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BIOECOLOGY OF BANANA INHABITING MILLIPEDE, *ANOPLODESMUS SAUSSUREI* (HUMB.) (DIPLOPODA : PARADOXOSOMATIDAE)

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ABSTRACT

A detailed study of life history and ecology of banana inhabiting millipede, *Anoplodesmus saussurei* (Humb.) found at Nischindapur (Howrah : West Bengal) has been made in the laboratory as well as in the field. Its various developmental stages, food and feeding habits and reproductive behaviour have also been studied.

Introduction

Millipedes are found in damp and humid situations under the rotten bark of logs, old trees and soil litter. They feed on decaying vegetable matter, soil and soil litter. Blower (1955) described millipedes as essential animals of the forest floor. Life history of several species of millipedes have been successfully studied and described by Davenport *et al.*, (1952) ; Blower and Gabbutt (1964) ; Blower (1970) ; Blower and Miller (1974 & 1977) ; Brookes (1974), Heath *et al.*, (1974) and Spaull (1976). Although the genus *Anoplodesmus* is represented in India only by 4 species (Attem, 1936), surprisingly enough there appears to be no work so far, on their life histories except for the work of Puttarudriah and Shivashankar Sastry (1959) on *Ktenostreptus* sp. damaging chillies, cotton etc. in Mysore state. Besides this some general statement were also given by Fletcher (1914), Ramakrishna (1935) and Puttarudriah (1958) regarding some Indian millipedes.

Thus to determine the number and duration of young stages, morphological changes in different stadia in the life history, food and feeding habits of a banana inhabiting millipede, *Anoplodesmus saussurei* (Humb.), investigations were undertaken here in Calcutta (West Bengal). It is most commonly found in decaying banana stems moving very frequently in and around the banana plantation during May to November. It is bright chestnut or dark chocolate brown, but the mature specimens are black in colour ; lateral keels are pale yellow ; head, antennae, legs and underside brown.

Materials and Methods

Specimens were collected from the decaying banana stems and also from the banana plantation at Nischindapur (Howrah : West Bengal) during June and July, 1978. Hand samples were taken on each sampling occasion to provide material for assessing breeding condition. The collected live individuals were taken into laboratory and were maintained in the standard wide mouthed glass jars filled to a depth of about 10 cms. with rich, dark

humus litter and pieces of rotten banana stems collected from the same habitat. These jars were covered with muslin colth tightly. During the course of observation some fresh green leaves (Jute, pumpkin etc.) bread and rotten fish were also provided to study the food and feeding habits. Brood chambers with eggs formed by the adult pair, were kept in separate petridishes alongwith soil, decaying vegetable and litter to study incubation period, hatching, etc. Jars and petridishes were moistened with water at regular intervals to ensure the requisite moisture. During the course of observations the maximum and minimum temperature recorded in the laboratory were 36°C and 24·1°C and the maximum and minimum relative humidity percentage recorded were 99% and 53% respectively.

Results & Observations

Food and Feeding : Millipedes exhibit preference in their choice of food and it varies with species to species (Drift, 1965). Chemical basis of food preference in millipedes have been studied and reported by Sakwa (1974). Detailed food and feeding habits of an interesting millipede have also been given by Puttarudriah and Shivashankar Sastry (1959) and Bano *et. al.*, (1976). They have reported that millipedes are found to feed on decaying vegetable matter, many economic crops and soil.

The *A. saussurei* was found feeding in the field on decaying banana stems, soil under fallen leaves and some green leaves present in the banana plantations at Nischindapur (Howrah) and Chandan Nagar (Hooghly). Under laboratory conditions it was observed that these millipedes were feeding mainly on decaying vegetables and rotten banana logs. Sometimes it was also observed that they prefered decaying fish, green leaves of jute and pumpkin plants.

Tunneling : Tunneling has been observed in the laboratory. Young individuals start tunneling from third instar stage (3rd Stadium). In this stage they make tunnels, ending in a chamber, only for moulting. From fourth instar stage (4th Stadium) and onwards they make tunnels to build up their nests ete. The horizontal tunnels are inter-communicated inside the soil having a number of vertical tunnels opening to the surface of the soil.

Millipedes start construction of their own tunnels by holding a small mass of soil with the help of its gnathochelarium and labrum and push back from the particular spot with the help of legs (Plate I, fig. D). This process was repeated by the adults several times and they complete the formation of tunnels. A 3 cm deep and 0.5 cm in diameter tunnel was constructed within 6 hrs. of time. When soil is loose and it is full of food materials, the millipedes starts eating the soil to build their tunnels.

Courtship and Mating (Plate I, figs. A-C) : The male follows the female moving very close to it with its head end in apposition with that of female and feels it with antenna. When female permits male try to come on her back from posterior end of the body. After sometime the anterior portion of the male touches the ground and pair turns laterally holding each other with the help of legs. However, the posterior part of the body of the male remains on the back of the female. Then, their anterior parts of the body come in close contact laterally. Afterwards the male move a little forward so that genital openings of both come in contact. Thus the copulation is established. They remain in this position for about 5 minutes after which

male separates itself and moves away. Whereas the female remains at rest for about 5 to 7 minutes. It has been observed that process of courtship and mating may last for about 4 hours. On the basis of field observations it has been found that mating occurs during May to October.

