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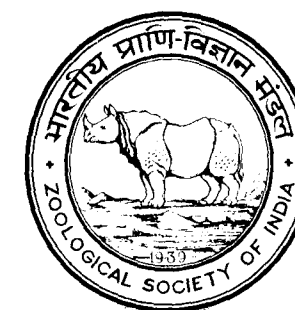
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Studies on Indian Enchytraeidae (Oligochaeta : Annelida)—I

Description of three new Species

BY N. R. PRABHOO,

(Department of Zoology, Government College, Chittur-Cochin).

(With 3 Text-figures)

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Introduction

Though a good amount of work has been done on Indian Oligochaeta in general (Stephenson 1924, 1928, 1930; Aiyar 1929) the group Enchytraeidae has received only little attention. The only information available regarding this group is from the study of Stephenson (1928) who has recorded three species of *Enchytraeus* and two species of *Fridericia*. Out of Stephenson's three species of *Enchytraeus*, *Enchytraeus barcudensis* has later been separated and placed under a new genus *Stephensoniella* by Cernovitov (Nielson and Christenson 1959). Nielson and Christenson (1959) in their critical revision of the European species of Enchytraeidae however, regard this genus to be of doubtful validity but prefer to maintain it in the absence of familiarity with the species. Stephenson (1924) has described another species of *Enchytraeus* from Assam as *Enchytraeus cavicola* (Steph). This species however, correctly accommodates itself in the genus *Hemienchytraeus*, a genus erected by Cernovitov. Thus altogether six species are known from India, belonging to four genera, viz., *Enchytraeus*, *Hemienchytraeus*, *Fridericia* and *Stephensoniella* out of a total of twenty accepted genera of Enchytraeidae.

The species described below are from the collections made during April 1959 to March 1960 from different tea-growing areas at Vandiperiyar and

Wayanad in Kerala. The main task of the collections was to make an investigation into the species composition of the microfauna of the soil leading to a study of the population levels and annual cycles of the species. During a total of seven visits made at different seasons of the year to the sites mentioned above, Enchytraeidae were found to be present in considerable numbers. On examination, three new species have come to light and they are described below.

Material and Methods

The specimens were collected from soil samples taken from a depth of 2 cm. to 8 cm. The worms were separated from small quantities of the soil by a steel needle with the aid of dissection microscope and brushed into spring-water in which they were kept for 12 to 24 hours. By this time the activity of the worms was very much retarded and they had emptied much of their gut contents. They were then examined alive. Subsequently the worms were placed in watch glass and were fixed individually by splashing hot 10% formalin and were then stored in 10% formalin. Transverse and longitudinal sections, 10 μ thick, were cut and were stained in Heidenhain's Iron Haematoxylin or Mallory's Phosphotungstic Haematoxylin.

Genus *ACHAETA* Vejodovsky 1877.

This genus is characterised by the absence of setae, but certain ovoid or pear-shaped transparent bodies called setal follicles occupy the position of some or all missing setal bundles. The transition between oesophagus and intestine more or less sudden. Intestinal diverticula absent, peptonephridia absent but oesophageal appendages present (some of which have been called peptonephridia). Dorsal vessel originates in VI, VII or VIII. Lymphocytes of one kind. Nephridia with well developed interstitial tissue. Sperm sac compact when present. Egg sac absent. Spermathecae without diverticula and not communicating with oesophagus.

This is the first record of this interesting genus from India.

ACHAETA NIELSENI sp. nov.,

Description: (Fig 1.) Medium sized species about 8 mm. to 10 mm. long; segments 34 to 38. Only dorsal setal follicles present, large, more than half the diameter of the body. Clitellum extends over XII to XIII; gland cells of the clitellum more or less rectangular, arranged in transverse rows. Three pairs of septal glands in septa IV/V, V/VI and VI/VII, well developed and all united dorsally. First and second pair slightly larger than the third and are provided with anteriorly directed ventral lobular extensions. Chloragogen cells begin from VII forming a dense layer in the preclitellar region, posteriorly the cells larger, containing refractile globules. Dorsolateral oesophageal appendages absent. Lymphocytes oval or spindle shaped. The latter about one-third the diameter of the worm. Dorsal blood vessel originates in VII, no heart-like enlargements observed at the origin. Seminal vesicles

present. Sperm funnels almost cylindrical, three times as long as broad, with a distinct collar, narrower than the funnel, provided with a dense fringe of cilia. Sperm duct pulsatile wound into a loose spiral. Spermathecae short confined to V. The elongated ectal end gradually narrows into a very short duct which immediately enlarges into a small ampulla almost of the same size as the ectal enlargement mentioned above; no distinct canal; whole of the spermatheca has a wavy outline.

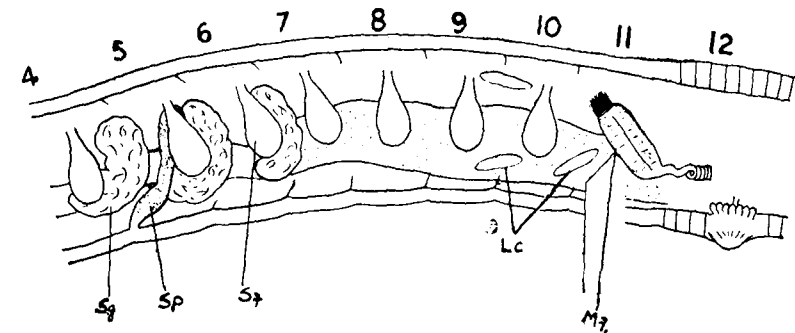


Fig. 1 *Achaeta nielsenii* sp. nov. Side view, segs IV-XII.

Mf. - Male funnel, Sf-Setal follicle, Sg-Septal Gland, Sp-Spermatheca, Lc-Lymphocyte.

Holotype: On slide to be deposited in the Zoological Survey of India.

Paratypes: In 10% formalin to be kept in the Zoological Survey of India and in the Department of Zoology, University College, Trivandrum.

Locality: Anakkal Estate and Churakkulam Estate at Vandiperiar. 2,000 to 3,000 feet above sea level.

Notes on Habitat: Collected from moist soil around the tea-bush, concentrated in the layer 2 cm. to 6 cm. deep, but also found in small numbers even up to 12 cm. depth. Found in large numbers in moderately wet loamy soil, but scanty in very wet clayey soil.

Discussion: The new species described above resembles closely *A. bohémica* Vjeodovsky in the number of segments, presence of only dorsal setal follicle, absence of dorsolateral oesophageal appendages and origin of chloragogen cells, but differs from it in that the spermathecae are short and confined to V instead of extending into VII, seminal vesicles present and dorsal blood vessel originating in VIII instead of VII. It resembles *A. camerani* Cognetti in the size and shape of the spermathecae, origin of dorsal blood vessel and in the nature of lymphocytes, but can be distinguished from the latter by the presence of setal follicles, absence of dorsolateral oesophageal appendages, presence of seminal vesicles and origin of chloragogen cells in VII instead of V.

The species is named after Dr. C. O. Nielsen of Møls laboratory, Denmark, in appreciation of his courtesy and help in this investigation.

ACHAETA INDICA sp. nov.,

Description: (Fig. 2) Small species about 7 mm. long; segments 31 to 36. Setal follicles absent. Clitellum extending from XII- $\frac{1}{2}$ to XIII with gland cells as in *A. nielsenii* sp. nov. Certain triangular, granulate masses in some segments extend into the body cavity. Brain cylindrical two and half times as long as wide, not incised behind. Septal glands three pairs, well developed, united dorsally. Those at IV/V and V/VII slightly larger than that at VI/VII. Chloragogen cells arise from V and from a dense layer from VIII. Dorsolateral oesophageal appendages present, well developed. Lymphocytes discoidal rounded, nucleate and densely packed with granules; about one-fourth or one-fifth the diameter of the body. Dorsal blood vessel arises in VII. Seminal vesicles present. Sperm funnels cylindrical, three times as

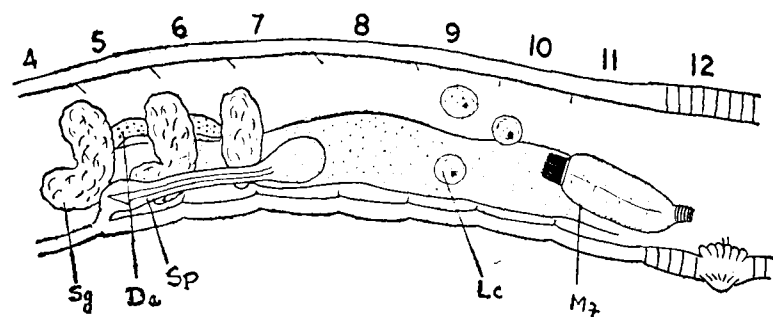


Fig. 2 *Achaeta indica* sp. nov. Side view. Segs IV-XII.
Da. - Dorsolateral Oesophageal appendage, Lc-Lymphocyte,
Mf. - Male funnel, Sg-Septal gland, Sp-Spermatheca.

long as wide, large, occupying the whole of XI and slightly extending into the posterior part of X, provided with a distinct collar possessing a dense fringe of cilia; sperm duct coiled. Spermathecae long, extending into VII, with a short almost vertical ectal end, abruptly enlarging into a globular region with a distinct lumen containing spermatozoa; from this region a long duct leads posteriorly, without any conspicuous bendings, and enlarges at VI/VIII into an elongated globular region with a wavy outline suggesting the presence of gland cells; this may be called the ampulla and it occupies the anterior three-fourths of the segment VII. A distinct lumen is visible in the ectal receptacular region and through the duct but not in the ampullary region.

Holotype: On slide to be deposited in the Zoological Survey of India.

Paratype: In 10% formalin to be kept in the Zoological Survey of India and in the Department of Zoology University College, Trivandrum.

Locality: Sentinel Rock Estate, Wayanad. 2,500 to 3,000 feet above sea level.

Notes on habitat: From moist loamy soil 2 to 12 cm. deep, around the tea-bush. Found in largest numbers in level areas on hill tops during early monsoon days.

Discussion: The new species described above resembles *A. camerani* Cognetti in the absence of setal follicles, nature of clitellum and in the origin of chloragogen cells. But this species can be distinguished by the origin of dorsal blood vessel which is in VII instead of VIII, the presence of well developed dorsolateral oesophageal appendages, the lymphocytes discoidal and rounded instead of oval and spindle-shaped, the presence of seminal vesicles, and the length and structure of spermathecae which extend up to VII instead of V. It also resembles *A. maorica* Benham in the absence of setal follicles. Details of lymphocytes and chloragogen cells in *A. maorica* are not known. However, the origin of dorsal blood vessel in X, long spermathecae extending into X with gland cells at the ectal end and very small sperm funnels occupying $\frac{1}{2}$ XI in *A. maorica* are characters which serve to distinguish the species form *A. indica* sp. nov.

