	57.0	51.5
L. of the head	7.0	8.0	7.36	9.5	12.0	10.66
Br. of the head	10.0	11.0	10.4	15.0	16.0	15.6
L. of the pronotum	5.5	6.0	5.75	9.0	10.0	9.7
L. of the tegmen	26.0	28.0	27.12	40.0	45.0	42.3
L. of the hind femur	20.0	23.0	21.5	29.0	32.0	30.8
Br. of the hind femur	2.0	2.0	2.0	3.0	3.05	3.02
L. of the hind femur	19.0	21.0	19.91	26.5	30.0	27.9

Distribution : INDIA : (Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu

and Kashmir, Kerala, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and it is found commonly in West Bengal); Elsewhere : SOUTH YEMEN; AFGHANISTAN; SAUDI ARABIA; BANGLADESH; PAKISTAN; IRAN; SRI LANKA; THAILAND; TIBET; NORTH YEMEN.

Remarks : It is recognised by the slender and strongly elongated body, equal length of head and pronotum, wing with acute apex, and at maturity at the base of the wings pink in colour.

16. *Phlaeoba infumata* (Brunner)

(Figs. 17a-d)

1893. *Phlaeoba infumata* Brunner V. Wattenwyl : 124

1910. Kirby : 133

1989. Tandon and Shishodia : 106, 107

Diagnostic features : Male : Medium size. Body slender and laterally compressed. Integument rugosely punctured. Head shorter than pronotum but as broad as it; face bent downwards; frontal ridge sulcated throughout, widened towards the clypeus; fastigium of vertex short, apex obtusely rounded. Antennae ensiform, longer than head and pronotum together. Pronotum strongly punctured; prozona longer than metazona; median carina continuous, extends up to the end of pronotum and it is cut by all the three sulci; first sulcus present only on the dorsum, second and third extend beyond the middle of lateral lobe; lateral carinae present; posterior margin of metazona angulated and obtusely rounded at apex. mesosternal lobes with equal length and breadth, inner margin rounded; Mesosternal interspace longer than its breadth and concave. Supra-anal plate triangular, tongue shaped with a wide concave median sulcus. Cercus straight conical at apex pointed. Subgenital plate navicular with acutely conical at apex. Epiphallus bridge shaped, undivided, ancorae large and more or less spindle shaped, lophi large, anterior process of lateral plate distinct and rounded, posterior lateral process obtusely rounded (Fig. 17d.)

Female : More robust and larger than male. antennae as long as head and pronotum together or slightly shorter. Subgenital plate with posterior margin angulated with acute apex. Anterior ovipositor valves curved and hook like at its tip and strongly sclerotised, subgenital plate smooth.

Colour : Light brown or yellowish brown to deep brown, some black spots are present on the tegmen, tip of the tibial spines black.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	1.98	2.60	2.24	2.88	3.5	3.23
L. of the head	3.0	3.8	3.35	4.1	4.7	4.4
Br. of the head	6.0	7.0	6.64	8.2	9.0	8.4
L. of the pronotum	4.1	5.0	4.65	5.5	6.5	5.96
L. of the tegmen	1.85	2.38	2.11	2.5	2.7	2.52
L. of the hind femur	1.30	1.55	13.90	1.80	1.35	1.82
Br. of the hind femur	2.6	2.8	2.65	3.0	3.15	3.06
L. of the hind tibiae	10.0	12.0	11.14	13.5	15.5	12.3

Distribution : INDIA : (Arunachal Pradesh, Madhya Pradesh, Orissa, Punjab and West Bengal); Elsewhere : BURMA; HAINAN; KUANGRUNG; KWANGSI; MALACCA; YUNNAN.

Remarks : This is unique species can easily be recognised in having equally broad shape of head and pronotum, unicoloured ensiform antennae and wings with smoky colouration at apex.

17. *Aiolopus thalassinus tamulus* (Fabricius)

(Fig. 18a-d)

1798. *Gryllus tamulus* Fabricius : 195

1968. *Aiolopus thalassinus tamulus*, Hollis : 347

Diagnostic Features : Male : Medium size. Body slender and laterally compressed. Integument finely pitted. Head shorter than pronotum ; face strongly bent downwards ; frontal ridge flat, gradually diverging towards clypeus ; fastigium of vertex elongate, apex angulated. Antennae as long as or longer than head and pronotum together. Pronotum tectiform, rugosely punctuate prozona shorter than metazona, a little constricted in the middle ; median carina well developed and cut by the posterior sulcus only ; lateral carinae absent ; posterior margin of metazona excurved and apex rounded. Mesosternal interspace with equal length and breadth. Supra anal plate short, triangular, with a sulcus from base to the middle. Cercus simple, apex obtuse, subgenital plate short, subconical, with rounded apex. Epiphallus as figured (Fig. 18d).

Female : Larger and more robust than male. Anterior ovipositor valves long, unarmed, tip of the anterior valves urged upwards. Subgenital plate plane.

Colour : Green or brown, two parallel brown stripes present on the vertex which extends up to the back of pronotum ; a green stripe present along the costal area of tegmen ; hind tibiae red at the apex and broadly separated by median black band followed by broad bluish grey band.

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	20.0	22.0	20.9	24.5	29.0	26.4
L. of the head	2.7	2.9	2.82	2.82	3.4	3.34
Br. of the head	5.2	5.6	5.4	6.0	6.3	6.2
L. of the pronotum	3.6	4.0	3.8	4.5	5.5	5.0
L. of the tegmen	20.0	22.0	21.3	23.0	28.0	25.7
L. of the hind femur	11.0	13.0	12.3	12.5	16.0	14.9
Br. of the hind femur	3.4	3.5	3.45	3.7	4.2	4.12
L. of hind tibiae	9.2	10.5	9.8	12.0	13.0	12.54

Distribution : INDIA (Andhra Pradesh, Bihar, Kerala, Karnataka, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and subsequently recorded from West Bengal). Elsewhere : AUSTRALIA ; BANGLADESH, BURMA, CELEBES ; CHINA ; CHRISTNANASIS IS ; JAPAN ; JAVA ; PAPUA ; NEW GUINES ; PHILIPINES ; SABAH ; SINGAPORE ; SRI LANKA, SUMATRA ; TAIWAN ; THAILAND, TIMOR.

Remarks : It can easily be recognised by the shape of pronotum and with a little constriction in the middle, the frontal ridge continuously narrowed upwards, hind tibiae with yellow base, greyish blue in middle and red at apex.

Subfamily : OEDIPODINAE

18. *Oedaleus abruptus* (Thunberg)

(Figs. 19a-b)

1815. *Gryllus abruptus* Thunberg : 233.

1884. *Oedaleus abruptus* Saussure : 117

1910. Kirby : 226

1981 Ritchie

Diagnostic Features : Male : Size small. Body more or less laterally compressed. Integument finely wrinkled and pitted. Head shorter than pronotum ; face slightly bent downwards and lightly convex ; frontal ridge parallel, sulcated and extends up to the upper margin of clypeus ; fastigium of vertex longer than wide. Antennae filiform, longer than head and pronotum together. Pronotum tectiform ; prozona slightly shorter than metazona or somewhat equal ; median carina low and cut by one groove ; lateral carinae as in figure (Fig. 19a) ; Posterior margin or metazona obtusely angular. Mesosternal lobes small, much wider than long, inner margin rounded. Mesosternal interspace is wider than length. Supra-anal plate short, triangular, apex obtuse. Cercus simple, base much broad. Subgenital plate as usual. Epiphallus rectangular with narrow bridge ancorae small ; lophi lobe shaped and jointed on internal sides with branches of bridge ; lateral plate large ; apex of anterior projection rounded, and posterior projection acutangular (Fig. 19b).

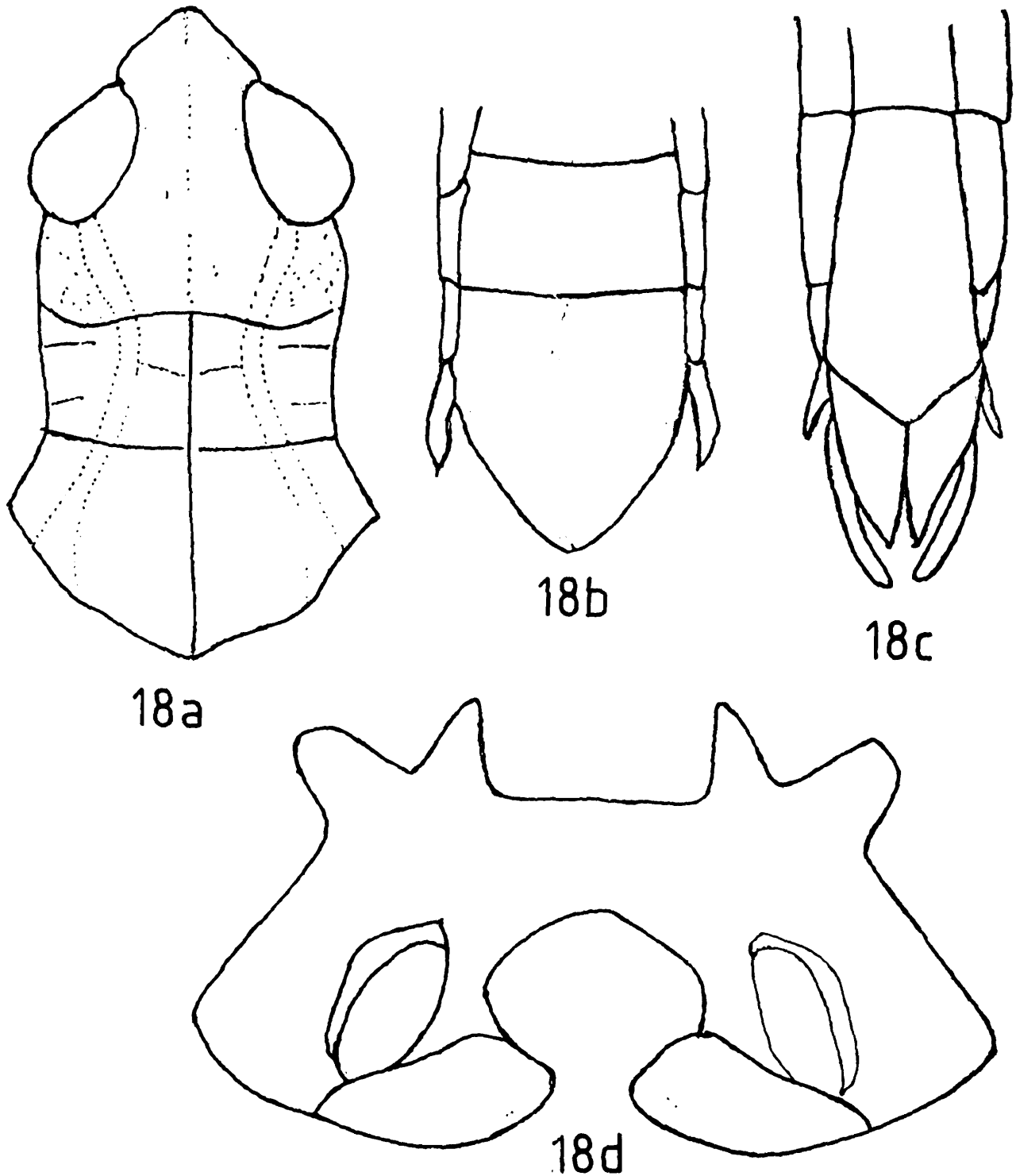
Female : Larger than male. Anterior ovipositor valves strongly sclerotised, tip curved. Subgenital plate normal.

Colour : Colour is variable either green or brown sometimes with light brown or light green and white mark on the dorsum of pronotum with white incomplete cross mark ; tegmina brown or green with three pale bands before the middle ; hind femur with two indistinct dark transverse bands on external upper margin and medial areas ; tibiae reddish or glaucous, pale toward the base.

Measurement (mm.) :

	<i>Male</i>			<i>Female</i>		
	<i>Range</i>			<i>Range</i>		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	14.9	16.5	15.4	18.0	21.0	20.0
L. of the head	2.2	2.3	2.24	2.9	3.1	3.02
Br. of the head	4.5	5.0	4.7	5.9	6.2	6.0
L. of the pronotum	3.8	4.0	3.89			
L. of the tegmen	14.5	16.2	15.4	17.0	20.0	18.4
L. of the hind femur	9.8	10.5	10.2	11.5	12.5	12.1
Br. of the hind femur	2.8	2.72	3.1	3.1	3.4	3.25
L. of the hind tibiae	7.9	8.3	8.05	10.9	12.0	11.47

Distribution : INDIA : (Arunachal Pradesh, Andhra Pradesh, Bihar, Kerala, Karnataka, Orissa, Punjab, Rajasthan, Tamil Nadu and common in West Bengal); Elsewhere BANGLADESH ; BURMA ; NEPAL ; THAILAND ; PAKISTAN ; SRI LANKA.



Figs. 18 a-d. *Aiolopua th. tamulus* — 18a, head and pronotum; 18b, subgenital plate of male (ventral view); 18c, external genitalia of female (ventral view); 18d, epiphallus.

Remarks : The species may be easily recognised by its size, incomplete cross marking on the dorsum of pronotum.

19. *Trilophidia annulata* (Thunberg)

(Figs. 20a-b)

1815. *Gryllus annulatus* Thunberg : 234

1910. *Trilophidia annulata* Kirby : 244

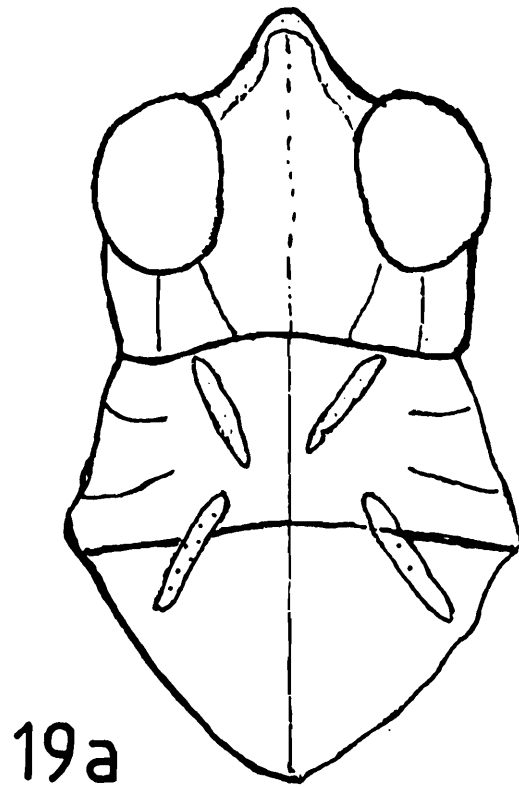
1914. Kirby : 9

1965. Hollis : 251

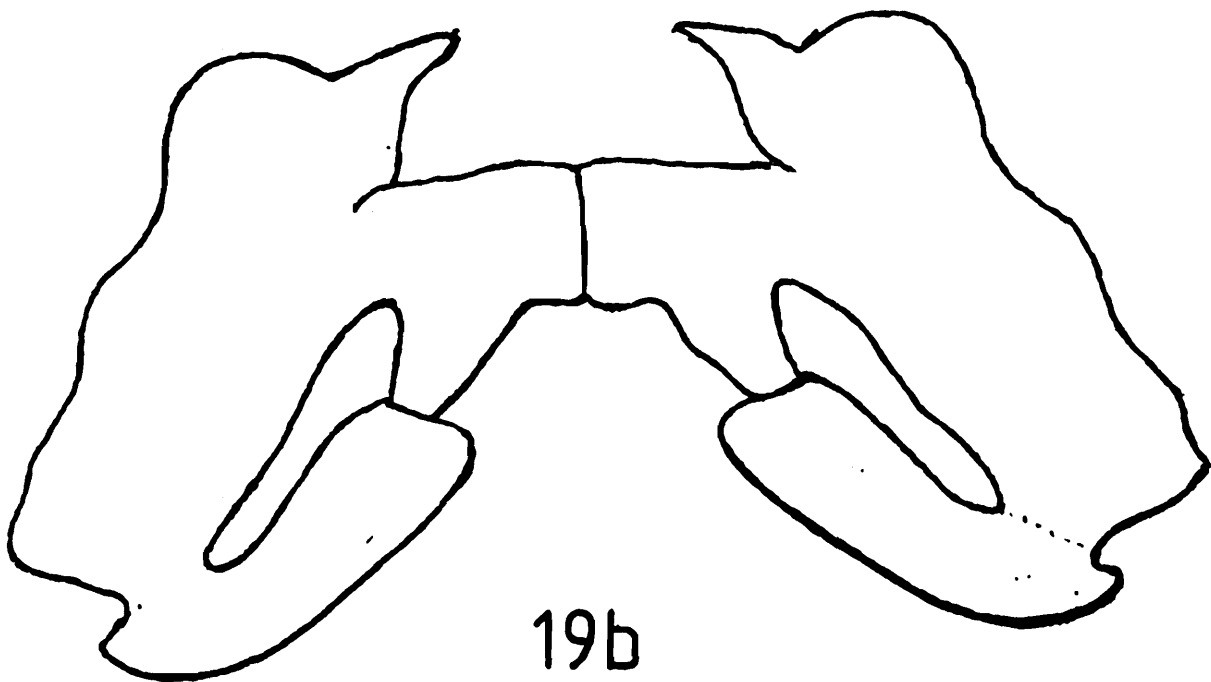
Diagnostic Features : Male : Small size. Body more or less slender and laterally compressed. Integument strongly rugose and hairy. Head shorter than pronotum ; face concave, more or less arch shaped ; frontal ridge irregularly sulcated and extends up to the clypeus ; fastigium of vertex trapezoid, a pair of tubercles present on vertex and the apex truncate. Antennae filiform, longer than head and pronotum together. Pronotum tectiform with well marked crest ; prozona shorter than metazona, constricted in the middle, tooth like projections present on median carina on the dorsum of prozona ; metazona with weak median carina ; first sulcus strongly divergent and somewhat weak in metazona, third sulcus present before its middle, lateral carinae irregularly present, posterior margin of metazona rectangular with obtuse apex. Mesosternal lobe longer than broad, inner margin rounded. Mesosternal interspace broad and more or less twice than its length. Supra-anal plate triangular, apex obtusely rounded. Cercus simple, conical, the base broad and as long as supra-anal plate. Subgenital plate as usual but hairy and directed upward. Epiphallus with narrow bridge, ancorae broad at base, narrow at apex, which is curved inwardly, lateral plate large and slightly elevated in the middle, lophi large, joined with the bridge by a narrow projection, posterior lobe broad, bent towards right side (Fig. 20d).

Female : Large and more robust than male. Anterior ovipositor valves moderate in size, apex highly sclerotised. Subgenital plate hairy and apex medially angular.

Colour : Brown to grey or dark grey with black spots, tegmen grey, posterior part deep brown or black with yellow spot, hind femur with two black markings on upper lateral side, hind tibiae with brown bands at the base and in the middle and posteriorly black band separated by white band, spines black at the tip.

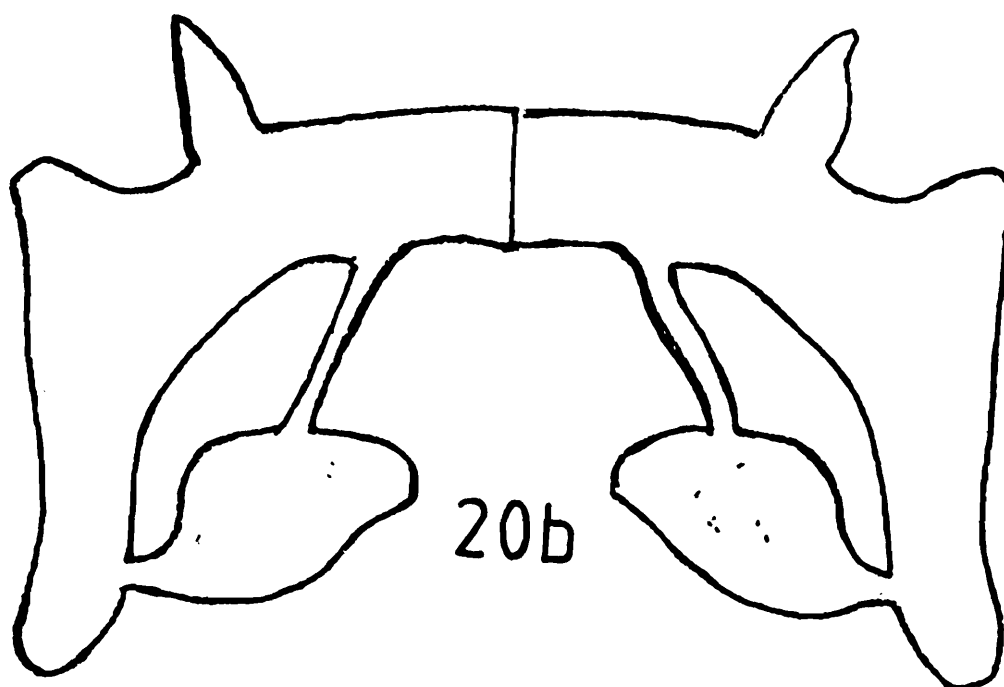
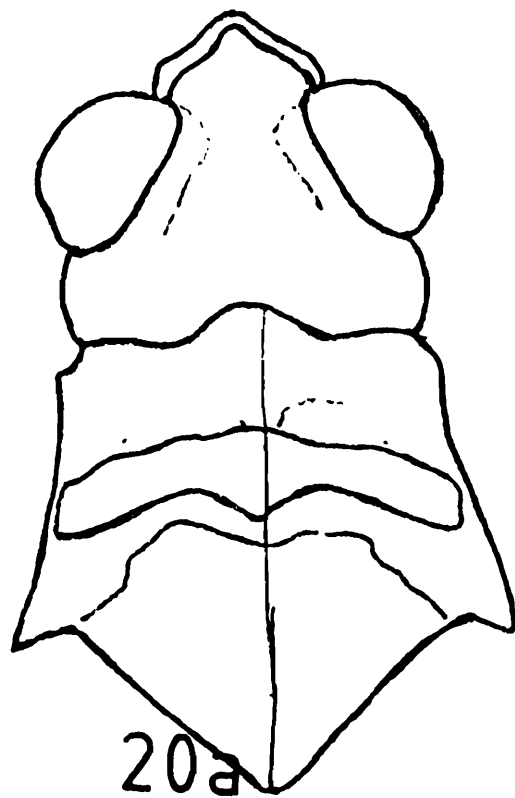


19a



19b

Figs. 19 a-b. *Oedaleus abruptus* — 19a, head and pronotum ; 19b, epiphallus.



Figs. 20 a-b. *Trilophidia annulata* — 20a, head and pronotum ; 20b, epiphallus.

Measurement (mm.) :

	Male			Female		
	Range			Range		
	Min.	Max.	Mean	Min.	Max.	Mean
L. of the body	13.0	15.5	14.5	17.5	22.0	18.7
L. of the head	2.1	2.3	2.16	2.6	2.9	2.75
L. of the pronotum	3.1	3.33	3.2	4.0	4.4	4.2
L. of the tegmen	14.0	17.0	14.8	16.0	19.0	17.6
L. of the hind femur	8.0	9.2	8.3	9.6	13.0	10.9
Br. of the hind femur	3.0	3.0	3.0	3.7	4.0	3.9
Br. of the head	4.0	4.3	4.1	4.9	5.3	5.16
L. of the hind tibiae	6.8	7.0	6.39	7.5	8.0	7.8

Distribution : INDIA : (Arunachal Pradesh, Andhra Pradesh, Assam, Bihar, Goa, Himachal Pradesh, Kerala, Madhya Pradesh, Tamil Nadu, Orissa, Uttar Pradesh and W. Bengal); Elsewhere: BANGLADESH BURMA ; CHINA ; HAINAN ; HONKONG ; JAPAN ; JAVA ; KOREA ; MALAYA ; NORTH KALIMANTAN ; PHILIPPINES ; SARAWAK ; SINGAPORE ; SRI LANKA ; TAIWAN ; THAILAND.

Remarks : This unique species can easily be identified by peculiar well marked crest of pronotum, which is strongly bilobed in profile.

Taxonomy of nymphs of some grasshoppers

This chapter deals with the nymphal taxonomy of the following five species.

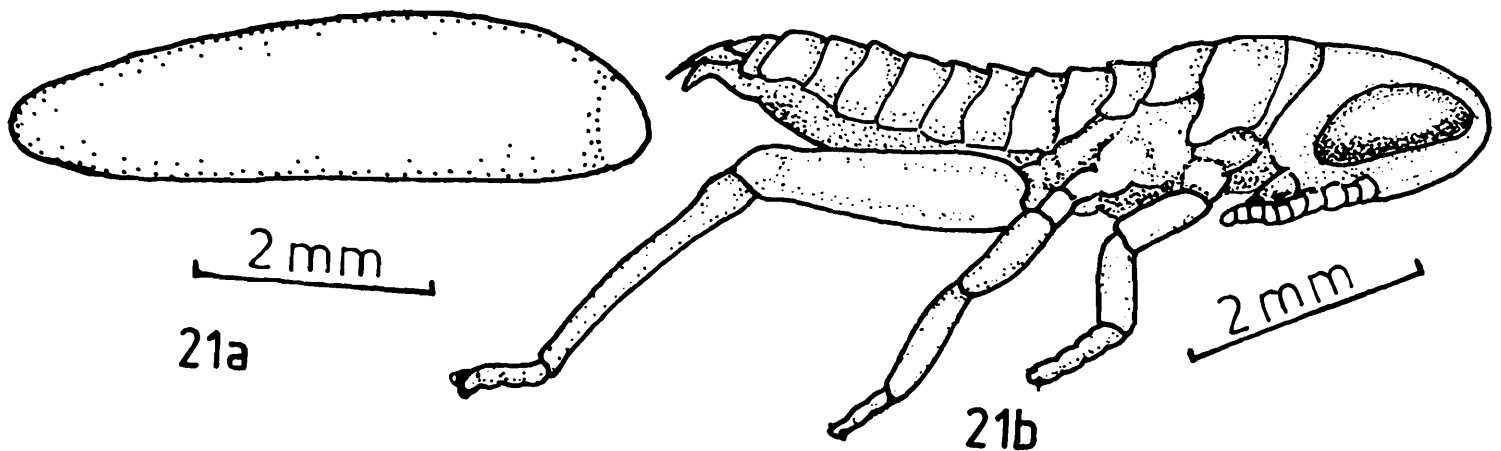
1. *Spathosternum pr. prasiniferum*
2. *Acrida exaltata*
3. *Phlaeoba infumata*
4. *Aiolopus th. tamulus*
5. *Atractomorpha crenulata*

The above species are associated with major crops and vegetables of West Bengal. The attempt has been made to prepare nymphal keys of the studied species for the first time in India. As large number of agricultural workers encounter them during control operations and refer to Z. S. I. for identification etc. The following important lactromic characters have been in the pupuration of the nymphal keys.

1. *Spathosternum prasiniferum prasiniferum* (Walker)

Key to the identifications of different nymphal instars
(Male and female)

1. Eighth sternum of abdomen without ovipositor valves ; ninth sternum of abdomen with subgenital plate Males (2)
 - Eighth sternum of abdomen with a pair of small ovipositor valves, ninth sternum also with a pair of small valves, developed into posterior ovipositor valves... Females (6)
2. Apical segment of antennae more or less club shaped prosternal tubercle not developed or ill developed, apex of the subgenital plate not reaching beyond one third length of paraprocts (3)
 - Apical segment of antennae filiform ; prosternal tubercle well developed ; apex of the subgenital plate reaching beyond the one third length of the paraprocts (4)
3. Antennae, 12 segmented ; apex of the subgenital plate deeply emarginate.....instar I, male
 - Antennae 13-14 segmented ; apex of the subgenital plate less emarginate.....instar II, male
4. Hind wing pads not overlapped the fore wing pads with faint trachiation ; apex of subgenital plate shallow or transverse instar III, male
 - Hind wing pads overlapped the forewing pads with pronounced trachiation ; apex of subgenital plate more or less obtusely pointed (5)

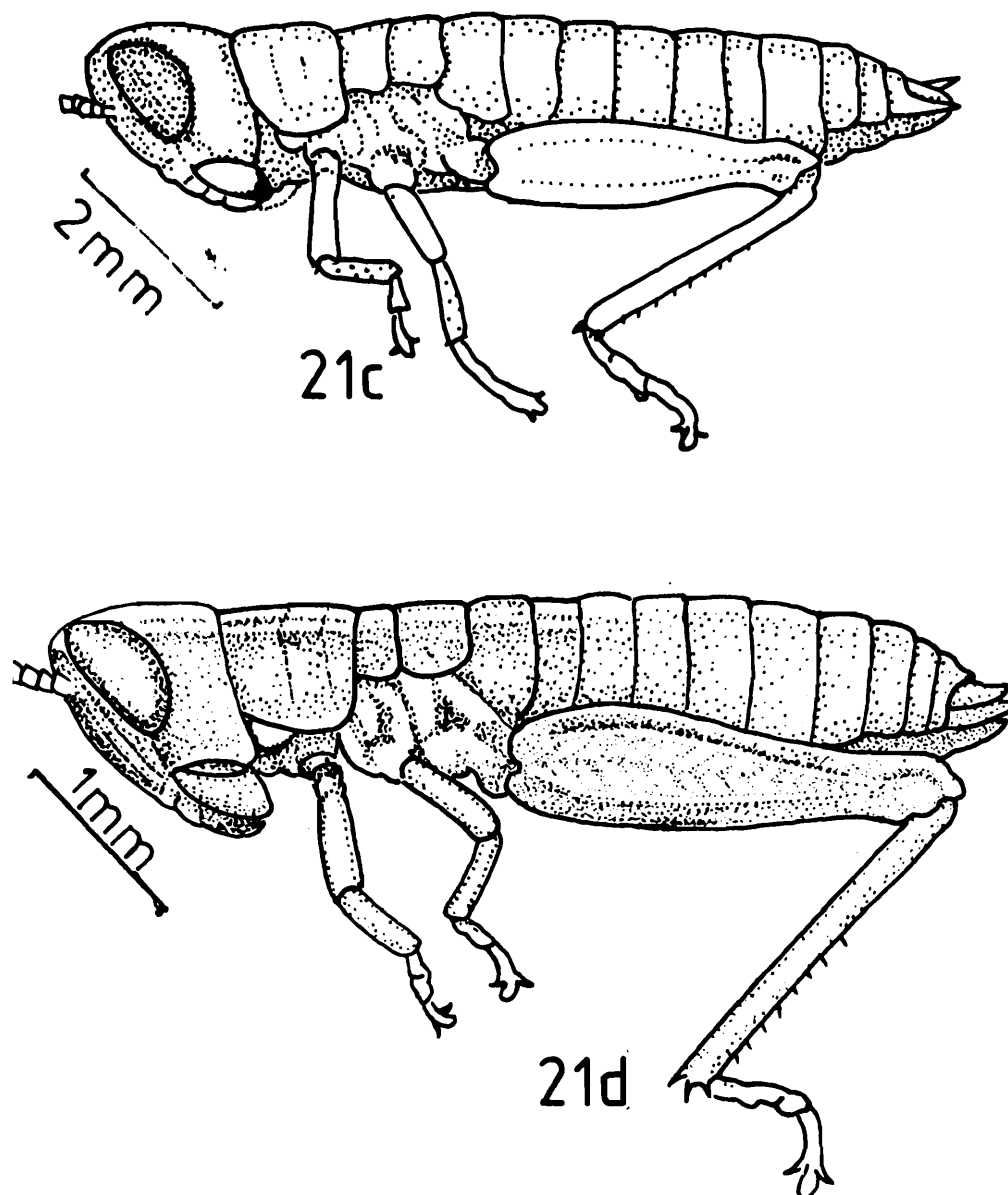


Figs. 21 a-b. *Spathosternum pr. prasiniferum* — 21a, egg ; 21b, vermiform larva.

5. Hind wing pads reaching beyond the middle of first tergite, apex of subgenital plate reaching just above the end of paraprocts instar IV, male
 - Hind wing pads reaching upto the end of third tergite ; apex of subgenital plate reaching beyond the paraprocts instar V, male
6. Wing pad blunt and downwardly directed ; posterior margin of pronotum clearly incurved (7)
 - Wing pads not so blunt and posterior margin of pronotum transverse or outcurved.. (8)
7. Anterior and posterior ovipositor valves not well developed instar I, female
 - Anterior and posterior ovipositor valve more or less well developed instar II, .. female
8. Fore wing pads not overlaped by hind wing pads ; inner valves of ovipositor developed (9)
 - Fore wing pads overlaped by hind pad ; inner valves of ovipositor overlaped (10)
9. Fore wing pad 0.6 to 0.7 mm. in length, posterior ovipositor valves covering half of the paraproct instar III, female
 - Fore wing pads 1.0 mm. in length, posterior ovipositor valves covering three fourth of the paraprocts instar IV, female
10. Hind wing pads 1.6 to 1.7 mm. in length, and reaching beyond the middle of first tergite ; posterior ovipositor valves reaching upto the apex of paraprocts instar V, female
11. Hind wing pads 4.2 to 4.3 mm. in length and reaching upto the apex of second tergite ; posterior ovipositor valves reaching beyond the paraprocts instar VI, female

Egg pod and Eggs (Fig. 21a)

The freshly laid egg pod of *Spathosternum pr. prasiniferum* was light yellow to deep brown in colour. Egg pods were soft, spongy and containing a number of eggs. The egg pods subcylindrical, little curved in the middle lower and being obtusely rounded or convex in shape, having top slightly concave. The other part partly composed of dried forthy material, the plug is situated at the top. The egg pod measuring 1.2 to 2.2 cm. in length (M. 1.6 cm.).



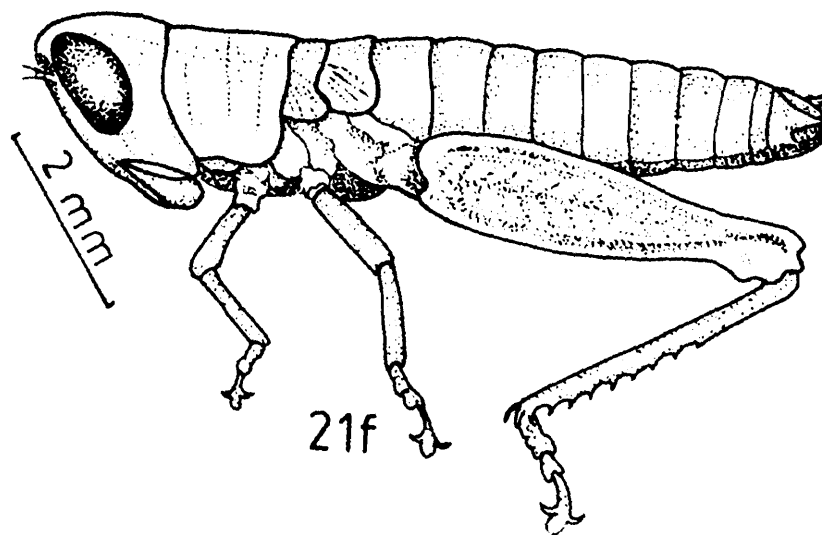
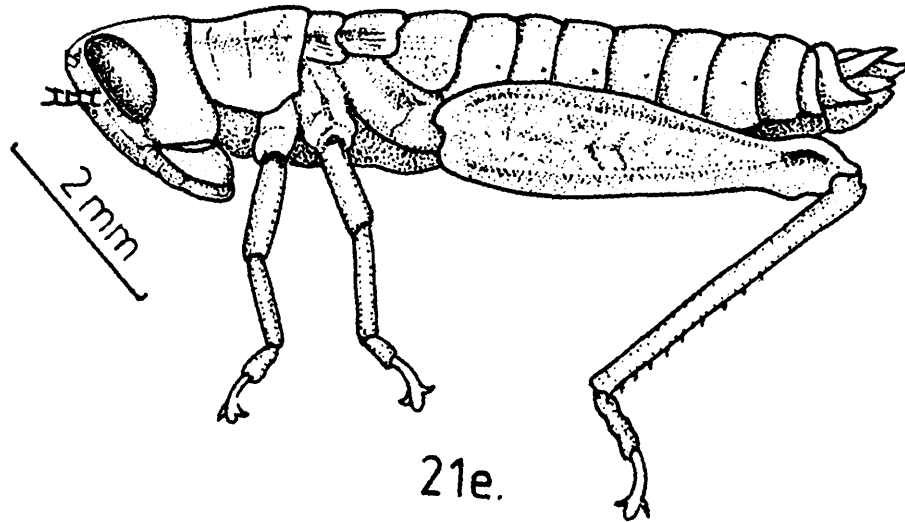
Figs. 21 c-d. *Spaihosternum pr. prasiniferum* — 21c, first instar male ; second instar female.

Freshly laid eggs are light yellow in colour but after one and half hour to two hours it became deep yellow. Eggs were rice shaped, arranged obliquely in pod, measuring 3.3 to 3.6 mm. (M. 3.42 mm.) in length and breadth being 1.5 mm. (Fig. 21a).

Vermiform Larvae (Fig. 21b)

Colour : General body colour always green. Body almost cylindrical in shape, laterally compressed and enclosed in a thin transparent membrane like a sac, but with a separate sleeves for the legs and the distal part of Antennae measuring 5.47 (5.0 to 6.0) mm. N = 20, in length. Head subglobular, obtusely bent downwards with rounded apex, fastigium of vertex short. Ocelli not visible. Antennae with 10 segments, flagellum lies close to the body towards the posterior end of head. Prosternal tubercle not detectable. Pronotum subcylindrical and its posterior margin

deeply concave or incurved in shape. Wing pad rudiment not differentiated from terga. Legs with fore, middle and hind legs lying close to the body, basal lobe of hind femur not clearly developed, external apical spine of hind femur not detectable. External genitalia of both the sexes with supra anal plate downwardly directed and then bent towards the cephalic end of the body, cerci bent downwards, inwards and parallel to the end of abdomen. Male subgenital plate hardly covered the base of the para-procts. Female anterior or lower ovipositor valves hardly detectable in the



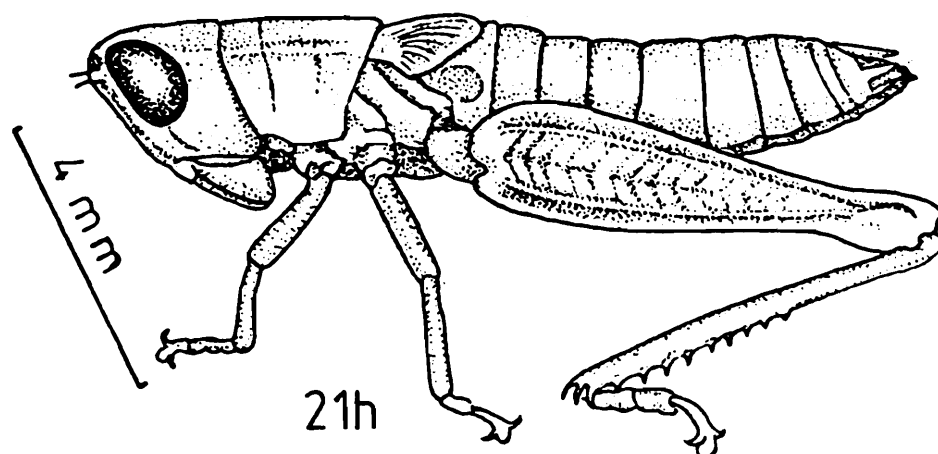
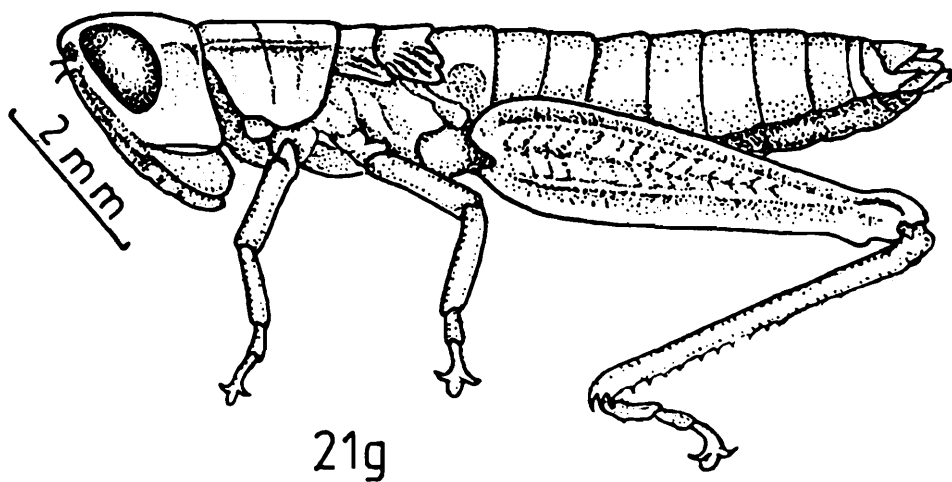
Figs. 21 e-f. *Spathosternum pr. prasiniferum* — 21e, third instar female ; 21f, third instar male.

eighth sternum, posterior or upper ovipositor valves also hardly detectable.

First Instar : (Fig. 21c)

Colour : Nascent hopper always light green in colour, within a few hours it acquires original green colour. The compound eyes brown with smoky tinge, antennae and femur light pinkish in colour, tibiae green, sternum faintly pinkish. Body cylindrical, narrow, compressed laterally,

tympanal depression absent measuring 5.3 (5.0 to 5.5) mm. $n = 20$, in length (both the sexes). Head subconical, rounded at apex, vertex short angular measuring 0.99 (0.9 to 1.1) mm. $n = 20$, in length and 1.71 (1.65 to 1.72) mm. $n = 20$, in breadth. Ocelli hardly detectable. Antennae filiform (Fig. 22a) with 12 segments measuring 1.03 (1.0 to 1.1) mm. $n = 20$, in length. Prosternal tubercle not detectable. Pronotum subcylindrical, posterior margin deeply concave or incurved measuring 0.64 (0.6 to 0.68) mm. $n = 20$, in length along the median carina. Wing pads with rudiments of mesonotum or fore wing pads and metanotum or hind wing pads slightly differentiated from terga, hind margin of both of the wing pads directed vertically downwards, at apex blunt and rounded, trachiation not distinct, fore wing pad measuring 0.3 mm. $n = 10$, in length. Hind femur with upper and lower basal lobe equal and measuring 2.12 mm. $n = 20$, in length. Hind tibiae with external apical spine detectable, measuring 1.9 (1.6 to 2.0) mm. in length. External genitalia of male (Fig. 23a) ninth abdominal sternum bears a plate like form known as subgenital plate which covered only base of the paraprocts, with deep emarginate at



Figs. 21 g-h. *Spathosternum pr. prasiniferum* — 21g, fourth instar female ; 21h, third instar male.

apex. Female with anterior or lower ovipositor valves short and transverse on eighth abdominal sternum ; posterior or upper ovipositor valves small, triangular, and present in the ninth sternum (Fig. 23b).

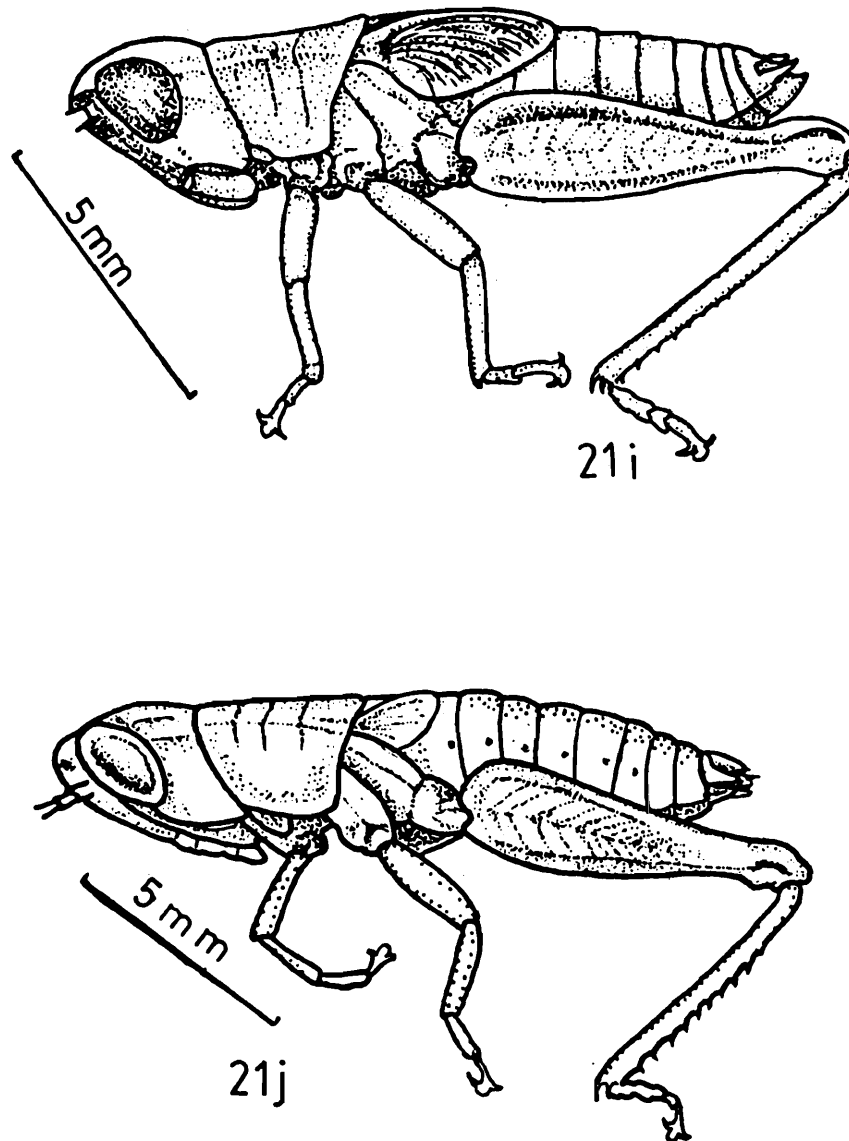
Second Instar (Fig. 21d)

Colour : The colour as in first instar, except the colouration of antennae and hind femur, which became a faint pinkish. Body narrow, cylindrical a little tympanal depression appeared measuring 6.36 (6.0 to 6.7) mm. n = 20, in length. Head measuring 1.25 (1.2 to 1.3) mm. n = 20, in length and 2.04 (1.9 to 2.2) mm, n = 20, in breadth. Ocelli clearly detectable. Antennae apically less club shaped (Fig. 23b), 13 to 14 segmnts measuring 1.25 (1.2 to 1.3) mm. n = 20, in length. Prosternal tubercle not detectable. pronotum shape same as previous instar, posterior margin less incurved or concave and measuring 1.0 (0.95 to 1.1) mm. n = 20, in length. Wing pads with rudiments more prominent than those of first instar, steaky pattern of trachiation appeared for future venetion fore wing pad measuring 0.38 (0.36 to 0.39) mm. n = 15, in length. Hind femur with upper basal lobe longer than lower basal lobe measuring 2.84 (2.8 to 3.0) mm. n = 20, in length. Hind tibiae measuring 2.58 (2.5 to 2.7) mm. n = 15, in length. External genitalia of male (Fig. 23c) with subgenital plate less emarginate at apex. Female with anterior or lower ovipositor valves more clearly developed. Posterior or upper ovipositor valves also clearly developed (Fig. 23d.)

