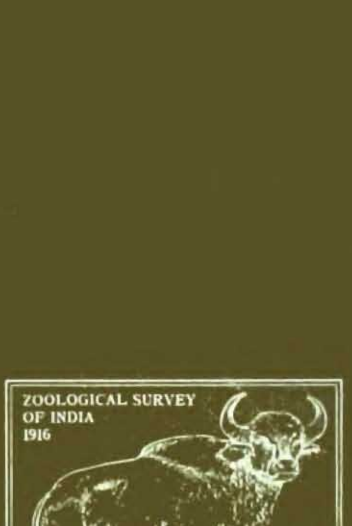
BULLETIN

OF THE

ZOOLOGICAL SURVEY OF INDIA



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BULLETIN OF THE ZOOLOGICAL SURVEY OF INDIA

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Short Communication

Bull. zool. Surv. India, 1 (2) : 95-98, 1978

COMPOSITION OF THE HONEYDEW EXCRETED BY THE LAC INSECT, *KERRIA LACCA* (KERR) (HOMOPTERA : COCCOIDEA)

II. CARBOHYDRATES

R. K. VARSHNEY

Zoological Survey of India, Calcutta

ABSTRACT

Honeydew of the lac insect, *Kerria lacca*, is rich in sugars. By means of paper partition chromatography four carbohydrates, *viz.*, glucose, fructose, sucrose and an unidentified oligosaccharide have been detected in the honeydew of mature females. The sap of a host-plant, *Moghania macrophylla*, was also analysed and found to contain only first three of them. Probable identification of the unidentified compound has been discussed.

INTRODUCTION

The honeydew of aphids and coccids contains much unabsorbed organic matter, *e. g.*, carbohydrates, amino acids and amides (Rockstein, 1964 ; Wigglesworth, 1965). In freshly excreted honeydew water soluble carbohydrates account for more than 80% of the total weight, the remaining 20% being water, nitrogen containing compounds and traces of other material (Ewart and Metcalf, 1956). Among the nitrogenous constituents uric acid is reportedly most common in the excreta of insects.

Little is known about the honeydew of the lac insect, *Kerria lacca* (Kerr). The amino acids and amides present in the honeydew of mature females have been reported in the Part I of the present study (Srivastava and Varshney, 1966). It was not possible to detect uric acid in the lac insect honeydew. Mittler (1958) also failed to find evidence of uric acid in case of *Tuberolachnus salignus*. However, the honeydew of lac insect is quite rich in sugars, as evident from the large number of ants which are attracted to it, as well as by the growth of a sooty black fungus on the surfaces of leaves and shoots where honeydew droplets fell.

The present study was carried out initially at the Indian Lac Research Institute, Ranchi, and later continued at the Deptt. of Zoology, Patna University. It forms a part of the thesis of the author, approved for the Ph. D. degree of the Patna University (Varshney, 1972).

MATERIAL AND METHODS

The composition of honeydew was analysed by the paper partition chromatography. Fresh honeydew droplets from mature lac insect females growing on experimental host-plants, particularly *Moghania macrophylla*, were used. Fresh droplets were collected by means of a fine micropipette and these were deposited directly on the chromatographic filter papers. Chromatograms were developed unidimensionally as well as two—dimensionally. The first development was made in phenol-water (80 : 20 v/v) and the second in *n*-butanol- ethanol - acetone - water (5 : 4 : 3 : 2 v/v). Some other solvent systems were also tried for the second development, *viz.*, *n*-butanol - acetic acid - water (4 : 1 : 5 v/v, upper layer), and ethyl acetate - acetic acid - water (4 : 1 : 5 v/v, organic phase). The dried chromatograms were treated with benzidine - trichloroacetic acid reagent by dipping technique of Harris and MacWilliam (1954). The silver nitrate method of Trevalyan *et al.* (1950) was also tried, but as it was observed to make spots heavier, it was abandoned. The carbohydrates were identified by comparing the R_f. with standard chromatograms, which were

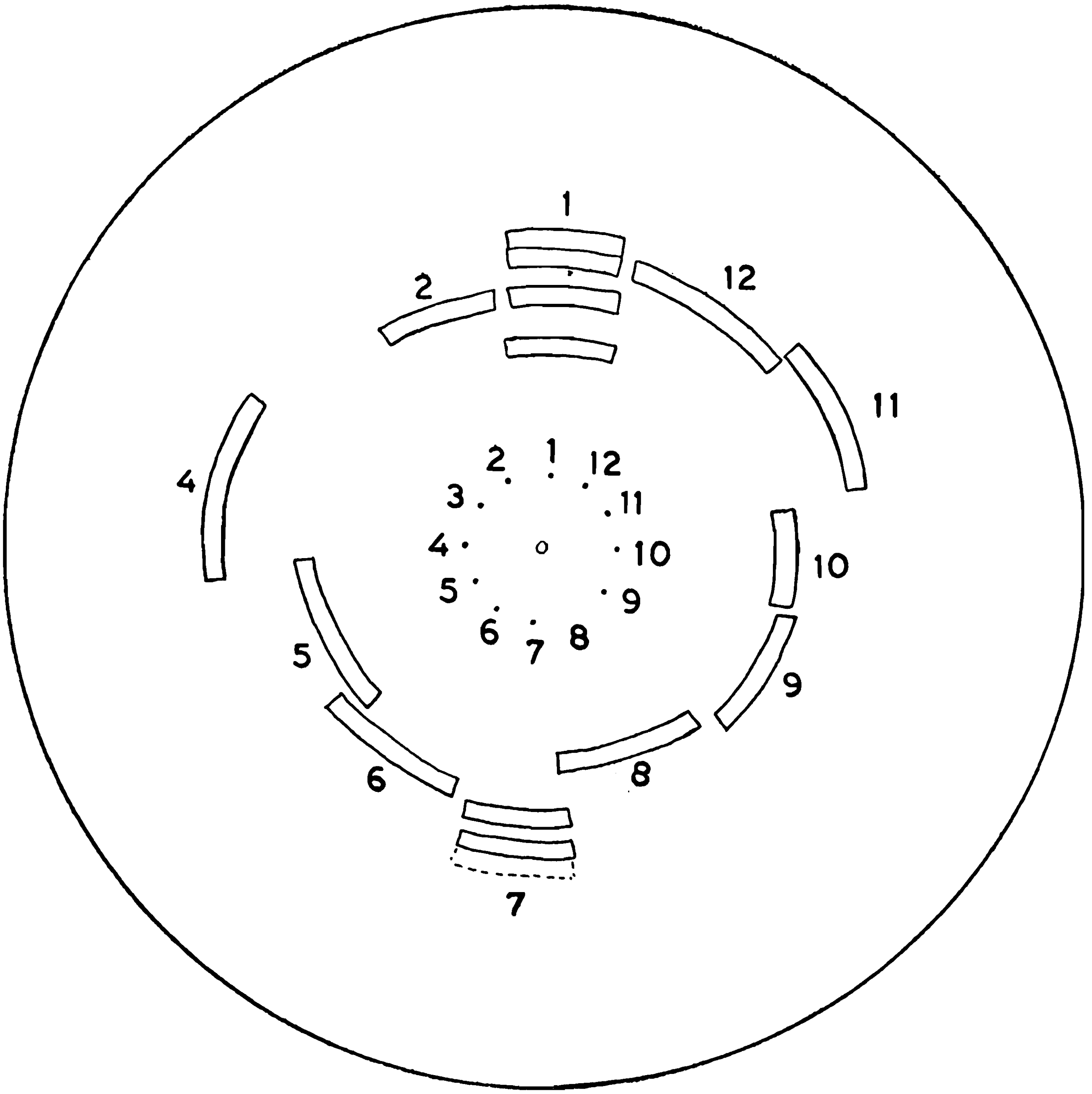

Fig. 1. Circular chromatogram showing some pure carbohydrates, and the carbohydrates separated from the honeydew of *Kerria lacca* and the sap of host-plant *Moghania macrophylla* : 1. Honeydew, 2. sucrose, 3. trehalose, 4. arabinose, 5. melibiose, 6. maltose, 7. sap of host-plant, 8. raffinose, 9. lactose, 10. melizitose, 11. fructose 12. glucose.

prepared from known pure carbohydrates developed in exactly similar conditions.

Circular chromatography was also attempted for analysis. Such chromatograms were spotted with the honeydew of lac insect female, sap of the *Moghania macrophylla* host-plant, as well as a number of pure carbohydrates side by side, and developed horizontally in *n*-butanol-ethanol-acetone-water (5 : 4 : 3 : 2 v/v) solvent system. The spots were revealed by the benzidine-TCA reagent.

RESULTS AND DISCUSSION

The honeydew of lac insect, *K. lacca*, is a clear watery fluid in the fresh state. On getting dry, however, its drops become white or yellowish-white due to presence of heavy quantity of sugars. Four carbohydrates have been detected in the present study. These are glucose, fructose, sucrose and an unidentified oligosaccharide compound. The sap of the host-plant *Moghania macrophylla* was found to contain only first three of them, the fourth sugar was absent (Fig. 1).

This fourth unidentified compound invites attention. It appeared on the chromatograms below the spot of sucrose and its R_f value suggested it to be an oligosaccharide. The compound apparently comes closer to raffinose and melibiose, as shown in Fig. 2. It is well known that the heavier molecular weight of a compound lowers its R_f value. By comparing the unidentified carbohydrate compound with other known pure carbohydrates, the possibility of the former being a monosaccharide or disaccharide does not exist. It may, hence, most probably be a trisaccharide.

Many other carbohydrates have been recorded from the honeydew of other coccids and aphids. Gray and Fraenkel (1953) discovered a trisaccharide in the honeydew of aphid, *Aphis spiraecola* and two coccids, *Pulvinaria vitis* and *Pseudococcus citri*. Bacon and Dickinson (1957) have showed that a trisaccharide, melizitose, present in the honeydew of *Eucallipterus tiliae* was an insect product and produced due to the enzymatic action on sucrose within the insect body. In the honeydew of another coccid, *Icerya*

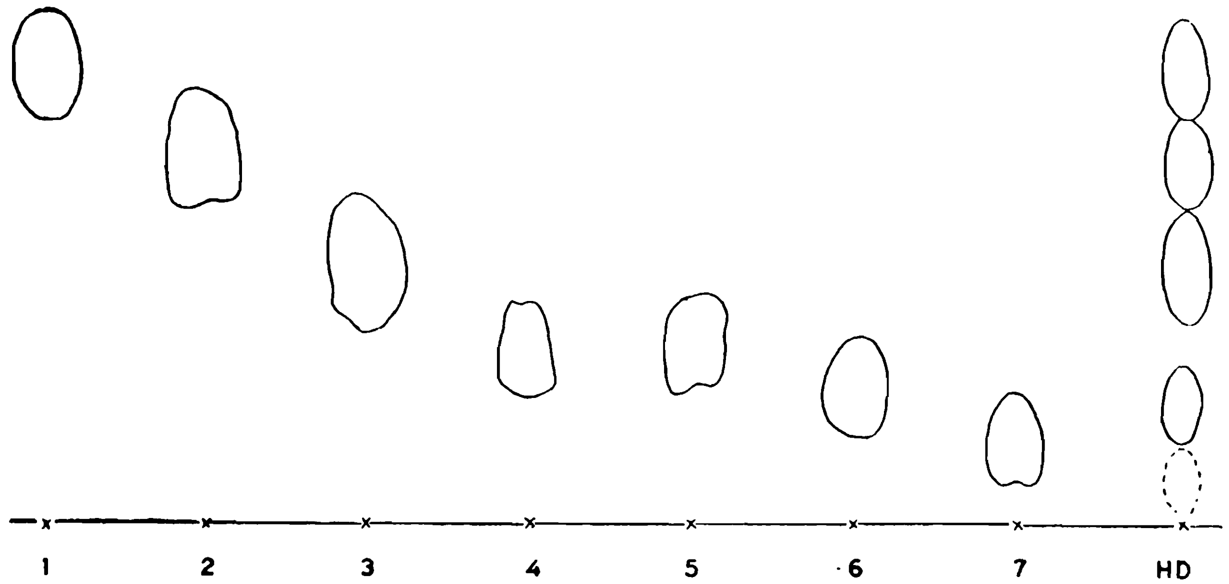

Fig. 2. Chromatogram showing some pure carbo-hydrates and the carbohydrates separated from the honeydew of *Kerria lacca* : 1, Fructose, 2. glucose, 3. sucrose, 4. melizitose, 5. maltose 6. melibiose, 7. raffinose, HD, honeydew.

purchasi, the presence of trisaccharide melizitose has been reported along with an enzyme which is said to be capable of synthesizing it from sucrose present in that insect (Ewart and Metcalf, 1956). The unidentified carbohydrate of the honeydew of lac insect, reported in the present study, is evidently produced during the metabolic activity within the insect body, as it is absent in the sap of the host-plant (Fig. 1). This carbohydrate might have been produced due to the action of an enzyme, perhaps invertase, on other carbohydrates present in the gut of the lac insect. Such a possibility is expected since it is now established that invertase is capable of forming oligosaccharides due to the transglucosylase activity, which has been reported in many plant sucking insects (Duspiva, 1953, 1954 ; Saxena and Bhatnagar, 1961 ; Srivastava and Auclair, 1962).

It seems that like other coccids and aphids, the lac insect also takes amino-acids and carbohydrates from the host-plant in excess of its requirement and thus passes this excess in the honeydew. The significance of this wasteful method of feeding is generally supposed to lie in a deficiency of some compound in the sap of host-plant, which is unknown as yet and deserves investigation.

ACKNOWLEDGMENTS

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INTRA SUBSPECIFIC HAEMOGLOBIN POLYMORPHISM IN *BANDICOTA BENGALENSIS KOK* (GRAY)

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ABSTRACT

Intra subspecific haemoglobin polymorphism in *Bandicota bengalensis kok* (Gray) is reported. Hb^S is considered a generic feature in the genus *Bandicota*. Presence of both Hb^J and Hb^S haemoglobin in the same sample is noted.

INTRODUCTION

In an attempt to clear the confusions created in Ellerman's (1961) classification of the genus *Bandicota* Agrawal and Chakraborty (1976) reduced the number of the subspecies of *B. bengalensis* from seven to three. The three subspecies (*B. b. bengalensis*, *B. b. kok* and *B. b. gracilis*), which are now merged under a common subspecies *B. b. bengalensis* were differentiated previously on most controversial overlapping characters, like fur colour, texture, external and osteological measurements. On comparing *B. bengalensis* (*B. b. kok* (*lordi*) (Wroughton) with material present in the Zoological Survey of India, Calcutta all were found only to be the forms with size differences of the same subspecies, *B. b. bengalensis* (Pradhan, in press). The application of new taxonomical techniques like karyology and biochemical taxonomy correlated with those of external morphology and osteology confirms the status of subspecies or species in a genus. The karyological studies carried out in different subspecies of *B. bengalensis* have shown that the species, *B. bengalensis*, possesses same Karyotype in all these subspecies (Avirachan *et al.* 1971, Sharma & Raman, 1971). Though the karyological studies are apparently sufficient to confirm the inclusion of all above mentioned subspecies in a common subspecies *B. b. bengalensis*, any conclusion without reference to biochemical techniques may not be in order. The transferin and haptoglobin patterns of the genus *Bandicota* have already been reported (Deoras and Pradhan, 1976 ; Pradhan, 1975). The present paper deals with another blood protein, haemoglobin, which has a great significance in biochemical taxonomy of the genus *Bandicota*.

MATERIAL AND METHODS

The material for biochemical tests were provided by Bombay Municipal Corporation and for taxonomic studies by Zoological Survey of India, Calcutta. Fresh blood was collected from the live stock of field rats by puncturing the heart. The blood clot containing rich quantity of haemoglobin was separated from the serum and was treated with phosphate buffer (pH 8.9). Haemoglobin oozed out from R.B.C. mass and dissolved in the buffer solution. The haemoglobin concentration was brought close to the dilu-

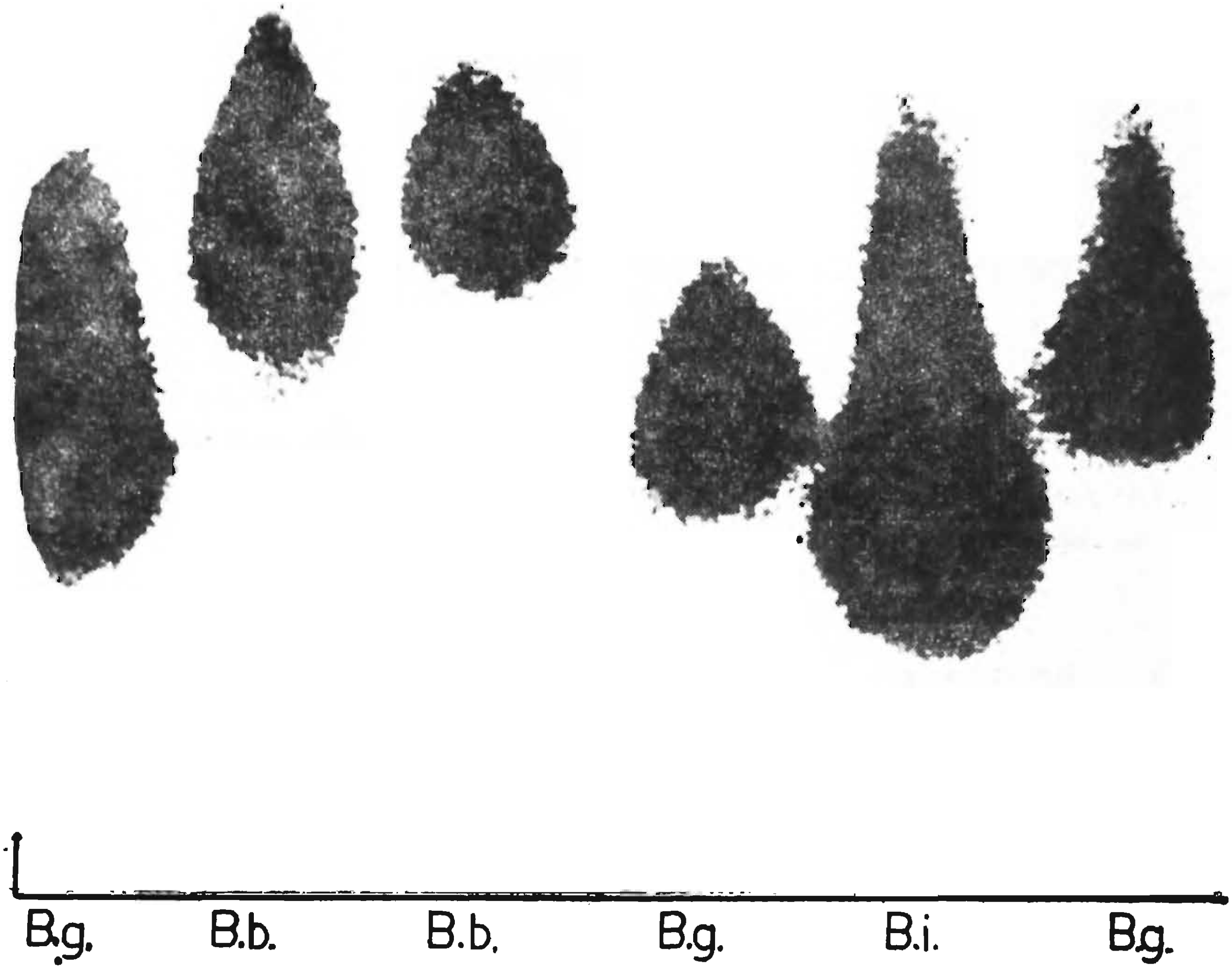

Fig. 1 : *Bandicota* hacmoglobin patterns by paper electrophoresis.

tion of 0.5 gm. / 100 ml. The solution was kept in freeze for 12-24 hours at 4°C. The samples were then run for paper electrophoresis. The electropherograms were then dried in oven and the mobility of bandicoot haemoglobin was studied without giving any post electrophoretic treatments to the strips. The procedure adopted for the present studies was from Pauling *et al.* (1949).

RESULTS AND DISCUSSION

Figs. 1 and 2 show the paper electropherograms showing the mobility of bandicoot haemoglobin. Almost all the samples possess 1/1 type of haemoglobin comparable to normal human type. *B. bengalensis* possesses the fastest moving haemoglobin (Hb) while *B. gigantea* possesses slower and *B. indica* has got the slowest moving Hb. But this difference in mobility is not significant to draw any concluding line of specific separation. The difference in the mobility might have been caused by the local differences in the electrical or the ionic field during the electrophoretic run. One sample of *B. bengalensis* shows the presence of an additional Hb band (Fig. 2). The occurrence of the two haemoglobin bands in the same sample was confirmed by repeating the run.

Marchlewska-koj (1967) has shown that rats possess 1/1 type of haemoglobin comparable to the normal human type Hb^{A} (Anonymous 1964). As the genus *Bandicota* possesses the Hb^{S} type which is slower than Hb^{A}, Hb^{S} is considered a generic feature with regard to the genus *Bandicota.*

The most interesting type of Hb is seen in an exceptional type of *B. bengalensis* possessing two bands. The fastest moving band is comparable to Hb^{J}. In the present studies a crossbreed between the Hb^{S} and Hb^{J} (1/2 type) is being reported. Unfortunately the naturally occurring pure breeds of the Hb^{J}

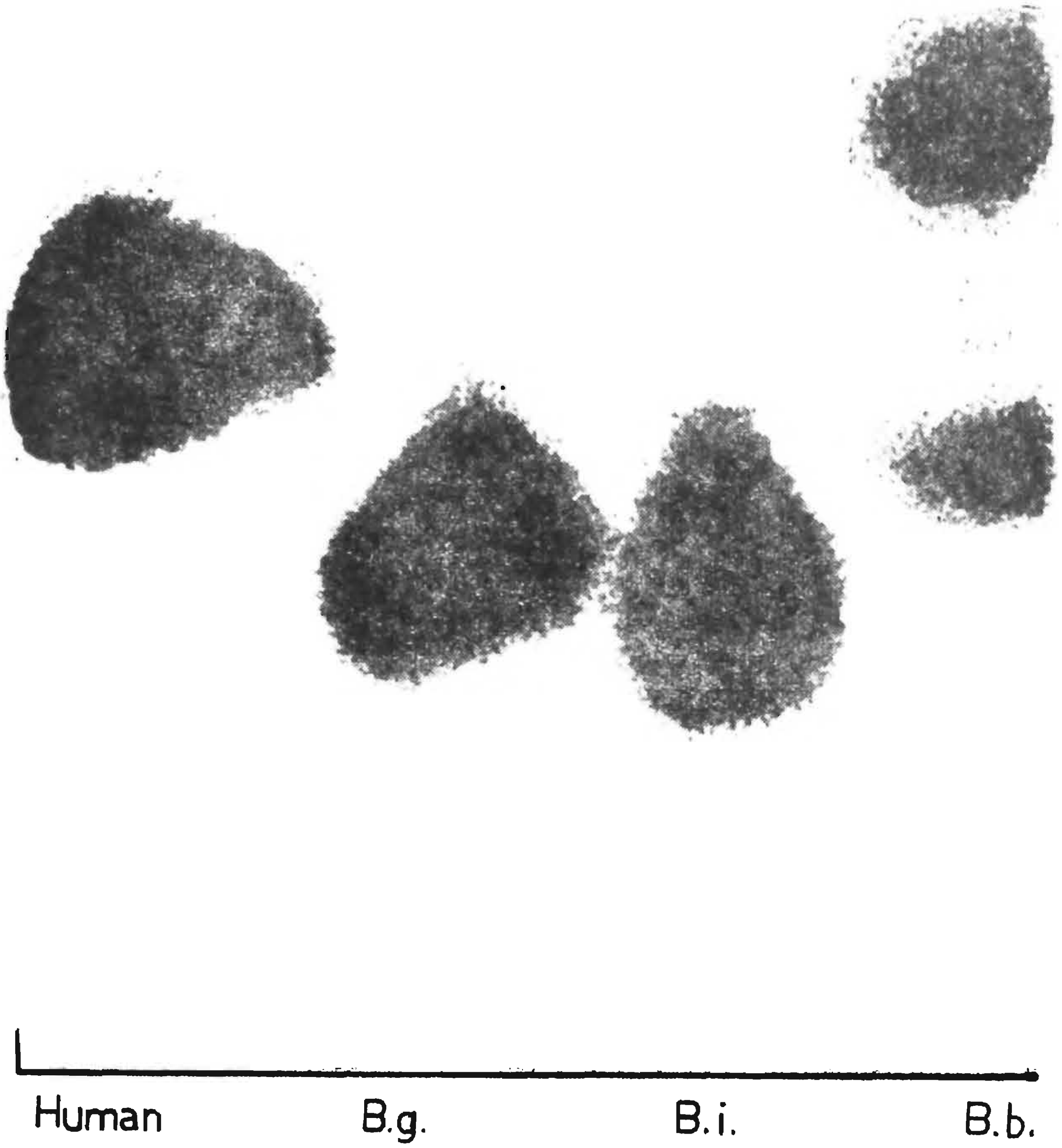

Fig. 2 : *Bandicota* haemoglobin patterns Showing intrasubspecific haemoglobin polymorphism in *B. bengalensis.*

type field rats were not available for external morphological studies. But the occurrence of Hb^J and Hb^S in a single animal itself confirms the intra-subspecific haemoglobin polymorphism. If the homozygous Hb^J and Hb^S types are located separately and if their external morphological and osteological studies are carried out, then the differences, if present, can be pointed out. And if these differences are sufficient to separate these group into separate subspecies, then the subspecies ***B. b. bengalensis*** (comprising ***B. b. bengalensis***, ***B. b. kok*** and ***B. b. gracilis***) will have to be divided into two groups depending upon the length of differences.

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The authorwishes to express his deep sense of gratitude to Dr. P. J. Deoras, Professor Emeritus, Bombay for his valuable guidance. The author is thankful to the Director, Zoological Survey of India, Calcutta, and the Health Officer Bombay Municipal Corporation, for providing the material for the present studies, to Dr. S. N. Naik of Tata Cancer Research Institute, Bombay for his help and suggestions and also to Dr. B. K. Tikader, Deputy Director, Zoological Survey of India, Western Regional Station, Poona, for his cooperation.

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Bull. zool. Surv. India, 1 (2) : 103-106, 1978

STUDIES ON SOME AVIAN HAEMATOZOA FROM JAMMU AND KASHMIR, INDIA

N. C. NANDI AND A. K. MANDAL

Zoological Survey of India, Calcutta

ABSTRACT

Sixty seven birds belonging to 39 species and subspecies were examined for haematozoa, 18 birds (26·8%) of 17 species harboured one or more blood parasites. The genera *Trypanosoma*, *Leucocytozoon*, *Haemoproteus* and *Plasmodium* were recorded in addition to microfilarial parasites. All the parasites are reported herein for the first time from this region. A number of parasites have also been noted for the first time from India and from new hosts.

INTRODUCTION

Although some reports of the blood parasites of wild birds have been published since 1897, the results have unfortunately not followed any uniform pattern. In some cases, no attempt has been made to identify the various parasites as to species ; in others, only protozoan parasites have been included, and even of these, the genera embraced have varied. Still another fact limiting the value of all surveys, is the relatively small sampling which can be obtained of many of the bird species examined, thus resulting in negative findings, or giving insufficient data for significant comparisons. The present survey deals with the blood parasites of 67 birds from Jammu and Kashmir.

MATERIAL AND METHODS

A total of 67 birds belonging to 39 species have been examined for the blood parasites from Jammu and Kashmir. The birds were shot in the year 1974 and 1976, and the smears were taken from the bleeding wounds. The blood smears were stained with Leishman's or Giemsa's stain. The smears were checked under low power of a microscope (400 ×) and subsequently under immersion-oil (1000×).

RESULTS AND DISCUSSION

Of the 67 birds of 39 species examined, 18 birds (26.8%) belonging to 17 species and subspecies showed parasitaemia in their blood. The results are presented in Table 1. Infections with species of *Haemoproteus* in 10 birds (14.9%), *Leucocytozoon* in 6 birds (8.9%) and microfilariae in 7 birds (10.4%) were recorded. The genera *Plasmodium* and *Trypanosoma* were noted, each in a single individual only. The occurrence of *Haemoproteus* is comparatively substantial. Infections with *Leucocytozoon* and microfilariae were revealed in relatively higher proportions than *Plasmodium* and *Trypanosoma*. Double and multiple infections were recorded in 6 birds belonging to 6 species. The barred owlet, *Glaucidium cuculoides* harboured quadruple infections *viz.*, two haemosporidians, *Haemoproteus cellii* and *Leucocytozoon danilewskyi* ; a haemoflagellate, *Trypanosoma avium* and microfilaria. However, all the parasites are reported herein for the first time from this region of India.

Six species of *Haemoproteus viz., H. borgesi, H. cellii, H. dicruri, H. oryzivorae, H. postoris* and *H. thereicerycis* in addition to two undetermined species were detected. ***Haemoproteus cellii*** in *Glaucidium cuculoides* and ***Strix aluco biddulphi***, is reported here for the first time from India and from new hosts. Four species of *Leucocytozoon* viz. ***L. danewskyi, L. dubreuili, L. fringillinarum*** and ***L. ilmajoris***, and two unnamed species are reported for the first time from India. A perusal of literature indicates that they constitute new host-parasite records. ***Plasmodium relictum*** was encountered in *Muscicapa t. thalassina* which appeared to constitute new host-parastie record (*vide* Garnham, 1966). ***Trypanosoma avium*** is reported from India for the first time from *Glaucidium cuculoides*. All the microfilarial parasites have been communicated earlier in a separate paper (Nandi and Mandal, in press).

The present survey reveals a higher incidence of haematozoa (26.8%) in general from Jammu and Kashmir in comparison to that of Godavari River Basin, Nasik and Ahmednagar districts, Maharashtra (13.3% ; Nandi, 1976) and Orissa (12.7% ; Nandi and Mandal, 1977). The surveys from Godavari River Basin and Orissa showed only infections with ***Haemoproteus*** and ***Plasmodium***, while the birds from Jammu and Kashmir had relatively rich in varied types of haematozoa fauna comprising *Leucocytozoon, Trypanosoma* and microfilariae in addition to *Haemoproteus* and ***Plasmodium***. The higher rate of parasitism is presumably a result of higher vector activity and density. The occurrences of *Trypanosoma* and *Plasmodium* recorded from a single bird in each case, are probably much lower than the true figure as the examination of blood smear is a poor method for the diagnosis of these parasites. It is expected that the further study with improved method of diagnosis (Diamond and Herman, 1954 ; Bennett, 1962 ; Herman *et al.*, 1966) will reveal the true prevalence of parasites.

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TABLE 1. Prevalence of blood parasites in birds from Jammu and Kashmir

Bird species	Number of birds		Parasite	Locality
	exam.	inf.		
ACCIPITRIDAE				
Buteo v. vulpinus (Gloger)	1	1	*Haemoroteus* sp.	Jhayyar, Kotli
CAPITONIDAE				
Megalaima zeylanica (Gmelin)	1	1	*Haemoproteus thereicerycis*	Jhayyar, Kotli
CORVIDAE				
Garrulus lanceolatus Vigors	1	1	*Haemoproteus* sp.	Patnitop, Uddampur
DICRURIDAE				
Dicrurus adsimilis (Bechstein)	3	1	*Haemoproteus dicruri*	Patnitop, Uddampur
FRINGILLIDAE				
Carpodacus erythrinus (Pallas)	1	1	*Leucocytozoon fringillinarum* and microfilariae.	Daksum Anantnag
Carpodacus erythrinus roseatus (Blyth)	1	1	*Leucocytozoon fringillinarum* and microfilariae	Daksum Anantnag
Mycerobas affinis (Blyth)	1	1	*Leucocytozoon* sp. and microfilariae	Daksum Anantnag
MUSCICAPIDAE				
Garrulax lineatus (Vigors)	2	1	Microfilariae	Ramban, Doda
Muscicapa t. thalassina Swainson	1	1	*Plasmodium relictum*	Patnitop, Uddampur
Myiophoneus caeruleus (Scopoli)	2	2	*Haemoproteus oryzivorae*	Jhayyar Kotli and Ramban, Doda
PICIDAE				
Jynx torquilla himalayana Vaurie	1	1	*Haemoproteus borgesi* and microfilariae	Daksum Anantnag
Picus s. squamatus Vigors	4	1	*Leucocytozoon* sp.	Patnitop, Uddampu
PYCNONOTIDAE				
Pycnonotus leucogenys humii Oates	2	1	*Leucocytozoon dubreuili* and *L. majoris*	Ramban, Doda
STRIGIDAE				
Glaucidium cuculoides (Vigors)	1	1	*Haemoproteus cellii, Leucocytozoon danilewskyi, Trypanosoma avium* and microfilariae	Ramban, Doda
Strix aluco biddulphi Scully	1	1	*Haemoproteus cellii*	Shar Khrew, Anantnag
STURNIDAE				
Acridotheres t. tristis Linnaeus	3	1	*Haemoproteus pastoris*	Ramban, Doda
UPUPIDAE				
Upupa epops Linnaeus	3	1	Microfilariae	Ramban, Doda
Uninfected species*	37			
Total	67	18 (26.8%)		

*Uninfected species : ACCIPITRIDAE—*Milvus migrans* (Boddaert) (1) ; *Neophron perenopterus ginginianus* (Latham) (2) ; ALCEDINIDAE—*Alcedo athis bengalensis* Gmelin (2) ; CAMPEPHAGIDAE—*Pericrocotus flammeus* (Forster) (1) ; CAPITONIDAE—*Megalaima virens marshallorum* Swinhoe (1) ; CHARADRIIDAE—*Tringa hypoleucos* Linnaeus (1) ; *Tringa nebularia* (Gunnerus) (1) ; CINCLIDAE—*Cinclus pallasii* Temminck (1) ; COLUMBIDAE—*Streptopelia chinensis* (Scopoli) (2) ; CORVIDAE—*Corvus macrorhynchos intermedius* Adamso (4) ; *Corvus splendens* Vieillot (2) ; *Cissa flavirostris cucullata* (Blyth) (1) ; EMBERIZIDAE—*Emberiza cia par* Hartet (1) ; MOTACILLIDAE—*Anthus trivialis haringtoni* Witherby (1) ; MUSCICAPIDAE—*Turdus unicolor* Tickell (3) ; *Monticola cinclorhynchus* (Vigors) (1) ; *Saxicola ferrea* Gray (1) ; *Pomatorhinus e. erythrogenys* Vigors (1) ; *Phylloscopus subaffinis* (Ogilive-Grant) (1) ; PICIDAE—*Picoides himalayensis albescens* (Baker) (2) ; PSITTACIDAE—*Psittacula krameri borealis* (Neumann) (3) ; PYCNONOTIDAE—*Pycnonotus cafer* (Linnaeus) (3) ; STURNIDAE—*Sturnus pagodarum* (Gmelin) (2).

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EFFECTS OF ORGANIC MATTER AND WATER CONTENT OF SOIL ON THE DISTRIBUTION OF COLLEMBOLA (INSECTA) IN AN UNCULTIVATED FIELD OF WEST BENGAL * †

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ABSTRACT

The present study deals with the influence of two major soil factors on the distribution of collembolan fauna extracted by modified Tullgren funnel methods at Barsul village, Burdwan District, West Bengal, during the period from January, 1971 to December, 1973 at monthly interval.

A total of 1,902 individuals were extracted belonging to ten genera. *Lepidocyrtus* (*Acrocyrtus*) *heterolepis* was the most abundant taxon comprising 12.93% of the total population. The peaks of the density of collembola occurred in July, when the factors like organic carbon and water content of soil also attained their respective maximum concentration.

A regression, correlation and analysis of variance was done between the two soil factors and abundance of collembola and their inter-relationships are discussed.

INTRODUCTION

There is a vast and varied assemblage of animals in the soil ecosystem, the profound importance of which in the formation of soil and increasing its fertility has in recent year, been brought to light by many workers through a series of ecological studies.

The important influence of soil moisture and organic matter (organic carbon) separately on the population density and the distribution of collembola has been studied notably by Agrell (1941), Rapoport and Tschapek (1967), Vannier (1970), Joosse (1970), Asharf (1971), Choudhuri and Roy (1972) and Kaczmarek (1975). Observations are, however, lacking for the cumulative effects of the organic carbon and water content of soil on the distribution of collembola in an uncultivated alluvial field of Burdwan district, West Bengal. In the present studies the influence of these two main factors on the seasonal variations and the distribution of different species has been discussed.

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* This investigation was carried out in the Department of Zoology, University of Burdwan during 1971-74.

† The paper was read at the "All India Symposium on environmental Biology" held at the University of Kerala, Kariavattom, Trivandrum, on December 27th 1977.

SAMPLING SITES AND METHODS

This work was carried out in a large uncultivated area which were thickly covered with herbs and shrubs (At Barsul village, Burdwan district).