Key to known species of *Achaeta*

- | | |
|--|---|
| 1. Setal follicles present in the position of at least some of the missing setal bundles. | 3 |
| Setal follicles absent | 2 |
| 2. Spermathecae confined to V, dorsal blood vessel arises in VIII. | <i>A. camerani</i> Cognetti |
| Spermathecae extending up to VII, dorsal blood vessel arises in VII. | <i>A. indica</i> sp. nov. |
| Spermathecae extending up to X, dorsal blood vessel arises in X. | <i>A. maorica</i> Benham |
| 3. Only dorsal setal follicles present | 4 |
| Both dorsal and ventral setal follicles present | 6 |
| 4. Dorsolateral oesophageal appendages present, septal glands 2 pairs, spermathecae extend up to X, dorsal vessel in VI. | <i>A. vesiculata</i> Nielson & Christensen. |
| Dorsolateral oesophageal appendages absent, septal glands 3 pairs. | 5 |
| 5. Spermathecae extending as far as VII, dorsal vessel arises in VII. | <i>A. bohemicus</i> Vejdovsky. |
| Spermathecae confined to V, dorsal blood vessel arises in VIII. | <i>A. nielsenii</i> sp. nov. |
| 6. Spermathecae present | 7 |
| Spermathecae absent. | <i>A. affinis</i> Nielson & Christensen |
| 7. Spermathecae extending as far as X. | <i>A. danica</i> Nielson & Christensen |
| Spermathecae extending only to VII. | <i>A. eisneri</i> Vejdovsky |

Genus. *HEMIENCHYTRAEUS* Cernovsikov 1935.

Setae straight and few in number, 2 in all species known so far. Head pore on prostomium. Dorsal pores absent. Brain slightly incised or

rounded posteriorly, with thick circumpharyngeal connectives. Transition between oesophagus and intestine gradual or more or less sudden. Unpaired dorsal salivary gland. No other oesophageal or intestinal diverticula. Dorsal vessel arising in the clitellar region XII-XIII. Blood colourless. Three pairs of primary septal glands. Interstitial tissue of nephridia well developed; anteseptal large consisting of funnels and coils of nephridial canal; origin of efferent duct variable in position. Sperm duct long, often coiled into a spiral. Penial bulb compact but often much reduced in size. Spermathecae simple and not communicating with the oesophagus.

HEMIENCHYTRAEUS THEAE sp. nov.,

Description: (Fig. 3) Medium sized worms about 10 mm. to 12 mm. long, somewhat whitish in colour when mature. Segments 31 to 41. Prostomium rather conical, with a large head pore. Dorsal pores absent. Cutaneous

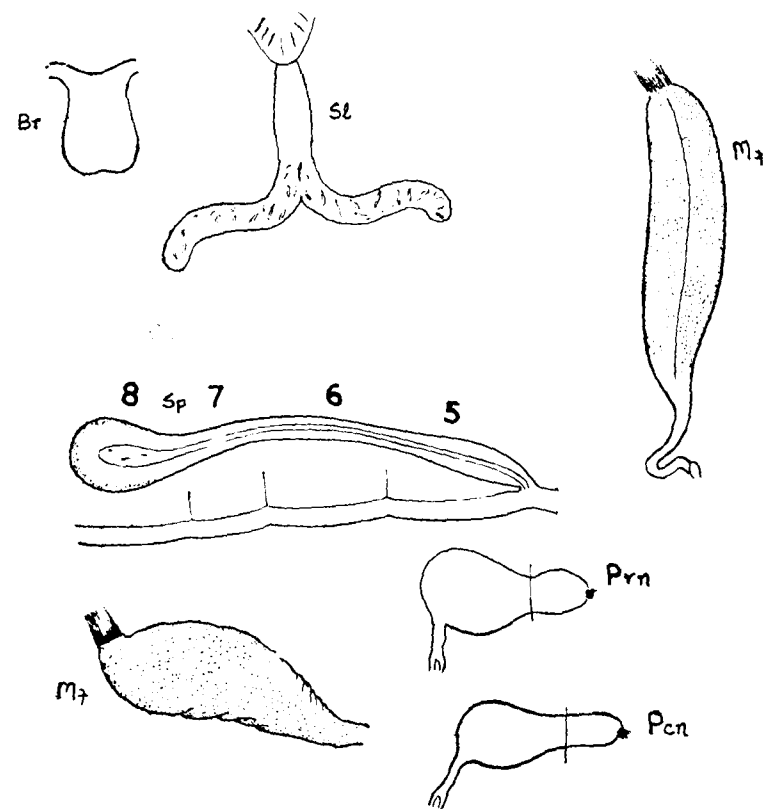


Fig. 3 *Hemienchytraeus theae* sp. nov.

Br. - Brain, Mf-Male funnel in live specimen, Mf'-Same after fixation,

Pcn. - Pre clitellar nephridium.

Pcn. - Post clitellar nephridium, Sl-Salivary gland.

Sp. - Spermatheca.

Numerals indicate the number of segments.

glands present in three rows per segment, one row at the level of setal bundles; a second anterior to and a third posterior to the level of setal bundles; they are very small and inconspicuous. Setae four bundles per segment and two setae per bundle throughout the length of the body, straight distally but with distinct ental hook. Clitellum extends over XII, with gland cells irregularly arranged, in live specimens not arched but becomes arched after fixation because of the constriction of its anterior and posterior extremities. Septal glands three pairs, well developed, anterior two pairs united dorsally. Salivary glands unpaired with a dorsal median thin walled tube arising just behind the pharynx and bifurcating posteriorly, the branches occupy the segment IV to lie above first pair of septal glands, curve downwards and forwards and end near the ventral setal bundles; secondary branches or appendages absent; branches slightly longer than the median tube. Chloragogen cells begin from half of VI. contain refractile globules. In the antecitellar region both anteseptal and postseptal are short and globular; there is distinct constriction at the region of the septum; efferent duct postero-ventral and vertical, coils of nephridial canal clearly visible in the postseptal. In the post-clitellar region both anteseptal and postseptal more elongated and narrower than that at the antecitellar region; efferent duct inclined and directed posteriorly. Lymphocytes spindle-shaped and oblong, former about the same size or slightly smaller than the length of the setae occurring in large numbers posteriorly. Brain slightly incised posteriorly, about one and a half times as long as broad, with thick circumpharyngeal connectives. Seminal vesicles present. Sperm funnels elongated and narrow, about four times as long as broad, without distinct collar, occupying the whole of XI; sperm duct does not extend beyond XIII. Spermathecae simple, extending into VIII; whole of ampulla in VIII with a wavy outline and distinct lumen containing bulk of spermatozoa; it narrows at VIII/VII to form a long duct which slightly enlarges in V to form an elongated ectal end. A canal is visible throughout the ectal receptacle and duct which expands in the ampulla. No accessory glands.

Holotype: On slide to be deposited in the Zoological Survey of India.

Paratypes: In 10% formalin to be kept in the Zoological Survey of India and Department of Zoology, University College, Trivandrum.

Locality: Anakal Estate and Churakkulam Estate at Vandiperiyar 2000 to 3000 feet above sea level.

Notes on habitat: The worms occur in large numbers especially in low level areas in moist soil around the tea-bush at a depth of 2 cm. to 10 cm. more concentrated in the layer 2 cm. to 6 cm. deep. Mature forms occur in largest numbers during February April.

Discussion: The new species described above differs from all other known species of *Hemienchytraeus* by its combination of characters. It, however, approaches very nearly *Hemienchytraeus* (*Enchytraeus*) *cavicola* especially

in the structure of spermathecae and nephridia. But it is easily distinguished from *H. cavicola* by the comparatively large sperm funnels occupying the whole of XI, the absence of post pharyngeal bulbs, the uncoiled and thick cylindrical branches of the salivary gland, three rows of cutaneous glands per segment and the possession of a large head pore on the prostomium. The possession of a head pore is characteristic of the genus *Hemienchytraeus* and its absence in *Hemienchytraeus cavicola* (Steph) together with the rather incomplete description of species, make it necessary to re-examine the type specimen of Stephenson to recognize its correct taxonomic status.

Summary

Three new species of Enchytraeidae viz, *Achaeta nielsenii*, *Achaeta indica* and *Hemienchytraeus theae* are described. They are collected from moist humus from tea-growing tracts of South India.

Acknowledgements

I have great pleasure in expressing my indebtedness to Dr. K. K. Nair, Professor of Zoology, Government College, Chittur-Cochin for guidance and instruction. I am grateful to Dr. C. O. Nielsen and Dr. B. Christensen of Denmark for examining the material and confirming the determination of species and offering their comments. I am thankful to Professor T. N. Ananthakrishnan of Loyolla College, Madras, for making available some references and to Professors C. K. D. Panicker and R. R. Iyer of Government College, Chittur for certain facilities for my work. I am obliged to the Indian Tea Board for financial aid which made this work possible.

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The Dorsal Metathoracic Spines of *Labidura riparia* Pallas (Labiduridae, Dermaptera) and their Functional Significance

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(Communicated by Prof. S. M. H. KHATIB, F.Z.S.I.)

(With 3 Text-figs.)

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Introduction

During the progress of studies on the biology and morphology of *Labidura riparia* Pallas, it was observed that this earwig is entirely incapable of flight. The living insects were induced to fly in various ways but they never made any attempt. The power of flight seems to have been totally lost although both the wings are well-developed. The wing, muscles however, are degenerate. The contentions of Walker (1869) and Eastop (1953) that the forceps in *Labia minor* are used occasionally for unfolding the wings by unlocking the spines does not, therefore, hold good in this species.

Eastop (1953) records the presence of hook-like spines on the dorsal surface of metathorax in the families Labiduridae, Labidae and Forficulidae, but he could not describe in detail the metathoracic spines in *Labidura riparia* for lack of sufficient material.

Description

In *Labidura riparia*, on either side of the conspicuous mid-dorsal ridge in the metathorax (Fig. 2. *sp*) there are three alternating rows of hook-like hairs

with pointed apices bent downward. These hairs are more dense posteriorly. The number of hairs on each side is more than seventy as against forty in

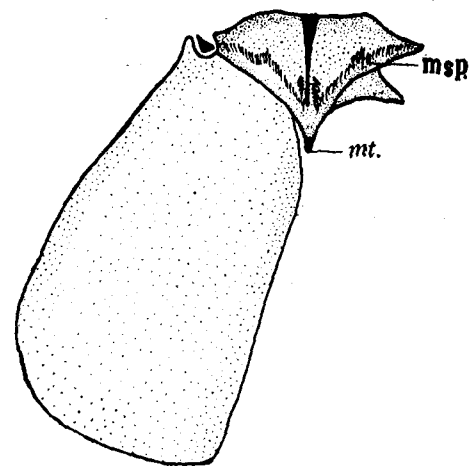


Fig 1.

Labia minor. The hairs of the innermost row are the longest, those of the middle row are very short, and of the outer row slightly shorter than the hairs of the inner row.