Third Instar (Figs. 21e,f)

Colour : As in the previous instars, but from this instar the colour changes simulating the surroundings to the colour of vegetations or soil conditions which may be green to straw yellow or light brown or greenish brown, a faint dark bluish brown stripes extend behind the eye to sixth terga along the lateral carinae of pronotum. Eyes deep brown and surrounded by yellowish band, the pink colour absent from the antennae and hind femur from this instar.

Body same as first and second instar, a little tympanal depression appeared from this instar and measuring 8.6 (8.0 to 9.3) mm. n = 20, in length. Head from this instar and measuring 8.6 (8.0 to 9.3) mm. n = 20, in breadth. Antennae (Figs 22c-d) consist of 15-16 segments, and measuring 1.54 (1.5 to 1.6) mm. n =20, in length. Prosternal tubercle detectable. Pronotum same as second instar except the posterior margin transverse and measuring 1.43 (1.4 to 1.47) mm. n = 20, in length. Wing pads of male more or less trangular in shape trachiation more distinct, fore wing pads or mesonotum reaching at least one third length of the way along the costal margin of hind wing pads and fore wing pads measuring 0.7 mm. n = 10, in length. Female with fore wing pad reaching at least one fourth length of way along the costal margin of hind wing

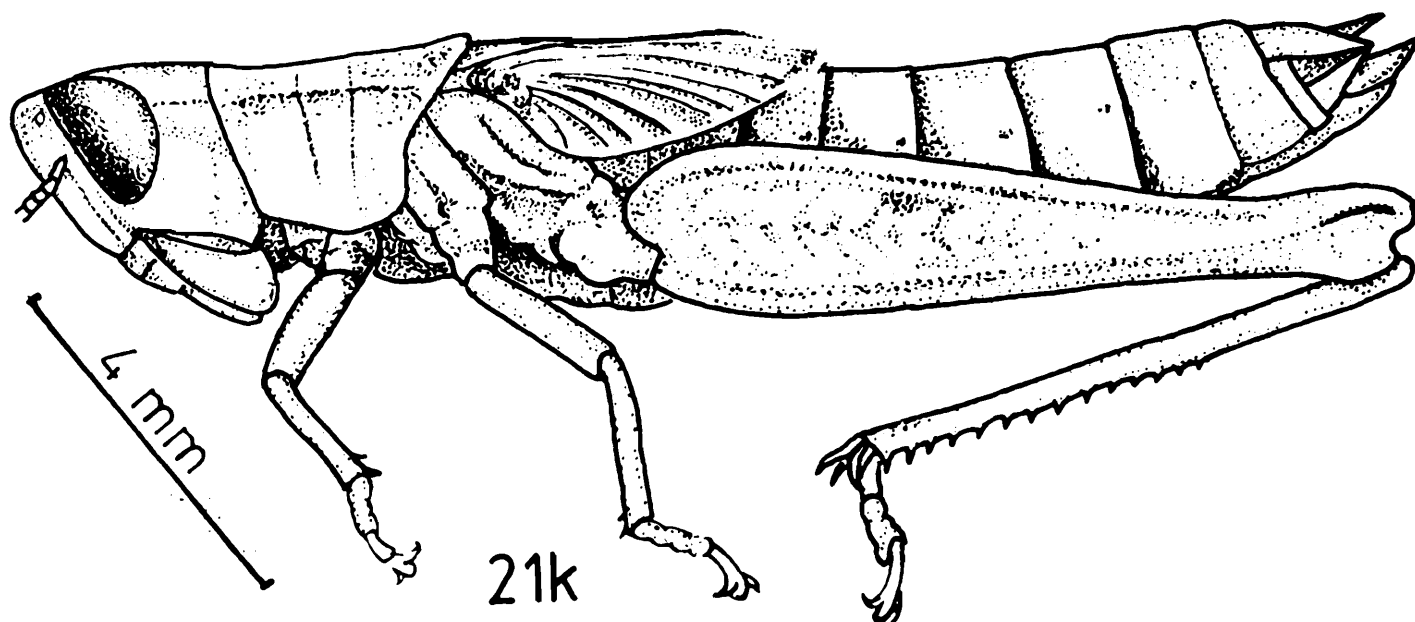


Figs. 21 i-j. *Spathosternum pr. prasiniferum* — 21i, fifth instar male ; 21j, fifth instar female.

pads and measuring 0.6 mm. $n = 20$, in length. Hind femur with upper basal lobe more longer than the lower basal lobe and measuring 3.81 (3.7 to 3.9) mm. $n = 15$ in length in male and in female measuring 3.72 (3.9 to 4.9) mm. $n = 15$, in length. Hind tibiae with measuring 3.35 (3.3 to 3.6) mm. $n = 20$, in length (in both the sexes). External genitalia of male (Fig. 23e) with posterior margin of subgenital plate transverse and covered half of the paraprocts. Female with anterior or lower ovipositor valves reaching the half way between the sternal groove ninth ; posterior or upper ovipositor valves covered half of the paraprocts, inner valves appeared in between the base of posterior ovipositor valves (Fig. 23f).

Fourth Instar (Figs. 21g, h)

Colour : More or less as in third instar except a dark bluish stripe extended from the middle

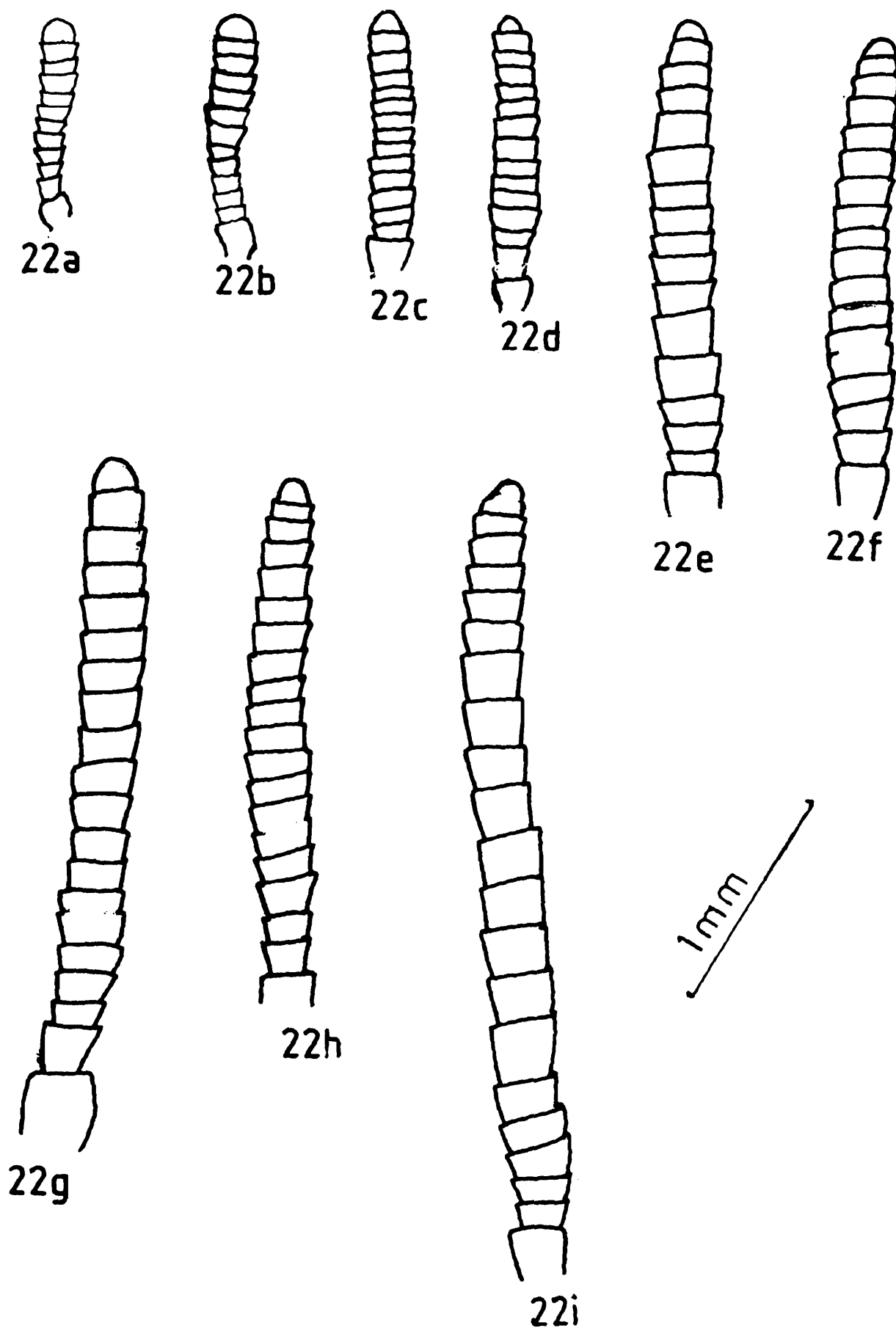


Figs. 21 k. *Spathosternum pr. prasiniferum* — Sixth instar female.

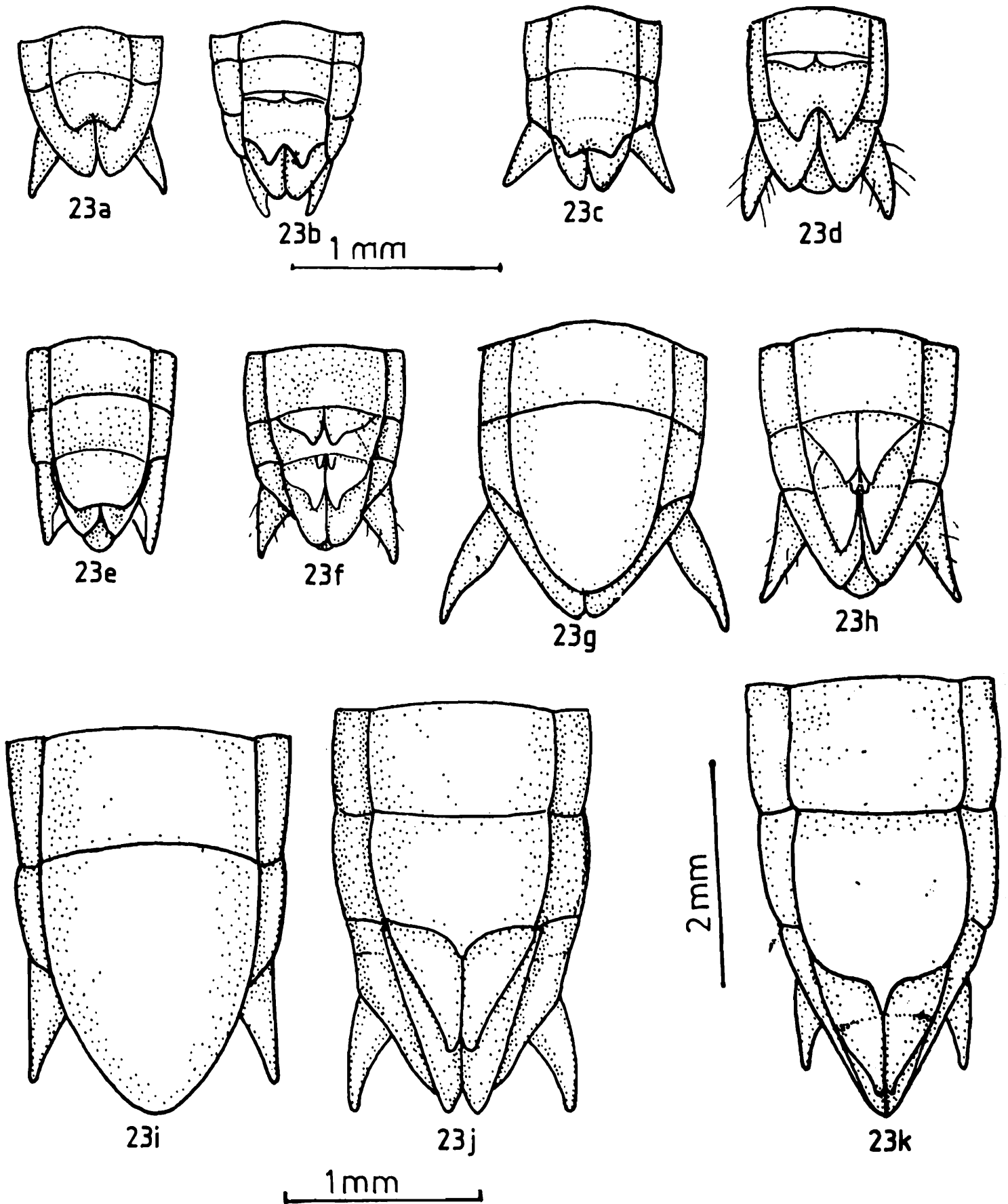
of the eye to the last tergite along the lateral carinae of pronotum. Body of male measuring 10.8 (10.5 to 11.5) mm. $n = 15$ in length and female measuring 12.0 (11.8 to 12.6) mm. $n = 15$ in length. Head measuring 2.19 (2.0 to 2.4) mm. $n = 20$ in length and 3.44 (3.2 to 3.7) mm. $n = 15$ in breadth. Antennae with segments 17-18 (Figs. 22e-f) and measuring 2.51 (2.48 to 2.57) mm. $n = 20$, in length. Prosternal tubercle clearly detectable. Pronotum with posterior margin of male convex or out curved and measuring 2.38 (2.3 to 2.4) mm. $n = 15$, in length and in female measuring 2.52 (2.43 to 2.6) mm. $n = 15$, in length. Wing pads with rudiments of male longer and reversed in position such as hind wing pads overlap the fore wing pad, hind wing pad reaching just above the hind margin of abdominal tergite one and measuring 1.48 (1.4 to 1.6) mm. $n = 15$, in length. Wing pads with rudiments of female reaching half of the way along the costal margin of hind wing pads, trachiation more distinct for future venation and fore wing pads measuring 1.59 (1.57 to 1.6) mm. $n = 15$ in length. Hing femur measuring 6.01 (4.5 to 5.2) mm. $n = 15$, in length. External genitalia of male (Fig. 23g) with subgenital plate extended just before the end of paraprocts and the extremity obtusely rounded. Female (Fig. 23h) with anterior ovipositor valves or lower valves covered the one fourth length of posterior ovipositor valves ; posterior ovipositor valves or upper valves covered the three fourth of the paraprocts ; inner margin of posterior valves sharply divergent between then ; inner velvies developed more distinctly.

Fifth Instar (Figs. 21i, j)

Colour : Varies from deep green, straw yellow to light brown depending on the substratum



Figs. 22 a-i. *Spathosternum pr. prasiniferum* (antennae) — a, first instar male ; b, second instar female ; c, third instar male ; d, third instar female ; e, fourth instar male ; f, fourth instar female ; g, fifth instar male ; h, fifth instar female ; i. sixth instar female.

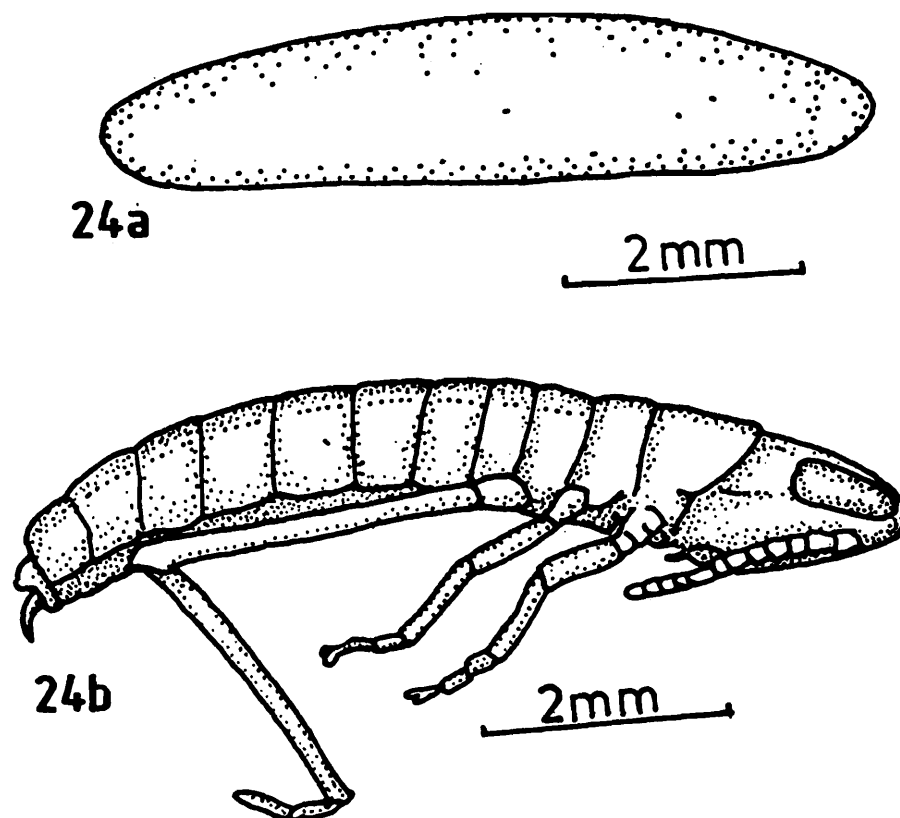


Figs. 23 a-k. *Spathosternum pr. prasiniferum* external genitalia (ventral view) — a, first instar male ; b, second instar female ; c, second instar male ; d, second instar female ; e, third instar male ; f, third instar female ; g, fourth instar male ; h, fourth instar female ; i, fifth instar male ; j, fifth instar female ; k, sixth instar female.

of the surroundings. Body of male measuring 13.8 (13.2 to 14.3) mm. n = 15, in length ; In female measuring 12.5 (12.0 to 13.2) mm. n = 15, in length. Head of male measuring 2.17 (2.1 to 2.2) mm. n = 15, in length and 3.78 (3.7 to 4.0) mm. n = 15, in breadth ; In female with head measuring 2.05 (2.0 to 2.1) mm. n = 15, in length and 3.73 (3.7 to 3.8) mm. n = 15, in breadth. Antennae of male with 19 to 20 segments (Fig. 45) measuring 3.43 (3.4 to 3.5) mm. n = 15, in length ; In female antennae with 18 to 19 segments measuring 2.9 (2.8 to 3.0) mm. n = 15, in length (Fig. 22g, h). Prosternal tubercle more clearly developed than the previous instars and apex obtusely rounded. Pronotum with posterior margin concave or out curved and apex obtusely rounded ; In male measuring 2.9 (2.8 to 2.98) mm. n = 15, in length ; In female measuring 2.64 (2.6 to 2.8) mm. n = 15, in length. Hind wing pads of male reaching upto the joint of second tergite, some times reaching before the joint of third terga, parallel trachiation more distinct hind wing pads measuring 3.9 (3.8 to 4.1) mm. n = 15, in length ; Hind wing pads of female overlapping the fore wing pads and hind wing pads reaching before the first tergite measuring 1.63 (1.6 to 1.7) mm. n = 15, in length. Hind femur of male measuring 7.4 (7.2 to 7.6) mm. n = 15, in length ; In female measuring 6.38 (6.3 to 6.5) mm. n = 15, in length. Hind tibiae of male measuring 5.85 (5.8 to 6.0) mm. n = 15, in length ; in female measuring 5.3 (5.2 to 5.5) mm. n = 15, in length. External genitalia of male (Fig. 23i) with tip of the subgenital plate extended beyond the paraprocts and the apex obtusely rounded ; Female (Fig. 23g) with anterior ovipositor valves covered just above the tip of the paraprocts, in this instar the inner margin of two posterior valves come in close contact with each other ; posterior margin of sternite 8th indented ; inner valves overlapped.

Sixth Instar (Fig. 21k)

Colour : Same as previous instar. Body measuring 15.8 (15.6 to 16.0) mm. n = 15, in length. Head measuring 2.53 (2.4 to 2.6) mm. n = 15, in length and 4.32 (4.1 to 4.5) mm. n = 15 in breadth. Antennae with 21 to 22 segments (Fig. 22i) Prosternal tubercle with apex a little transverse in shape. Pronotum with posterior margin obtusely rounded and measuring 3.34 (3.0 to 3.4) mm. n = 15, in length. Wing pads with rudiments more triangular in form and the hind wing pads reaching beyond the hind margin of second tergite, trachiation more distinct measuring 3.7 (3.0 to 3.5) mm. n = 15, in length. Hind femur measuring 8.1 (7.9 to 8.4) mm. n = 15, in length. Hind femur measuring 8.1 (7.9 to 8.4) mm. n = 15, in length. Hind tibiae measuring 6.50 (6.4 to 6.7) mm. n = 15, in length. External genitalia (Fig. 23h) with tip of the anterior ovipositor valves reaching just above the apex of the posterior ovipositor valves ; posterior ovipositor valves reaching beyond the paraprocts.



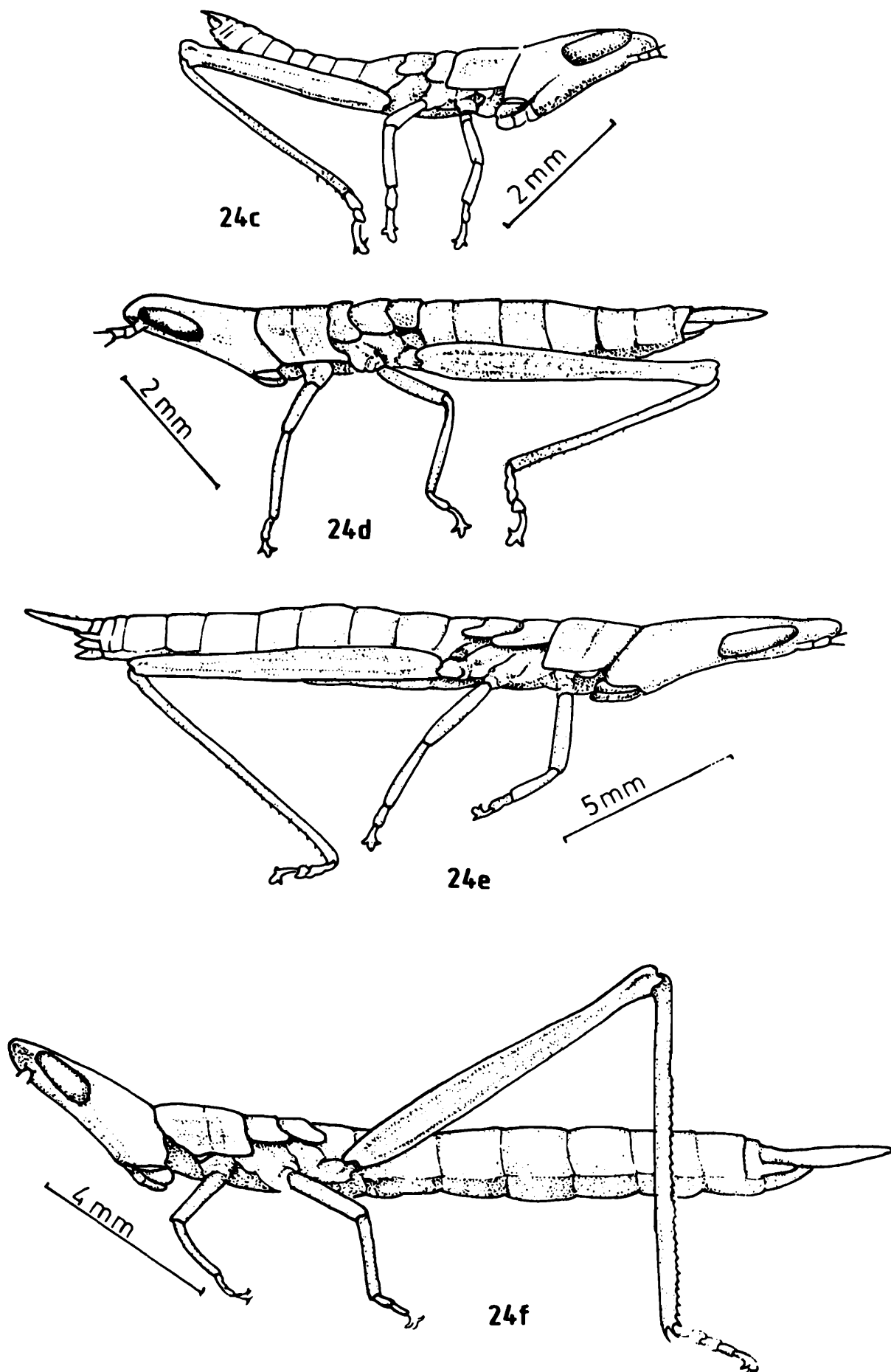
Figs. 24 a-b. *Acrida exaltata* — a, egg ; b, vermiform larva.

2. *Acrida exaltata* (Walker)

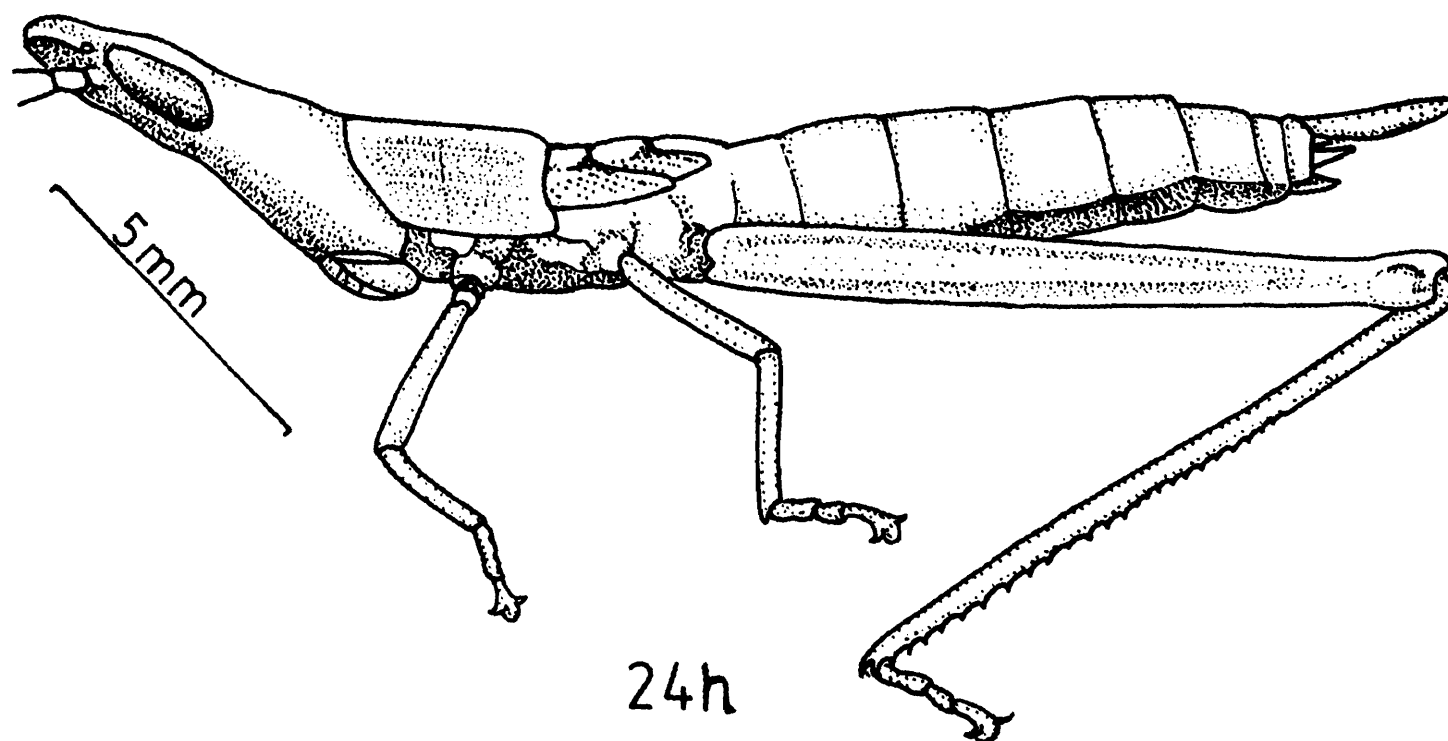
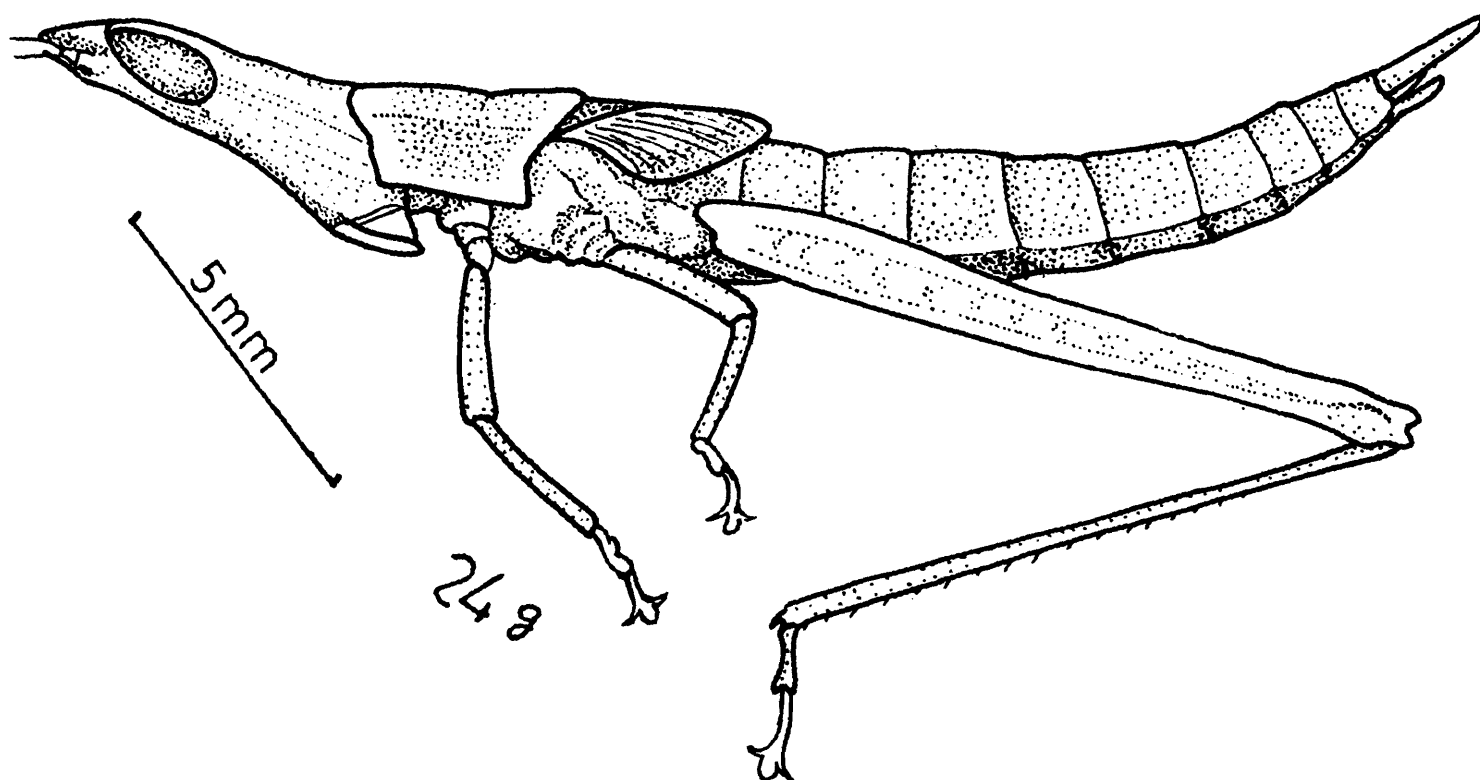
Key to the identifications of nymphal instars

(Male and female)

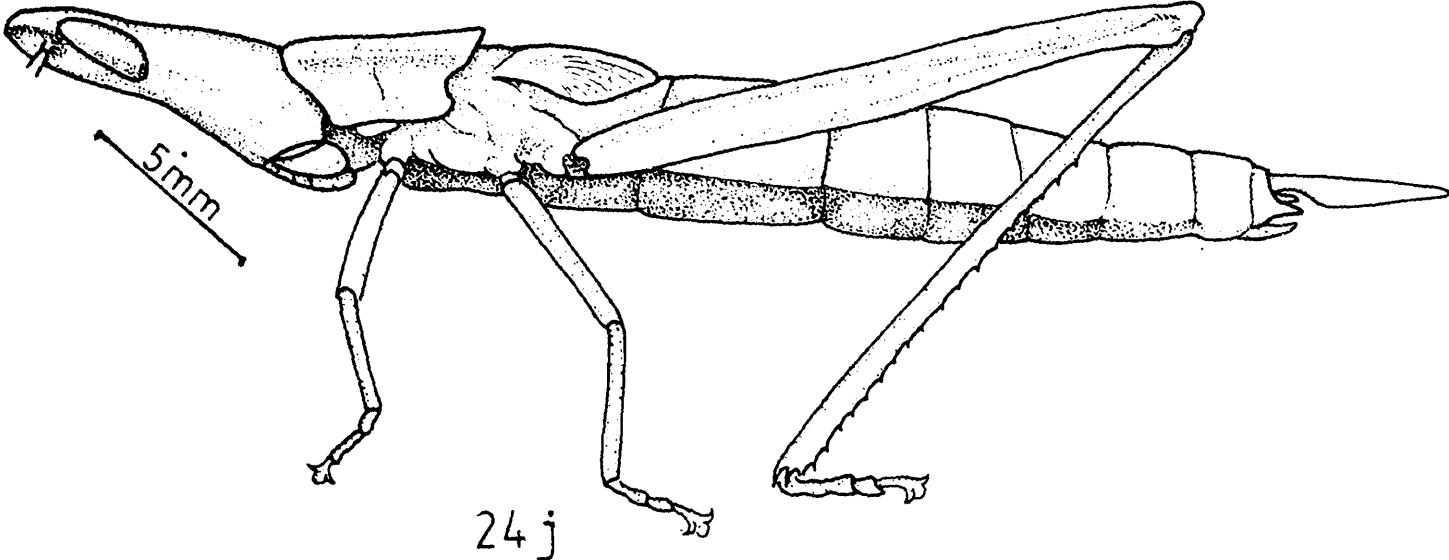
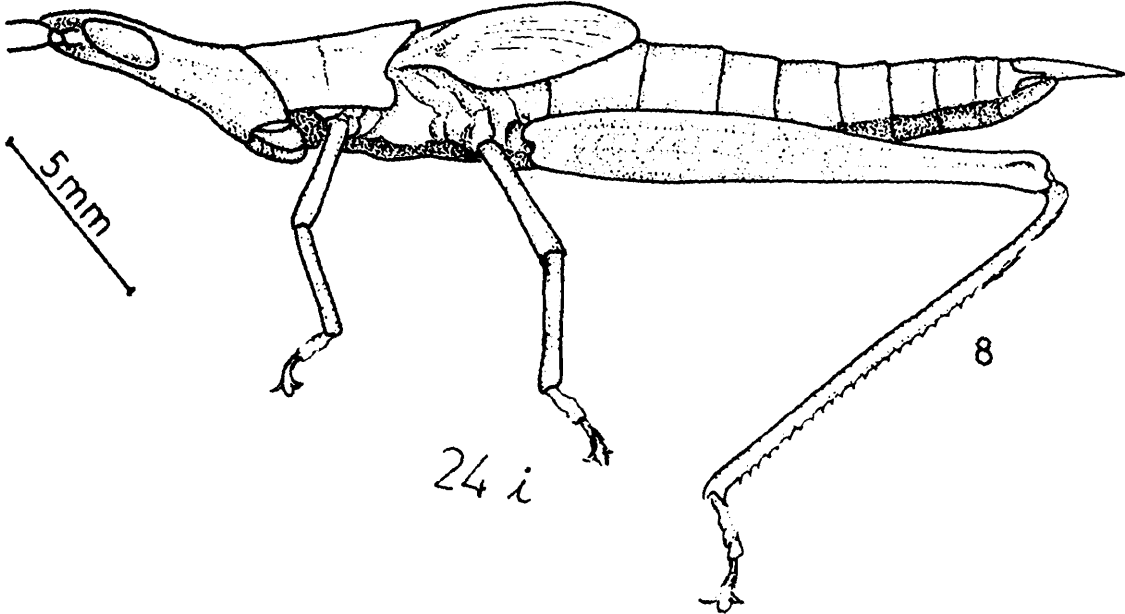
1. Anterior ovipositor valves absent on eighth abdominal sternum..... Males (2)
- Anterior ovipositor valves present on eighth abdominal sternum Females (6)
2. Tympanal depression not clearly developed ; supra anal plate less than 2.0 mm. in length 3
- Tympanal depression clearly developed ; supra anal plate 2.0 mm. or more than 2.0 mm in length 4
3. Head length 1.8 to 1.9 mm. in length ; supra anal plate 0.6 to 0.65 mm. in length...
..... instar I, male
- Head length 3.0 to 3.1 mm. in length ; supra anal plate 1.0 in length
..... instar II, male



Figs. 24 c-f. *Acrida exaltata* — c, first instar male ; d, second instar female ; e, third instar male ; f. third instar female.



Figs. 24 g-h. *Acrida exaltata* — g, fourth instar male ; h, fourth instar female.



Figs. 24 i-j. *Acrida exaltata* — fifth instar male ; j, fifth instar female

4. Wing pads measures 1.2 to 1.3 mm. in length ; supra anal plate 2.0 mm. in length....
..... instar III, male
- Wing pads measures more than 1.2 to 1.3 mm. in length supra anal plate more than
2.0 mm. in length5
5. Posterior margin of subgenital plate extended at the end of paraproct ; supra anal plate
measures 2.8 mm. in length instar IV, male
- Posterior margin of subgenital plate extended beyond the paraprocts ; supra anal plate
measures 4.0 mm. in length instar V, male
6. Antennae not more than 3.4 mm. in length ; Wing pads downwardly vertically
directed ; trachiation hardly detectable7
- Antennae not more than 3.4 mm. in length ; Wing pads begin to projects obliquely
backwardes and forming definite lobe for future venation ; trachiation easily detectable
for future venation8
7. Antennae with 12 segments ; head measures 2.5 to 2.6 mm. in breadth
..... instar I, female
- Antennae with 14 segments ; head measures 4.0 to 4.15 mm. in breadth
..... instar II, female
8. Fore wing pad reaches one fourth length of the way along the length of costal margin
of hind wing pad instar III, female
- Fore wing pad reaches more than one third of way along the length of costal margin
of hind wing pad9
9. Posterior margin of pronotum transverse ; Anterior ovipositor valves reaches upto the
ninth sternum instar IV, female
- Posterior margin of pronotum acutely excurved ; Anterior ovipositor valves reaches
more than at the base of posterior ovipositor valves on ninth sternum 10
10. Hind wing pad reaches above the middle of abdominal tergite 1 ; posterior ovipositor
valves reaches above the end of paraproct instar V, female
- Hind wing pad reaches beyond the middle of abdominal tergite 2 ; posterior ovipositor
valves reaches beyond the paraproct instar VI, female

Egg Pod and Eggs (Fig. 24a)

The freshly laid egg pod of *Acrida exaltata* was almost straight, mostly uniform in size with lower part slightly thickened and measuring 6.8 (4 to 8.4) cm. in length.

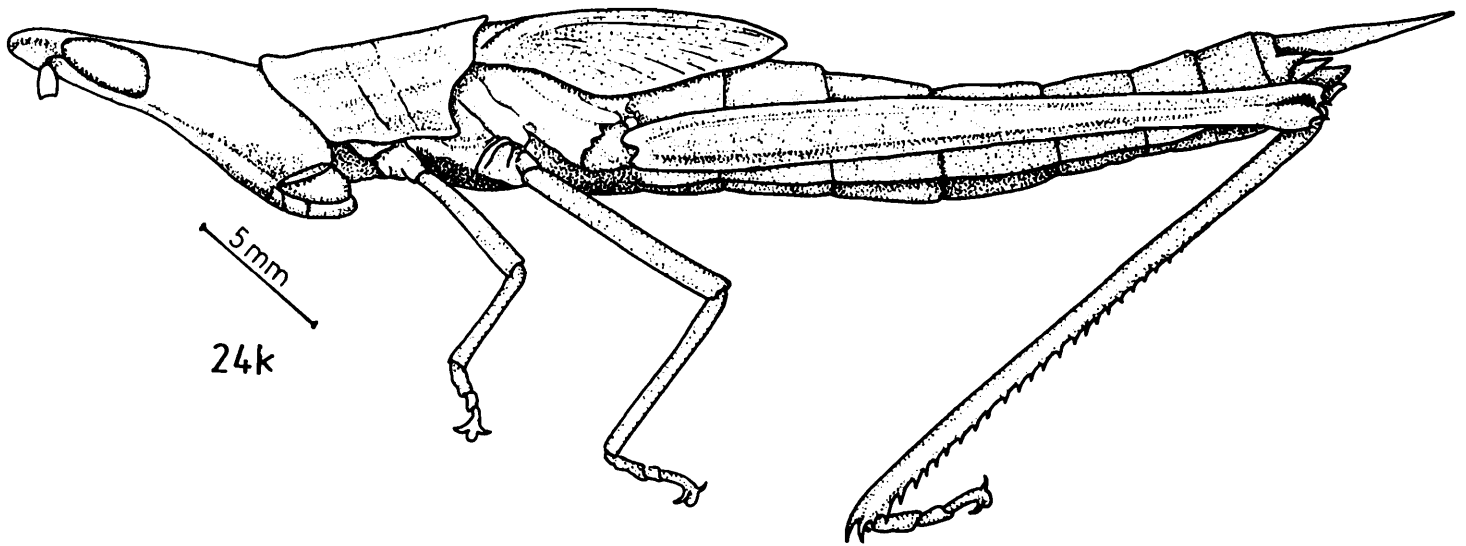
The freshly laid eggs of *Acrida exaltata* were whitish yellow in colour but they became deep brown in colour after about 5 to 7 hours of deposition. Eggs were elongated in shape, rounded at both ends slightly swollen in middle. The length varied from 5.9 to 6.2 (M6.15) mm. and the width being 1.5 mm. (Fig 24a).

Vermiform Larvae (Fig. 24b)

Colour : Always straw yellow to brown in colour, some times light brown spots were present on the body. Eyes brown to deep brown, tip of the posterior tibiae black. Body cylindrical, narrow laterally compressed soft and delicate in nature measuring 7.0 (6.8 to 7.1) mm. n = 20 in length. Head short, apex widely rounded bent downwards, ocelli not detectable. Antennae with 12 segments. Pronotum cylindrical its posterior margin deeply concaved or incurved legs with fore, middle and hind legs not well developed, external apical spine absent. External genitalia with cerci conical, apex sharply pointed, vertically downwardly directed which are parallel to the body. Supra-anal plate elongate and angular in position. Subgenital plate hardly detectable. Female with anterior and posterior ovipositor valves also hardly detectable.