Ovipositon : Egg laying in *A. saussurei* generally commenced during June to October, showing nearly 2 to 3 weeks interval between mating and egg laying. Process of egg laying in the millipedes is very interesting and has been recorded by several workers. Theobold (1904) and Sinclair (1922) have observed that the females of *Julus terrestris* deposit eggs in a nest, made up of small particles of soil mixed with saliva. The nests are rounded with a small hole at the top and just after oviposition hole was closed by the female.

The process of egg laying in *A. saussurei* was observed in the laboratory. Both male and female make a tunnel into the soil at a depth of about 2 cm to 5 cm and construct an earthen chamber at the end of the tunnel with the help of soil and saliva. The depth of the chamber of inside the soil depends upon the moisture contents of the soil—drier the soil, deeper the position of the chamber. The inner surface of the chamber is smooth and about 1.5 cm in diameter. It has a small opening to its upper surface through a curved tunnel. The eggs were laid in 3 batches with an interval of 2 to 3 days. In each chamber only one batch of 250-300 eggs were laid in a cluster as the eggs were coated with a sticky substance that caused them to clump together (Plate II, figs. A &B). It was interesting to note that the opening at the upper end of the nest was not closed after oviposition in this species.

Incubation Period and Hatching : The incubation period in this species was observed in the laboratory during the month of August 1978. It was found to be 4-5 days.

Mature eggs hatched in the "split stage" (Davenport *et al.*, 1952), by splitting in egg shells into two halves with a small connection between each other, like hinged hemispheres.

Breeding Records : The study was begun with the adult individuals collected from the field on 31. 7. 78 and among them three adult couples were kept seperately in three Glass jars half filled with fresh humus, collected from the same field, known to be free of eggs or early stages. Immediately after their captivity in the jars all the three pairs were seen in courtship which ended in copulation on the same day, *i. e.*, 31. 7. 78 evening. Out of these three pairs only one pair survived and the other two female individuals died before egg laying. The survived female millipede laid eggs in three batches on 20. 8. 78, 22. 8. 78 and 25. 8. 78. So from our present observations in the laboratory it can be told that the time between the copulation and egg laying is about 20-25 days. After hatching samples were preserved at regular intervals for detailed study of each stadium. Out of these egg batches some individuals of the second egg batch gradually moulted to miniature adults after passing through 7 stadia and the time taken was about 2 months.

Breeding records of *Anoplodesmus saussurei* (Humb.) reared in the laboratory is tabulated in table 1 & 2.

DEVELOPMENTAL STAGES

Apart from egg and adult seven different 'Stadia' are found in between these two phases in their life cycle.

TABLE—1

No. of egg hatches	I	II	III
Date of egg laying	20.8.78	22.8.78	25.8. 78
Date of hatching, *i. e.*, onset of Stadium I	25.8.78	27.8.78	30.8.78
Moulted to Stadium II	26.8.78	28.8.78	31.8.78
,, ,, Stadium III	1.9.78	4.9.78	6.9.78
,, ,, Stadium IV	11.9.78	11.9.78	12.9.78
,, ,, Stadium V	15.9.78	16.9.78	—
,, ,, Stadium VI	—	21.9.78	—
,, ,, Stadium VII	—	25.9.78	—
,, ,, Miniature adult	—	24.10.78	—

(Breeding records of *Anoplodesmus saussurei* (Humb.) in the laboratory)

TABLE—2

Stadium	No. of Post-cephalic segments	Pairs of legs		Body measurements		Duration of each Stadium (in day)
		Male	Female	Length (in) mm	Width (in) mm	
Stadium I	7	3	3	0.58-0.70	0.25-0.30	1
,, II	9	6	6	1.41-1.72	0.29-0.36	6-7
,, III	12	10	11	2.35-2.58	0.41-0.43	7-10
,, IV	15	16	17	3.53-4.70	0.51-0.56	4-5
,, V	17	22	23	6.28-6.85	0.80-0.97	5
,, VI	18	26	27	8.57-9.26	1.10-1.19	4
,, VII	19	28	29	14.28-15.10	1.60-1.77	30
Adult	20	30	31	28.22-32.44	3.66-4.70	—

(Characteristics of developmental stages)

Eggs :—(Plate II, Fig. A & B) The eggs were approximately round, about 0·44 mm to 0·45 mm in diameter. They were appearing pearly with a creamy white smooth surface. All the eggs were coated with a sticky substance that caused them to adhere together among themselves which is also water repellent by nature. As the eggs mature the colour of the egg shell turned brownish.