The soil found there, were alluvial in nature. Three plots, each 5 meter square were selected. From each plot 36 randomly distributed samples were drawn at monthly intervals over a period of three consecutive years (from January, 1971 to December, 1973) with the help of a soil sampler cf. Auerbach and Crossley (1960). Extraction of material from the soil was carried out in the modi-

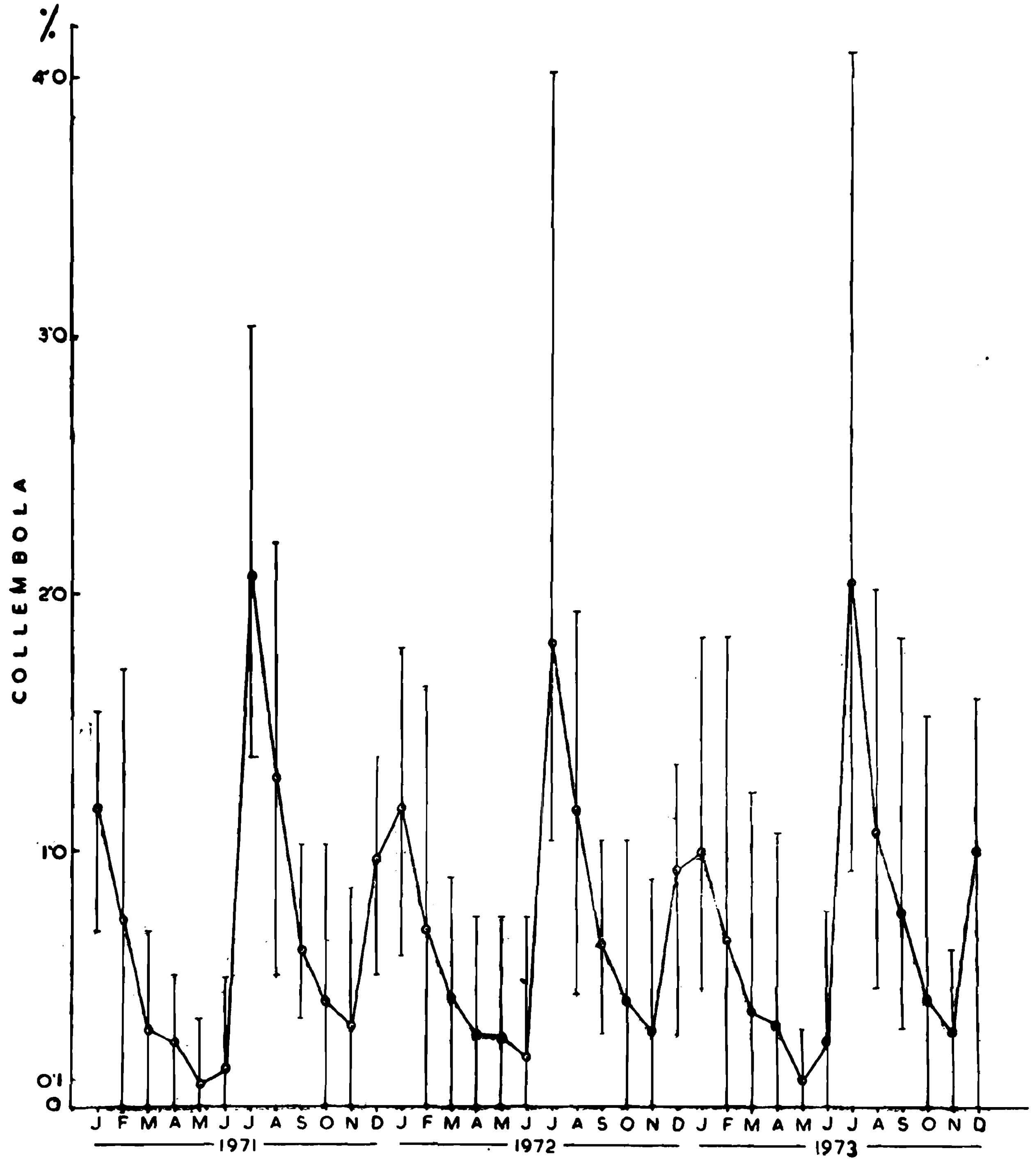

Fig. 1. Seasonal change in total number of Collembola for each month in percentage.

fied Tullgren's apparatus (Murphy 1962) for five days at 40°C temperature, water content of soil was determined as a percentage difference between dry and wet weight of soil after drying for 24 hours at 105°C. Organic carbon of soil was determined by titration (Walkley and Black 1934) method.

RESULTS

A list of the collembola extracted is presented in table 1 together with their individual percentage in each month. The species of collembola obtained from all the samples belonged to ten genera *Lepidocyrtus, Folsomides, Isotomina, Subisotoma, Alloscopus, Folsomina, Pseudosinella, Cyphoderus, Entomobrya* and *Lobella* (Table 1). The species *Lepidocyrtus* (*Acrocyrtus*) *heterolepis* was most dominant being found in all samples and comprising 12.93% of the total population. In order of dominance other forms were *Cyphoderus javanus* (11.98%), *Isotomina thermophila* (10·56%), *Lepidocyrtus* (*L.*) *medius* (8.83%), *Folsomina* sp. (8.30%), *Folsomides purvulus* (7.99%), *Cyphoderus albinus* (7.88%), *Pseudosinella* sp. (7.8%), *Subisotoma fitchoides* (7.51%), *Lobella* (*L.*) *maxillaris* (6.62%), *Entomobrya* sp. (5.88%) and *Alloscopus tetracantha* (4.31%).

SEASONAL VARIATION

From figure 1, it would be seen that the percentage of total number of the collembola had single excessive peak in July and minimum in May except in the year 1972 when the minimum number were obtained in the month of June might be due to untimely heavy rain fall during the 2nd week of May. Throughout the sampling period ranging from January, 1971 to December, 1973 it actually exhibited gradual increase from last week of June and attained its peak in July followed by gradual decline upto end of November and partial higher peak during December-January might be due to prevalence of winter maxima, caused by population fluctuation (rise) of a few species of collembola (Table 1).

SPECIES WISE MONTHLY FAUNAL CHANGE

Figure 2 shows the monthly change of

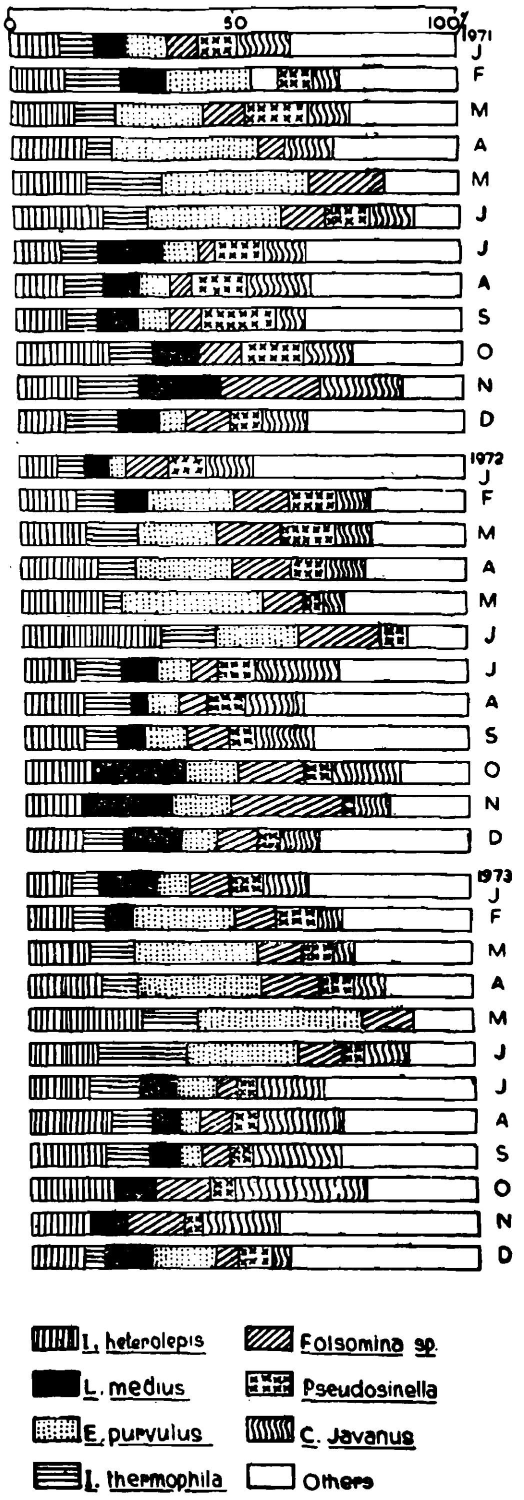

Fig. 2. Seasonal change in percentage of dominant species of collembola for each month.

TABLE 3. Showing mean value of soil factors and Collembola population in different months.

	1971			1972			1973		
MONTH	Collembola (Mean)	Water Content (%)	Organic Carbon (%)	Collembola (Mean)	Water Content (%)	Organic Carbon (%)	Collembola (Mean)	Water Content (%)	Organic Carbon (%)
Jan.	82	10.5	2.18	94	11.5	2.38	78	11.0	1.75
Feb.	51	9.0	1.68	56	7.5	1.14	51	10.5	1.67
Mar.	21	9.0	1.28	34	7.0	1.27	29	9.5	1.62
Apr.	18	9.3	1.22	23	6.5	1.12	25	9.2	1.42
May	6	8.3	1.06	22	7.0	1.24	8	8.5	1.32
Jun.	10	9.5	1.02	16	7.5	1.17	20	9.0	1.53
Jul.	146	16.0	3.52	146	15.5	2.87	161	16.5	2.73
Aug.	89	14.0	2.07	93	14.5	2.18	84	15.5	2.38
Sep.	43	12.5	2.17	51	12.5	1.73	60	13.5	2.87
Oct.	29	11.1	1.36	33	11.5	1.49	33	12.0	1.62
Nov.	22	10.0	1.76	24	10.0	1.29	23	11.0	1.24
Dec.	68	12.0	2.03	75	11.0	1.5	78	11.5	1.89

faunal structure. The percentage of dominant species of each month are shown in table 2.

SOIL FACTORS

Soils of these plots were alluvial in nature dark grey in colour with mean water holding capacity 41.92%. In May water content of soil was 8.3% in 1971, 7% in 1972 and 8.5% in 1973 and organic carbon content was 1.06% in 1971, 1.24% in 1972 and 1.32% in 1973. Month of July in each sampling year showed maximum water content (16% in 1971, 15.5% in 1972 and 16.5% in 1973). Amount of organic carbon was usually found to be maximum in July. However, in 1973 content of organic carbon was maximum in September. Mean values of soil factors (Table 3) revealed more or less identical edaphological characteristic of plots concerned. Mechanical analysis of soils sampled showed high percentage of clay matter (Table 4).

TABLE 4. *Showing mechanical analysis of soil.*

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)
4.00	10.00	31.5	54.00

STATISTICAL TREATMENT OF DATA

Data pertaining to soil factors and population density were subjected to statistical analysis for finding out regression correlation and dependence of number of collembola

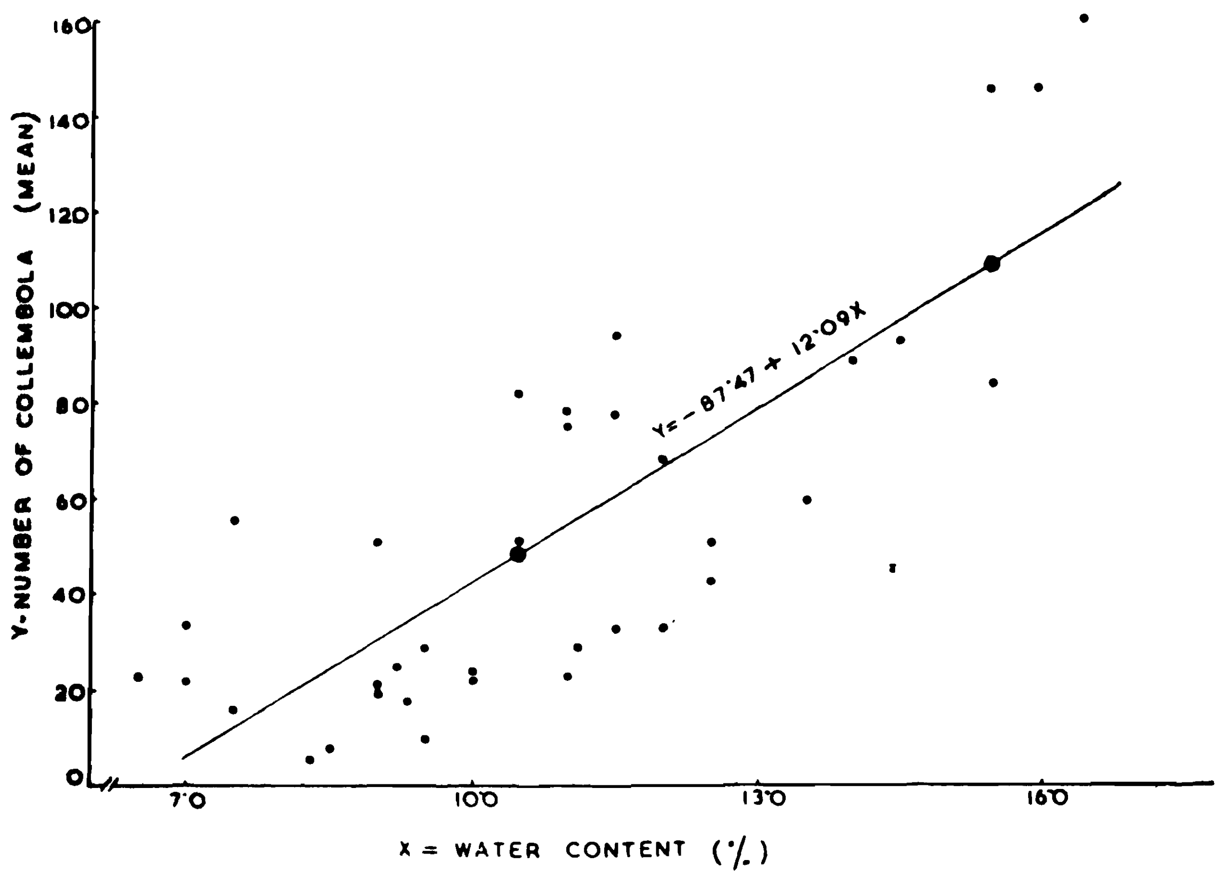

Fig. 3. Regression line with scattered diagram of Collembolans on water content (%).

(Y) on each of two variables (organic carbon and water content) considered here (Table 5).

TABLE 5. *Showing relationship between collembolan population and soil factors.*

	Mean	Correlation coefficient between no. of collembola and two factors	Regression line of no. of collembola (Y) on factors (X). Y=a+bx
Y : No. of Collembola	52.83		
Water content	10.86	0.8003 **	Y= −78.47+12.09x
Organic carbon	1.74	0.8562 **	Y= −47.25+57.52x

** Significant at 1% level.

Regression lines were obtained by pulling together data for all three years observed. These combined regression lines drawn along with respective scattered diagrams were shown in figures 3 & 4 correlation coefficient study (second column of table 5) showed the significant positive correlation with population density.

Analysis of variance study (Table 6) showed that the difference exists between sampling years and between months of a sampling year and the monthly variation was reasonably constant throughout.

DISCUSSION

The total population of collembolan fauna extracted from this site when considered together showed numerical variation with the change of season (Table 2) it was lowest in May and maximum in July (Fig. 1) this finding confirms the results of Choudhuri and Roy (1972). This pattern of fluctuation appeared to be a bit different from Europe and America Weis-Fogh (1948),

TABLE 6. *Showing analysis of variance.*

	Year	Month	Error	Total
Degree of freedom	2	11	22	35
Sum of squares	312	55046	561	55919
Mean square	156.00	5004.18	25.50	
Frequency	6.1176	196.2424 **		

** Significance at 1% level.

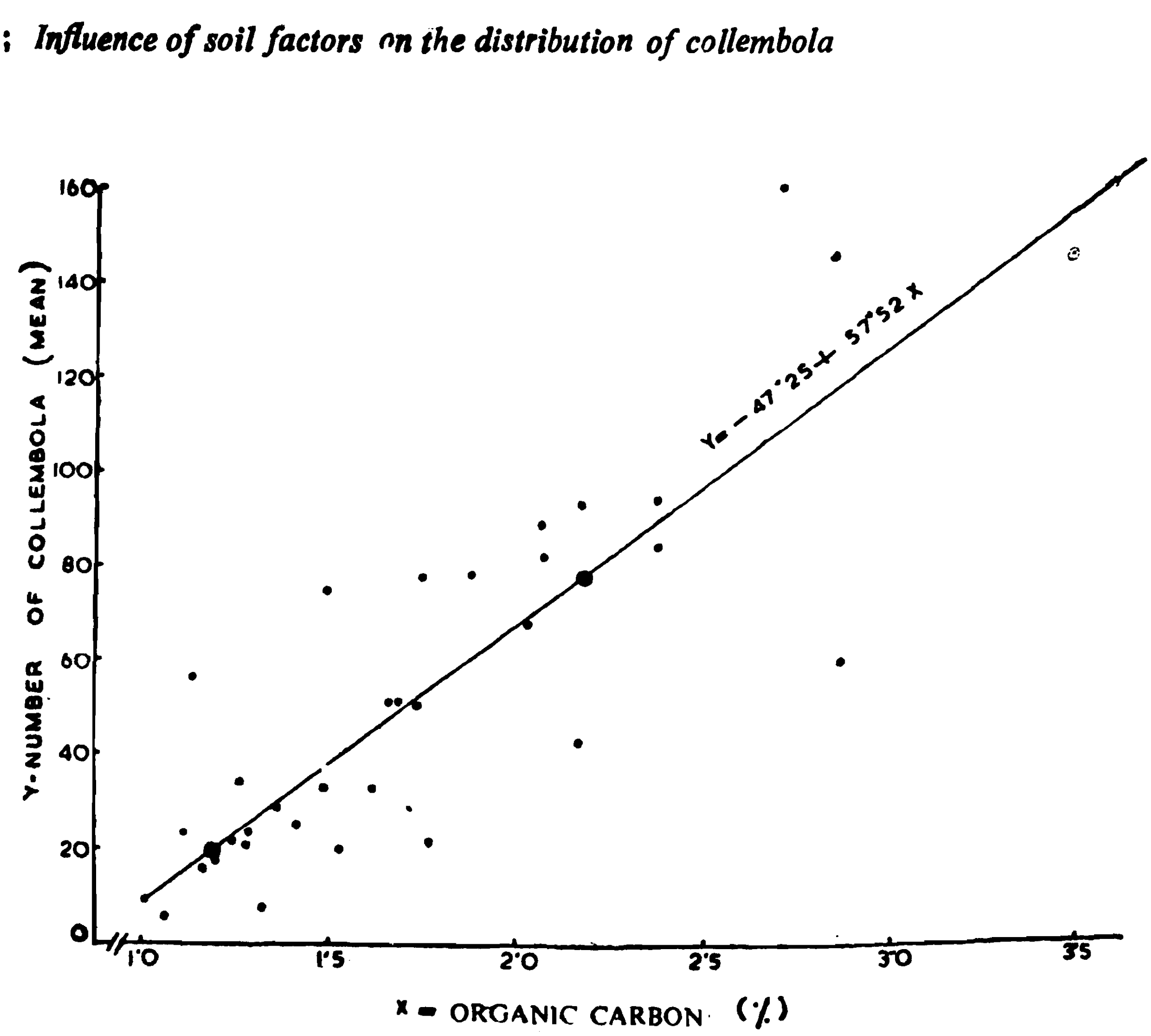

Fig. 4. Regression line with scattered diagram of collembolans on organic carbon (%).

Macfadyen 1952) Sheals (1957), Haarlov (1960) and others observed that collembolan population attained their maxima at some period between late autumn and early spring and felt to minimum in summer months. In this study the dominant species like *Lepidocyrtus* (*Acrocyrtus*) *heterolepis*- *Cyphoderus javanus*, *Lepidocyrtus* (*Lepido cyrtus*) *medius* etc. attained their respective maximum peak in July. When factors like water-content and organic carbon (except in 1973) attained their maximum concentration. Haarlov (1960), Christiansen *et al.* (1961), Davis, (1963), Vannier (1970), Joosse (1970), Choudhuri and Roy (19 2) and Kaczmarek (1975) have studied the effects of either of soil moisture or of organic matter as important ecological factors in the life of collembola. The results obtained in this investigation not only confirm the above views but also clearly indicate that in the given alluvial soil field the water-content and the organic carbon were very important on the distribution of population density.

The content of these two factors exhibited a strong positive correlation with the collembolan population in this study, maximum population density of collembola grew with the increasing organic carbon and water-content level during higher precipitation periods while during lower precipitation period in the summer months it decreased.

It can be suggested that the organic carbon and water-content of soil exerted the following influence on the collembolan population either singly or jointly (a) maintained the soil reaction, (b) controlled humification and nitrification (c) stimulated the growth of macro-and microflora. Moreever it seemed likely that in some instances wetness or dryness as such influenced the soil fauna indirectly rather than directly since these factors particularly organic carbon largely determined the type and density of vegetation which in turn contributed towards the augmentation of soil organic matter. The latter not only served as a source of food but also influenced the amount of living space available for microarthropods.

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CULTURING AND LIFE HISTORY STUDIES OF *ROTYLENCHULUS RENIFORMIS* LINFORD AND OLIVEIRA ON BRINJAL (NEMATODA)

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ABSTRACT

Embryonic, post-embryonic and post-infection developments of the nematode, *Rotylenchulus reniformis* Linford and Oliveira, parasitizing the egg plant (*Solanum melongena* L. var. purple round) in West Bengal are described. Four moults including the one within the egg shell are observed. Second stage larvae utilizes the reserve food received from the egg during development. Heteromorphism of the tails of the second and third stage larvae is reported for the first time. The immature female is the infective stage of this nematode. Females complete its development in 20-25 days and males in 12-16 days at an average temperature of 24-35°C.

INTRODUCTION

A good amount of work has been carried out on the life cycle of *Rotylenchulus reniformis* amongst others by Linford and Oliveira (1940), Nakasono (1966), Birchfield (1962) and Rebois (1973). In India Nath *et al.* (1969), Khan and Khan (1969), and Sivakumar and Seshadri (1971) have also contributed to the study of the life cycle of *R. reniformis*.

Life history studies of *R. reniformis* were taken up because of the facts that (1) survey carried out by us revealed that *R. reniformis* was one of the commonest and dominating nematodes parasitizing vegetable crop of West Bengal, and (2) whereas three moults have been reported by Linford and Oliviera (1940) in *R. reniformis*, Nakasono (1966) and Sivakumar and Seshadri (1971) have reported four moults in the same nematode. Moreover, its life history has not been studied on egg plant. Hence, it was decided to study the embryonic, post-embryonic and post-infection development of *R. reniformis* on egg plant (*Solanum melongena* L. var. purple round) under laboratory conditions.

MATERIAL AND METHODS

Culturing : *Rotylenchulus reniformis* was cultured on tomato (*Lycopersicon esculentum* Mill. var. best in all) by single egg mass technique. Field soil and sand were mixed in proportion of 1 : 1 and autoclaved at 1.4 kg. cm.^{2} pressure up to two hours. About 10 days old tomato seedlings were transplanted singly in sterilized soil filled in 9 x 3 cm. diameter glass tubes. Initially five tubes were prepared. Single egg mass was collected from around the female of *R.*

reniformis infesting roots of okra collected from field. This egg mass was placed for hatching at room temperature in petri dish, 6 cm. in diameter, containing distilled water. About 20-25 larvae were inoculated with the help of a fine pipette in the vicinity of roots by making three small holes. The holes were closed with sterilized soil and irrigated lightly.

About 40 days after inoculation each tube with plant was placed in inverted condition in a 500 ml. beaker containing water. After about 15 minutes each tube was tapped gently at its bottom, so that the plants along with fine roots came out intact. These roots were again washed carefully taking care to prevent any loss of egg masses and nematodes. Roots were observed under a stereoscopic binocular microscope and egg masses were collected from the roots. These egg masses were placed in petri dishes for hatching of larvae and sub-culturing was done by inoculating these larvae on tomato, okra (*Abelmoschus esculentus* (L.) Moench. var. pusa sawani) and brinjal (*Solanum melongena* L. var. purple round) seedlings growing in sterilized soil filled in 15 cm. earthen pots. These pots were kept on fire bricks so as to prevent any inter-pot contamination, the entire experiment being designed on cemented floor. Whenever *R. reniformis* nematodes were required for different experiments these were obtained from the pure cultures thus established in the laboratory.

Life history : Nematodes used for these studies were obtained from pure cultures developed vide *supra*. Adult females were carefully removed from roots or left attached to the fine roots and kept separately in small glass cavity blocks containing tap water for laying eggs. Some uncleavaged eggs were selected for studying embryonic development. Eggs were mounted singly in a small drop of tap water on a 22 mm. square coverglass which was then inverted over a cavity slide containing very thin layer of water at the bottom. Each coverglass was sealed on the slide with petroleum jelly along the margin so as to keep the coverglass in position and to check the evaporation of moisture. These cavity slides were stored at room temperature in petri dishes with a moist filter paper at the bottom of the latter to reduce evaporation from hanging drops. During the experiment maximum temperature range was 31—38.8°C (Average maximum temperature 35°C) and minimum temperature was 20—27.4°C (Average minimum temperature 24°C).

Egg masses recovered from pure cultures were dissected to remove males and previously hatched larvae if present inside them. These egg masses were placed for hatching in 10 cm. x 10 cm. petri dishes containing tap water. The hatched larvae (second stage larvae) of uniform age were placed in tap water in the glass cavity blocks for studying post-embryonic development. The water in the cavity blocks was changed every day.

Sex differentiation could be observed only in the third stage larvae ; female and male larvae were separated for further development. Some larvae were fixed daily, starting just after hatching till the male larvae became adult and female larvae developed into immature females. The larvae were stained in 0.1% cotton blue lactophenol or acid fuchsin lactophenol and mounted on glass slides.

Post-infection development was studied simultaneously by using second stage larvae hatched out from the same lot. Two egg-plant seeds were grown in sterilized sand-filled, 9 x 3 cm. glass tubes. Second stage larvae of uniform age were inoculated in these tubes by making small holes near the plants, when plants were at two leaf stage. Observations were started after 24 hours of inoculation. Five tubes were washed and processed daily in the same manner as for culture studies. Roots were stained in 0.1% acid fuchsin or cotton blue lactophenol and cleared in pure lactophenol. Nematodes were carefully dissected out from the roots and mounted in lactophenol or glycerine. Some small pieces of fine roots with nematodes *in situ* were also mounted. These observations were continued till the females started laying eggs. Several adult females were also mounted on glass cavity slides. Body dimensions were taken and camera lucida drawings of different stages made.

RESULTS

Female deposited 5-9 eggs within 24 hours in glass cavity blocks containing tap water. To begin with a fully formed egg was held in the anterior part of the uterus then it passed slowly to the mid region of uterus (Plate 1, A). From uterus the egg was expelled through vagina by contraction and retraction of vaginal walls. The eggs were laid singly and were in single-celled (Fig. 1, A), rarely two-celled, stage. Eggs measured 78-102 x 36-52 µm and were more or less oblong in shape. Each egg consisted of an outer smooth shell or chorion lined internally by a thin vitelline membrane and completely filled with protoplasm. Protoplasm comprised a large nucleus in the middle and cytoplasmic globules of variable size.

EMBRYONIC DEVELOPMENT

Durations of different stages of embryonic development are given in table 1.

After 1-2 hours of deposition, the egg underwent first transverse cleavage and divided into two equal blastomeres a and b (Fig. 1, B). A polar body was visible in between the two cells on lateral side. The second and third divisions were also transverse and took place first in the anterior cell (a) Fig. 1, C) and then in the posterior cell (b). The embryo now consisted of four cells or blastomeres c, d, e and f. (Fig. 1, D). The fourth division was a longitudinal cleavage, by which the anterior most cell (c) divided and gave rise to five cell stage g, h, d, e, f (Fig. 1, E). After this the cleavage was very rapid and gave rise to eight cell stage (Fig. 1, F) ; exact sequence could not be observed. Thereafter the cell divisions were very fast and were in different planes, giving rise to multicellular structure (Fig. 1, G) ; later on these cell differentiated in two layers (Fig. 1, H).

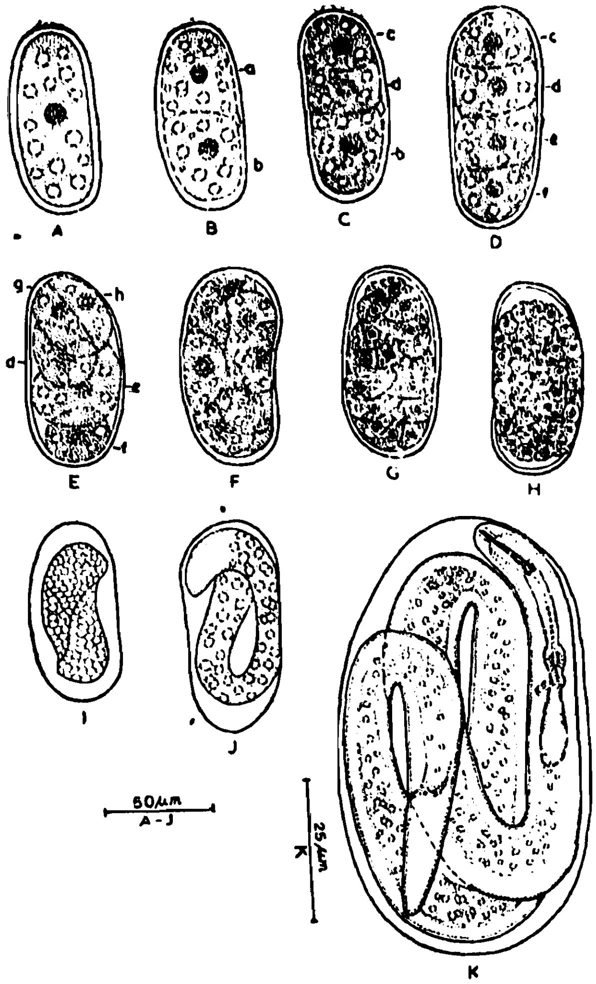

Fig. 1. Embryonic development of *Rotylenchulus reniformis* A—Single celled stage, B—2—celled stage, C—3—celled stage, D—4—celled stage, E—5—celled stage, F—8—celled stage, G & H—Multicellular stages, I—Tadpole stage, J—First stage larva, K—Second stage larva within egg.

This was followed by the tadpole stage (Fig. 1, I). When the embryo reached the tadpole stage, there was a vigorous movement and condensation of protoplasm resulting in the formation of a vermiform structure. This was the first stage larva showing movement inside the egg shell (Fig. 1, J). After sometime the larva stopped movement and became quiescent—a prelude to first moult. During the first moult, the prorhabdion appeared first, then the body annulations and cephalic framework made their appearance. Oesophagus and intestine became more prominent. First moult cuticle was observed by puncturing the shell with the help of a needle.

The second stage larva (Fig. 1, K) made movements by coiling and uncoiling its body inside the egg shell. Lips of the second stage larva were observed pressing against the egg shell. The anterior half portion of the larva came out with slight jerk and then slowly left the egg shell.

POST-EMBRYONIC DEVELOPMENT

On no occasion any larval or moulting

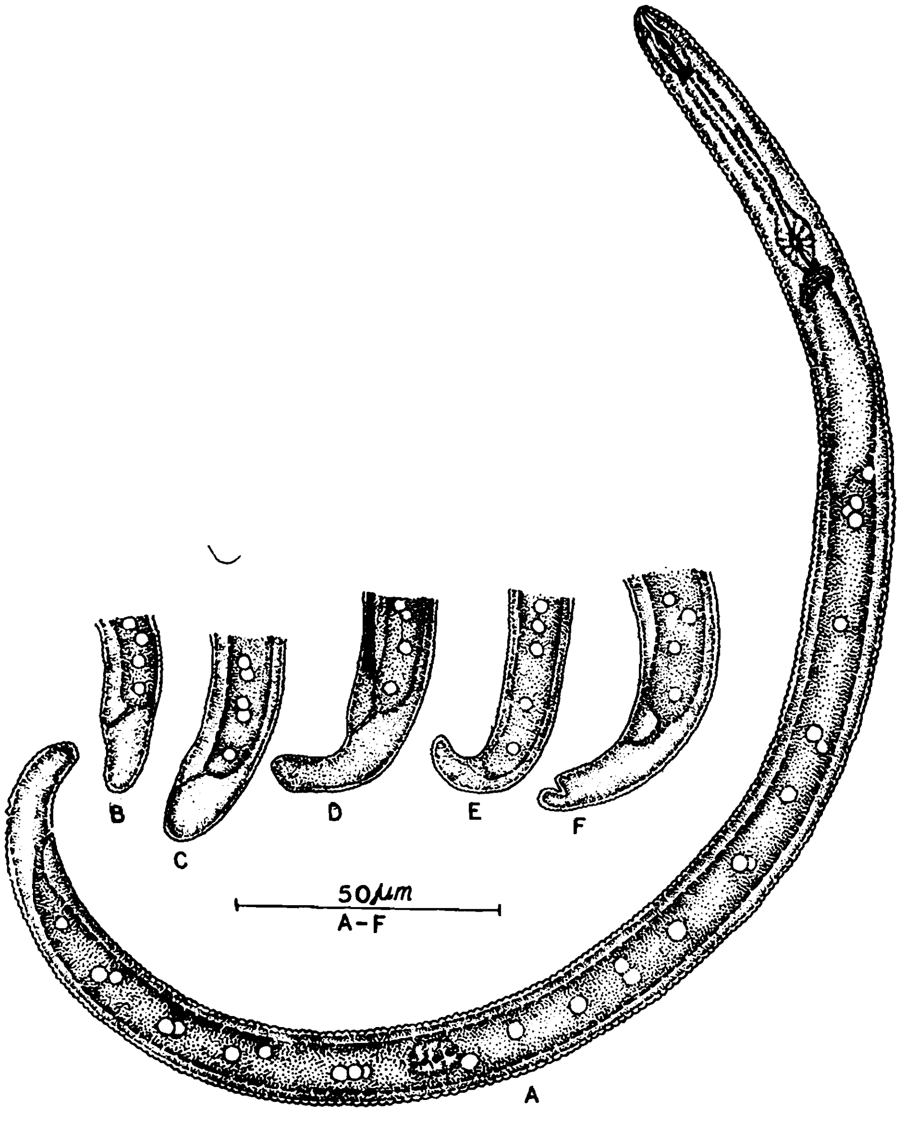

Fig. 2. Post—embryonic development of *Rotylenchulus reniformis* A—Second stage larva, B—F—Heteromorphic tails of stage larva.

stage was found in or attached to the roots of the host plant. These studies are based on development of *R. reniformis* in water. Dimensions and duration of different stages of post-embryonic development are given in tables 2 and 3 respectively.

Second stage larva ;

Second stage larva (Fig. 2, A) hatched out from the egg ; it was very active. Head truncate with 4-5 annules, cephalic framework well developed 3-5 µm high and 6-7 µm in diameter, stylet well developed 13-16 µm long with rounded basal knobs, latter 2-3 µm wide. Dorsal oesophageal gland orifice 10-16 µm posterior to stylet base. Procorpus tubular, median bulb 8-11 x 6-8 µm in diameter with well developed crescentic valve plates. Oesophageal gland overlapping intestine lateroventrally or laterally. Nerve ring encircling short narrow isthmus, about 49—64 µm from anterior end. Excretory pore 63—78 µm from anterior end. Hemizonid 2—3 annules wide and 1—6 body annules above the excretory pore. Tail 13—24 µm long comprising 15—25 annules and generally with rounded terminus. However, heteromorphic tail observed in this stage (Fig. 2, B-F).

Genital primordium 11—15 µm long oval in shape and 64—73% of body length, comprising three cells in the larva forced out after puncturing of the shell and in the larva just hatched out normally. Later on, it became a four celled structure and remained as such during the complete durotion of second stage larva. Anterior and posterior cells of genital primordium were smaller than the two central cells.

This larva did not show any sex differentiation.

Second moult :

On the fifth day of hatching the larva ceased its activity and assumed an arcuate shape. Moulting started on the sixth day after hatching when basal part of the stylet (knob + shaft) disappeared first. Procorpus, median bulb with valve became indistinct. Cuticle of the second stage larva started separating from anterior end and gradually extended to the posterior end. Conus (anterior part of stylet) was cast off with moulting cuticle and remained attached to it. Cephalic framework of second stage larva was also visible in the moulting cuticle.

Third stage larva :

Third stage larva was enveloped within the second moult cuticle and was very inactive. Sex of the third stage larva could be identified by seeing male third stage larva, which had a bulging on ventral side of the tail around the anus (cf. plate IIA & B).

Female larva (Fig. 3, A)—Head truncate, with 4—5 annules and marked with slight depression in the middle at the location of buccal orifice. Cephalic framework weakly developed. Stylet absent. Oesophagus with less organised procorpus, latter expanded slightly at anterior end. Median bulb showing only a suggestion of valve ; true crescentic plates in median bulb absent. Nerve ring around short narrow isthmus, 48—64 µm from anterior end. Lumen of the oesophagus and the oesophago-intestinal valve not visible. Tail 17—24 µm long comprising 20—26 annules with rounded terminus.