First Instar (Fig. 24c)

Colour : General colour of the body always straw yellow brown, brown dots are present on the head and extends upto the end of pronotum laterally, a stripe of deep brown colour is extended from anterior of pronotum to last terga along the lateral carinae on each side, tip of the hind tibiae and tarsi black, abdomen whitish yellow. Body cylindrical, narrow, elongate and laterally compressed, tympanal depression absent measuring 7.6 (7.0 to 8.0) mm., n = T20, in length. Head with acutely conical, apex widely rounded, very elongate measuring 1.83 (1.8 to 1.88) mm., n = 25, in length and 2.54 (2.5 to 2.6) mm., n = 20, in breadth. Ocelli hardly detectable. Eyes : stripe single. Antennae ensiform as of adult shape, with 12 segments (Fig. 25a) flagellum of 7 annuli clearly segmented with indication of 3 more and measuring 2.2 mm. n = 20, in length. Prosternal tubercle absent. Pronotum subcylindrical, posterior margin deeply incurved or concave in shape, measuring 1.07 (1.1 to 1.2) mm. n = 20, in length along the median carina. Rudiments of wing pad hardly detectable, hind margin of mesonotum or fore wing pad and metanotum or hind wind pad vertically downwardly directed, trachiation not distinctly appeared and fore wing pads measuring 0.3 mm. n = 20, in length. Hind femur with

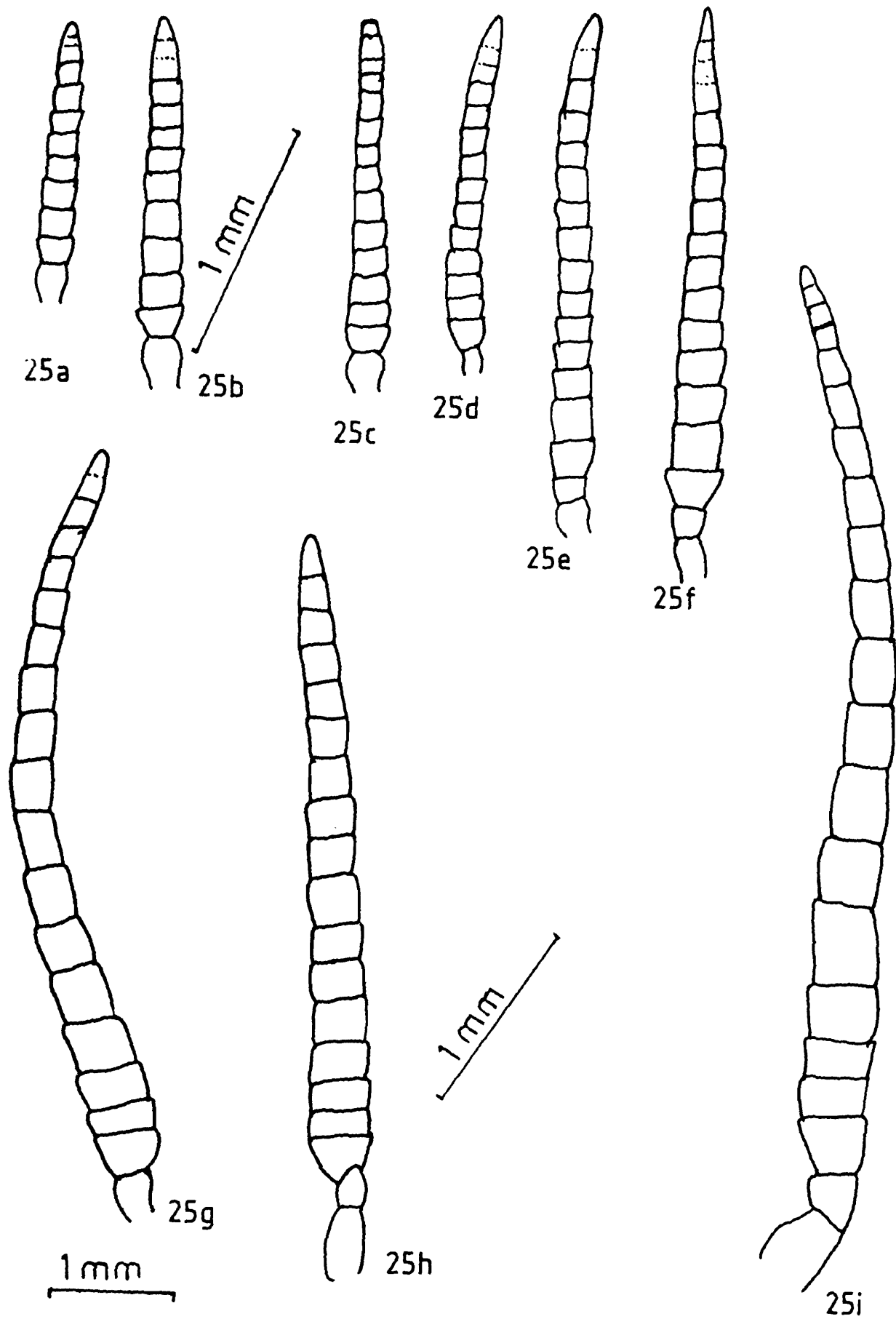


Figs. 24 k. *Acrida exaltata* — k, Sixth instar female.

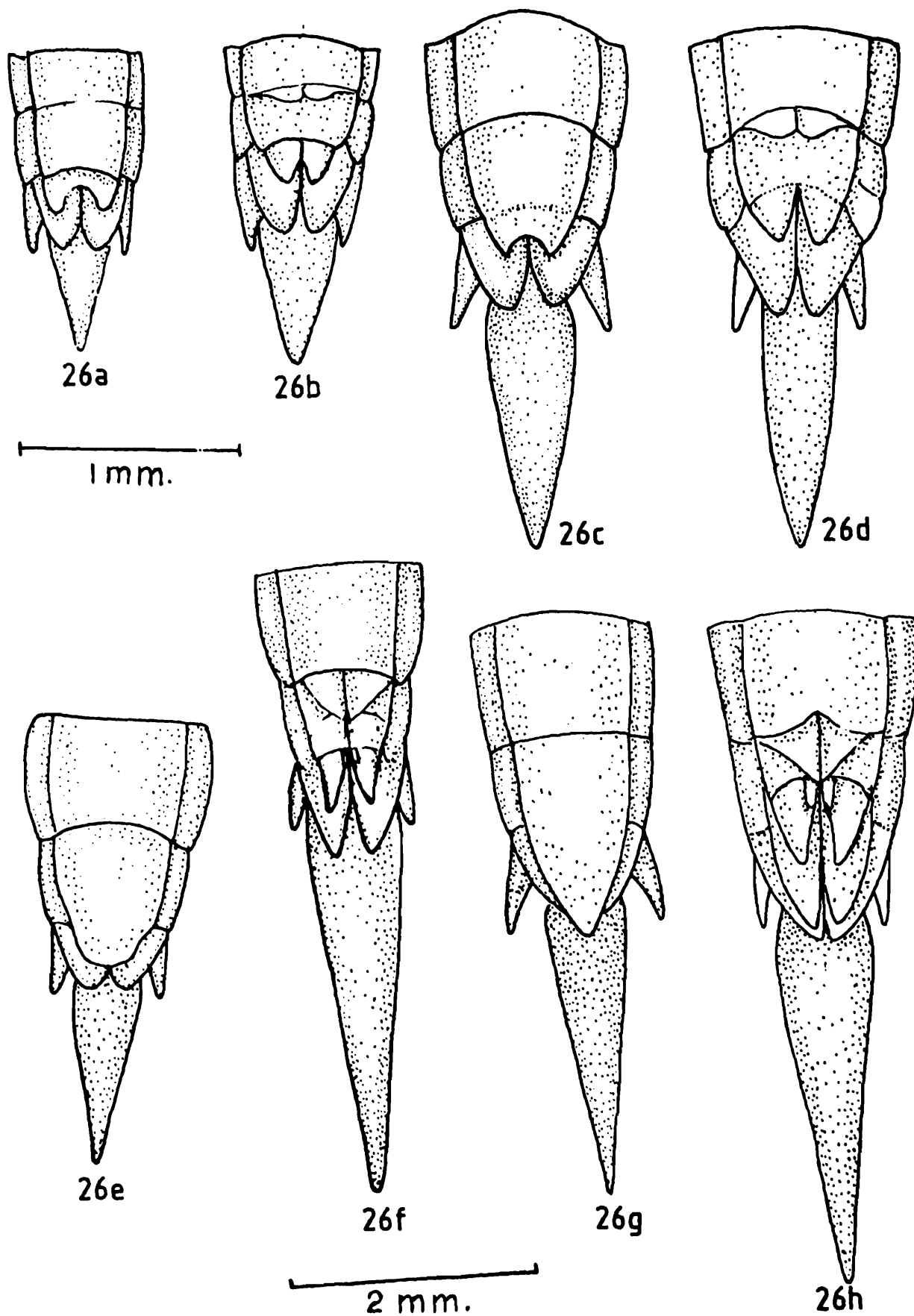
thin, very elongate, upper basal lobe longer than lower basal lobe measuring 3.58 (3.52 to 3.6) mm. $n = 20$, in length. External genitalia with cerci small, acutely conical at apex, remarkable change observed in supra-anal plate (in both the sexes). It is small, narrow, elongate and angular in all the nymphal instars and it increases in size in every instars, but during the adult it is reduced to normal short shape, like the generic character and measuring 0.6 to 0.64 mm. $n = 20$, in length, ninth abdominal sternum of male bears a plate like form known as subgenital plate which covered only the base of paraprocts with deep emarginate apex (Fig. 26a). Female with anterior or lower ovipositor valves short and denticular in projection and present on eighth sternum, posterior or upper ovipositor valves small, triangular and present on ninth abdominal sternum (Fig. 26b).

Second Instar (Fig. 24d)

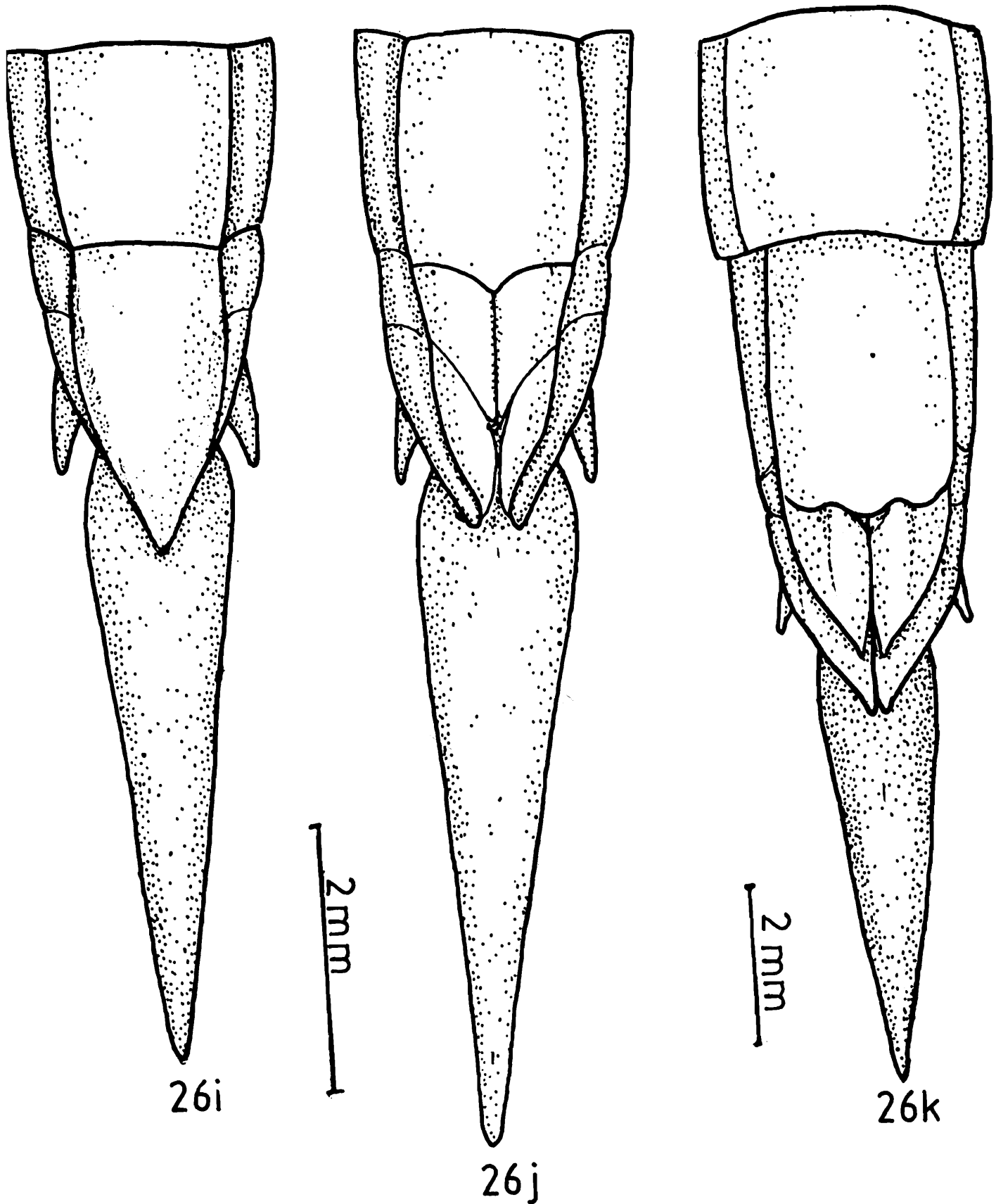
Colour Same as previous instars. **Body** Tympanal depression faintly appeared and measuring 11.8 (11.0 to 13.0) mm. $n = 20$, in length. **Head** measuring 3.04 (3.0 to 3.2) mm. in length and 4.1 (4.0 to 4.15) mm. $n = 20$, in breadth. Ocelli clearly detectable. Eye stripe 2 in number. **Antennae** with 13 to 14 segments flagellum of 9 annuli, clearly segmented with the indication of 3 more annuli measuring 3.3 (3.2 to 3.4) mm. $n = 20$, in length (Fig. 25b). **Pronotum** Shape same as previous instars, posterior margin less incurved measuring 14.9 (14.9 to 15.7) mm. $n = 20$, in length. **Wing pads** Rudiments of wing pads clearly visible and still it is vertically downwardly directed, steaky pattern of trachiation appeared and fore wing pad or mesonotum measuring 0.46 (0.4 to 0.5) mm. in length. Upper basal lobe of hind femur slightly



Figs. 25 a-i. *Acrida exaltata* (antennae) — a, first instar male ; b, second instar female ; c, third instar male ; d, third instar female ; e, fourth instar male ; f, fourth instar female ; g, fifth instar male ; h, fifth instar female ; i, sixth instar female.



Figs. 26 a-h. *Acrida exaltata* (external genitalia) — a, first instar male ; b, first instar female ; c, second instar male ; d, second instar female ; e, third instar male ; f, third female ; g, fourth instar male ; h, fourth instar female.



Figs. 26 i-k. *Acrida exaltata* (external genitalia) — i, fifth instar male ; j, fifth instar female ; k, sixth instar female.

longer than lower basal lobe measuring 5.98 (5.8 to 6.5) mm. n = 24, in length. External genitalia with supra-anal plate measuring 1.00 mm. n = 10, in length. Male with posterior margin of subgenital plate less emarginate at apex (Fig. 26c). Female ; Anterior ovipositor valves or lower valves slightly larger in size, posterior ovipositor valves also larger in size (Fig. 26d).

Third Instar (Fig. 24e-f)

Colour : From this instar the colour is changed from straw yellow to green. Body with tympanal depression clearly appeared from this instar. Male measuring 17.8 (17.2 to 19.5) mm. n = 20, in length. Female measuring 18.9 (17.3 to 21.0) mm. n = 20, in length. Head : Male measuring 3.5 (3.7 to 4.0) mm. n = 20, in length and 5.15 (5.1 to 5.25) mm. n = 20, in breadth. Female measuring 4.0 (3.9 to 4.3) mm. n = 20, in length and 5.4 (5.3 to 5.5) mm. n = 20, in breadth. Eyes : Stripe 3, antennae with 15 segments flagellum of 10 annuli clearly segmented measuring 1.7 (1.6 to 1.8) mm. n = 20, in length (Fig. 25c-d). Pronotum ; posterior margin of pronotum slightly incurved or transverse. Male measuring 2.02 (2.0 to 2.3) mm. n = 20, in length. Female measuring 2.13 (2.0 to 2.3) mm. n = 20, in length. Wing Pads : rudiments of wing pads more or less triangular in shape, posterior lateral angle directed obliquely backwards along the hind wing pad, trachiation distinctly appeared for future venation. Male : Fore wing pad of mesonotum extending at least one third length of way along the costal margin of hind wing pad and fore wing pad measuring 1.23 (1.2 to 1.3) mm. n = 20, in length. Female : Forewing pad or mesonotum extending at least one fourth length along the costal margin of hind wing pad or metanotum and fore wing pad measuring 1.02 (0.9 to 1.1) mm. n = 20, in length. Hind femur with upper and lower basal lobes equal. Male measuring 7.83 (7.5 to 8.1) mm. n = 20, in length, Female measuring 8.25 (8.0 to 8.4) mm. n = 20, in length. Hind tibiae of male measuring 7.83 (7.5 to 8.1) mm. n = 20, in length ; Female measuring 7.86 (7.7 to 8.2) mm. n = 20, in length. External genitalia with supra anal plate 2.0 mm. in length ; Subgenital plate in male narrowed posteriorly, posterior margin slightly incurved or transverse and reaching more than half of the paraprocts (Fig. 26e) Female with anterior or lower ovipositor valves triangular in shape, reaching just before the base of the posterior ovipositor valves, inner margin of posterior or upper valves from the base to the apex slowly bifurcated and reaching more than half of the paraporct, inner valves appeared (Fig. 26f).

Fourth Instar (Fig. 24g-h)

Colour : Green or starw according to the colour of the food. Body : Male measuring 24.3 (24.0 to 25) mm. n = 20, in length. Female measuring (24 to 26.0) mm. n = 20, in length. Head of male measuring 5.1 (4.9 to 5.3) mm. n = 20, in length and 6.65 (6.45 to 6.8) mm. n = 20, in

breadth, in female measuring 5.6 (5.5 to 5.8) mm. n = 20, in length and 7.2 (7.0 to 7.5) mm. n = 20, in breadth. Eye with 4 stripes. Antennae with 16 to 17 segments flagellum of 14 annuli clearly segmented and last 2 to 3 annuli are not clearly segmented measuring 4.15 (4.1 to 4.2) mm. n = 20, in length (in case of both the sexes, (Fig 25e-f). Pronotum with posterior margin of pronotum is clearly out curved or excurved in Male, measuring 3.15 (3.1 to 3.2) mm. in length, in female measuring 3.23 (3.2 to 3.3) mm. n = 20, in length. Wing pads : Wing pads in male have turned through 180° angle so that anterior margin directed upwards, so the surface is towards the body wall, fore wing pads covered by the hind wing pads, and hind wing pads reaching upto the middle of abdominal tergite 1 and 2 measuring 2.72 (2.7 to 2.8) mm. n = 20, in length. Female with fore wing pad directed obliquely backwards and reaching at least half of the way along the costal margin of hind wing pad measuring 1.78 (1.7 to 1.8) mm. n = 20, in length. Hind femur with lower basal lobe slightly longer than upper basal lobe. Male measuring 11.2 (11.0 to 11.5) mm. n = 20, in length. Female measuring 12.32 (12.0 to 12.5) mm. n = 20, in length. Hind tibiae of male measuring 10.2 (10.0 to 10.) mm. n = 20, 1 length ; Female measuring 11.32 (11.0 to 12.0) mm. n = 10, in length. Male with posterior margin of subgenital plate out curved or excurved, obtusely rounded at apex and extended upto the end of paraproct (Fig. 26g). In female the posterior margin of 8th sternum, with a notch in the middle, anterior ovipositor valves or lower valves reaching upto the base of posterior ovipositor valves or upper valves. Posterior or upper ovipositor valves reaching half way of the paraprocts, inner margin sharply divergent, inner valves still visible (Fig. 26h).

Fifth Instar (Fig. 24h, k)

Colour : Varies from green to straw yellow or greenish brown depending upon the substratum of the surroundings. ***Body*** : Male measuring 28.5 (27.5 to 29.5) mm. n = 20, in length. Female measuring 35.6 (34.0 to 37.0) mm. n = 20, in length. ***Head*** : Male measuring 6.1 (5.9 to 6.2) mm. n = 20, in length and 8.6 (8.4 to 8.7) mm. in breadth. Female measuring 7.28 (7.1 to 7.5) mm. n = 20, in length and 10.0 (9.5 to 11.0) mm. n = 20, in breadth. ***Eye*** : Stripes 5 in number. Antennae with 18 to 19 segments (Figs. 25g-h) flagllum of 16 to 17 annuli clearly segmented with the indication of 1 to 2 more annuli anteriorly. In male measuring 9.60 (9.5 to 9.7) mm. n = 20, in length. In female measures 9.24 (9.2 to 9.4) mm. n = 20, in length. Pronotum posterior margin of pronotum out curved or excurved, a small triangle is formed mdially which is obtusely rounded at apex. Male measuring 4.2 (4.0 to 4.3) mm. n = 20, in length. Female measuring 5.22 (5.0 to 5.6) mm. n = 20, in length. Wing pads of male larger in size, trachiation more distinct, hind wing pad reaching middle of the second tergite between 2 & 3 measuring 6.45 (6.2 to 6.7) mm. n = 20, in length. In female the fore wing pad and have turned through 180 so that the anterior margins are directed upwards and former outer surfaces towards the body wall, hind wing pads reaching just above the abdominal tergite 1, measuring 4.22 (4.1 to 4.3)

mm. n = 20, in length. Hind femur with lower basal lobe more longer than the upper basal lobe. In male, measuring 14.8 (14.5 to 15) mm. n = 20, in length, white in female measuring 15.7 (15 to 16) mm. n = 20, in length. Hind tibiae, in male measuring 13.6 (13 to 14) mm. n = 20, in length while in female measuring 15.0 (14.5 to 16) mm. n = 20, in length. *External genitalia* supra anal plate measuring 4.0 mm. in length. Male : Posterior margin of subgenital plate reaching one third length of beyond the paraprocts from above (Fig. 26i). Female : Posterior margin of 8th sternum in the middle with a denticular projection, anterior or lower ovipositor valves triangular in shape with the indication of sclerotised tip and reaching up to the half way of the posterior ovipositor valves, posterior or upper ovipositor valves touching their inner side and reaching just above the paraproct ; inner valves overlapped (Fig. 26j).

Sixth Instar (Fig. 24i)

Colour : Same as previous instar. Body measuring 48.3 (45.5 to 50.0) mm. n = 20, in length. Head measuring 9.7 (9.2 to 10.2) mm. n = 20, in length and 14.37 (14.0 to 15) mm. n = 20, in breadth. Eyes with 6 stripes. Antennae with 20 to 21 segments (Fig. 25i) measuring 13.75 (13.0 to 14.5) mm. n = 20, in length. Pronotum with posterior margin more acutely out curved or excurved, medially measuring 8.75 (8.0 to 9.2) mm. n = 10, in length. Hind wing pads are clearly triangular in shape, trachiation more distinct, reaching beyond the middle of second tergite measuring 10.77 (10.6 to 11.5) mm. n = 20, in length. Hind femur measuring 24.0 (22.0 to 25.0) mm. n = 20, in length. Hind tibiae measuring 22.16 (19.5 to 24.0) mm. n = 20, in length. *External genitalia*, posterior margin of 8th sternite with a distinct denticular projection between the anterior or lower ovipositor valves, middle of anterior ovipositor valves elevated, the tip highly sclerotised, projecting upwards and reaching upto the three fourth of the posterior of upper ovipositor valves, posterior ovipositor valves reaching beyond the paraprocts and more robust in shape and the tip of the valves highly sclerotised (Fig. 26 k).

3. *Phlaeoba infumata* (Brunner)

Key to the identifications of different nymphal instars

(Male and female)

1. Anterior ovipositor valves absent on eighth abdominal sternite ; subgenital plate present on ninth abdominal sternite Males (2)
- Anterior ovipositor valves present on eighth abdominal sternite ; subgenital plate present on eighth abdominal sternite Females (6)

2. Upper and lower basal lobe length of hind femur equal or lower basal lobe slightly longer than upper basal lobe ; length of the subgenital plate shorter than breadth....3
 - Upper basal lobe distinctly longer than lower basal lobe ; length of subgenital plate equal or longer 4
3. Head width 2.4 to 2.5 mm. in length ; subgenital plate covers only base of the paraprocts and tip or subgenital plate deeply emarginate instar I, male
 - Head width 3.1 mm. in length ; subgenital plate covers half of the paraprocts and tip less emarginate instar II, male
4. Wing pads more or less triangular in shape ; apex of subgenital plate transverse not elevated in the middle and covers three fourth of the paraprocts instar III, male
 - Wing pads clearly triangular in shape ; apex of subgenital plate acutely conical, elongated, elevated in the middle and extended beyond the paraprocts..... 5
5. Hind wing pads reaching just above the hind margin of first tergite ; posterior margin of pronotum transverse instar IV male
 - Hind wing pads reaching before the posterior margin of 3rd tergite ; posterior margin of pronotum out curved..... instar V male
6. Wing rudiments downwardly directed and blunt 7
 - Wing rudiments obliquely backwardly directed and less blunt 8
7. Antennae 12 segmented ; anterior ovipositor valves small, truncate and not clearly developed ; posterior ovipositor valves small and more or less elongated instar I, female
 - antennae more than 10 segment anterior ovipositor valves more clearly developed posterior ovipositor valves more elongated instar II, female
8. Antennae with 14 to 15 segments ; anterior ovipositor valves touching the ninth sternite groove and apex more or less attenuated but not sclerotised ; posterior valves covers half of the paraprocts instar III, female
 - Antennae with more than 16 segments ; anterior ovipositor valves extending beyond the base of the posterior ovipositor valves, apex more attenuated and sclerotised ; posterior ovipositor valves reaching more than half of the paraprocts 9

9. Posterior margin of subgenital plate not indented medially ; inner line of posterior ovipositor valves not touching along each other posteriorly instar IV, female
- Posterior margin of subgenital plate indented medially ; inner line of posterior ovipositor valves touching along their inner margin 10
10. Antennae 19 segmented ; tip of the anterior valves covered half of the posterior ovipositor valves ; posterior ovipositor valves extended upto the end of the paraprocts instar V, female
- Antennae 20 segmented ; tip of the anterior ovipositor valves extended three fourth of the posterior ovipositor valves ; both anterior and posterior ovipositor covered the paraprocts instar VI, female

Egg Pod and Eggs

A freshly laid egg pod of *Phlaeoba infumata* was almost uniformly cylindrical and slightly curved in the middle. The posterior end rounded and concave and the upper end flat or slightly convex. Egg pod measuring 2.3 to 5.2 cm. in length (M 3.9 cm.).

A freshly laid egg of *Phlaeoba infumata* was bright yellow in colour, it was cylindrical, blunt at both ends and have a curvature in the middle. The eggs were arranged obliquely in the egg pod one after another. Each egg measures 4.6 to 4.9 mm. in length (M 4.75 mm.) and width being 1.55 mm. (Fig. 27a).

Vermiform Larvae (Fig. 27b)

Colour : General body straw or pale yellow to brown in colour, a brownish white streak with deep brown spot extended from vertex to last abdominal tergite along the mid dorsal region, on the lateral side of head and pronotum to end of abdomen a greyish brown colour streak was present on both sides. Eyes deep brown to black, tip of the posterior tibiae black.

Body almost cylindrical, compressed laterally, tympanal depression not developed, measuring 6.4 (6.1 to 6.5) mm. n = 20, in length. Head subglobular, obtusely bent downward with rounded apex, fastigium of vertex short. Antennae with 10 segments, flagellum lying close to the body. Pronotum cylindrical, its posterior margin deeply incurved or concave. Legs with fore, mid and hind legs also lying close to the body, basal lobe of hind femur not clearly developed.

External genitalia : (The whole complex of the terminal structures of the abdomen were referred to as the external genitalia (Dirsh, 1968) which are directly responsible for the copulation and reproduction. For closing the anal opening following parts are also present such as supra anal plate, the paired paraproct) Cerci small, apex sharply pointed and directed vertically downwards and parallel to the abdomen. Subgenital plate of male was present in the 9th sternum, Female of anterior ovipositor valves or lower valves were present on 8th sternum which was hardly detectable, in the 9th sternum posterior or upper ovipositor valves were present.

First Instar (Fig. 27c)

Colour : Fresh hopper whitish yellow in colour but within 2 hours original straw or brown colour with deep spot appeared. Eyes brown to black with smoky tinge and yellowish border around. Clypeus and labrum deep brown. Abdomen whitish yellow. Body cylindrical, compressed laterally, tympanal depression not clearly developed measuring 6.24 (6.0 to 6.5) mm. n = 20, in length. Head relatively robust in comparison to the posterior part of the body measuring 1.55 (1.5 to 1.6) mm. n = 20, in length 2.45 (2.4 to 2.5) mm. n = 20, in breadth. Ocelli detectable. Antennae ensiform with 12 segments (Fig. 28a). Flagellum of 8 annuli with indication of 2 more annuli measuring 2.48 (2.3 to 2.7) mm. n = 20, in length. Pronotum cylindrical, posterior margin deeply or concave measuring 1.06 (1.0 to 1.2) mm, n = 20 in length, along the median carina. Wing pads rudiments of hind margin of mesonotum or fore wing pads and meta notum or hind wing pads directed vertically downward, blunt rounded at apex, without clear indication of trachiation, slightly differentiated from terga and fore wing pads measuring 1.92 (1.8 to 2.0) mm. n = 20, in length. Hind femur of lower basal lobe longer than upper one measuring 3.19 (3.0 to 3.3) mm. n = 20, in length. Hind tibiae measuring 3.1 (3.0 to 3.2) mm. n = 20, in length.

External genitalia : Sub genital plate of male with small deeply emerginate at apex, length shorter than breadth and covering only base of the paraprocts (Fig. 29a). Female with sternum 8th of the abdomen bearing pair of small and truncate valves which later developed into anterior or lower ovipositor valves, sternum 9th of abdomen bearing another pair of small triangular valves which later developed into posterior or upper ovipositor valves (Fig. 29b).

Second Instar (Fig. 27d)

Colour : General body colour same as first instar, eyes brown to black with smoky tinge. Body cylindrical, laterally compressed, tympanal depression faintly appeared measuring (8.4 to 9.4) mm. n = 20, in length. Head less robust in comparison to the posterior part of the body measuring 2.05 (1.9 to 2.2) mm. n = 20, in length and 2.46 (2.4 to 2.55) mm. n = 20, in breadth.

Ocelli clearly detectable from this instar. Antennae with 13 to 14 segments, flagellum of 10 annuli with the indication of 2 more annuli measuring 3.18 (3.10 to 3.2) mm. $n = 20$, in length (Fig. 28b). Pronotum shape same as 1st instar, posterior margin less incurved or concave measuring 1.57 (1.5 to 1.67) mm. $n = 20$, in length. Wing Pads : Rudiments of wing pads more clearly visible, presence of steaky pattern of trachiation which indicates the future venation, hind margin of mesonotum or forewing pads or metanotum or hind wing pads same as 1st instar and fore wing pads measuring 0.26 (0.25 to 0.27) mm. in length, $n = 20$, in length. Hind femur of lower basal lobe slightly longer than upper basal lobe measuring 4.05 (4.0 to 4.1) mm. $n = 20$, in length. Hind tibiae measuring 3.95 (3.8 to 4.0) mm. $n = 20$, in length.

External genitalia : Subgenital plate of male narrowed with less emerginate at apex, length shorter than breadth and covered half of the paraprocts (Fig. 29c). Anterior ovipositor valves or lower valves of female clearly developed ; posterior ovipositor valves or upper valves angular and elongated in shape, inner margin deeply separated (Fig. 29d).

Third Instar (Fig.27e-f)

Colour : General body colour more or less like second instar except the colour became more bright. Eyes were deep brown to black with more smoky tinge at the anterior margin, a light brown stripe extending behind the eye to 5th terga along the lateral carinae on both the sides. Body with tympanal depression clearly developed measuring 11.7 (11.0 to 12.3) mm. $n = 20$, in length. Head now proportioned to the abdomen measuring 2.46 (2.4 to 2.6) mm. $n = 20$, in length and 3.7 (3.6 to 3.8) mm. $n = 20$, in breadth. Antennae with number of segments 16, also occasionally 15 at the right and 16 at left and vice versa, flagellum of 12 annuli with the indication of 1 or 2 more deep brown to black annuli measuring 2.1 (2.0 to 2.2) mm. $n = 10$, in length (Fig. 28c-d). Pronotum with posterior margin slightly concave or incurved measuring 2.1 (2.0 to 2.2) mm. $n = 20$, in length. Wing pads with less blunt, lower posterior angles of mesonotum or fore wing pad or metanotum or hind wing pads begin to project and more or less triangular in shape, which form the definite lobe for future tegmina and wings, trachiation more distinct in both the sexes. Fore wing pads of male reaching at least one third length along the costal border of hind wing pad measuring 0.67 (0.65 to 0.7) mm. $n = 20$, in length ; Fore wing pads of female extended at least one fourth of length along the costal margin of hind wing pads measuring 0.45 mm. $n = 20$, in length. Hind tibiae measuring 5.52 (5.4 to 5.9) mm. $n = 20$, in length.

External genitalia : Apex of subgenital plate of male transverse or slightly incurved, length and breadth equal and the tip extending three fourth length of paraprocts (Fig. 29e). Anterior

or lower ovipositor valves of female touching the posterior margin of ninth sternum groove, posterior ovipositor valves or upper valves covering almost half of the paraprocts, inner margin of posterior valves slow separated or divergent from each other, inner valves also developed in between the posterior ovipositor valves (Fig. 29f).

Fourth Instar (Fig. 27g, h)

Colour : General body colour straw yellow to deep brown, numerous deep brown dots scattered all over the body and legs, eyes deep brown to black. Body in male measuring 14.8 (14.0 to 15.0) mm. n = 20, in length ; In male measuring 2.86 (2.8 to 2.9) mm. n = 20, in length and 4.6 (4.5 to 4.8) mm. n = 20, in breadth ; In female measuring 2.92 (2.8 to 3.0) mm. n = 20, in length and 4.6 (4.5 to 4.7) mm. n = 20, in breadth. Antennae with number of segments 18 and flagellum of 15 annuli with the indication 1 more deep brown annuli measuring 4.68 (4.5 to 4.8) mm. n = 20, in length (Fig. 28e-h).

Pronotum : With posterior margin transverse, in male measuring 2.83 (2.8 to 2.9) mm. n = 20, in length ; Female measuring 2.9 (2.8 to 3.0) mm. n = 20, in length.

Wing pads : Wing pads of male reversed in direction and shifted on its back and pointing upwards, turned rounded on their axis so outer surface become the inner and developed numerous unbranched parallel veins, fore wing pad concealed by the hind wing pads, tip of the hind wing pads not touching the margin of first abdominal tergite measuring 2.82 mm. n = 20, in length (Fig. 137). Female with lower posterior angle of fore and hind wing pads or meso and metanotum form the definite lobe for future tegmina and wings, trachiation more distinct, fore wing pads backwardly directed about one third of way along the costal margin of hind wing pads measuring 0.68 (0.65 to 0.7) mm. n = 20, in length (Fig. 138). Hind femur measuring 8.33 (8.1 to 85.) mm. n = 20, in length. Hind tibiae measuring 7.34 (6.8 to 7.8) mm. n = 20, in length.

External genitalia : Apex of subgenital plate of male acutely conical, tip of the subgenital extending beyond the paraprocts (Fig. 29). Anterior ovipositor or lower valves of female smooth, angular with little sclerotised tip and crossed the base of the posterior ovipositor valves and it covered more than half of the paraprocts, inner margin not touching along each other, inner valves partly visible (Fig. 29h).

Fifth Instar (Fig. 27i-j)

Colour : No remarkable changes in colour pattern than the previous instars.

Body : Measuring 19.87 (18.0 to 20.5) mm. n = 20, in length. Female measuring 19.26 (17.0 to 21.0) mm. n = 20, in length. Head measuring 3.35 (3.2 to 3.5) mm. n = 20, in length and 5.41 (5.2 to 5.8) mm. n = 20, in breadth. Antennae with number of segments 20, occasionally 21 in male, flagellum comprises clear 16-17 annuli with the indication of 2 more dark brown annuli measuring 6.52 (6.0 to 7.2) mm. n = 20, in length (Fig. 28g-h). Pronotum with posterior margin of pronotum outcurved or convex in shape measuring 3.65 (3.4 to 3.9) mm. n = 20, in length.

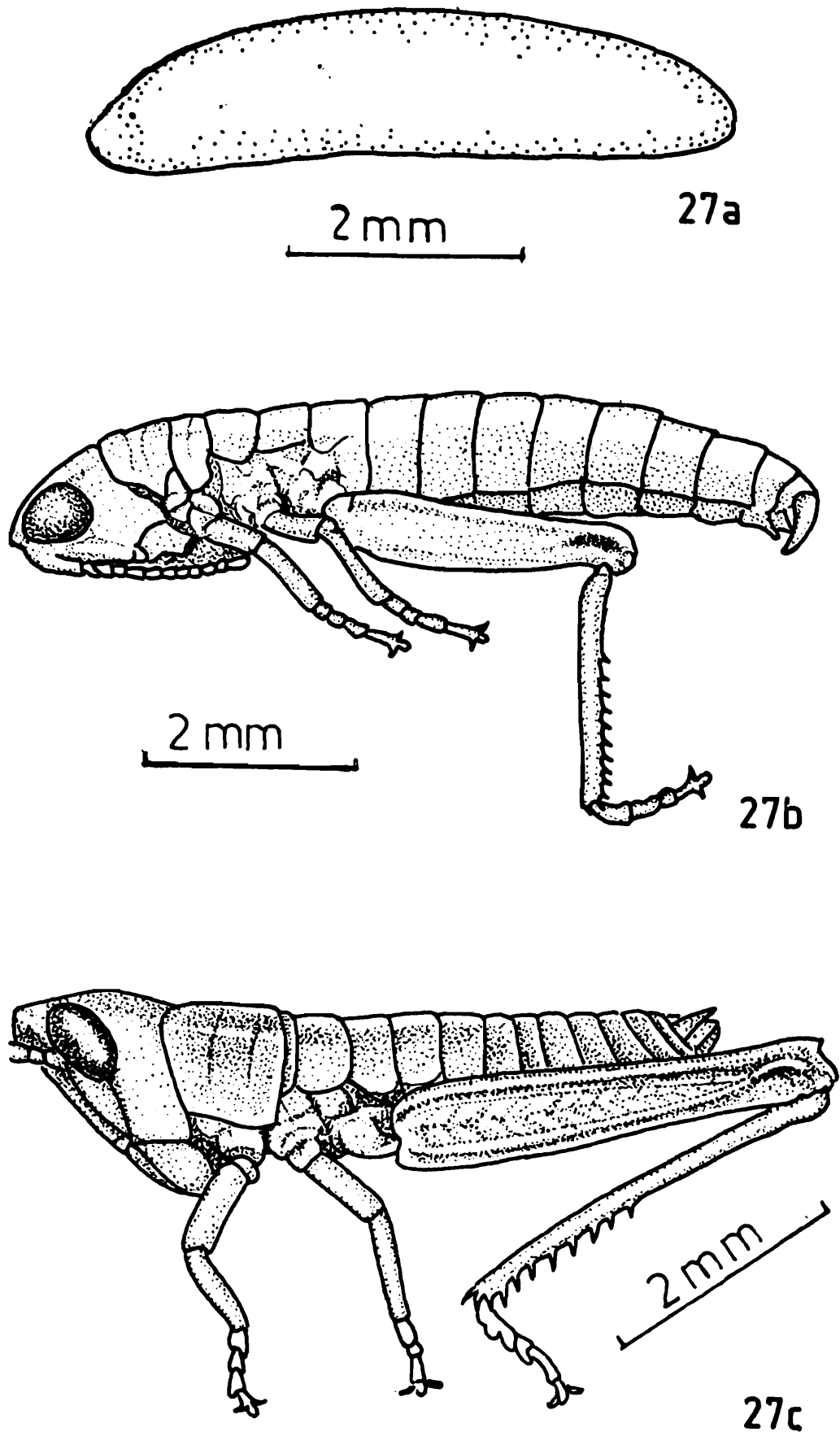
Wing pads : Wing pads of male more clearly developed and forming the triangular in shape and remain pointing upwards, hind pads not touching the abdominal tergite 3, parallel trachiation more distinct measuring 5.8 (5.3 to 6.2) mm. n = 20, in length. Female wing pads reversal similar to the respective fourth instar of male hopper, hind wing pads extend just above the 1st abdominal tergite measuring 2.9 (2.7 to 3.1) mm. n=20, in length.

Hind femur with upper basal lobe longer than lower basal lobe measuring 11.15 (10.5 to 12) mm. n = 20, in length and 2.36 (2.1 to 2.2) mm. n=20, in breadth. Hind tibiae measuring 9.34 (9.0 to 9.5) mm. n=20, in length.

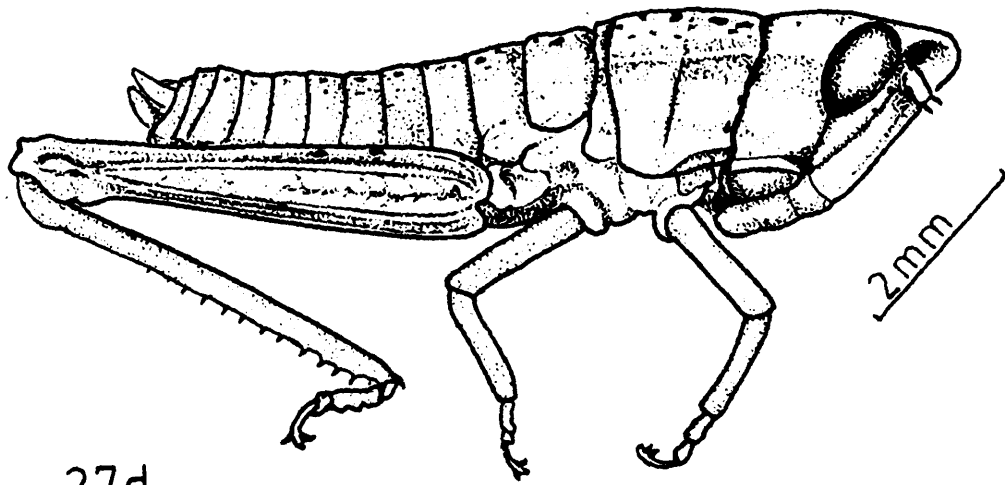
External genitalia : Apex of subgenital plate of male more acutely conical, tip of the subgenital plate extending more beyond the paraprocts, middle of the subgenital plate elevated (Fig. 29i) Female with triangular projection appeared in between the base of the anterior or lower ovipositor valves and the shape angular, more or less robust, the tip more sclerotised and covering more than half of the paraprocts, posterior or upper ovipositor valves extending at the end of paraprocts and not touching upper ovipositor valves extending at the end of paraprocts and not touching along their inner side at the extrimity, inner valves overlapped (Fig. 29j).

Sixth Instar : (Fig. 27k)

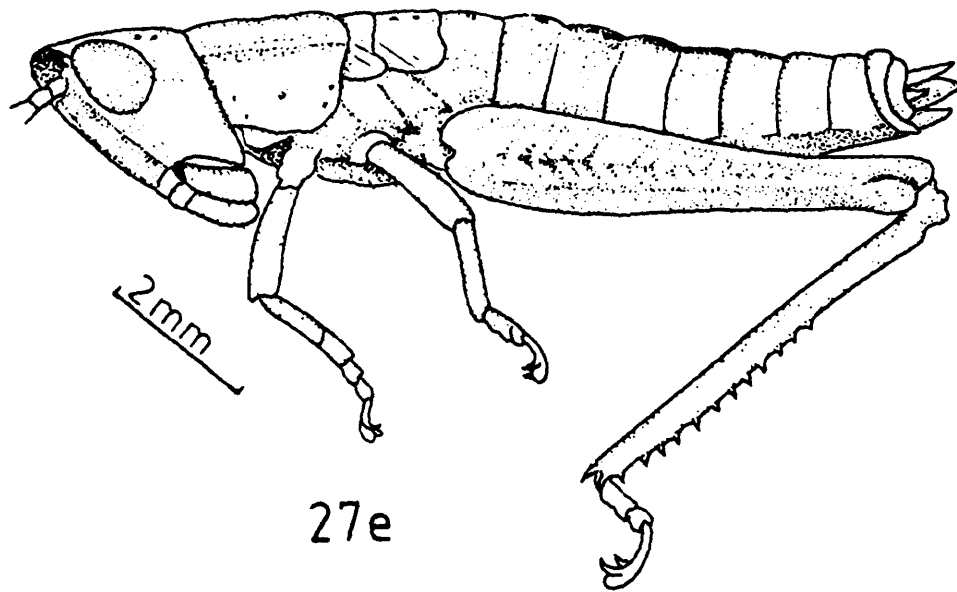
Colour : General body colour of fresh hopper straw yellow, wing pads light green just after moulting but after half an hour the colour of the wing pads were brown. Body measuring 23.1 (22.0 to 24) mm. n = 20, in length. Head measuring 3.95 (3.9 to 4.7) mm. n = 20, in length and 6.3 (6.0 to 6.6) mm. n = 20, in breadth. Antennae with 22 segments flagellum of 19 annuli with the indication of 1 more annuli measuring 7.55 (7.3 to 8.0) mm. n = 20, in breadth. Antennae with 22 segments flagellum of 19 annuli with the indication of 1 more annuli measuring 7.55 (7.3 to 8.0) mm. n = 20, in length (Fig. 28i). Pronotum with posterior margin measuring 6.14 (6.1 to 6.2) mm. n = 20, in length. Wing pads more extended, hind wing pad touching the posterior margin of tergite 3 measuring 6.3 (6.2 to 6.5) mm. n = 20, in length. Hind femur measuring 13.34 (13.0 to 14) mm. n = 20, in length. Hind tibiae measuring 11.5 (10.8 to 12.3) mm. n = 20, in length. **External genitalia** of female triangular projection on 8th sternum indented more prominent in between the anterior ovipositor valves, anterior ovipositor valves more robust, angular, tip strongly sclerotised and extending three fourth length of posterior ovipositor valves and it extended beyond the paraproct (Fig. 19k.)