Anteriorly, each elytron bears a prominent longitudinal ridge on its under surface near the inner edge on which are borne about fifty thick and short spines pointing downwards. (Fig. 3. *sp*). The ridge gradually fades out as the posterior region is reached. In repose the spines on the ridge are

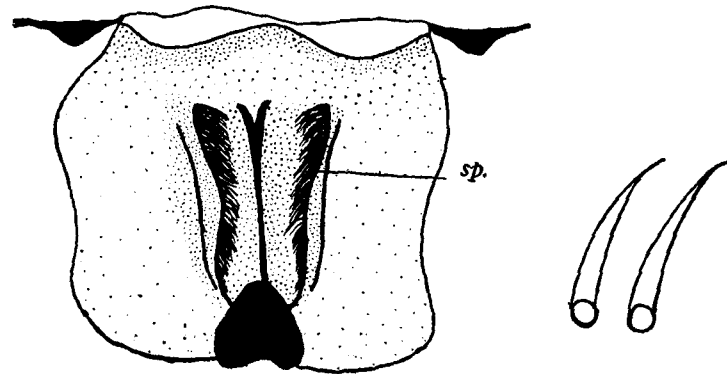


Fig 2.

interlocked with the long sweeping hairs of the metathorax, thus keeping the elytra in position. These spines are more closely packed anteriorly than

posteriorly. The two hind wings are folded so as to leave a space in between through which the elytral spines and the metathoracic hairs are in contact. Eastop (1953) thinks that the mid-dorsal tubercle (Fig. 1. *mt*) borne on the mesothorax and which overlaps the metathorax in *Labia minor* is concerned with the opening of the elytra. No such function can be ascribed to the dorsal mesothoracic tubercle in *Labidura riparia*.

Eastop (1953) agrees with Walker (1869) regarding the function of the forceps in *Labia minor*, according to whom they are only used for unfolding the wings by unlocking the spines. Since *Labidura riparia* does not open out its wings the forceps are used for offence and defence only as described by Burr (1910).

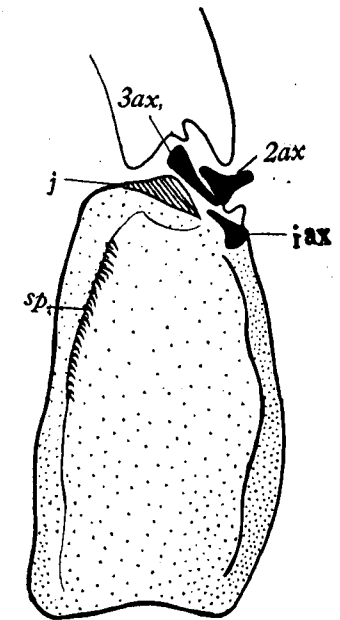


Fig 3.

Summary

The arrangement of the metathoracic hairs and the elytral spines has been described in detail for the first time in *Labidura riparia*.

Since the insect never takes to wings the mesothoracic tubercle cannot be "concerned in opening the elytra" as is suggested by Eastop (1953). The forceps has also no role in unfolding the wings and its only function is offence and defence.

The wing muscles are degenerated although the wings are well developed. All attempts to induce the animal to take to wings failed.

Acknowledgments

I wish to express my deep gratitude to Dr. S. M. H. Khatib, Head of the department of Zoology, College of Science, Nagpur, for his valuable guidance and encouragement. My thanks are also due to Dr. L. B. Kajale, Principal, College of Science, Nagpur, for providing all the facilities to work in the institution, and also to the Nagpur University for the award of the Research Training Scholarship.

List of Abbreviations

1. ax—First axillary sclerite
2. ax—Second axillary sclerite
3. ax—Third axillary sclerite
- j—Jugum
- m.sp.—Meso-thoracic spine
- mt.—Mid-dorsal tubercle
- sp.—Spines

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Copepods Associated with Indian Mollusks

(a) Description of *Conchylivorus maximus* sp. nov.,
(Cyclopoida-Clausidiidae) from *Sanguinolaria (Soleletellina) diplos* (Gmelin)
(Lamellibranchiata - Psammobiidae)

BY KOSARAJU REDDIAH,*

Annamalai University Marine Biological Station, Portonovo.

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Introduction

The genus *Conchylivorus* was created by Bocquet and Stock (1957) with *C. solensis* as the type species and distinguished from the eight already existing genera of the family Clausidiidae by the structure of the antenna, the mandible and maxillule, by the presence of the paragnaths and by the lichomolgoid type of the 5th leg. *C. solensis* was obtained from the mantle cavity of *Solen marginatus* Don., in the coast of France near Roscoff. Gooding (1957) described another species, *C. cardii* Gooding from *Cardium echinatum* L. in Bighury Bay near Plymouth, England. The following year Bocquet and Stock downgraded Gooding's species into a subspecies and referred to it as *C. cardii cardii* Gooding, restricting its occurrence in *Solen marginatus*, *Cardium echinatum* (type host) and *Meretrix chione* (L.). They then erected a new subspecies, *C. cardii tapetis* Bocquet and Stock as occurring in *Tapes decussatus* (L.) (type host), *T. pullastra* (Montagu) and *T. aureus* (Gmelin). Humes and Cressey (1958) added two other species, *C. torosus* Humes and Cressey and *C. lobatus* Humes and Cressey, obtained from *Macra glabrata* L. (type host) and *Cardita ajar* Bruguiere (type host) respectively, which were dredged off Lumley beach, Free town, Sierra Leone in west Africa. *C. torosus* was also found in *Macra largillerti* at Pointe-Noire.

The genus *Conchylivorus* has now been found in the Indian waters for the first time being represented by *C. maximus* sp. nov., occurring in the mantle cavity of *Sanguinolaria (Soleletellina) diplos* (Gmelin) at Puddupetta near Portonovo, (Coromandal coast), South India. *C. maximus* is the largest

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of all the species of the genus so far described, and the specific name '*maximus*' is therefore proposed.

***Conchylurus Maximus* sp. nov.,**

Types: 17 ovigerous adult females and 7 non-ovigerous adult females and 18 adult males were obtained from the mantle cavity of 25 adult hosts of *S. (Soletellina) diplos* dug out in the beach in low tide at Puddupetta near Portonovo, on 9th February 1960. Holotype and allotype and paratypes (4 ovigerous adult females and four adult males), all preserved in about 10% formalin have been sent to the British Museum (Natural History). About the same number of paratypes have been sent to the United States National Museum, Zoologisch Museum, Amsterdam Museum National d'Histoire Naturelle, Paris and the Indian Museum, Calcutta.

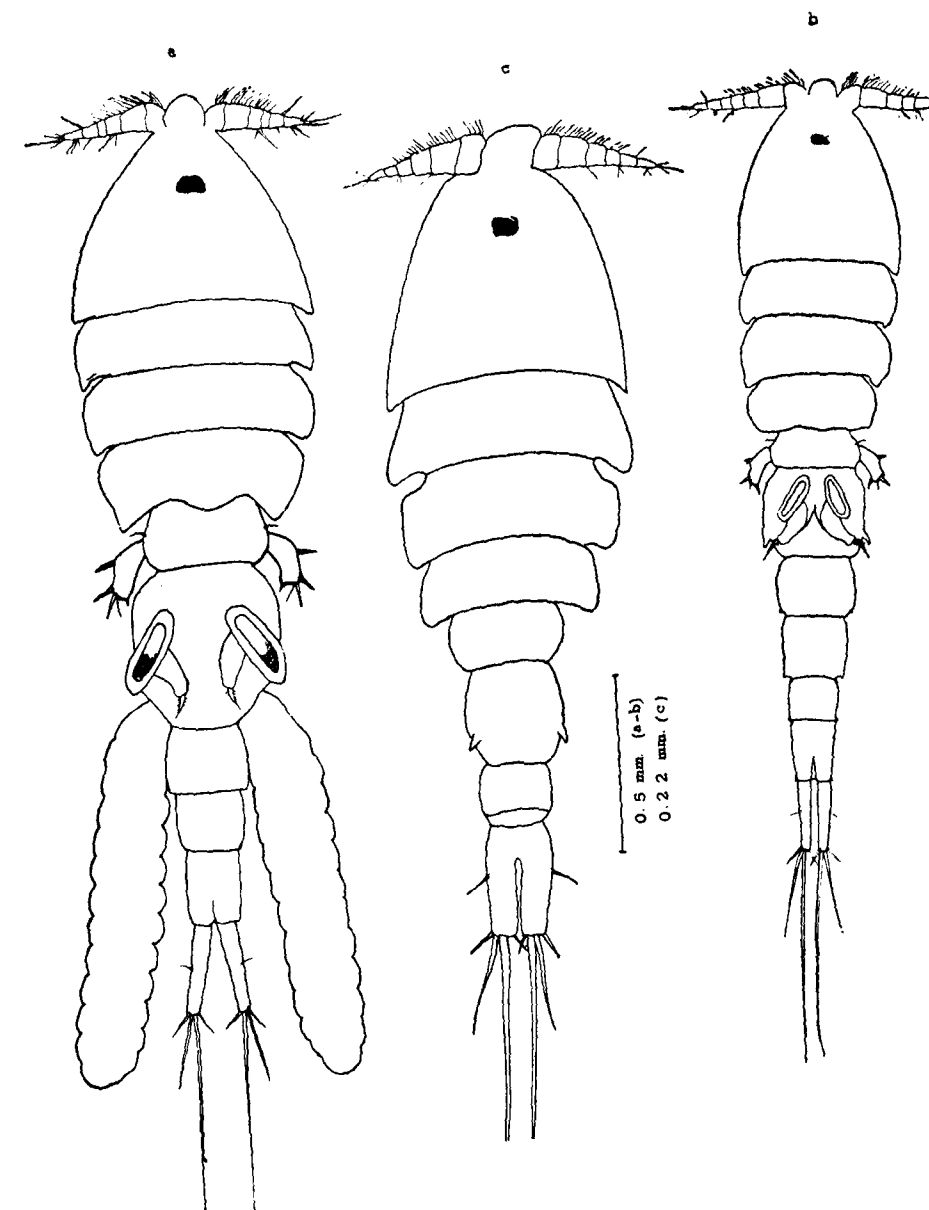
Description of the adult female: Mean length (from the tip of the rostrum to the end of the caudal rami) 2.5 mm. ranging in size from 2.3 to 2.8 mm. and a mean width of 0.57 mm. ranging in size from 0.5 to 1.63 mm., based on the measurement of 15 specimens.

The body shape (Text-fig. 1 a) is cyclopoid. The middle part of the prosome is moderately expanded. The cephalosome is narrower in front and measures about half the total length of the prosome. The cephalosome and the succeeding metasomal segments are produced at their postero-lateral corners. The 4th pedigerous segment is slightly longer but less wider than the two preceding segments. The posterior part of this segment presents a distinct wavy outline. The length of the cephalothorax including the 5th pedigerous segment equals half the total body length.