Stadium I (Fig. 1, A-F) : The young hatched through the rupture of egg shells, non-motile, transparent and whitish in colour. All the individuals of the Stadium I, lying in a group in the chamber where they hatched, curved and comma (,) like in outline. Body covered with fine small white setae. Usually 3 pairs of legs but in some cases rudiment of 4th pair legs present. Body composed of

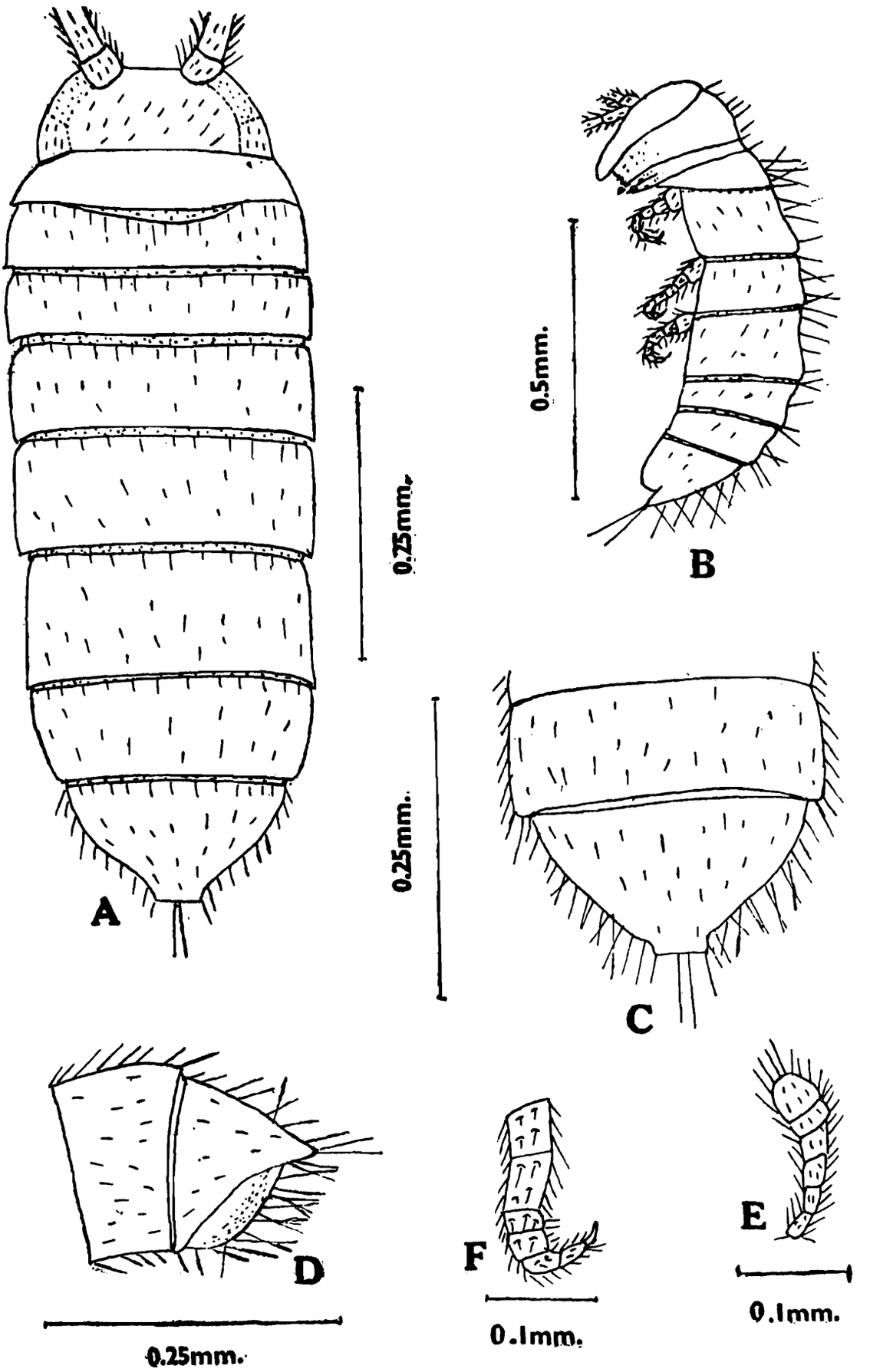


Fig.—1 (A—F) : First instar of *Anoplodesmus saussurei* (Humb.) (A—Dorsal view, B—Lateral view, C—Pygidium dorsal view, D—Pygidium lateral view, E—Antenna, F—Leg.)