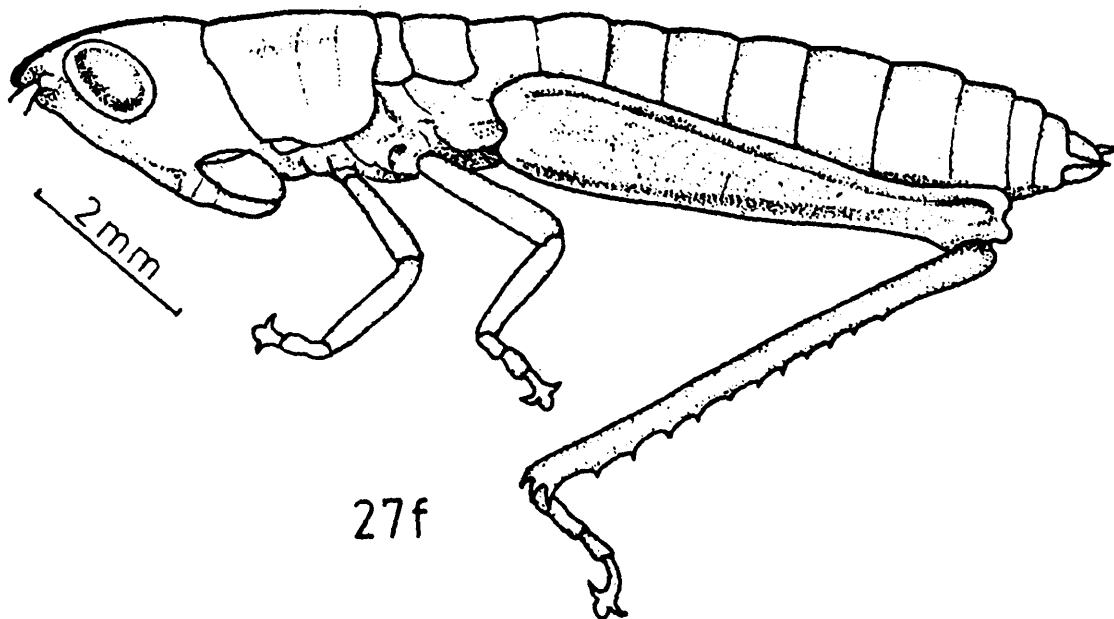
Figs. 27 a-c. *Phlaeoba infumata* — a, egg ; b, vermiform larva ; c, first instar male.



27d

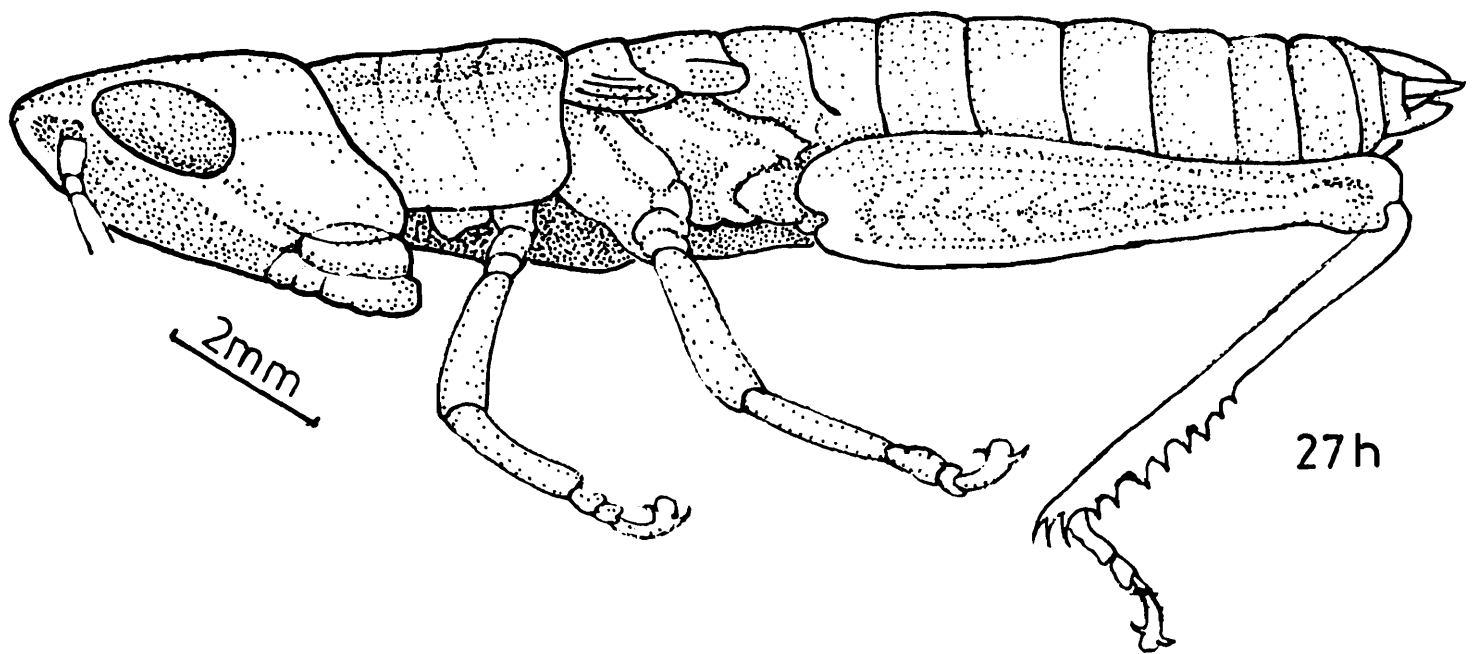
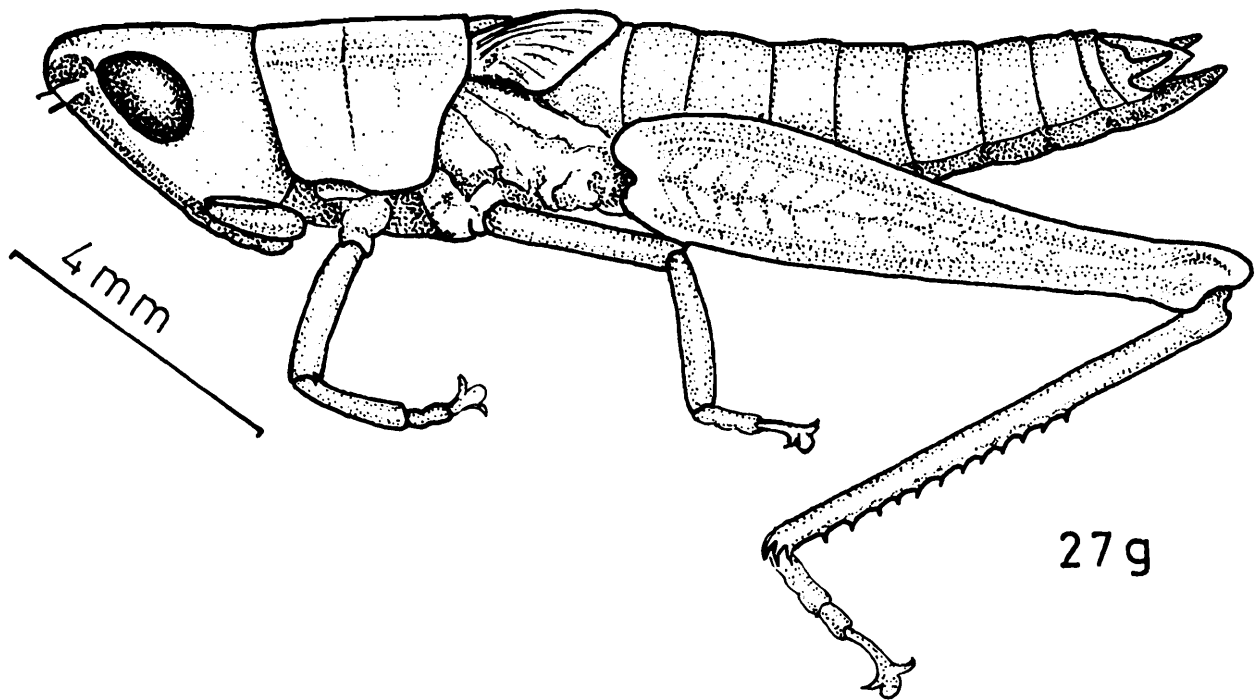


27e

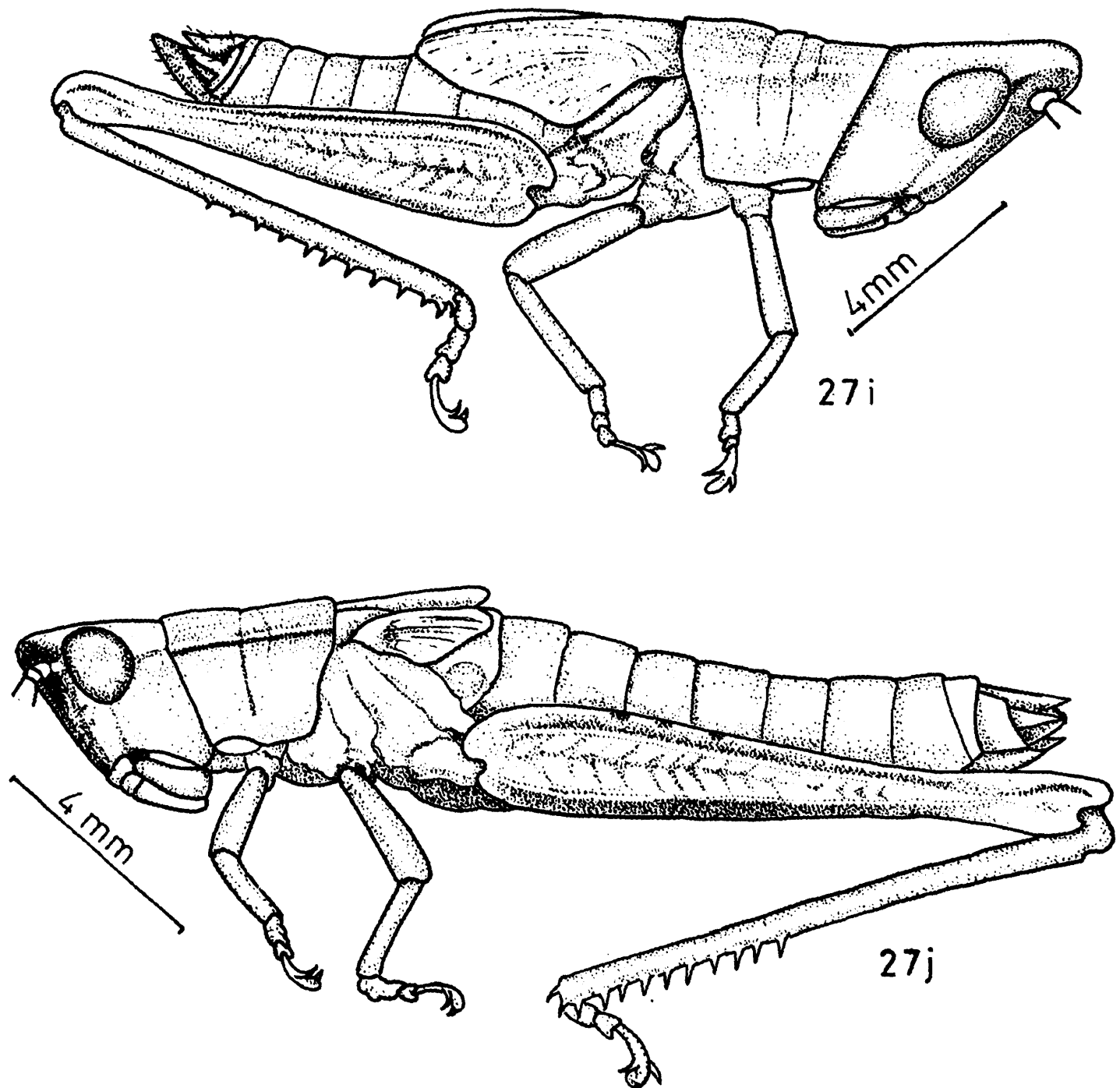


27f

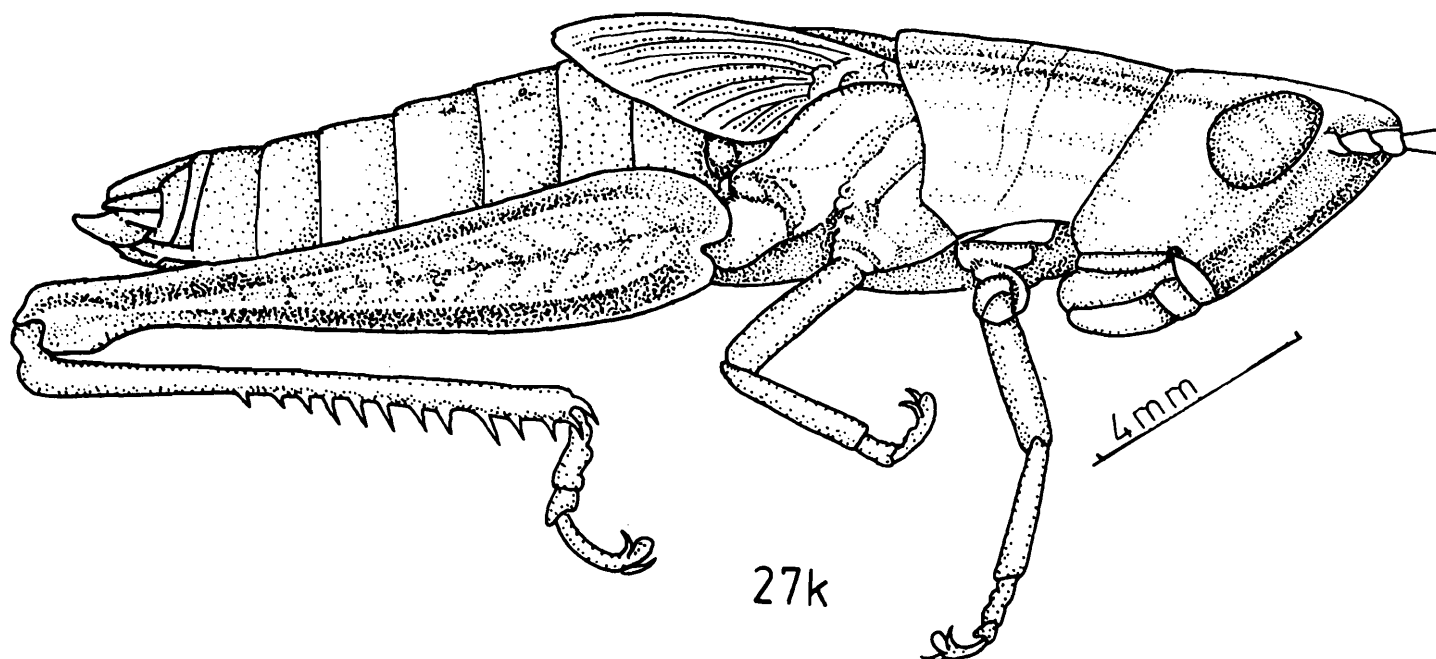
Figs. 27 d-f. *Phlaeoba infumata* — d, second instar female ; e, third instar male ; f, third instar female.



Figs. 27 g-h. *Phlaeoba infumata* — g, fourth instar male ; h, fourth instar female.



Figs. 27 i-j. *Phlaeoba infumata* --- i, fifth instar male ; fifth instar female.

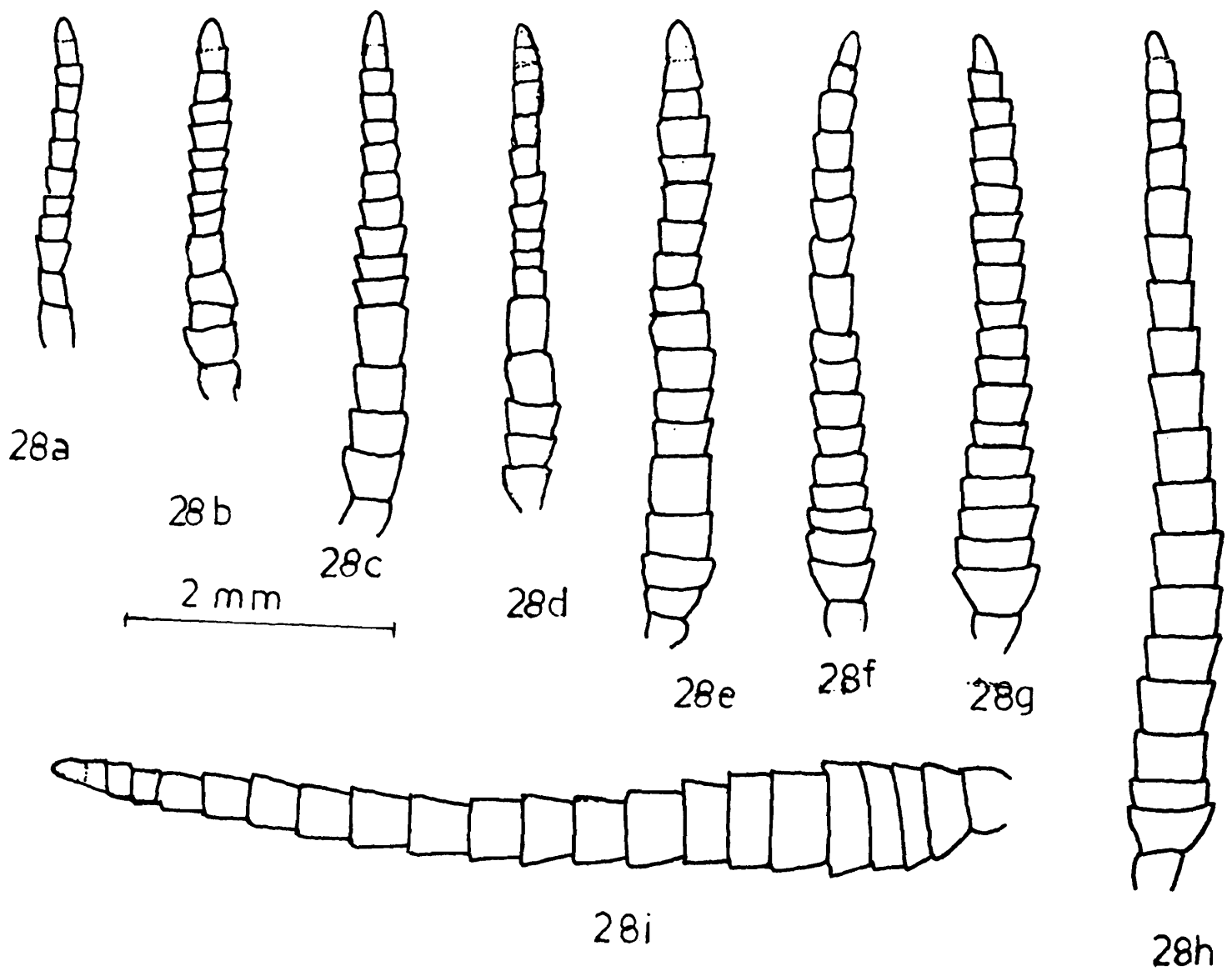


Figs. 27 k. *Phlaeoba infumata* — k, sixth instar female.

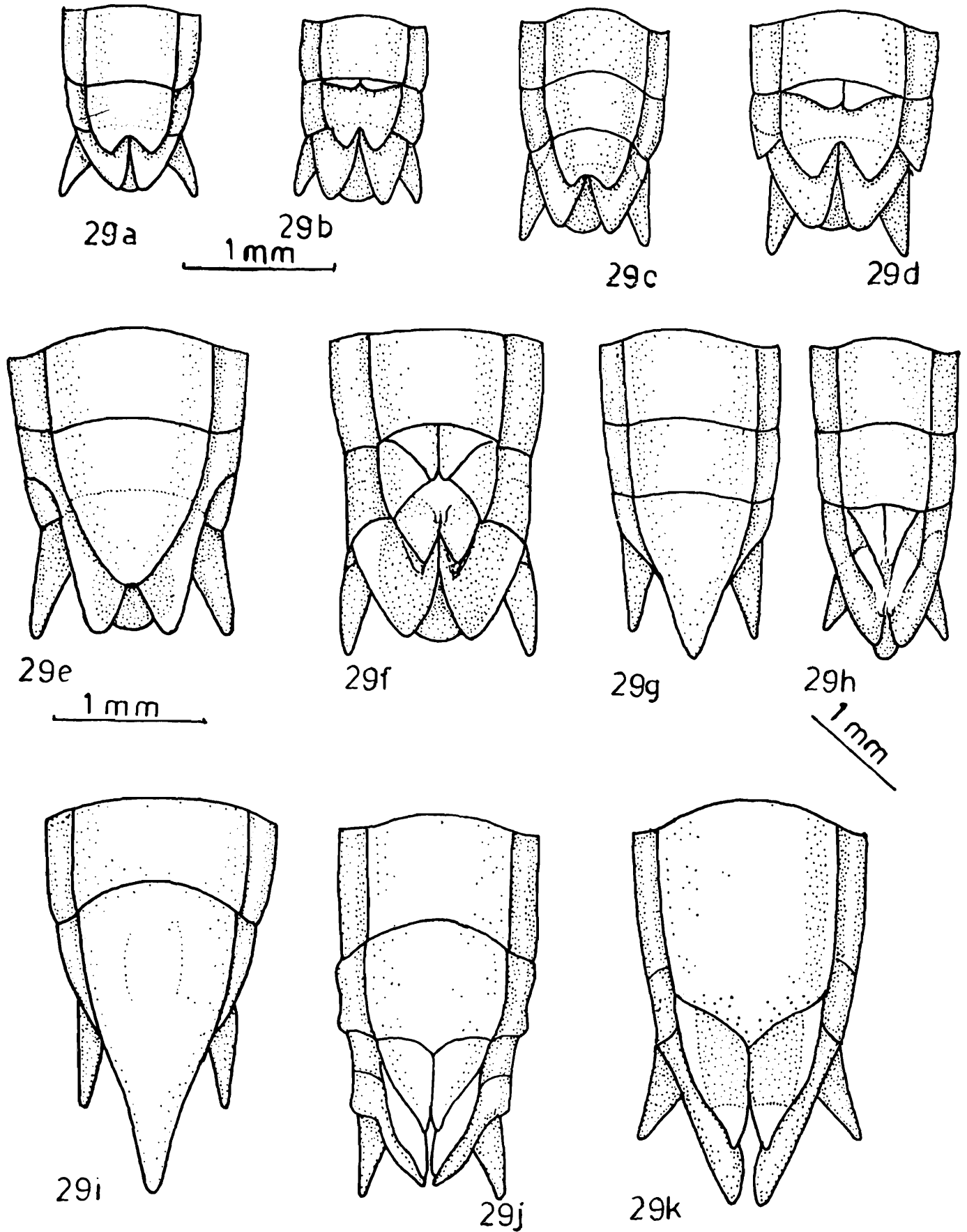
4. *Aiolopus thalassinus tamulus* (Fabricius)

Key to the identifications of different nymphal instars
(Male and female)

- 1. Subgenital plate present on ninth sternite Male (2)
- Subgenital plate absent on ninth sternite..... Female (6)
- 2. Wing rudiments absent or hardly detectable..... 3
- Wing rudiments distinctly detectable 4
- 3. Antennae 12 segmented, femur length 2.5 to 2.6 mm..... instar I, male
- Antennae 14 segmented, femur length 3 to 3.2 mm..... instar II, male
- 4. Wing rudiments present on the side of the body , subgenital plate reaching upto the half of the paraprocts instar III, male
- Wing rudiments present on the dorsum , subgenital plate reaching more than half of the paraprocts 5



Figs. 28 a-i. *Phlaeoba infumata* (Antennae) — a, first instar male ; b, second instar female ; c, third instar male ; d, third instar female ; e, fourth instar male ; f, fourth instar female ; g, fifth instar male ; h, fifth instar female ; i, sixth instar female.

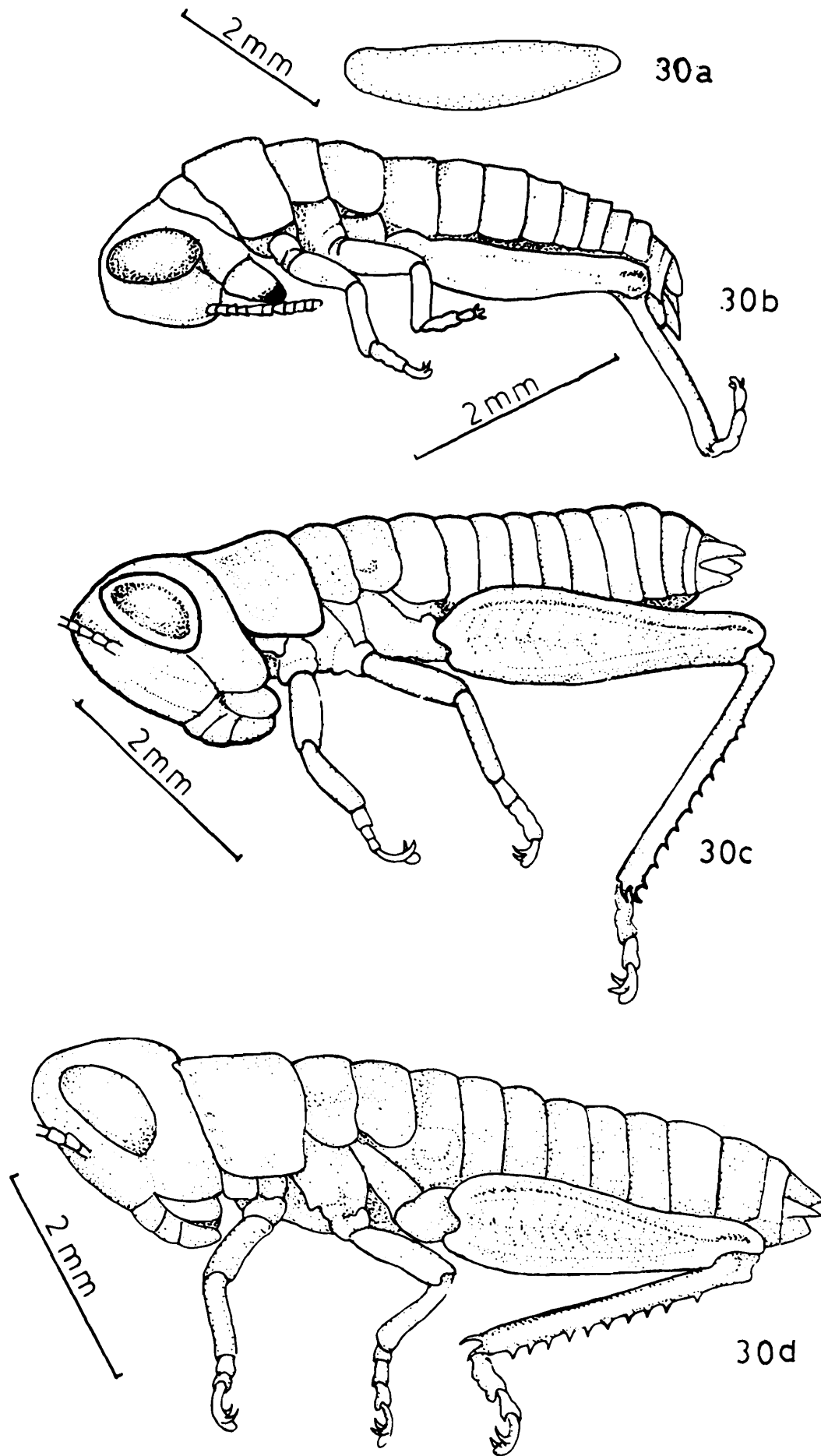


Figs. 29 a-k. *Phlaeoba infumata* (external genitalia) — a, first instar male ; b, first instar female ; c, second instar male ; d, second instar female ; e, third instar male ; f, third instar female ; g, fourth instar male ; h, fourth instar female ; i, fifth instar male ; j, fifth instar female ; k, sixth instar female.

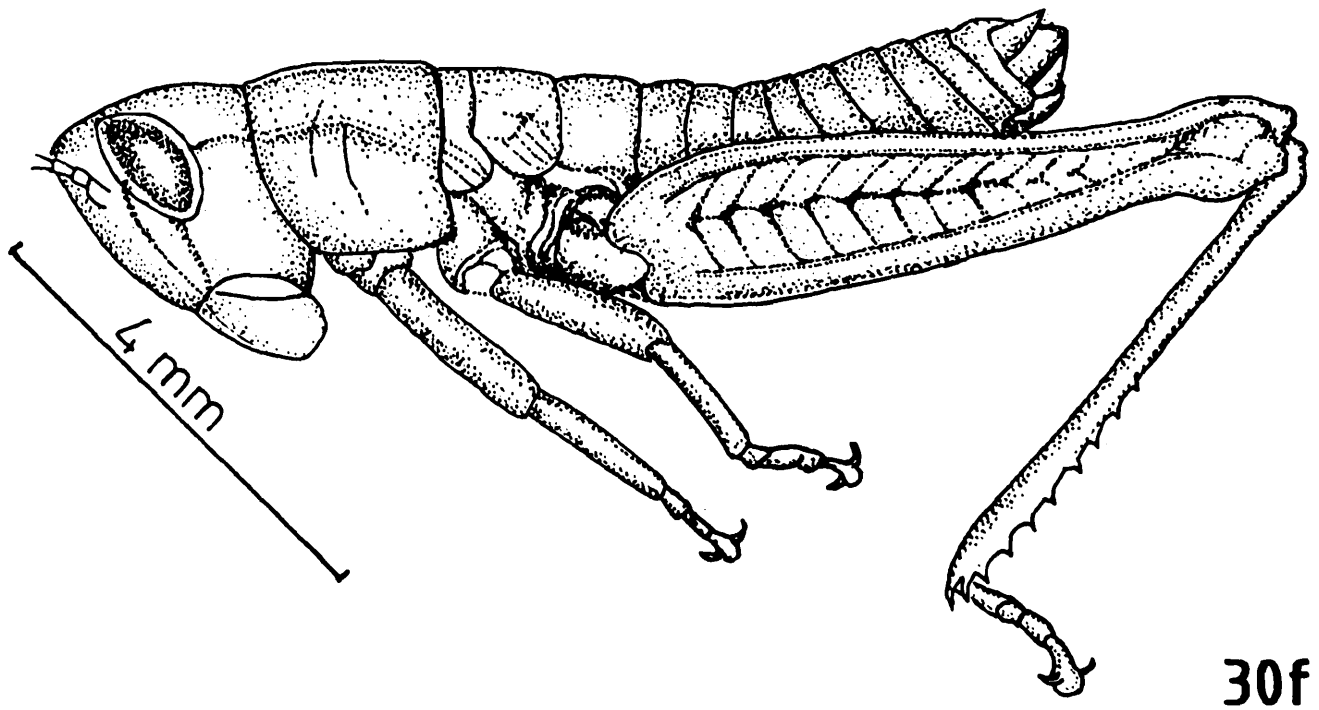
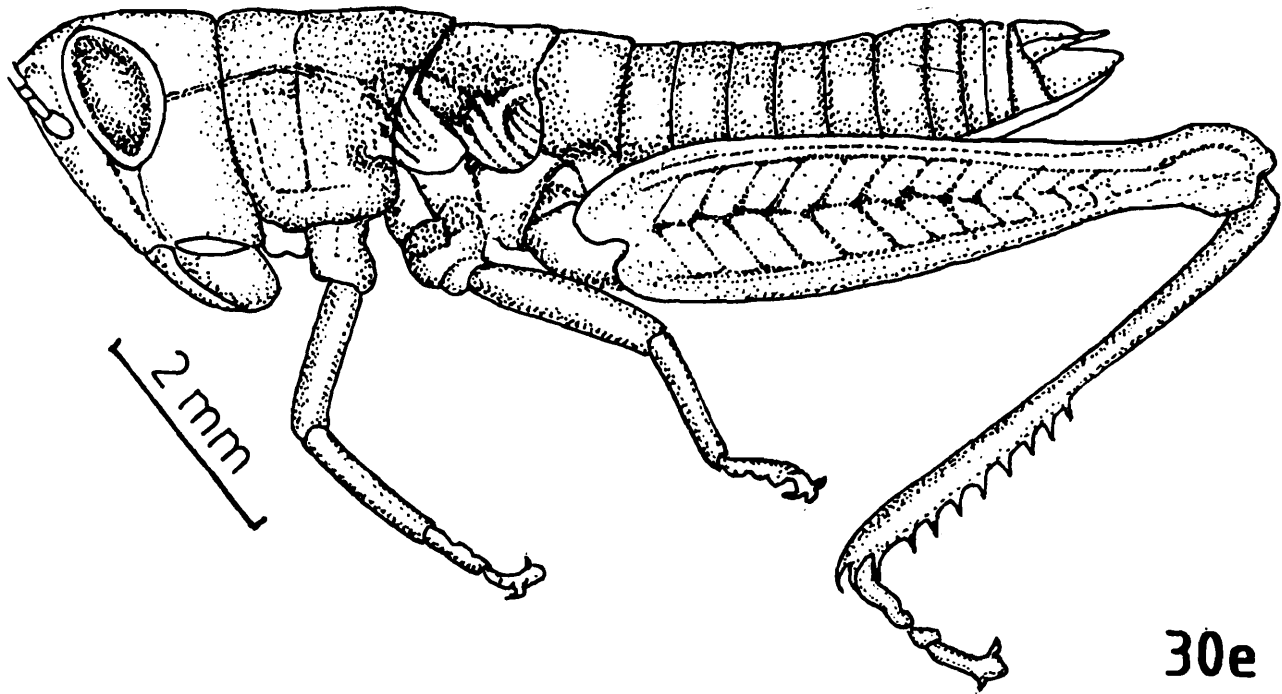
5. Wing rudiments usually shorter than pronotum , subgenital plate reaching just above the end of paraprocts instar IV, male
- Wing rudiments usually longer than pronotum , subgenital plate covering paraprocts entirely..... instar V, male
6. Pronotum length 0.9 to 1.0 mm , trachiation of tegmen not clearly developed or hardly detectable (7)
- Pronotum length more than 0.9 to 1.0 mm , tegmen clearly developed and easily detectable 8
7. Body length 5.0 to 5.2 mm , anterior ovipositor valves not clearly developed..... instar I, female
- Body length 5.9 to 6.2 mm , anterior ovipositor valves clearly developed instar II, female
8. Anterior ovipositor valves crosses anterior margin of ninth sternite, posterior ovipositor valves reaching upto the half of the paraprocts instar III, female
- Anterior ovipositor valves reaching more than half of the ninth sternite, posterior ovipositor valves reaching more than half of the paraprocts 9
9. Posterior ovipositor valves not touching their inner margin at the end , inner valves still visible instar IV, female
- Posterior ovipositor valves touching their inner margin , inner valves overlapped. 10
10. Anterior ovipositor valves reaching two third length of the posterior ovipositor valves instar V, female
- Anterior ovipositor valves reaching three fourth length of the posterior valves instar VI, female

Egg pod and Eggs

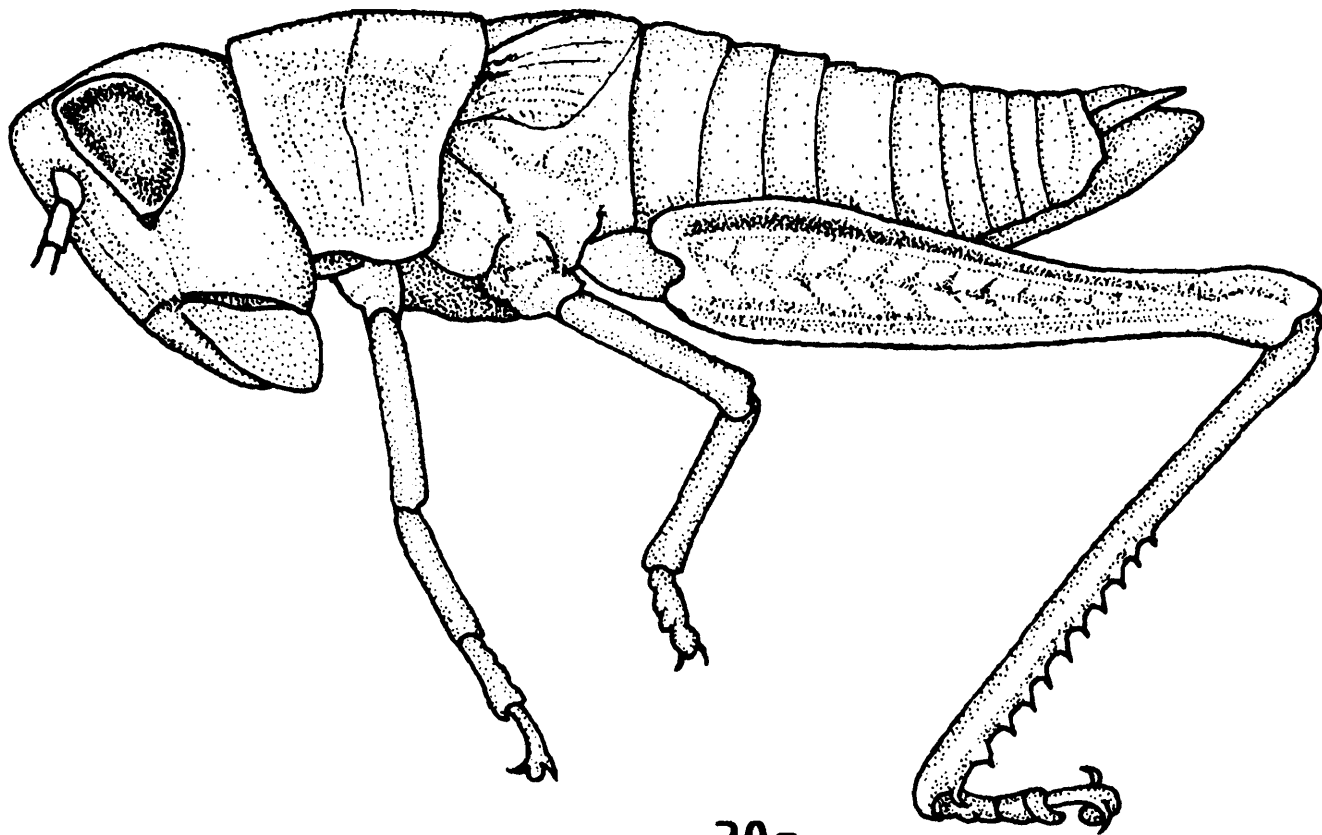
The freshly laid egg pod of *Aiolopus th. tamulus* was light brown in colour and later it transferred into deep brown. It was almost cylindrical in shape, its upper portion was slightly narrow-ed than the lower, Occasionally slight curvature was noticed in the middle. The egg-mass



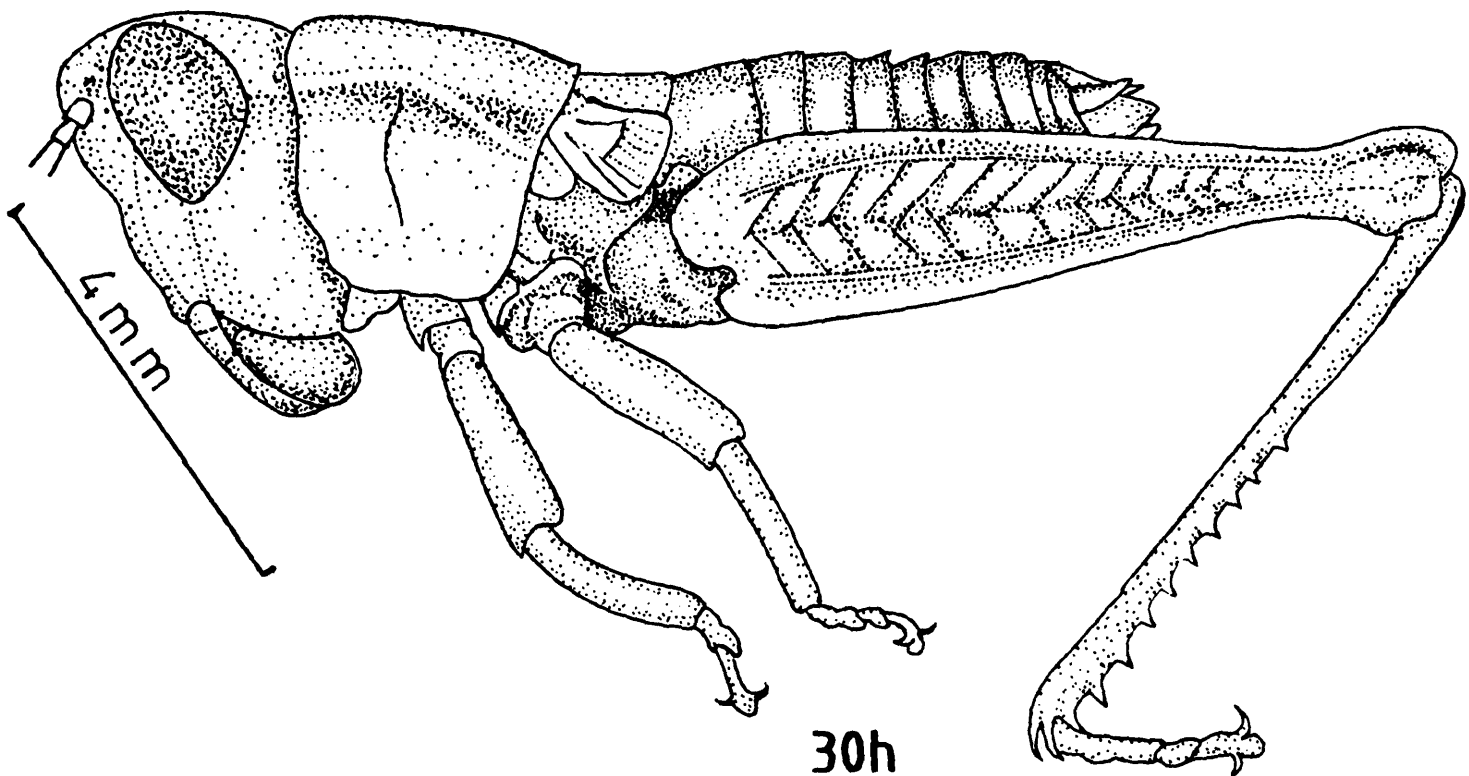
Figs. 30 a-d. *Aiolopus th. tamulus* — a egg ; b vermiform larva ; c first instar male d second. instar female.



Figs. 30 e-f. *Aiolopus th. tamulus* — e, third instar male ; f, third instar female.