The genital segment is slightly longer than wide and polygonal in shape. The spermatophoral grooves at its postero-lateral angles are set with deep brown cement for the attachment of spermatophores. The 6th legs arise from about the middle of the segment from an indistinct inter-segmental region. Two long and slender ovisacs are attached to the posteriorly converging sides of the genital segment which extend to about the level of the 2nd (from outside) caudal seta. Each ovisac measures 1.17 mm. in length (range: 0.91-1.25 mm.) and width of 0.17 mm. (range: 0.13-0.2 mm) based on the measurement of 16 specimens. Each ovisac contains about 70 eggs.

There are three post-genital segments of gradually diminishing widths. The first two are about equal in length and each bears a small projection at each postero-lateral corner. The third is slightly longer than either of the preceding two and slightly shorter than the caudal ramus. The two caudal rami are long and slender with two dorsal setae on each, one situated near the middle of the outer margin of the ramus and the other on the inner distal corner. There are four terminal setae on each ramus of which the inner and outer are about equal in length, while the third (from inside) is thrice that of the second in length.

Rostrum (Text-fig. 2 k) is clear in both the dorsal and the ventral views. The front part is almost a square while the basal part is narrower. The median eye is large and conspicuous in dorsal view.



Text-Fig. 1. *Conchylurus maximus* sp. nov., (a) adult female, dorsal view; (b) adult male, dorsal view; (c) immature male, dorsal view.

The antennule (Text-fig. 2. e) is about half the length of the cephalosome and consists of six segments of which the second is the longest and fourth

the shortest. The combined length of the first three segments is about the same as the last three segments together. There are numerous setae on the segments as shown in the figure; the last two segments bear aesthetascs.

The antenna (Text fig. 2 f) is four segmented of which the first is much the longest and on its outer distal corner a long barbed seta is borne. Close to it is a small but conspicuous projection. The proximal end of this segment bears an accessory structure which narrows distally bearing a few spinules on its outer free margin. The second segment bears a barbed seta and at least two rows of denticles similar to those found on the free margins of the leg segments. The third segment bears a strong claw and a feathered seta. The fourth segment bears 7 setae at its tip with the proportionate lengths, shown as in the figure. Of these, only four setae have bent tips. In addition, the second, third and fourth segments bear numerous long bristles on their outer free margins.

The labrum (Text-fig. 2 m) posteriorly, has four lobes of which the middle two are set with minute bristles at their edges. The paragnath (fig. 3) is a vase-shaped structure fringed with fine hairs. Its position between the mandible and maxilla appears to be the same as shown by Humes and Crassey (1958) in *C. lobatus*.

The maxillule (Text-fig. 3 n) is unsegmented with a broad base and possesses three prominent outer setae of equal lengths. The distal part is produced, and its tip is set with one short and two long spines.

The mandible (Text-fig. 3 o) consists of a single long segment. The distal portion has a long narrow neck terminating in three long lappets with the proportionate lengths and widths as indicated in the figure.

The maxilla (Text-fig. 3 q) is 2-segmented. The terminal segment distally presents two lobes on which 3 long stout and pointed spines are borne. They do not, however, give a claw-like appearance as shown by Gooding (1957) in *C. cardii cardii*.

The maxilliped (Text-fig. 3 r) consists of a single segment with a broad base and is spinose on its outer margins. It is also set with patches of fine spinules ventrally (not shown in fig.). Distally it bears a heavily chitinised and strong claw. Gooding (1957) considers that this claw is a modified second segment.

The arrangement of the mouth parts and the post-oral protruberances are as shown in the ventral view of the cephalosome of the adult male (Text-fig. 2 d).

The four swimming legs (Text-fig. 3. s-v), each consists of a 2-segmented protopod, a 3-segmented endopod and a 3-segmented exopod of similar

lengths. The distribution of articulated spines and setae are as shown in table I. The articulated spines are all sheathed and the setae are all plumose. A process situated terminally on each exopod may be regarded as either a long spine or a short seta and is sheathed on its outer and is plumose on its inner margin. It is denoted by an asterisk in table I. In addition to these articulated spines most of the segments bear rows of spinules and fixed processes as indicated in the figures. The characteristic large sheathed spine on the basipodite of the first leg is also present in this species.

The fifth leg (Text-fig. 2. i) consists of a single segment attached to each lateral margin of the fifth pedigerous segment. It has a single unsheathed spine at about the middle of the segment and two sheathed spines on its distal free margin. The inner free margin terminates in an unarticulated spine. The outer terminal sheathed spine has a long plumose seta at its base. The terminal margin has a row of closely set spinules; those near the outer sheathed spine are longer. There is a seta dorsally on each lateral margin of the 5th pedigerous segment at about the origin of the 5th leg.

The sixth legs (in Text-fig. 1 a, b) are represented by a pair of projections bearing finely plumose setae at their tips.

Colour: The colour of the body of the live specimen is light brown and that of the eye spot brick red. Colour of the spermatophores brown.

Description of the adult male: The adult male (Text-fig. 1 b) differs from the adult female in size, in the shape of the body, in the structure of the maxilliped and genital segment and in the number of the postgenital segments.

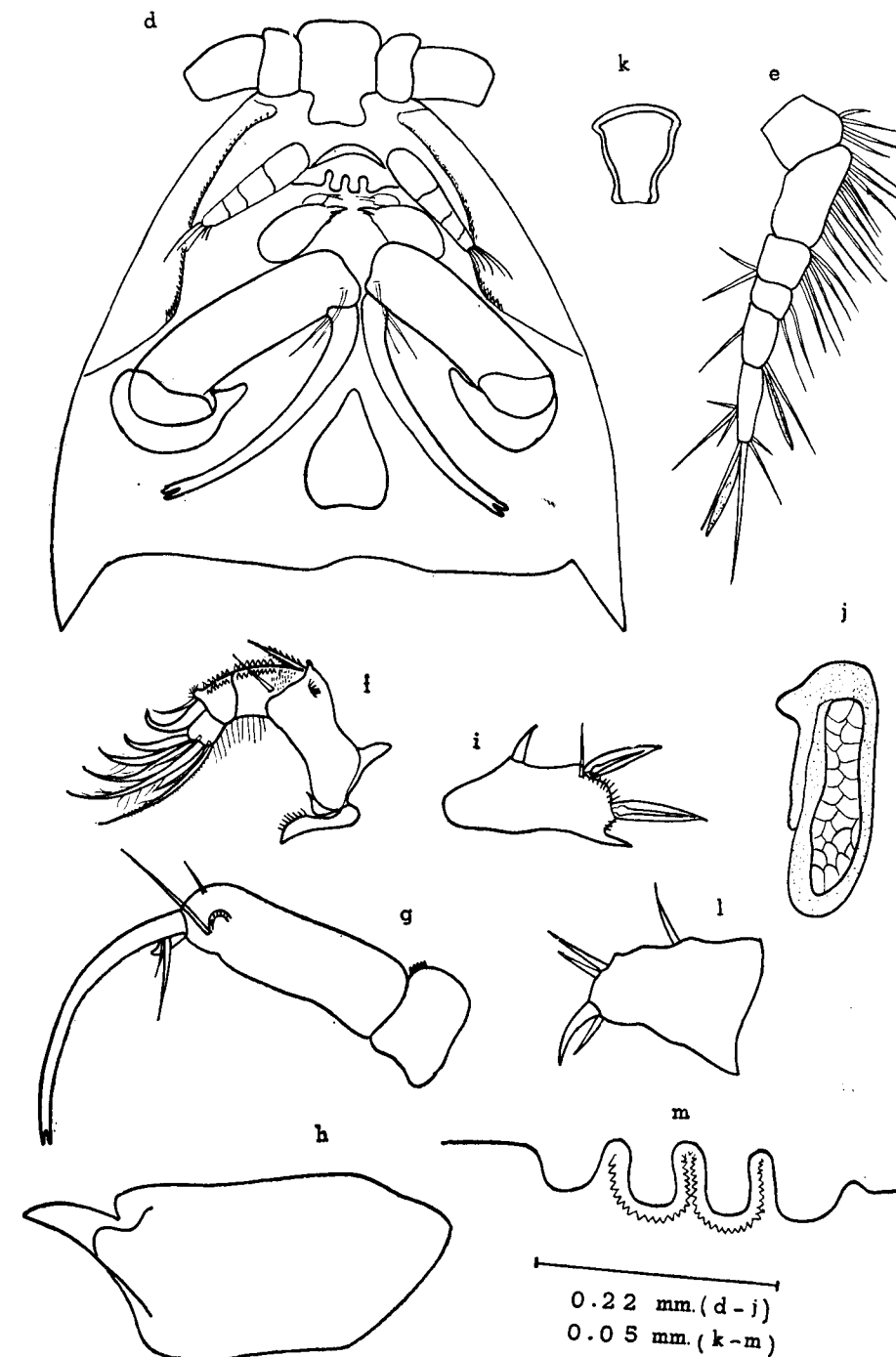
Mean length of the male 2.1 mm. (range: 1.9 mm. — 2.2 mm.) and width 0.46 mm. (range: 0.43 — 0.5 mm.) based on the measurement of 18 specimens. The anterior part of the cephalosome is wider than in the female. The genital segment is nearly a square containing two large spermatophores, each measuring about 0.21 mm. in length. Each spermatophore (fig. 2 j) is three times as long as broad containing follicles of spermatogenic tissue in the centre. The canaliculus extends to nearly 2/3 the length of the spermatophore. The postero-lateral corners of the genital segment form heavily chitinised and thick spines. As common in adult males of Cyclopoids, the number of postgenital segments is four.

The mouth parts resemble those of the female except that the maxilliped (Text-fig. 2. g) bears a long claw. It is three segmented; the basal segment is short and armed with a small row of spinules at its outer distal corner. The second segment is long bearing four unequal setae distally and terminating in a short process and a long claw. The claw bears two or three small serrations in the middle. The fifth leg is similar to that of the female.