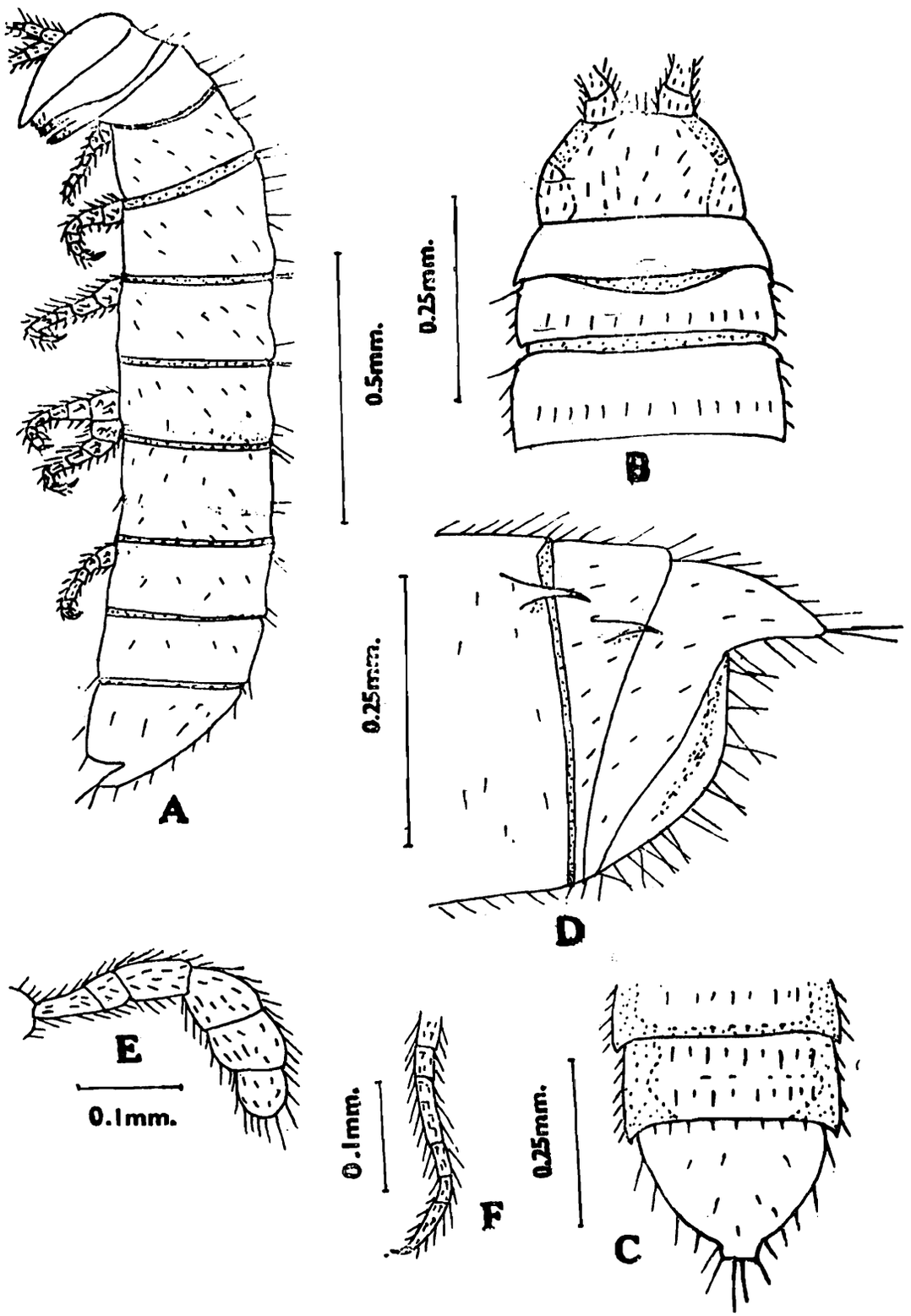


Fig.—2 (A—F) : Second instar of *Anoplodesmus saussurei* (Humb.) (A—Lateral view, B—Dorsal view of anterior portion of body, C—Pygidium dorsal view, D—Pygidium lateral view, E—Antenna, F—Leg.)