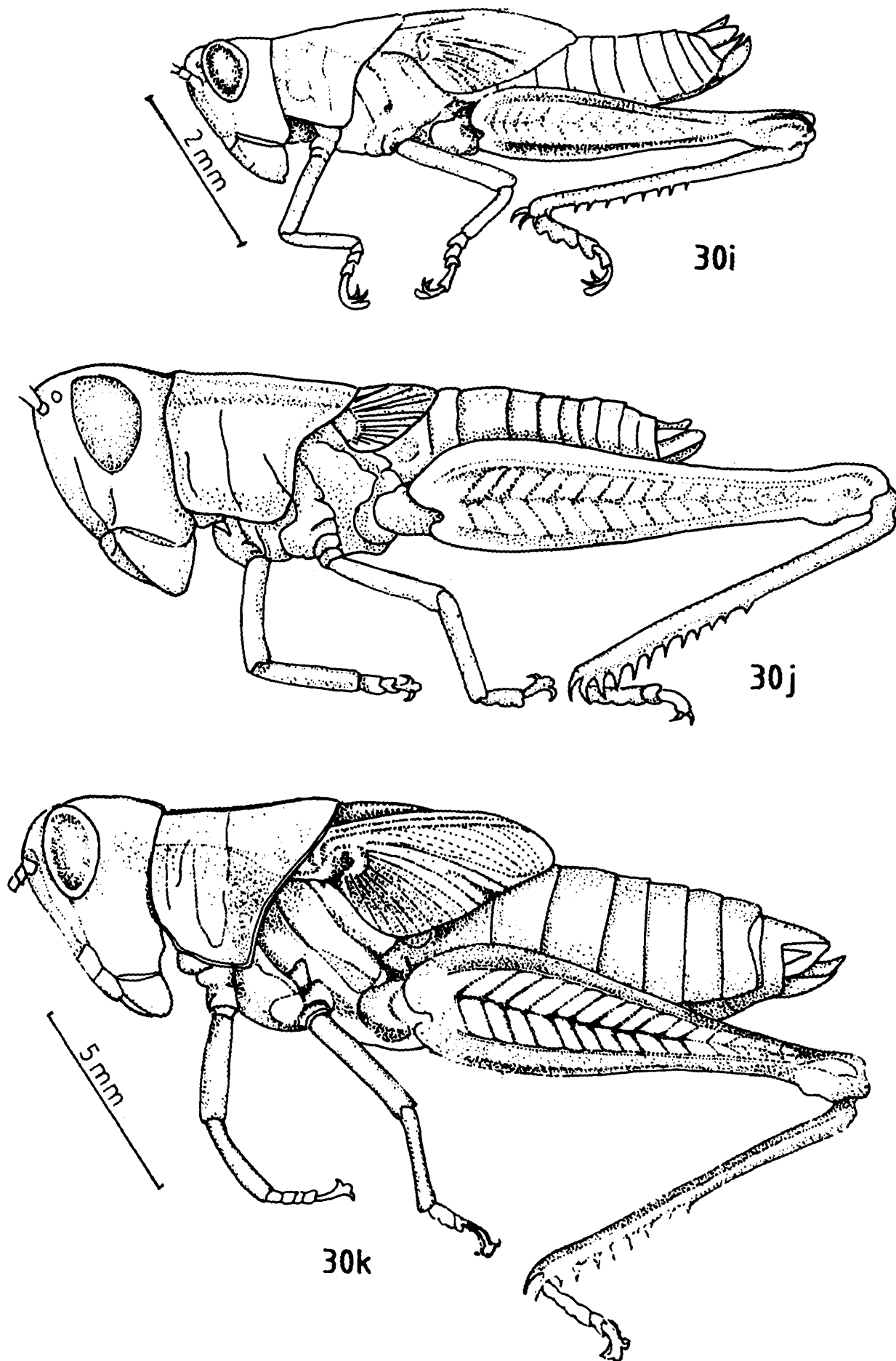


30g



30h

Figs. 30 g-h. *Aiolopus th. tamulus* — g, fourth instar male ; h, fifth instar female.



Figs. 30 i-k' *Aiolopus th. tamulus* — i, fifth instar male ; j, fifth instar female ; k, sixth instar female.

occupying 2/3rd of the lower part of the egg pod and the upper part consisting of spongy forthy materials. The egg pod measures 2.0 to 4.0 cm. in length.

The number of eggs in pod of *Aiolopus th. tamulus* varied from 16 to 46. The eggs were arranged in the pod vartically but occasionally in oblique row. The length varied from 3.7 to 3.9 mm. and maximum breadth being 1.05 mm. (Fig. 30a).

Vermiform Larvae (Fig. 30b)

Colour General body colour was always light to pale brown. Body cylindrical, laterally compressed tympanal depression not visible at this stage, the vermiform larvae was very soft and delicate in nature, both shape and appearance same as previous species. Body measuring 5.3 (5.0 to 5.45) mm. n = 20, in length. Head obtusely rounded at apex and bent downwards, mandibles not clearly developed, ocelli not detectable. Antennae with 10 segments and tip of the antennae club shaped. Pronotum sub-cylindrical, posterior margin concave or incurved. Legs with fore, middle and hind legs also lying close to the body, basal lobe of hind femur not clearly developed. External genitalia with supra anal plate bent downwards and projecting towards the head in parallel to the body and the cerci were also bent downwards, and inwards parallel to the abdomen.

First Instar (Fig. 30c)

Colour : General body colour straw yellow or light brown, with some deep brown spots scattered over throughout the body. The compound eyes were straw yellow ornamented with brown sculpture, yellow stripe present around the eye, tip of the antennae deep brown, posterior tip of the hind tibiae black and also the tip of the tibial spine black in colour. Body more or less narrow, some what laterally compressed tympanal depression not clearly visible measuring 5.18 (4.9 to 5.5) mm. in length (in both the sexes). Head comparatively robust in comparison to the posterior part of the body, apex subglobular obtusely rounded measuring 1.08 (1.0 th 1.1) mm. n = 30, in length and 1.95 (1.9 to 2.0) mm. n = 30, in breadth. Ocelli visible. Antennae with 12 segments, flagellum of 7 annuli with clear segmentation and with the indication of 3 more club shaped indistinct annuli at apex measuring 1.1 mm. n = 30, in length (Fig. 31a). Pronotum subcylindrical, posterior margin concave or incurved measuring (0.7 to 0.78) mm. n = 20, in length along the median carina. Wing pad rudiments were very small and slightly differentiated from terga, hind margin of mesonotum or fore wing pads and metanotum or hind wing pads downwardly directed, along the costal margin with rounded at apex and fore wing pad measuring 0.2 mm. n = 20, in length. Hind femur with upper basal lobe longer than lower basal lobe measuring 2.55 (2.5 to 2.6) mm. n = 20, in length, and 0.73 mm. n = 20, in breadth. Hind tibiae

measuring 2.35 mm. $n = 20$, in length. External genitalia Subgenital plate of male deeply concave at apex or incurved and not clearly developed (Fig. 32a). Female with anterior or lower ovipositor valves small denticular in shape and not clearly developed and posterior or upper ovipositor valves also were ill developed (Fig. 32b).

Second Instar (Fig. 30d)

Colour General colour of the body was light or pale brown with deep brown spots were scattered over the pronotum and abdomen. Body shape same as previous instar, tympanal depression not clearly developed measuring 6.2 (5.9 to 6.3) mm. $n = 20$, in length. Head shape same as first instar measuring 1.0 (0.9 to 1.09) mm. $n = 20$, in length and 1.94 (1.8 to 2.0) mm. in breadth. Ocelli clearly developed from this instar. Antennae with 14 segmented, flagellum of 10 annuli clearly segmented with the indication on 2 more indistinct club shaped annuli measuring 1.45 (1.4 to 1.5) mm. $n = 20$, in length (Fig. 31b). Pronotum with subcylindrical, posterior margin less concave or incurved measuring 1.05 (0.95 to 1.1) mm. $n = 20$, in length. Wing pads were slightly prominent hind margin of mesonotum or fore wing pad and metanotum or hind wing pads also downwardly directed along the costal margin, fore wing pad measuring 0.29, $n = 20$, in length. Hind femur with upper basal lobe slightly longer than lower basal lobe measuring 3.06 (2.9 to 3.3) mm. $n = 20$, in length and 0.95 (0.9 to 1.0) mm. $n = 20$, in breadth. Hind tibiae measuring 2.85 (2.8 to 2.9) mm. $n = 20$, in length. *External genitalia* male subgenital plate less concave or at the apex incurved (Fig. 32c), in female with anterior ovipositor valves and posterior ovipositor valves more or less clearly developed (Fig. 32d).

Third Instar (Fig. 30e-f)

Colour General body colour brown some times changing to green in head,, pronotum, wing pads and hind femur depending on the green colour of the surrounding vegetation. Body shape was same as previous instar and measuring 8.03 (7.2 to 8.6) mm. $n = 20$, in length. Head with measuring 1.68 (1.6 to 1.75) mm. $n = 20$ and 2.28 (2.6 to 3.0) mm. $n = 20$ in breath. Antennae clearly filliform in shape with 16 to 17 segmented, flagellum of first 12 annuli clearly segmented but with the indication of 2 to 3 more annuli at apex measuring 2.39 (2.36 to 2.43) mm. $n = 20$, in length (Figs. 31c-d). Pronotum cylindrical, posterior margin shallowly incurve or transverse measuring 1.47 (1.4 to 1.55) mm. $n = 20$, in length. Wing pads of male with rudiments of mesonotum or fore wing pads and metanotum or hind wing pads more prominent, faint streak of trachiation appeared in both the wing pads. In male mesonotum or fore wing pads extending up to the half of the hind wing pads along the costal margin and fore wing pads measuring 0.6 (0.56 to 0.64) mm. in length. In female fore wing pads extending one third length of the hind wing pads along the costal margin and fore wing pads measuring 0.38 (0.34 to 4.0) mm. $n = 20$,

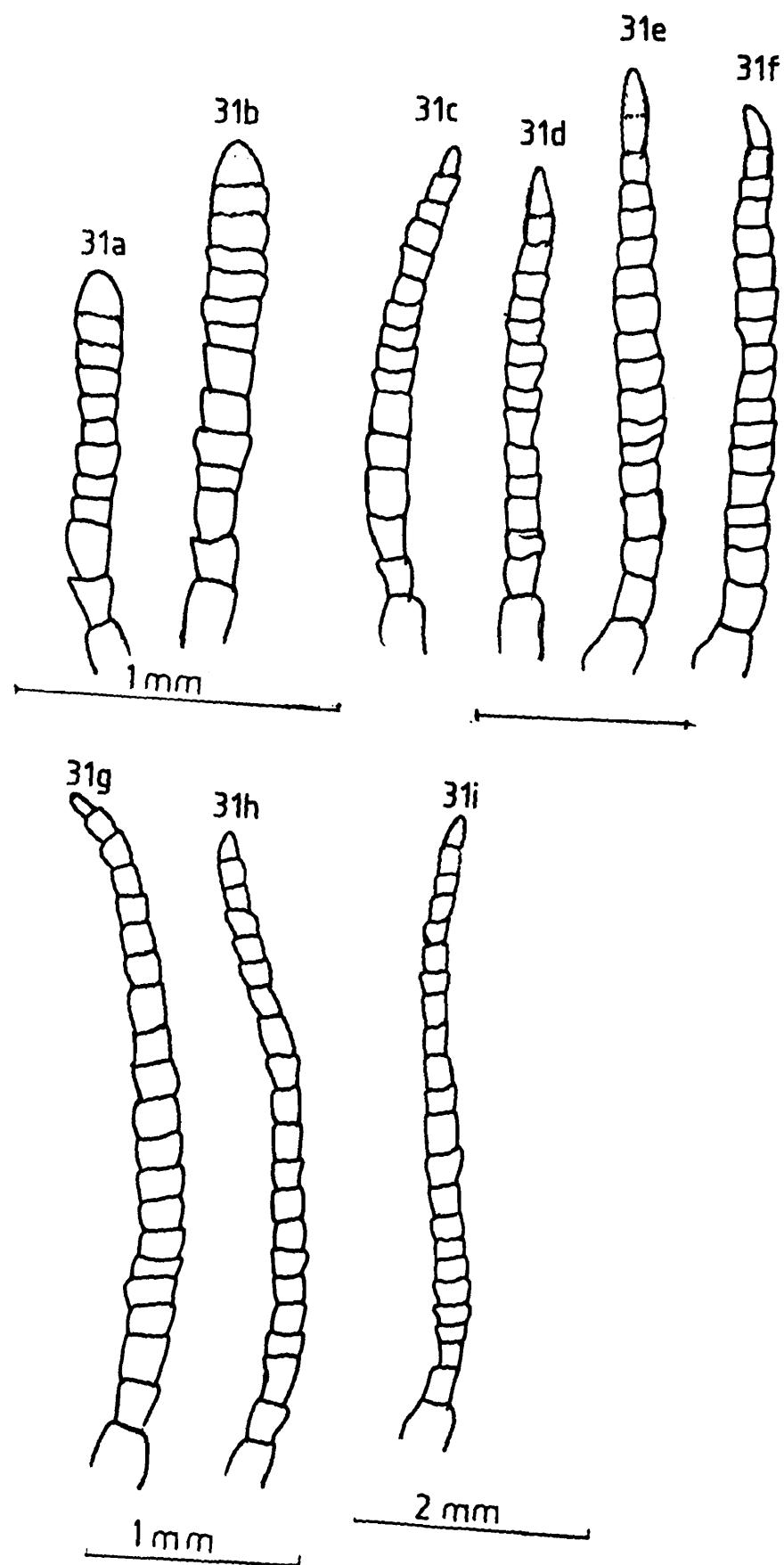
in length. Hind femur with upper basal lobe more longer than lower basal lobe measuring 4.65 (4.4 to 4.8) mm. n = 20, in length and 1.4 mm. n = 20, in breadth. Hind tibiae measuring 4.0 (3.8 to 4.1) mm. in length. *External genitalia* of male posterior margin of subgenital plate shallowly incurved or transverse and reaching upto the half of the paraprocts (Fig. 32e). In female with anterior ovipositor valves crossing the ninth sternum. Posterior ovipositor valves or upper valves reaching just above the half of the paraprocts, inner lines of posterior ovipositor valves sharply divergent along each other, inner valves develop in between the base of the posterior ovipositor valves (Fig. 32f).

Fourth Instar (Fig. 30g–h)

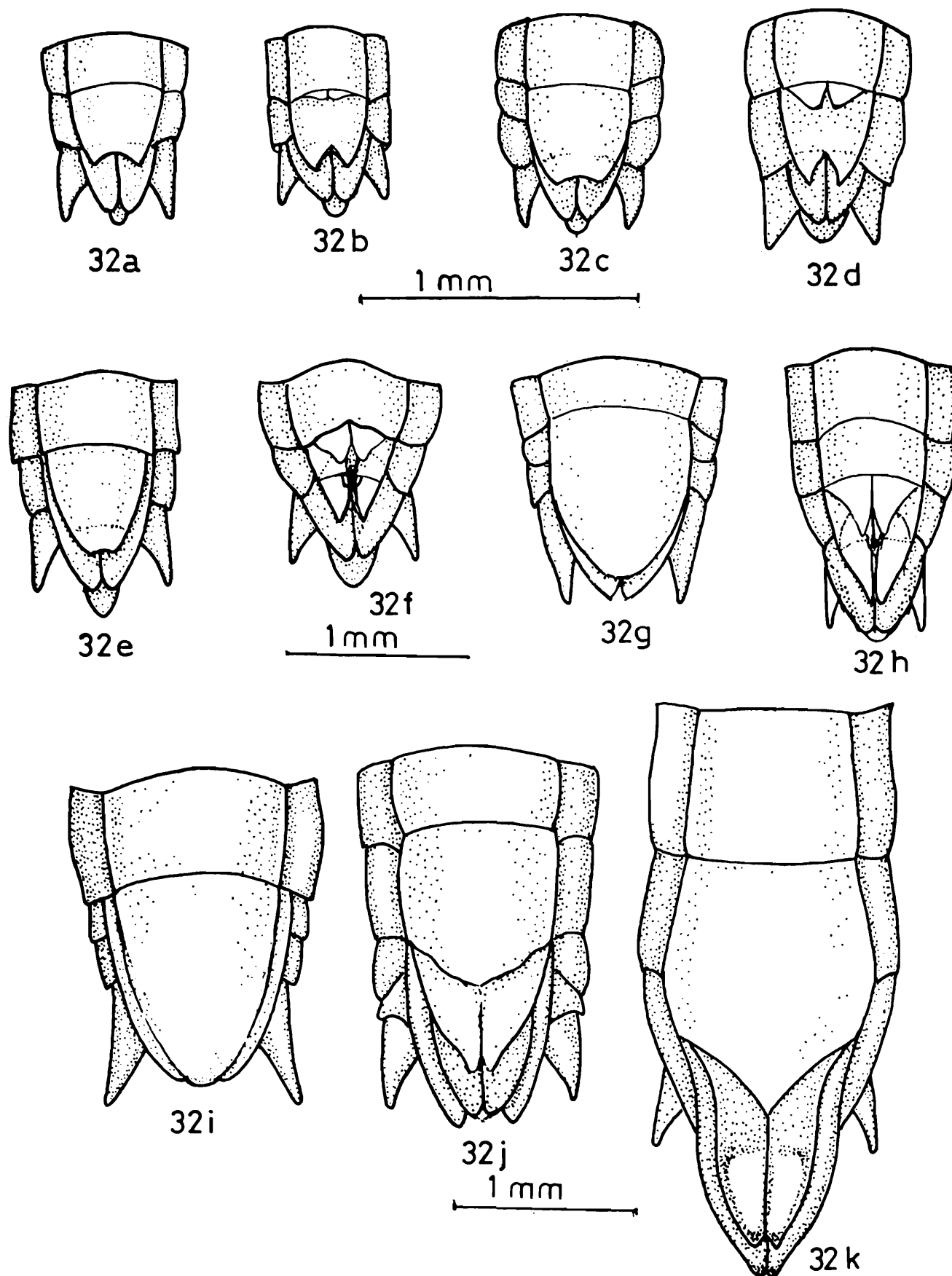
Colour General colour of the body same as third instar, but in male nymphs some black spots appeared in the wing pads. Body with tympanal depression clearly developed measuring 11.4 (10.5 to 13.0) mm. n = 20, in length. Head with measuring 2.15 (1.95 to 2.4) mm. n = 20, in length and 3.6 (3.3 to 3.8) mm. n = 20, in breadth. Antennae filiform, with segments, 18-19 flagellum of 14-15 annuli clearly segments with the indication of 1 more annuli at apex and measuring 3.2 (3.1 to 3.32) mm. n = 20, in length (Fig. 31e-f). Pronotum with posterior margin out curved and measuring 2.4 (2.1 to 2.6) mm. n = 20, in length. Wing pads of male triangular in shape mesonotum or fore wing pads and metanotum or hind wing pads turned through 180° angle, so hind wing pads overlapped the fore wing pads and hind wing pads extending upto the posterior margin of abdominal tergite 1. measuring 1.74 (1.7 to 1.8) mm. n = 20, in length, in female mesonotum or fore wing pads extending more than half of the hind wing pads along the costal margin and fore wing pads measuring 0.7 (0.65 to 0.74) mm. n = 20, in length. Hind femur with measuring 6.7 (6.4 to 7.2) mm. n = 20, in length. *External genitalia* of male with tip of the subgenital plate not reaching upto the end of the paraprocts and apex slightly out curved (Fig. 32g). In female with anterior or lower ovipositor valves reaching upto the base of posterior ovipositor valves, inner valves partly covered by posterior ovipositor valves (Fig. 32h).

Fifth Instar (Fig. 30i-j)

Colour Same as previous instar. Body measuring 14.1 (13.0 to 14.5) mm. n = 20, in length. Head measuring 2.33 (1.3 to 2.4) mm. n = 20, in length and 4.4 (4.3 to 4.45) mm. n = 20, in breadth. Antennae with 20 to 21 segments, the flagellum of 19 annuli clearly segmented and only the last one incomplete at apex measuring 4.23 (4.2 to 4.28) mm. n = 20, in length (Fig. 31g-h). Pronotum with posterior margin concave or clearly outcurved, apex obtusely rounded measuring 3.36 (3.3 to 3.45) mm. n = 20, in length. Wing pads of male more triangular in shape and hind wing pads reaching upto the posterior margin of tergite 3, parallel trachiation



Figs. 31 a-i. *Aiolopus th. tamulus* (Antennae) — a, first instar male; b, second instar female; c, third instar male; d, third instar female; e, fourth instar male; f, fourth instar female; g, fifth instar male; h, fifth instar female; i, sixth instar female.



Figs. 32 a-k. *Aiolopus th. tamulus* (External genitalia) — a, first instar male ; b, first instar female ; c, second instar male ; d, second instar female ; e, third instar male ; f, third instar female ; g, fourth instar male, h, fourth instar female ; i, fifth instar male , j, fifth instar female ; k, sixth instar female.

more distinct measuring 5.0 (4.8 to 5.1) mm. n = 20, in length , In female metanotum or hind wing pads turned by rotation through 180° angle as a result hind wing pads overlapped fore wing pads the hind wing pads crossing the abdominal tergite 1, measuring 2.9 (2.28 to 2.35) mm. n = 20, in length. Hind femur measuring 6.4 (6.3 to 6.5) mm. n = 20, in length. Hind tibiae measuring 7.1 (7.0 to 7.2) mm. n = 20, in length. *External genitalia* of male subgenital plate reaching at the end of paraprocts and its apex clearly out curved and obtusely rounded (Fig. 32i). In female with anterior or lower ovipositor valves reaching upto the one third length of paraprocts, posterior or upper ovipositor valves reaching just above the end of paraprocts, inner valves overlapped (Fig. 32j).

Sixth Instar (Fig. 30k)

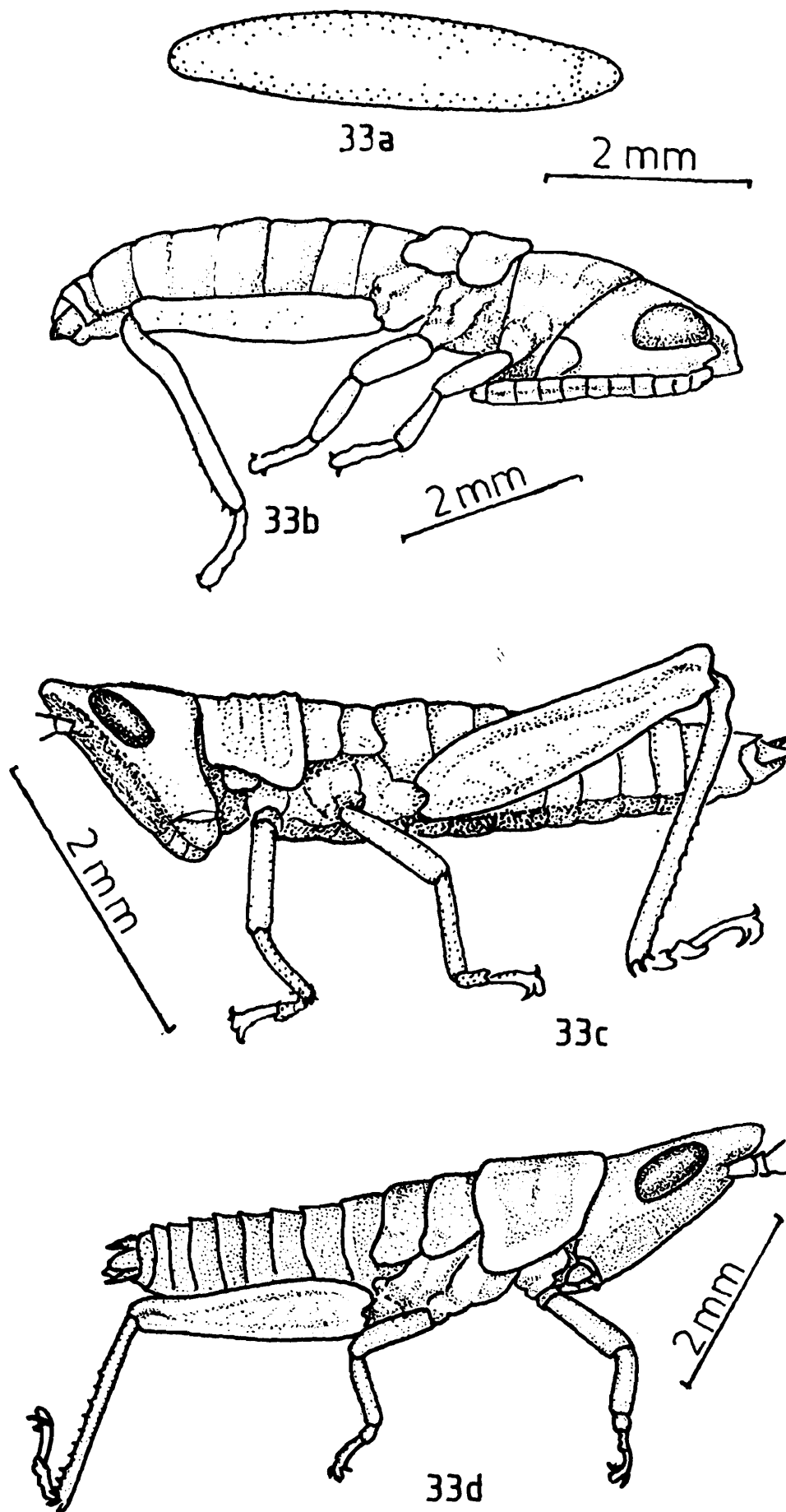
Colour Same as previous instar. Body measuring 8.25 (8.0 to 8.4) mm. n = 20, in length. Head measuring 3.0 (2.95 to 3.1) mm. n = 20, in length. Antennae with 21-22 segments and measuring 5.58 (5.5 to 5.8) mm. n = 20 in length (Fig. 31i). Pronotum of posterior margin prominently out curved measuring 3.73 (3.7 to 3.82) mm. n = 20, in length. Wing pads more clearly developed metanotum or hind wing pads extending upto the abdominal tergite 2 and measuring 5.5 (5.4 to 5.55) mm. n = 20, in length. Hind femur with upper basal lobe more longer than lower basal lobe measuring 10.5 (10.3 to 10.7) mm. in length. Hind tibiae measuring 9.2 (8.6 to 9.8) mm. n = 20, in length. *External genitalia* of female with anterior ovipositor valves reaching three fourth length of the posterior ovipositor valves, posterior ovipositor valves reaching beyond the paraprocts (Fig. 32k).

5. *Atractomorpha crenulata* (Fabricius)

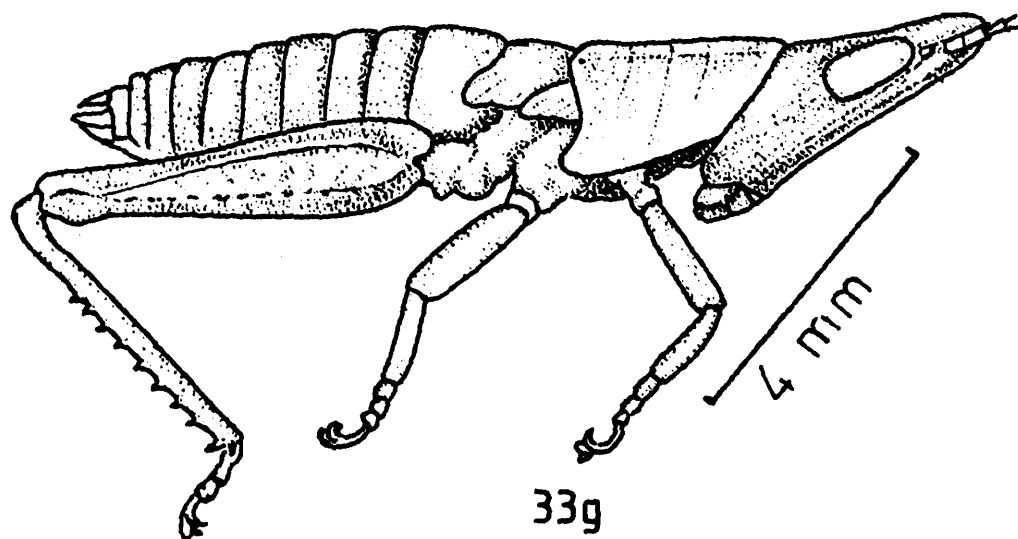
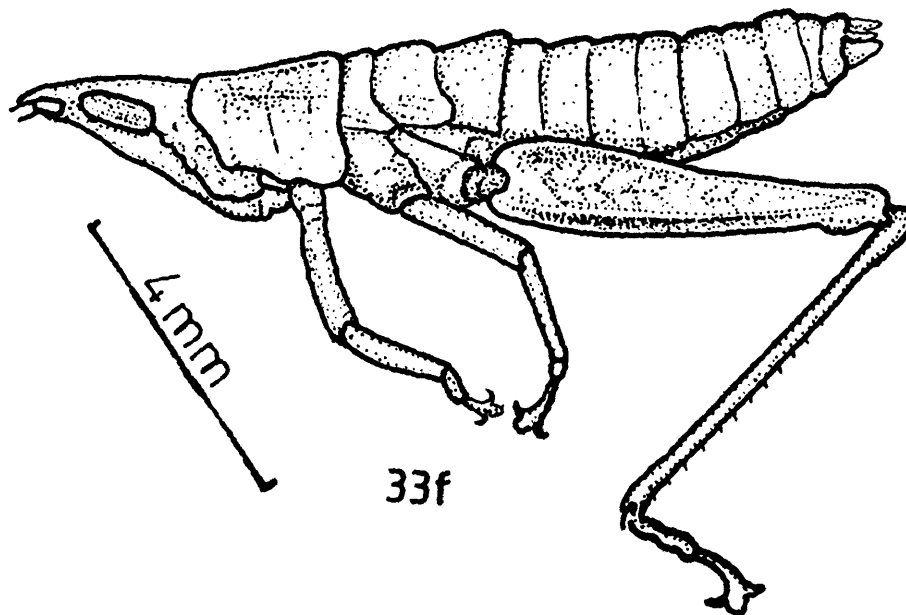
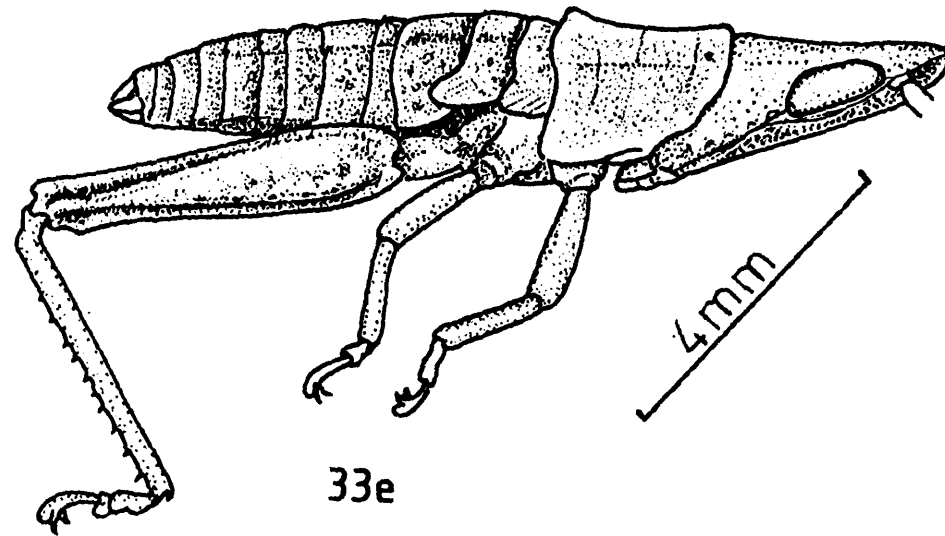
Key to the identifications different nymphal instars

(Male and female)

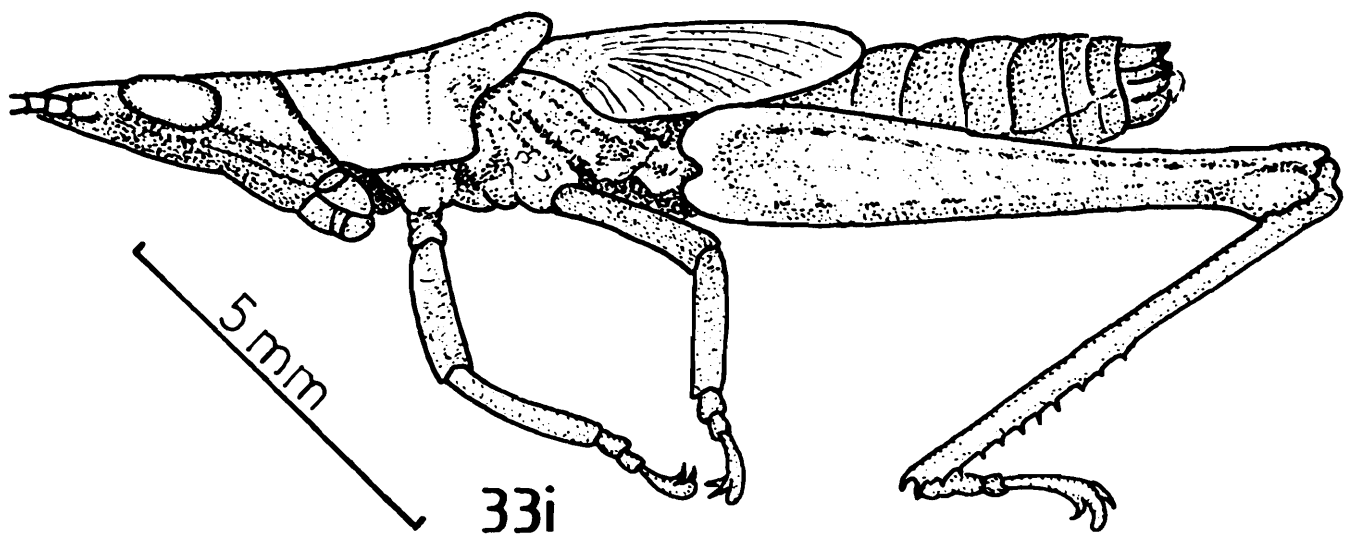
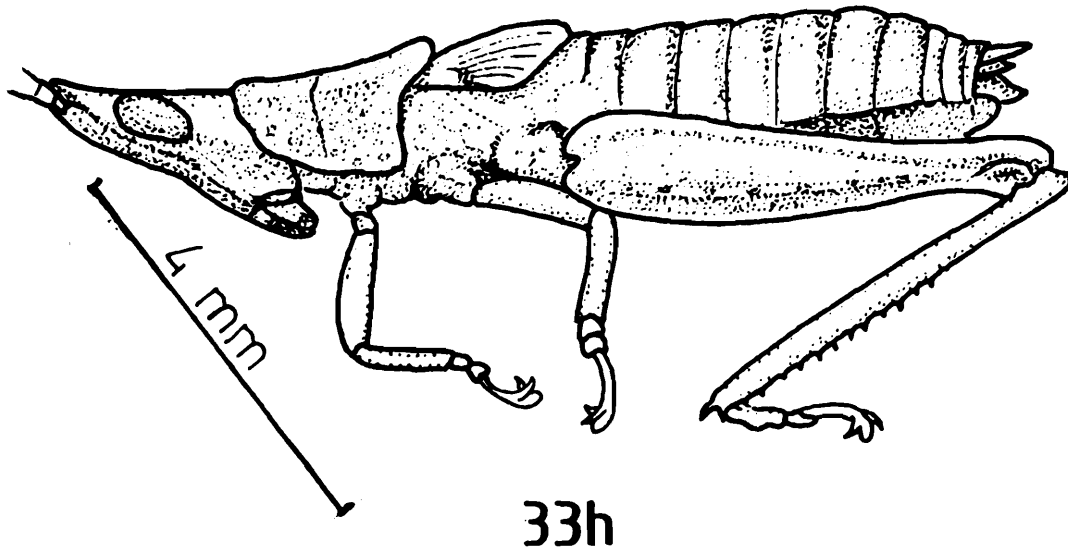
1. 9th sternum of abdomen bears a subgenital plate with an emarginate apex , absence of valves on sternite 8th Male (2)
- 8th sternum of abdomen bears a small valves, initially short and truncate, which later developed into ovipositor valves Male (6)
2. Subgenital plate never cover more than one third length of the paraproct 3
- Subgenital plate always cover more than one third length of the paraproct 4



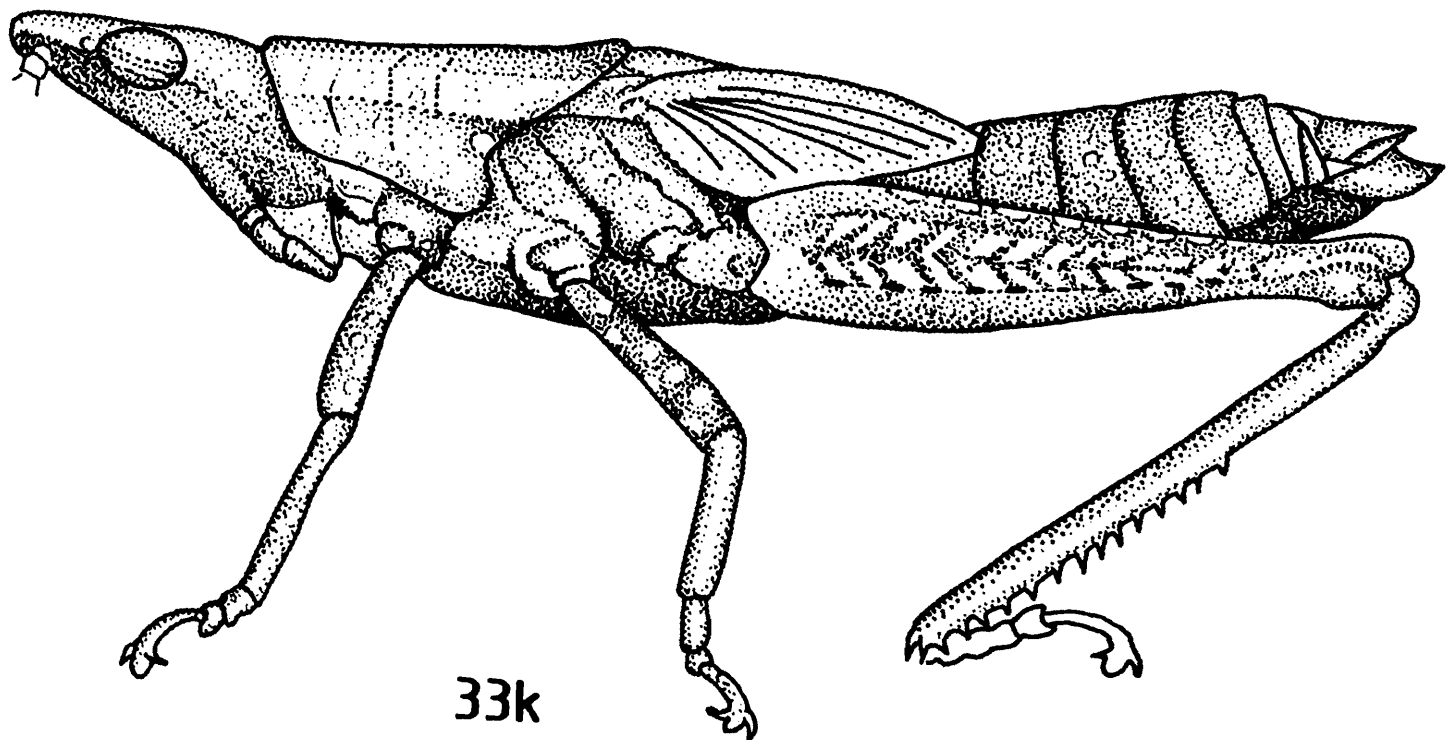
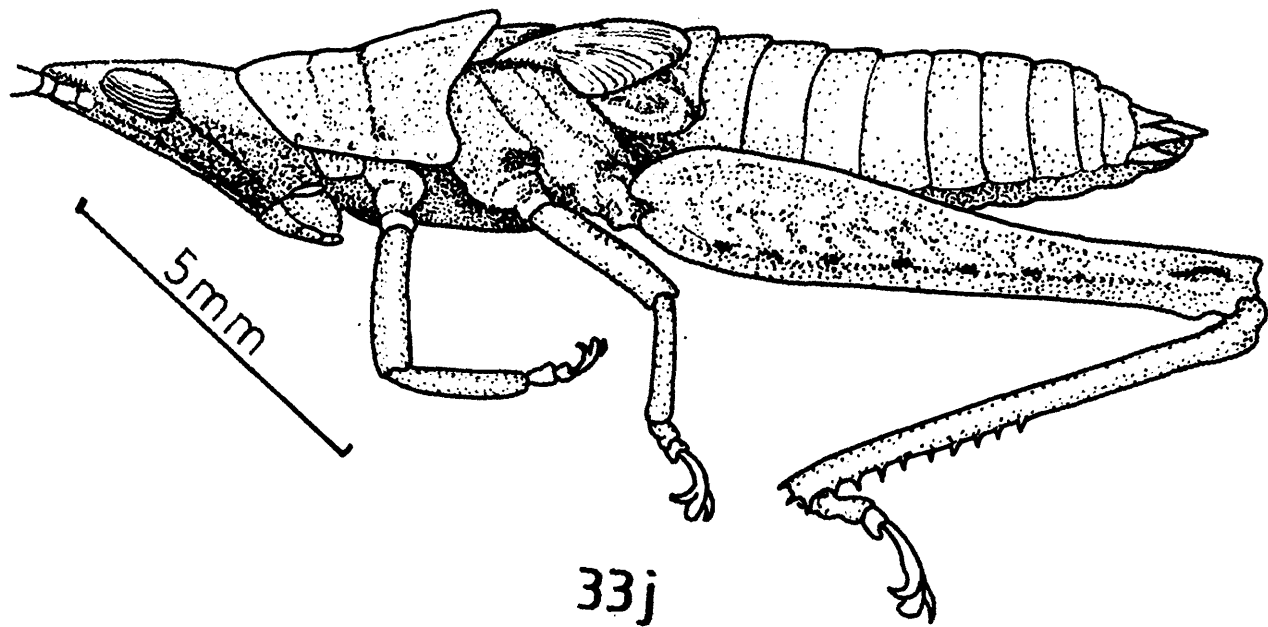
Figs. 33 a-d. *Atractomorpha crenulata* — a, egg ; b, vermiform larva ; c, first instar male ; d, second instar female.



Figs. 33 e-g. *Atractomorpha crenulata* — e, fourth instar female; f, third instar female; g, third instar male.



Figs. 33 h-i. *Atractomorpha crenulata* — h, fourth instar male ; i, fifth instar male.



Figs. 33 j-k. *Atractomorpha crenulata* — j, fifth instar male; k, sixth instar female.

3. Fore and hind wing pad distinctly blunt and directed downwardly , subgenital plate narrowed, deeply emarginate covering only the base of the paraprocts....instar I, male
 - Fore and hind wing pad less blunt, both of the wing pads slightly oblique and directed backwardly , subgenital plate less deeply emerginate covering one third length of rhe paraproctsinstar II, male
4. Posterior margin of pronotum lighter straight or slightly curved inwardly , Hind wing pad overlapped by the fore wing pad instar III, male
 - Posterior margin of pronotum outwardly curved , Fore wing pads overlapped by the hind wings pad 5
5. Antennae 14 to 15 segmented , Posterior margin of pronotum rounded and outwardly curved , Tip of the subgenital plate obtuse and reaching just above the end of the paraprocts instar IV, male
 - Antennae 17 to 18 segmented , Posterior margin of pronotum acute at apex outwardly , tip of the subgenital plate reaching at the end of the paraprocts instar V, male
6. Lower basal lobe of hind femur longer than its upper basal lobe (7)
 - Lower basal lobe of hind femur either distinctly shorter or equal to upper basal one (8)
7. Single eye stripe Anterior and posterior ovipositor valves ill developed instar I, female
 - Tow eye stripes , Anterior ovipositor valves more or less angular , posterior ovipositor valves more longer and elongated instar II, female
8. Wing pads not rotated with costal margin along mid dorsal line of the body , inner valves developed..... (9)
 - Wing pads rotated with costal margin along mid dorsal line of the body , inner valves overlapped (10)
9. Three eye stripes , Fore wing pad reaching upto the one fourth length of the hind wing pads Anterior ovipositor valves crosses the 9th sternum groove posterior ovipositor valves reaching up to the half of the paraprocts instar III, female

- Four eye stripes, Fore wing pads reaching upto the half of the length of hind wing pads , Anterior ovipositor valves angular and crosses the base of the posterior ovipositor valves, posterior ovipositor valves reaching more than half of the paraprocts
..... instar IV, female
- 10. Five eye stripes , Anterior ovipositor valves reaching half way length of posterior ovipositor valves, posterior ovipositor valves reaching just above the paraprocts
..... instar V, female
- Six eye stripes Anterior ovipositor valves reaching three fourth of the length of posterior ovipositor valves , Posterior ovipositor valves reaching beyond the paraprocts
..... instar VI, female

Egg pod and Eggs (Fig. 33a)

The freshly laid egg pod light yellow to brown in colour and after two hours it changed in to darkbrown. It has almost straight and uniform in size and slightly curved in middle. The length of the pod measuring 3.7 (3.1 to 4.2) cm.

Freshly laid eggs are light brown in colour but it became dark brown in colour within 6 to 9 hours after deposition. The eggs were densely set in the egg pod and the number varies from 12 to 66. The eggs were rounded at both ends, slightly curved in the middle the length varies from 3.6 (3.0 to 3.8) mm. in length and maximum breadth being 1.4 mm. (Fig. 33a).

Vermiform Larvae (Fig. 33b)

Colour General body colour always green. Body cylindrical, laterally compressed and measuring 4.4 (4.0 to 4.9) mm. n = 20, in length. Head subglobular and bent downwards, ocelli not developed, tympanal depression not appeared. Antennae with 9 segments, bent downwards and close to the body. Pronotum subcylindrical, posterior margin cvurved or deeply incurved. Legs with fore, middle and hind legs attached close to the body , basal lobe of hind femur not clearly developed. Externmal genitalia with supra anal plate down towards the body and projecting towards head parallel, cerci and supra-anal plate bent downwards and inwards parallel to the abdomen. Subgenital plate of male hardly detectable , Anterior and posterior ovipositor valves also hardly detectable.