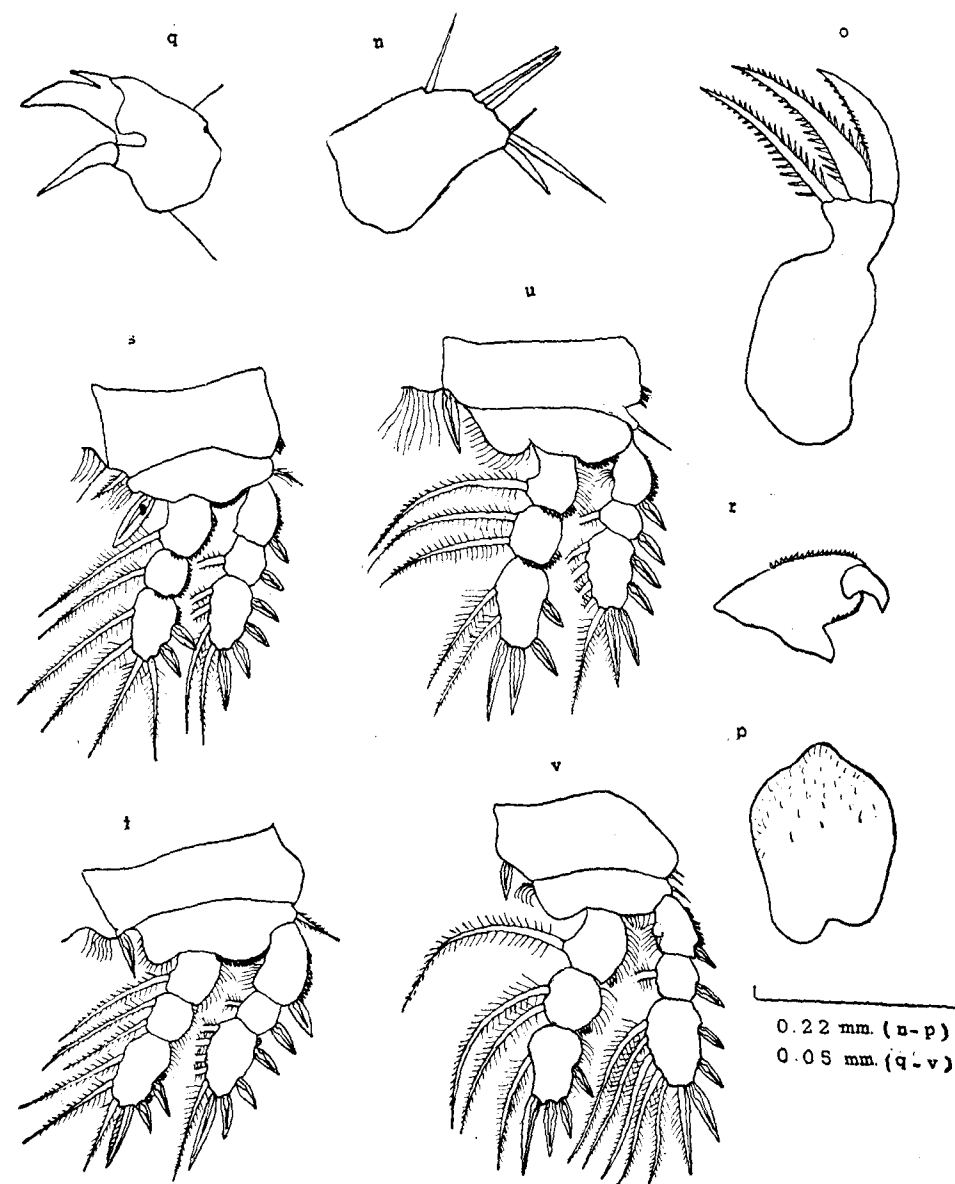
TABLE I.

Articulated processes (spines and setae) on the swimming legs of *C. maximus* sp. nov., Spines are denoted by Roman, setae by arabic numerals. pl-p4, 1st to 4th swimming legs. Si, St, Se., inner, terminal and outer margins of the segments. Numerals marked* include one process intermediate between a spine and a seta.

	Protopod			Endopod						Exopod					
	1	2		1	2	3	3	1	2	3	1	2	3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se
P1	1	0	1	1	1	0	1	0	1	0	0	I	1	I*	III
P2	1	0	0	1	1	0	2	0	2	0	0	I	1	I*	III
P3	1	0	0	1	1	0	2	0	2	0	0	I	1	I*	III
P4	1	0	0	0	1	0	2	0	1	0	0	I	1	I*	III



The plumose setae of the sixth leg are slightly longer than those of the female. The colour of the body and of the eye spot are as in the female.



Text-Fig. 3. *Conchylivorus maximus* sp. nov., Adult female; (u) maxillule (u) mandible; (p) paragnath; (g) maxilla; (r) maxilliped; (s-v) first to fourth legs.

Immature male: One immature male was found in a later collection of about 10 copepods obtained from the same locality. It measured 1 mm.

in length and 0.3 mm. in width. It differs from the adult male in having a small second post genital segment, a small claw to the second segment of the maxilliped (fig. 2 h), and the genital segment without the spermatophores. It differs considerably from the Copepodid V of *C. torosus* described by Humes and Crassey (1958) and it is likely that the immature male of *C. maximus* may have belonged to Copepodid IV.

Affinities and specific diagnosis: *C. maximus* differs from the other species so far described including the nameless species mentioned by Humes and Crassey (1958, p. 928) in size, in the shape of the genital segment, in the presence of an accessory structure to the first segment of the antenna, caudal rami being longer than the last abdominal segment, in the structure of the labrum, in the absence of the setae in the female maxilliped and in the absence of an outer seta on the basipodite of the fourth leg.

C. maximus differs from—

- (a) *C. solensis* in the shape of the cephalosome, in the presence of aesthetascs on the last two segments of the antennule and in the presence of a longer spine in the distal outer border of the 5th leg.
- (b) *C. cardii cardii*: in the shape of the cephalosome, in having a longer outer distal spine of the 5th leg and in the number of eggs in each ovisac being 100.

It agrees with *C. cardii cardii* in the presence of aesthetascs on the last two segments, in having claws with bent tips and in the junctions of the postgenital segments not being crenulated.

Most of the differences observed between *C. maximus* and *C. cardii cardii* appear the same as those as shown by the former with *C. cardii tapetis*. *C. maximus* resembles *C. cardii tapetis* in the shape of the cephalosome.

- (c) *C. torosus*: in the shape of the cephalosome, in the structure of the claws without bent tips, in the shorter and stouter claw of the male maxilliped, in the junctions of the post genital segments being crenulated, and in the number of eggs in each ovisac. *C. maximus* closely approaches this species in the structure of the mandible.
- (d) *C. lobatus*: in the presence of crenulations at the junctions of the postgenital segments. *C. maximus* resembles *C. lobatus* in the structure of the fifth leg.

Bionomics: *C. maximus* is quite common in its host at Puddupetta in the intertidal zone, north of the Velalr estuary. The rate of infestation is two in one on the average; some containing as many as seven copepods in

one host, while others contained none. The copepods are usually free in the mantle cavity and sometimes clinging to the mantle. Which part of the host do these copepods actually infect in nature remains to be observed.

The fact that the female genital segment is set with the spermatophores shows that the eggs have reached maturity. Segmented eggs were also observed in a few cases. This copepod exhibits remarkable host specificity at Puddupetta in that it was not observed in the other bivalves, *Meretrix meretrix* L. and *Catalysia opima* from the same locality.

Summary

A hitherto undescribed species of *conchylurus* (*C. maximus* sp. nov.) is described and compared with the other species of the genus.

Acknowledgements

I am grateful to Prof. R. V. Seshaiya, Director, Marine Biological Station Portonovo, for kindly providing facilities and material for carrying out this work and for his constant encouragement. I should like to extend my thanks to Dr. P. Govindan, Head of the Dept. of Zoology, Annamalai University for supplying me on loan an eye piece micrometer (graticule) and to the University Grants Commission for a Post-Doctoral Fellowship.

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On the Development of the Eel-Like Fish *Symbranchus bengalensis* (McClelland).

BY K. RANGARAJAN* AND J. JACOB,

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S. India).

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Introduction

Fishes of the order Symbranchiformes are represented in Indian waters by only three forms, viz: *Amphipnous cuchia* (Ham. Buch), *A. fossorius* Nayar, and *Symbranchus bengalensis* (McClelland). Though the bionomics of these fishes have been described in some detail (Das 1927, 1946, Nayar 1951) very little is known of their development. This is not surprising as their scanty occurrence and peculiar egg laying habits make them rather difficult material for study and the present observations on the development of *Symbranchus bengalensis* (McClelland) would, it is hoped, be of interest. The occurrence of this species at Portonovo has been recorded earlier (Chacko *et al* 1954).

Material

During October 1959, some eggs and larvae were collected from burrows 1½ — 2 feet deep in the mud flats near station 'B' of the Vellar estuary (Description of Vellar estuary, and location of estuarine stations, vide, Jacob and Rangarajan (1959a). This region is completely exposed during low tides and submerged under high salinity waters during high tides. The eggs and larvae were removed from the burrows during low tide and transferred to the laboratory and maintained in water from the same locality collected during high tides.

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Observations

The earliest stage that we have been able to collect is shown in Fig. 1. The egg is large, more or less spherical and measures about 4.5 — 5.0 mm. in diameter. The yolk is yellow in colour and opaque and embedded in the yolk are a large number of oil droplets. The embryo appears as a thin streak lying flat over the yolk and at this stage when about sixty-four somites could be counted, the anterior end of the neural tube has differentiated into fore, mid and hind brain. The optic cup and the invagination of its outer wall which would later form the lens are also seen. The auditory vesicles have just appeared. There is as yet no sign of circulation.

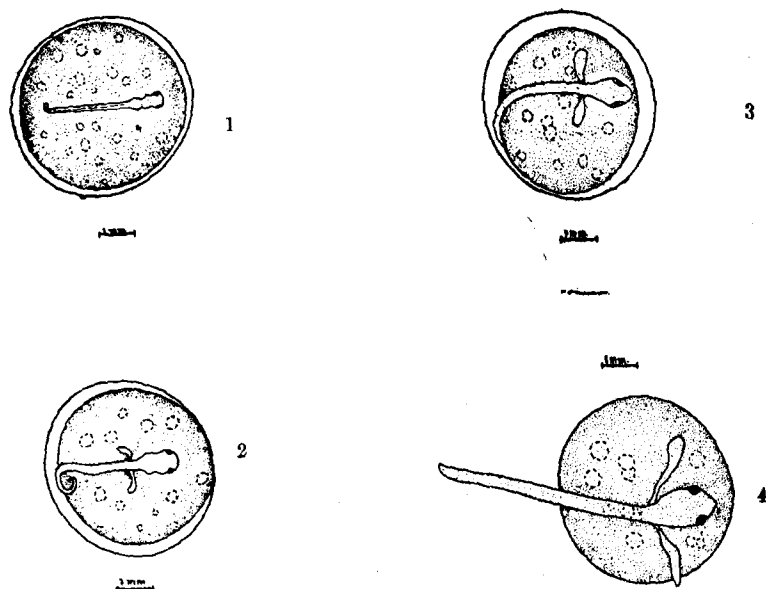


Fig. 1. An egg in an early stage of development. (Dorsal view)

Fig. 2a. An egg four days later to that shown in Fig. 1. (Dorsal view).

Fig. 3. An egg nearly six days after that in Fig. 1 and just before hatching. (Dorsal view).

Fig. 4. An 8 mm. larva, two days after hatching. (Dorsal view).

Within the next twenty-four hours, the embryo increases in length and shows various developments. At the end of this period 122—125 somites could be counted. The anterior end is now slightly elevated from the yolk and the eye has differentiated further, the lens being formed. The heart is formed and it now pulsates at the rate of about 70 beats per minute. The alimentary canal is also formed and it opens to the exterior at the level of the 68th somite. Small buds which later develop into the pectorals make their appearance on the next day, viz., the third day after collection.