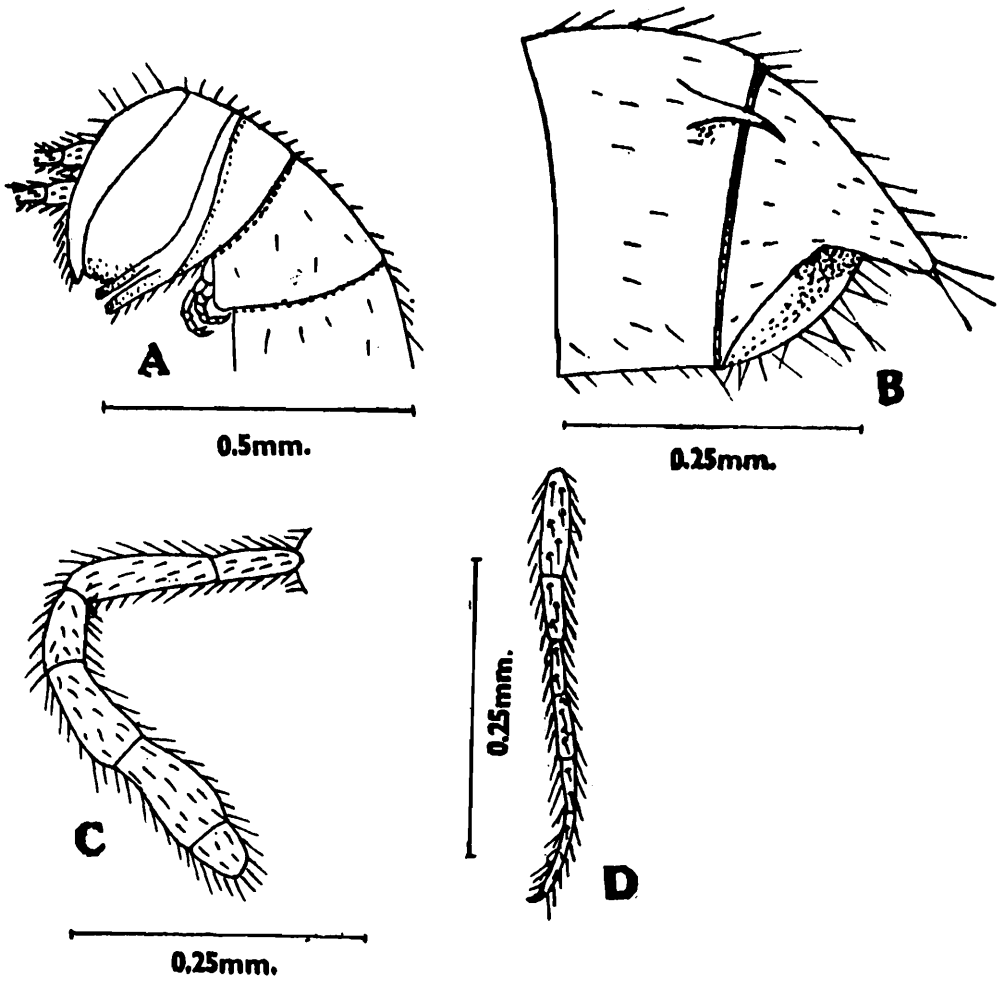


Fig.—3 (A—D) : Third instar of *Anoplodesmus saussurei* (Humb.) (A—Lateral view of anterior portion of body, B—Pygidium lateral view, C—Antenna, D—Leg)

head and 7 post-cephalic segments. Head bears one pair of small 6 segmented club shaped antennae. The individuals of stadium I observe complete starvation before they display community moulting to enter in the Stadium II.

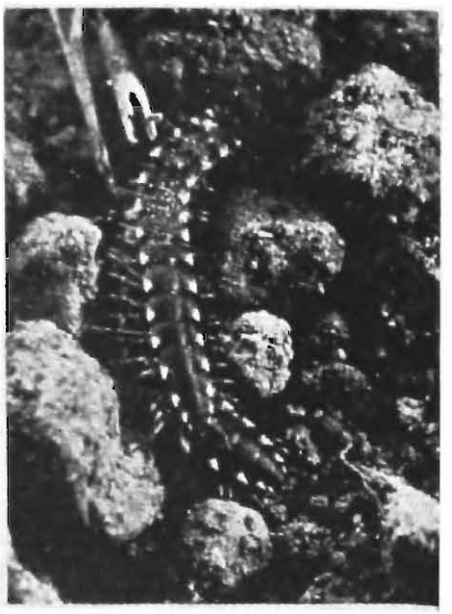
Stadium II (Fig. 2, A-F) (Plate II. fig. C) : All individuals of this Stadium also found in a group inside the chamber. Individuals non-motile just after moulting and become active on following days. Sometimes they move to the soil surface. Body creamish white in colour with 9 post-cephalic segments and 6 pairs of legs. Antenna 6 segmented and club shaped. Individuals do not feed in in the earlier part but in later phase they start feeding.

Individuals do not build seperate chambers for moulting, show community moulting in any suitable covered place inside the soil.

Stadium III (Fig. 3, A-D) : Body 12 post-chephalic segmented with 10 and 11 pairs of legs in male and female respectively. Body light brown, gradually changing to light yellow near lateral keels. Antenna 6 segmented gradually attaining a cylindrical form, rather than club shape.