First Instar (Fig. 33c)

Colour General body always green in colour, eyes pale yellow to brown, presence of

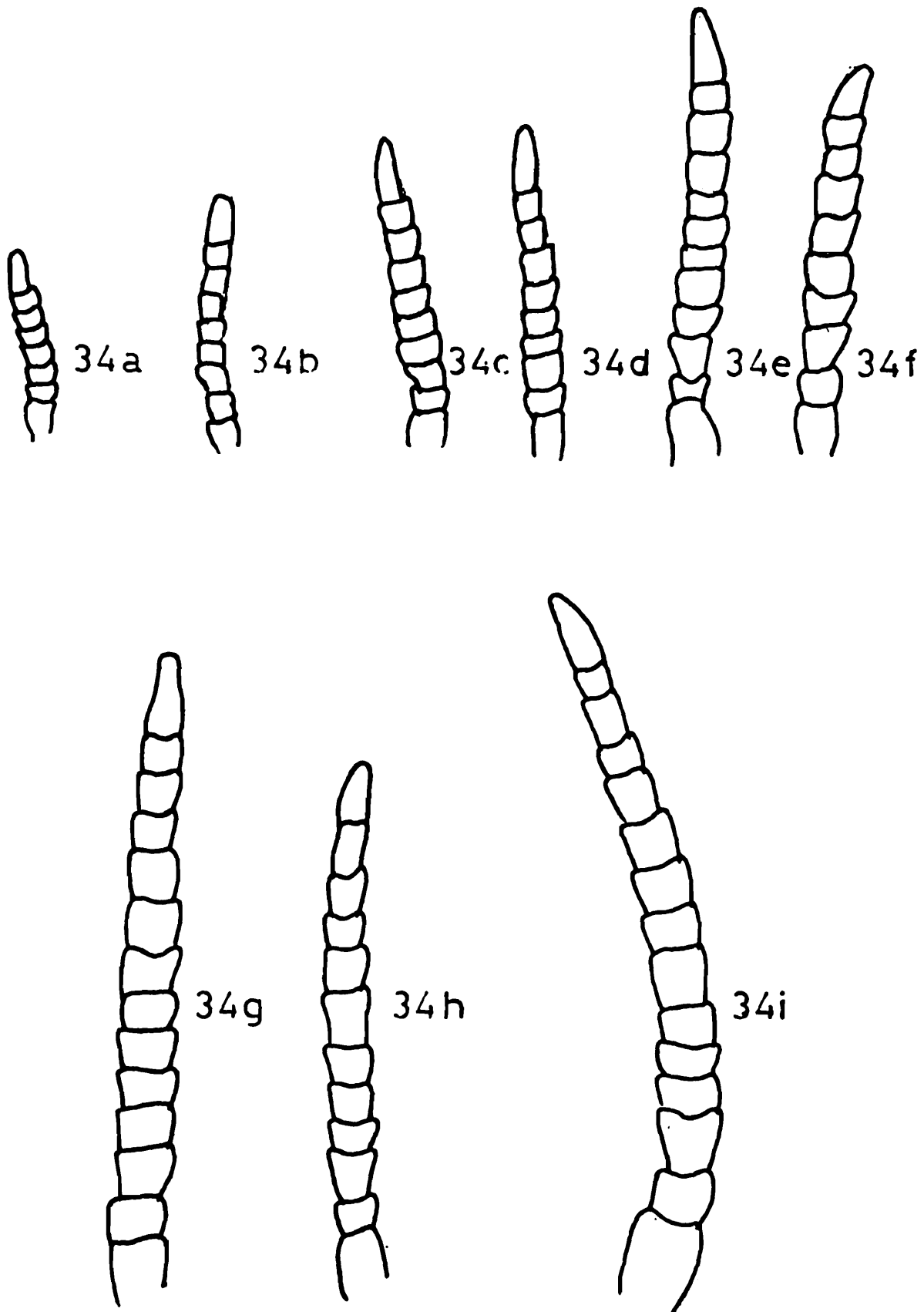
alternate white and pinkish band in the first and second pairs of legs, hind tibia light bluish green in colour. Body cylindrical, narrow, laterally compressed and measuring 5.1 (4.6 to 5.4 mm. in length. Head obtusely conical, extended forward and measuring 1.02 (1.0 to 1.05) mm. n = 25, in length. Ocelli faintly visible. Antennae ensiform, segments 12, flagellum of 7 annuli clearly segmented and last 3 annuli not clearly segmented measuring 1.35 (1.30 to 1.40) mm. = 25, in length (Fig. 34a). Eyes with single eye stripe. Pronotum sub-cylindrical, posterior margin deeply concave or out curved measuring 0.7 mm. n = 25, in length along the median carina. Wing pads slightly differentiated from tergites. hind margin of mesonotum or fore wing pad and metanotum or hind wing pad directed downwardly with the costal margin and fore wing pad measuring 0.36 mm. n = 25, in length upper basal lobe of hind femur longer than lower basal lobe and measuring 1.92 (1.8 to 2.0) mm. n = 20, in length. External genitalia of male with tip of the subgenital plate deeply concave or incurved and covering only base of the paraprocts (Fig. 35a). Female with anterior and posterior ovipositor valves ill developed (Fig. 35b).

Second Instar (Fig. 33d)

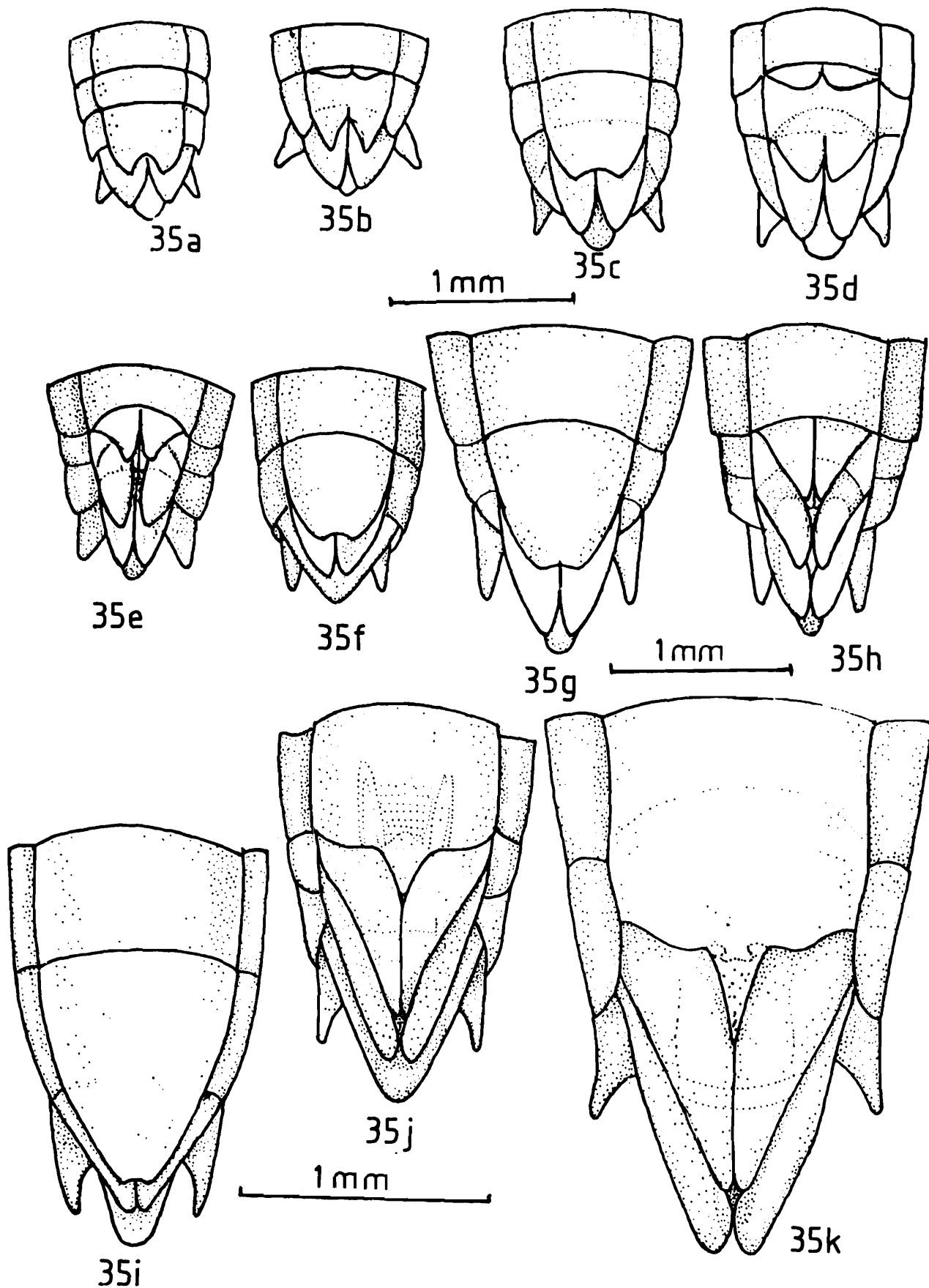
Colour Same as first instar. Body shape same as first instar, tympanal depression hardly detectable and measuring 6.14 (5.7 to 6.6) mm. n = 25, in length. Head Head same as in first instar, and measuring 1.32 (1.2 to 1.4) mm. n = 25, in length. Ocelli clearly visible. Eyes with two stripes measuring 0.7 mm. n = 20, in length. Antennae with 13 segments, flagellum consisting of 8 annuli with the indication of 3 more and measuring 1.74 (1.7 to 1.8) mm. n = 25, in length (Fig. 34b). Pronotum with posterior margin less incurved and measuring 1.15 (1.0 to 1.25) mm. n = 25, in length. Wing pads rudiments more prominent than those of first instar hind margin of mesonotum or fore wing pad and metanotum or hind wing pad extending downwards and fore wing pad measuring 0.45 (0.4 to 0.5) mm. n = 25, in length Hind femur with upper basal lobe slightly longer than lower basal lobe and measuring 2.66 (2.6 to 2.8) mm. n = 25, in length. External genitalia of male with tip of the subgenital plate less incurved (Fig. 35c). Female with anterior or lower ovipositor valves and posterior or upper ovipositor valves clearly developed. (Fig. 35d).

Third Instar (Fig. 33e-f)

Colour : Body colour green, some times changed to straw yellow or pale brown depending upon the colour of the vegetation and soil condition of their habitat, other characters are same as previous instar. Body with visible tympanal depression and measuring 8.76 (7.9 to 9.5) mm. n = 25, in length. Head measuring 1.8 (1.7 to 1.85) mm. n = 25, in length. Eyes with three stripes. Ocelli clearly detectable. Antennae with 15 to 16 segments the first 10 annuli clearly segmented, but with the indication of 3 to 4 more and measuring 1.2 (1.9 to 2.2) mm. n = 25.



Figs. 34 a-i. *Atractomorpha crenulata* (Antennae) — a, first instar male; b, second instar female; c, third instar male; d, third instar female; e, fourth instar male; f, fourth instar female; g, fifth instar male; h, fifth instar female; i, sixth instar female.



Figs. 35 a-k. *Atractomorpha crenulata* (External genitalia) — a, first instar male ; b, first instar female ; c, second instar male ; d, second instar female ; e, third instar male ; h, fourth instar female ; i, fifth instar male ; j, fifth instar female ; k, sixth instar female.

in length (Fig. 34c-d). Pronotum with posterior margin transverse and measuring 1.63 (1.6 to 1.7) mm. n = 25, in length. Wing pads with rudiments such as mesonotum or fore wing pad or metanotum or hind wing pad less blunt in hind margin, lower posterior angle of fore wing pad and hind wing pad begins to project and more or less triangular in shape, faint trachiation appears in both wing pads. Male with fore wing pads extending one third length along the way of costal margin of hind wing pad and measuring 0.85 (0.8 to 0.9) mm. n = 25, in length. Female with fore wing pad extending one fourth of length of hind wing pad along the way of costal margin and measuring 6.8 (6.5 to 7.0) mm. n = 25, in length, hind femur with upper and lower basal lobe equal, measuring 5.36 (5.2 to 5.5) mm. n = 25, in length. External genitalia of male subgenital plate more prominently developed and the tip shallowly incurved or transverse reaching upto the half of the paraproct (Fig. 35e). Female with anterior or lower ovipositor valves prominently developed not touching the posterior margin of sternite 9, its posterior and acutely pointed, tip of the posterior or upper valves reaching upto the half of the paraproct, inner margin of posterior valves sharply divergent, inner valves developed in between the inner margin of two posterior valves near base (Fig. 35f).

Fourth Instar (Fig. 33g-h)

Colour General body colour green, sometimes pale yellow to brown simulating to the colour of the surrounding vegetation, eyes straw yellow to brown in colour, tip of the antennae dark green, alternate band of pink colour and hyaline sometimes absent in the first and second pair of legs. Body Male measuring 12.25 (12.0 to 13.0) mm. n = 25, in length. Female Measuring 12.0 (11.5 to 12.5) mm. in length. Head Male measuring 2.52 (2.4 to 2.7) mm. n = 25, in length. Female Measuring 2.44 (2.3 to 2.6) mm. n = 25, in length. Eyes with four eye stripes measuring 1.1 mm. in length. Antennae with 16 to 17 segments, first 12 annuli clearly segmented and next two to 3 annuli incomplete and measuring 3.3 (2.9 to 3.4) mm. n = 25, in length (Fig. 34e-f). Pronotum with posterior margin convex or outcurved and measuring 2.45 (2.3 to 2.5) mm. in length. Wing pads with rudiments triangular in shape, trachiation more distinct. Hind wing pads of male or metanotum of male turned through 180° overlapping the fore wing pad and hind wing pads extending upto the joint of first tergite and measuring 1.9 (1.85 to 2.9) mm. n = 20, in length. Female with forewing pad not overlapped and extending upto the half of the length of hind wing pads along the way of costal margin of hind wing pads and fore wing pads measuring 1.1 (1.0 to 1.4) mm. n = 25, in length. Hind femur with lower basal lobe slightly longer than upper basal lobe and measuring 7.45 (7.36 to 7.6) mm. n = 25, in length. External genitalia of male with tip of the subgenital plate outcurved and covered three fourth of the paraproct (Fig. 35g). Female with anterior or lower ovipositor valves reaching half of the way of posterior ovipositor valves reaching more than half of the paraproct and not touching the base along the inner margin, inner valves still visible (Fig. 35h).

Fifth Instar (Fig. 33-i-j)

Colour Same as previous instar. **Body** Male measuring 15.8 (15.0 to 16.5) mm. in length. Female Measuring 15.4 (15.0 to 16.0) mm. in length. **Head** measuring 3.04 (3.0 to 3.1) mm. n = 25, in length and 4.88 (4.8 to 5.0) mm. n = 25, in breadth. **Female** Measuring 3.05 (2.9 to 3.2) mm. n = 25, in length and 5.0 (4.8 to 5.2) mm. in breadth. **Eyes** with 5 eye-stripes measuring 1.25 (1.2 to 1.3) mm. n = 25, in length. **Antennae** with 18 segments, first 14 annuli of flagellum clearly segmented but in others two incomplete annuli segment and measuring 4.8 (4.7 to 5.0) mm. n = 25 in length (Figs. 34g-h). **Pronotum** with posterior margin of pronotum convex or outcurved, Male Measuring 3.5 (3.4 to 3.6) mm. n = 25 length. Female Measuring 3.48 (3.4 to 3.55) mm. n = 25, in length. **Wing pads** more larger and distinctly triangular in shape, trachiation more clearly appeared for future venation, Hind wing pad of male reaching upto the posterior margin of 3rd terga and measuring 4.53 (4.4 to 4.7) mm. n = 25, in length, hind wing pad of female rotated through 180° angle overlapping fore wing pad and reaching upto the middle of first abdominal tergite and measuring 3.7 (3.5 to 4.0) mm. n = 25, in length. **Hind femur** with upper basal lobe more longer than lower basal lobe and measuring 7.5 (7.4 to 7.6) mm. n = 25, in length.

External genitalia of male with subgenital plate more convex or outcurved, posterior margin obtusely conical and reaching just above the end of the paraprocts (Fig. 35i). Female with anterior or lower ovipositor valves more longer and angular in shape and reaches upto three fourth length of the upper or posterior ovipositor valves and posterior ovipositor valves reaches just above the end of the paraproct, a denticular projection appeared in between the anterior ovipositor valves basally, inner valves completely overlapped (Fig. 35j).

Sixth Instar (Fig. 33k)

Colour Same as previous instar. **Body** Measuring 21.00 (19.0 to 23) mm. n = 25, in length. **Head** Measuring 3.96 (3.8 to 4.1) mm. n = 25, in length and 6.1 (5.8 to 6.3) mm. n = 25, in breadth. **Eyes** with six eye-stripes and measuring 1.52 (1.5 to 1.56) mm. in length. **Antennae** with 20 segments first 16 annuli completely segmented and with markings on 2 more segments and measuring 5.72 (5.3 to 6.2) mm. n = 25, in length (Fig. 34i). **Pronotum** measuring 5.18 (4.8 to 5.3) mm. n = 25, in length. **Wing pads** with hind wing pad more larger in size reaching above or just touching the posterior margin of third tergite. **Hind femur** with upper basal lobe more longer than lower basal lobe and measuring 9.27 (9.1 to 10.5) mm. n = 25, in length. **External genitalia** of male with subgenital plate completely covered the paraprocts and tip reaching beyond the paraprocts (Fig. 35h). **External genitalia** of female with anterior or lower ovipositor valves reaching before the end of posterior ovipositor valves and posterior ovipositor valves extending beyond the paraprocts.

BIOLOGY OF SOME GRASSHOPPER SPECIES

The study of the life history of grasshopper pests are not only important from the academic point of view but it will also help in formulating the control measures of these insect pests. Therefore a detailed life history of the pest grasshoppers have been conducted in the laboratory of the following species *Phlaeoba infumata* ; *Spathosternum prasiniferum prasiniferum* ; *Aiolopus thalassinus tamulus* ; *Acrida exaltata* ; *Atractomorpha crenulata*. The characters of different instars of each species have already been discussed in the previous chapter. The following further observations were made in this regard. Mean life cycle of studied grasshoppers were completed within 83.16 to 121 days in male and 89.06 to 136.8 days in female. The mean incubation period of the studied grasshoppers varied from 20 to 26.8 days and the total mean life span from hatching until death were 62.1 to 95 days in male and 68.0 to 110 days in female.

Mechanism of Moulting

Before moulting each nymph selects and isolated area like leaf blades and stem of grasses which were provided to them as food and some times the wall or net of the cages. They held those objects firmly with their legs and keep their head downwards. The nymph then moved its abdomen rhythmically, as a result, the cuticle ruptured along the mid dorsal line of the head region. The antennae then drew upward to lie against the frons and started to remove the old cuticle. The rupture of the cuticle gradually extended from the head through wings over the abdomen upto seventh segment. Then it slowly remove the cuticle from the body which then adhered to the tip of the abdomen and ultimately it was removed by the hind legs. An average of 15 to 30 minutes time being taken for splitting the cuticle, till the insect was completely free from the exuviae.

Sexual Maturation and Precopulation Period

Adults of all the grasshoppers attained sexual maturity without any change in their morphology. The time required from the final moulting to the first copulation period was noted. It varies from species to species and also from one sex to the other. The maturation was obtained to take place in 5 to 7 days in male and 7 to 9 days in female in *Phlaeoba infumata* , 2-4 days and 4-7 days in *Spathosternum prasiniferum prasiniferum* , 4-6 days and 5-8 days in *Aiolopus thalassinus tamulus* , 7-9 days and 10-13 days in *Acrida exaltata* , 3-6 days and 4-7 days respectively in *Atractomorpha crenulata* (Table 1-5). Sometimes the female become ready for copulation after 24 hours of the last moult (Table 1-5).

The type of copulation appeared to be the "riding type" in short horned grasshoppers in

general. In this process the male ride on the back of female in an end to end position. Besides this, two other types are also found dorsolateral position, where the male and females remain side by side and the opposite position, keeping the head in opposite direction.

Copulation appeared to take place more actively during the day time from 8.30 am to 5.00 pm. The mode of copulation and its duration varies very little from species to species among these grasshoppers. After attaining the sexual maturity, male *Phlaeoba infumata* crawled towards its female partner and touched the body with the help of antennae. After courtship for about 5 to 10 minutes the female partner allowed her mate to copulate. Prior to this phenomenon, the abdomen of the male was bent towards the right side of female and the terminal end of both sexes are interlocked. The cerci of the male played an active role in the process of interlocking. The fore legs held the posterior thorax or the first abdominal segments keeping hind pair of legs free. Sometimes, the hind pairs of legs of the male hold the hind legs of the female. The mating lasted for about 20 to 50 minutes sometimes extending upto 3 hours. A pair was observed to copulate 4 to 7 times in the laboratory. The females were seen to be copulated by the male even after the first or second oviposition.

In *Spathosternum pr. prasiniferum*, male bent its abdomen either from the left or from the right side. The duration of copulation ranged from 30 to 150 minutes, extending upto 480 minutes in many cases. The process in *Aiolopus th. tamulus* seemed alike as *spathosternum pr. prasiniferum* except the terminal part of the abdomen of the female at the time of interlocking remained downward in vertical position and it did not move for grazing. The entire process lasted generally for 20 to 35 minutes with extension upto 70 minutes. The copulation was noted 3 to 6 times for a pair. The process of copulation in *Acrida exaltata* was observed similar to that of previous one but these species preferred to use lateral side mode for copulation more often as the male was much smaller in size than the female. Each pair copulated 2 to 5 times and copulation lasted for about 40 to 120 minutes extending upto 720 minutes.

In *Atractomorpha crenulata* the process of copulation was also as that of the previous one. The copulation normally lasted for about 30 to 130 minutes with a frequency of 3-6. in the laboratory the duration of copulation lasted for about 660 minutes in some exceptional cases. During copulation the female did not take any food. Sometimes it was observed that the male paused for a while on the back of the female even after the completion of the copulation.

Interval between copulation and oviposition

the interval between copulation and the first laying of egg was found to vary from individual to individual and even from species to species depending upon the factors like temperature, humidity and availability of food. The females of *Phlaeoba infumata* deposited its first egg pod

after copulation in 8 to 15 days (M 11.75 days), *Spathosternum pr. prasiniferum* in 9 to 15 days (M 11.5 days), *Aiolopus th. tamulus* in 10 to 20 days (M 13.5 days), *Acrida exaltata* in 12 to 20 days (M 15.8 days). *Atractomorpha crenulata* deposited after 10 to 18 days (M 14.75 days) of intervals (Table 5-9).

Selection of sites for oviposition

The selection of sites by the females for deposition of egg-pods is very important, since successful hatching of eggs depends in the proper selection of sites by the female grasshoppers. Therefore, the type of soil texture is an essential factor for the deposition of eggs. The selection of sites by some major grasshoppers in the laboratory is described below.

The species *Phlaeoba infumata* moved from the wall, of the cage of leaf blade of grasses to the floor of the cage for selecting the suitable site for deposition of eggs. It was noticed that the species preferred soil with 20% to 25% moisture. On searching suitable soil it touched the top of soil bed with the antennae. It then removed the soil particles with the help of the apical part of the abdomen and pushed the ovipositor by raising the head and thorax portion of the body. The insect penetrated its abdomen a depth of 2.4 cm. to 6.6 cm. (M 5.2 cm.). The digging operation was accomplished by rotating the abdomen at an angle of 85° to 90° from right to left and viceversa. In this way the female made 2 to 6 holes in the soil but it would use only one hole for deposition the egg pods and others remained unused. As the ovipositor was pushed down into the soil, the abdominal segments extended gradually to almost double the length of its normal length. The time taken for this entire operation was normally found to range from 10 to 30 minutes but it might extend to 40 minutes. A similar pattern of oviposition behaviour was also seen in case of *Spathosternum pr. prasiniferum*. The grasshopper preferred a medium of loose soil containing 20% to 25% moisture in the soil. The species deposited its egg pod to a depth of 1.2 cm. to 2.4 cm. (M 2.0 cm). During the digging operation the abdomen rotated from 80° to 85° angles. The time taken by the grmslr in drilling varied from 6 to 10 minutes extending sometimes to 25 minutes. The gravid female of *Aiolopus th. tamulus* showed a peculiar behaviour. It became restless moving here and there to find suitable site for oviposition with the aid of its antennae. It preferred 13% to 18% of soil moisture to make a hole in 10 to 20 minutes in the usual manner. The depth of the hole measured from 2.8 to 5.3 cm. (M 4.3 cm) and the abdomen of the individual rotated therein at angle of 70° to 90° The female *Acrida exaltata* preferred about 20% to 27% moisture in the soil. The process of digging operation was same as before except the abdomen was introduced to more depth than other three species. The depth of the hole was measured 9 cm. to 12.5 cm. (M 10.8 cm.) and it took time about 20 to 45 minutes in making the hole. In case of *Atractomorpha crenulata* the female preferred loose soil with sufficient moisture of 28% to 38%. The egg-pods were laid to a depth of about 2.5 cm. to 3.9

cm. (M 3.2 cm.) and the abdomen was rotated from 75° to 85° angle. The entire process of making hole took about 18 to 50 minutes (Table 4-5).

Oviposition

The gravid female of all these species of grasshoppers after selection of sites, put the tip of the abdomen to the desired depth in the hole made by her and retractors its abdomen slightly. Before laying of eggs a spongy silvery white secretion was squeezed out of the accessory gland through the tip of the abdomen. This glandular secretion with the help of surrounding soil formed a tube like structure known as egg-pod. The secretion actually acts as an adhesive to harden the wall of the cases. When the egg reached the tip of the abdomen, the secretion stopped for a while and light yellow eggs with foamy substances were laid. During the deposition of eggs, the abdomen contracted a little but never rotated. When the egg laying was complete some more substances came out and after that the female lifted its abdomen and sealed the hole with a plug made up of soil and forthy materials. This whitish forthy material when comes in contact with air turned into a deep brown colour. The abdomen and hind legs played the main role in plugging of egg pod. After oviposition the female remained quiet for a while. The time required for deposition of eggs and the release of forthy secretion of different species are given in (Tables 5-9). The abdominal tip of each of these species when reached upto their desired depth for deposition of egg in the soil, the abdomen contracted a little before deposition. The contraction varies from species to species ranging approximately from 0.15 to 0.50 cm.

Post oviposition period

The longevity of the females after deposition of eggs varied from species to species. In the present observation the following longevity has been recorded.

After completion of laying of egg-pods the female of all the above mentioned species become sluggish, less active lose weights and ultimately die *Phlaeoba infumata* died within 10 to 14 hours. The longevity of an adult *Phlaeoba infumata* female varies from 25 to 40 days (M 34.4 days). In case of *Spathosternum pr. prasiniferum* female varies from 17 to 43 days (M 32.5 days) , *Aiolopus th. tamulus*, the female required 31 to 43 days (M 33.5 days) , In *Acrida exaltata* the longevity was 53 to 73 days (M 62.5 days) in female , Similarly the female *Atractomorpha crenulata* required 26 to 41 days (M 35 days).

Incubation period

The Period from the deposition of egg into soil upto the period of hatching is known as

incubation period of the egg. The incubation period of each species was as follows *Phlaeoba infumata* 18-23 days (M 20.26 days) (Tab. 10) , *Spathosternum pr. prasiniferum* 19-24 days (M 21.06 days) (Tab. 14) *Aiolopus th. tamulus* 19-22 days (M 21.33 days) (Tab. 12) *Acrida exaltata* 20-26 days (M 22.8 days) (Tab. 13) , *Atractomorpha crenulata* 16-24 days (M 20.0 days) (Tab. 14).

Hatching

Before hatching the embryo performs a vigorous wrigling movement of the body inside the egg-pod. the hatching starts at the top of egg-pod with occurrence of orifice and ultimately it ruptures and through which the 'vermiform larvae' emerges on the soil surface with the head directed upward and become enclosed within a thick transparent membrane like sac, but separate sleeves for the legs, the distal part of the antennae and cerci. After reaching the soil surface the cuticle of larvae ruptured along the dorsum of the head and thorax by vigours knocking of the cervical ampulla and by wrigling movement of the body and lastly the membrane from the hind legs. These shedding of skin is known as intermediate moult.

The hatching period

In *Phlaeoba infumata*, the hatching took place with 12 to 35 minutes or upto 10 hours in some exceptional cases. The hatching period of *spathosternum pr. prasiniferum* eggs varies from 10 to 20 minutes or more with a maximum period of 6 hours. The eggs of *Aiolopus th. tamulus* generally hatched within 15 to 25 minutes or extends upto 16 hours. Eggs of *Aerida exaltata* hatched within 35 to 50 minutes, sometime extending up to 24 hours. *Atractomorpha crenulata* needs 25 to 65 minutes to hatch, which sometime extended upto 12 hours.

The time for intermediate moulting requires 25 seconds to 3 minutes in *Phlaeoba infumata* , 15 seconds to 2 and half minutes in *spathosternim or. prasiniferum* , 12 seconds to 3.5 minutes in *Aiolopus th. tamulus* , 30 seconds to 4 minutes in *Acrida exaltata* , and 10 seconds to 2.6 minutes in *Atractomorpha crenulata*.

Egg-Pods and Eggs

In grasshopper the number of egg-pods laid by a female was directly proportional to the frequency of mating. The fertility was observed after counting the total hatched nymphs of an egg pod and the remaining unhatched eggs were considered as the unfertilised eggs. The mortality of the egg was estimated by counting the number of unfertilised eggs present in the pod. It was estimated that *Phlaeoba infumata* laid 1 to 4 egg pods (M 2.8) in her life time and the

number of eggs per pod was from 8 to 25 (M 15.4). The number of pods deposited by *Spathosternum pr. prasiniferum* was 3 to 4 (M 3.5) containing 7 to 14 eggs (M 11.6) per pod (Tab. 17). *Aiolopus th. tamulus* deposited 2 to 4 egg pods (M 3.12), each having 14 to 47 (M 24.0) eggs per pod *Acrida exaltata* laid 4 to 7 egg pods within her life time having 15 to 56 (M 41.4) eggs in each pod (Tab. 19) and *Atractomorpha crenulata* deposited 3 to 4 (M 3.5) pods in her life time with 10 to 66 eggs in a pod (Tables 5-9).

Out of 290 eggs in 15 egg pods 276 were seen to hatch (95.17%) in *Phlaeoba infumata* In *Spathosternum pr. prasiniferum* out of 174 eggs in 15 egg pods 156 were developed (90.20%). Out of 360 eggs of 15 egg pods in *Aiolopus th. tamulus* 328 nymphs emerged (91.11%). In *Acrida exaltata* out of 414 eggs in 10 egg pods 390 nymphs came out (94.27%) and where as in *Atractomorpha crenulata* out of 544 eggs pods 485 were hatched (89.15%).

Sex ratio

Sex ratio of the emerging grasshopper have been calculated from first instar nymph and the number of each sexes were expressed in percentage. (Tables 10-14). On the basis of 276 exs. obtained from 15 selected egg pods of *Phlaeoba infumata*, it was observed that the percentages of male and female were 53.62% and 46.38% respectively, In *Spathosternum pr. prasiniferum* percentage of male was 54.14% and female was 45.86% in 157 exs. after 15 egg pods, In *Aiolopus th. tamulus*, the percentage of male was 49.70% and female 50.30% from 328 exs. The percentage of male was 51.50% and the female was 48.50% in case of 390 exs. of *Acrida exaltata*. In *Atractomorpha crenulata* the same being 8.40% and 51.56% from 485 examples in 15 egg pods.

Mortality of nymphs

In the present investigation, 100 hoppers were encountered for each of the following species for studying the percentage of mortality. The rate of nymphal mortality of *Phlaeoba infumata*, *Spathosternum pr. prasiniferum*, *Aiolopus th. tamulus*, *Acrida exaltata* and *Atractomorpha crenulata* respectively were 24%, 20%, 16%, 26% and 30%. The maximum nymphal mortality was observed in case of *Atractomorpha crenulata*. In general it was observed that the maximum rate of mortality was recorded in the first instar while minimum being in the 3rd instar in male and 4th instar in female (M 35.5 days).

Number of moulting and duration of nymphal stages

From table 15, it may be observed that the number of moults and their duration appeared

to vary from species to species. The nymphs of *Phlaeoba infumata* were found to pass through 5 moults in male and 6 in female to reach the adult stage. Instars of the male and female of *Spathosternum pr. prasiniferum* was variable. Normally there were 5 moults in male and 6 moults in females (excluding the intermediate) moult of vermiform larvae. In *Aiolopus th. tamulus* there occurred 5 moults in male and 6 moults in females. *Acrida exaltata* generally passed through 5 moults in male and 6 moults in female. Sometimes one additional moults were found in that case i.e. male became adult after 6 moult and female became adult after 7 moult. The number of moults in *Atractomorpha crenulata* was 5 in male and 6 in female, the 6th instar being the adult for male and 7th instars being the adult for female, extra moult was not evident in any case.

It may be evident from the table 15, that the total duration of nymphal stages of male *Phlaeoba infumata* were found to range from 32 to 44 days (M 36.2 days) and that of female from 38 to 45 days (M 41.5 days). In *Spathosternum pr. prasiniferum* the total duration of nymphal stages of male were from 30 to 36 days (M 34.3 days) and 33 to 38 days (M 35.5 days) in female, while in *Aiolopus th. tamulus* were 26 to 34 (M 31 days) and in female 34 to 44 days (M 37.0). In case of *Acrida exaltata* it ranged from 34 to 48 days (M 40) in male and 45 to 55 days (M 47.5 days) in male and in 35 to 40 days (M 36.8 days) in female (Table 15).

Cannibalism

Some of the grasshoppers were observed to feed the exuviae or shed skin and the dead bodies of their fellows the healthy one seemed to bite the weaker ones. It was noticed that the phenomenon is more pronounced in *Phlaeoba infumata* and *Aiolopus th. tamulus*, and *Acrida exaltata* but the cannibalism started from third instar in male and fourth instar in female. Cannibalism was not noted in *Spathosternum pr. prasiniferum* and *Atractomorpha crenulata*.

ECOLOGICAL STUDIES AND POPULATION FLUCTUATIONS

The grasshopper fauna obtained from the site consisted of 12 species under 11 genera namely *Atractomorpha crenulata*, *Gesonula punctifrons*, *Spathosternum prasiniferum prasiniferum*, *Oxya fuscovittata*, *Oxya hyla hyla*, *Phlaeoba infumata*, *Acrida exaltata*, *Aiolopus thalassinus tamulus*, *Tristria pulvinata*, *Triolophidia annulata*, *Eyprepocnemis alacris alacris*, *Eupreponotus inflatus* (Table 16). The species *Spathosternum prasiniferum prasiniferum* was the most dominant (42.68% of total population) taxa. The species *Atractomorpha crenulata* (41.28%) *Oxya fuscovittata* (32.43%), *Phlaeoba infumata* (32.20%) and *Oxya hyla hyla* (17.38%) occupied second third, fourth and fifth position respectively in order of dominance. The population of other species was numerically low and highly irregular in distribution pattern (Fig. 36-45).

Population Fluctuations

It is evident from the Table 17 that the annual maxima and minima of total grasshopper population including male, female and nymph exhibited three major peaks throughout the sampling period. Highest peak was observed during November (12.08%), August (11.60%) and minimum was observed in December (3.08%). The population maxima of the five pre-dominant grasshoppers species when considered individually varied from month to month. *Spathosternum prasiniferum prasiniferum* showed their peak in August (Fig. 36). *Atractomorpha crenulata* showed its peak in may (Fig. 37), *Oxya fuscovittata* was maximum in July (Fig. 38) *Phlaeoba infumata* showed 2 peaks one in February and other during November (Fig. 39) and *Oxya hyla hyla* showed their annual maxima during July and October (Fig. 40). The maximum population of male (4.88%), female (2.88%) and nymphs (5.40%) were recorded in August, November and May respectively (Tables 18-20). When the total male, female and nymph population were taken into account, it showed that nymph constituted the major portion of total populations (46.02%), then male (34.82%) and minimum population was that of female (19.16%). Beside five species the other species namely, *Atractomorpha crenulata*, *Gesonula punctifrons*, *Spathosternum prasiniferum prasiniferum*, *Phlaeoba infumata*, *Oxya hyla hyla*, *Acrida exaltata* and *Eyprepconemis alacris alacris* were also obtained in each month of the year.

Table 4. Districtwise distribution of economically important grasshoppers of West Bengal

Name of the species	Districts
1. <i>Hieroglyphus banian</i>	Bankura , Burdwan , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia.
2. <i>Gesonula punctifrons</i>	Burdwan , Birbhum , Coochbihar , Darjeeling Howrah , Jalpaiguri , Medinipur , Murshidabad 24-Parganas , West dinajpur.
3. <i>Spathosternum pr. prasiniferum</i>	Burdwan , Birbhum Coochbihar Darjeeling Howrah , Hoogly , Jalpaiguri Malda , Murshidabad Nadia 24-Parganas Purulia West dinajpur.
4. <i>Oxya fuscovittata</i>	Bankura , Birbhum , Burdwan , Coochbihar , Darjeeling , Howrah , Jalpaiguri , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas.

Name of the species	Districts
5. <i>Oxya hyla hyla</i>	Bankura , Birbhum , Burdwan , Coochbihar , Darjeeling , Howrah ; Jalpaiguri , Medinipur , Murshidabad , 24-Parganas , Purulia , West dinajpur.
6. <i>Oxya nitidula</i>	Darjeeling , Jalpaiguri , Maldah , Medinipur , 24-Parganas , Purulia.
7. <i>Tristria pulvinata</i>	Burdwan , Howrah , Jalpaiguri , Nadia , 24-Parganas , Purulia.
8. <i>Eupreponotus inflatus</i>	Darjeeling , Howrah , 24-Parganas.
9. <i>Eypreocnemis al. alacris</i>	Burdwan , Bankura , Birbhum , Darjeeling , Maldah , Medinipur , 24-Parganas.
10. <i>Catantops pinguis innotabilis</i>	Bankura , Darjeeling , Coochbihar , Maldah , Medinipur , 24-Parganas.
11. <i>Cyrtacanthacris tatarica</i>	Bankura , Burdwan ; Darjeeling , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia.
12. <i>Acrida exaltata</i>	Bankura , Birbhum , Burdwan , Coochbihar , Darjeeling , Jalpaiguri , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia , West dinajpur.
13. <i>Phlaeoba infumata</i>	Burdwan , Coochbihar , Darjeeling , Howrah , Jalpaiguri , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia.
14. <i>Aiolopus th. tamulus</i>	Bankura ; Birbhum , Burdwan , Coochbihar , Darjeeling , Hoogly , Howrah , Jalpaiguri , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia.
15. <i>Oedaleus abruptus</i>	Bankura , Birbhum , Burdwan , Coochbihar , Darjeeling , Jalpaiguri , Maldah , Medinipur , Murshidabad , Nadia , 24-Parganas , Purulia.

- | | |
|---|---|
| 16. <i>Trilophidia annulata</i> | Bankura , Birbhum , Burdwan , Darjeeling ,
Howrah , Hoogly , Jalpaiguri , Maldah , Medinipur
Murshidabad , Nadia , 24-Parganas , Purulia. |
| 17. <i>Choroedocus robustus</i> | Darjeeling , Jalpaiguri , Medinipur , 24-Parganas. |
| 18. <i>Atractomorpha crenulata</i> | Bankura Birbhum Burdwan Darjeeling
Jalpaiguri Maldah , Medinipur Murshidabad
Nadia , 24-Parganas , Purulia. |
| 19. <i>Chrotogonus tr. trachypterus</i> | Bankura , Birbhum , Burdwan , Maldah , Medinipur ,
Murshidabad , Nadia , 24-Parganas , Purulia. |
-

ROLE OF PHYSICAL FACTORS ON GRASSHOPPER

It is clear from the present observations that minimum population of grasshoppers was associated with low humidity and low air temperature. It can be concluded that the moderate temperature and humidity (30°C and 70.2%) have direct influence with the maximum population of grasshoppers (Table 21).

STATISTICAL ANALYSIS OF ECOLOGICAL DATA

Data pertaining to physical factors and grasshopper populations were subjected to statistical analysis for finding out the regression correlation and dependence of number of grasshoppers (Y) on each of two variables (humidity and air temperature) considered here (Table 22). Regressions were shown in the 4th column of the (Table 32). The two physical factors namely air temperature and relative humidity showed a definite influence of the fluctuations and to some extent on the distribution of total grasshoppers fauna and also the individual species including its male, female and nymphs. Statistical analysis (Table 22) indicated that these two factors and direct positive correlation with almost all the grasshopper species, but not significant in most of the cases. The species *Gesonula punctifrons* showed a negative correlation with its total population and male population but female population had negative correlation with air temperature, but all these correlation were not significant. It might be concluded from this observation that the temperature and the humidity prevailing in this site were not favourable for this species. Besides this the population of male and female of *Oxya hyla hyla* showed negative non-significant correlation with humidity and the nymphs of *Eyprepocnemis alacris alacris* showed a negative non-significant correlation with humidity (Table 22).