Four days after collection, the embryo appears greatly increased in size, and the tail now lies curved over the yolk as shown in Fig. 2a. At this stage four pairs of gills are clearly seen and the pectorals are well developed lobate structures (Fig. 2 b.). The dorsal and anal fins could be made out as thin membranous folds and are continuous around the tail. There are 127 somites present of which 67 are pre-anal. The dorsal fin originates at

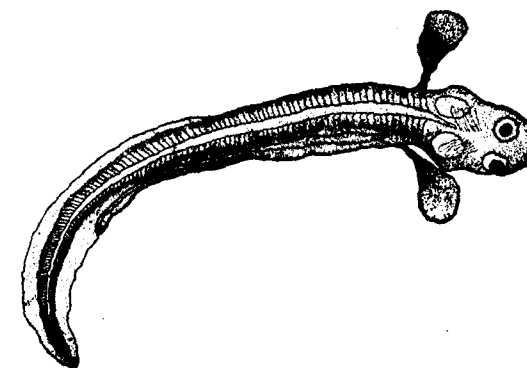


Fig. 2b. An embryo at about the stage shown in Fig. 2. a. (Dorso-lateral view).

about the level of the 38th somite and the anal appears to arise from just behind the vent. At this stage circulation is well established, the blood is slightly red in colour and the heart beats vigorously at the rate of about 90 per minute. The embryo now exhibits vigorous movements of the tail.

After another two days, viz., 6 days after the earliest stage described in this report, the embryo hatches out. During this period (4—6 days) the general increase in the dimensions of the embryo may be seen by comparing Figs. 2 a and 3. The embryo just before hatching (Fig. 3) lies curved over the yolk. The eyes are developed and the pectorals are alternately flapped about forward and backward. The circulation is vigorous and the blood vessels (not shown in the figure) ramify over the yolk. The dorsal aorta travels backward till the end of the tail, then takes a sharp turn and travels forward a short distance to emerge out of the embryo just posterior to the anus. It then divides into three branches which after a tortuous course through minute ramifications over the yolk, join the heart anteriorly as three branches. Two blood vessels that branch out from the aorta just anterior to the base of the pectorals, travel forward one on either side of the head and also join the heart.

The vigorous lashing movements of the tail puncture the chorion and the embryo wriggles out, tail emerging first. A larva two days after hatching is shown in Fig. 4. It measures about 8 mm. in length and the major portion of the yolk being still unabsorbed, persists as a spherical mass. The pectorals are most conspicuous and active at this stage. The dorsal fin fold

now appears to arise slightly in front of the level of the anus instead of the level of the 38th somite and is continuous around the tail with the similarly membranous anal, which as before, appears to commence behind the vent. The first traces of pigmentation now appear on the dorsal surface of the larva, a little posterior to the pectorals.

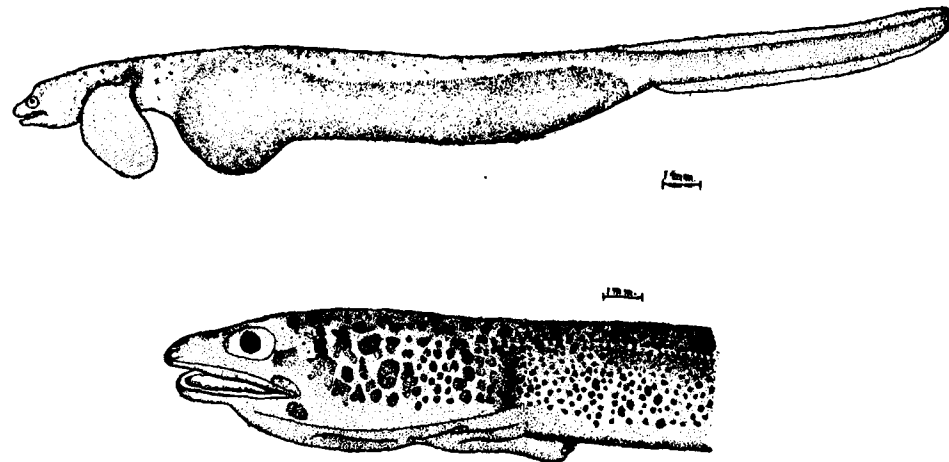


Fig. 5. A 24 mm. larva. (Dorsal view).

Fig. 6. The head of a juvenile specimen of *Symbranchus bengalensis* (Side view).

Further development of the larva:—The stage next examined was a 24 mm. larva (Fig. 5). The persisting yolk mass at this stage is reduced and much elongated, extending from a little behind the pectorals to about the anal opening. The upper jaw is slightly longer and the tips of both the jaws are rounded and fleshy. The cleft of the mouth is nearly horizontal and extends beyond the posterior edge of the orbit. The gill openings are confluent and the single slit is situated medianly on the ventral side. The dorsal and the anal fins are low membranous folds without fin rays and extend as in the 2-day old larva described earlier. A caudal fin is hardly present. The pectorals are now comparatively reduced in size and appear more rounded.

In another 30 days the larva described above grows to a length of about 42 mm. when the yolk mass is imperceptible, being present only as a thin streak along the ventral side. The juvenile (Fig. 6) has now almost assumed the appearance and general characteristics of the adult described by the earlier authors (Day 1878, Nayar 1951), the pectorals having completely disappeared even when the larva measured 35 mm. in length.

Summary

Some developmental stages of the eel-like fish *Symbranchus bengalensis*, obtained from the mud flats in Vellar estuary have been described. Though

it has not been possible to determine the exact age of some of the examined stages, the characteristic features during development such as the early appearance of the pectorals, their gradual shrinking and final disappearance, the time of appearance, the nature and extend of the dorsal and anal fins, etc., etc., have been followed.

Acknowledgment

It is a pleasure to thank Prof. R. V. Seshaiya for his interest and encouragement.

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A New Genus of Trematode *Paragemmaecaputia* (Monogenea) from the gills of *Sphyraena obtusata* Cuv. & Val.*

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South India)

(With 5 Text-figures)

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Introduction

While examining fishes obtained at Mandapam for their gill parasites, the author collected twelve specimens from the gills of *Sphyraena obtusata* Cuv. & Val. These specimens differ from the known genera; hence they are treated as a new genus and a detailed account of it is presented in this paper.

Paragemmaecaputia crassicauda n.g. et n.sp.

These worms are elongate and narrow; their length ranges from 1.25 mm. to 1.92 mm. The sides of the body are almost parallel from the level of the beginning of the testes to the proximal region of the haptor and its width is approximately one-seventh the total length. The width of the body anterior to the testes narrows gradually; it is half the maximum width about the level of the intestinal bifurcation and beyond this level to the anterior end, the sides of the body are almost parallel. This portion forms something like a 'neck' to the body and the anterior end has a square margin. Head glands numbering 14 are arranged in a row in the region in front of the buccal suckers. The worm presents a corrugated appearance from the level behind the anterior third of the oviducal field to the region in front of the haptor. The haptor is approximately one-seventh the total length and four

pairs of clamps are present on short peduncles. The clamp is of the gastro-cotylid type. Its size ranges from $44 \times 44 \mu$ to $72 \times 57 \mu$. The haptor ends in a median terminal lappet, 0.08 mm. to 0.12 mm. long. It has three dissimilar pairs of anchors; the outer pair is from 27μ to 30μ the inner pair is from 14μ to 17μ and the middle pair is from 12μ to 14μ .

Mouth is subterminal. The buccal suckers are aseptate and their size ranges from $30 \times 18 \mu$ to $42 \times 20 \mu$. The pharynx is oval and its size ranges from $25 \times 22 \mu$ to $48 \times 31 \mu$. Intestinal bifurcation is situated at a distance equal to one-fifth of the total length of the worm from the anterior end. The intestinal limbs extend to the level of the second pair of clamps where they terminate blindly.

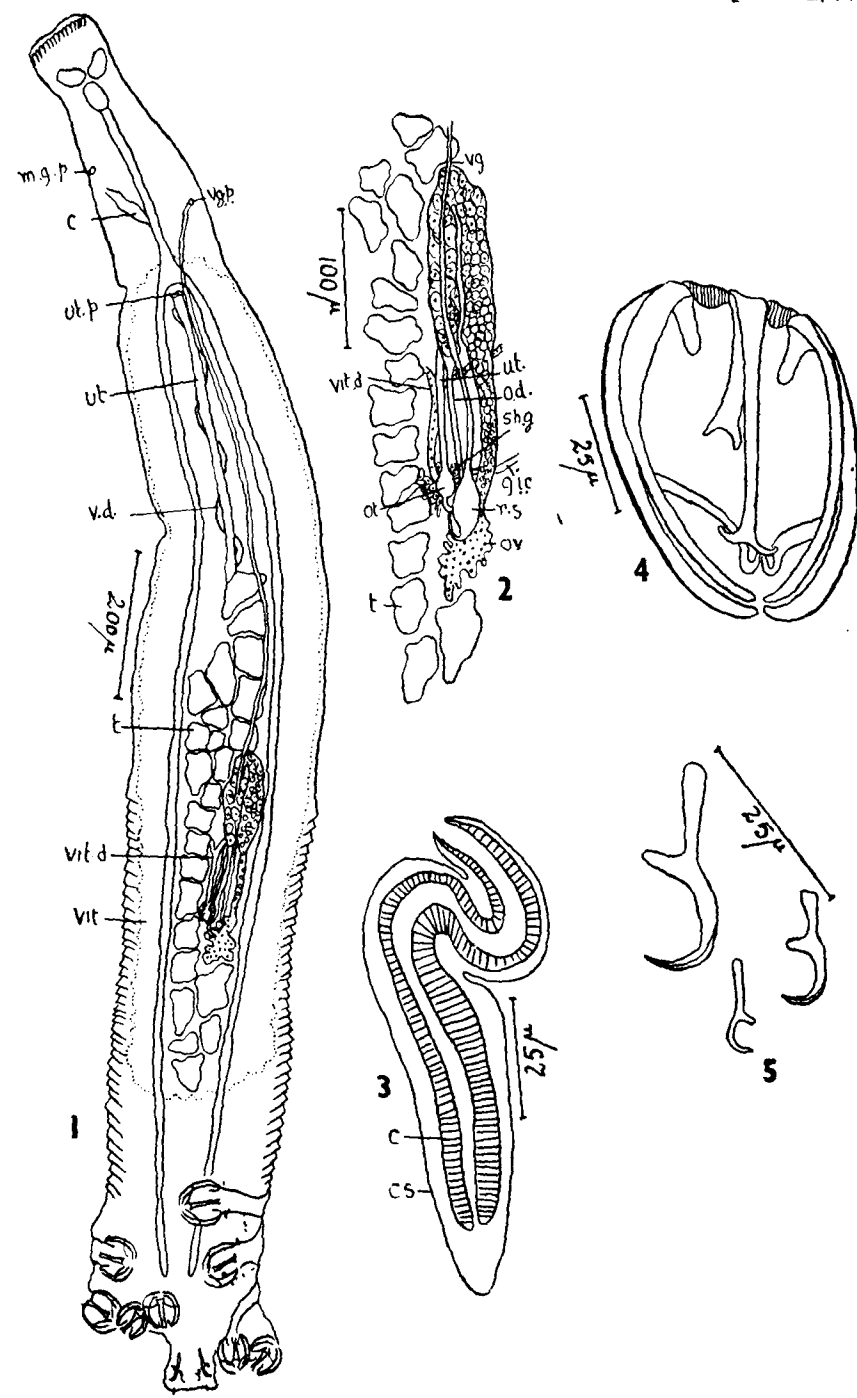
Testes zone occupies the anterior four-sevenths of the hinder half of the worm and it extends into the proximal half to a distance equal to one-sixth of its (proximal half) length. The number of testes ranges from 22 to 25 of which 10 to 14 are pre-ovarial, 6 to 8 are para-ovarial and the rest are post-ovarial. The para-ovarial testes are arranged one behind the other close to the left caecum whereas the pre and post-ovarial testes are arranged in two irregular rows. The size of the testes ranges from $24 \times 16 \mu$ to $82 \times 48 \mu$. Vas deferens is median up to the level of the intestinal bifurcation and beyond the level it is lateral on the left side close to the oesophagus. It opens at the unarmed muscular cirrus which is $70 \mu - 83 \mu$ long. Male pore is submarginal and is also unarmed. It is situated about half way from the anterior end to the region of the intestinal bifurcation.