Genital primordium 21—40 µm long of 10—12 cells and situated at 69—74% of body length from anterior end. Two cells

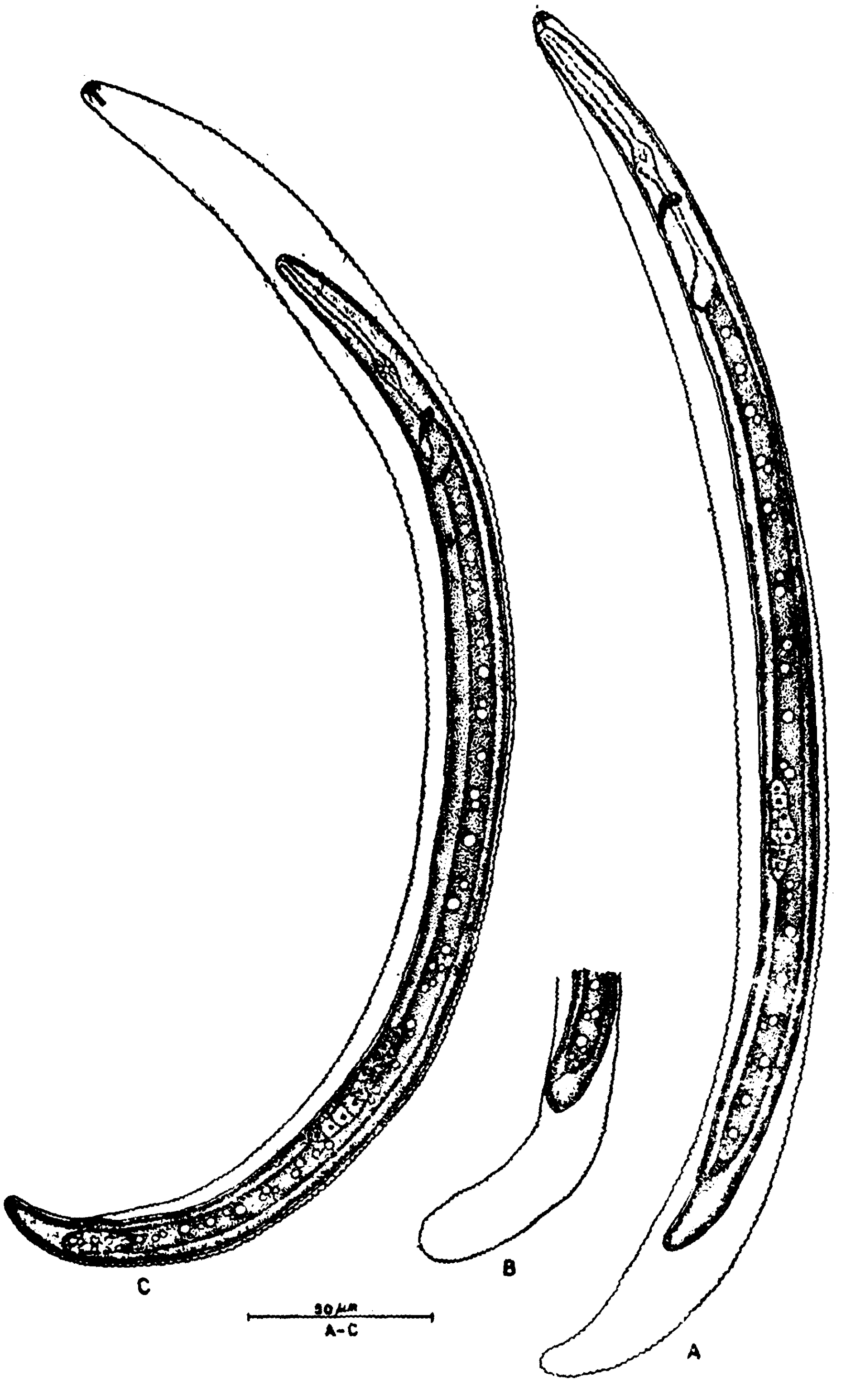

Fig. 3. Post—embryonic development of *Rotylenchulus reniformis* A—Third stage female larva, B—Heteromorphic tail of third stage female larva, C—Third- stage male larva.

of genital primordium arranged on either end and cells in the middle in two rows with 3—4 cell in each row.

One third stage female larva was observed with cylindrical arcuate tail with broadly rounded terminus. Anal pore of this larva was situated much posterior towards tail terminus in comparison with other (normal) larvae. Moulting cuticle enveloping third stage heteromorphic larva indicates that this variability of tail shape continues from second stage larva (Fig. 3, B).

Male larva (Fig. 3, C)— The tail portion near the anal region was slightly bulged (plate II, B). A mass of cells was formed in the rectal region - the spicule primordium. These two characters differentiated the male third stage larva from the female third stage larva. The genital primordium, 25—48 µm long, consisted of 12—14 cells, a single anterior cell followed by 3 cells arranged in two rows in the middle and then 5—7 cells in a single row. Other morphological characters were similar to those of female third stage larva.

Third moult :

Third moulting cuticle appeared inside the second moult cuticle. Third moulting cuticle was very smooth and finer than the second moulting cuticle. Conus part of stylet of of second stage larvae was siill attached to second moult cuticle. Cephalic framework was not visible in third moulting cuticle. Fourth stage larva could be seen within the two moulting cuticles. Movement of larva was very sluggish during moulting.

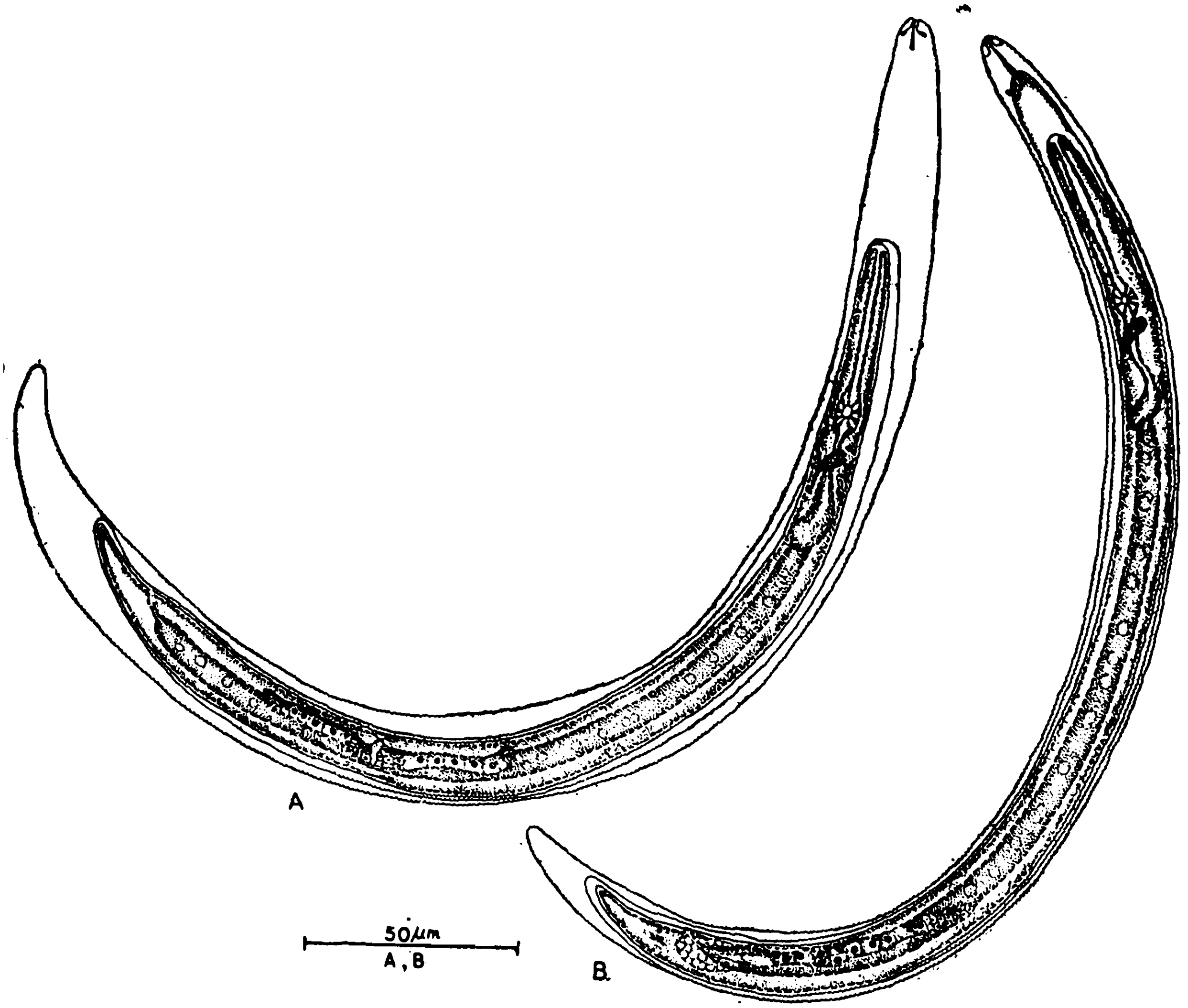

Fig. 4. Post-embryonic development of *Rotylenchulus reniformis* A—Fourth stage female larva, B—Fourth stage male larva.

During the third moult gonad of female and male larvae were differentiated into ovary and testis.

Fourth stage larva :

Female larva (Fig. 4, A)— The fourth stage female larva resembled the third stage female larva in general morphological characters except in the development of gonad. Stylet absent ; median bulb without crescentic valve plates. Excretory pore 42—60 µm from anterior end. Tail 20—24 µm long with rounded terminus.

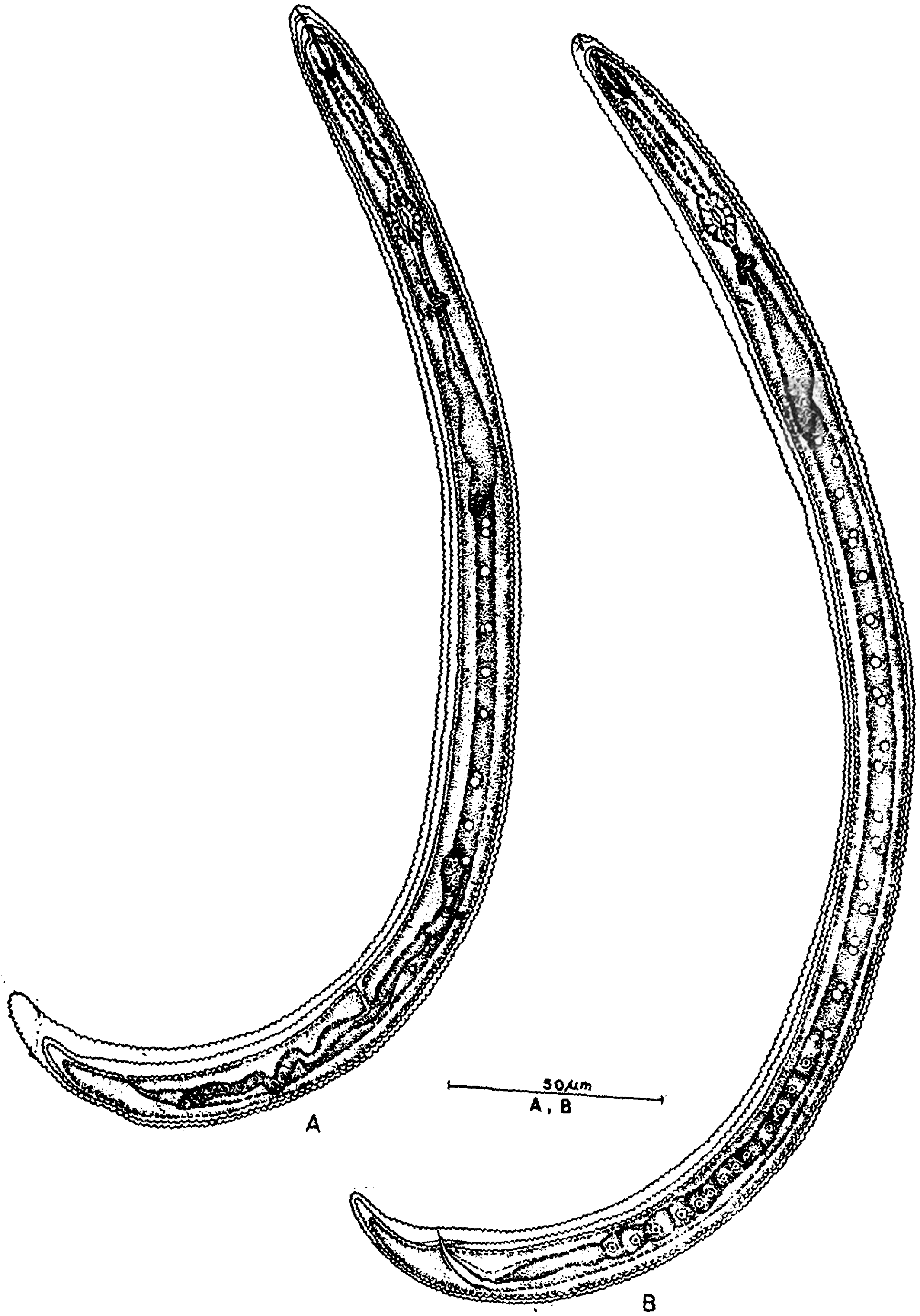

Fig. 5. Post-embryonic development of *Rotylenchulus reniformis* A—Immature female within moulting cuticles, B—Adult within moulting cuticles.

Anterior and posterior gonads were now discernible because of a slight suggestion of vagina and a hyaline area corresponding to vulva having appeared. Each gonad consisted of cells arranged in a single row except in the middle, in front of vagina, where three rows of 3—4 cells each occurred. Spermatheca not formed. This stage, after moulting, developed into immature females.

Male larva (Fig. 4, B)— The fourth stage male larva developed after 2—3 days of third stage male larva and lasted for 1—2 days and then underwent fourth moult. Larva could be identified by the bulging portion of tail around anus caused by the spicule primordium ; faintly cuticularised markings of spicula and gubernaculum were located in the spicule primordium. Cells of the gonad were arranged in a single row except for a few cells in two rows in the middle. Posterior end of gonad reached up to the vicinity of spicule primordium.

Fourth moult :

Fourth moult started 24 hours after the appearance of the fourth stage larva. The fourth moult cuticle was also smooth and slightly thicker than the third moult cuticle. During this moult the stylet and the crescentic plate of median bulb appeared again. There was an increase in size of the gonads. Both the ovaries started forming loops and the vulva was fully formed ; this stage is referred to in literature as immature female. In the male spicula and gubernaculum were fully formed. To begin with, the male and immature female were covered by three moulting cuticles for 1—2 days (Fig. 5, A & B) and then escaped out of these cuticles (Fig. 6 A & B).

Immature female (Fig. 6, A) :

This is the most active stage of the nematode. Immature female possessed well developed cephalic framework, stylet procorpus, median bulb with sclerotized crescentic plates and oesophageal gland overlapping intestine lateroventrally. Anterior and posterior ovary started getting looped.

POST-INFECTION DEVELOPMENT

Only the immature or young females were observed penetrating the roots. Male was not observed penetrating the roots. About one third to half the anterior portion of young female was seen penetrating the roots. Several immature young females were dissected out within 24 hours of penetration. These females were observed with offset head, ¼th part of stylet mostly coming out from the oral aperture ; procorpus. median bulb and oesophageal gland enlarged. Female started gradually bulging on ventral side near the vicinity of vulva after 24—48 hours of penetration. Both the ovaries increased in size, each forming one loop (Fig. 7, A & B). There was a slight increase in diameter of the tail.

Development of female was continued till it attained a typical reniform shape. Swollen female body was filled up with developing gonads. Secretion of gelatinous matrix was observed on the fifth day of infection. One to three eggs were laid on sixth to seventh day of infection.

Males were observed in the gelatinous matrix before the eggs were laid in it. Cleavaged eggs were observed inside the female body (plate I, B & C). In the females which could be easily detached from the roots, there were more cleavaged eggs as compared to those females which

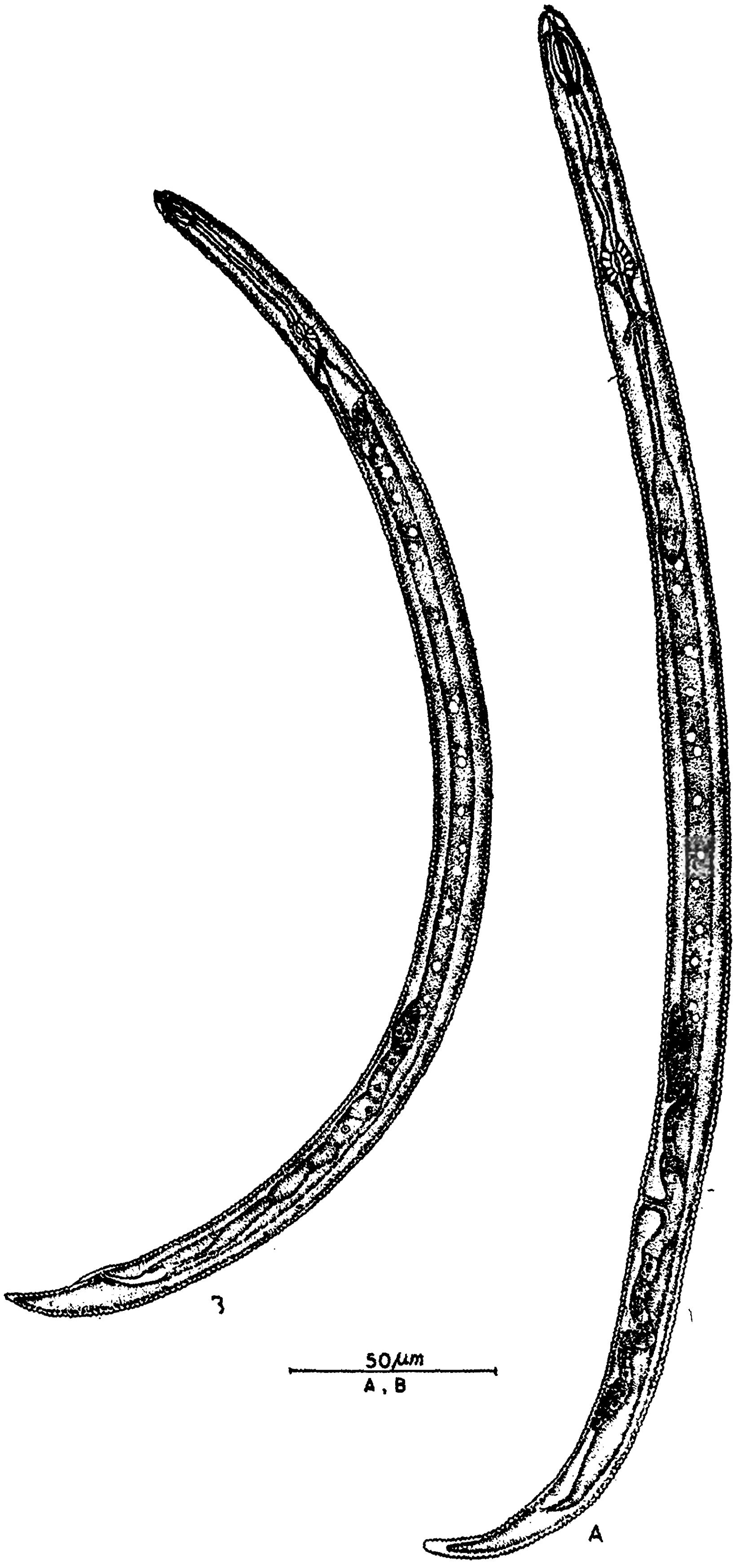

Fig. 6. Post-embryonic development of *Rotylenchulus reniformis*
A—Immature female, B—Adult male.

could not be detached easily from the roots.

Discussion

That the second stage larva of *Rotylenchulus reniformis* after passing through the usual moults and stages, developed into mature males or immature females in water without feeding showed that egg of *R. reniformis* contains ample amount of reserve food materials which is passed on to the larva and consumed during development. The experiment conducted also confirms that it is only the immature female which is the infective stage of this nematode. Linford and Oliveira (1940) stated that *R. reniformis* completed its (egg to egg) development on cowpea in 25 days. Nath *et al.* (1969) reported that this nematode developed (egg to egg) in 29 days on castor at 30-32°C. Sivakumar and Seshadri (1971) reported that *R. reniformis* completed its egg to egg life cycle on okra var. pus sawani within 24—29 days. However, they did not record, or, at least state, the temperature at which their studies were carried out. Rebois (1973 stated that *R. reniformis* developed rapidly at 29.5°C on soyabean and the female completed its life cycle in 19 days. In the present experiment females of *R. reniformis* completed their development on egg plant (*Solanum melongena* var. purple round) in 20—25 days at an average temperature of 24—35°C. Males of *R. reniformis* completed their development in 12—16 days.

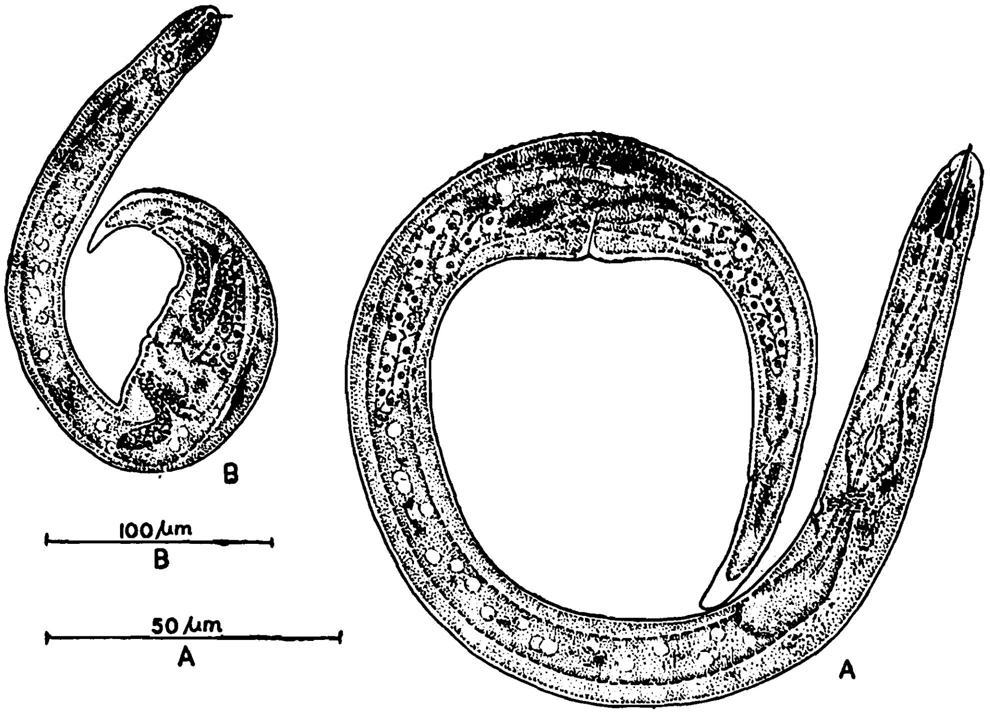

Fig. 7. Post-infection development of *Rotylenchulus reniformis* A—Young female after 48 hours, B—Female at matrix secreting stage.

Embryonic development of *R. reniformis* was found basically similar to that of other plant parasitic nematodes. During the present observations two cells resulting after first cleavage were observed to be somewhat equal and are consistent with the findings of Sivakumar and Seshadri (1971). However, Khan and Khan (1969) reported both cells unequal (anterior larger and posterior smaller). Linford and Oliveira (1940) did not notice one moult inside the egg shell and reported only three moults in *R. reniformis*. The present study confirms the findings of Nakasono (1966) and Sivakumar and Seshadri (1971) that there are four moults in *R. reniformis*, one of which is inside the egg shell.

Heteromorphism in the shape of the tails of the second and third stage female larva is being reported for the first time in this genus. This phenomenon has been reported by Minton and Golden (1968), and Gupta and Edward (1974) in *Hoplolaimus* spp. and Mathur and Prasad (1972) in *Hirshmanniella oryzae*.

Linford and Oliveira (1940) found that sex of the third stage larva could be identified by the bulging tail of male larva. The spicule primordium, as described by Hirschmann (1962) in *Ditylenchus triformis*, and Sivakumar and Seshadri (1971) in *R. reniformis*, was observed in the present case in the third and the fourth stage male larva. Sivakumar and Seshadri (1971) also illustrated this structure in third and fourth stage larva. However, they did not mention anything about spicule primordium in the text ; perhaps they did not attach much importance to these characters in the differentiation of sex.

Steiner and Buhrer (1964) postulated that the mating took place in pre-parasitic life of the nematode and doubted this for a case of paedogenesis. In the present study it was observed that the spermatheca was not formed in immature females. Spermatheca filled with sperm was observed only in mature females. Moreover, several males were observed in the gelatinous matrix near the vulva in mature females before egg laying ; probably these were attracted by females for copulation. However, copulation was not observed. It thus seems that mating occured only when female attained maturity. The present findings are consistent with those of

TABLE 1. Duration of embryonic stage of *R. Reniformis*.

Stage	Time in hours	
	Duration of stage	Duration from egg deposition
1—2 cells	1— 2	1— 2
2—3 cells	3	4— 5
3—4 cells	1— 2	5— 7
4—5 cells	3— 4	8—11
5—8 cells	14—18	22—29
8 to multi celled	16—20	38—49
Multi-celled to first stage	32—39	70—88
First stage to second stage	21—25	91—113
Second stage to hatching	29—34	121—147 (5-6 days)

TABLE 2. Dimensions of post-embryonic stages of *R. reniformis*

Sl. No.	Stage	No. of specimens measured	Length in µm	a	b	c	Length of genital primordium or gonad in µm	Body width at genital primordium or vulva in µm	Stylet in µm	Remarks
1	Second stage larva	20	313—390	19—23	3.6—4.3	14—30	11—15	14—17	13—17	
2	Third stage larva	10 ♀ ♀	265—370	19—24	3.3—4.2	16—19	21—40	13—16	—	Stylet absent
		10 ♂ ♂	287—382	21—23	3.9—4.4	17—20	25—48	—	—	Stylet absent
3	Fourth stage larva	10 ♀ ♀	260—368	20—27	3.6—4.4	14—17	60—98	13—15	—	Stylet absent
		10 ♂ ♂	270—380	22—24	3.9—4.5	14—18	70—130	—	—	Stylet absent
4	Immature female encased in moulting cuticle	5	310—340	22—24	2.6—3.2	14—16	86—98	11—18	14—20	
5	Mature male encased in moulting cuticle	5	350—380	27—28	3.7—3.8	15—18	115—125	—	12—16	
6	Immature female free from moulting cuticle	10	380—425	22—26	2.9—3.4	13—18	86—115	13—16	16—20	
7	Mature male free from moulting cuticle	10	335—410	25—29	3.7—4.2	15—20	100—165	—	12.6—14	
8	Mature female	10	434—510	—	—	—	—	98—130	12.6—14	

TABLE 3. Duration of different stages of life history of *R. reniformis*.

Stage	Duration in day	
	Male	Female
Egg	5—6	5—6
Second-stage larva	4—5	4—5
Third stage larva	2—3	2—3
Fourth stage larva	1—2	3—4
Pre-oviposition period	—	6—7
	12—16 days	20—25 days

Linford and Oliveira (1940), Nakasono (1966) and Sivakumar and Seshadri (1971).

Some females of *R. reniformis* retained cleavaged eggs inside the body just as some *Heterodera* spp. lay some eggs in the egg mass and retain others in their body ; the females with eggs in their body later form the cyst. However, as female of *R. reniformis* does not form cyst, one reason for this phenomenon that can be suggested is that the females age or under certain ecological conditions loose, at least in part, the muscular tonicity of uteri or vagina or both. Under such circumstances expulsion of eggs is delayed and embryonic development starts inside the female body. This explanation, however, needs further elucidation. Or, it is possible that embryonic development inside the body of the mother is just a case of adaptive (parallel) evolution in the development of the phenomenon of endoparasitism.

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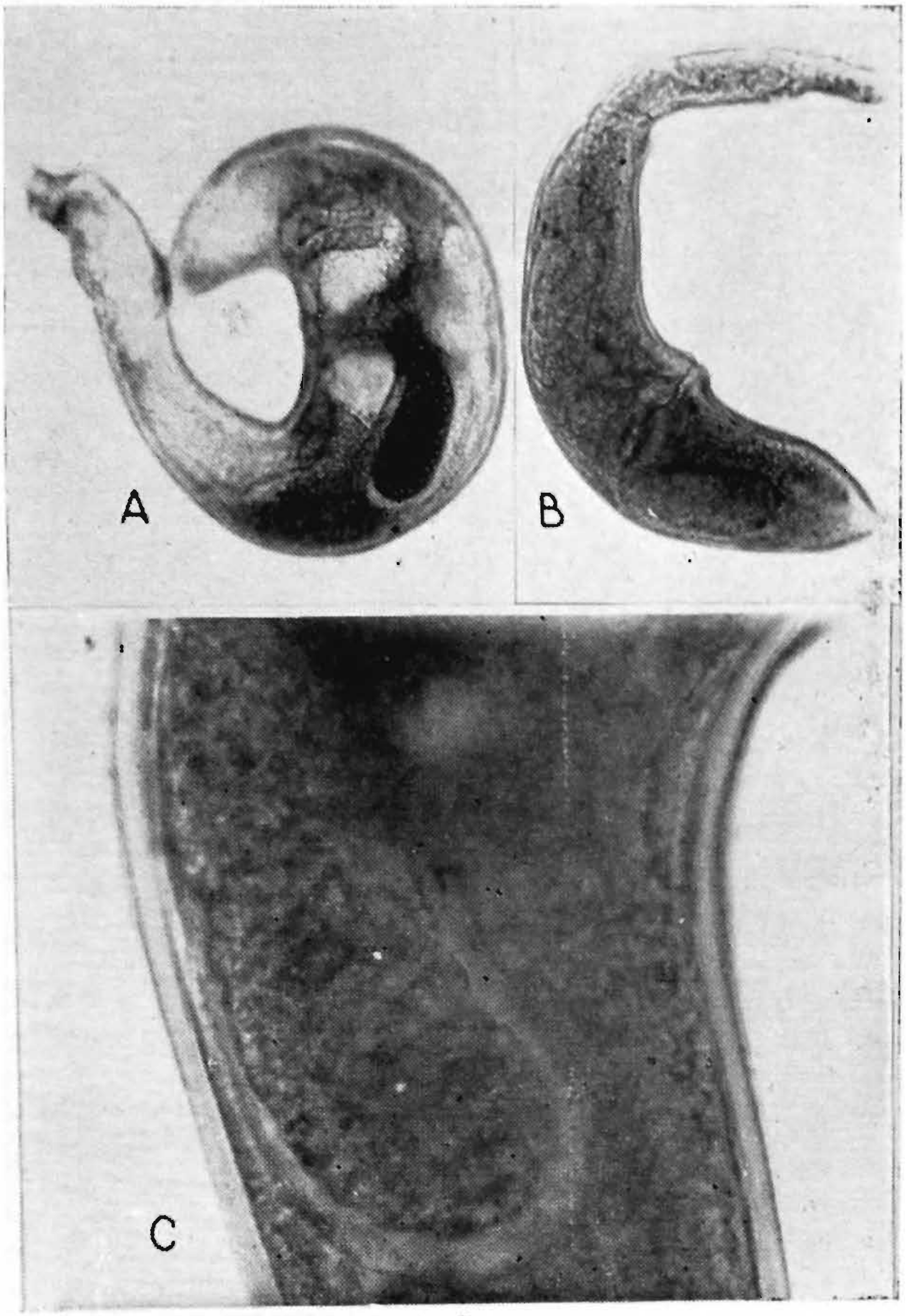
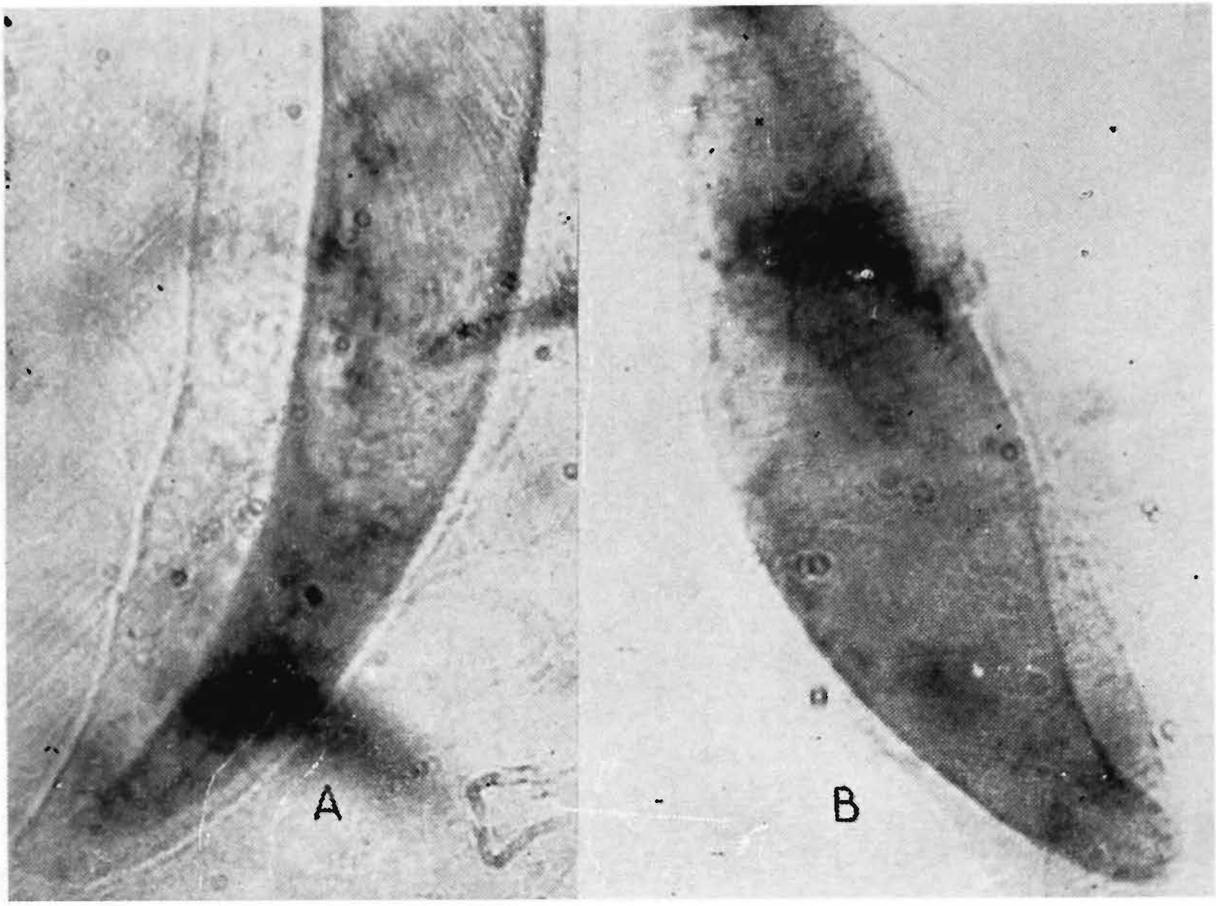
PLATE 1



Rotylenchulus reniformis

A—Adult gravid female showing egg in uterus before egg laying.
B—Adult gravid female showing cleavaged eggs retained inside the body
C—A cleavaged egg inside the female body.



Post—embryonic development of ***Rotylenchulus reniformis***
A—Tail of female third stage larva, B—Tail of male third stage larva.

Bull. zool. Surv. India, **1** (2) ; 129-133, 1978

TRENDS OF EVOLUTION IN THE CYPRINOID GENERA *PSILORHYNCHUS* AND *PARAPSILORHYNCHUS*

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ABSTRACT

Trends of evolution in the Cyprinoid genera *Parapsilorhynchus* Hora and *Psilornhynchus* McClelland have been traced. The familial status of *Parapsilorhynchus* and specific validity of *Parapsilorhynchus discophorus* Hora as well as the composite nature of the genus *Psilorhynchus* have also been pointed out.

Hamilton Buchanan (1822) described two interesting hillstream species, *Cyprinus sucatio* and *Cyprinus balitora,* from the rivers of Northern Bengal. McClelland (1839) created the genus *Psilorhynchus* for these two species, under the family Cyprinidae. Subsequently Hora and Mukherji (1935) described another species *Psilorhynchus homaloptera* from Naga Hills. And Menon and Datta (1964) described a fourth species *Psilorhynchus pseudecheneis* from Nepal.

Hora (1925) created the family Psilorhynchidae to accommodate the genus *Psilorhynchus* and distinguished it from Cyprinidae by such basic characters like the typical air bladder which is greatly reduced and is either entirely free in the abdominal cavity or is partially covered by bone, peculiar type of mouth and lips, single row of pharyngeal teeth, completely ossified, broad plate-like basipterygium and the presence of a number of unbranched rays in the paired fins, especially pectoral fins (Hora and Mukherji, 1935).

It can be seen from the distribution of the species so far described that the family Psilorhynchidae is restricted itself in distribution to Himalayan drainage (Hamilton, 1822, Hora and Mukherji, 1935 ; Menon and Datta, 1964 ; Kaushiva, 1951 ; Majumdar, 1951 ; David, 1953).

Annandale (1919) described a species *Psilorhynchus tentaculatus* from the hillstreams of western ghats. Hora (1920) distinguished this species from the species of *Psilorhynchus* in the presence of a pair of barbels, air bladder in being normal cyprinid type and in the presence of a characteristic rudimentary disc behind the lower lip and created a new genus *Parapsilorhynchus* (obviously under the family Cyprinidae) to accommodate this species. Subsequently two more species, *Parapsilorhynchus prateri* Hora & Misra (1939) from Deolali, Nasik District and *Parapsilorhynchus discophorus* Hora (1921) from Vasishti valley, Ratnagiri District, both the species from Western ghats, were described. *Parapsilorhynchus tentaculatus* was also reported from Satpura Hills (Hora, 1925) and Bailadila range in Bastar (Hora, 1938).