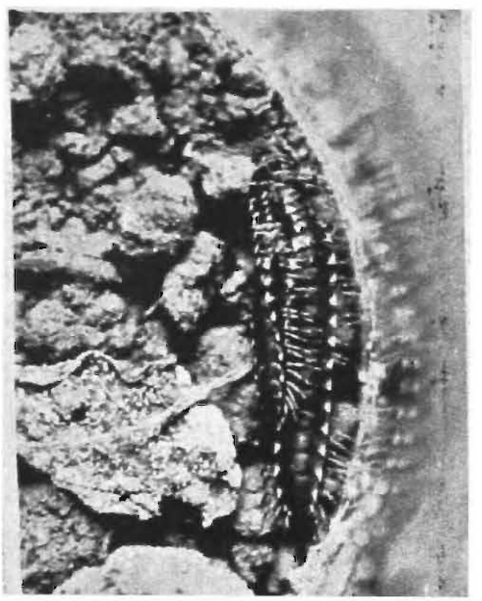
PRASAD, DEY & KHAN

PLATE I

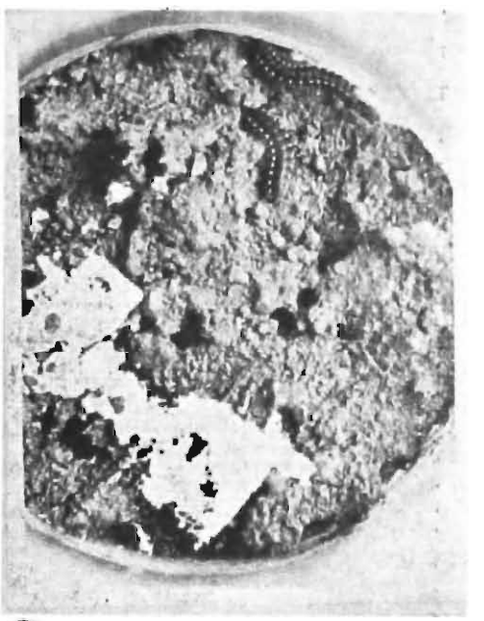


A

B

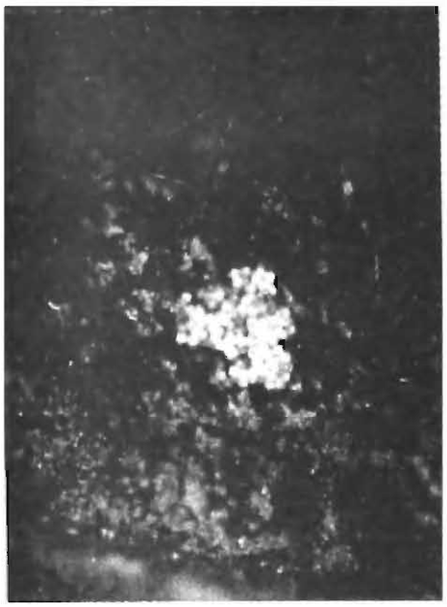


C

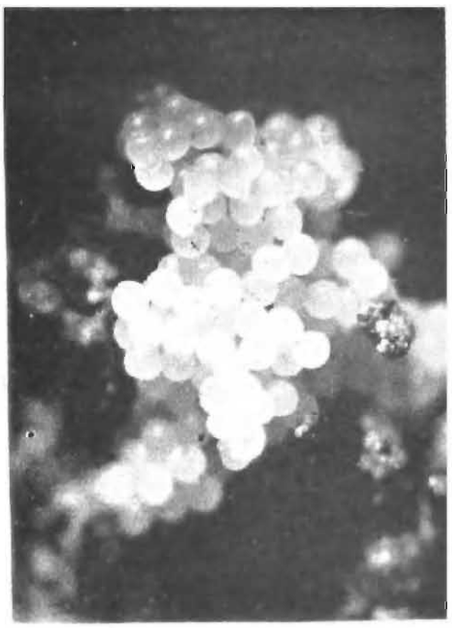


D

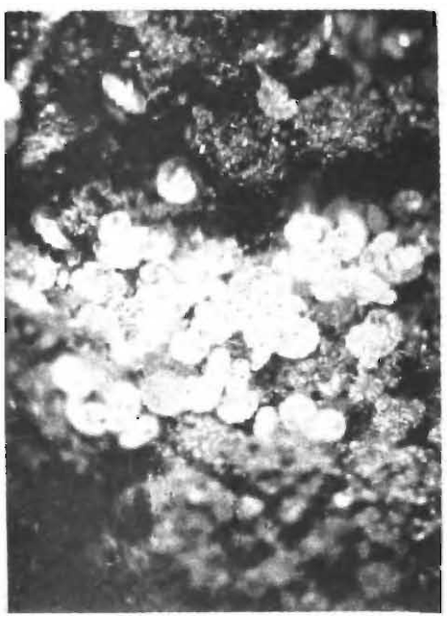
(A—D) : Showing courtship, mating and tunneling of *Anoplodesmus saussurei* (Humb.) (A—Courtship, B & C—Mating, D—Tunneling).



A



B



C

D

(A—D) : Showing eggs, second instars and moulting of *Anoplodesmus saussurei* (Humb.) (A—Egg cluster *in situ*, B—Enlarged view of egg cluster, C—Second instars just after moulting *in situ*, D—Seventh instar adult moulting inside the moulting chamber *in situ*.)