Ovary is lobed and its size ranges from $56 \times 45 \mu$ to $81 \mu \times 55 \mu$ and it is situated close to the inner side of the right caecum at the junction of the middle third with the hinder third of the worm. The oviduct also extends parallel to the right caecum, close to it, on the inner side to a length equal to one third the length of the testicular zone. It curves backwards and extends halfway down. The distal end of the oviduct is continued by a narrow duct which curves in front of the ovary. It is enlarged into the ootype which is surrounded by the shell glands. Beyond the ootype the oviduct is continued as the uterus which is median and opens by a transverse slit-like opening situated immediately behind the intestinal bifurcation. The horizontal slit ventral to the bifurcation of the oesophagus in *Gemmaecaputia corrugata*, referred to as the vaginal opening by Tripathi (1957 p. 110, Fig. 50) might probably correspond to the uterine opening.

Vitelline follicles extend from the region of the intestinal bifurcation to the end of the testes region. Transverse vitelline ducts originate about the middle level of the oviducal field. They unite to form the common vitelline duct about the same level and it extends posteriorly to a length equal to one third the length of the oviducal field. Posteriorly it opens at the ootype. Genito-intestinal canal runs obliquely in front of the ovary and opens at the

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Figs. 1-5. *Paragemmaecaputia crassicauda* n.g. et n.sp.
Fig. 1. Entire worm (dorsal view), Fig. 2. Enlarged view of the gonadal region and their ducts (dorsal view), Fig. 3. Cirrus and the Cirrus sac, Fig. 4. Clamp (ventral view), Fig. 5. Anchors.

ootype on the one end and at the right caecum on the other. Vaginal opening is lateral on the right side of the median line and is situated at a level midway between the male pore and the intestinal bifurcation. The vaginal canal runs obliquely backwards and is close to the inner side of the right caecum beyond the intestinal bifurcation. It opens at the oviduct just behind the ootype. Vaginal canal is enlarged into the receptaculum seminis at the level of the ovary and its size ranges from $46 \times 28\mu$ to $58 \times 36\mu$.

The genus *Paragemmaecaputia* resembles *Vallisia* Perugia & Parona (1890), *Vallisiopsis* Subhadrappa (1951), *Allodiscocotyla* Yamaguti (1953), *Pseudomazocraes* Caballero & Bravo (1955) and *Gemmaecaputia* Tripathi (1957) in the presence of gastrocotylid clamps and their number is limited to a maximum of four on each side of the haptor. It differs from *Vallisia* and *Vallisiopsis* in that the body and the haptor are symmetrical, in having an unarmed cirrus and three pairs of anchors. It agrees with *Allodiscocotyla* and *Pseudomazocraes* in the presence of symmetrical body and haptor, three pairs of anchors and a single vagina but differs from them in the presence of pre- and para-ovarial testes in addition to the post-ovarial, unarmed cirrus and vagina. It closely resembles *Gemmaecaputia* in the presence of pre-, para- and post-ovarial testes, unarmed cirrus and vagina and head glands but differs from it in the presence of terminal lappet with three pairs of anchors. Hence it is described as a new genus and is represented by a monotypic species namely *Paragemmaecaputia crassicauda*.

Generic diagnosis:—Allodiscotylineae having body and haptor symmetrical; with four pairs of pedunculated gastrocotylid clamps; with terminal lappet having three pairs of anchors; testes pre-, para and post-ovarial in position; cirrus and vagina lateral on either side of the median line and unarmed.

Specific diagnosis: *Paragemmaecaputia* having terminal lappet 0.08 mm. to 0.12 mm. long with three pairs of anchors, the outer pair 27μ to 30μ long; the inner pair 14μ to 17μ and the middle pair 12μ to 14μ long; clamp-size is from $44 \times 44\mu$ to $72 \times 57\mu$ worm's length is from 1.25 mm. to 1.92 mm.; testes numbering 22 to 25 are pre-, para- and post-ovarial; ovary size is from $56 \times 45\mu$ to $81 \times 55\mu$.

Discussion: Hargis (1957) included in the subfamily Vallisiinae genera *Vallisia* Perugia & Parona (1890), *Vallisiopsis* Subhadrappa (1951), *Protomicrocotyle* Johnston & Tiegs (1922), *Lethacotyle* Manter & Prince (1953), *Allodiscocotyla* Yamaguti (1953) and *Pseudomazocraes* Caballero & Bravo (1955) and transferred the subfamily from the family Discocotylidae to the family Gastrocotylidae on the basis of the presence of gastrocotylid clamps in the above genera. But Tripathi (1957) is of the opinion that these genera, though they happen to possess gastrocotylid type of clamps, need not be included in the family Gastrocotylidae as their number is limited to a maximum of eight and the present author has brought forth ontogenic as well as

morphological evidences in support of this contention (In press); thus agreeing with Tripathi who has created a new family Allodiscocotylidae and assigned his genus *Gemmaecaputia* along with the other genera listed by Hargis except *Lethacotyle*. Genera *Allodiscocotyla*, *Pseudomazocraes*, *Gemmaecaputia* differ from *Vallisia* and *Vallisiopsis* in that the former group of three genera have the body and haptor symmetrical and have pedunculated clamps whereas the latter group has the body and the haptor asymmetrical and the body axis bent at an angle; thus agreeing with Tripathi for the creation of a new subfamily Allodiscotylinae who has included *Allodiscocotyla*, *Gemmaecaputia* in it. Genus *Pseudomazocraes* of which no mention was made by him should also be included under this subfamily as for the reasons mentioned above. Genus *Paragemmeacaputia* is also assigned under this subfamily as it possesses characters that are shared by the subfamily Allodiscotylinae.

The author differs from Tripathi for having retained the genus *Protomicrocotyle* in the subfamily Vallisiinae along with *Vallisia* and *Vallisiopsis*, thereby resulting in the suppression of the subfamily Protomicrocotylinae. The author has presented reasons in support of removing the genus *Protomicrocotyle* from the subfamily Vallisiinae and reviving the subfamily Protomicrocotylinae to include it and has discussed therein the taxonomic position of *Lethacotyle* and *Bilateracotyle* (In press).

Summary

A description of *Paragemmeacaputia crassicauda* n.g. et n.sp., based on 12 specimens obtained from the gills of *Sphyræna obtusata* Cuv. & Val. at Mandapam, is presented and its taxonomic position is discussed with related genera having gastrocotylid clamps, limited to a maximum of eight, on the haptor.

Acknowledgements

I am grateful to Dr. N. K. Panikkar and Dr. S. Jones for their guidance and encouragement in my work. I thank the Ministry of Education Government of India, for the award of a Senior Research scholarship.

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Abbreviations

c. cirrus, c.s. cirrus sac, g.i.c. genito-intestinal canal, m.g.p. male genital pore, o.t. ootype, o.d. oviduct, r.s. receptaculum seminis, sh.g. shell gland, t. testes, ut. uterus, ut.p. uterine pore, v.d. vas deferens, vg. vagina, vg.p. vaginal pore, vit. vitellaria, vit.d. vitelline duct.

On the Breeding Habits and Early Developmental Stages of *Petroscirtes pibunctatus* Day.*

BY S. DUTT AND V. VISVESWARA RAO,
(Department of Zoology, Andhra University, Waltair).
(With 1 Text-figure)

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Introduction

Day (1878—'88) described six species of *Petroscirtes* (Family Blenniidae) from the Indian coast, of which one species *P. bipunctatus* was being reported for the first time. Norman (1943) split up the genus into several others, on the basis of some external characters. Beaufort and Chapman (1951) described altogether 21 species from the Indo-Australian Archipelago, but did not record *P. bipunctatus* Day among these. So far, only Bhattacharya (1916) has described a few developmental stages of one of the Indian species, *P. bhattacharyae* Chaud. From the reports to date, it would appear that the different species occur in the sea (pelagic and among sea weeds, as well as benthic), in brackish water (Beaufort and Chapman *op. cit.*) and 'in areas of low salinity' (Bhattacharya *op. cit.*).

In the course of investigations on the fishes of the Gautami branch of the Godavary river, under a scheme sponsored by the Indian Council of Agricultural Research, we have come across a few specimens of two species of *Petroscirtes*, *P. bipunctatus* Day and *P. punctatus* Cuv. and Val.

P. bipunctatus and P. punctatus

P. bipunctatus Day: Body yellow with pink reflections. Dorsal, anal and caudal fins pinkish. Half the margin of the dorsal and anal black. Pectoral colourless. There are five vertical blue bands on the head, one on snout, two across eye, and two on opercle. A small band on the base of pectoral. 6 vertical bands on the body, the first two being complete and

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the rest reduced to dark patches on the base of dorsal and dark spots on the lateral line. On preservation these bands turn deep brown.

P. bipunctatus Cuv. and Val.: Head and upper part of the body violet, abdomen and the posterior part of the body being purple. There are 3 vertical blue bands on the head, one of which is in front of the eye. Six horizontal blue lines on the body, two of which are below the lateral line and extend upto the origin of anal fin. Rest of the lines are above the lateral line, and are discontinuous from the level of the anal fin, the one at the base of the dorsal being broadest and darkest of all. Free margins of anal and dorsal white; there is a horizontal dark band passing across the middle of the dorsal fin. All the fins are violet in colour.

P. bipunctatus

T.l.	St.l.	Hd.	Eye	Sn.	Ht.	Fin rays			
						D	A	P	V
6.3	5.50	1.3	0.35	0.40	0.90	XIII + 19	23	13	2 o +
5.1	4.35	1.1	0.30	0.35	0.80	XII + 19	23	13	2 o

P. bipunctatus

4.5	3.80	0.8	0.25	0.25	0.65	XVI + 15	23	13	2 o +
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Petroscirtes spp. in Mangroves

In the course of collection of mangrove plants like *Avicennia* for the study of wood boring organisms, we came (Ganapati and Rao 1959), across for the first time, the phenomenon of these fish occupying bores made by either *Teredo* or *Bankia*. In view of the fact that the bore had been already vacated by the borer, the exact agent responsible could not be determined; it could have been made by either of these two, of the various borers in the area, described by Ganapati and Rao, (*op. cit.*). The bore is so selected that it is always submerged under water both during high and low tides.