It is very interesting to note that the two most related genera should have restricted distribution each, one in Himalayan drainage and the other in Western Ghats.

The authors collected the three species of the genus *Parapsilorhynchus* from Western Ghats and specimens of the four species of the genus *Psilorhynchus* (including two type specimens) were obtained from the National Collection of Zoological Survey of India and came to the conclusion that *Parapsilorhynchus discophorus* is a good species (cf. Hora, 1925) and that the genus *Parapsilorhynchus* cannot be retained in the family Cyprinidae in view of its possessing certain basic characters like more than one undivided pectoral rays, presence of a callous thickening behind the lower lip (different from that of *Garra* where it is a regular muscular sucker-type disc), in having a typical body shape (spatulate and broad snout, back greatly arched, the under surface flattened, the paired fins horizontally placed with broader base, well spread and in level with the flattened belly etc.) nor can be kept in the family Psilorhynchidae in view of the presence of a free well developed air bladder, a pair of barbels, two rows of pharyngeal teeth, presence of a callous thickening behind the lower lip etc. Consequently, a new family Parapsilorhynchidae should be created to accommodate the genus *Parapsilorhynchus*. Further a close study of the distribution of the species of the genera *Psilorhynchus* and *Parapsilorhynchus* vis-a-vis their morphology indicates the following possible evolutionary course.

The fact that both the genera are very closely related to each other (consequently *Parapsilorhynchus tentaculatus*, the type species of the genus *Parapsilorhynchus* was originally discribed under the genus *Psilorhynchus* (Annandale, 1919) and their present day distribution, i.e., one genus in the Himalayan drainage and another genus in Western Ghats, suggest that both genera has a common origin somewhere in the north of Eastern Himalayas (i.e., Southern China from where the present day freshwater fishes were considered to have been evolved (Menon, 1973) and subsequently migrated towards southwest *via* Eastern Himalayas, Garo Hills—Rajmahal Hills, Satpura Range to Western Ghats, during the pleistocene glacial period when the gap between Garo and Rajmahal hills was elevated and hence connected due to the general lowering of the sea level in view of the glaciation (Hora, 1944, 1949). The forms left back at Eastern Himalayas have evolved into the genus *Psilorhynchus* and must be primitive in view of the higher number of unbranched pectoral rays and developed their own specializations like reduced air bladder, single row of pharyngeal teeth, broad spatulate mouth, broad based and horizontally placed paired fins etc. The early Psilorhynchid species must have had relatively large number of undivided pectoral rays and lateral line scales, smaller eyes etc., something like the present day species *viz*, *P. pseudecheneis* and *P. homaloptera*. Out of this stock must have evolved somewhat recent group with fewer unbranched pectoral fin rays and lateral line scales, bigger eyes etc., like the present day species *P. sucatio* and *P. balitora* and spread out westward in the Himalayan drainage.

These two groups of species of the genus *Psilorhynchus* (*pseudecheneis* and *homaloptera* on the one hand and *sucatio* and *balitora* on the other) also differ from each other in other morphological characters like body shape (dorso-ventrally compressed anteriorly and laterally compressed posteriorly in the first group and spindle-shaped in the second group), base of the paired fins (broad in the first groups and narrow in the second group),

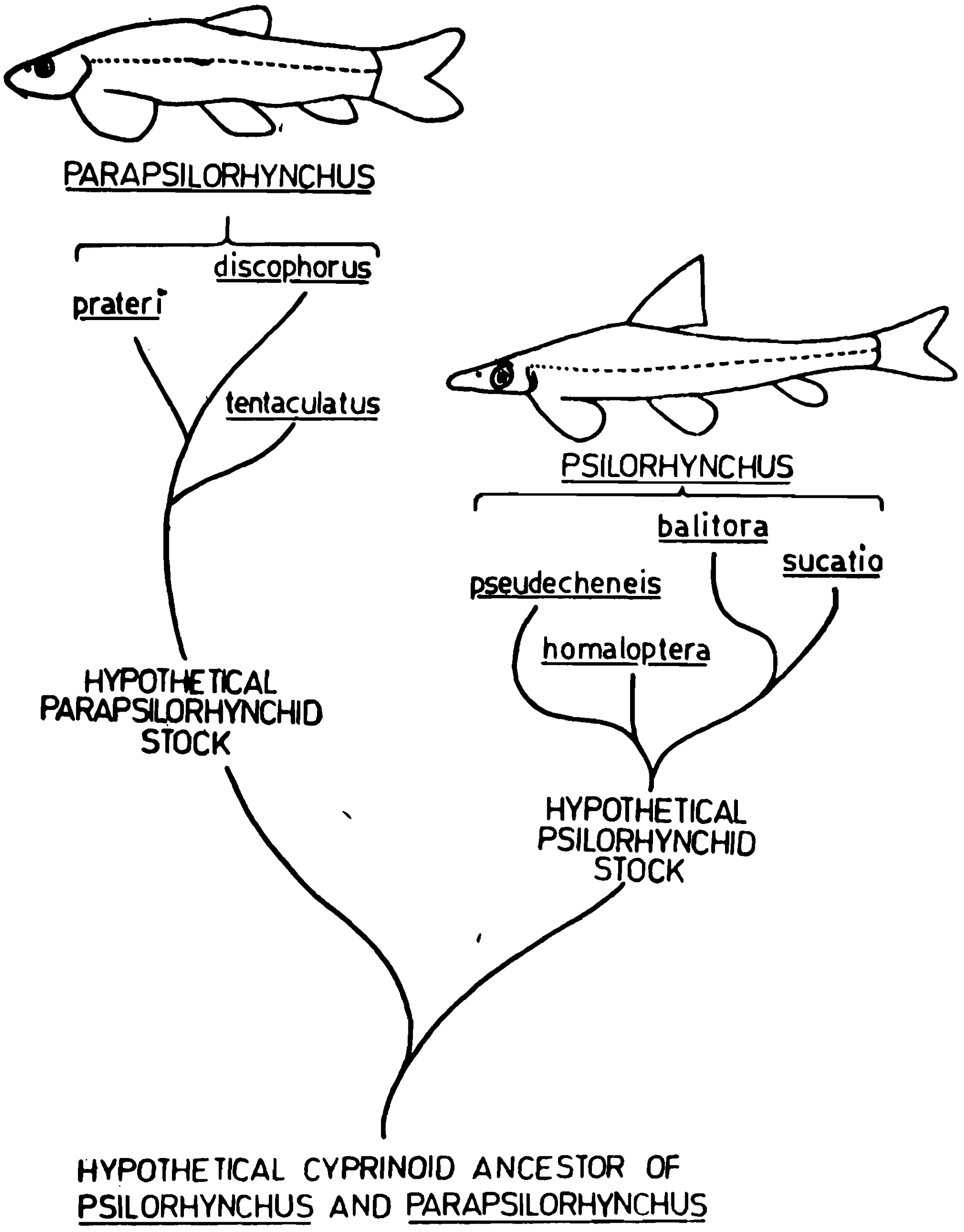

Fig. 1. Trends of evolution in the cyprinoid genera *Psilorhynchus* and *Parapsilorhynchus*.

presence (second group) or absence (first group) of scales on the chest and presence (first group) or absence (second group) of lateral foramina in the basipterygium. In view of this marked grouping of species it is felt that the original *Psilorhynchus* genus actually comprises of two genera, one *Psilorhynchus* proper consisting of the species *sucatio* and *balitora* (since *P. sucatio* is the type species of the genus *Psilorhynchus* (Mukherji, 1933) and the species *pseudecheneis* and *homolaptera* might represent another genus.

The forms that migrated westward during the pleistocene glaciation must have been something like the present day *Parapsilorhynchus tentaculatus* (with a lower number of unbranched pectoral rays than *Psilorhynchus*, but higher than those of the present day species of *Parapsilorhynchus*, with a rudimentary thickening in the posterior part of lower lip etc.). The fact that *Parapsilorhynchus tentaculatus* is reported from places along the course of migration (Satpura Hills etc.,) besides Western Ghats shows that not only it was once a well distributed species but also indicates its migratory route. *Parapsilorhynchus tentaculatus* is obviously primitive form compared to *P. discophorus* and *P. prateri* in view of the fact that while in *P. tentaculatus* the unbranched pectoral rays are three, in *prateri* and *discophorus* they are two. The thickening of the disc behind the lower lip is rudimentary (i.e. in formative stage) in *P. tentaculatus* whereas both in *prateri* and *discophorus* the thickening is complete and prominent. In fact it is not difficult to imagine *tentaculatus* or its ancestral form as a sort of a connecting link in the evolution from the genus *Psilorhynchus* (where there are many unbranched pectoral rays and no thickening, or disc behind the lower lip) to the genus *Parapsilorhynchus* (where the maximum number of unbranched pectoral rays are 3 and with a thickening or disc behind the lower lip). Those populations restricted in the Nasik region of the Godavari River must have specialized and developed the disc-like thickening behind the lower lip as well as small scales on the body and have evolved into the species *prateri* though remaining small in size as in *tentaculatus*. The latter species is mainly restricted to the tributaries of the Krishna River in the Western Ghats (Poona and Mahabaleswar), although it has a wider distribution than the other two species. The population that has gone west and southwest (Koyna River and Vasishti Valley) has evolved into the species *discophorus* growing to larger size and with fuller body, scales largest in the genus and smaller eyes.

The evolution and relationships of the species of the two genera *Psilorhynchus* and *Parapsilorhynchus* can be diagrammatically shown as in the accompanying figure (Fig. 1).

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ON *NYCTIBATRACHUS MAJOR* BOUL. (RANIDAE) WITH A DESCRIPTION OF ITS TADPOLE

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ABSTRACT

The present account is a brief redescription of the type-species, *Nyctibatrachus major* Boulenger, to incorporate the new characters. Notes on ecology of the species are given. The tadpole is described for the first time. A key to the identification of the species known so far under the genus is also provided.

INTRODUCTION

Genus *Nyctibatrachus* is endemic to Western Ghats extending as far north as Bombay. Five species and one subspecies of the genus are so far known. These are *N. pygmaeus* (Günther) from the Anaimalai hills (Boulenger, 1882), *N. major* from Wynad and Aryankavu range near Shencottah (Boulenger, 1882 ; Annandale, 1910 as *Rana travancorica*), *N. sanctipalustris* from Brahmagiri hills, Coorg, including the subspecies *sanctipalustris modestus* from Shimoga (Rao, 1920), *N. sylvaticus* from Hassan, Mysore (Rao, 1937) and *N. humayuni* from N. Kanara, Mahabaleshwar and Khandala, Bombay (Bhaduri and Kripalani, 1955).

The concept of Amphibian systematics and characters which form its basis have undergone major changes within the last 90 years somuchso that Boulenger's short descriptive accounts of the species leave considerable ambiguity with regard to many details in contrast to the recent detailed description of *N. humayuni* by Bhaduri and Kripalani. This is more so for *N. major* which has been designated as type-species of the genus. Its description is so brief that Bhaduri and Kripalani (*loc. cit.*) had to borrow topotypes of *N. major* from the British Museum of Natural History to establish the specific distinctness of *N. humayuni*. Nothing is known about the type-locality, habitat or ecology of *N. major*.

Special efforts were therefore made by the author to collect these frogs during a faunistic survey tour to Wynad in 1976 as a result of which 42 specimens were collected. A detailed study has brought to light a number of characters hitherto unknown for the species some of which would be of positive help in tracing the phylogeny and affinities of the genus *Nyctibatrachus*.

One important character cited for the separation of *Nyctibatrachus* and *Nannobatrachus* from *Rana* and *Micrixalus* (Boulenger, 1890) is the vertical condition of the pupil in the former. Study of the present material, however, shows that the utility of this character cannot be relied upon since preserved material shows an almost circular, elliptical or rhomboidal pupil. Annandale (1910) described it as a new species of *Rana* (*travancorica*) presumably because of this condition of pupil which is characteristic of *Rana*. Rao (1937 p. 400) has pointed out the unreliability of this character in the separation of *Nannobatrachus* from *Nannophrys*.

MATERIAL

42 young and adults were collected as under :—

(1) One example from the Baveli forest at Manantoddy, Cannanore Dist., Altitude 650 metres, coll. R. S. Pillai, Oct. 7, 1976.

(2) 41 examples from Kurichiat Reserve forest, Chedleth, Wynad, Altitude 825 metres, coll. R. S. Pillai, Oct. 15, 20 and 21, 1976. The small stream from where they were collected ultimately joins the Kabbani River which is a tributary of the Cauvery System.

DESCRIPTION

Colour : Dorsum in adults very dark or brownish black. Upper side of limbs dark brown with black cross bars. Upper and lower lips uniformly dark. Throat (upto coracoid level) marbled with brownish grey or sepia. Belly, ventral part of forelimbs and proximal ventral part of thighs immaculate.

Juveniles (upto about 25 mm body size) less dark, brownish. A narrow dark transverse band connecting the two dark upper eyelids. Two more such broad transverse patches behind this and a few longitudinal patches on either side of dorsum. Limbs crossbarred upto digital tips. Lower temporal area pale. Upper and lower lips with thin vertical white stripes. Whole of venter devoid of pigmentation.

Head : Depressed, slightly broader than long ; snout obtusely pointed, slightly longer than eye. Nostrils dorsal, elevated and close together, their distance being less than inter-orbital space. Eyes with elliptical or rhomboidal pupil, its diameter a little longer than inter-orbital space and little less than snout. Upper eyelid narrow, lower with a small papilla at its hind corner. Tympanum indistinct, covered over by smooth skin which in a few examples is loose. Vomerines cushion-like, oval and close together behind the level of choanae. Tongue large, bifid, with depressed impressions of vomerines on its attached part.

Forelimbs : Short, about half the length from snout to vent. Fingers free, with bulbous tips devoid of circum-marginal groove.

Hindlimbs : Short and robust, about 1½ times body length ; tibia stout being twice as long as broad, shorter than forelimb and equal to foot ; tibio-tarsal articulation of the adpressed hindlimb reaching eye, heels not touching when limbs are folded at right angles to the body. Toes two-thirds webbed, the free phalanges on each toe being as follows :

First	Second		Third		Fourth		Fifth
	int.	ext.	int.	ext.	int.	ext.	
1	2	1	2½	1	2½	2½	1

Toe tips with small discs which are about as long as broad, with crescentic circum-marginal grooves. The grooves form deep pockets which open out at the dorsal extremity of discs, the proximal lip being notched. Terminal phalanx with a transverse expansion distally. Outer metatarsal separated by web almost to base and with distinct dermal fold. Inner metatarsal tubercle narrow, elongated, about half the length of inner toe measured from the distal end of tubercle. Prominent dermal fold from proximal end of the inner metatarsal tubercle to tarso-metatarsal articulation. No outer tubercle.

Skin : Corrugated with numerous short, irregular folds all over dorsum and flank. Snout with a median longitudinal narrow fold from upper lip to the level of nostrils where it bifurcates and run toward anterior corner of eyes. A short transverse fold connecting the two upper eyelids and another longer one parallel to it a little distance behind. An arching supratemporal fold from hind corner of eye towards shoulder and a short fold from lower part of eye to angle of jaw ; these two folds incompletely encircling the tympanic region. Upper eye-lid warty. Hind part of dorsum with small white-tipped tubercles which extend to around vent. Tibia and tarsus similarly studded. Throat longitudinally rugose, belly with faint transverse folds and grooves. Vermiculation less in Juveniles.

TABLE 1. Body mesurements in mm of *Nyctibatrachus major* Boul. from Wynad

Body parts	1	2	3	4	5	6	7
1. Length of head and body (from tip of snout to vent)	36	35	32	31	30	25	23
2. Length of head (from tip of snout to angle of jaws)	13	13	11	11	10	9	9
3. Width of head (at angle of jaws)	15	14	14	13	13	11	11
4. Length of snout (from tip of snout to anterior corner of eyes)	7	7	6	5.5	6	4.5	4.5
5 Length of eye (maximum from anterior to posterior corner)	5	5	5	5	5	4	4
6. Minimum inter-orbital distance	4	4	3	3	3	3	3
7. Distance between anterior edge of nostris and tip of snout	3.5	4	3.5	3	3	3	3
8. Length of forelimb	19	17	17	16	16	12	13
9. Length of hand	10	10	8.5	8	8	7	6
10. Length of first finger	4	4	4	4	4	3.5	3
11. Length of second finger	5	5	5	5	5	4	4
12. Length of third finger	7	7	6	6	6	5	5.5
13. Length of hind limb	50	50	43	44	44	37	38
14. Length of tibia	16	15	15	14	12	10	11
15. Length of foot	16	16	15	15	15	12	11
16. Length of first toe	4	4	4	4	4	3	3
17. Length of second toe	6	6	6	5.5	6	5	5
18. Length of third toe	8	8	8	7	7	7	6
19. Length of fourth toe	15	16	13	13	13	12	12

Ecology and field notes :

The single specimen from Manantoddy was taken from under a dead log from a slushy part of the forest near the origin of a small stream. The 41 examples were all collected from a six kilometre-stretch of heavily leech-infested forest stream flowing over a muddy bed among large boulders and stones. The water was only a metre or two across with occasional pools and rocky cisterns. All specimens were collected from under stones in shallow water. On lifting the cover they would dart to the nearest stone and creep under with commendable agility. Seldom did they try to bury themselves in mud and none tried to leave the water and take shelter in the matty undergrowth that grew next to the water's edge. It was evident that they were admirably adapted for life in rock crevices and under stones. The digital discs on toes with their pocket-like excavations enable them to cling fast to stones and prevent them from being washed away even in fairly swift current.

Remarks : Presence of a deep circum-marginal groove on toe-discs has not been mentioned in any of the earlier descriptions of the species. Neither did Bhaduri and Kripalani (1955) mention its presence in the topotype which they have examined. While *N. humayuni* possesses such grooves on digits of both limbs, *N. major* has them only on hind limbs, the finger tips being merely swollen I have not examined the other three species of *Nyctibatrachus* but it is quite probable that they also may be having these grooves. If this be so, the genus *Nyctibatrachus* would find a place close to *Hylorana* (Genus *Rana*).

KEY TO THE KNOWN SPECIES OF NYCTIBATRACHUS

1.	Skin of dorsum (excluding head) smooth	*pygmaeus*
1.	Skin of dorsum with closely set folds	2
2.	Toes nearly fully webbed ..	3
2.	Toes half webbed	4
3.	Fingers with discs and horizontal circum-marginal grooves	*humayuni*
3.	Finger tips merely swollen and without circum-marginal grooves	*major*
4.	Canthus rostralis present	*sylvaticus*
4.	Canthus rostralis absent	*sanctipalustris*

DESCRIPTION OF THE TADPOLE

(Figs. 1, A & B)

Tadpoles were collected from certain rocky cisterns along the course of the stream in Kurichiat forest at Chedleth from where adults have been taken. Out of the three examples, two are without limbs, the third with short hindlimbs. Two more tailed juvenile frogs have been collected, all these constituting a fairly complete series connecting the young frog with the tadpole.

Colour : Head and body blackish with two close whitish longitudinal patches on the hind half. Dusky below ; tail whitish with a few transverse bars dorsally.

Head and body : Oval, slightly flattened, ventral surface a little convex. Tip of snout bluntly rounded. Nostril nearer to anterior corner of eye than to tip of snout. Inter-narial distance less than inter-orbital space. Eyes dorsal, placed about one-third distance between tip of snout and base of tail. A row of minute glands encircling the orbit is continued forwards to meet its fellow a little behind tip of snout. Spiracle sinistral, tubular and lying almost in between tip of snout and base of tail, the opening being vertically elliptical. Vent situated dextrally.

Mouth disc : Small, directed downwards and slightly forwards, without horny teeth. Anterior lip distinct, consisting of a large median

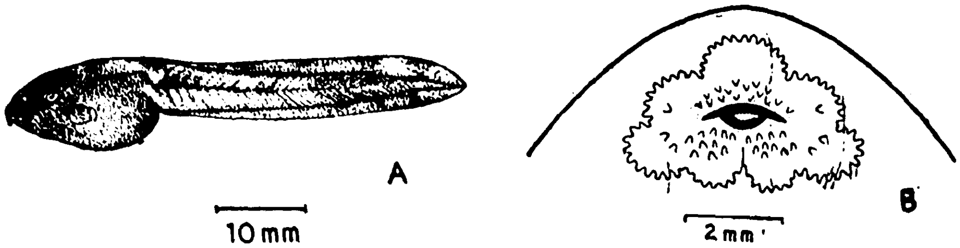

Fig. 1. Tadpoles of *Nyctibatrachus major* Boul. A. Lateral view of tadpole ; B. Mouth disc.

lobe overhanging the mouth and two lateral extensions, fringed with papillae. One or two rows of longer papillae between this lip and the upper beak. Posterior lip divided into 4 backwardly directed lobes with a deep median cleft and edged with papillae. Beaks black, narrow, the lower V-shaped one being broader than the upper. Both beaks very finely serrated.

Tail : One and a half to twice the length of head and body, tapering to a blunt point rather abruptly. Tail membrane a little deeper dorsally than ventrally, the upper usually commencing from the posterior part of the body slightly in front of the ventral.

Annandale (1918a ; 1918b footnote on p. 28) has remarked about the peculiar structure of the mouth disc in the tadpoles of *Rana leptodactyla* and *R. semipalmata* collected from the hills of S. India as exceptions to Ranidae in the absence of horny labial teeth and the well developed suctorial mouth disc. Tadpoles of *R. leptodactyla* bear a striking resemblance to that in *Nyctibatrachus major* described above. This and the facts that Annandale's identification was not based on a complete series and the observations of Rao (1920) on the larvae of true *leptodactyla* constitute ample proof that Annandale's *leptodactyla* was nothing other than tadpoles of *N. major.*

TABLE 2. Measurements in mm of tadpoles of *Nyctibatrachus major* Boulenger

Body parts	1	2	3	4
1. Total length	37	48	52	40
2. Length of head and body	15	16	18	19
3. Width of head and body	10	10	11	9
4. Length of tail	22	32	34	21
5. Max. height of tail	8	7	9	5

No. 3 With only hind legs
No. 4 With both fore- and hind legs

Remarks : It has to be admitted that our present knowledge on the taxonomy of Indian tadpoles is very scrappy because of the fact that many of the descriptions have not been properly connected up with their adults.

While referring tadpoles of *N. pygmaeus* described earlier (1918a) to *Philautus* (=*Ixalus*) *variabilis,* Annandale (1919) states that the true tadpoles of *Nyctibatrachus* do not have horny teeth and resemble those of *R. semipalmata.* By virtue of the fact that a member of the genus *Rana* is very unlikely to possess a tadpole described under *R. semipalmata* it stands to reason that Annandale's material collected by Gravely from Parambikulam could only have belonged to *N. pygmaeus*. The close similarities of this tadpole with those of both *N. major* and *N. humayuni* (Bhaduri and Kripalani, 1955) strongly support this.

Thus we have descriptions of tadpoles of three species *viz. N. major*, *N. pygmaeus* and *N. humayuni* showing very close similarities to each other and exhibiting a basic pattern in the presence of overhanging, lobulate lips fringed with papillae and absence of horny labial teeth. A comparison of these with the tadpole of *N. sanctipalustris* (Rao, 1923) reveals that the latter constitutes a deviation from the pattern in the retention of labial teeth, absence of papillae on the anterior lip and presence of certain rounded melanin-pigmented papillae. Tadpole of the fifth species, *N. sylvaticus* is as yet unknown.

ACKNOWLEDGEMENTS

I am thankful to the Director, Zoological Survey of India, Calcutta and to Dr. A. G. K. Menon, Deputy Director, Zoological Survey of India, Madras for all facilities to carry out this study.

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Bull. zool. Surv. India, **1** (2) : 141-145, 197

THE SYSTEMATIC POSITION OF *LAEMOPHLOEUS SEMILAETANEUS* GROUVELLE (COLEOPTERA : CUCUJIDAE : LAEMOPHLOEINAE)

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ABSTRACT

A new genus *Heterojinus* for the species *Laemophloeus semilaetaneus* Grouvelle is established and its taxonomic position is discussed.

INTRODUCTION

Grouvelle (1913) described the species *Laemophloeus semilaetaneus* from Rotung : Assam, Tibet Frontier (India) based on one example, which has been deposited in Zoological Survey of India, Calcutta. Since then nobody has dealt with this species. Authors have studied the type specimen and found that this species is unlike to any other known Cucujidae have tarsal joint 1 not shorter than joint 4. Arrow (1920) established the genus *Cucujinus* with description of a new species *Cucujinus micromma* from Africa. Grouvelle (1899 & 1906) described *Laemophloeus congureli* and *Laemophloeus brevipennis* from Reunion and Madagascar respectively. Lefkovitch (1962) transferred these two *Laemophloeus* species to the genus *Cucujinus* and subdivided into two subgenera *Cucujinus* s.str. and *Paracucujinus*, *Laemophloeus semilaetaneus* Grouvelle has close resemblances with the subgenus *Cucujinus* s.str. specially in their general appearance, transverse head, apical margin of clypeus with five sinuations, lateral line in front of eyes and prothorax grooved, front coxal cavities closed behind, mesocoxal cavity open outwardly, sternal fitting between mesocoxae distinctly concave posteriorly, median impressed line on metasternum not extending upto apex, femora flattened and dilated.

The species *Laemophloeus semilaetaneus* Grouvelle cannot be assigned to any family of clavicorn beetles as at present defined by Crowson (1955). The following characters should be sufficient to establish its distinctness :

(1) The tarsal formula 5-5-5 excludes it from cerylonid group.

(2) Outwordly open mesocoxal cavities exclude it from Phalacridae, Propalticidae, Cryptophagidae, Languriidae and Erotylidae.

(3) Front trochantin not exposed and lack of outer keel or denticle on front tibiae exclude from Nitidulidae and Smicripidae.

(4) Elytra not distinctly truncated, absence of antennal club exclude it from Rhizophagidae.

(5) Normal front trochanter, absence of tarsal claws with large basal tooth and absence of femoral line on ventrite 1 exclude it from Byturidae and Biphyllidae.

(6) Simple tarsi and absence of bisetose empodium between tarsal claws separate it from Protocucujidae.

(7) Hind coxae widely separated, presence of fronto-clypeal suture and front coxae closed behind separate it from Lamingtoniidae.

(8) Front coxae round and trochantin unexposed separate it from Boganiidae, Cavognathidae, Phloeostichidae and Sphindidae.

(9) Absence of distinct antennal club and lack of subocular grooves separate it from Helotidae.

(10) Gular sutures not confluent and mesocoxal cavities open outwardly exclude it from Passandridae.

(11) Tarsal joint 3 not lobed below, front coxal cavities narrowly closed behind and absence of antennal club exclude it from Silvanidae.

(12) First tarsal joint not smallest and ventrite 1 distinctly smaller than ventrite 5 separate it from Cucujidae.

Though the species *Laemophloeus semilaetaneus* is clearly a Clavicornia, yet it is not to be referrable to any hitherto family of that group. No attempt has been made here to define a new family for this species, probably it could be included under the family Cucujidae and subfamily Laemophloeinae, if the definition of the family Cucujidae is modified.

Although it shows many similarities with genus *Cucujinus* s.str. as mentioned earlier but the chief differences of the genera *Cucujinus* Arrow and *Heterojinus* gen.nov. are as follows :

	Cucujinus Arrow	*Heterojinus* gen. nov. (Fig. 1 A, B)
1.	Tarsal joint 1 shorter than joint 4 and as broad as joint 2.	Tarsal joint 1 slightly longer than joint 4 and broader than joint 2.
2.	Ventrite 1 twice as long as ventrite 2 and about as long as ventrite 5.	Ventrite 1 about as long as ventrite 2 and distinctly shorter than ventrite 5.
3.	Transverse line at the base of pronotum absent.	Transverse line at the base of pronotum present and joined with lateral lines.
4.	Front angle of pronotum acute and hind angle rounded.	Front and hind angle of pronotum rounded.
5.	Labrum either semicircular or triangular in shape.	Labrum transverse and its apical margin truncated.
6.	Elytral cells are obsolate.	Elytra with incomplete outer line of third cell.

Genus **Heterojinus** gen.nov. (Fig. 1 A, B)

Type species *Laemophloeus semilaetaneus* Grouvelle (by monotypy)

General appearance (Fig. 1A) elongated, flattened, shiny, last segment of abdomen exposed.

Head transverse, apical margin of clypeus with five sinuations, fronto-clypeal suture distinct and irregularly curved, median line

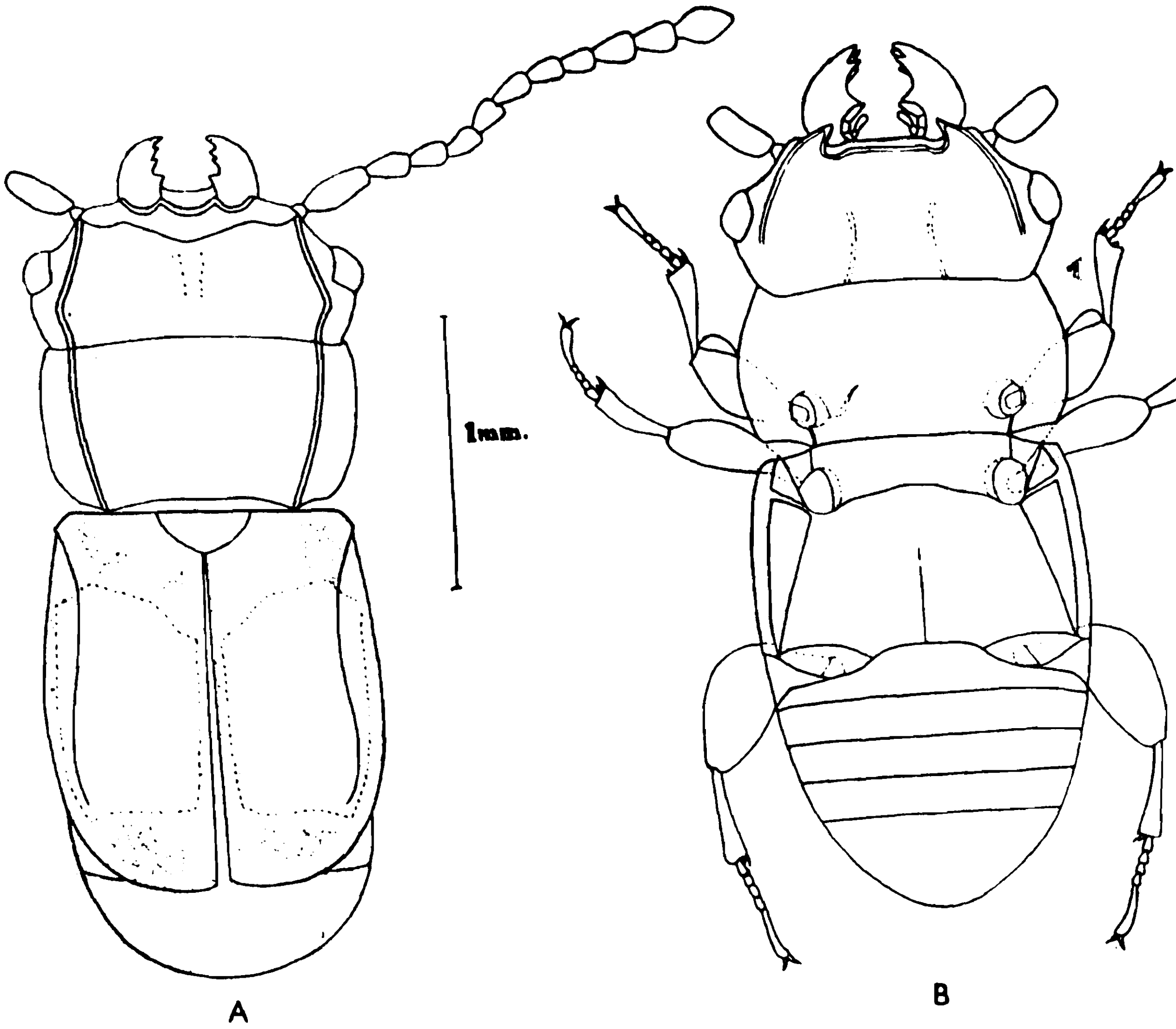

Fig. 1. *Heterojinus semilaetaneus* (Grouvelle), ♂ A. dorsal view ; B. ventral vie

on vertex absent, lateral line in front of eyes grooved and diverging posteriorly. Eyes moderately large, a little advance from base and finely faceted. Ventral surface with gular suture widely separated, genae normal and with a blunt spine at apex and a grooved line at inner margin of eye present. Antennae (Fig. 1A) about half of body length, scape robust and more than two times longer than its width, pedicel slightly longer than segment 3, segments 3-8 subequal, segments 9-11 forming indistinguishable club. Mandible with four apical teeth. Maxillary palpi with segments 2 & 3 subequal and segment 4 distinctly longer than segments 2 & 3 together, labial palpi with segment 3 more than 1.5 times longer than segment 2. Labrum transverse, its apical margin truncate and fringed with hairs.

Prothorax (Fig.1, B), distinctly transverse, slightly narrowed in front and behind, lateral margins arched, lateral grooves united posteriorly with basal transverse line, front and hind angle of pronotum rounded. Front coxae spherical, widely separated, its cavities narrowly closed posteriorly, intercoxal process of prosternum slightly concave at apex.

Meso-metathorax (Fig. 1, B) meso-and meta-coxae widely separated and in the same line of front coxae, mesocoxal cavity open outwardly. Metasternum transverse, median impressed line extending two thirds of its length, sternal fitting between mesocoxae in a curved line.

Elytra incomplete and exposing last segment of abdomen, slightly longer than its combined width, humeral angle rounded, apical angle subtruncate and each elytron with incomplete outer line of third cell.

Legs moderately long, trochanter short and simple, hind femora more flattened and delated tibia with two unequal spurs at apex, tarsal formula 5-5-5 in male (female unknown), tarsal segment 1 broader and longer than segment 4, segment 2 longer than segment 3, segment 5 about as long as segments 1-4 together, claws simple.

Abdomen (Fig. 1, B) slightly broader than long, intercoxal process of ventrite 1 broad and its apical margin almost straight, ventrite 1 slightly longer than ventrite 2, ventrites 2-4 subequal, ventrite 5 distinctly longer than ventrite 4.

Habitat : Under bark
Distribution India : Assam.

Heterojinus semilaetaneus (Grouvelle) (Fig. 1 A, B)

Laemophloeus semilaetaneus Grouvelle, 1913, *Rec. Ind. Mus.*, 8 : 108.

General appearance broadly elongated, flattened, shiny, glabrous, head and pronotum deep reddish black, elytra reddish black with large lactescence spot.

Head 2.7 times wider than long, apical margin of clypeus with five sinuations and boarderd internally, fronto-clypeal suture distinct, irregularly curved and two triangular, elongated short groove below the fronto-clypeal suture present, puncturation on vertex large, deep and moderately closely arranged. Eyes flat and finely faceted. Antennae reddish black. Prothorax two times wider than long, puncturation on disc small, finely and sparsely distributed. Scutellum subpentagonal, wider than long, rounded at apex, finely and sparsely punctured. Elytra 1.2 times longer than its combined width, finely and sparsely punctured. Puncturation on ventral surface of head large, deep and moderately closely arranged, each ventrite finely and moderately closely punctured.

Measurements : Total length 2.96 mm ; length of head 0.50 mm ; width of head across eyes 1.18 mm ; length of antenna 1.69 mm ; length and width of prothorax 0.58 mm, 1.13 mm ; length and width of elytra 1.62 mm, 1.23 mm.

Material examined : 1 ex. ♂ (Type) INDIA : ASSAM TIBET FRONTIER : Rotung, altitude 1400 ft, Abor Exp., Regd. No. 2519/19, 2.i.12, Kemp, under bark (deposited in Zoological Survey of India, Calcutta).

Distribution : India : Assam

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Bull. zool. Surv. India, 1 (2) : 147-149, 1978

ON A NEW SPECIES OF *HALAMMOHYDRA* (ACTINULIDA, HYDROZOA) FROM ANDAMANS, INDIA

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ABSTRACT

A new species of the interstitial solitary hydrozoan, *Halammohydra andamanensis*, collected in the intertidal sands of Rangat Bay, Middle Andamans (Bay of Bengal), is described. The odd number of both the whorls of tentacles and the linear neck, are remarkable features of the species. Some ecological notes on the species, are given.

INTRODUCTION

One of the fascinating contributions to systematic zoology during the present century is the discovery and study of aberrant cnidarians inhabiting the interstitial environment of marine sediments. Hitherto, six species of the curious solitary hydrozoan *Halammohydra* Remane are known widely to occur on European coasts (Clausen, 1967). Outside Europe, *Halammohydra* has recently been reported from the east coasts of India (Rao and Ganapati, 1966 ; Rao, 1975) and North America (Clausen, 1971). Collections of interstitial fauna from the intertidal sands of Rangat Bay in the Middle Andamans, made by the author during March 1974, contained specimens of yet another undescribed halammohydrid, which is being reported here as a new species.

SYSTEMATIC ACCOUNT

Family HALAMMOHYDRIDAE
Genus **Halammohydra** Remane, 1927

Halammohydra andamanensis sp. n.