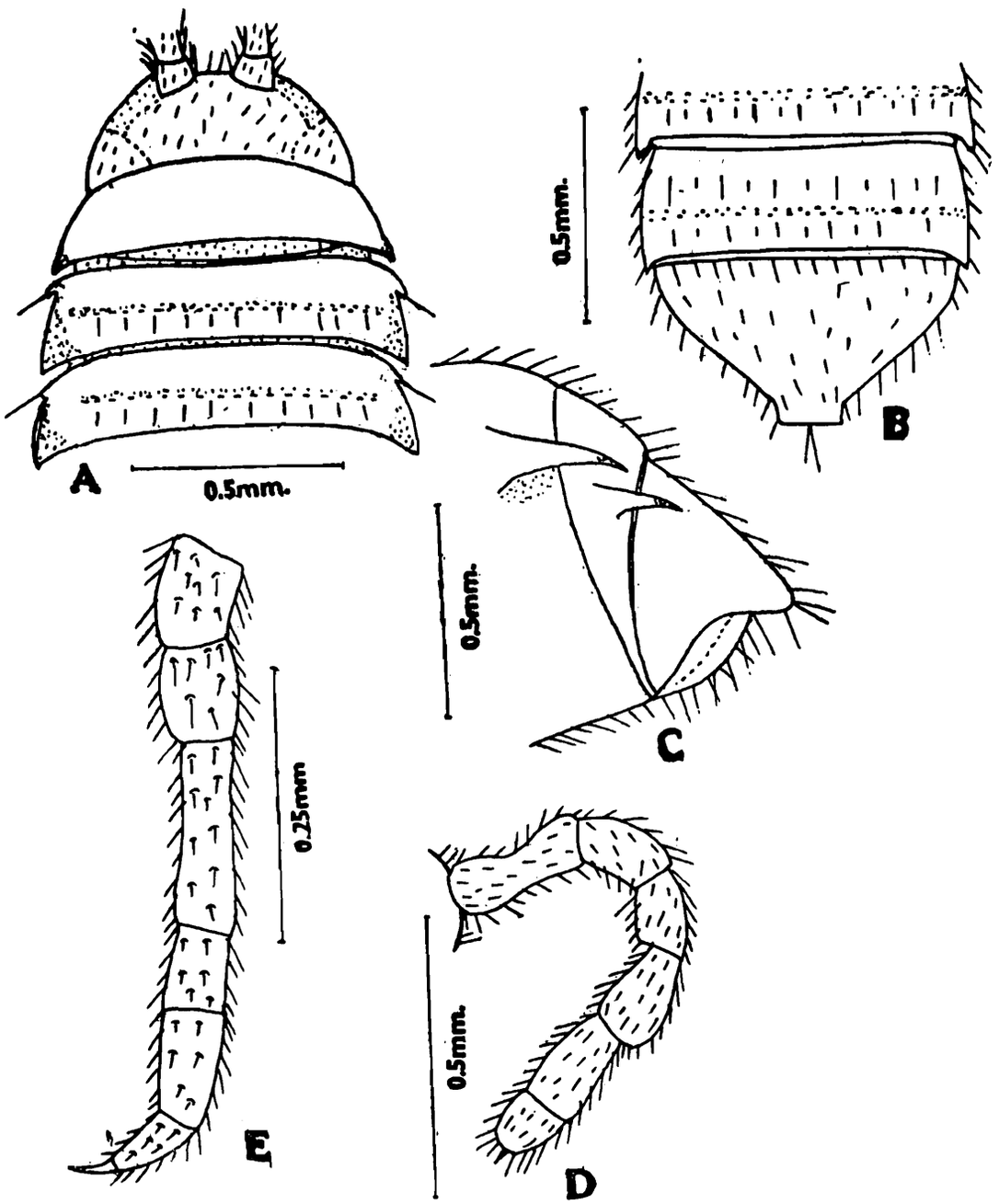


Fig.—4 (A—E): Fourth instar of *Anoplodesmus saussurei* (Humb.) (A—Dorsal view of anterior portion of body, B—Pygidium dorsal view, C—Pygidium lateral view, D—Antenna, E—Leg,

Individuals construct their own moulting chambers individually right from this Stadium and onwards.

Stadium IV (Fig. 4, A-E) : Young ones very active and brownish in colour ; darker than the previous stadium, Lateral keels developed. Body 15 segmented with 16 and 17 pairs of legs in male and female respectively. Anterior pair of the appendages of seventh post cephalic segment in male shows an impression of future gonopod.

Stadium V : Body brownish with 17 post-cephalic segments and 22 and 23 pairs of legs in male and female respectively. Antenna