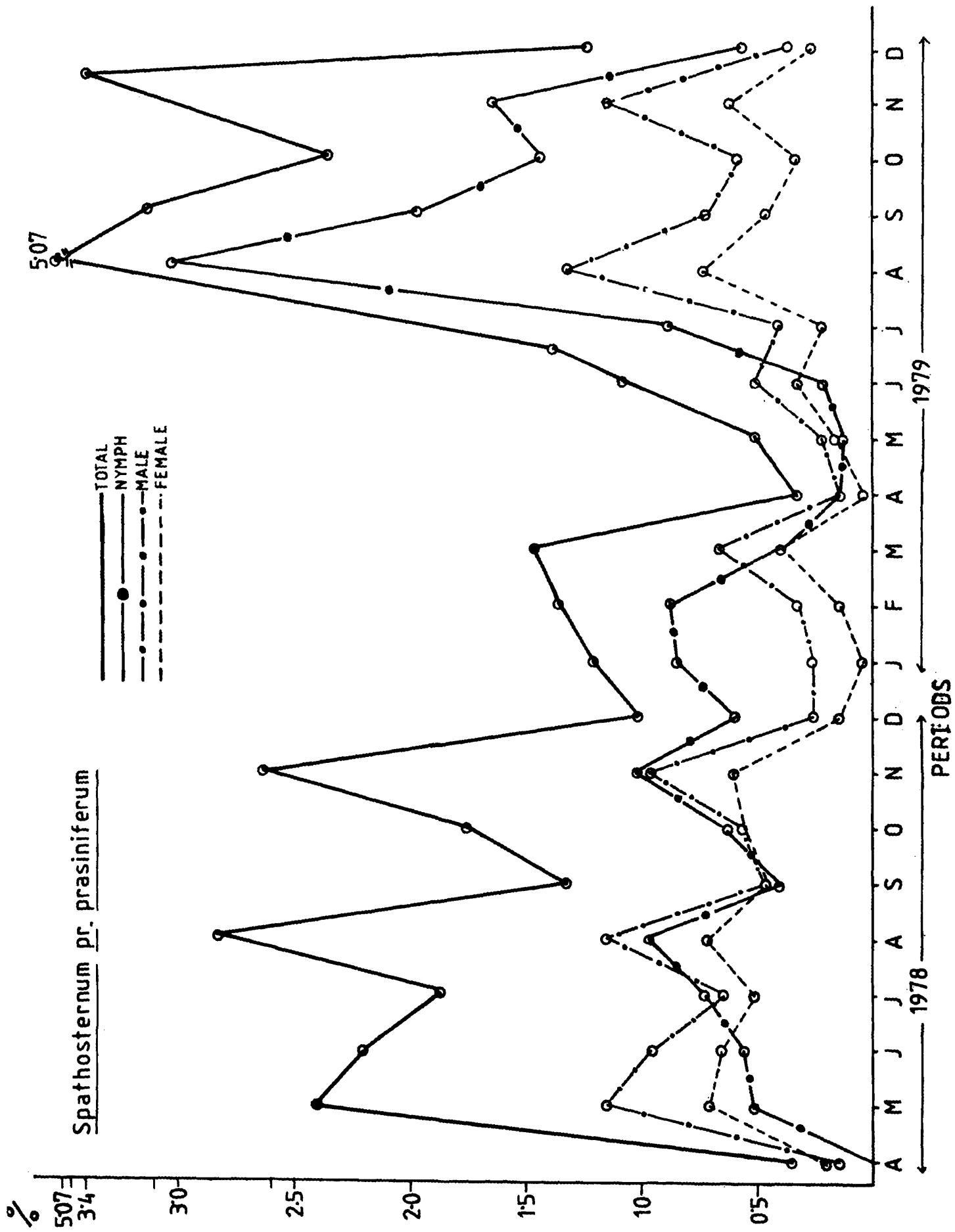


Fig no - 36

Fig. 36. Showing monthly fluctuations of population of *Spathosternum pr. prasiniiferum* (%)

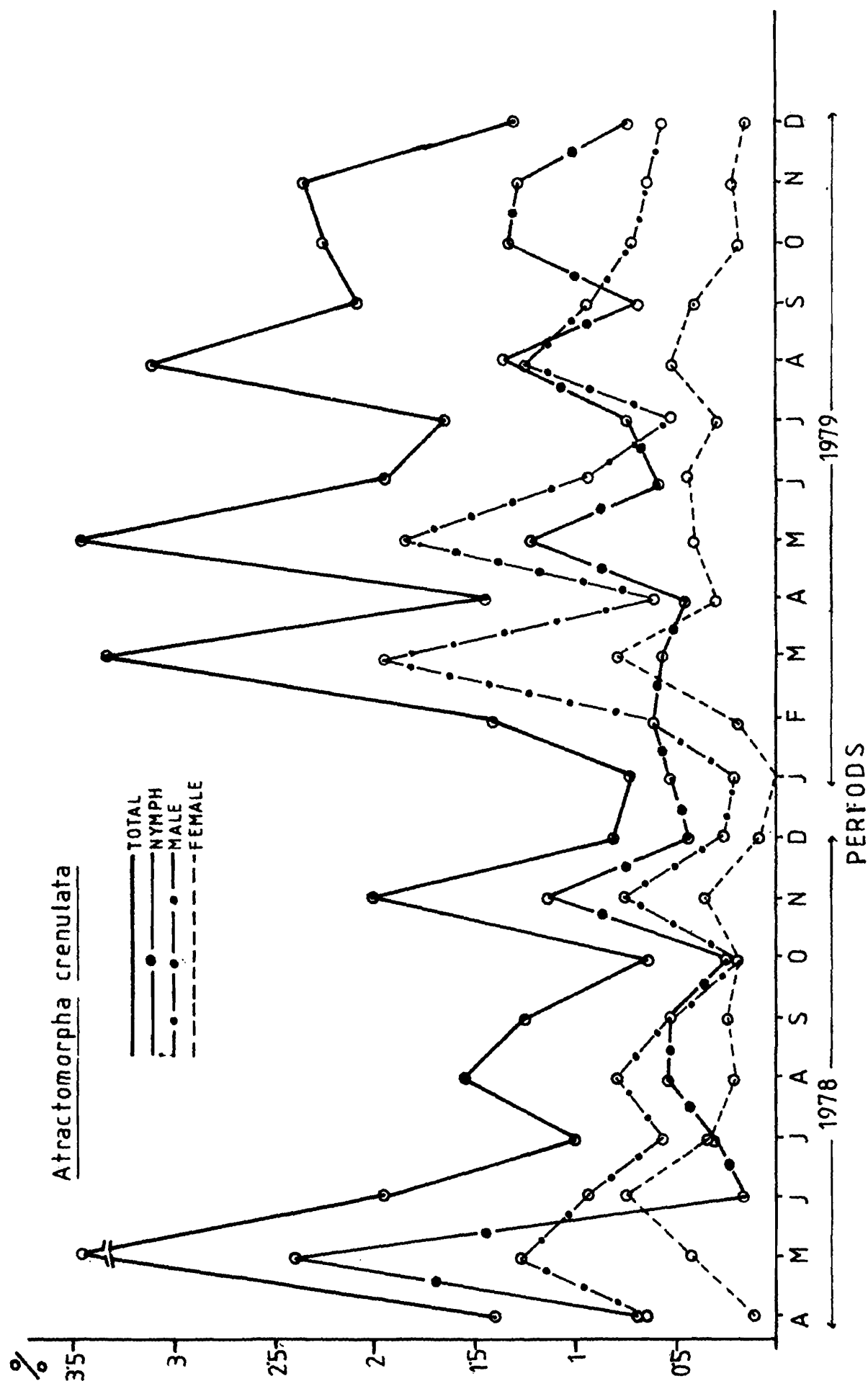


Fig. 37. Showing monthly fluctuations of population of *Atractomorpha crenulata* (%)

Fig. no-37

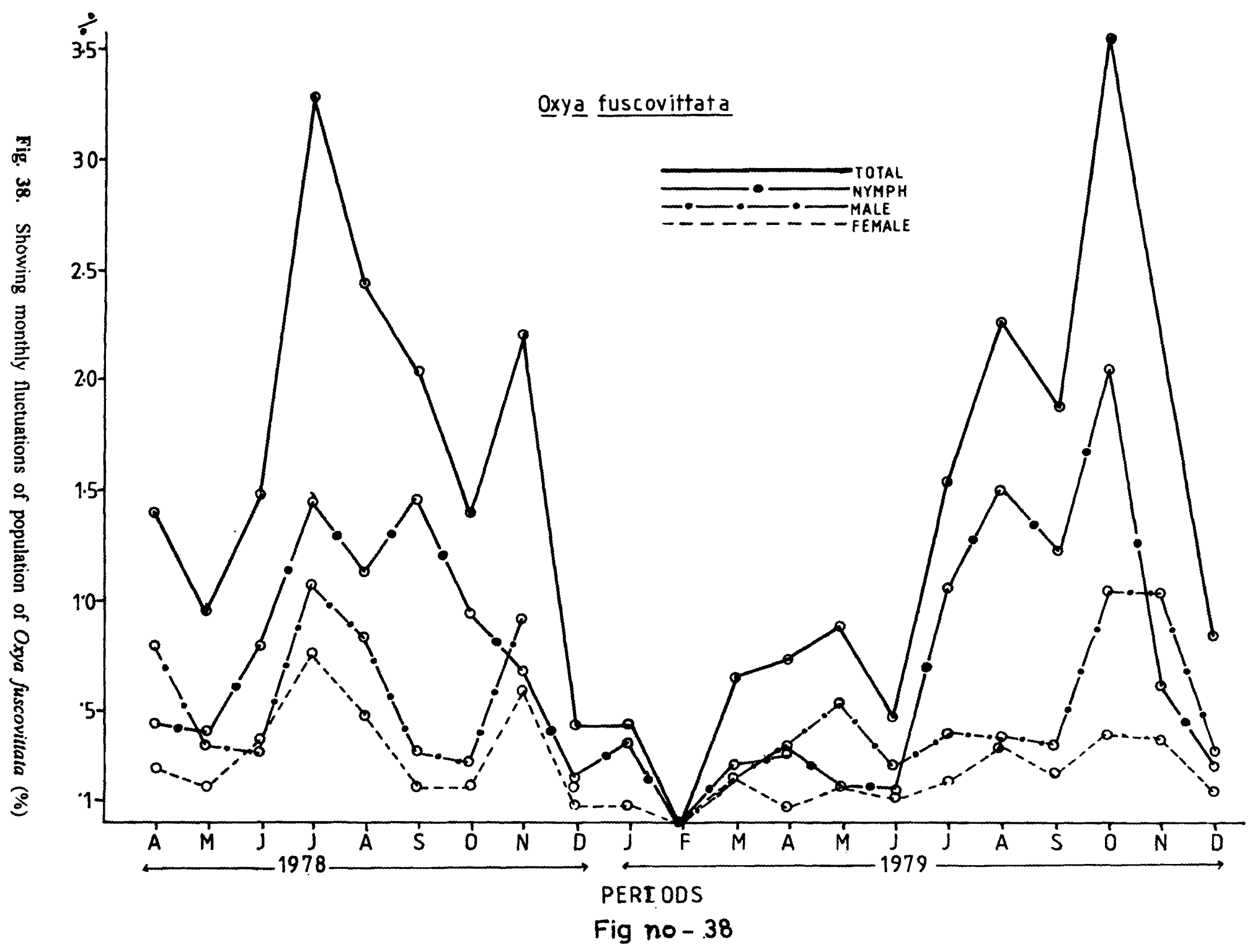


Fig. 38. Showing monthly fluctuations of population of *Oxya fuscovittata* (%)

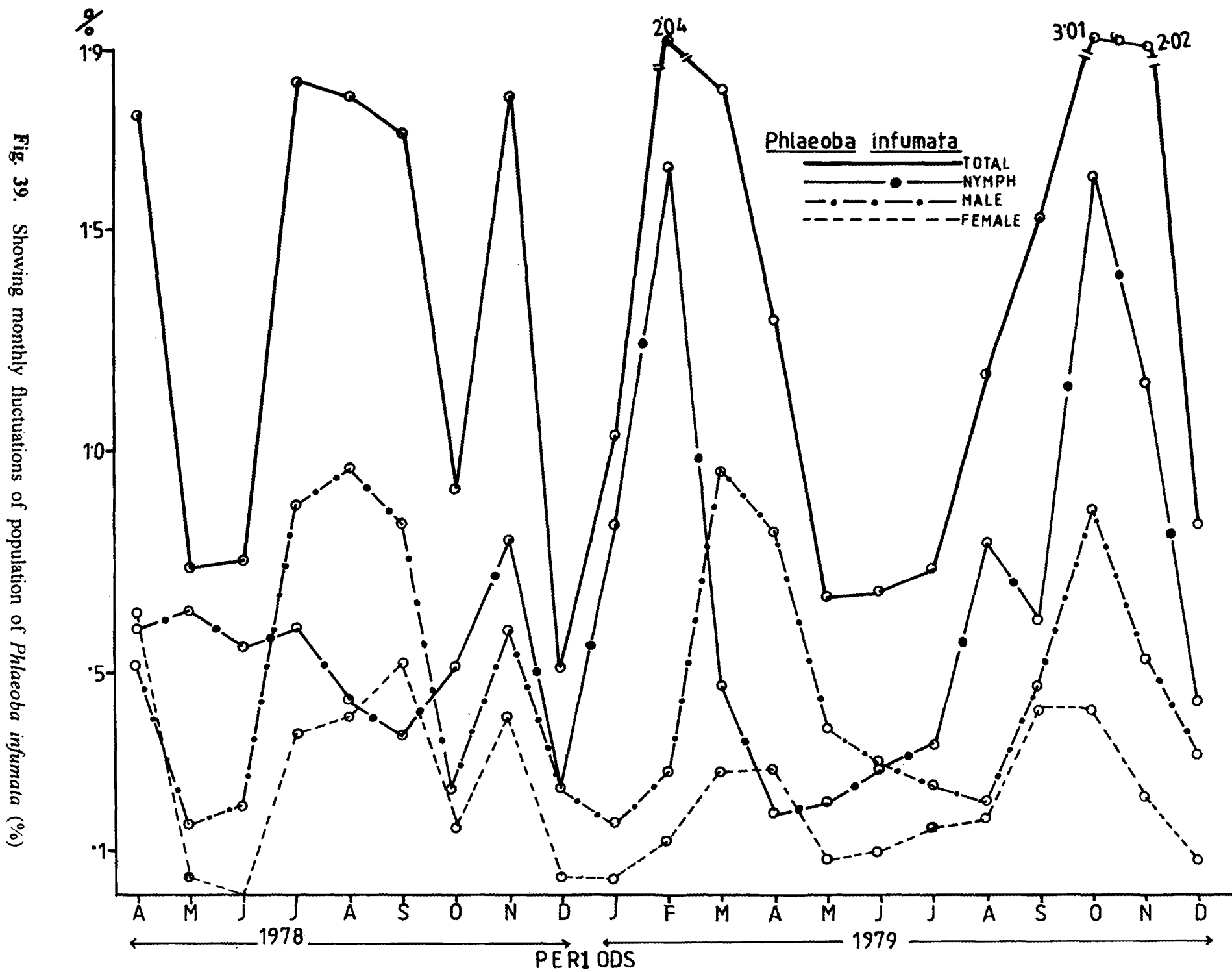


Fig. no - 39

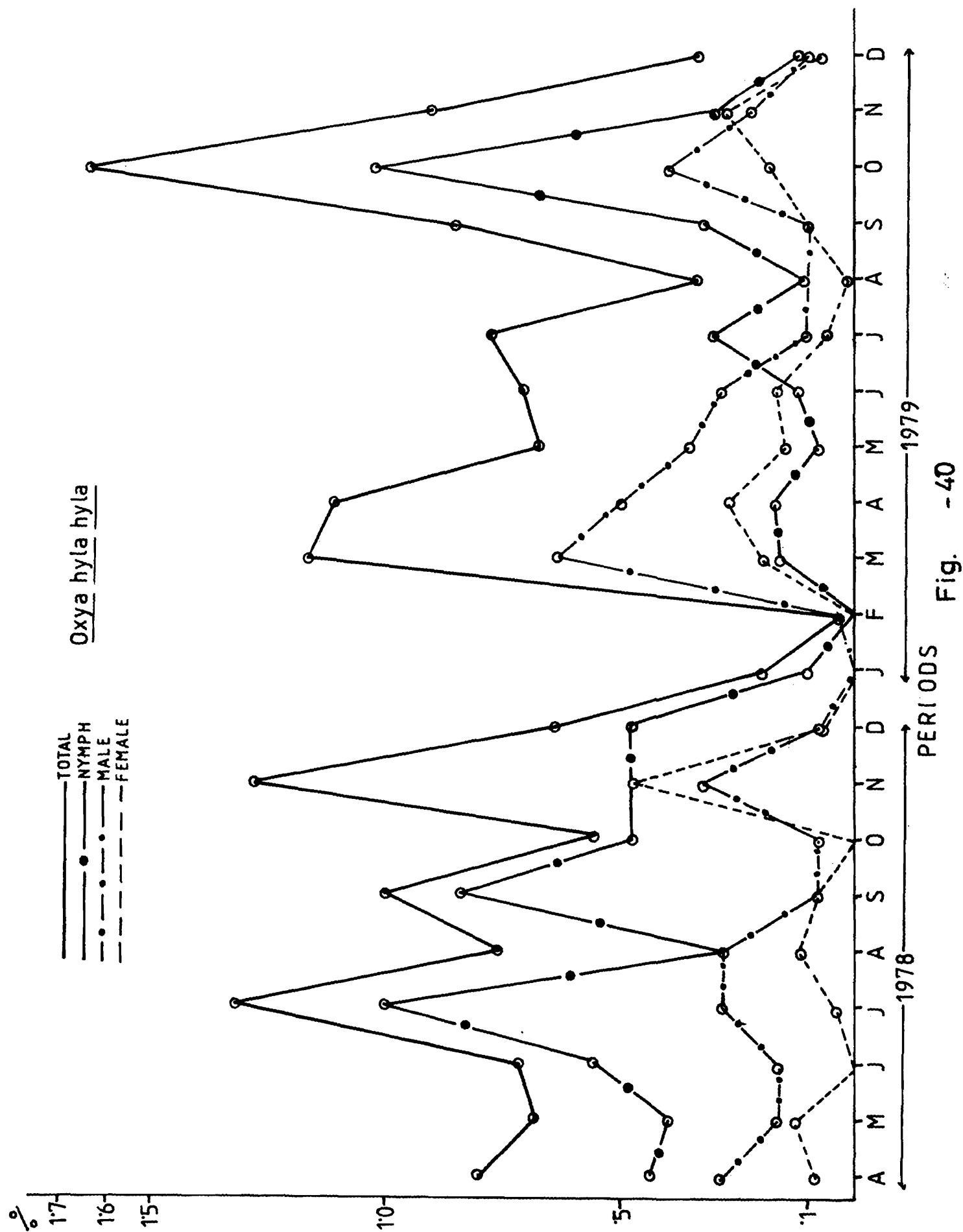


Fig. 40. Showing monthly fluctuations of population of *Oxya hyla hyla* (%)

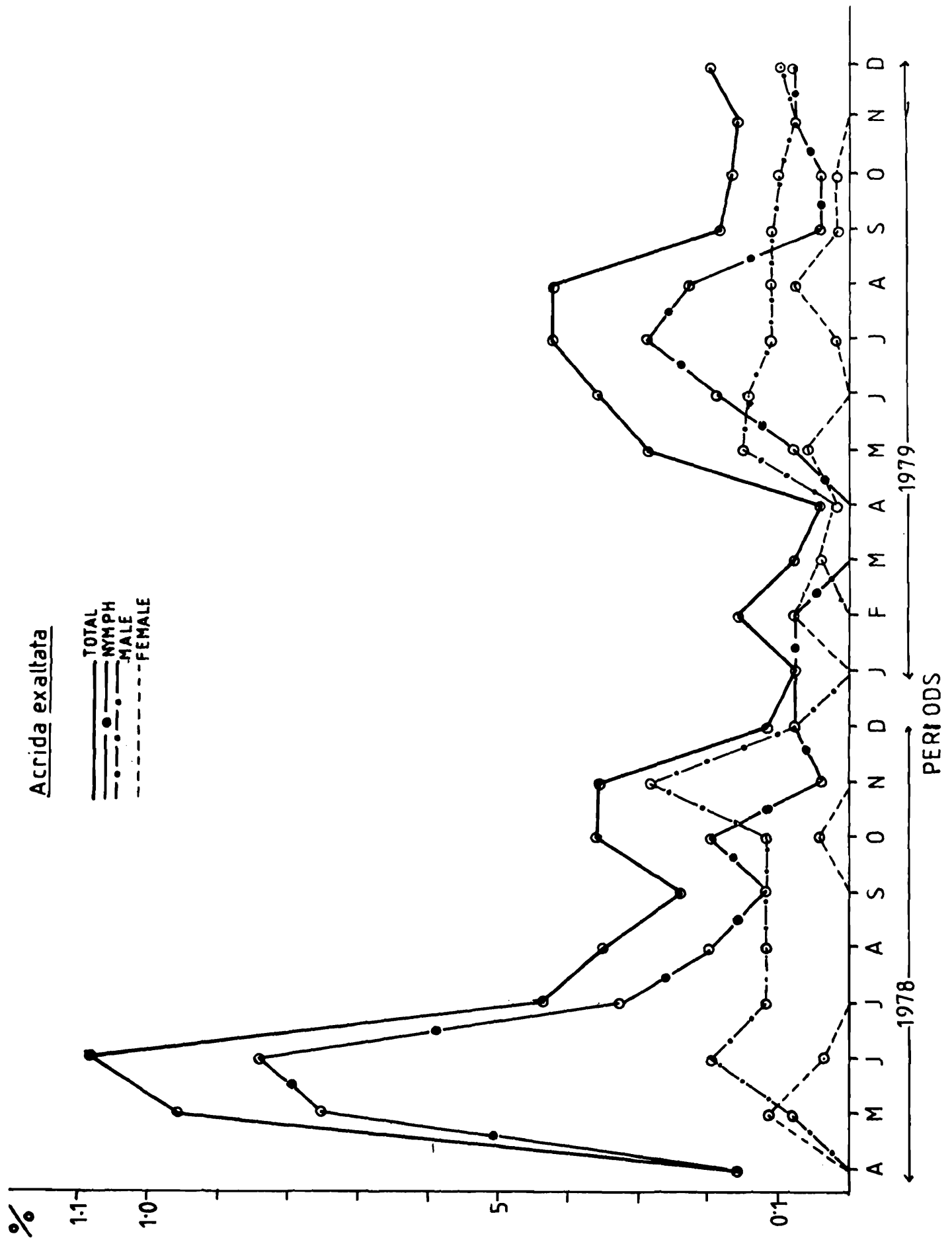


Fig. 41

Fig. 41. Showing monthly fluctuations of population of *Acrida exaltata* (%)

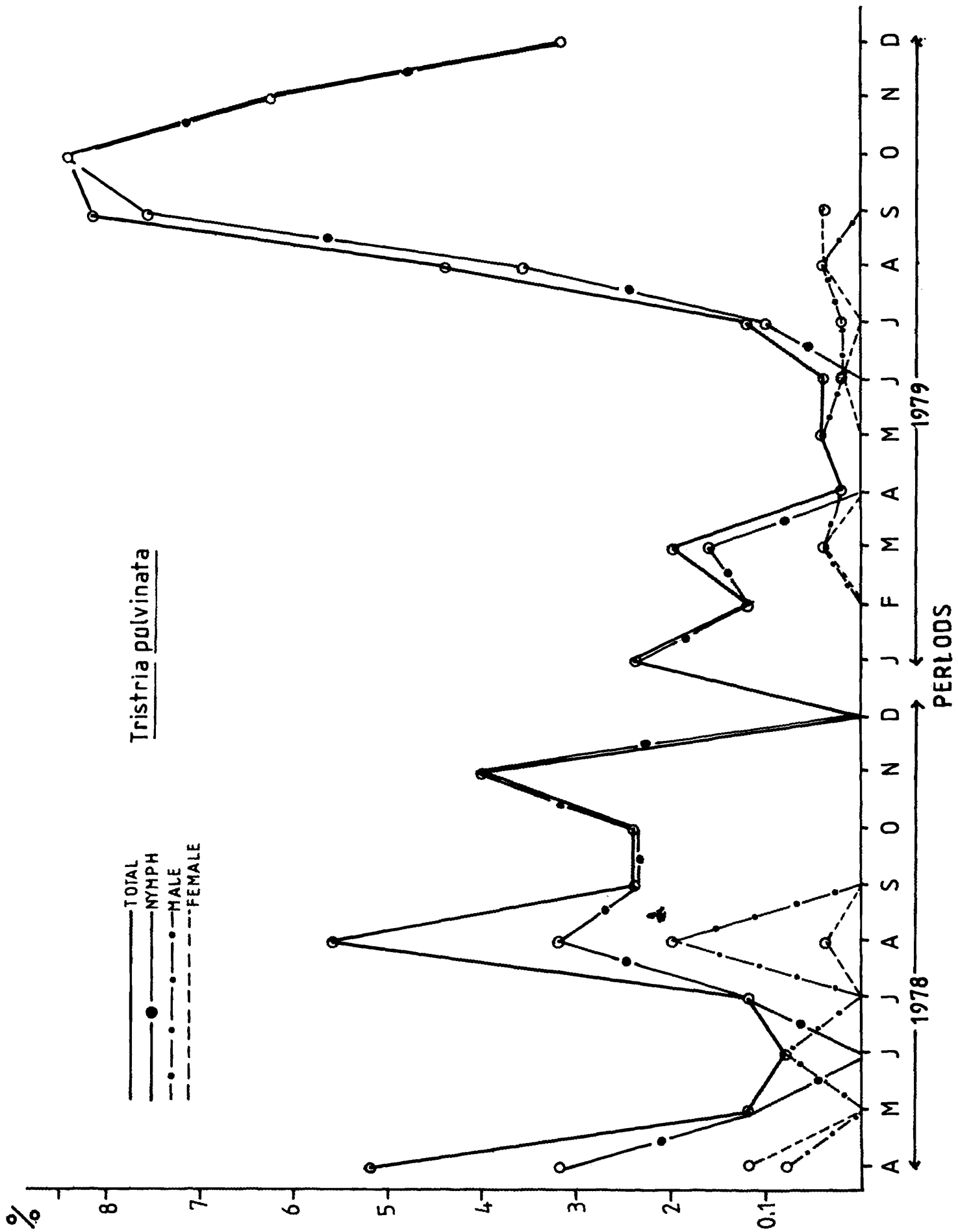


Fig. 42

Fig. 42. Showing monthly fluctuations of population of *Tristria pulvinata* (%)

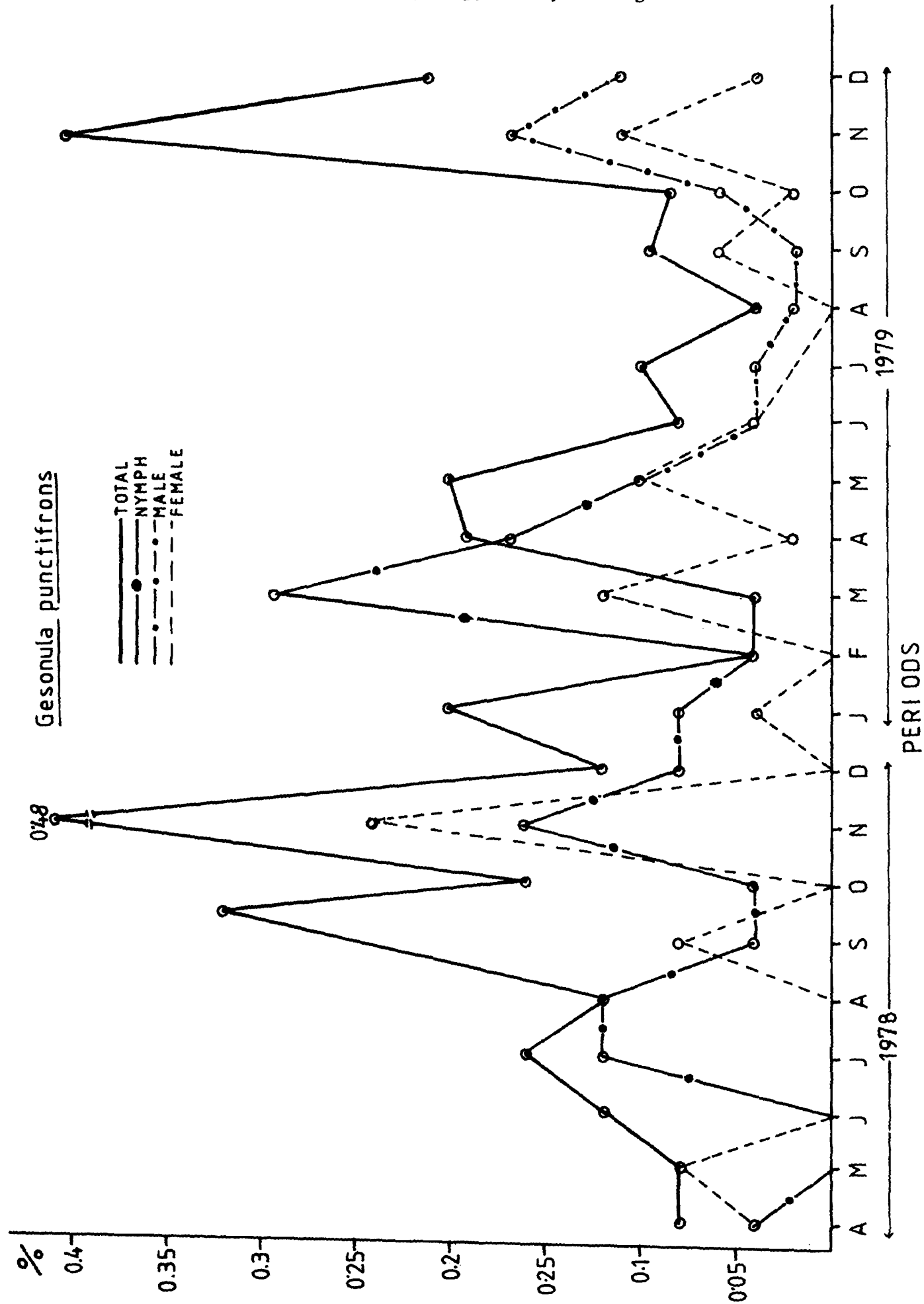


Fig. 43. Showing monthly fluctuations of population of *Gesonula punctifrons* (%)

Fig. -43

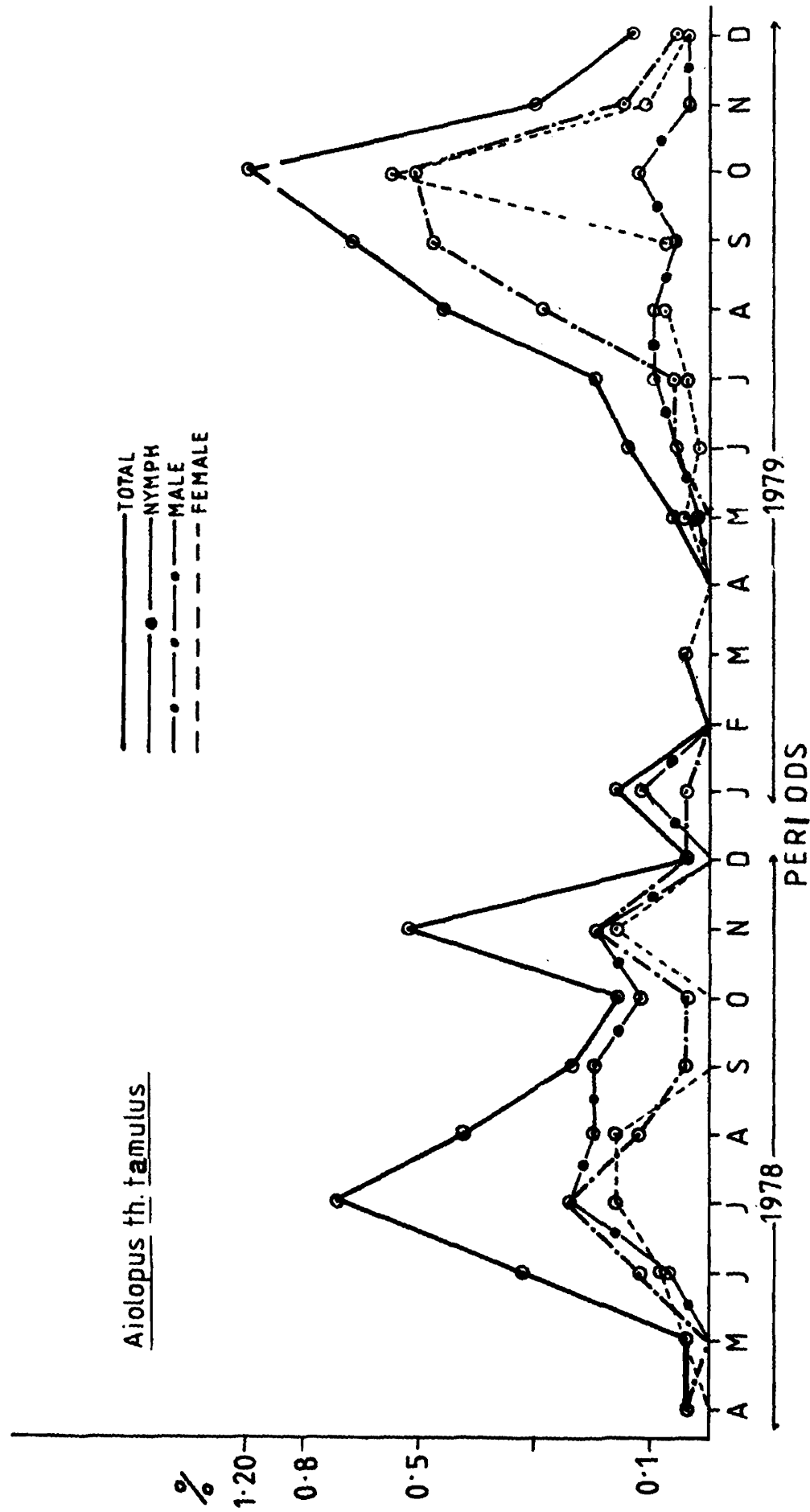


Fig. no-44

Fig. 44. Showing monthly fluctuations of population of *Aiolopus th. tamulus* (%)

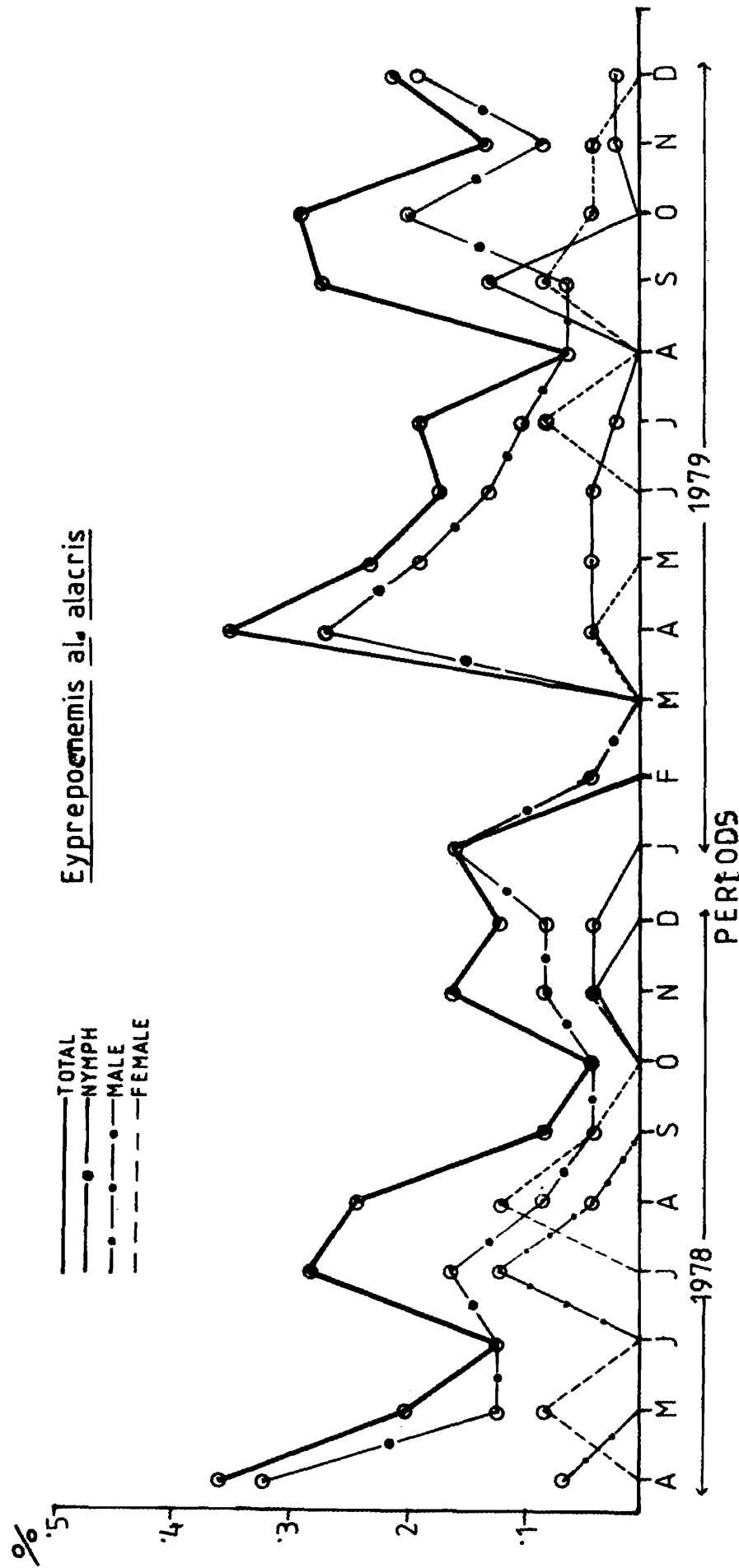


Fig. 10-45

Fig. 45. Showing monthly fluctuations of population of *Eyprepocnemis al. alacris* (%)

Table 5 : Showing the oviposition of *Phlaeoba infumata* recorded in the laboratory

Sl. No.	Date of final moult	Date of first	First oviposition date & Time		Time (Min)	Preoviposition (Days)	Time taken between first copulation and oviposition
			St.	End			
1.	26.04.82	03.05.82 (7 days)	15.05.82 (12.15 p.m.)	15.05.82 (12.35 p.m.)	20	19	12
2.	24.02.83	03.03.83 (7 days)	14.03.83 (12.50 p.m.)	14.03.83 (13.25 p.m.)	35	18	11
3.	26.03.83	01.04.83 (6 days)	14.04.83 (15.10 p.m.)	14.04.83 (16.00 p.m.)	50	20	13
4.	24.06.83	02.06.83 (8 days)	10.06.83 13.55 p.m.)	10.06.83 (14.20 p.m.)	25	16	8
5.	06.07.83	13.07.83 (7 days)	26.07.83 (15.45 p.m.)	26.07.83 (16.15 p.m.)	30	20	13
6.	20.03.83	29.03.84 (9 days)	10.04.84 (12.35 p.m.)	10.04.84 (13.10 p.m.)	35	21	12
7.	26.07.84	03.08.84 (8 days)	13.08.84 (15.10 p.m.)	13.08.84 (15.55 p.m.)	45	10	10
8.	04.07.85	12.07.85 (8 days)	29.07.85 (14.50 p.m.)	29.07.85 (15.40 p.m.)	50	20	15
Mean		7.5			36.45	18.0	11.75

Second oviposition date & Time		Time taken (min)	No. of egg pod laid in life time	Time between 1st & 2nd oviposition
St.	Com.			
20.05.82 (14.30 p.m.)	20.05.82 (13.00 p.m.)	30	2	5
19.03.83	19.03.83	30	3	5
20.04.83	20.04.83	35	3	6
—	—	—	1	—
30.07.83 (16.05 p.m.)	30.07.83 (16.45 p.m.)	40	3	4
17.04.84 (13.12 p.m.)	17.04.74 (13.32 p.m.)	20	2	7
19.08.84 (13.00 p.m.)	19.08.84 (13.25 p.m.)	25	3	6
01.08.85 (16.00 p.m.)	01.08.85 (16.35 p.m.)	35	3	3
		30.15	2.5	5.13

Table 6 : Showing the oviposition in *Spathosternum pr. prasiniferum* recorded in the laboratory

Sl. No.	Date of final moult	Date of first copulation	First oviposition		Time (Min)	Preoviposition (Days)	Time taken between copulation & oviposition	Second oviposition		Time taken (min)	No of egg pod laid in life time	Time between 1st & 2nd Oviposition
			Date & Time St.	Date & Time End				Date & Time St.	Date & Time End.			
1	12.05.82	17.05.82 (5 days)	31.05.82 (14.20 pm)	31.05.82 (14.40 pm)	20	19	14	04.06.82 (13.05 pm)	04.06.82 (13.25 pm)	20	4	4
2.	30.07.82	01.08.82 (2 days)	10.08.82 (13.10 pm)	10.08.82 (13.25 pm)	15	11	9	13.08.82 (16.20 pm)	13.08.83 (16.45 pm)	25	4	3
3.	24.09.82	28.09.82 (4 days)	09.10.82 (13.30 pm)	09.10.82 (13.15 pm)	15	16	12	13.10.82 (13.35 pm)	13.10.82 (13.55 pm)	20	3	3
4.	07.05.83	12.05.83 (5 days)	22.05.83	22.05.83	18	15	10	28.05.83	28.05.83	23	4	6
5.	22.07.83	25.07.83 (3 days)	05.08.83 (12.15 pm)	05.08.83 (12.35 pm)	20	14	11	30.08.83 (3.00 pm.)	30.08.83 (3.15 pm)	15	3	5
6.	14.04.84	18.04.84 (4 days)	28.04.84 (10.14 pm)	28.04.84 (10.30 pm)	16	14	10	30.04.84	30.04.84	18	4	2
7.	24.07.84	26.07.84 (2 days)	06.07.84 (12.10 pm)	06.07.84 (12.30 pm)	25	13	11	11.07.84 15.15 pm	11.07.84 (15.35 pm)	20	3	5
8.	22.07.85	25.07.85 (3 days)	09.08.85 (16.00 pm)	09.08.85 (16.22 pm)	22	18	15	10.08.85 (12.30 pm)	10.08.85 (12.54 pm)	24	3	2
Mean		3.5			19.75	15	11.5			20.7	3.5	3.75

Table 7 : Showing the oviposition of *Aiolopus th. tamulus* recorded in the laboratory

No of female specimens	Date of final moult	Date of first copulation	First oviposition Date & Time		Time taken (min)	Preoviposition (Days)	Time taken between first copulation and oviposition	Second oviposition Date & Time		Time taken (min.)	No of egg pod in life time	Time between 1st & 2nd Oviposition
			St.	End				St.	Com.			
1.	17.04.82	21.04.82 (4 days)	01.05.82 (14.10 pm)	01.05.82 (14.28 pm)	18	14	10	06.05.82 (13.40 pm)	06.05.82 (14.10 pm)	30	4	5
2.	26.04.82	12.04.82 (6 days)	26.04.82 (14.55 pm)	26.04.82 (15.20 pm)	25	20	14	28.04.82 (16.5 pm)	28.04.82 (16.27 pm)	22	2	2
3.	27.07.88	01.08.82 (5 days)	12.08.82 (15.25 pm)	12.08.82 (15.55 pm)	30	16	12	13.08.82 (16.35 pm)	13.08.82 (17.00 pm)	20	3	1
4.	03.10.82	09.10.82 (6 days)	26.11.82 (16.35 pm)	26.11.82 (17.00 pm)	25	25	17	19.11.82 (15.20 pm)	29.11.82 (15.45 pm)	25	2	3
5.	16.04.83	18.04.83 (2 days)	08.05.83 (14.40 pm)	08.05.83 (14.40 pm)	26	22	20	12.05.83 (15.00 pm)	12.05.83 (15.30 pm)	30	4	4
6.	04.07.83	07.07.83 (3 days)	19.07.83 (13.20 pm)	19.07.83 (13.40 pm)	28	15	12	26.07.83 (16.20 pm)	26.07.83 (16.48 pm)	28.3	27	
7.	07.06.85	12.06.85 (5 days)	24.06.85 (15.50 pm)	24.06.85 (16.20 pm)	30	17	12	26.06.85	26.06.85	20	4	2
8.	20.08.85	24.08.85 (6 days)	08.08.85 (14.20 pm)	08.08.85 (14.40 pm)	20	19	13	10.09.85	10.09.85	30	3	2
Mean			4.75		24.43	18.25	13.67			20.56	3.12	3.25

Table 8 : Showing the oviposition in *Acrida exaltata* recorded in the laboratory

Sl. No.	Date of final moult	Date of first copulation	First oviposition Date & Time		Time taken (min)	Preoviposition (Days)	Time taken between copulation & oviposition	Second oviposition Date & Time		Time taken	No of egg pod laid in life time	Time between 1st & 2nd Oviposition
			St.	End				St.	End.			
1.	24.05.82	05.06.82 (12 days)	19.06.82 (2.00 pm)	19.06.82 (2.50 pm)	50	26	14	23.06.82 (13.10 pm)	23.06.82 (13.50 pm)	40	5	4
2.	27.06.82	07.06.82 (10 days)	26.07.82 (11.30 pm)	26.07.82 (12.45 pm)	75	29	19	29.07.82 (15.20 pm)	29.07.82 (15.50 pm)	30	5	3
3.	23.08.82	02.09.82 (10 days)	20.09.82 (12.10 pm)	20.09.82 (12.55 pm)	45	28	18	28.09.82 (10.40 pm)	28.09.82 (11.45 pm)	65	6	8
4.	27.06.83	08.07.83 (11 days)	24.07.83 (11.00 pm)	24.07.83 (11.30 pm)	30	27	16	28.07.83 (12.15 pm)	28.07.83 (13.00 pm)	45	4	4
5.	06.04.86	16.04.86 (10 days)	28.04.86 (13.00 pm)	28.04.86 (14.00 pm)	60	22	12	03.05.86 (10.25 am)	03.05.86 (11.00 am)	35	7	5
Mean		10.6			52.0	26.4	15.8			43.0	5.4	4.8

Table 9 : Showing the oviposition of *Atractomorpha crenulata* recorded in the laboratory

Sl. No	Date of final moult	Date of first copulation	First oviposition Date & Time		Time taken (min)	Preoviposition period	Time taken between first copulation and oviposition	Second oviposition Date & Time		Time taken	No of egg pod in life time	Time between 1st & 2nd Oviposition
			St.	End				St.	Com.			
1.	01.04.82	04.04.82 (2 days)	14.04.82 (12.00 pm)	14.04.82 (12.40 pm)	40	13	10	25.04.82 (10.10 am)	25.04.82 (11.10 am)	60	2	11
2.	25.04.82	27.04.82 (2 days)	14.05.82 (13.00 pm)	14.05.82 (13.55 pm)	55	19	17	20.05.82 (10.00 am)	20.05.82 (11.45 am)	105	4	6
3.	18.06.82	26.06.82 (4 days)	03.07.82 (15.00 pm)	03.07.82 (16.10 pm)	70	15	11	07.07.82 (11.05 am)	07.07.82 (13.00 am)	115	3	4
4.	02.08.82	05.05.82 (3 days)	22.08.82 (11.00 am)	22.08.82 (12.15 pm)	75	20	17	26.08.82 (13.00 pm)	26.08.82 (13.30 pm)	30	3	4
5.	08.04.83	11.04.83 (3 days)	25.04.83 (14.00 pm)	25.04.83 (15.30 pm)	90	17	14	28.04.83 (13.10 pm)	28.04.83 (14.15 pm)	65	4	3
6.	20.07.83	26.07.83 (6 days)	09.08.83 (11.00 am)	09.08.83 (12.00 noon)	60	16	14	14.08.83 (10.20 am)	14.08.83 (11.50 am)	90	5	4
7.	25.04.84	28.04.84 (3 days)	15.05.84 (14.15 pm)	15.05.84 (14.50 pm)	35	19	17	21.05.85 (14.40 pm)	21.05.85 (15.25 pm)	45	4	6
8.	23.07.84	28.07.84 (5 days)	15.08.84 (10.15 am)	15.08.84 (11.00 am)	45	20	18	17.08.84 (13.50 pm)	17.08.84 (14.20 pm)	30	4	3
Mean		2.75			58.75	17.3	14.75			67.5	3.5	5.25

Table 10 : Showing egg laying, incubation period and hatching of eggs of *Phlaeoba infumata* in the laboratory

Sl. No. egg pod	Date of laying of egg pod	Incubation period	Date of hatching	No. of eggs pod	No of eggs hatched per pod	%	
						Male	Female
1.	15.05.82	19	03.06.82	8	8	62.50	37.50
2.	20.05.82	21	11.06.82	22	20	60.00	40.00
3.	14.03.83	22	06.04.83	23	21	61.90	38.10
4.	19.03.83	20	09.04.83	13	11	54.55	45.45
5.	14.04.83	21	05.05.93	17	16	50.00	50.00
6.	20.04.83	21	09.05.83	14	14	35.71	64.29
7.	29.04.83	23	21.05.83	25	25	52.00	48.00
8.	10.06.83	18	28.06.83	18	18	44.44	55.56
9.	10.04.84	19	29.04.84	25	24	58.33	41.67
10.	17.04.84	21	08.05.84	25	25	44.00	56.00
11.	25.04.84	23	18.05.84	16	14	64.29	35.71
12.	13.08.84	19	02.09.84	20	17	58.82	41.18
13.	19.08.84	18	07.09.84	18	18	50.00	50.00
14.	29.07.85	19	17.08.85	25	25	56.00	44.00
15.	01.07.85	20	21.08.85	21	20	55.00	45.00
Mean		20.26		19.33	18.4	53.62	46.38