(Fig. 1)

Material : Holotype, Regd. No. P. 2720/1, ♀, 570 µ long ; loc. Rangat Bay (Lat. 12° 28′ 40″ N and Long. 92° 54′ 20″ E), Middle Andamans, in coarse sand 5 - 10 cm. below surface, intertidal zone, 15 March 1974 coll. G. C. Rao. Paratypes, Regd. No. P 3005/1, 2 ♀+1 ♂, 540 - 590 µ long, collection data as above. The types are deposited in the National Zoological Collections at the Zoological Survey of India, Calcutta.

Description : All the seven adult specimens examined morphologically belonged to the same population and attained a total length of 520 - 600 µ. Body elongated. opaque and sparsely ciliated. Gastric tube 420 - 460 µ long, 50 - 60 µ wide and makes up about ⅘ of total length. Neck about 10 µ wide, unusually elongated and about 100 µ long. Aboral cone strikingly conical in shape, 35 × 30 µ in size, with little developed adhesive organ occupying about 1/3 of upper part of cone. Adhesive organ nearly conical in shape and attains about 12×10 μ in size.

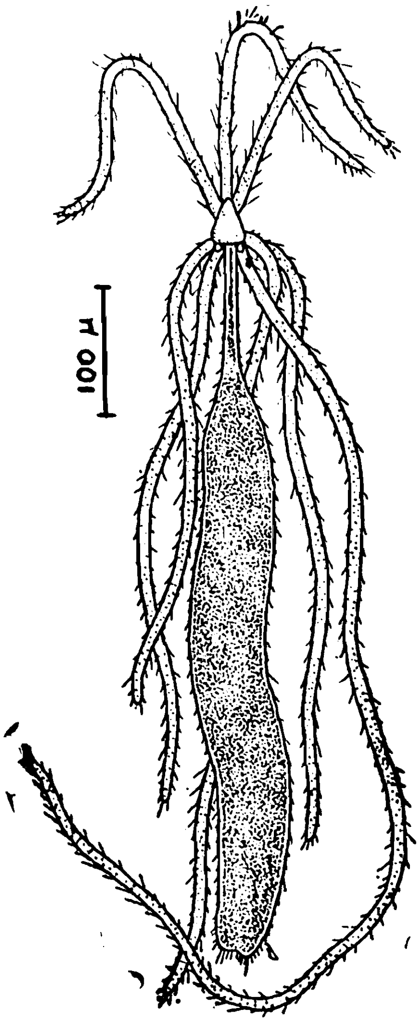

Fig. 1. *Halammohydra andamanensis* sp. n. Adult, habit.

Two distinct whorls of slender tentacles and nearly globular statocysts constantly numbered 3+5+5. Tentacles do not bulge or taper at their base. Anterior tentacles nearly of same size, while posterior ones are longer and vary in size. One of the posterior tentacles always longer than the others. During locomotion, anterior tentacles directed forwards, while posterior ones trail behind. Tentacles generally extend completely during locomotion, while certain amount of annulation often occurs distally at rest. Five statocysts alternating with posterior tentacles are lithostyle type and about 5 μ in diameter. Cnidome consists of two types of nematocysts, *viz.*, nearly spherical stenoteles of two size categories and oval atrichous isorhizas. Macrostenoteles are *c.* 6.4-7.2×6.0-6.8 μ; microstenoteles *c.* 4.0-5.2×3.8-5.0 μ; and isorhizas *c.* 3.4×2.2 μ. Sexes separate. Males and females with one gonad only.

Remarks : The structure of the new species presents all the peculiar features characteristic of the genus and meets all the biological needs of the interstitial environment. The odd number of both the whorls of tentacles and the linear neck, are remarkable features of the species. Among the seven known species of the genus, the present form closely approaches *Halammohydra vermiformis* Swedmark and Teissier in the worm-like shape of body, size of adhesive organ and the disposition of tentacles, but differs from the latter in the following features : (1) body size, (2) shape of aboral cone and neck, (3) number of posterior tentacles and statocysts, and (4) size of nematocysts.

Until now, *H. octopodides* Remane and *H. chauhani* Rao are the only two species of the genus recorded from the interstitial system of Indian Ocean. The discovery of *H. andamanensis* Rao from an isolated area of Bay of Bengal is of considerable zoogeographical importance and also indicates the interesting way evolution of species has occured within the genus.

Ecology : The cnidarian is an inhabitant of coarser sands mixed with fine shell gravel and little detritus 5-10 cm. below surface between the low and half-tide levels of the intertidal zone. The sands are mostly silicious and angular ; their texture varied between 300 and 600 μ in mean diameter. Temperature and salinity of interstitial water in the habitat at the time of collection were 28.6°C and 34o/oo., respectively.

The species is free-moving, agile and

exhibits weak powers of adhesion to substratum, probably correlated with the reduced number of tentacles and the small aboral adhesive organ. The atrichous isorhizas on tentacles also appear to assist the animal in adhering to substratum. Locomotion is effected by ciliary gliding and a speed up to 2 cm./minute was recorded in a thin layer of coarser sediment spread in a petri dish. The vermiform body enables the animal to move through the interstices with considerable ease. The hydrozoan is negatively phototactic and a predator, feeding on micrometazoans of sand.

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EVOLUTIONARY TREND IN TWO SYMPATRIC SPECIES OF *GONIOCOTES* (PHTHIRAPTERA : ISCHNOCEROPHTHIRINA) WITH REMARKS ON HOST PHYLOGENY

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ABSTRACT

The evolutionary trend in two sympatric species, viz., *Goniocotes mayuri* and *G. parviceps* parasitic on *Pavo cristatus* and *P. muticus*, is discussed in this paper. Based on the parasite data, host phylogeny is also discussed.

INTRODUCTION

Sympatricity among two species of *Goniocotes* found on the Indian Peafowl (*Pavo cristatus* Linne) and the Green Peafowl (*P. muticus* Linne) was recently discovered by the authors (Lakshminarayana and Emerson, 1971). One of the species of the sympatric pair, *G. parviceps* (Piaget), has been known for more than ninety years and was first described from material collected off the Indian Peafowl in the Amsterdam and Rotterdam zoological gardens. In addition to records from museum skins or zoological garden birds, it has been found on the type host in India and Nepal and off *P. muticus imperator* from Thailand. The other member of the sympatric pair, *G. mayuri** Lakshminarayana and Emerson, has been found only on *P. cristatus* in India, Nepal and the Yorks Zoo, and so far has not been encountered on *P. muticus*. Several collections of Chewing-lice from the latter host from Thailand have been examined, but *G. mayuri* was not found. While describing *G. mayuri* the present authors gave diagnostic characters of *G. parviceps* also, and casually remarked that the former with a symmetrical male genitalia is phylogenetically older to the latter with asymmetrical genitalia. The present paper is to elucidate further our observations on the trend in evolution in these two sympatric species and the light they throw on the phylogeny of their hosts.

The diagnostic characters of the two species are presented in a comparative way (Table I) before discussing the evolutionary trend (see also fig. 1, A—E). We stated elsewhere (Lakshminarayana and Emerson,

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* *ri* in *mayuri* should be pronounced as *re* in congregation.

1971) that while the males are easily separable, the females are seperable with difficulty. Therefore, the males are more useful in discussing the evolutionary trend.

TABLE 1. Diagnostic characters of *Goniocotes mayuri* and *parviceps*

Character	*mayuri*	*parviceps*
	Male	***Male***
1. Temporal margin	Constricted	Not constricted
2. Marginal temporal carina	Narrow, weakly sclerotized	Wide, heavily sclerotized
3. Marginal temporal setae	Slender	Robust, nearly spinous
4. Form of seta on first antennal appendage	Small and lanceolate	Long and fine
5. Shape of the lateral prothoracic margin	Nearly rectangular	"Winged"
6. Shape of abdominal tergite I	Sharply projecting over thorax anterolaterally	Normal
7. Setae on tergite VIII	Four	Two
8. Setae on terminal abdominal tergite	Six	Eight
9. Genitalia	Symmetrical	Asymmetrical
	Female	***Female***
1. Size	Large	Slightly smaller
2. Setae on terminal abdominal tergite	Four long and short setae	Six long and four short setae
3. Shape of internal vulval chamber	Prominent, circular-shaped	Not prominent and discernible

The trend in evolution, based on the males, can be summarized as follows :

The weakly sclerotized marginal temporal carina in *G. mayuri* (*fig.*1A, *m.c.*) is heavily sclerotized in *G. parviceps.* The slender temporal seta in *G. mayuri* are robust and spiniform in *G. parviceps.* The lanceolate seta on the first antennal appendage of *G. mayuri* is modified into a fine and long seta in *G. parviceps* (figs. 1B and D). Sikora and Eichler, 1941, according to Clay, (1949) found that within the 'Ischnocera' antennae play a dominant part in mating and that one member of the sympatric pair always shows antennal variation. This suggests that the fine long seta might be playing a significant role probably sensory, in discriminating the female of its own species, which is otherwise alike to its counterpart in the sympatric pair. The nearly rectangular prothorax in *G. mayuri* is modified into a "winged" form in *G. parviceps.* Likewise, the first abdominal tergite which is strongly projecting into pterothorax anterolaterally in *G. mayuri*, became normal in *G. parviceps.* The most significant evolutionary change is perceptible in the male genitalia in that the symmetrical genitalia in *G. mayuri* (fig. 1C) has undergone a change into an asymmetrical one in *G. parviceps* (fig. 1E) and can be easily derived from the symmetrical one in *G. mayuri*, (and not the reverse). hence phylogenetically *G.*

parviceps is assumed as younger to *G. mayuri*. This change has obvious advantage in preventing interbreeding between *G. parviceps* and *mayuri* populations. Mayr (1969) stressed the importance of genitalia in the evolution and evaluation of sympatric species.

REMARKS ON HOST PHYLOGENY

It was shown (*vide supra*) that *G. mayuri* is phylogenetically older than *G. parviceps*. While *G. mayuri* is now known only from the Indian peafowl (*Pavo cristatus*), *G. parviceps* is known from the Indian Peafowl and the Green Peafowl (*P. muticus*) also.

Delacour (1951) and Ripley (1961) recorded the distribution of *P. cristatus* in India as south of the Indus River and east to longitude 90°E., and in Nepal and Ceylon from sea level to nearly 1550 meters in the scrub jungle, sal forest, and semicultivated areas.

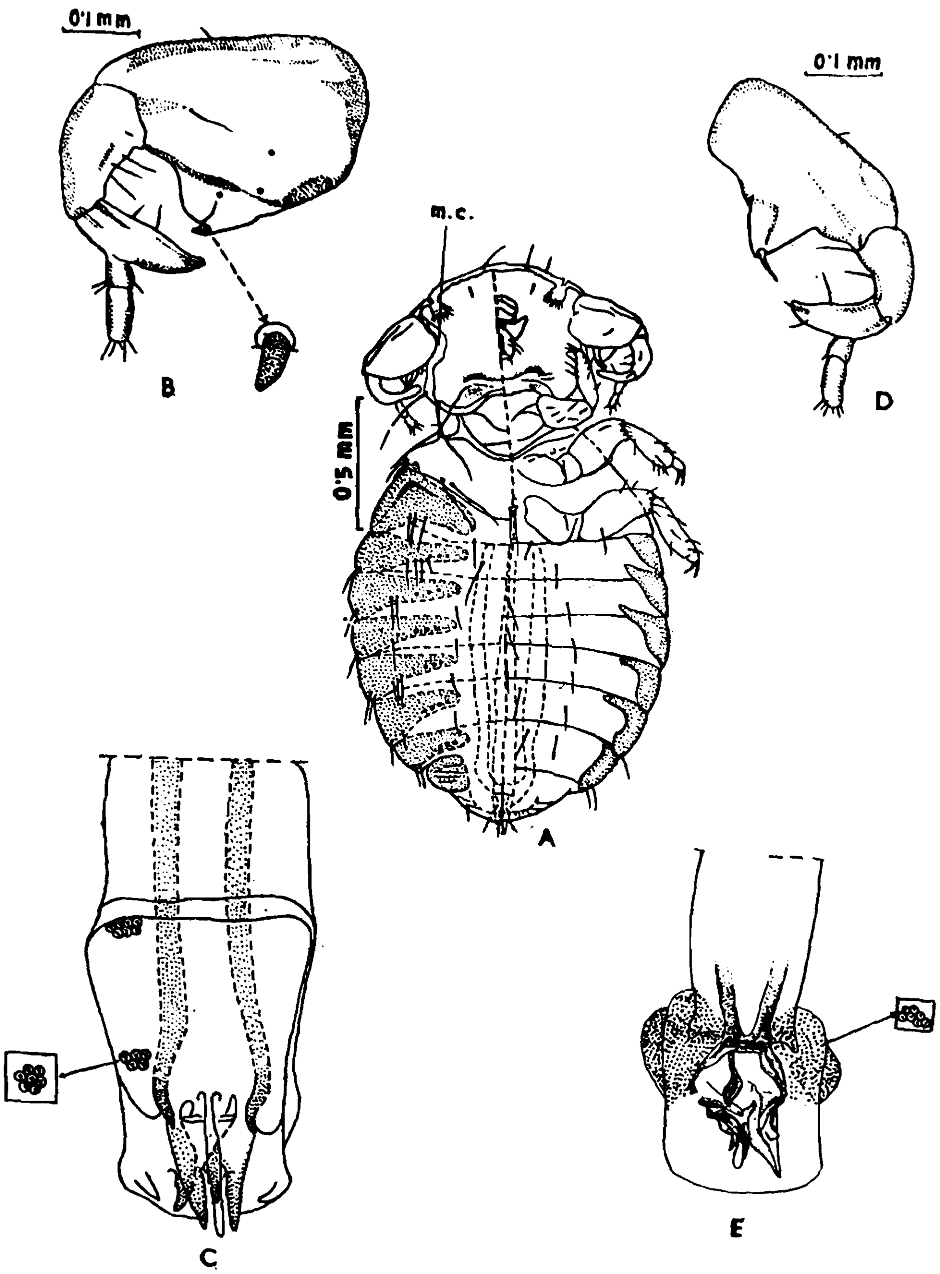

Fig. 1. *Goniocotes mayuri* ; A. Male ; B. Male antenna ; C. Male genitalia ; G. *parviceps* ; D. Male antenna ; E. Male genitalia.

The Green Peafowl, *Pavo muticus,* has three subspecies, viz., *spicifer, imperator* and *muticus.* Of these *spicifer* occurs along the south-eastern border of Assam, in the hittagong and Lushai Hills where it is now scarce, and it formerly occurred in Manipur and North Cachar. It also occurs in western Burma, probably as far east as the Irrawaddy River. The subspecies *imperator* inhabits the whole "Indo-China", the extreme south of Yunnan, Thailand south to Kra, and eastern Burma as far west as the Salween-Irrawaddy divide. The subspecies *muticus* is found in Java and the Malay peninsula probably north to the Isthmus of Kra ; it has not been found in Sumatra and Borneo (Delacour, 1951) (Fig. 2.).

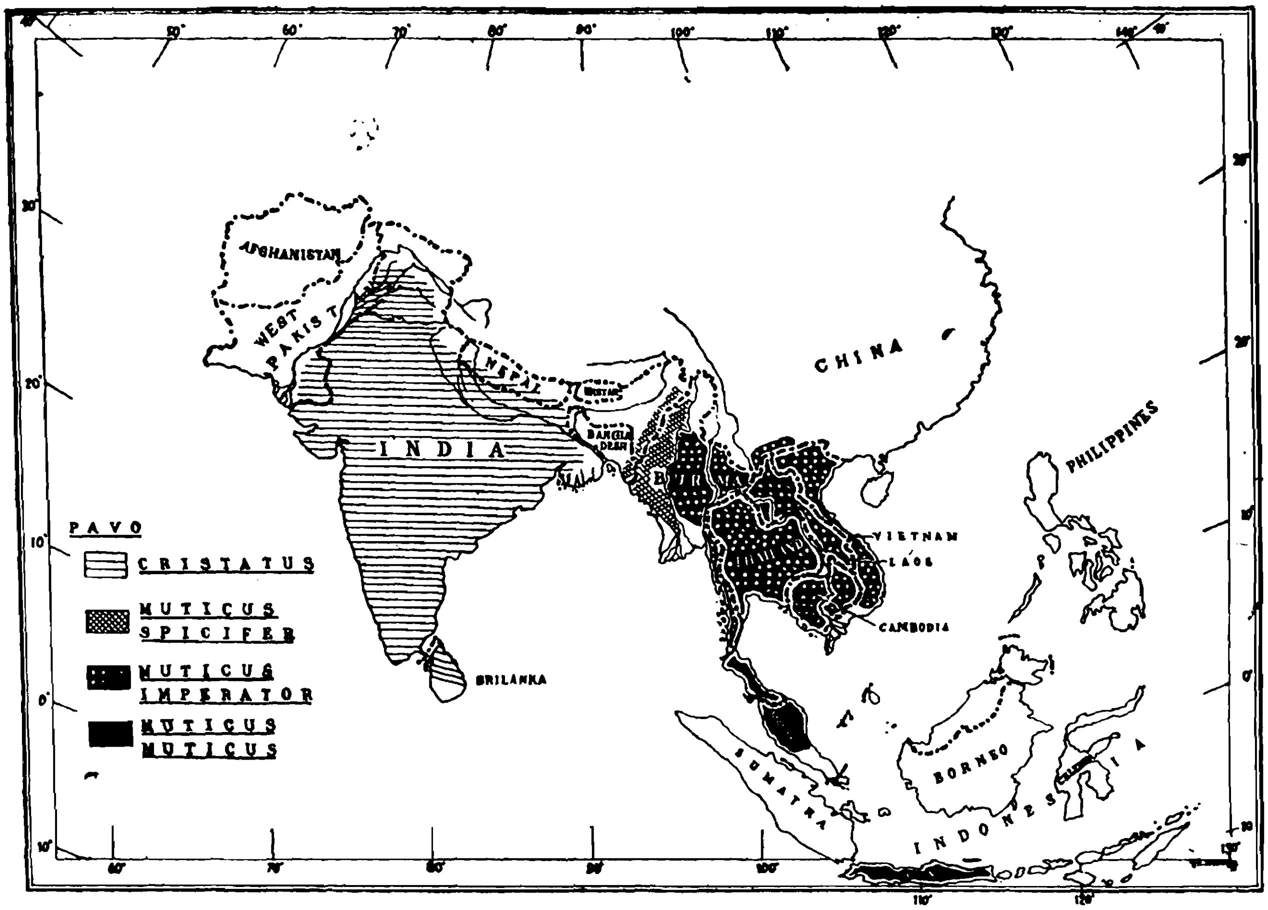

Fig. 2. Distribution of the Peafowls (modified after Delacour, 1951).

Pavo cristatus lives in scrub jungles, sal forests and semi-cultivated fields, while *Pavo muticus* is found in evergreen and moist deciduous forests and long grass. Also, it does not ascend mountain slopes above 1250 meters, although it is numerous just below that altitude (Delacour, 1951).

It is well known that the rise of the Himalaya and Pleistocene glaciation brought remarkable changes in the physiography of India and affected the faunal and floral components of both Palaearctic and Oriental regions. It is easy to conjecture that the open country species, *Pavo cristatus,* might have undergone mutation into *Pavo muticus* in the Indo-Chinese subregion consequent to the development of a thick forest background, since mutations in *Pavo* are well known. According to Delacour (op. cit.) *P. cristatus* has frequent mutations (albinos and black-winged *nigripennis*), and *P. muticus* even speciated to subspecies level. Further, the green mutation in the ancestral *P. cristatus* might have found to be of greater protective value in thick green forest back-ground from the great cats, as the predatory animals like the leopards and tigers are said to be their enemies (Sumati, 1971). It was also possible that *P. muticus* might have lost continuity with the *P. cristatus* populations for considerable period of the geological history.

Among Mallophaga *s.l.*, it is well known that the feather structure on which these avian parasitic forms feed, affect the head structure of the latter (Clay, 1949 and 1951). The colouration in *Pavo* is mainly iridescent and therefore, the structure and arrangement of the barbs and barbules are responsible for the colour. Chandler (1916) attributes the changeable metallic lilacs, fiery reds, blues, greens and purples in Galliformes, to the highly refrangent simple rod like barbules. This author further adds that in the peafowls, the highly iridescent blue, green, and bronze colours are the result of barbules which are totally metamorphosed in both base and pennulum ; the green in the peafowl chiefly produced by barbules which are conspicuously ringed or cross-ringed in both base and pennulum. Sumati (1971) on the other hand, mentions that the barbules in the blue peafowl are twisted at the base so that they lie with their flat faces up and covered by three layers of Keratin (0.4 *u* thick) which like the soap bubble reflects the blue colour due to interferenee of the light ; alternatively, she records that the distribution of highly refractive melanin granules with higher refractive index than Keratin gives the iridescence (possibly by Tyndall effect*). It is assumed that when *P. cristatus* transformed into *P. muticus*, *G. mayuri* populations from the ancestral *P. cristatus* also passed on to the mutating form *P. muticus*, whose feather structure was undergoing certain modifications. The altered feather structure, i.e., the development and rearrangements of barbules (for the colour change from blue to green) might have necessitated the weakly sclerotized head of G. *mayuri* modified into a heavily sclerotized head as in *G. parviceps*, followed by other structural modifications including the asymmetry of the genitalia. Interbreeding between the unmodified *G. mayuri* populations and the incipient species *G. parviceps*, perhaps has been prevented by the male genital asymmetry.

When *P. cristatus* and *P. muticus* populations are re-united due to changed geo-ecological conditions, natural interbreeding might have occurred wherever possible. In this connection, it may be recalled that Delacour (op. cit.) stated that the two species of peafowls freely interbreed and produce fertile offsprings (which also incidentally indicates the chromosomal compatibility and that they are closely related and the hypothesis that *muticus* is possibly a mutant species of *cristatus*). During these chance matings, it was possible for some members of the newly evolved *G-parviceps* gaining access to *P. cristatus* and *G. mayuri* populations also to *P. muticus*, a second or subsequent times. *G. parviceps* could get established easily on *P. cristatus* as it is a stronger form, while *G. mayuri* transferred for the second time could not get established on *P. muticus*, since the feather structure has already undergone radical change, and the feeding on it might have posed a problem to the newly acquired *G. mayuri* populations. The original *mayuri* populations did not face this problem, because they were evolving into *parviceps* synchronously with that of the *muticus* host. Thus, either due to physical handicap or in conjunction with the inter-specific competition with the stronger and more adapted *G. parviceps*, the newer populations of *G. mayuri* could not get established a second or subsequent times on *P. muticus*, and eliminated. The asymmetrical genitalia, coupled with the fine long antennal seta in *G. parviceps* might have helped in recognizing its female and thus interbreeding with *G. mayuri* populations might have been prevented either on *P. cristatus* or *P. muticus* (when *mayuri* populations were transferred in subsequent times) (see also Lakshminarayana, 1977).

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ABNORMAL SWARMING BEHAVIOUR OF THE SEDENTARY POLYCHAETE (*LOIMIA MEDUSA* VAR. *ANNULIFILIS* GRUBE, 1871 : TEREBELLIDAE) OFF WALTAIR COAST

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ABSTRACT

The swarming of terebellid polychate worms (*Loimia medusa* var. *annulifilis* Grube, 1871) on the seasurface observed along the continental shelf off Waltair coast (east coast of India), at about 10 fathom line for a stretch of 5 km. is recorded here as a case of abnormal activity. The worms were of wide range of sizes and had no morphological changes indicative of epitokous condition. Individual worms were surfacing and sinking continuously.

As no previous record of swarming or surfacing of either juveniles or adult terebellid worms is known, it is considered that these worms have reacted to changes in the environmental factors such as anaerobic conditions developing at the sea-bed.

INTRODUCTION

The phenomenon of swarming associated with spawning is common among polychaetes, and has been reported in a number of families. *viz*, Neridae, Syllidae and Eunicidae (Koringa, 1947 ; Clark, 1961 ; 1965 ;). Records of non-spawing swarming migrations are also available in sedentary polychaetes belonging to Scalebregmidae (Fage & Legender, 1925 ; Clark, 1954) and Polyoptholmidae (Fage & Legender, 1925 ; Thampi, 1958). However, swarming in most of the polychaetes have been observed mainly during nights, but rare instances of their spawning during day are also known (Verrill, 1873 ; Herpin, 1928). The occurrence of terebellid polychaetes during the day time, therefore, is considered to be of interest as there are no previous records of their swarming behaviour.

OBSERVATIONS

On the early hours of 8. 7. 1966, during a routine plankton collection trip of Waltair coast along the 10 fathom line, worms of an inch or more in length were found surfacing sporadically all over the sea surface and then sinking. The behaviour of the surfacing worms was noteworthy in the sense that on reaching the surface they spread out their tentacles and drifted for a second or two and then sank. A horizontal five minute haul was taken against the current with a 0.5 m organdie net which yielded about 1978 worms. The worms varied from 0.5 to 3.5 cm in length, majority of them being between 2.5 to 3 cm. At the time of collection it was low tide period and the weather was cloudy. The worms were identified as *Loimia medusa* var. *annulifilis* Grube, 1871. As the research boat was engaged in plankton collection at other stations off the coast, a subsequent plankton collection from this same station could be collected only after a gap of five days. Since no worms were seen surfacing on this day, in addition to the usual five minute horizontal haul, a vertical haul of five minute duration was also taken with the same net in order to verify the presence of these worms, which could collect forty-three worms from the mid-water level.

Information from the fishermen of the coast indicated that this was the first time that they came across this sort of worms surfacing, and added that fishing on this day was far below normal since the worms interfered with their fishing operations by entangling themselves in the nets. Fishing on this day was far below normal. It was further learnt from the fishermen, who were fishing on all these five days duration, that the worms were surfacing only on the first day and subsequently were encountered only at the depths in reduced numbers. These observations indicate that the worms were gradually resettling at the bottom after this unusual phenomenon.

The collected worms were transfered into a glass jar containing surface sea-water from the same station and the behaviour inside the jar was studied at the laboratory. All the worms in the jar swam to the surface by a wriggling movement and with their tentacles widely spread out. After exposing their tentacles for a few seconds on the water surface they sank to the bottom. This behaviour continued for about two hours. Later they began resting at the bottom of the jar for longer periods before they surfaced again. After a period of four hours even this surfacing and wriggling activity of the worms stopped and the worms settled as a heap at the bottom of the jar. Two of the worms started to rebuild their tubes by using the few sand grains that were present at the bottom of the jar by chance. This indicates the possibility of the other worms too to rebuild their tubes in case sand grains were present.

The worms were pink in colour, and through their transparent body wall could be seen the orange coloured alimentary canal and brown coloured associated organs. The coelomic fluid of the thoracic region was spacious and filled with fluid. Waves of peristaltic movement could be seen passing through the body from the anterior to the posterior end. The dorsal blood vessel was also clearly visible. The tentacles had alternately arranged rings of brown and cream colour patterns.

When a well grown animal was pressed under a coverslip, no eggs were extruded from the body as it should if the worms were mature enough to spawn. Microscopic examination of the coelomic fluid of the thoracic region showed the presence of round and irregularly shaped cells, presumably amoebocytes and trophocytes (Leibman, 1946 ; 1947).

DISCUSSION

As known from the earlier reports, swarming of polychaete worms was invariably associated with spawning, although non-spawning swarming migrations are also known. A few phyllodocids have been observed to swarm as a prelude to their return to the bottom for egg-laying in mucous capsules (Gravier, 1896 ; Gravier and Danton, 1928 ; Clark, 1954). The significance of these migrations are not known. Analysing the swarming of polyoptholmids, Thampi (1958) observed that "it is influenced neither by lunar periodicity nor maturity but could be considered as a photopositive reaction although there is no conclusive evidence for this".

There are clear reasons to believe that the swarming behaviour exhibited by the present species could not be attributed to spawning because, (1) the animals were not mature, (2) morphological changes usually associated with maturity of errand polychaetes like enlargement of eyes, modification of setae etc. were not found, (3) specimens of varied sizes were found in the swarm and (4) previous studies from the same area indicate that the terebellids breed between October and April, but the present swarming was observed in July.

The occurrence of varied sizes of worms in the swarm is of particular interest since the observations of earlier workers indicated that the worms of approximately the same size and stage of maturity alone are known in spawning swarm. However, *Perineris cultefera* (Herpin, 1928) and *Neris ra a* (Gravier and Danton, 1928) have been observed, sometimes, to swarm before they are fully epitokous.

An examination of earlier records show that the swarming behaviour of marine organisms occur either during spawning or just before spawning which is associated with the phases of the moon (Koringa, 1947 ; Clark, 1961). In the present instance, although the worms were observed to swarm during the last phase of the moon, it is difficult to associate it with the lunar cycle since the swarm mostly consisted of immature worms. Whether the swarming behaviour could be taken to indicate a pelagic phase in the bottom living sedentary *Loimia medusa*, as it is in *Arinicola marina* (Meek and Storrow, 1924), in Scalebregmidae (Clark, 1954) or in Ophilidae (Thampi, 1958) is difficult to ascertain.

CONCLUSION

Keeping in mind the observations on the behaviour of the captive worms in the laboratory, one could presume that these worms were subjected to some unusual or otherwise unfavourable conditions in their niche, hence were migrating to the surface. Since their swimming power was practically nil, except for the wriggling movement of the body, the worms naturally sank back to the bottom only to reappear again at the surface in order to avoid the unfavourable conditions at the sea-bed. The occurrence of these worms in decreasing numbers on subsequent days also indicates that this unfavourable bottom condition at the sea was diminishing gradually day by day.

Since the hydrological parameters such as temperature, salinity, pH, turbidity and dissolved oxygen content were not taken from the station of observation, it is difficult here to attribute whether any drastic change in any of these parameters could have caused this swarm. But the only possible reason which could have caused this swarming or surface migration is presumably a possible oxygen depletion at the sea-bed, since the exposure of tentacles by these worms above the seasurface at the time of surfacing seems to be suggestive of an attempt for respiration of atmospheric air through their tentacular surface.

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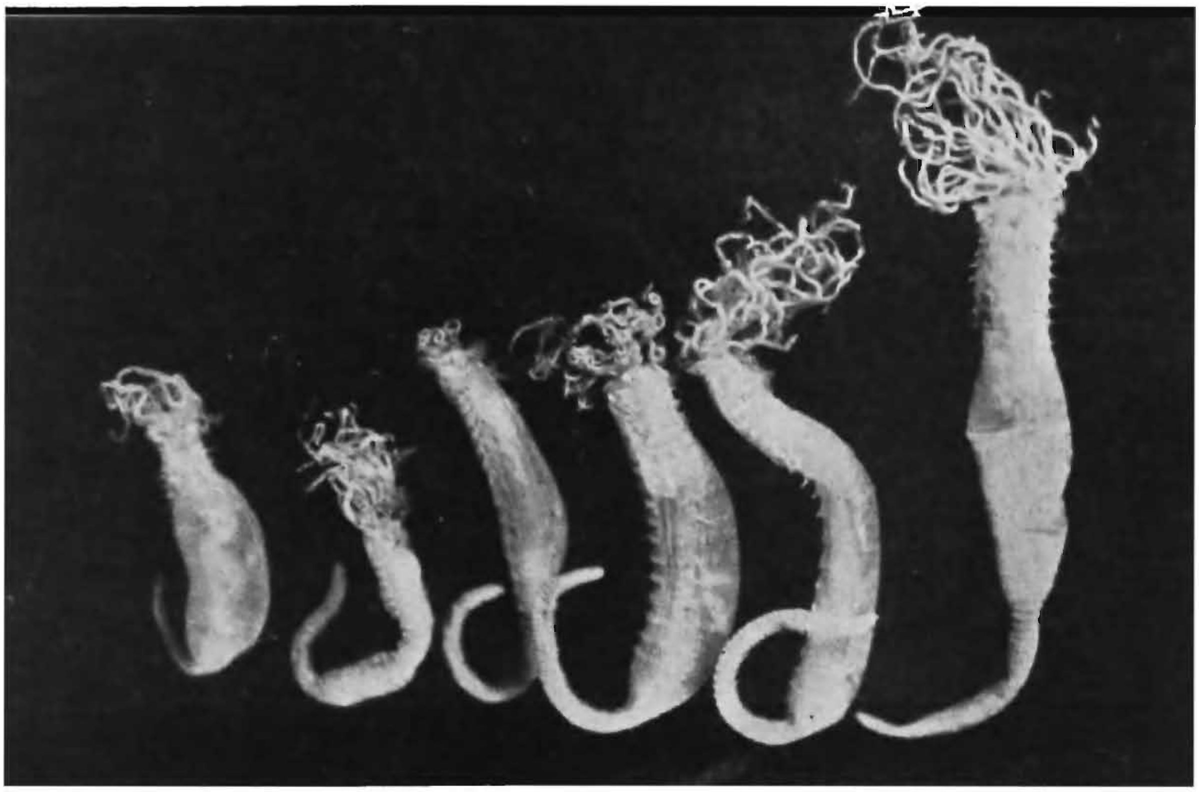

Loimia medusa var. *annulifilis* Grube (1871) : Varied sizes of worms are indicative of non-spawning swarming migration.

Bull. zool. Surv. India, 1 (2) : 161-166, 1978

SEASONAL PERIODICITY OF ZOOPLANKTON IN ENNORE ESTUARY, MADRAS DURING 1975 AND 1976

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ABSTRACT

The fluctuation and abundance of Zooplankton, with special reference to dominant groups like copepods and chaetognaths collected from Ennore estuary during 1975 and 1976 are discussed. Observations on the fluctuation of certain phytoplankton such as *Asterionella* and *Coscinodiscus* that were abundant in the collections are also made.

INTRODUCTION

Ennore estuary is situated at fifteen km. away from Madras city. It is three km. in length, one km. in width and depth varies from 1.5 to 2.5 m. Koratalayar river forms the main channel for this estuary besides the Buckingham canal and Red Hills surplus channel. Prior to dredging by Ennore thermal station, the sand bar at the mouth remained closed at least for six months in a year, and connected with the Bay of Bengal only during the north-east monsoon period (October–December).

The hydrobiology and fisheries of Ennore estuary were studied in detail by several workers (Chacko, 1956, 1963 ; Chacko and Rajagopal, 1962 ; Evangeline and Subbiah, 1969). All these investigations were carried out prior to dredging when the bar mouth of the estuary remained open only during the north-east monsoon period. Whereas, the present investigations were carried out after the dredging has been completed and the estuary became connected to the sea throughout the year. These investigations were undertaken with a view to find out the impact of dredging on the hydrology and plankton of the Ennore estuary.

MATERIAL AND METHODS

The material for this investigation was obtained from 50 zooplankton samples collected between May 1975 and September 1976 from two fixed stations (Fig. 1) one near the bar mouth and the other about 1 km. away from the bar mouth. Due to unavoidable circumstances samples could not be collected during January and February 1976. Zooplankton and water samples were collected from these two stations twice in a month. A half m. nylon ring net was used for collecting the zooplankton. The net was towed at the surface for ten minutes from a country boat between 7 and 8 AM.

The plankton samples were fixed in 5% formalin and the volume was determined

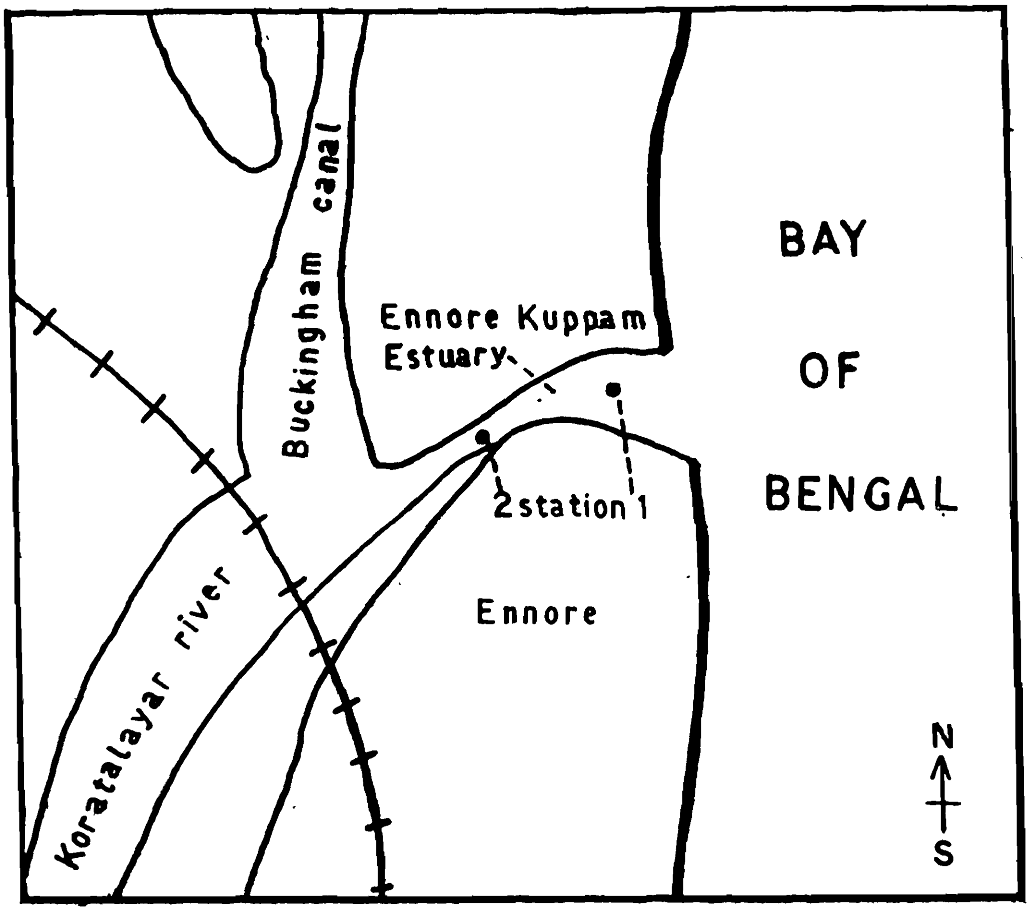

Fig. 1. Map of Ennore estuary showing the station position

by the displacement method. Then the plankton was diluted to 250 ml. from which (after stirring well) a subsample of 2 ml. was examined in a Sedgewick-rafter cell, for the enumeration of different organisms. For macroplankton like Chaetognatha, the entire volume of the plankton was analysed and the number was counted. Water samples collected from the two stations, where the plankton samples were also collected, were analysed for salinity and temperature.