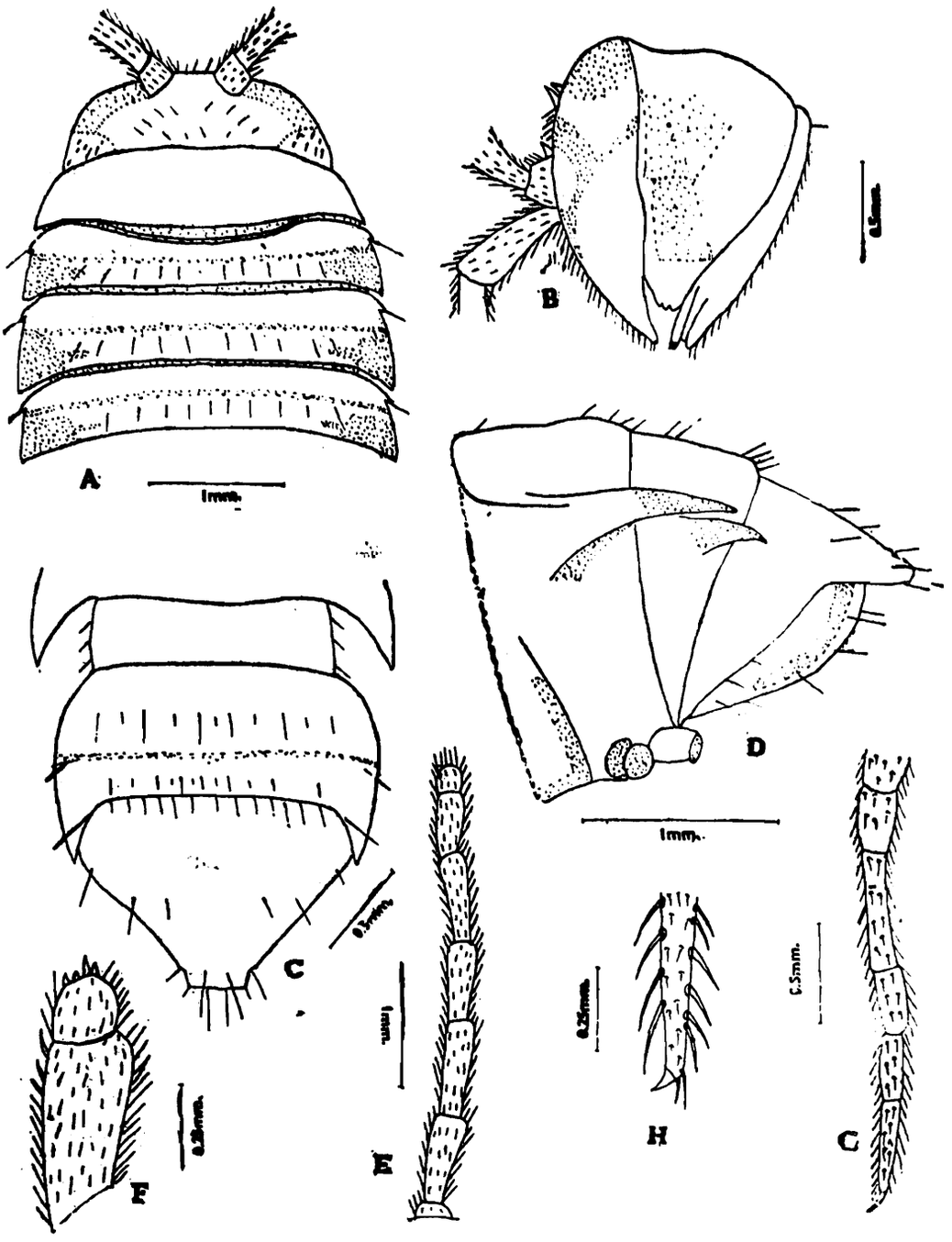


Fig.—5 (A—H) : Seventh instar of *Anoplodesmus saussurei* (Humb.) (A—Dorsal view of anterior portion of body, B—Lateral view of anterior portion of body, C—Pygidium dorsal view, D——Pygidium lateral view, E—Antenna, F—Enlarged view of anterior segments of Antenna, G—Leg, H—Enlarged view of tarsus.)

more elongated ; lateral keels well developed.

Stadium VI : Body with 18 post-cephalic segments and 26 and 27 pairs of legs in male and female respectively. Other details almost like the previous Stadium.

Stadium VII (Fig. 5, A-H) : Body chocolate brown with 19 post-cephalic segments and 28 and 29 pairs of legs in male and female respectively. Lateral keels very prominent and pale yellow in colour. Head, antenna, legs and underside of the body brown. 4 medium sized spines present at the anterior end of the 6 segmented antennae. Gonopods more developed in male.

Miniature adult : Body colour dark chocolate brown with 20 post cephalic segments and 30 and 31 pairs of legs in male and females respectively. Individuals undergo further 5 or 6 moults to attain its full adult size, gonopods well developed. During these moultings there is no further addition of any post cephalic segments or legs but only the size is increased. In each successive moults the body colour becomes darker, gradually leading to deep chocolate brown or nearly black.

Discussion

Detailed life cycle and ecology of *Anoplodesmus saussurei* (Humb.) collected from banana field at Nischindapur (Howrah : West Bengal) was studied alongwith its food and feeding habits, tunneling, moulting and reproductive behaviours in the laboratory as well as in field. In the field it was feeding on decaying banana stems, soil under follen leaves and green leaves present in the banana plantation and in laboratory on decaying vegetables, rotten banana stems, decaying fish, green leaves of jute and pumpkin plants. The process of courtship and mating were continued for about 4 hours. Both male and female construct a tunnel into the soil at a depth of about 2 cm to 5 cm with the help of soil and saliva for egg laying. The eggs were laid in 3 batches with an interval of 2 to 3 days. In each chamber only one batch of 250-300 eggs were laid in the form of a cluster which were coated with a sticky substances that caused them to clump together. It was interesting to note that opening at the upper end of the nest was not closed after oviposition. The eggs gradually moulted into full miniature adults after passing through 7 stadia and the time taken was about two months.

It was observed that young ones of earlier egg batches which were laid just at the starting of monsoon (May-June) reach maturity before starting of winter (October-November). Young ones of later egg batches which were laid in late monsoon period (August-September) did not attain maturity in the same year. They go for hibernation during the winter and summer. As soon as the monsoon starts in the following year, they complete their development through successive moults. So it takes about 5/6 months or a year for the maturity of this group of millipede.

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