Table 11 : Showing egg laying, incubation period and hatching of eggs of *Spathosternum pr. prasiniferum* in the laboratory

Sl. No. egg pod	Date of laying of egg pod	Incubation period (days)	Date of hatching	No. of eggs pod.	No of eggs hatched per pod	%	
						Male	Female
1.	31.05.82	19	19.06.82	14	11	63.64	36.36
2.	04.06.82	21	25.05.82	10	9	44.44	55.56
3.	06.06.82	22	26.06.82	13	12	58.33	41.67
4.	11.06.82	20	01.07.82	10	10	40.00	60.00
5.	10.08.82	20	30.08.82	11	8	50.00	50.00
6.	13.08.82	19	01.09.82	14	14	50.00	50.00
7.	16.08.82	20	04.09.82	14	13	69.23	30.77
8.	17.08.82	24	10.09.82	7	4	75.00	25.00
9.	09.10.82	23	01.11.82	8	8	37.50	62.50
10.	13.10.82	22	04.10.82	14	14	42.86	57.14
11.	22.05.82	22	13.06.83	12	10	60.00	40.00
12.	28.05.83	23	20.06.83	14	14	50.00	50.00
13.	01.06.83	21	21.06.83	10	7	57.14	42.86
14.	28.04.84	19	17.05.74	9	9	57.14	42.86
15.	30.04.84	21	20.05.84	14	14	64.29	35.71
Mean		21.06		11.60	10.47	54.14	46.38

Table 12 : Showing egg laying, in cubation period and hatching of eggs of *Aiolopus th. tamulus* in the laboratory

Sl. No. egg pod	Date of laying of egg pod	Incubation period	Date of hatching	No. of eggs pod	No of eggs hatched per pod	%	
						Male	Female
1.	01.05.82	18	19.05.82	29	29	62.07	37.93
2.	06.05.82	19	25.05.82	14	9	66.67	33.33
3.	10.05.82	20	30.05.82	38	36	47.22	52.78
4.	16.05.82	19	04.06.82	14	11	45.45	54.55
5.	12.08.82	17	29.08.82	30	28	42.86	57.14
6.	13.08.82	18	31.08.82	17	14	57.14	42.86
7.	26.11.82	22	17.12.82	10	9	45.45	54.55
8.	29.11.82	21	20.12.82	27	24	41.67	58.33
9.	19.07.83	22	10.08.83	15	11	54.55	45.45
10.	26.07.83	21	16.08.83	47	47	44.68	55.52
11.	28.07.83	20	17.08.83	26	25	45.45	54.55
12.	24.06.85	19	13.07.85	19	17	54.55	45.45
13.	26.06.85	21	17.07.85	22	19	57.09	42.11
14.	30.06.85	20	20.07.85	38	38	52.63	47.37
15.	05.07.85	21	27.07.85	14	11	36.36	63.45
Mean		21.33		24	21.80	49.70	50.30

Table 13 : Showing egg laying, incubation period and hatching of eggs of *Acrida exaltata* in the laboratory

Sl. No. egg pod	Date of laying of egg pod	Incubation period (days)	Date of hatching	No. of eggs pod	No of eggs hatched per pod	%	
						Male	Female
1.	19.06.82	23	12.07.82	55	53	56.6	43.4
2.	23.06.82	20	13.07.72	37	33	57.6	42.4
3.	26.07.82	22	17.07.82	33	33	57.6	42.4
4.	29.07.82	22	19.08.82	15	15	40.0	60.0
5.	20.09.82	23	14.10.82	51	48	43.75	56.25
6.	24.07.83	25	18.08.83	29	27	55.55	44.44
7.	28.07.83	23	20.08.83	55	51	53.0	47.0
8.	28.04.86	26	24.05.86	56	54	53.7	46.3
9.	03.05.86	20	23.05.86	48	46	52.17	48.0
10	07.05.86	24	31.05.86	35	30	50.0	50.0
Mean		22.8		41.4	39.0	51.50	48.50

Table 14 : Showing egg laying, incubation period and hatching of eggs of *Atractomorpha cremulata* in the laboratory

Sl. No. egg pod	Date of laying of egg pod	Incubation period (days)	Date of hatching	No. of eggs pod	No of eggs hatched per pod	%	
						Male	Female
1.	14.04.82	03.05.82	18	12	8	62.50	37.50
2.	25.04.82	15.05.82	20	20	18	44.44	55.56
3.	14.05.82	02.06.82	19	40	36	61.11	38.89
4.	20.05.82	08.06.82	19	47	45	44.44	55.56
5.	24.05.72	13.06.82	20	28	28	50.00	50.00
6.	02.06.82	20.06.82	18	10	9	44.44	55.56
7.	03.07.82	24.07.82	21	62	50	42.00	58.00
8.	07.07.82	29.07.82	22	46	43	46.51	53.49
9.	15.07.82	08.08.82	24	36	29	55.17	44.83
10.	22.09.82	08.10.82	17	27	22	50.00	50.00
11.	26.09.82	11.10.82	16	30	24	41.67	58.33
12.	25.04.83	09.05.83	17	66	66	45.45	54.55
13.	28.04.83	17.05.83	19	30	26	46.15	53.83
14.	01.05.83	22.05.83	21	24	24	58.33	41.67
15.	15.05.84	02.05.84	19	66	60	43.33	56.67
Mean			20.46	36.27	89.15	48.04	51.96

Table 15 : Duration of nymphal life (days) of Isolated hoppers reared for development in B.O.D. incubator ($33 \pm 2^\circ\text{C}$).***Phlaeoba infumata***

Number of instars	1	2	3	4	5	6	7	Mean total days
Male								
Mean (days)	6.5	7.0	7.6	7.0	9.4			36.2
Range (days)	5-8	5-8	6-9	7-9	8-12			32 - 44
Female								
Mean (days)	6.0	6.5	7.3	8.4	8.6	10.5		41.5
Range (days)	5-8	5-8	6-9	7-11	7-10	10-14		38-45

Spathosternum pr. prasiniferum

Number of instars	1	2	3	4	5	6	7	Mean total days
Male								
Mean (days)	6.0	6.0	5.5	6.7	9.4			34.3
Range (days)	5-7	5-7	6-8	6-9	8-11			30-36
Female								
Mean (days)	5.7	5.6	6.0	6.5	8.0	10.6		35.5
Range (days)	5-7	5-7	5-7	6-7	7-9	8-12		33-38

Contd.... Table 15 :

Aiolopus th. tamulus								
Number of instars	1	2	3	4	5	6	7	Mean total days
Male								
Mean (days)	4.5	4.8	5.8	7.5	8.5			31
Range (days)	4-6	4-6	5-8	6-10	7-13			26-34
Female								
Mean (days)	4.6	4.9	5.5	7.0	8.0	10.0		37.0
Range (days)	4-6	4-6	5-8	6-10	7-12	8-14		34-44
Acrida exaltata								
Male								
Mean (days)	5.4	6.0	6.7	9.2	10.7			40.0
Range (days)	5-6	5-7	7-9	8-11	9-13			34-48
Atractomorpha crenulata								
Male								
Mean (days)	5.3	5.6	6.2	7.6	8.5			31.5
Range (days)	5-6	5-6	5-7	5-9	7-10			29-35
Female								
Mean (days)	5.2	5.5	6.5	7.0	8.3	9.8		36.8
Range (days)	5-6	5-7	5-8	6-9	7-10	8-12		35-40

Table 16 : Showing Percentage of total population

Sl. No.	Name of the species	Year		Total
		1978-1979	1979-1980	
1.	<i>Atractomorpha crenulata</i>	20.40	22.24	42.64
2.	<i>Gesonula punctifrons</i>	2.28	1.90	4.10
3.	<i>Spathosternum pr. prasiniferum</i>	20.46	22.22	42.68
4.	<i>Oxya fuscovittata</i>	16.78	15.65	32.43
5.	<i>Oxya hyla hyla</i>	8.81	8.57	17.38
6.	<i>Phlacoba infumata</i>	16.78	14.42	31.20
7.	<i>Acrida exaltata</i>	4.21	3.85	6.69
8.	<i>Aiolopus th. tamulus</i>	2.68	3.49	6.17
9.	<i>Tristnia pulvinata</i>	2.84	3.85	6.69
10.	<i>Trilophidia annulata</i>	3.04	2.91	3.95
11.	<i>Eyprepocremis al. alacris</i>	1.84	2.38	4.22
12.	<i>Eupreponotus inflatus</i>	0.12	0.16	0.28

Table 17 : Showing monthly fluctuation of population of different grasshopper species expressed in percentage (4 sites in West Bengal).

Sl. No.	Name of the species	1978									
		M O N T H									
		A	M	J	J	A	S	O	N	D	
1.	<i>Atractomorpha crenulata</i>	1.44	4.08	1.88	1.00	1.56	1.28	0.64	2.00	0.80	
2.	<i>Gesonula punctifrons</i>	0.08	0.08	0.12	0.16	0.12	0.32	0.16	0.48	0.12	
3.	<i>Spathosterum pr. prasiniferum</i>	0.36	2.40	2.20	1.88	2.84	1.32	1.76	2.64	1.00	
4.	<i>Oxya fuscovittata</i>	1.40	0.96	1.48	3.28	2.44	2.04	1.40	2.20	0.44	
5.	<i>Oxya hyla hyla</i>	0.80	0.68	0.72	1.32	0.75	1.00	0.56	1.28	0.64	
6.	<i>Phlaeoba infumata</i>	1.76	0.84	0.76	1.84	1.80	1.72	0.92	1.80	0.52	
7.	<i>Acrida exaltata</i>	0.16	0.96	1.08	0.44	0.32	0.24	0.36	0.36	0.12	
8.	<i>Aiolopus thalasinus tamulus</i>	0.04	0.04	0.32	0.64	0.48	0.24	0.16	0.52	0.04	
9.	<i>Tristria pulvinata</i>	0.52	0.12	0.08	0.12	0.56	0.24	0.24	0.40	0.00	
10.	<i>Trilophidia annulata</i>	0.12	0.28	0.20	0.44	0.48	0.80	0.32	0.12	0.00	
11.	<i>Eyprepocnemis al. alacris</i>	0.36	0.20	0.12	0.28	0.24	9.08	0.04	0.16	0.12	
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	
Mean		7.04	10.64	8.96	11.40	11.60	9.28	6.60	12.08	3.80	

Contd.....

Table 17 : Showing monthly fluctuation of population of different grasshopper species expressed in percentage (4 sites in West Bengal).

Sl. No.	Name of the species	M O N T H														
		1979					J		1980							
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1.	<i>Atractomorpha crenulata</i>	0.72	1.40	3.32	1.47	3.45	1.94	1.65	3.10	2.09	2.25	2.34	1.31	0.80	0.19	0.57
2.	<i>Gesonula punctifrons</i>	0.20	0.40	0.40	0.19	0.20	0.08	0.10	0.04	0.12	0.11	0.42	0.21	0.30	0.10	0.08
3.	<i>Spathosternum pr. prasiniferum</i>	1.20	1.36	1.48	0.34	0.51	1.06	1.49	5.07	3.12	2.36	3.39	1.22	1.24	0.80	1.58
4.	<i>Oxya fuscovittata</i>	0.44	0.00	0.68	0.74	0.89	0.49	1.64	2.25	1.79	3.49	2.02	0.84	0.84	0.13	0.53
5.	<i>Oxya hyla hyla</i>	0.20	0.04	0.16	1.11	0.68	0.71	0.78	0.34	0.85	1.64	0.90	0.34	0.59	0.10	0.55
6.	<i>Phlaeoba infumata</i>	1.04	2.04	1.72	1.30	0.67	0.69	0.74	1.18	1.53	3.01	1.83	0.84	0.63	0.90	1.12
7.	<i>Acrida exaltata</i>	0.80	0.16	0.08	0.04	0.29	0.36	0.42	0.42	0.19	0.17	0.17	0.20	0.04	0.02	0.00
8.	<i>Aiolopus thalasinus tamulus</i>	0.16	0.00	0.04	0.00	0.06	0.14	0.20	0.46	0.62	1.20	0.34	0.14	0.14	0.17	0.10
9.	<i>Tristria pulvinata</i>	0.24	0.12	0.20	0.02	0.04	0.04	0.12	0.44	0.82	1.01	0.63	0.32	0.00	0.30	0.11
10.	<i>Trilophidia annulata</i>	0.40	0.08	0.16	0.08	0.23	0.40	0.40	0.63	0.32	0.34	0.16	0.08	0.15	0.10	0.04
11.	<i>Eypreocnemis al. alacris</i>	0.16	0.04	0.00	0.35	0.23	0.17	0.19	0.06	0.27	0.29	0.13	0.21	0.25	0.11	0.13
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.00
Mean		4.48	5.28	9.24	5.64	7.25	6.08	7.73	12.99	11.72	15.91	12.34	5.71	4.98	2.92	4.81

**Table 18 : Showing monthly fluctuation of total male grasshopper population expressed in %
(4 sites in West Bengal)**

Sl. No.	Name of the species	M O N T H												1979			
		1978												A	M	J	J
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
1.	<i>Attractomorpha crenulata</i>	0.64	1.24	0.96	0.32	0.84	0.52	0.20	0.80	0.28	0.20	0.60	1.96	0.72	1.83	0.95	0.50
2.	<i>Gesonula punctifrons</i>	0.04	0.00	0.00	0.12	0.12	0.04	0.04	0.16	0.08	0.08	0.04	0.28	0.17	0.10	0.04	0.04
3.	<i>Spathosternum pr. prasiniferum</i>	0.16	0.16	0.96	0.64	1.16	0.48	0.56	0.96	0.24	0.24	0.32	0.68	0.15	0.21	0.51	0.40
4.	<i>Oxya fuscovittata</i>	0.80	0.36	0.32	1.08	0.84	0.32	0.28	0.92	0.16	0.00	0.00	0.20	0.34	0.55	0.25	0.40
5.	<i>Oxya hyla hyla</i>	0.28	0.16	0.16	0.28	0.27	0.08	0.08	0.32	0.08	0.00	0.04	0.64	0.50	0.36	0.29	0.11
6.	<i>Phlaeoba infumata</i>	0.52	0.16	0.20	0.88	0.96	0.84	0.24	0.60	0.24	0.16	0.28	0.96	0.82	0.32	0.30	0.25
7.	<i>Acrida exaltata</i>	0.00	0.08	0.20	0.12	0.12	0.12	0.12	0.32	0.04	0.00	0.00	0.04	0.02	0.15	0.17	0.11
8.	<i>Aiolopus thalasianus tamulus</i>	0.04	0.00	0.12	0.24	0.12	0.04	0.04	0.20	0.04	0.04	0.00	0.00	0.00	0.00	0.06	0.06
9.	<i>Tristria pulvinata</i>	0.08	0.00	0.08	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.04	0.02	0.02
10.	<i>Trilophidia annulata</i>	0.00	0.12	0.12	0.12	0.20	0.40	0.12	0.04	0.00	0.00	0.00	0.08	0.06	0.06	0.15	0.13
11.	<i>Eyprepocnemis al. alacris</i>	0.04	0.00	0.00	0.12	0.04	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.04	0.04	0.04	0.00
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	2.60	3.28	3.12	3.92	4.88	2.84	1.72	4.40	1.20	0.72	1.28	4.88	2.84	3.72	2.78	2.04

Contd.....

Table 18 :

Sl. No.	Name of the species	1979					1980			
		A	S	O	N	D	J	F	M	
1.	<i>Atractomorpha crenulata</i>	0.26	0.95	0.63	0.84	0.42	0.17	0.08	0.36	
2.	<i>Gesonula punctifrons</i>	0.02	0.02	0.06	0.17	0.11	0.13	0.04	0.04	
3.	<i>Spathosternum</i> pr. <i>prasiniiferum</i>	1.31	0.72	0.59	1.14	0.38	0.30	0.27	0.61	
4.	<i>Oxya fuscovittata</i>	0.38	0.36	1.05	1.03	0.42	0.00	0.00	0.11	
5.	<i>Oxya hyla hyla</i>	0.10	0.10	0.40	0.23	0.11	0.00	0.00	0.11	
6.	<i>Phlaeoba infumata</i>	0.21	0.48	0.97	0.44	0.32	0.25	0.36	0.40	
7.	<i>Acrida exaltata</i>	0.11	0.11	0.10	0.08	0.10	0.00	0.00	0.00	
8.	<i>Aiolopus thalasianus tamulus</i>	0.29	0.48	0.51	0.15	0.06	0.06	0.04	0.08	
9.	<i>Tristria pulvinata</i>	0.04	0.02	0.00	0.00	0.00	0.00	0.10	0.00	
10.	<i>Trilophidia annulata</i>	0.30	0.17	0.10	0.04	0.04	0.04	0.06	0.00	
11.	<i>Eyprepocnemis al. alacris</i>	0.13	0.00	0.00	0.02	0.00	0.00	0.02	0.02	
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.06	0.06	0.00	0.00	0.00	0.00	
Mean		4.02	3.54	4.45	4.20	1.98	0.95	0.95	1.73	

**Table 19 : Showing monthly fluctuation of total male grasshopper population expressed in %
(Average of 4 sites in West Bengal)**

Sl. No.	Name of the species	1978				1979							
		A	M	J	J	A	S	O	N	D	J	F	M
1.	<i>Atractomorpha crenulata</i>	0.12	0.44	0.76	0.36	0.20	0.24	0.20	0.32	0.08	0.00	0.20	0.80
2.	<i>Gesonula punctifrons</i>	0.04	0.08	0.00	0.00	0.00	0.08	0.00	0.24	0.00	0.04	0.00	0.12
3.	<i>Spathosternum pr. prasiniferum</i>	0.02	0.72	0.68	0.52	0.72	0.44	0.56	0.60	0.16	0.12	0.16	0.40
4.	<i>Oxya fuscovittata</i>	0.24	0.16	0.36	0.76	0.48	0.16	0.16	0.60	0.08	0.08	0.00	0.20
5.	<i>Oxya hyla hyla</i>	0.08	0.12	0.00	0.04	0.12	0.08	0.00	0.48	0.08	0.00	0.00	0.20
6.	<i>Phlaeoba infumata</i>	0.00	0.04	0.00	0.36	0.40	0.52	0.16	0.40	0.04	0.04	0.12	0.12
7.	<i>Acrida exaltata</i>	0.00	0.12	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.08	0.04
8.	<i>Aiolopus thalasinus tamulus</i>	0.00	0.04	0.08	0.16	0.16	0.00	0.00	0.16	0.00	0.00	0.00	0.04
9.	<i>Tristria pulvinata</i>	0.12	0.16	0.08	0.16	0.20	0.24	0.04	0.04	0.00	0.00	0.00	0.00
10.	<i>Trilophidia annulata</i>	0.12	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.04
11.	<i>Eyprepocnemis al. alacris</i>	0.00	0.08	0.00	0.00	0.12	0.04	0.00	0.04	0.00	0.00	0.00	0.00
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1.56	1.96	2.00	2.36	2.44	1.80	1.16	2.88	0.44	0.28	0.56	2.12

Contd.....

Table 19 :

Sl. No.	Name of the species	1979				1980							
		A	M	J	J	A	S	O	N	D	J	F	M
1.	<i>Atractomorpha crenulata</i>	0.20	0.40	0.42	0.27	0.50	0.42	0.19	0.21	0.15	0.04	0.04	0.10
2.	<i>Gesonula punctifrons</i>	0.02	0.10	0.04	0.02	0.00	0.06	0.04	0.11	0.04	0.06	0.06	0.02
3.	<i>Spathosternum pr. prasinerum</i>	0.04	0.17	0.34	0.21	0.74	0.46	0.34	0.61	0.27	0.15	0.04	0.11
4.	<i>Oxya fuscovittata</i>	0.08	0.17	0.11	0.19	0.36	0.21	0.40	0.38	0.17	0.11	0.00	0.06
5.	<i>Oxya hyla hyla</i>	0.27	0.15	0.17	0.06	0.02	0.10	0.19	0.29	0.08	0.02	0.00	0.02
6.	<i>Phlaeoba infumata</i>	0.28	0.08	0.10	0.15	0.17	0.42	0.42	0.23	0.08	0.10	0.13	0.25
7.	<i>Acrida exaltata</i>	0.02	0.06	0.00	0.02	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.	<i>Aiolopus thalasinus tamulus</i>	0.00	0.04	0.02	0.04	0.08	0.08	0.55	0.11	0.04	0.00	0.02	0.00
9.	<i>Tristria pulvinata</i>	0.02	0.11	0.17	0.13	0.21	0.13	0.17	0.06	0.02	0.02	0.02	0.02
10.	<i>Trilophidia annulata</i>	0.00	0.00	0.02	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.02	0.02
11.	<i>Eypreponemis al. alacris</i>	0.04	0.00	0.00	0.08	0.00	0.08	0.04	0.04	0.00	0.00	0.00	0.00
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
Total		1.07	1.28	1.39	1.17	2.20	2.02	2.36	2.01	0.85	0.50	0.33	0.60

**Table 20 : Showing monthly fluctuation of total population of nymphs expressed in %
(Average of 4 sites in West Bengal)**

Sl. No.	Name of the species	1978										1979	
		A	M	J	J	A	S	O	N	D	J	F	M
1.	<i>Atractomorpha crenulata</i>	0.68	2.40	0.16	0.32	0.52	0.52	0.24	0.88	0.44	0.52	0.60	0.56
2.	<i>Gesonula punctifrons</i>	0.00	0.00	0.21	0.04	0.00	0.20	0.12	0.12	0.04	0.08	0.00	0.00
3.	<i>Spathosternum pr. prasiniferum</i>	0.00	0.52	0.56	0.72	0.96	0.04	0.64	1.08	0.60	0.84	0.88	0.40
4.	<i>Oxya fuscovittata</i>	0.36	0.44	0.80	1.44	1.12	1.56	0.96	0.68	0.20	0.36	0.00	0.26
5.	<i>Oxya hyla hyla</i>	0.44	0.40	0.56	1.00	0.36	0.84	0.48	0.48	0.48	0.20	0.00	0.32
6.	<i>Phlaeoba infumata</i>	0.00	0.00	0.12	0.24	0.20	0.20	0.12	0.16	0.00	0.12	0.00	0.00
7.	<i>Acrida exaltata</i>	0.60	0.64	0.56	0.60	0.44	0.36	0.52	0.80	0.24	0.84	1.64	0.48
8.	<i>Aiolopus thalasinus tamulus</i>	0.00	0.00	0.00	0.16	0.08	0.16	0.16	0.04	0.00	0.04	0.08	0.08
9.	<i>Tristria pulvinata</i>	0.32	0.12	0.00	0.12	0.32	0.24	0.24	0.40	0.00	0.24	0.12	0.16
10.	<i>Trilophidia annulata</i>	0.32	0.12	0.12	0.16	0.08	0.04	0.04	0.08	0.08	0.16	0.04	0.00
11.	<i>Eyprepocnemis al. alacris</i>	0.16	0.76	0.84	0.32	0.20	0.12	0.20	0.04	0.08	0.08	0.08	0.00
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Mean		2.88	5.40	3.84	5.12	4.28	4.64	3.72	4.80	2.16	3.48	3.44	2.26

Contd.....

**Table 20 : Showing monthly fluctuation of total population of nymphs expressed in %
(Average of 4 sites in West Bengal)**

Sl. No.	Name of the species	1979										1980	
		A	M	J	J	A	S	O	N	D	J	F	M
1.	<i>Atractomorpha crenulata</i>	0.44	1.22	0.57	0.88	1.35	0.72	1.43	1.29	0.74	0.59	0.08	0.11
2.	<i>Gesonula punctifrons</i>	0.00	0.00	0.00	0.04	0.02	0.04	0.00	0.13	0.06	0.11	0.00	0.02
3.	<i>Spathosternum pr. prasiniferum</i>	0.15	0.13	0.21	0.88	0.01	0.94	0.43	0.64	0.57	0.78	0.50	0.68
4.	<i>Oxya fuscovittata</i>	0.32	0.17	0.13	0.05	0.50	1.22	2.04	0.61	0.25	0.72	0.13	0.36
5.	<i>Oxya hyla hyla</i>	0.34	0.17	0.26	0.61	0.23	0.65	1.05	0.38	0.15	0.57	0.10	0.42
6.	<i>Phlaeoba infumata</i>	0.00	0.02	0.06	0.10	0.10	0.06	0.13	0.04	0.04	0.08	0.11	0.02
7.	<i>Acrida exaltata</i>	0.19	0.21	0.29	0.34	0.80	0.63	1.62	1.06	0.44	0.29	0.40	0.48
8.	<i>Aiolopus thalasinus tamulus</i>	0.00	0.06	0.08	0.13	0.11	0.02	0.08	0.06	0.02	0.10	0.02	0.02
9.	<i>Tristria pulvinata</i>	0.00	0.00	0.00	0.10	0.36	0.76	1.01	0.63	0.32	0.00	0.19	0.10
10.	<i>Trilophidia annulata</i>	0.27	0.19	0.13	0.10	0.06	0.06	0.25	0.08	0.19	0.25	0.11	0.11
11.	<i>Eyprepocnemis al. alacris</i>	0.00	0.08	0.19	0.29	0.23	0.06	0.06	0.08	0.10	0.04	0.02	0.00
12.	<i>Eupreponotus inflatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean		1.75	2.25	1.91	4.52	7.77	6.16	9.10	6.10	2.88	3.53	1.66	2.50

Table 21. Showing month wise fluctuations temperature and relative humidity

Month	Temperature (°C)	Humidity (%)
1978		
April	35.0	93.6
May	35.65	91.5
June	32.9	95.6
July	33.2	94.0
August	29.3	94.0
September	32.2	92.0
October	32.4	85.0
November	30.0	70.2
December	4.0	58.5
1978		
January	23.5	63.7
February	25.0	50.2
March	30.5	53.0
April	32.5	70.3
May	37.3	75.0
June	32.75	68.9
July	29.25	77.5
August	34.0	88.8
September	35.0	92.5
October	33.0	86.5
November	29.5	76.6
December	25.0	66.6
1979		
January	23.62	60.0
February	24.5	70.5
March	29.75	76.5

Table 22 : Showing relationship between grasshoppers population and two parameters of (Temperature and Humidity)

Parameters	Mean	'r' value	Regression equation $Y = a + bx$
<i>Atractomorpha crenulata</i>			
Y Total population of male, female & nymph.	67.25		
Air temperature	30.41	0.56*	$Y = 128.25 + 6.43x$
Humidity	77.06	0.14	$Y = 31.80 + 0.46x$
Y Total population male	27.96		
Air temperature	30.41	0.60*	$Y = -69.89 + 3.22x$
Humidity	77.06	0.07	$Y = 19.59 + 0.11x$
Y Total population of female	10.46		
Air temperature	30.41	0.64*	$Y = -25.06 + 1.17x$
Humidity	77.06	0.19	$Y = 2.62 + 0.10x$
Y Total population of nymph	28.83		
Air temperature	30.41	0.36	$Y = -33.29 + 2.04x$
Humidity	77.06	0.19	$Y = 10.05 + 0.24x$
<i>Gesonula punctifrons</i>			
Total population of male, female & nymph.	6.54		
Air temperature	30.41	-0.18	$Y = 13.02 + -0.21x$
Humidity	77.06	-0.30	$Y = 14.90 + 0.11x$
Total population of male	3.17		
Air temperature	30.41	-0.19	$Y = 6.98 + -0.13x$
Humidity	77.06	-0.45	$Y = 9.89 + -0.09x$
Total population of female	1.71		
Air temperature	30.41	0.09	$Y = 0.63 + -0.04x$
Humidity	77.06	-0.22	$Y = -0.41 + -1.09x$
Total population of Humidity	1.67		
Air temperature	30.41	-0.25	$Y = 5.45 + -0.12x$
Humidity	77.06	-0.16	$Y = -0.60 + 0.02x$

Contd. ... Table 22

Parameters	Mean	'r' value	Regression equation Y = a + bx
<i>Spathesternum pr. prasiniferum</i>			
Y Total population of male, female & nymph.	69.92		
Air temperature	30.41	0.21	Y = - 18.44 + 2.99x
Humidity	77.06	0.30	Y = - 25.65 + 1.24x
Y Total population of male	22.33		
Air temperature	30.41	0.27	Y = - 9.53 + 1.05x
Humidity	77.06	0.34	Y = - 7.06 + 0.38x
Y Total population of female	13.21		
Air temperature	30.41	0.43	Y = - 15.03 + 0.93x
Humidity	77.06	0.46	Y = 9.80 + 0.30
Y Total population of nymph	34.38		
Air temperature	30.41	0.10	Y = 6.16 + 0.9x
Humidity	77.07	0.21	Y = - 8.78 + 0.56x
<i>Oxya fuscovittata</i>			
Y Total population of male, female & nymph.	51.71		
Air temperature	30.41	0.38	Y = - 65.07 + 3.84x
Humidity	77.06	0.48*	Y = - 58.8 + 1.43x
Y Total population of male	16.21		
Air temperature	30.41	0.40	Y = - 27.70 + 1.44x
Humidity	77.06	0.36	Y = - 12.83 + 0.38x
Y Total population of female	8.33		
Air temperature	30.41	0.37	Y = - 9.15 + 0.57
Humidity	77.06	0.45*	Y = 7.41 + 0.20x
Y Total population of nymph	27.17		
Air temperature	30.41	0.29	Y = - 28.23 + 1.82x
Humidity	77.06	0.46*	Y = - 38.56 + 0.85x

Contd. ... Table 22

Parameters	Mean	'r' value	Regression equation $Y = a + bx$
<i>Oxya hyla hyla</i>			
Y Total population of male, female & nymph.	27.29		
Air temperature	30.41	0.41	$Y = -29.71 + 1.88x$
Humidity	77.06	0.18	$Y = 7.96 + 0.25x$
Y Total population of male	7.54		
Air temperature	30.41	0.48*	$Y = 8.60 + 0.01x$
Y Total population of female	4.21		
Air temperature	30.41	0.28	$Y = -5.09 + 0.31x$
Humidity	77.06	-0.10	$Y = 6.68 + -0.03x$
Y Total population of nymph	16.17		
Air temperature	30.41	0.21	$Y = -8.66 + 0.82x$
Humidity	77.06	0.38	$Y = -18.15 + 0.3x$
<i>Phlaeoba infumata</i>			
Y Total population of male, female & nymph.	49.00		
Air temperature	30.41	0.21	$Y = 4.50 + 1.48x$
Humidity	77.06	0.18	$Y = 19.70 + 0.39x$
Y Total population of male	17.63		
Air temperature	30.41	0.25	$Y = -3.56 + 0.25x$
Humidity	77.06	0.09	$Y = -6.25 + 17.87x$
Y Total population of female	7.96		
Air temperature	30.41	0.38	$Y = -8.82 + 0.57x$
Humidity	77.06	0.39	$Y = -4.78 + 0.17x$
Y Total population of nymph	17.17		
Air temperature	30.41	0.03	$Y = 18.59 + 0.15x$
Humidity	77.06	0.13	$Y = 9.81 + 0.10x$

Contd. ... Table 22

Parameters	Mean	'r' value	Regression equation $Y = a + bx$
<i>Tristria pulvinata</i>			
Y Total population of male, female & nymph.	11.38		
Air temperature	30.41	0.19	$Y = - 7.53 + 0.62x$
Humidity	77.06	0.32	$Y = - 13.23 + 0.32x$
Y Total population of male	0.92		
Air temperature	30.41	0.06	$Y = 0.32 + 0.02x$
Humidity	77.06	0.11	$Y = - 0.27 + 0.01x$
Y Total population of female	0.50		
Air temperature	30.41	0.31	$Y = - 1.39 + 0.06x$
Humidity	77.06	0.31	$Y = - 0.88 + 0.02x$
Y Total population of nymph	9.96		
Air temperature	30.41	0.16	$Y = - 6.18 + 0.53x$
Humidity	77.06	0.26	$Y = - 9.99 + 0.26x$
<i>Trilophidia annulata</i>			
Y Total population of male, female & nymph.	9.54		
Air temperature	30.41	0.45*	$Y = - 17.70 + 0.90x$
Humidity	77.06	0.44	$Y = - 10.37 + 0.26x$
Y Total population of male	3.73		
Air temperature	30.41	0.42	$Y = - 8.03 + 0.39x$
Humidity	77.06	0.44*	$Y = - 5.58 + 0.12x$
Y Total population of female	3.83		
Air temperature	30.41	0.61*	$Y = - 11.80 + 0.51x$
Humidity	77.06	0.44*	$Y = - 5.58 + 0.12x$
Y Total population of nymph	1.92		
Air temperature	30.41	0.07	$Y = 1.28 + 0.03x$
Humidity	77.06	0.07	$Y = 1.50 + 0.01x$

Contd. ... Table 22

Parameters	Mean	'r' value	Regression equation $Y = a + bx$
<i>Acrida exaltata</i>			
Y Total population of male, female & nymph.	9.38		
Air temperature	30.41	0.52*	$Y = - 20.97 + 1.00x$
Humidity	77.06	0.49*	$Y = - 11.95 + 0.28x$
Y Total population of male	3.13		
Air temperature	30.41	0.52*	$Y = - 7.06 + 0.34x$
Humidity	77.06	0.14	$Y = - 0.08 + 0.01x$
Y Total population of female	0.79		
Air temperature	30.41	0.48*	$Y = - 3.21 + 0.13x$
Humidity	77.06	-0.14	$Y = - 0.08 + 0.01x$
Y Total population of nymph	5.46		
Air temperature	30.41	0.38*	$Y = - 10.70 + 0.53x$
Humidity	77.06	0.50*	$Y = - 10.49 + 0.21x$
<i>Phlaeoba infumata</i>			
Y Total population of male, female & nymph.	10.42		
Air temperature	30.41	0.23	$Y = - 12.83 + 0.76x$
Humidity	77.06	0.33	$Y = - 13.89 + 0.31x$
Y Total population of male	4.79		
Air temperature	30.41	0.28	$Y = - 10.24 + 0.49x$
Humidity	77.06	0.37	$Y = - 9.89 + 0.19x$
Y Total population of female	2.79		
Air temperature	30.41	0.20	$Y = - 5.94 + 0.29x$
Humidity	77.06	0.25	$Y = - 52.21 + 0.10x$
Y Total population of nymph	2.83		
Air temperature	30.41	-0.03	$Y = 3.34 + 0.02x$
Humidity	77.06	0.39	$Y = - 1.97 + 0.06x$

Contd. ... Table 22

Parameters	Mean	'r' value	Regression equation $Y = a + bx$
<i>Eyrepocnemis al. alacris</i>			
Y Total population of male, female & nymph.	7.13		
Air temperature	30.41	0.16	$Y = 0.35 + 0.22x$
Humidity	77.06	0.19	$Y = 4.84 + 0.03x$
Y Total population of male	1.0		
Air temperature	30.41	0.35	$Y = - 2.92 + 0.13x$
Humidity	77.06	0.24	$Y = - 1.05 + 0.03x$
Y Total population of female	0.92		
Air temperature	30.41	0.24	$Y = 1.36 + 0.07x$
Humidity	77.06	0.30	$Y = - 1.27 + 0.03x$
Y Total population of nymph	5.21		
Air temperature	30.41	0.02	$Y = 4.63 + 0.02x$
Humidity	77.06	-0.09	$Y = 7.16 + 0.03x$
<i>Eupreponotusw inflatus</i>			
Y Total population of male, female & nymph.	2.62		
Air temperature	30.41	0.10	$Y = - 1.74 + 0.14x$
Humidity	77.06		
Y Total population of male	1.25		
Air temperature	30.41	0.09	$Y = - 0.66 + 0.06x$
Humidity	77.06	0.44*	$Y = 0.05 + 0.01x$
Y Total population of female	0.66		
Air temperature	30.41	0.07	$Y = - 0.38 + 0.03x$
Humidity	77.06	0.07	$Y = - 0.08 + 0.01x$
Y Total population of nymph	0.67		
Air temperature	30.41	-0.06	$Y = 1.38 + - 0.03x$
Humidity	77.06	-0.11	$Y = 1.98 + - 0.02x$

* Significant at 5% level.

DISCUSSION

The results presented in this investigations were based on a detailed sample survey of all the districts of West Bengal. Grasshoppers fauna encountered in this study belonged to 17 general of the families Acrididae and Pyrgomorphidae. The taxonomy and morphological characters of the adult species showed no marked variations from the descriptions of earlier workers like Dirsh (1961), Bei-Binko (1963), Hollis (1971), Tandon (1976), Ritche (1981), Bhowmik (1984, 85, 86), and Osmani and Shafee (1985). But the distribution of some forms differed markedly in their abundance from one district to other. Moreover, not a single species of grasshopper was recorded from all the 17 districts of West Bengal. Only two species namely, *Spathosternum pr. prasiniferum* and *Oxya fuscovitta* were recorded from 14 districts of West Bengal. These variations in the faunal make up might be due to the differences in the vegetation and crop condition of the district concerned (Diwvedi 1977 and Hazra et al. 1981, '84)

The biology of the species like *Spathosternum pr. prasiniferum*, *Acrida exaltata*, *Phlaeoba infumata*, *Aiolopus th. tamulus* and *Atractomorpha crenulata* studied in the laboratory showed that the time requirement for sexual maturity varied from species to species and from one sex to other. Marked variations were observed among the different individuals of the same species. In general, it was observed that the males took less time for sexual maturity than females corroborating Kevan et al (1974) and Bhowmik (1986). In some cases both male and female took much longer time for their sexual maturity as it was observed in case of *Spathosternum pr. prasiniferum* (Iqbal et al 1974). The reason for taking long time for first courtship was not clear from their observations. But the variations in the time of maturity within the individuals of the same species might be due to the absence of a specific food plants. Parihar (1974) noted *Poeceilocerus pictus* failing to mature unless it took the meal of *Calotropis* plants. After first mating, the oviposition of a female started on various dates as observed for these grasshoppers, ranging from 11.75 (*Spathosternum pr. prasiniferum*) to 15.8 days (*Acrida exaltata*) even after receiving the same favourable condition. (Tables 5-9). The reason for such behaviour could not be explained (John et al 1981).

The soil condition appeared to play an important role for the oviposition. It was observed in the present study that the species like *Phlaeoba infumata* and *Acrida exaltata* preferred loose sandy soil. When soil was hard and disturbed, *Phlaeoba infumata* was seen to deposit their eggs on the upper layer while in the undisturbed field, the eggs were laid in the lower depth. Similar observation in *Atractomorpha crenulata* was observed by Srivastava (1957). The longevity of the adult females after egg laying varied from one species to another, depending mainly on the temperature, humidity and palatability of food (Kevan and Lee 1974).

It is evident from tables 6-10 that the mean incubation period of egg of *Acrida exaltata* was

maximum (22.8 days) and minimum in *Atractomorpha crenulata* (20 days). The little variations in the incubation of different species might be due to the availability of moisture and the presence of favourable temperature in soil (Keven et al, 1981).

The maximum percentage of hatching of eggs were observed in *Phlaeoba infumata* (95.17%) and minimum in *Atractomorpha crenulata* (89.16%). The hatchability of grasshopper eggs might depend mainly upon the soil temperature, moisture and also the fertility of the eggs (Khan and Aziz, 1974) (Tables 10-14).

The duration of nymphal life was maximum in the *Acrida exaltata* (47.5 days) female and minimum in *Aiolopus th. tamulus* (31.0 days) (Tables 15). The prolonged nymphal period of the grasshopper seemed to be due to inadequate nutrition as well as some physical parameters (Wigglesworth 1953).

The result exhibited as highest peak in November and two other showed comparatively lower peaks in the month of October and July agreed with the observations of Diwivedi (1977) and Hazra (1981, '84). The population of nymphs out numbering the adults of both the sexes, confirming with the works of Hazra et al (1981, '84).

Except *Gesonula punctifrons*, all other grasshopper species in the present study showed a positive correlation with the temperature and humidity (Table 22) which indicated the role of these two physical factors in the fluctuations of populations. Moreover, the statistical analysis failed to show the significant correlation between grasshopper population and physical factors in most cases. Therefore, it could be concluded from the present study that the temperature and humidity exerted influences on the size, quality and the distribution of grasshopper population as indicated by Chapman (1962), Uvarov (1977), Hazra et al (1984) and Tandon et al (1988). It is interesting to note that the two species namely the *Atractomorpha crenulate* and *Phlaeoba infumata* seemed different nymphal instars throughout the year, suggesting that these two species perhaps breed continuously throughout the year (Table 20) or this might be due to the prevalence of similar food plants and other ecological conditions throughout the year in the present field of study (Uvarov, 1977).

The time of emergence as hoppers and the time when maximum adults and nymphs occurred in the field would help in forecasting their out breaks in West Bengal (Mondal and Shishodia 1982).

It is interesting to note that all the nineteen species of grasshoppers have been collected from paddy, while ten species from maize and only six species from wheat (Table 1).

The reason for the high preference to paddy plants by the grasshoppers is not clear. When

monthwise occurrence of these species in paddy were analysed it was observed that infestation of all the species were found in the month of October and they were totally absent in January and June-July (Table 4).

The occurrence of these species were highly irregular in cereals crops and in other vegetables (Table 4). Therefore, it can be concluded from the above findings that some of these grasshopper species may be considered as serious pests of major crops like paddy, maize and wheat and doing considerable damage to other vegetables. It agrees with the findings of Kushwaha et al (1977), Iqbal and Aziz (1974) and Tandon et al (1988). But a definite conclusion could not be made on this aspect at this juncture unless more detailed laboratory observations were made with different species on several soil types and food.

SUMMARY

The present study deals with the taxonomy, biology and ecology of some economically important grasshoppers. The taxonomy of each adult species deals with synonym, diagnostic character, and distributions and key to the identification of species including the illustrations of different parts of the grasshoppers. There are about 340 species of grasshopper have been recorded so far from India, some are recognised as a pest of crops and vegetables. In the present study a total of 19 species belonging to 17 genera of the families Acrididae and Pyrgomorphidae have been described from West Bengal as pest of crops and vegetables. The family Acrididae which includes 17 species and 15 genera. Another family Pyrgomorphidae includes only two species belonging to the subfamily Pyrgomorphinae.

The nymphal taxonomy of 5 grasshoppers species viz *Spathosternum prasiniferum prasiniferum* (Walker), *Acrida exaltata* (Walker), *Phlaeoba infumata* (Brunner), *Aiolopus thalassinus tamulus* (Fabricius) and *Atractomorpha crenulata* (Fabricius) have also been carried out in the laboratory, which are usually important pests of crops and vegetables in W. Bengal as well as in India. During the study the measurements of eggs and egg pods, detailed characteristics of vermiform larvae and their instars with the key to identifications of different instars of each species are also provided.

The biology of these grasshoppers have been carried out in the laboratory by providing grasses like *Cyperus rotundus* and *Enhydra flactuens* at their food. It has been observed that in most cases the males took less time for sexual maturity than females. After first mating the starting of oviposition of a 'female' varies from 8 days to 15 days in *Phlaeoba infumata*, *Spathosternum pr. prasiniferum* starts its oviposition within 9 to 15 days, *Aiolopus th. tamulus* starts its oviposition within 10 to 16 days, *Acrida exaltata* starts within 12 to 20 days and

Atractomorpha crenulata starts within 10 to 18 days. No phase variation was observed in any of the above species of grasshoppers in respect of colour, hatching or fledging. Oviposition always takes in moist soil and dry soil is not suitable for this purpose. Extra moulting was found in *Phlaeoba infumata* male and in both the sexes of *Acrida exaltata*.

Seasonal abundance of short horned grasshoppers recorded from agricultural crops and vegetational sites have also been investigated in the district of 24 parganas of West Bengal.

The grasshopper fauna obtained from this site constituted of 12 species belonging to 11 genera viz. *Atractomorpha crenulata*, *Gesonula Punctifrons*, *Spathosternum pr. parsiniferum*, *Oxya fuscovittata*, *Oxya hyla hyla*, *Phlaeoba infumata*, *Acrida exaltata*, *Aiolopus th. tamulus*, *Trilophidia annulata*, *Tristria pulvinata*, *Eyprepocnemis al. alacris*, *Eupreponotus inflatus*. Of the species, *Spathosternim pr. prasiniferum* is the most dominant species and represents (42.68%) of total population followed by *Atractomorpha crenulata* (41.28%) , *Oxya fuscovittata* (32.43%) , *Phlaeoba infumata* (31.20%) , *Oxya hyla hyla* (17.38%) , occupied second, third, fourth and fifth position respectively in order of dominance. The population of other species is numerically low and highly irregular in distributional pattern. Of total population one highest peak was observed in November (12.08%) and the lowest being in the month of October (11.60%) and July (11.40%).

The maximum population of male (4.88%), female (2.88%) and nymph (5.40%) was recorded in May, August and November. It was seen that nymph constituted the major portion of populations (46.02%) during consideration of total male, female and nymph population, then came male (34.82%) and minimum was that of female (19.16%). Except *Gesonula punctifrons* all other grasshopper species in the present study showed a positive correlation with the temperature and humidity. It has also been found that the *Atractomorpha crenulata* and *Phlaeoba infumata* have several broods per year as their different nymphal instars were found throughout the year.

List of grasshoppers and their occurrence in major crops and vegetables in West Bengal are also provided.

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