HYDROLOGICAL CONDITIONS

The surface water temperature of the estuary ranged from 26° 4′ C to 32° 3′ C, with a minimum during December, 1975 and maximum during May, 1976. The occurrence of minimum and maximum temperature values coincides with the seasonal changes such as monsoon and summer.

The salinity ranged during the period of observations from 2‰ to 35‰. Wide fluctuations in surface salinity values were noted during October–December, 1975 when the estuary is flooded with rain water. During the rest of the period the salinity values were in the range of 24.5‰ to 33.5‰.

PLANKTON

The volume of the zooplankton varies from 0.4 to 3.6 ml. Three peaks were noted during the period of investigation, one in may 1975, second in November 1975 and the third in June

1976 (Fig. 2). The values were very low during September 1975 and May 1976.

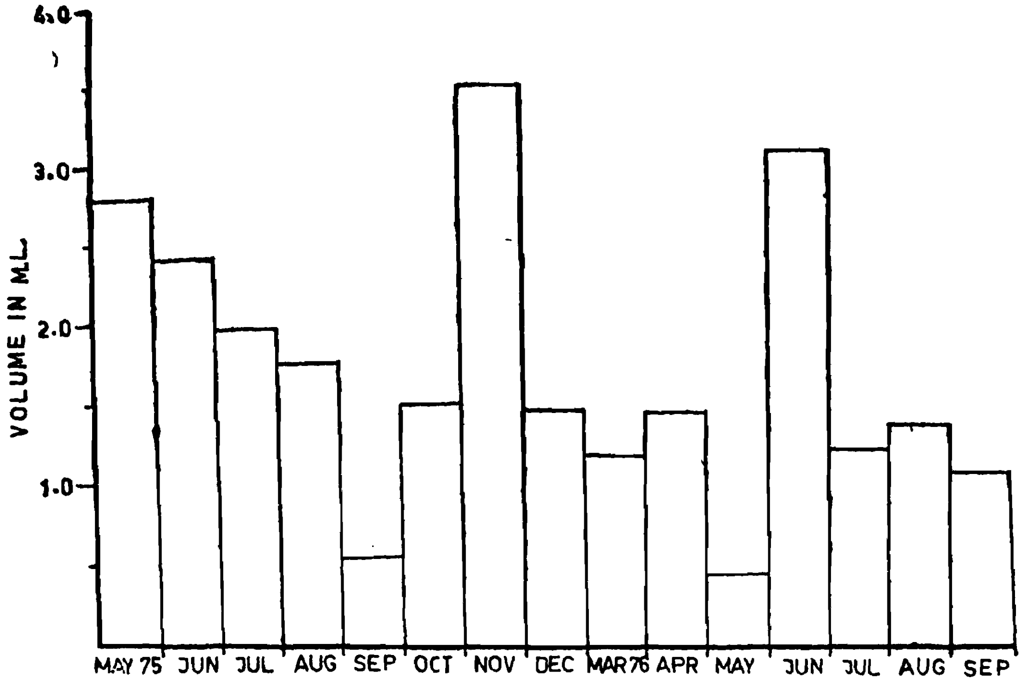

Fig. 2. Fluctuation of Zooplankton in Ennore estuary from May 1975 to September 1976.

The volume of zooplankton was mainly controlled by the larval forms of copepodss uch as nauplii, zoea and copepodites (Fig. 3). Adult copepods were very few and even among the adults only calanoids were the dominant forms. The other forms like medusae, polychaete larvae, *Lucifer*, Chaetognatha, *Oikopleura*, *Penilia*, Cypris larvae, *Tomopteris*, bivalve larvae, fish eggs, fish larvae, ostracods and nematodes were also noticed.

Chaetognatha were seen in all the plankton samples collected during the period of investigation except in may, 1976. Altogether 1800 specimens of chaetognaths belonging to *Sagitta bedoti* Beraneck, *Sagitta inflata* Grassi and *Sagitta pulchra* Doncaster were present. Maximum number of specimens were obtained during August 1976 (Fig. 4). *Sagitta inflata* forms more than 55% of the chaetognaths followed by *S. bedoti* (44%). The chaetognath population based on the present investigation does not show any definite pattern of fluctuation in abundance, as seen in Fig. 4 there are several peaks and downs.

Along with the zooplankton certain important diatoms like *Coscinodiscus* and *Asterionella* were also seen in large numbers in the samples collected from the estuary. They also have been studied for their seasonal fluctuation in abundance. Both these have shown two peaks, (Fig. 5) one during the north-east monsoon (November-December 1975) and the other during south-west monsoon (June-July, 1976). During these months the plankton samples were fully dominated only with phytoplankton especially these diatoms.

DISCUSSION

The present study revealed wide variations

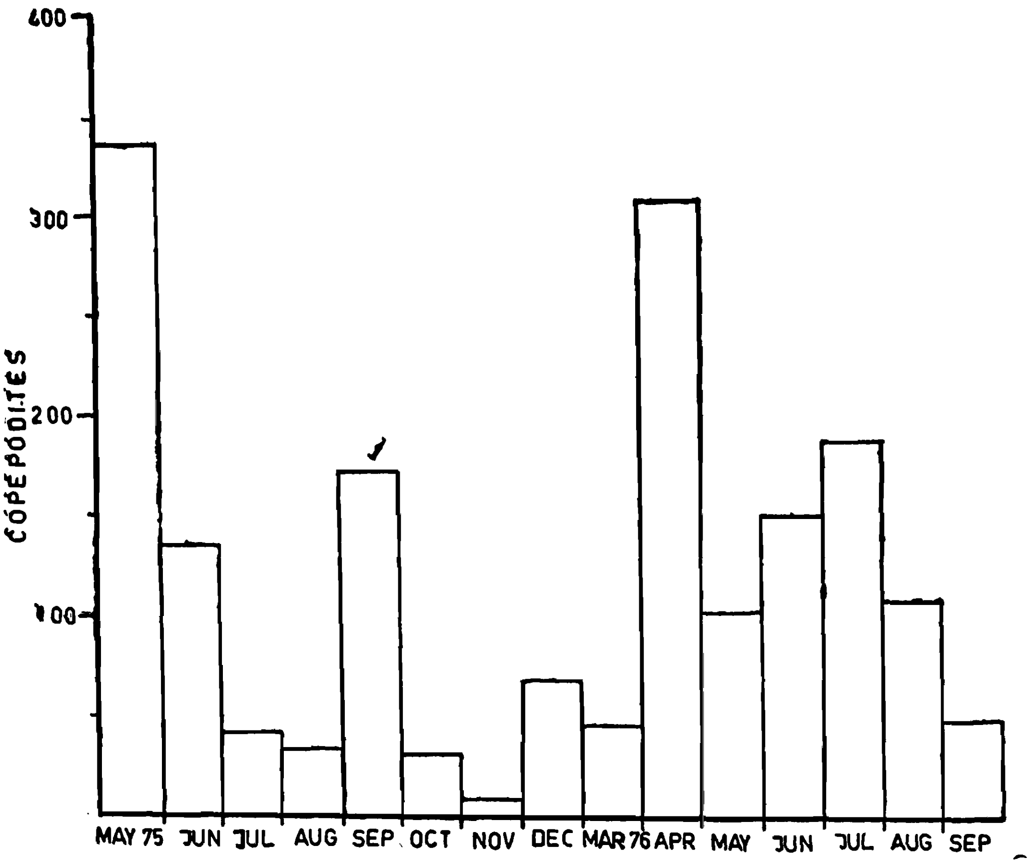

Fig. 3. Fluctuation of Copepodites in Ennore estuary from May 1975 to September 1976.

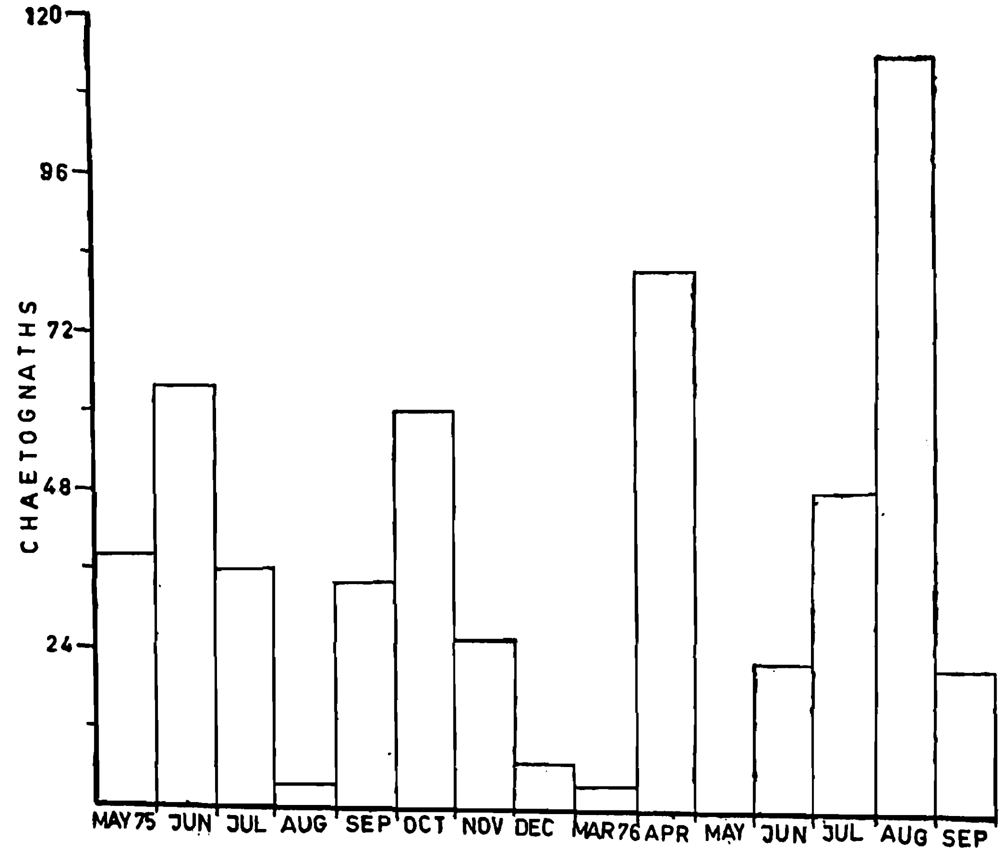

Fig. 4. Fluctuation of Chaetognaths in Ennore estuary from May 1975 to September 1976.

in hydrological factors and zooplankton. The occurrence of the temperature minimum and maximum coincides with the seasonal changes in this area. But the salinity gradient depends upon the relative balance of factors like run off waters from the land, rainfall, evaporation and wind action. Here wide fluctuation in surface salinity was noticed during October-December, due to monsoon effect. Prior to dredging, the maximum salinity values were even 46.7‰ (Chacko and Rajagopal, 1962). Then evaporation was playing a prominent role in controlling the salinity variations. After dredging, since the estuary is kept open regularly, the high salinity values were uncommon. In nearby Pulicat lake, salinity values reach upto 57‰ (50.5‰ average) in premonsoon months because of evaporation (Menon and Raman, 1977). Based on salinity values, this estuary is mixohaline in nature as the other estuaries nearby like Cooum estuary, Adayar estuary and Kovelong estuary.

Among the phytoplankton, the following diatoms namely *Coscinodiscus* and *Asterionella* were dominant. The two peaks noted during this investigation coincide with the north-east monsoon and south-west monsoon (Fig. 5). This may be due to the run off from the land which resulted in addition of nutrients to the estuary.

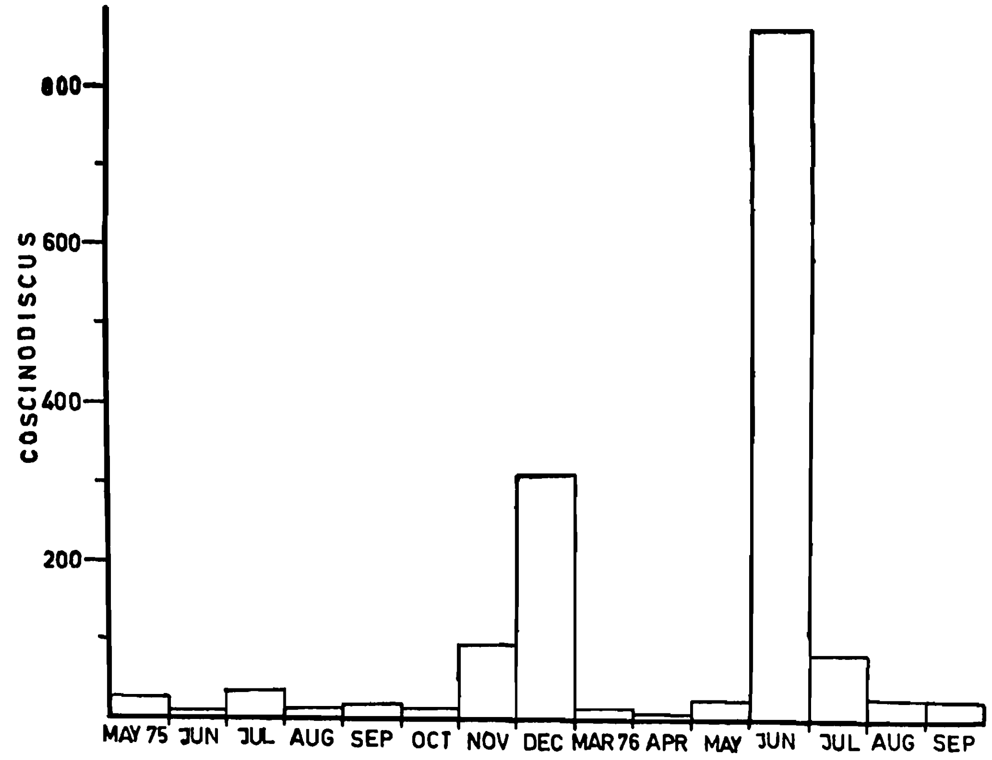

Fig. 5. Fluctuation of *Coscinodiscus* in Ennore estuary from May 1975 to September 1976.

The zooplankton volume also indicate more or less the same situation. The phytoplankton peak is followed by zooplankton maxima (Fig. 2). Here calanoid copepods outnumber the other adult plankton forms as stated by Davis (1950) planktonic copepods, especially calanoids live and often are dominant both in freshwaters and in the sea. As in other estuarine specimens of Chaetognatha, (Srinivasan, 1972, 1977) here also the specimens are smaller in size because they are living in a habitat where there is a wide fluctuation in salinity.

Considering the quality of plankton, prior to dredging the variety of plankton were more. During 1960-61, the diatoms *Coscinodiscus* and *Rhizosolenia* were common throughout the year. Among the zooplankton, copepods and nauplii were common. Prawn larvae and fish eggs were noted from June to November, (Chacko and Rajagopal, 1962). During 1965-1967 *Noctiluca*, *Foraminifera*, *Ceratium*, ctenophores, *Lucifer*, *Sagitta* and *Oikopleura* were recorded. Larval crustaceans, copepods, fish eggs and larvae were common throughout the year. Occasionally swarming of rotifers and mysids were noticed, (Evangeline and Subbiah, 1969). But during the recent investigations larval crustaceans, copepods, *Coscinodiscus* and *Asterionella* were the common forms. Besides bivalve larvae and polychaete larvae appeared during March-July. *Lucifer* and medusae were also recorded during the same period. During July, benthic forms like polychaetes, nematodes and ostracods were noted, perhaps because of turbulance. Pontellid nauplii appeared during August-September.

Prior to dredging, the closed and undisturbed estuary formed a safe nursing ground for fishes and other organisms. Hence the landings were found to be good. Particularly during May-June (Evangeline and Subbiah, 1969) mullet and prawn fishery were good. Since the estuary is kept open by mechanical means the silt generated in the process has adversely affected the fishery and the habitat has become less favourable for fish and other organisms and the fish landings have been considerably reduced.

As this conclusion is based on a short period of investigation, a detailed study based on several features such as transparency, conductivity, pH, salinity, dissolved oxygen, benthic fauna and fish landings is currently undertaken to have a better understanding about the ecology of Ennore ecosystem.

ACKNOWLEDGEMENTS

Our sincere thanks are due to the Director, Zoological Survey of India, Calcutta and to Dr. A. G. K. Menon, Deputy Director, Southern Regional Station, Madras for the keen interest and encouragement shown during the period of investigation.

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DESCRIPTION OF *HAEMATOPINUS OLIVERI* SP. NOV. (ANOPLURA : HAEMATOPINIDAE) PARASITIZING *SUS SALVANIUS* IN INDIA

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ABSTRACT

A new species of sucking lice, *Haematopinus oliveri* sp. nov. has been illustrated and described from *Sus* (*Porcula*) *salvanius*, a rare species of swine, from N. W. Assam in India.

Six species of sucking lice, all belonging to *genus Haematopinus*, are known to parasitize members of the family Suidae (Artiodactyla). Of these *H. meinertzhageni* Werneck ex. *Hylochoerus meinertzhageni*, *H. phacocoeri* Enderlein ex. *Phacochoerus aethiopicus* (Pallas), *H. latus* Newman ex. *Potamochoerus porcus* (Linnaeus) are known from Ethiopian Region ; *H. suis* (Linnaeus) parasitizing wild boars in the Oriental Region and domestic pigs from all over the world, *H. apri* Gour parasitizing wild boars of Europe, *Sus scrofa* in the Palearctic Region ; and *H. ludwigi* Weisser parasitizing *Sus verrucossus* is from Philippine Islands (Stimie and Merwe, 1967 ; Weisser, 1974).

A new species of lice parasitizing *Sus* (*Porcula*) *salvanius* is being described in this paper. The species is named after Mr. William L. R. Oliver, Jersy Wildlife Preservation Trust, U. K. in grateful appreciation of his courtesy to supply the valuable specimens, collected by him, for this study. Morphological terminology of Weisser and Kim (1972) is followed in this paper.

Haematopinus oliveri sp. nov.

(Figs. 1-3)

Female (Fig. 1) : General body colouration is paler. Total body length 4.1 mm. (X, N=3) ; range 3.9 to 4.2 mm.

Head (Fig. 2) : Slightly longer than wide, with distinct ocular points ; head index (head length : head width x 10) X=16.1. Arrangement of setae typical haematopinoid type, as shown in figure ; clypeus, ocular sinuses and occipital regions well sclerotized. Antennae 5 segmented, sensoria separate, situated on the distal end of segment 4 & 5.

Thorax : Dorsum with distinct notal pit and one large dorsolateral well-chitinized projections of metanotum, metathoracic pleural phragma, on each side ; each half with prethoracic seta anteriorly, 1 mesothoracic seta next to spiracle, and 2 metathoracic setae near metathoracic pleural phragma Venter. with a well developed distinct thoracic sternal plate. Sternal plate 0.49 mm. long 0.36 mm. wide ; anterolateral projections triangular, enclosing the pits of prothoracic pleural apophyses, laterally with a median triangular protuberance.

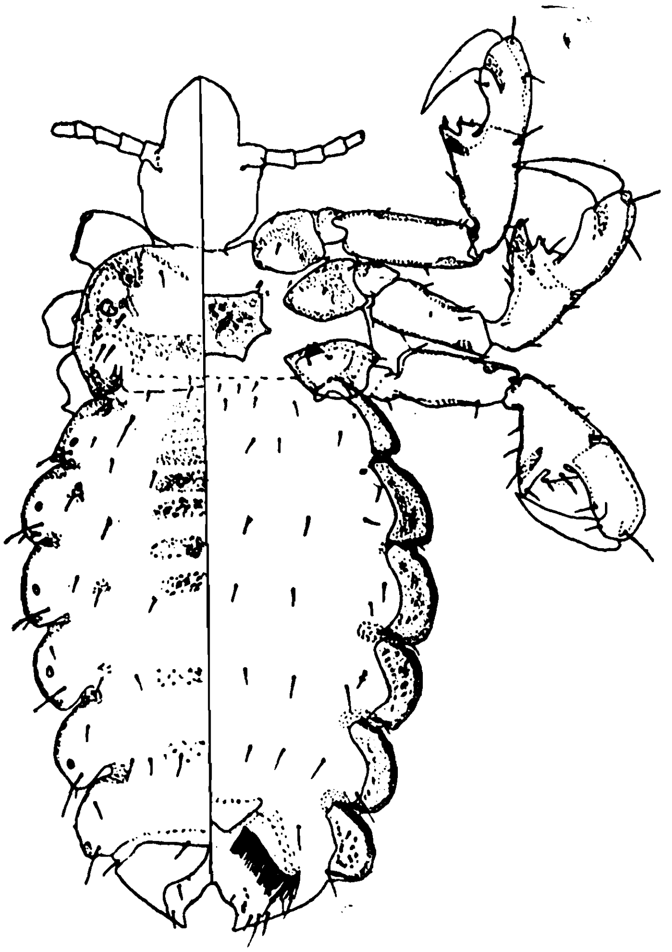

Fig. 1. *Haematopinus oliveri* sp. nov. Female, dorsal and ventral views (Setae on head and antennae omitted.

Legs : Typically haematopinoid type ; all the legs almost similar in size, tibiotarsi and claws comparatively large.

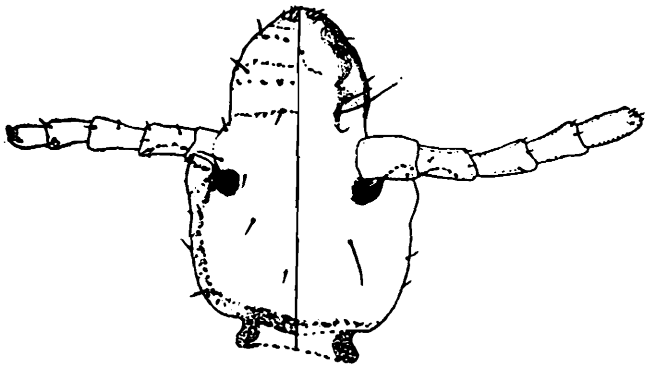

Fig. 2. *Haematopinus oliveri* sp. nov. Head, dorsal and ventral views,

Abdomen : Obovate, Tergites and sternites absent except some lightly pigmented patches dorsally and clasp-like deeply pigmented tergite of terminal segment, medially connected through weak sclerotized bridge. Chaetotaxy as shown in fig. 1. Paratergites large, well defined, present on segments III to VIII. Lateral margin deeply lobed, with the deepest incision between segments VI-VII and VII-VIII. Spiracles present on segments III to VIII.

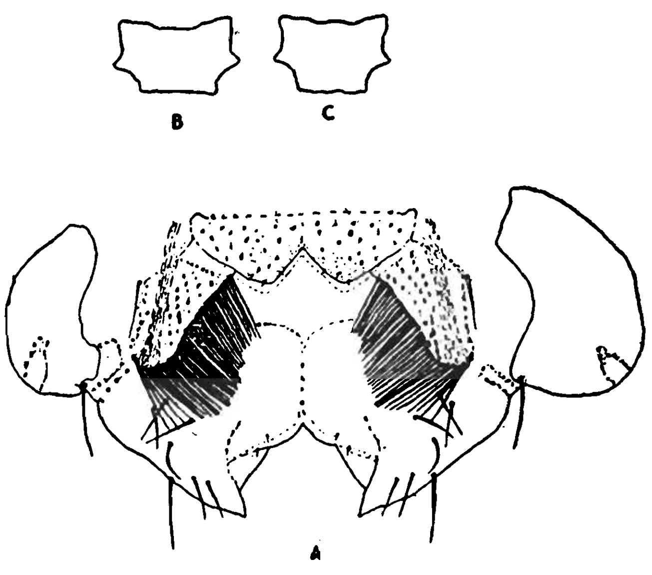

Fig. 3. *Haematopinus oliveri* sp. nov. A. Terminal abdominal segments ♀ B. C. Paratergites ♀

Genitalia (Fig. 3) : Gonopophyses (Gonopods) elongated, lobe-like , inner margin slightly divergent with almost rounded apex, fringed with numerous long setae. Each gonopophyses with a well developed, strongly chitinized apodeme, close to outolateral margin. Vulva possess the paired and serrated median lobes having several minute setae.

Male : Unknown.

Nymph 1-2 : Unknown.

Nymph 3 : Total body length 2-7 mm. (N=1). Similar to female, except for the thoracic sternal plate, genital sternites and tergite of terminal segment.

Diagnosis : *Haematopinus oliveri* sp. nov. closely resembles *H. ludwigi* Weisser but can be easily separated due to the complete absence of paratergite II, and by the shape of thoracic sternal plate. It resembles the Ethopian species (*H. latus. H. phacochoeri, H. meinertzhageni*) due to the relatively short head but easily separable in the absence of paratergite II and the semilunar tergites of the abdomen. In the absence of paratergite II and shape of thoracic sternal plate it approaches the Palaearctic and Oriental species *H. suis* and *H. apri* also but falls well apart due to relatively short head. Thus, species on the basis of external morphology is an intermediate taxon between *H. suis* and *H. apri* on one side and remaining species parasitizing suidae on other side.

Type-data : Holotype ♀, paratypes 2 ♀ and one associated 3rd nymphal instar, *ex.* Pigmy-hog, *Sus* (*Porcula*) *salvanius* Hodgson, Dorrang, N. W. Assam, India, V. 1977, Coll. William L. R. Oliver. All the specimens are deposited in the National Zoological Collection of Zoological Survey of India, Calcutta, (Reg. No. 378-381/H16).

Host-distribution : *Sus salvanius* is having a restricted distribution in the Terai region of Nepal, Bhutan, Sikkim and N. W. Part of Assam in India.

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A PARTHENOPID CRAB, *ZEBRIDA ADAMSII* WHITE, 1847 INHABITING INTERSPACES OF SPINES OF THE SEA URCHIN, *SALMACIS VIRGULATA* L. AGASSIZ, 1846

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ABSTRACT

Association of a parthenopid crab, *Zebria adamsii* White with the echinoid *Salmacis virgulata* L. Agassiz, ezisting at 18-20 metres depth along the Madras sea coast is reported. Systematics and distribution of the echinoid hosts and its crustacean associates are noted. *Z. adamssi* is recorded for the first time from the Bay of Bengal. Field and laboratory observations revealed that the movements of tha crab in between the spines of the echinoid host cause minor damages to the spines at base.

INTRODUCTION

Whilst collecting marine fauna in the inshore regions of the Madras coast, on board R. V. Chota Investigator during December 1975 to August 1977, an interesting relationship between the parthenopid crab, *Zebrida adamsii* and host sea urchin, *Salmacis virgulata* was observed. The details of this association together with some experimental laboratory observations on the associates, and previous records of this species of crab from sea urchins are presented in this paper.

MATERIAL

Salmacis virgulata were obtained by operating the bottom trawl net opposite to the Madras University area, where this species of sea urchin occurred in abundance. The host species were examined for the presence of the parthenopid crabs, *Z. adamsii* both in the field and in the laboratory. In the same trawling ground two other species of sea urchins i. e., *Salmacis bicolor* L. Agassiz 1846 and *Temnopleurus toreumaticus* Leske, 1778 also occurred rarely.

OBSERVATIONS

Field observations : Examination of 1171 specimens of the sea urchin, *S. virgulata* during the period December, 1975 to August, 1977 (Table 1) yielded five males and two females of the parthenopid crab, *Z. adamsii.* Among the two females, only one, examined in October, 1976 was found to be ovigerous. It was also noted that the two other species of the sea urchins namely, S. *bicolor* and *T toreumaticus* which were not common in the sea area sampled (9 specimens of the former and 6 specimens of the latter were collected during the entire period of 21 months) did not harbour any specimen of *Z. adamsii.*

TABLE 1. Months of collection with number of host urchins examined and details of the crustacean associate

S. No.	Year & month	No. of Host (*S. virgulata*) examined	No. of crabs (*Z. adamsii*) observed	Sex of the crustacean associate	Width of the carapace (in mm.)
1.	December, 1975	25	1	♂	8.5
2.	January, 1976	58	—	—	—
3.	February	42	—	—	—
4.	March	120	—	—	—
5.	April	220	2	♂ ♂	7.0
6.	May	85	—	—	—
7.	June	62	—	—	—
8.	July	93	2	♂ & ♀	4.0 & 7.0
9.	August	108	—	—	—
10.	September	76	—	—	—
10.	October	31	1	♀ (ovigerous)	11.0
12.	November	18	—	—	—
13.	December	28	—	—	—
14.	January, 1977	—	—	—	—
15.	February	34	—	—	—
16.	March	47	1	♂	6.0
17.	April	—	—	—	—
18.	May	—	—	—	—
19.	June	—	—	—	—
20.	July	—	—	—	—
21.	August	124	—	—	—
	Total	1171	7		

The presence of *Z. adamsii* on the test of *S. virgulata* was mainly towards the oral end. In one association, a visible damage could be observed on the spines of the host, suggesting that the crab which had settled on the test a few weeks earlier had cut the base of the spines (Plate IV-a).

Laboratory experiments : Two sets of animal associations obtained in July 1976 and March, 1977 were kept in separate aquarium tanks containing running sea water in the laboratory. At the bottom of the tank some sand and pieces of shells and rocks were arranged to simulate the conditions of the inshore region. The crab was carefully dislodged and released in the same container. Within one hour the crab had resettled in the same spot from which it was dislodged. It was also noted that no damage to the spines of the host occurred during the two weeks of laboratory rearing of the associates in the tanks.

Systematic note and distribution of the crustacean associate :

A review of literature of the crabs of the genus *Zebrida* of Indo-west Pacific region reveals that there were two species, i. e., *Z. adamsii* White, 1847 and *Z. paucidentata* Flipse, 1930 (Serene, 1968). However, Suzuki and Takeda (1974) have questioned the validity of the species *Z. paucidentata*. From their point of view, it could be that *Z. paucidentata* which as recorded by Rauthbun (1910) could be juvenile form of *Z. adamsii*, and as such *Z. paucidentata* is to be considered as a synonym of *Z. adamsii*. The genus *Zebrida* is, therefore, a monotypical genus represented by *Z. adamsii*.

This Crustacean species is distinguished by the delicate madder pink of the body with darker (liver coloured) parallel longitudinal bands and alternating streaks on the carapace (Plate IV-b). The carapace is subrhomboidal with the flattened dorsum, the rostrum being formed by two large laminar teeth. The orbit is circular with the inner canthus filled by part of the antennal peduncle. The antennule is folded very obliquely. The chelipeds are stout, equal and short, being armed with laminar teeth. The ambulatory legs are strongly compressed and subchelate with the propodi and dactili. The male abdomen is composed of seven segments. The first male pleopod is shaped like the interrogation mark (Plate IV-c). The colour pattern and frontal and laminar teeth, and the first male pleopod are characteristic of this species.

Z. adamsii has so far been recorded from Japan, Borneo, Gulf of Siam, Torres Strait, Sri Lanka, Gulf of Mannar and coast of Travancore. Its recorded bathymetric range is from 10 to 55 metres (Suzuki and Takeda, 1974).

Systematic note and distribution of the echinoid host :

Of the two species of *Salmacis* i. e., *S. virgulata* and *S. bicolor* the former can be identified externally by their purple colour of the primary spines and the high test. Each ambulacral plate bears primary tubercle. The interambulacral plates are separated by distinct sutures. In *S. bicolor*, the primary spines are more or less bright red, with 4–7 narrow yellowish bands. The small spines are red. The primary tubercles occur on every second ambularcal plate. *T. tarumaticus* can be identified by their larger spines (compared to the diameter of the test), which are brown in colour with light to deep irregular bands. The coronal plate bears 1 to 3 primary tubercles.

S. virgulata has so far been recorded from the following shallow-water areas of the Indo-west Pacific regions : Ceylon area, Bay of Bengal, East Indies, Phillippine Island, China and Southern Japan (Clarke and Rowe, 1971).

S. bicolor has so far been recorded from the following shallow-water areas of the Indo-west Pacific regions : Isles of West Indian Ocean, Mascarene Island, East Africa and Madagascar, Red Sea, West India and Pakistan, Maldive area, Ceylon area, Bay of Bengal, East Indies, Phillippine Island, China and Southern Japan. *T. toreumaticus* has so far been recorded from the following shallow-water areas of the Indo-west Pacific regions ; East Africa and Madagascar, Red Sea, South East Arabia, Persian Gulf, West India and Pakistan, Maldive area, Ceylon area, Bay of Bengal, East Indies, North Australia, Phillippine Island, China and Southern Japan and South Pacific Island. (Clarke and Rowe 1971).

Present records :

The parthenopid crab, *Z. adamsii* is recorded for the first time from the Bay of Bengal. No record has been made of this crab in association with sea urchin from the Bay of Bengal. In the present study the animal associates (crab and echinoid) have been collected from 18-20 metres.

REMARKS

The occurrence of the parthenopid crab, *Z. adamsii* has been recorded earlier on other species of sea urchins like *Toxopneustes pileosus* and *Salmacis bicolor* Rathbun (1910), *Anthocidaris crassipina* (Urita, 1926), *Acanthocidaris* sp. (Blass, 1956), *Asthenosoma ijimai* (Doki. 1972), *Tripneustes gratilla* (Yamamoto, 1973, and Suzuki and Takeda, 1974). Yamamoto (1973) observed that *Z. adamsii* changed the host from *T. gratilla* to *Diadema setosum* in the aquarium. This view has been contradicted by Suzuki and Takeda (1974). In our observations on *S. virgulata* and the associate in the aquarium tank for more than two weeks, changing from one host to another, even among the same species was not observed.

Mortenson (1904) considered *Z. adamsii* causing damage to the tube feet of the host echinoid, as due to parasitism. Suzuki and Takeda (1974) decidedly concluded that this crab which is not a commensal of sea urchins was without doubt a parasitic species inflicting minor damages to the hosts. From our present observations it is concluded that the spines of the sea urchins get weakened due to the movement of the crab resulting in the minor damages to the spines at base. It is highly desirable to make further studies on the exact role played by *Z. adamsii* White in causing damages to the spines and tube feet of the sea urchins so as to elucidate the true relationship of the associates. Further the life-history of this crab has to be worked out in detail since this is not known. These two investigations are now in progress at this laboratory.

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The authors are grateful to Dr. T. N. Ananthakrishnan, Director, Zoological Survey of India, Calcutta for encouragement facilities given to undertake this work and for helpful suggestions in the preparation of this paper. One of us (S. Krishnan) is thankful to the CSIR, New Delhi for the award of the Pool Placement to work in the Marine Biological Station of the Zoological Survey of India, Madras.

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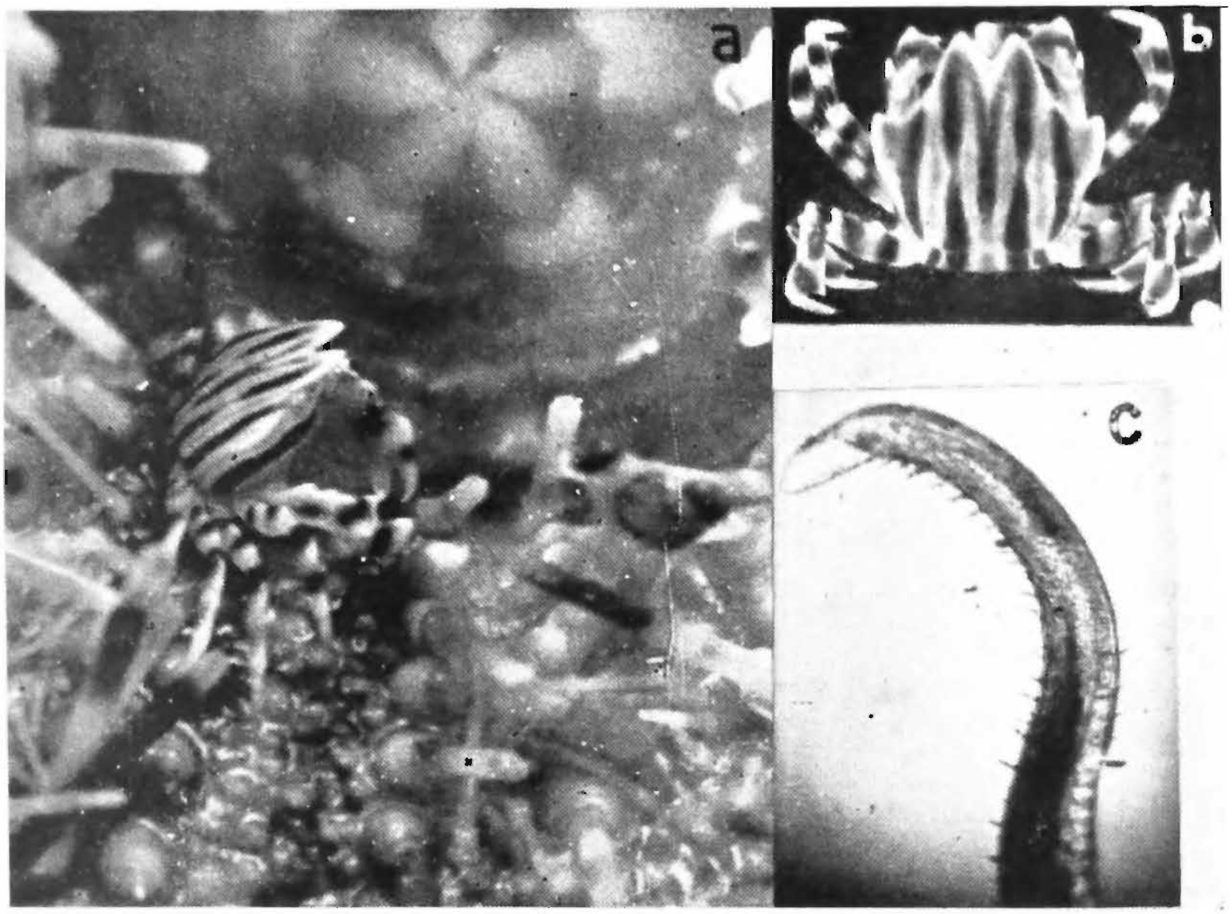

a—*Zebrida adamsii* on the host sea urchin, *Salmacis virgulata* oral side, showing the damage to the bases of the spines.
b—*Zebrida adamsii* dorsal view of female.
c—First male pleopod, abdominal view.

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A NEW CYMOTHOID OF THE GENUS *NEROCILA* FROM MADRAS

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and

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ABSTRACT

A new species of cymothoid Isopod, *Nerocila madrasensist* parasitic on gills of the fish *Hemiramphus* sp. collected from Madras sea shore waters, is described. A key to the Indian species of the genus *Nerocila* Leach is provided.

Introduction

While determining some marine Isopods pertaining to the genera *Livoneca, Irona* and *Nerocila* received from S. G. S. Arts College, Tirupati, the authors came across interesting material of the genus *Nerocila*. The species described here as new is based on the material collected by the junior author from Madras sea shore waters. All the material referred to above including those pertaining to *Nerocila* were collected from their parasitic 'lodges' in the gills of the fish, *Hemiramphus* sp. This Isopod crop seems to present its parasitic bloom on the host gills in the months of September to November.

The genus *Nerocila* Leach, 1818 is so far, known by the following species from the Indian region *viz.* :

1. *Nerocila sundaica* Bleeker
   Recorded off Godavari (Sacraments mouth) Andhra Pradesh and Ganjam coast (Orissa).

2. *Nerocila serra* Sch. & Mein.
   Reported off Devi river. Orissa coast-clining to the abdomen of *Arius sagor* (Hamilton). Vizagapatam coast-attached to throat of the sea-snake, *Hydrophis obscurus* Daud. and Ganjam coast (Orissa).

3. *Nerocila phaeopleura* Bleeker
   Bay of Bengal-found ecto-parasitic on *Histiophorus gladius.*

The authors are grateful to Director, Zoological Survey of India and Prof. V. Chandrasekharam, Head of the Department of Zoology. S. G. S. Arts College, Tirupati for the opportunity afforded to them in studying the material. The illustrations used in this paper are prepared by Shri A. K. Sardar, Artist, Z. S. I. to whom the authors thanks are due.

SYSTEMATIC ACCOUNT

Order	ISOPODA
Tribe	FLABELLIFERA
Family	CYMOTHOIDAE
Genus	**Nerocila Leach**

Nerocila madrasensis sp. nov.

(Figs. 1-3)

Description : Body oblong oval (Figs. 1 & 2) little less than half as long as wide. Surface glabous with reticulate network. Cephalon large, sub-quadrate, much wider than medianally long, with anterior margin straight, and both corners of the front rounded. The posterior margins produced into three lobes, all equal in size. Eyes quite large, oval in shape and situated in postero-lateral angles of head. First pair of antennae (Fig. 3C) stout and composed of eight articles and extend upto beginning of first thoracic somite. Second pair of antennae composed of ten articles extending upto middle of the first thoracic segment the last four articles being slender and gradually diminishing in size. Maxilliped (Fig. 3B) with a palp of two articles.

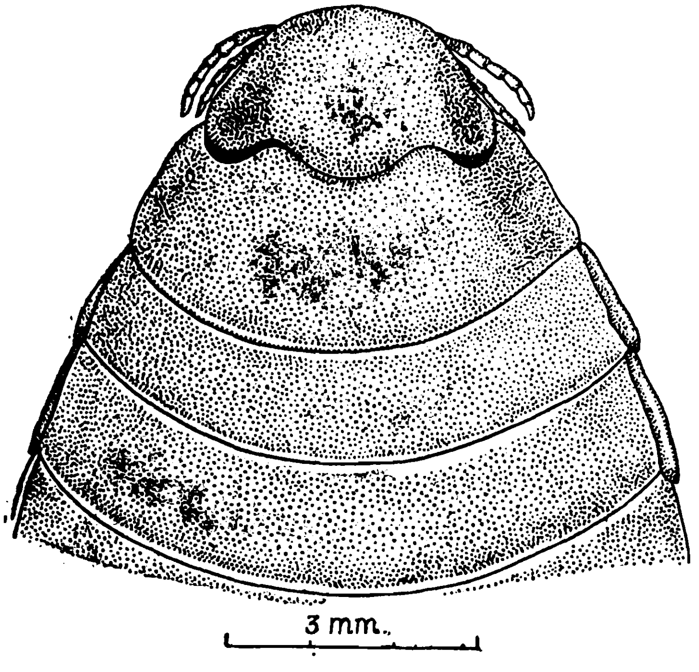

Fig. 1. *Nerocila madrasensis* sp. nov. Dorsal view of the cephalon and first few segments of thorax,

Thorax broadest at 6th segment diminishing in size at either ends gradually. First and sixth segments longer than others. post-lateral angles of last two segments acutely produced and extend beyond epimera. Epimera distinct on all segments with exception of first, first four small with their posterior margins rounded, last three acutely produced, the epimera extending beyond posterior margins of segments.

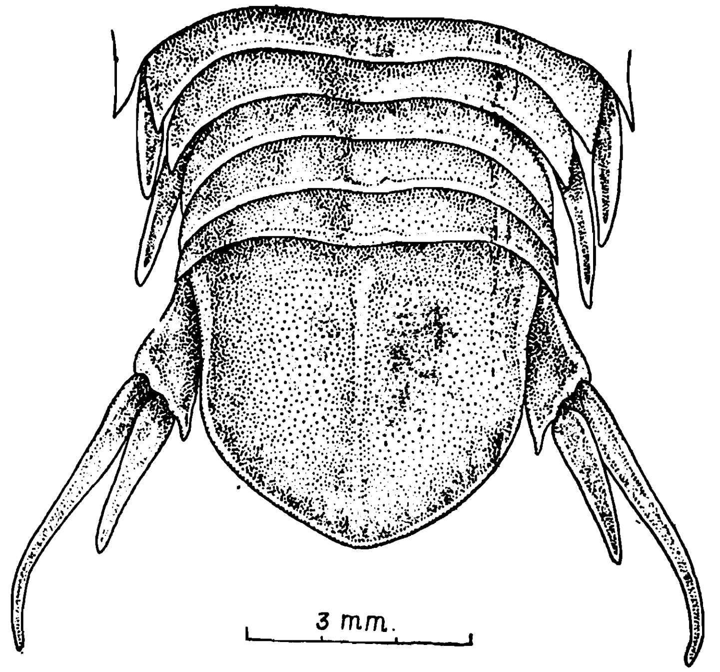

Fig. 2. *Nerocila madrasensis* sp. nov. Dorsal view of pleon and the uropoda

All segments of abdomen (Fig. 2) distinct. Sixth or the terminal segment broadly rounded posteriorly. Uropod (Fig. 3D.) lanceolate, inner branch broader at proximal and broadly pointed at distal ends. Outer branch twice as long as inner ramus, slightly narrower and produced to close extremities, outer branch also somewhat narrower at base compared with inner one.

Type specimens : *Holotype* : ♀, Madras (Tamil Nadu) Collector : *P. Venkata Ramaniah*, Reg. No. C. 1680/2

Paratypes : 2 ♀ ♀, with the same data as for the holotype, Reg. No. C. 1681/2.

All the specimens (females only) are incorporated in the National Collections of the Zoological Survey of India, Calcutta.

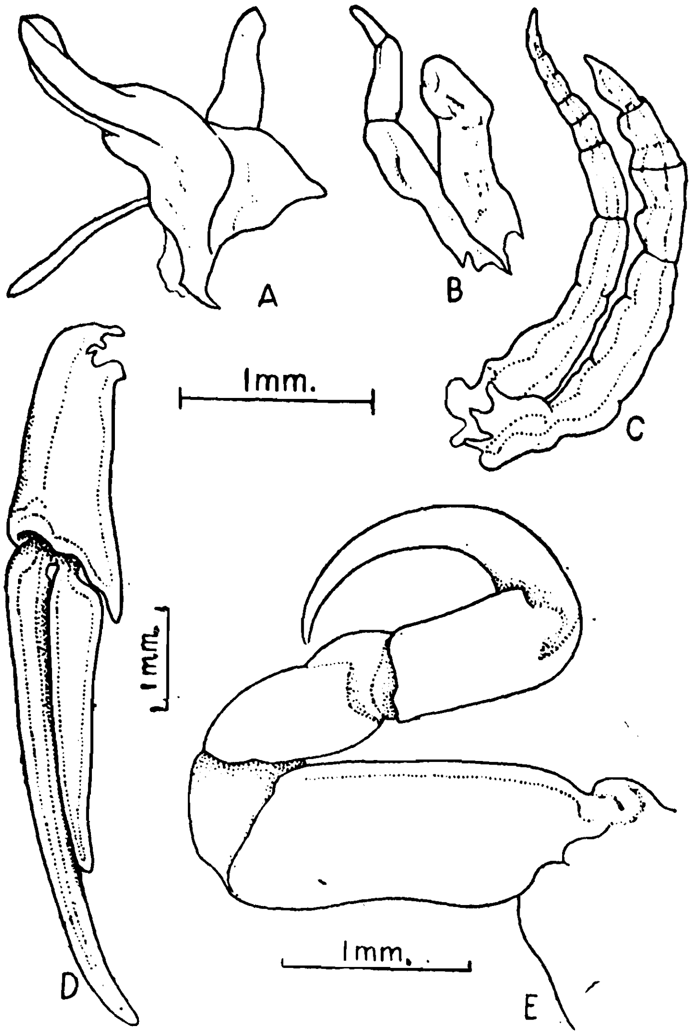

Fig. 3. *Nerocila madrasensis* sp. nov. (a) Maxilla (b) Maxilliped (c) Antennae (d) Uropoda (e) Seventh leg

Seventh leg (Fig. 3E) prehensile and terminate in long curved dactyli. Dark brown in colour except for one, with a little bluish tinge.

Length and breadth (greatest) of the holotype being 16 and 8 mm. respectively.

Remarks :— This species resembles *Nerocila serra* and *Nerocila trichura* to some extent, specially in the shape and size of the body and last segment of the abdomen, and with *Nerocila trichiura* and *Nerocila munda* regarding sub-quadrate shape of the cephalon. However, it differs from the above species in respect of shape and size of epimera of the thoracic segments, eyes, disposition, size and shape of appendages, specially the antennae, maxilla, maxilleped and the uropoda.

Key to the Indian species of the genus Nerocila

a. Postero-lateral angles of all the peraeon segments backwardly produced.

b. Cephalon almost quadrate with anterior border broadly rounded ; first antenna composed of nine articles and edges of endopod of Uropoda not serrate and one-third the size of exopod... .*phaeopleura*

bb. Cephalon almost quadrate with anterior border broadly rounded ; first antenna composed of eight articles and edges of endopod of Uropoda conspicuously serrate and more than half of exopod ....*serra*

aa. Postero-lateral angles of first peraeon segment only backwardly produced.

Cephalon triangular with anterior border broadly rounded ; first antenna composed of seven articles and endopod of Uropoda two-thirds that of exopod.... .*sundaica*

aaa. Postero-lateral angles of the first five peraeon segments not backwardly produced. Cephalon sub-quadrate with anterior border straight; first antenna composed of eight articles and endopod of Uropoda half the size of exopod.... ....*madrasensis*

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THREE NEW SPECIES OF THE GENUS *TABANUS* L. (DIPTERA : TABANIDAE) FROM ARUNACHAL PRADESH, INDIA

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ABSTRACT

Three new species, *viz.*, *Tabanus dominus*, *T minusculus* and *T kamengensis*, are described and illustrated from Arunachal Pradesh, India. The tabanid fauna of the State is also reviewed.

While dealing with the genera *Tabanus* L. and *Haematopota* Mg. of the family Tabanidae from Meghalaya, review of the relevant literature on the Indian fauna has been made (Datta and Biswas, 1977). In fact, knowledge on the family from Arunachal Pradesh is limited to the works by Philip (1970), Joseph and Rao (1972 a and b), Joseph and Parui (1973 and 1977) and, Joseph and Ray (1976). Of these authors, Philip (*op. cit.*) has described two species belonging to the genus *Tabanus* L. and two species to *Cydistomyia* Taylor ; while others' works concern the distribution only. This paper presents illustrated descriptions of three new species of *Tabanus* from Arunachal Pradesh (a part of erstwhile Assam, also called NEFA in the previous literature).

The type-specimens are deposited in the National Zoological collection of the Zoological Survey of India, Calcutta.

DISTRIBUTIONAL RECORDS IN ARUNACHAL PRADESH

It has already been pointed out by Datta and Biswas (*op. cit.*) that the distributional records of the Tabanidae in India are sometimes confusing, since, for example, Bigot (1892) frequently used "India" only for Assam to define the type-locality of certain species (Ricardo, 1911). Moreover, Arunachal Pradesh having its own characteristic mountainous terrain with diverse ecological niches may be relegated to have fauna of some distinction from that of the then Assam. It is, however, believed that a few more species occurring in the adjacent areas may eventually be included in the fauna of the State, wherefrom some widely distributed elements have been reported. Despite this in view, only those species which have definitely been reported from the jurisdiction of this State, are mentioned below : *Tabanus scutellus* Philip, *T. pullomaculatus* Philip, *Cydistomyia assamensis* Philip, *C. mouchai* Philip and *T. striatus* F. reported by Philip (1970) ; *Hybomitra hirta* (Walker) =*T.* (*Therioplectes*) *hirtus* by Joseph and Rao (1972 a) ; *Tabanus nephodes* Bigot, *T. auriflamma* Walker, *T. monotaeniatus* (Bigot), *Haematopota assamensis* Ricardo, *Chrysops* *dispar* (F.) and *C. designata* Ricardo by Joseph and Rao (1972 b) ; *Tabanus rubidus* Wiedemann, *T. fuscomaculatus* Ricardo and *Philoliche longirostris varipes* (Ricardo) (= Pangonia *longirostris varipes* Ricardo) by Joseph and Parui (1973) and, *abanus jucundus* Walker by Joseph and Ray (1976).

SYSTEMATIC ACCOUNT

Subfamily TABANINAE

Tribe TABANINI

Genus **Tabanus** Linnaeus

Tabanus Linnaeus, 1758, Systema Naturae, 10 : 601.
Type-species : *Tabanus bovinus* Linnaeus
(Latreille, 1810 : 443)

1. **Tabanus dominus** sp. n.

(Figs. 1-A, B, C)

A medium-sized dark brown species having ovoid frontal callus, reddish brown scape and pedicel, and entirely velvety black flagellum ; plate of flagellum with long dorso-basal tooth extended forward to over half of plate ; inconspicuously striped notum ; spur vein of wing longer than stem and no spot on abdomen.

Female : 15-17 mm in length.

Head : Eyes bare, uniformly buff-grey, unbanded (relaxed). Frons (Fig. 1-A) gradually divergent above ; index 1 : 4.8 ; yellow-pollinose and black-pilose, more at vertex. Frontal callus ovoid in shape with keel-like extension upward to about two-thirds of frontal height, almost resting on subcallus, without touching eye-margins, dark grey. Subcallus, face and parafacials yellow-pollinose ; face mostly with erect dark hairs and parafacials with long golden hairs as well. Antenna (Fig. 1-B) about 2.7 mm long ; scape and pedicel reddish brown, with black hairs ; pedicel with a very prominent dorsal spine ; flagellum entirely velvety black ; plate of flagellum with long dorsobasal tooth extended forward to over half of plate ; tooth with some black hairs, congregated more at apex. Palpus (Fig. 1-C) dark brown, slender blunt apically, black-haired.

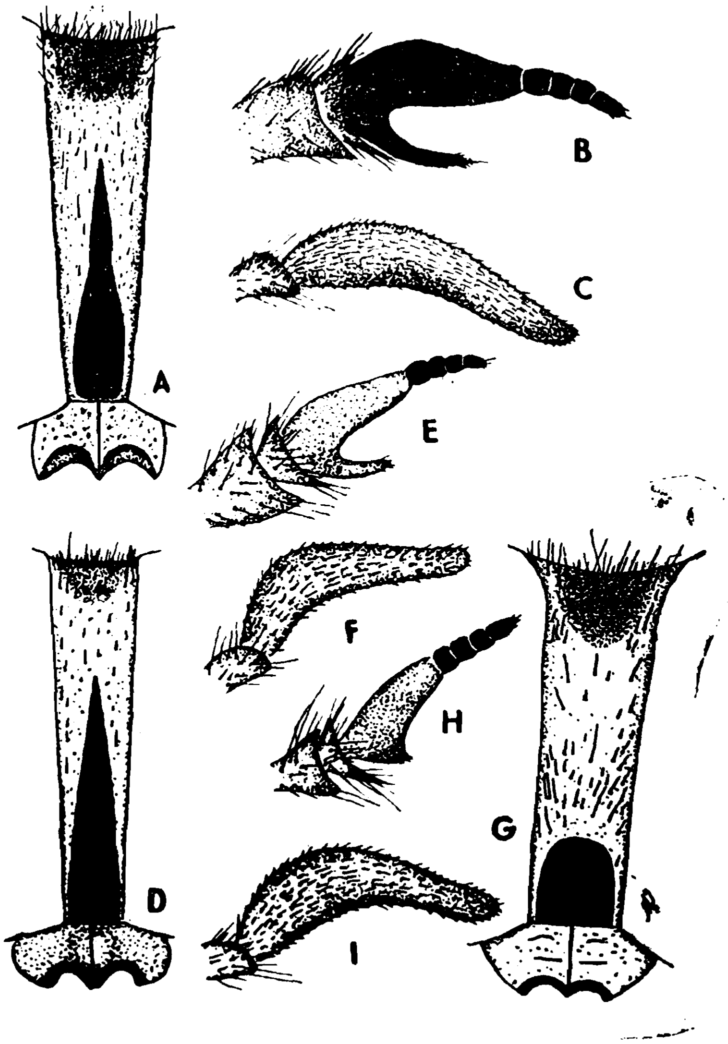

Fig. 1.

A—C. *Tabanus dominus* sp. n. A : frons ; B : antenna ; C : palpus.

D—F. *Tabanus minusculus* sp. n. D : frons ; E : antenna ; F : palpus.

G—I. *Tabanus kamengensis* sp. n. G : frons : H : antenna ; I : palpus.

Thorax : Notum black, with three extremely inconspicuous stripes extended from anterior margin to prescutellum, with yellow recumbent hairs except erect black-haired fore corners ; scutellum also black, mostly with yellow recumbent hairs. Pleura black, with both yellow and black recumbent hairs ; sternopleuron with long yellow erect hairs distally. *Wing* : 17-18 mm long, uniformly brown-tinted ; cell R5 open ; spur vein longer than stem ; basicosta black setose. *Legs* : Femora predominantly yellow-haired ; tibiae and proximal portions of tarsi brown, rest black ; hind tibial fringe black, inner hairs yellowish. *Haltere* : Brownish except yellow tip of knob.

Abdomen : Broad, nearly one-third of each tergum yellowish distally ; proximal two-thirds dark, predominantly yellow-haired ; terga with fringes of long golden hairs laterally but not so mesially. Sterna bluish black, with a long broad median black stripe extended upto tip of abdomen ; predominantly with yellow hairs.

Holotype ♀, INDIA : Arunachal Pradesh, Kameng District, Dirang Dzong, Chug, 2430 m ; 28. VII. 1961, Coll. *S. Biswas* *Paratypes* : 2 ♀ ♀, same data as holotype ; 1 ♀, Dirang Dzong, Chug valley, 2135 m., 10. VII. 1961, Coll. *S. Biswas* ; 2 ♀ ♀, Dirang Dzong, Jungle Camp, 1601 m., 21. VII. 1961, Coll. *S. Biswas*, 3 ♀ ♀, Dirang Dzong, Road side Camp, 1830m., 18. VII. 1961, Coll. *S. Biswas*.

Tabanus pullomaculatus Philip, 1970, described from Sikkim, Manipur and Arunachal Pradesh, India, and *T. fuscomaculatus* Ricardo, 1911, described and recorded from Burma and Uttar Pradesh, Manipur and Sikkim, India are differentiated from this new species so as to justify its identity.

	T. dominus	*T. pullomaculatus*	*T. fuscomaculatus*
1.	Dark brown species.	Reddish brown species.	Dark red species.
2.	Scape and pedicel of antenna reddish brown, flagellum velvety black ; dorso-basal tooth of plate extended forward to over half length.	Antenna uniformly red, sometimes darker apically, tooth not so much extended.	Scape and pedicel of antenna red ; flagellum black ; "Distinct tooth" presumably not spine-like.
3.	Notum inconspicuously striped.	Notum unstriped.	Notum unstriped.
4.	Spur vein of wing longer than stem.	Spur vein of wing shorter than stem.	Spur vein short, sometimes absent.
5.	No spot on abdomen.	Abdomen spotted.	Abdomen spotted.

2. **Tabanus minusculus** sp. n.

(Fig. 1-D, E, F)

A medium-sized reddish brown species having clubshaped frontal callus, reddish brown scape, pedicel and plate of flagellum, and somewhat darkened tip : broad and flat plate with a very prominent long tooth extended forward half way of plate ; spur vein of wing longer than stem ; unstriped or unspotted thorax and abdomen dorsally.

Female : 15-16 mm in length.

Head : Eyes bare, uniformly buff-grey, unbanded (relaxed). Frons (Fig. 1-D) gradually divergent above ; index 1 : 5.6 ; yellow-pollinose and thinly blackpilese above, more erect hairs at vertex. Frontal callus club-shaped, broad, dark brown, tapered above into a heavy median keel which attenuates in upper third of frons, nearly touching eye-margins and resting on subcallus ; two small but prominent black tubercles without ocelli below vertex. Sub callus, face and parafacials yellow pollinose-face mostly with dark erect hairs and parafacials with long pale yellow hairs as well. Antenna (Fig. 1-E) about 2 mm long ; scape, pedicel and plate of flagellum reddish brown and rest darkened ; pedicel with a prominent dorsal spine, and black hairs also with scape ; plate broad, flat, with a very prominent tooth extended forward halfway of plate ; tooth with four or five black hairs at tip. Palpus (Fig. 1-F) moderately swollen, blunt apically, dark brown, black-haired.

Thorax : Notum black, unstriped, with recumbent yellow hairs and erect black hairs ; fore corners with long yellow and black hairs ; scutellum also black, with long yellow and black hairs. Pleura brownish, with both yellow and black hairs ; sternopleuron with long yellow erect hairs mesially and distally. *Wing* : 15-16 mm long, uniformly brown-tinted ; cell R5 open ; spur vein usually longer than stem ; basicosta black setose.

Legs : In general reddish brown except somewhat darker fore tarsi ; predominantly black-haired. *Haltere* : Stem brownish and knob somewhat darker.

Abdomen : Broad, reddish brown, gradually dark-tinged posteriorly, predominantly black-haired ; terga with fringes of golden hairs almost uniformly. Venter with a long, broad, black median stripe extended upto tip, predominantly yellow-haired except black-haired stripe.

Holotype ♀, INDIA : Arunachal Pradesh, Kameng District, Dirang Dzong, Jungle Camp, 1601 m, 20.VII.1961, Coll. *S. Biswas* *Paratypes* : 1 ♀, same data as holotype ; 1 ♀, Kameng District, Nephra, Salari, 1270 m, 3. VII.1961, Coll. *S. Biswas.*

This new species resembles *Tabanus trinominatus* Senior-White, 1927 (=*Tabanus palpalis* Ricardo, 1911) described from India (exact locality unknown) in having club-shaped frontal callus, unstriped or unspotten thorax and abdominal terga but *trinominatus* possesses a short antennal tooth and dull yellow legs among certain other differences.

3. **Tabanus kamengensis** sp. n.

(Figs. 1-G, H, I).

A medium-sized dark brown species having subquadrate callosity, reddish brown scape, pedicel and plate of flagellum and black tip ; flat and narrow plate with a very small tooth ; occurrence of spur vein in wing optional ; legs black except brownish tibiae with blackish tips only ; unstriped or unspotted thorax and abdominal terga.

Female : 13-14 mm-

Head : Eyes bare, uniformly buff-grey, unbanded (relaxed), but shining pinkish in certain lights. Frons (Fig. 1-G) broad, slightly divergent above, with black spot at vertex, slightly raised along midline, index 1 : 3.7 ; yellow-pollinose and black pilose, more above callus. Callosity greyish, bulging, subquadrate with rounded upper corners, without touching eye-margins ; no upward extension,. Subcallus brown-pollinose ; face and parafacials off-white pollinose ; face with off-white erect hairs and parafacials with off-white long hairs. Antenna (Fig. 1-H) about 1.5 mm long ; scape, pedicel and plate of flagellum reddish brown and rest black ; pedicel with a prominent dorsal spine and black hairs also with scape ; plate flat and narrow with a very small tooth ; tooth with a very few black hairs at tip. Palpus (Fig. 1-I) somewhat narrow, blunt apically, brownish, black-haired ; in one paratype specimen palpus somewhat short and swollen basally.

Thorax : Notum almost black, unstriped, with recumbent golden hairs and erect black hairs, more, laterally ; scutellum also nearly black, with very few golden and black hairs. Pleura greyish, mostly with brown hairs ; sternopleuron with long off-white erect hairs. *Wing* : 12-13 mm long, uniformly brown-tinted ; cell R5 open ; spur vein absent in holotype and in one paratype but present in two other paratypes ; basicosta black setose. *Legs* : entirely black except brownish tibiae with blackish tips only ; hind tibial fringe black. *Haltere* : Stem brownish and knob darkened.

Abdomen : Tergum 2 reddish brown, gradually somewhat darkened to tip of abdomen ; tergum 1 darker than tergum 2 ; tergum 2 yellowish on anterior border ; terga predominantly dark haired, with fringes of golden hairs, more laterally ; sterna brownish to black at tip ; a median black stripe gradually widening to black tip ; no well-marked stripe in one paratype ; with golden hairs except on black-haired stripe.

Holotype ♀, INDIA : Arunachal Pradesh, Kameng District, Diarang Dzong, Chug, 2430 m, 28.VII.1961, Coll. *S. Biswas*. *Paratypes* : 1 ♀, same data as holotype ; 1 ♀, Dirang Dzong, Road side camp, 1930 m, 18.VII.1961, Coll. *S. Biswas* ; 1 ♀, Dirang Dzong, Sangli, 1678 m, 23.vii.1961, Coll. *S. Biswas*.

Tabanus scutellus Philip, 1970, described from Arunachal Pradesh and Sikkim, India, runs somewhat to the new species in the shape of the antenna and palpus (*cf.* Philip, 1970) but differs in the uniformly red antenna, a small black median callus, black apical fourth of the fore leg and triangles formed out of bright hairs on the abdominal terga 3 and 4.

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A NOTE ON THE SYSTEMATIC POSITION OF TWO SILUROID FISHES, *OMPOK PABDA* (HAM.) AND *OMPOK BIMACULATUS* (BLOCH)

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ABSTRACT

The salient osteological characters and its variations in skull, pectoral girdle, vertebral column, gill-rakers and anal fin of two Siluroid fishes, *Ompok pabda* (Ham.) and *O. bimaculatus* (Bloch.) are recorded. Importance of osteological characters in evaluating the exact taxonomic status of the species is discussed.

INTRODUCTION

Hora (1936), Haig (1952) and Misra (1959) considered *Ompok pabda* (Ham.) and *Ompok bimaculatus* (Bloch) as synonymous. Parameswaran *et al.* (1967, 1971) on the other hand adduced evidence on the basis of the bionomics of the two species, that they are different.

In order to verify whether the differences observed in the bionomics are reflected in the morphological make up of the species, some osteological investigation were made as has been done by Jayaram (1954, 1971), Tilak (1963, 1967), Seshagiri Rao (1974), Dutt and Reddy (1975). Significant differences were noticed in the characters of skull, pectoral girdle, vertebral column, gill-rakers and anal-fin. The salient features and variations which are of specific importance are enumerated here.

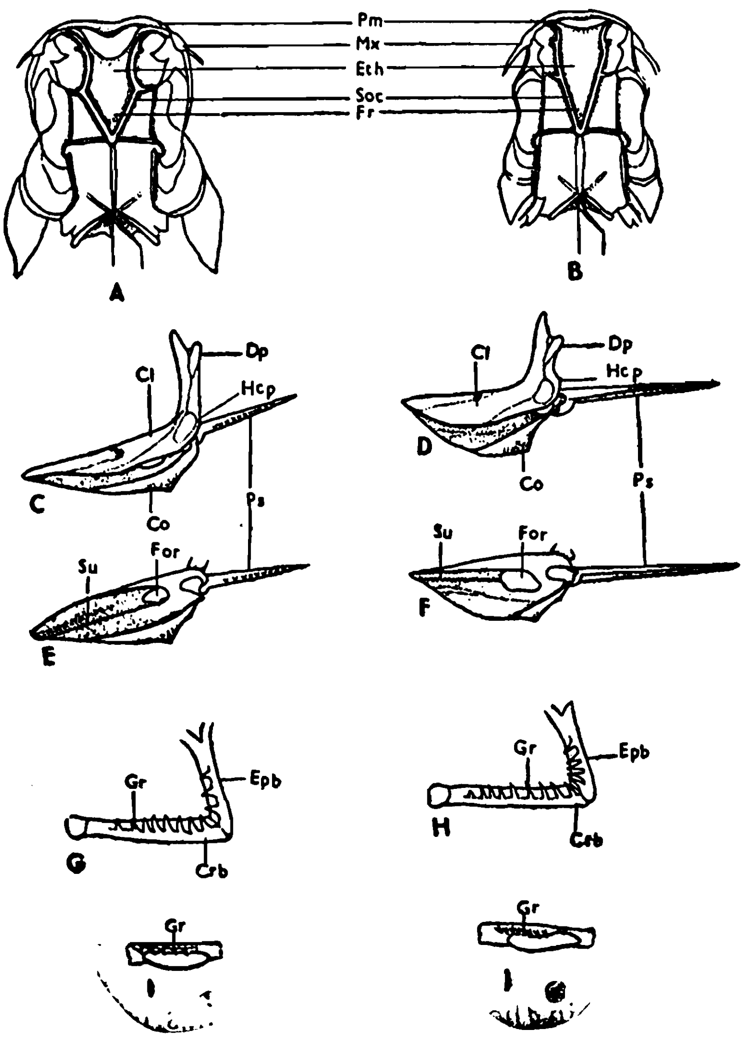
OBSERVATIONS

Skull (1) *Ethmoid* (Fig. 1A-B). It is a median anteriorly situated T-shaped bone articulating with the premaxillaries on the ventral side. Its anterior margin is deeply excavated in *O. pabda* (Fig. 1A) while emarginate *O. bimaculatus* (Fig. 1B).

(2) *Supra-Orbital canal* (Fig. 1A-B Soc) The lateral line system runs anteriorly into sensory canals on the head and are superficially placed below the skin. These are cartilaginous tubular canals running on the head and lodged in the dermal bones at some places and loose at others having external openings. They start from the base of the frontal bone and run anteriorly diverging gradually ahead along the nasal bones and are symmetrically disposed on either side. In the nasal region these are loosely attached to the dermal bones. The disposition of the supra-orbital canal differs in the two species and has been found to be consistent. In *O. pabda* it forms a vase shaped (Fig. 1A) structure with a long and concave neck. In *O. bimaculatus* it forms a more or less thistle or funnel shaped (Fig. 1B) structure having a tampering truncated cone. It has a small neck. This variation is

also noticed in young specimens. *Pectoral girdle* (Fig. 1C-F). It is well ossified, stoutly built and conspicuous by its elongated cleithral process (Tilak 1963 *a*). The cleithrum is large and well ossified while the coracoid is a broad and dagger-shaped bone attached to the ventral side of the cleithrum. The cleithrum has a dorsal process which is an upward prolongation of the lateral part. It is broad at its base and tapers towards its extremity with two terminal processes. On the posterior border at about its middle, the humero-cubital process (Fig. 1C) is given off which is very much reduced in the genus (Tilak 1963a). This process in *O. bimaculatus* is clearly distinguishable while in *O. pabda* it is absent.

The coracoid is suturally united with the cleithrum in most of its length in both the species, except at proximal base where they leave a large foramen in between. The suture in *O. bimaculatus* starts from the middle of the frontal margin of the foramen while in *O. pabda* it is in continuation with the lower margin of the foramen.



Eth. —Ethmoid
Soc. —Supra Orbital Canal
Fr. —Frontal
Mx. —Maxillary
Pm. —Premaxillary
Cl. —Cleithrum
Co. —Coracoid
D.p. —Dorsal process
P.s. —Pectoral spine
H.c.p. —Humero cubital process
Su. —Suture
For. —Foramen
Epb. —Epibranch
Crb. —Ceratobranch
G.r. —Gill raker

Fig. 1.A. Dorsalview of Skull of *O. pabda*.
B. Dorsal view of skull of *O. bimaculatus*.
C & E. Dorso-lateral and lateral (oeter) view of Pectoral girdle of *O. Pabda*.
D & F. Dorse-lateral and lateral (outcr) view of girdle of *O. bimaculatus*.
G & I. First and fifth gill arch of *O. pabda*.
H & J. First and fifth gill arch of *O. bimaculatus*..

As common in all siluroids (Tilak 1963a) the scapula is absent and the cleithra and coracoids do not form a symphysis but simply meet each other at their tips which are pointed.

The length and breadth ratio of the girdle has also been found to differ in the two species. In *O. pabda* the length is nearly thrice to that of its maximum breadth and in *O. bimaculatus* it is more or less twice.

The length of pectoral spine in relation to pectoral girdle also differs. In *O. bimaculatus* it is equal to the pectoral girdle while in *O. pabda* it is 2/3 to 3/4 of the girdle length. Further, the pectoral spine in *O. bimaculatus* is comparatively much strong and stout than in *O. pabda.*

Vertebral column : The number of vertebrae significantly varies in the two species. Total numbers of vertebrae including Urostyle ranges between 45 to 47 in *O.pabda* and 51 to 53 in *O. bimaculatus.*

Gill rakers : (Fig. 1G-J) The gill rakers are present only on ceratobranch and epibranch region of the gill arches in the two species. The gill rakers are in the form of spines. These rakers are clearly bony and there is only one row of it on the outer part of 1st and 2nd gill arch. There is variation in the shape and number of gill rakers particularly in 1st gill arch in the two species. These rakers are in the form of hooks curved at the tips in *O. pabda* while in *O. bimaculatus* they are simple and straight. In a few adult specimens of *O. pabda* bifid rakers are also noticed on ceratobranch of 1st gill arch.

The 1st and 5th left gill arches of *O. bimaculatus* bear 14 and 8 rakers on their outer margins respectively. In case of *O. pabda* the numbers are 11-12 on 1st and 5 on 5th gill arches. There is no overlapping of rakers particularly on the 5th gill arch and this is of considerable specific value in seperating the two species.

Anal sheath : The prolongation of the integument on the anal fin covers nearly 2/3 of the anal fin rays in *O. bimaculatus.* In the case of *O.pabda* it covers 1/3 of the anal fin rays.

DISCUSSION

Jayaram and Bhimachar (1967) reviewed the importance of osteological characters and have shown how these characters are useful in solving the problem of species complex in a genus. Tilak (1967) listed the important features of taxonomic value in Weberian ossicles and osteocranium. Deep concavity on the anterior margin of the ethmoid bone has been found to vary in the two species as stated above. Although not mentioned in the text it is evident from the illustrations given by Jayaram and Bhimachar (Op. cit. fig. 1) that similar variation is found in the two species of *M. aor* and *M. seenghala.*

Infra-orbitals have been enlisted by Tilak (Op. cit) as useful in taxonomy but arrangement of supra-orbitals has not been considered up till now. We have found that these characters are not variable and the emargination of ethmoid and dispostion of supra-orbitals in the two species remain constant irrespective of age.

Regan (1911) and Tilak (1963a) recognised the importance of pectoral girdle in distinguishing the families in siluroids. Tilak (Op. cit) extended this even upto specific level in some siluroids. The relative length of pectoral spine is also a very important one. Ford (1937) Clothier (1946 & 1950) and Lindsay (1962) made some studies on the variation in vertebral counts and other vertebral characters. Consideration of the vertebral count has shown that this number varies in two species and there is no overlapping.

In recent years gill rakers have drawn the attention of fish taxonomists (Regan, 1917 ; Dutt, 1959, 1963 ; Seshagiri Rao, 1974 ; Dutt and Reddy, 1975). The left 1st gill arch has been found to be of value in evaluating the status of a species. Our study on the rakers of gill arches shows that the 1st as well as the 5th left gill arches have the same specific value. The 5th gill arch has more stable number of rakers than the 1st.

Anal fin rays covered by integument for more than half of their length was considered as a characteristic feature of genus *Silurus* by Haig (1952), but as pointed out by Parmeswaran *et al.* (1967) her study was based on a heterogenous collection of *Ompok bimaculatus* and *O. pabda*. This is a character of specific value rather than a generic one.

As such it is clear that *O. pabda* is a separate and a valid species.

ACKNOWLEDGEMENT

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DISTRIBUTION OF SOIL PROTOZOA IN ASSOCIATION WITH NITROGEN FIXING BACTERIA.

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ABSTRACT

Relationship between protozoa and different types of nitrogen fixing bacteria observed in the alluvial soil samples from the rhizosphere of pulse and jute crops of West Dinajpur District of West Bengal is recorded. High population of *Paramoeba* sp. in the jute soil may be due to presence of *Azotobacter* which influenced the growth of the species.

INTRODUCTION

The microbial fauna of soil consists mainly of bacteria, protozoa, algae and fungi. Bacteria has a major role in bringing biological and chemical changes in soil as they grow vigorously. Soil protozoa and bacteria form a predator/prey relationship.

Cutler *et al.* (1922) showed the occurrence of amoebae, flagellates and ciliates in large numbers in normal soil both in active and cystic conditions. Singh (1964) indicated that fluctuations in the population of active and noncystic stages of amoeba, on the whole is inversely proportional to that of bacterial numbers. It has been observed that the presence of protozoa boost up the population of *Azotobacter* which helps the fixation of soil nitrogen. It has been shown that the lysate of protozoa can stimulate the population of *Azotobacter*. However, Singh (1964) observed that the strains of *Rhizobium* are generally not accepted to amoeba. Geltzer (1963) investigated the relationship of soil amoebae with the rhizospheres of plants and observed that protozoa are more in number and diverse in the plant rhizosphere than in the surrounding soil. This he explained due to bacteria finds favourable environment for development at rhizosphere which ultimately helps to built up the protozoan population.

The work on the relationship of nitrogen fixing bacteria and protozoa in natural soil has so far not been attempted. Obsenation presented here rela es to the relationship between protozoa and different types of N-fixing bacteria.

MATERIAL AND METHODS

Alluvial soil samples were colleeted from the rhizosphere of the pulse and jute crops of West Dinajpur district of West Bengal. Samples were cultured in the laboratory in (i) hay infution non nutrient agar (ii) soil extract non nutrient agar. Tne hay infusion medium is made up as follows ;

50 gm. of chopped hay and 100(ml. of

distilled water boiled gently, filtered and the liquid is made up to 1000ml. Hay infusion agar (1.5%) is made by adding agar and sterilizing at 15 lb pressure for fifteen minutes. For soil extract agar medium, 200 gm. of fertile soil and 500 ml. of tap water boiled gently for one hour, filtered and the liquid is made up to 500 ml in similar manner as in hay infusion agar method. Soil extract and hay infusion agars are poured in petri-dishes separately. Inoculation of samples were made 10^{-3} dilution and 10 replicates of culture were considered. The same soil samples repeated for five times. pH of the culture medium was maintained at 7.00. The room temperature recorded was 31°-33°C during the period of experiment. From time to time the culture plates were moistened with sterile distilled weter. At 72 hours, after inoculation, the protozoan population reaches maximum growth. During observation the agar of the culture plates were scooped from different parts of the plate and washed in distilled water. Observations were made under oil immersion lens (10×100) after fixing the material in carnoy and staining the same with Feulgen.

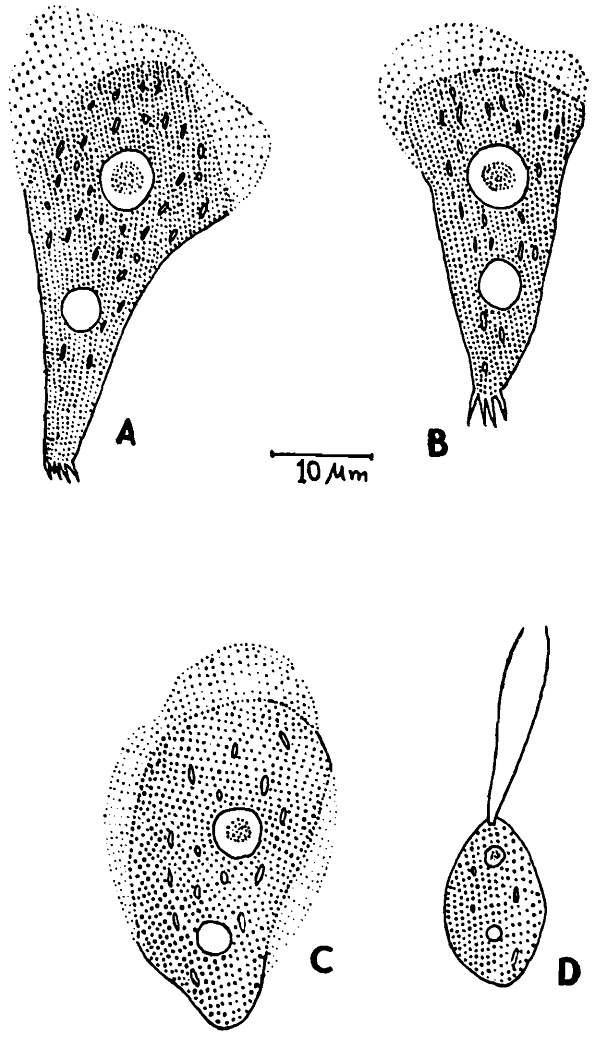

Fig. 1. *Naegleria* sp. A, B, C—Trophic forms : D-Flagellate stage.

OBSERVATIONS

The soil samples were collected from pulse and jute fields where agricultural factors were identical other than the crop. Each culture was made and maintained for a month. The results are as follows :

In the pulse field where the *Rhizobium* bacteria are present in large numbers, a succession of three ciliates were found. In 1st 10 days the species belonging to genera *Oxytricha*, *Colpoda* (Pl. V. A & B) and *Dileptus* were found and later on they were replaced by *Amoeba*, *Hartmanella* (Fig, 2) and *Naeglaria* (Fig. 1). Jute soil culture reveals the presence of only one species of genus *Paramoeba* (Pl. V, C) in high density. In pulse soil the species belonging to genus *Colpoda* constitue the 80% of the total population of protozoans in the 1st 5 days. The different ciliate species are common in occurrence are found in all types of soils.

DISCUSSION

The result shows that the protozoa particularly the amoeba present in the soil in high density where the *Azotobacter* is present in large numbers. The relation of free living amoebae to various types of bacteria indicates the complicated nature of these problems. Though in the begining it appears to be a clear case of relationship between predator

and prey. The amoeba are selective in feeding of the bacteria.

The reasons underlying the apparent selection of bacteria as food by protozo are by no means clear, The production of certain types of toxic pigments and exotoxins by certain bacteria are the main cause of non acep able by amoeba to these bacteria (Singh, 1941)

The presence of high population of a species of the genus *Paramoeba* in the jute soil may be due to the presence of *Azotabacter* which influenced the growth of the species. The presence of small numbers of amoeba in the pulse field may be explained due to the presence of *Rhizobium* bacteria which is non acceptable to amoeba. As the amoeba stimulate the population of *Azotobacter* which in turn helps in fixation of nitrogen. So it may be possible by inoculating pure culture of such amoeba in the soil to influence the growth of *Azotobactor*.

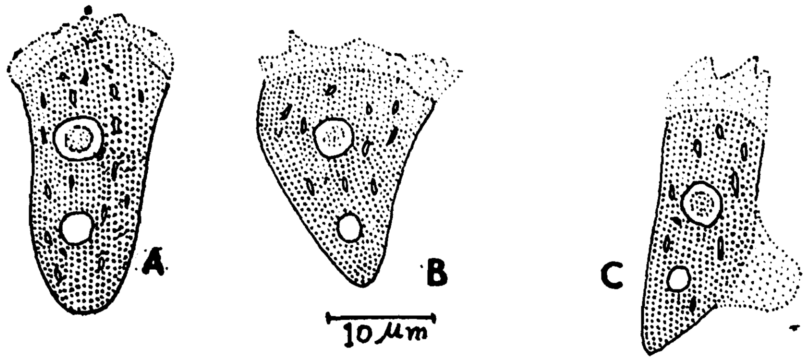

Fig. 2. *Hartmannella* sp. A, B, C—Trophic forms.

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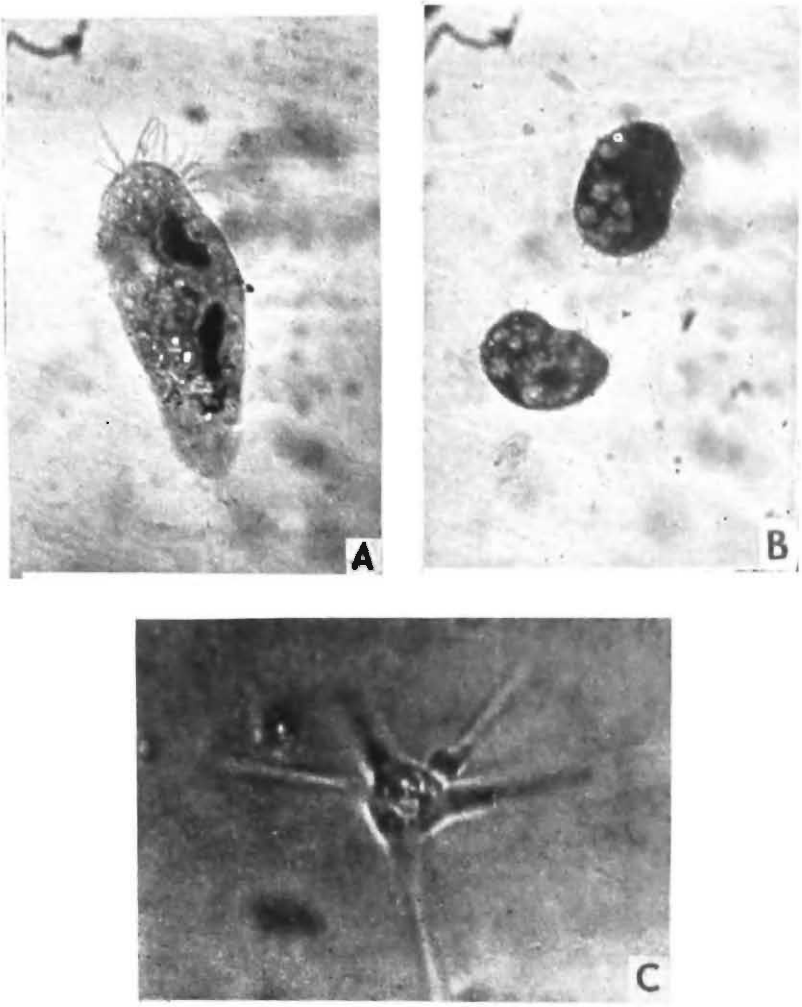

A. *Oxytricha* sp., B. *Colpoda* sp. C. *Paramoeba* sp.

Bull. zool. Surv. India, 1 (2) ; 197-201, 1978

POPULATION FLUCTUATIONS OF THREE SPECIES OF ANTHOPHILOUS THYSANOPTERA WITH NOTES ON THE BIOLOGY OF THE SEED FEEDING SPECIES *CHIROTHRIPS MEXICANUS* CRAWFORD

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AND

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ABSTRACT

Fluctuations in natural population of *Chirothrips mexicanus* Crawford along with two associated species, *Exothrips hemavarna* and *Haplothrips apicalis* on *Chloris barbata*, observed in the year 1977 are noted. High incidence of all the three species in June denotes their preference to high temperature, low humidity and optimum rain fall. Males outnumber through out the life cycle of *Chirothrips mexicanus*.

Available information relating to the fluctuations in natural populations with particular reference to anthophilous Thysanoptera (Evans 1935, Ottingen 1942, Davidson and Andrewartha 1948 a, b ; Smith 1953, Andrewartha and Birch 1954 ; Raizada 1961 ; Ananthakrishnan and Jagadish, 1965 ; Ward 1966 ; Ananthakrishnan and Viswanathan 1976 ; Viswanathan and Ananthakrishnan 1976) appear to indicate that in the total absence of density dependent factors, density independent factors such as rainfall, humidity and temperature could exert a control on the thrips population. The present observations include the population fluctuations involved in the regular annual rhythm in the rise and fall of the population of *Chirothrips mexicanus* Crawford, infesting *Chloris barbata* Sw., along with the periodicity and abundance of *Exothrips hemavarna* R. & M. and *Haplothrips apicalis* (Bagnall) also inhabiting the spikelets of *Chloris barbata.*

In an attempt to study the population fluctuations of different thrips species on *Chloris barbata*, from the field in which *Pennisetum* crop was previously raised, regular collections were made during the year 1977 (January to December) with samples taken from 100 plants of almost the same age. Studies on the life cycle and post embryonic development were carried out in the laboratory.

POPULATION TRENDS

Chirothrips mexicanus in view of its occur-

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rence almost throughout the year (January to October) is the primary species in *Chloris barbata*, while the associated species *Exothrips hemavarna* and *Haplothrips apicalis* occurring only during a five month period (May to September) are the secondary and tertiary species on the basis of their relative incidence. The maximum abundance of the primary species was in June, and the minimum was in October when the maximum and minimum temperature were 36.7°C and 27.1°C respectively. Further, the average rainfall and humidity in June were comparatively lower (86.4 mm. and 60%) than in October when the rainfall and humidity were high (638 mm. and 93%). The associated secondary and tertiary species *E. hemavarna*, *H. apicalis* also had their maximum abundance in conformity with the primary species *Chirothrips mexicanus* (Fig. 1). The higher incidence of

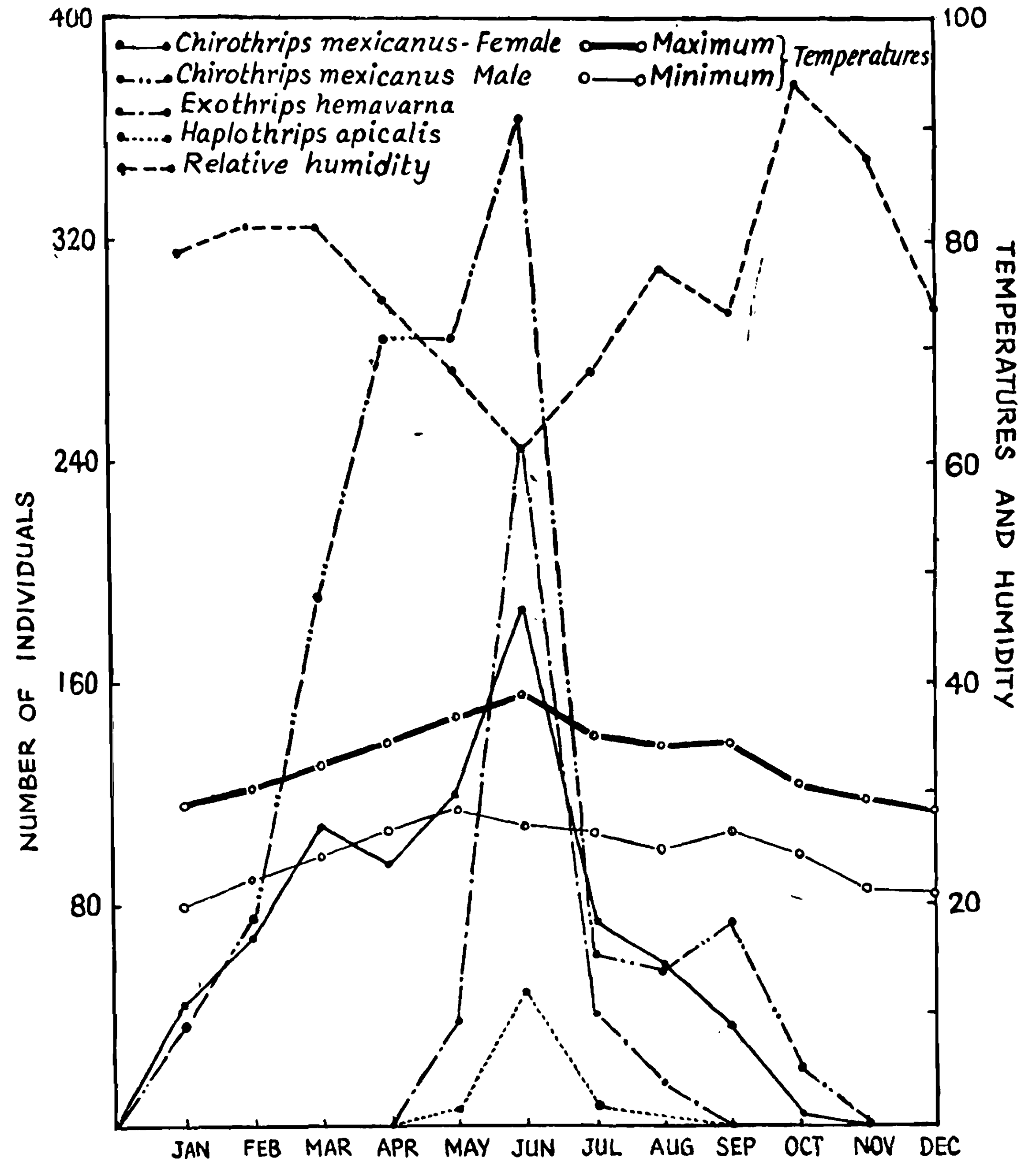

Fig. 1. Graph showing the effect of temperature humidity on the population of *Chirothrips mexicanus*, *Exothrips hemavarna* and *Haplothrips apicalis*.

all the three species during June (1977) suggest their preference to high temperature, low humidity and optimum rainfall.

BIOLOGY

In *Chirothrips mexicanus* both sexual and parthenogenetic modes of reproduction occur (Ananthakrishnan and Thirumalai, 1977). The thrips are active throughout the year except November and December. Oviposition starts 4-5 days after adult emergence, the eggs being laid at the tip of the developing ovules (Pl. VIC) partly embedded in the ovular tissue of *Chloris barbata*, the oviposition rate being 3-4 eggs per day. The total number of eggs laid by a single sexually reproducing female is 29 to 41 and 2 to 3 eggs/day/female under laboratory conditions. The ovary of parthenogenetically reproducing individuals shows four to six mature eggs at a time. The total duration of life cycle from egg to adult is of the range of 14-19 days.

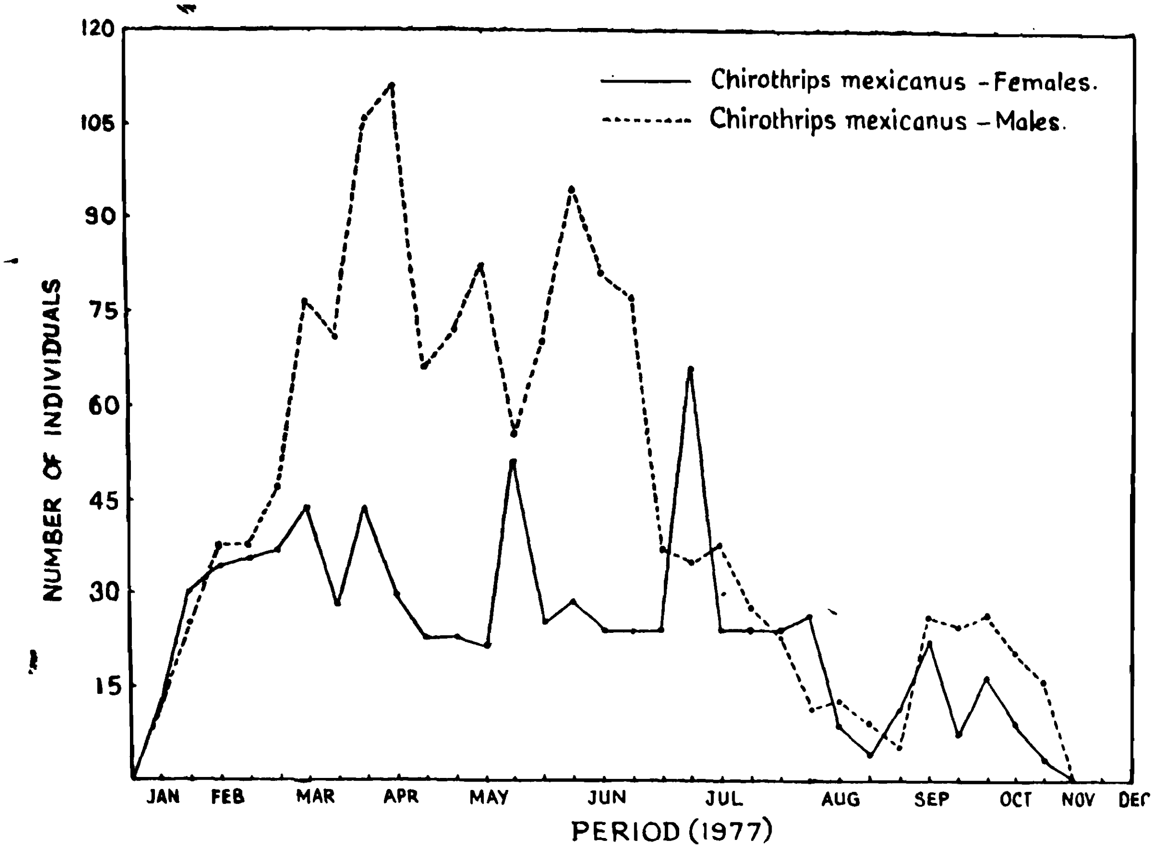

Fig. 2. Graph showing population fluctuation of males and females of *Chirothrips mexicanus* for the period 1977.

Males (Pl. VIA) comprise the major portion of the population in *Chirothrips mexicanus* throughout the year excepting January and July. The sex ratio is 1 : 1 to 5 : 1 (Males : Females) (Ananthakrishnan and Thirumalai, 1977). The abundance of male population (Fig. 2) throughout the life cycle is due to the arrehenotokous mode of reproduction, which appears to be the principal mode almost throughout its life span, besides normal sexual reproduction. Like *Thrips linarius* Uzel, *Caliothrips fasciatus* Pergande, *Haplothrips verbasci* (Osborne), *Scirtothrips citr* Moulton, the virgin females of *C. mexicanus* produce only male offspring, whereas fertilized females produce mostly females.

Discussion

The peak population of C. *mexicanus, E. hemavarna* and *H. apicalis* during June 1977 in particular, indicates their preference to low humidity and high temperature, as indicated by Viswanathan and Ananthakrishnan, (1976) in relation to *Micothrips fasciatus* Ananthakrishnan, an anthophilous species. The presence of *C. mexicanus* throughout the year excepting the period November and December characterised by high humidity and low temperature, and the abundance of *C. mexicanus* even in the situations with extreme climatic factors mark it as the most successful inhabitant. The absence of a predator throughout the period appears significant in that the principal environmental factors controlling the population of these Thysanop-

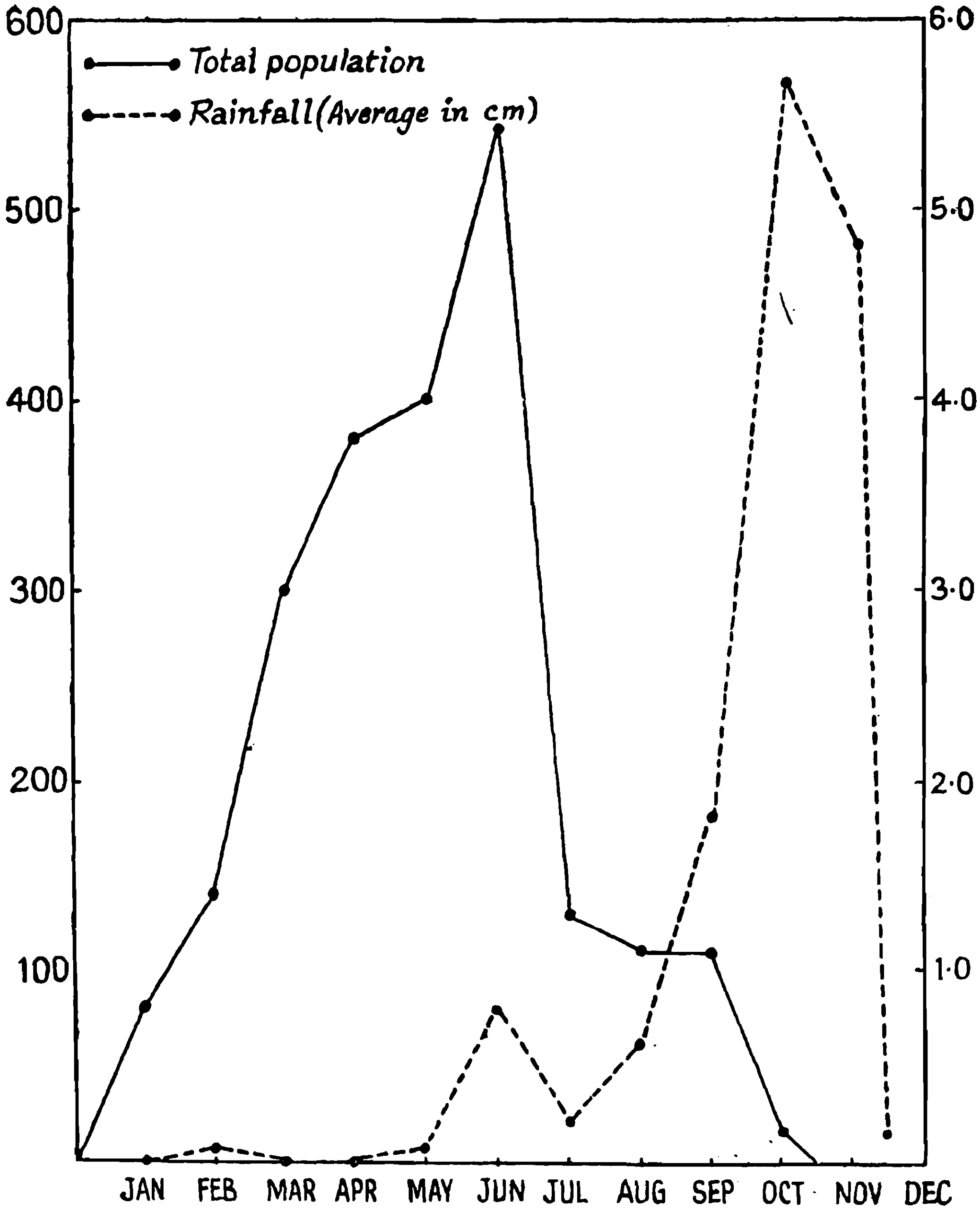

Fig. 3. Graph showing the trend of total population of thrips and average rainfall in the year 1977.

tera are the density independent ones – especially temperature and humidity. Davidson and Andrewartha (1948 a, b) and Andrewartha and Birch (1954) considered rainfall and temperature could together control thrips populations only when density dependent factors are totally absent. The present study in addition indicates that besides temperature and humidity controlling the population, an optimum rainfall also appears necessary (Fig. 3).

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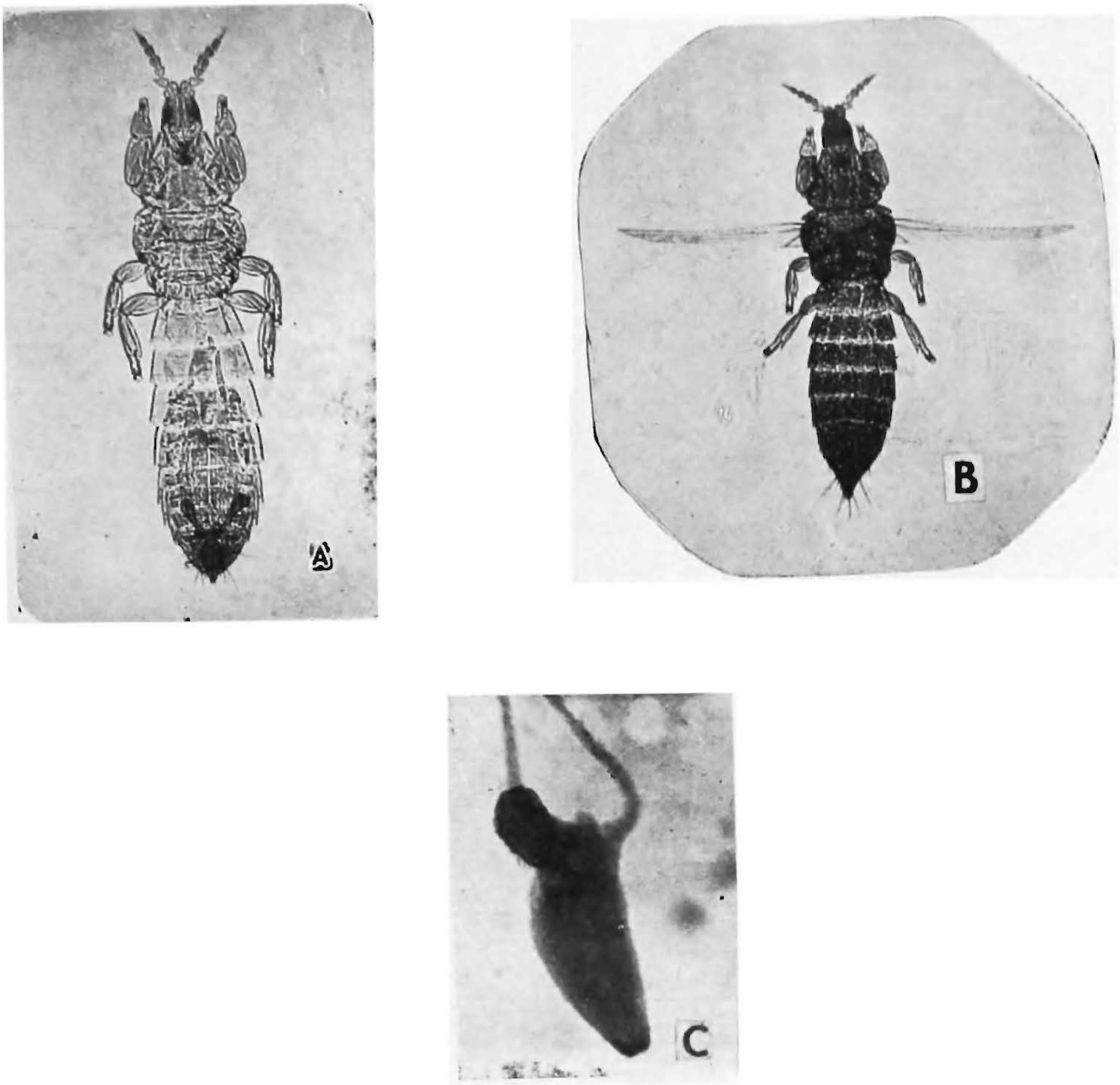

Chirothrips mexicanus Crawford
A, Male ; B. Female ; C. Egg inserted at the tip of the ovule of *Chloris barbata*.

SHORT COMMUNICATION

Bull. zool. Surv. India, **1** (2) : 203-205, 1978

SILUROID FISHES OF INDIA, BURMA AND CEYLON. 19. A NOTE ON THE SYSTEMATIC POSITION OF *TACHYSURUS SERRATUS* (DAY) (ARIIDAE)

Day (1878) described *Arius serratus* from a single specimen 114 mm. in standard length and collected from "Sind". He differentiated it from *A. thalassinus* (Rüppel) by its much shorter pectoral fins and longer maxillary barbels. In regard to dentition, Day noted three distinct villiform patches on either side on the palate, the vomerine patch being round, small and with an interspace between the two and with another rather longer oval patch "externally". Chandy (1954) and Misra (1976) merely included the species without making any comment. Munro (1955) however doubted the status of *serratus* and thought it may repressent the young of *thalassinus.*

In the course of our studies on the catfishes of the family Ariidae, the senior author collected 58 specimens of *T thalassinus* from different localitics both in the east and west coasts of India, representing different sizes ranging from 90 to 370 mm. in standard length. We have also examined Day's single specimen of *T. serratus* well preserved in the Zoological Survey of India, Calcutta under Regd. No. F. 467. A thorough search has also been made as to the possible availability of more specimens of *T. serratus* with negative result.

As stated previously *T. serratus* was differentiated from *T. thalassinus* principally by the teeth pattern. The dentition in siluroids as a whole, and in *Tachysurus* is highly variable associated as it is with growth. In general the basic pattern of number and location of the teeth patches remain more or less stable, the extent of the patches, the number of teeth on each patch, the crowded

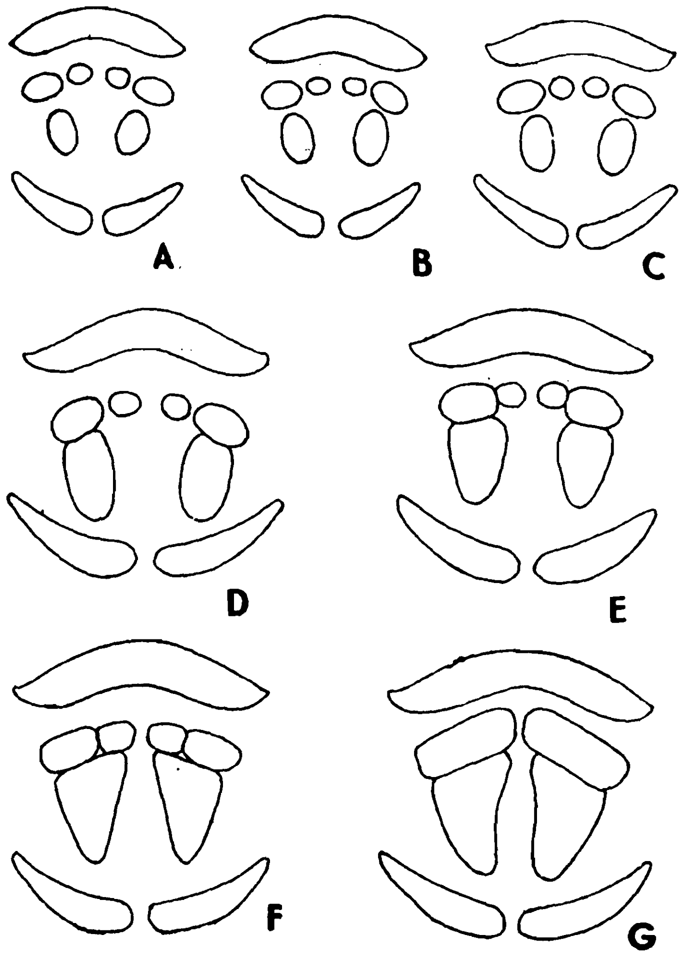

Fig. 1. Dentition in *Tachysurus* species. A and C to G. *T. thalassinus* different size ranges. B. *T. serratus* (See table, for details).

ZSI Regd. No.	Standard Length	No. of Examples	Teeth pattern on palate
F 1792/2 F 1823/2	90-100 mm.	8	Three distinct separate patches on either side (Fig. 1 A).
F 6413/1 F 3344/1 F 3350/1	101-110 mm.	5	Same as above but the interspace between patches slightly reduced.
F 3353/1 F 7370/2 F 536/2	111-120 mm.	5	Same as above.
F 7369/2	121-130 mm.	3	Same as above but the interspace between the patches, further reduced.
F 7370/2	131-140 mm.	3	Very little interspace between the patches.
F 5826/1 F 3550/1 F 7369/2	141-150 mm.	5	Same as above (Fig. 1 C.)
F 7369/2 F 7370/2	151-160 mm.	3	Anterior patches slightly fused. (Fig. 1 D.)
F 593/2 F 7369/2 F 7370/2	161-170 mm.	4	Same as above, but anterior inside patch not fused with posterior one.
F 13752/1 F 7369/2	171-180 mm.	3	Same as above (Fig. 1 E.)
F 536/2	181-190 mm.	2	Anterior inner and outer two patches completely fused but the posterior patch not fused completely. (Fig. 1 E.)
	191-200 mm.	3	All the three teeth patches completely fused, forming a single triangular patch.
	201-240 mm.	3	Same as above (Fig. 1 G.)
F 1307/1 F 569/2	241-250 mm.	3	Same as above.
	260-280 mm.	2	Same as above.
F 2236/1	290-300 mm.	2	Same as above.
F 2238/1 F 3351/1	311-330 mm.	2	Same as above.
	341-370 mm.	2	Same as above.

or sparse manner or the presence of teeth on each patch are highly variable, correlated with the size and age of the fish. Juveniles tend to have patches with some interspace and with growth the intervening areas in between the patches become crowded with teeth and no interspace is seen. In our examination of 58 examples of *T, thalassinus* this is clearly demonstrated (Fig. 1). The above distribution of material examined in respect of size and position of the teeth patches illustrate the fact.

It would appear that *T. serratus* (Day) represents only the juvenile of *T. thalassinus*. It may be noted that Day's species has not been subsequently recorded. Further, the other characters such as the length of pectoral fin and maxillary barbels are much more variable even within the same size groups amongst individuals, and as such undependable.

In view of the above reasons, *T. serratus* (Day) is relegated to the synonymy of *T. thalassinus* (Rüppell).

We are thankful to the Director, Zoological Survey of India, for facilities.

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