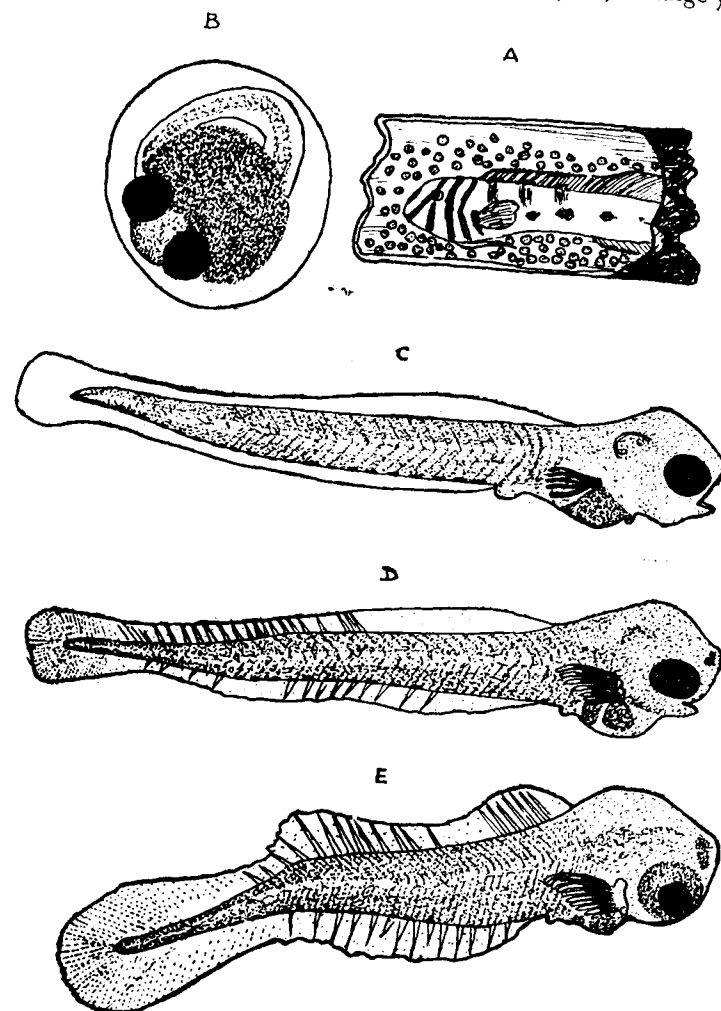
In this particular instance, the bore which was about 20 cm. in depth and 1.5 cm. wide was occupied by a female of *P. bipunctatus* and the male was lingering at the mouth of the bore. Both the specimens could be collected without difficulty along with a part of the entire stem. Close examination of the bore showed that the inner surface was covered to about half the extent with a layer of eggs embedded in a gelatinous matrix, with enough room for the female to keep watch over them. There is thus indication of the nesting habit in this fish, and also parental care.

Structure of the egg

The part of the stem with the bore and the two parents were brought to the laboratory in a bucket of water, and a few of the eggs were carefully removed with a pipette into a finger bowl with water.

Examination of the eggs within an hour of collection showed that the eggs were in a fairly advanced stage of embryonic development, the embryo exhibiting occasional movements within the egg.

The eggs measure 0.8 cm. to 0.9 cm. in diameter and are hemispherical in shape, the side attached to the inner surface of the bore being flat. The embryo can be clearly seen through the transparent egg membrane, when examined under the microscope. The granulated yolk, orange-yellow in



Test-fig. 1. Early Developmental Stages of *Petrosirtes*.

colour is enclosed in the yolk sac on the ventral side just behind the head with its prominent eyes. The tail is curved over the yolk mass. There are faint indications of differentiation of the myotomes.

Early Developmental Stages

The eggs started hatching within two hours of collection and the larvae could be reared upto 40 hours.

Larva, 6 hours (Fig. c): Measures 3.2 mm. and swims very actively, occasionally coming to the surface. The small yolk sac is bag-like and restricted to the area below the rudiments of the pectoral fins. In the distinctly formed head, a pair of auditory vesicles are clearly visible behind the eyes, and both the jaws are distinct. The anus is situated at the anterior third of the body. There is a continuous fin fold without any rays. Only the pectoral fin shows five black pigmented rays. Dark chromatophores are present along the ventral side of the tail. Of the 29 myotomes, 24 are post anal.

Larva, 20 hours (Fig. d): Measures 3.3 mm. The yolk is further reduced. Pigmentation of the tail is restricted to the middle region. A few chromatophores occur on the snout. Both dorsal and anal fins show rudiments of fin rays, but ventral fin rays are not yet formed. There is an increase in the number of pectoral fin rays, but the pigmentation is restricted to the proximal half of the rays. Number of myotomes is 38 of which 31 are post anal.

Larva, 40 hours (Fig. e): Measures 3.4 mm. Rudiments of brain are clearly visible. The yolk sac still persists but is very small. In the eye the cornea and pupil can be differentiated. Pigmentation of the tail is further restricted; that of the snout has spread further. There is an increase in the number of fin rays, both in the dorsal and anal fins. Although continuous, the two dorsal fins can be easily distinguished, the anterior one having slender and closely set spines. There are 42 myotomes, of which 34 are post anal.

Summary

Petrosirtes punctatus and *P. bipunctatus* occur in the mangroves of the Godavari estuary. The latter is observed to breed in bores in stems of mangrove vegetation formed by wood boring organisms. There is indication of nesting habit, and parental care. The eggs are hemispherical and are attached to the inner surface of the bore. Most of the yolk is absorbed before hatching.

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On the Morphology of The Neck and Thorax of *Schizodactylus monstrosus* Don.

BY N. NARAIN KHATTAR,
(Government College, Ajmer)

(With 9 Text-figures)

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Introduction

In an earlier paper (Khattar 1958), I described the morphology of the head capsule and mouth parts of *Schizodactylus monstrosus* Don. The present paper is in continuation of the first and deals with the morphology of the neck and prothorax of the same insect.

Much of the work on the thoracic sclerites of the members of the group Orthoptera was done by Crampton (1914 and 1918) and Snodgrass (1908). Martin (1916) has given a general account of the cervical and thoracic sclerites of insects, while Crampton (1917) has described in detail only the cervical sclerites. Davis (1927) while describing the anatomy and histology of the alimentary canal of *Stenopelmatus* (Stenopelmidae) made general remarks on the head of the insect, but no mention of the neck and prothorax was made. However, in the present paper an attempt has been made to deal with the details of the cervical and prothoracic sclerites of *Schizodactylus monstrosus* Don. Sclerites will.

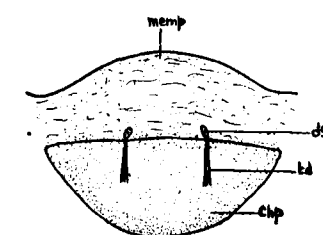
Material and Technique

The adult specimens were collected from the banks Annasagar and Foyasagar lakes, Ajmer, and were identified as *Schizodactylus monstrosus* Don. (Lefroy, 1909). The insects were made transparent by treating them with

10% solution of potassium hydroxide for 2 to 3 days. One percent solution of picro-indigo-carmin was used as stain, and the various structures were studied with the help of a dissecting binocular microscope.

THE NECK

The neck, also called as cervicum or eucervix (Crampton, 1917) is a membranous area connecting the head with the thorax. It is not visible either dorsally or laterally as it is covered over by the anterior rim of the pronotum. It is, however, clearly visible ventrally. The neck membrane is attached to the head capsule along the postoccipital rim bordering the foramen magnum. Anteriorly it is connected with the thorax along the under folded rim of the pronotum, and posteriorly it is continuous with the anterior margin of the prosternal region. The membranous character of the neck integument permits a greater freedom of movement to the head.



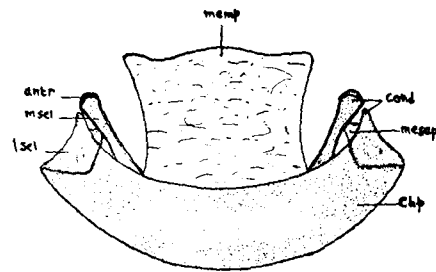
Text-Fig. 1. The Neck. (Dorsal view)

Embedded in the membranous walls of the neck region, are a number of sclerites, termed as the jugular sclerites (Crampton, 1918), or cervicalia or cervical sclerites (Huxley, 1878), or microthoracic sclerites (Verhoeff, 1902). These cervical sclerites are often mentioned as dorsal, lateral and ventral cervicals according to their location. The cervical sclerites serve to strengthen the walls of the neck and to furnish points of articulation for the head. Of these the lateral cervicals are strongly developed and mainly concerned in the cephalic and prothoracic articulations; while dorsally the cervical sclerites occur in the form of pockets.

Dorso-laterally, at the lower ends of the occipital ridges, the neck membrane bears on either side a single dorsal cervical sclerite. These sclerites are formed as invaginations of the neck membrane and, therefore, appear as mere pockets externally. On the inner side each sclerite bears a short wedge-shaped apodeme for the insertion of the neck muscles.

Ventro-laterally, the neck is supported on either side by a pair of ventro-lateral cervical sclerites, the mesial and the lateral, lying side by side. The mesial sclerite is more or less rod-shaped. Its anterior end forms a broad

condyle attached to the occipital condyle. The posterior end of the mesial sclerite is articulated with the chitinous part of the neck membrane. The anterior half of it on the dorsal side is slightly granulate, while internally it bears three distinct ridges. Two of these ridges, the marginal ridges, run



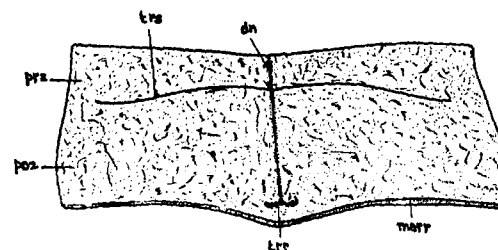
Text-Fig. 2. The Neck. (Ventral view)

throughout the lateral margins of the sclerite, while the third—the anterior ridge, runs around the proximal margin of the condyle. The lateral sclerite is in the form of a large boat having no ridges, and is smooth on the dorsal and ventral surfaces. Mesially it gives out a short apodeme, which slightly overlaps the lateral margin of the mesial sclerite. Anteriorly, each lateral sclerite also forms a small condyle which lies just below and laterad to the condyle of the mesial sclerite.

Ventrally the neck is distinguished into two parts, an anterior, broad, thin and membranous and with many wrinkles, and the posterior, broad thin and chitinous and with smooth dorsal and ventral surfaces. The anterior part which is to some extent square in outline is loosely attached to the dorsal border of the postmentum and the posterior which is crescentic in outline is attached with the prosternum on its posterior margin.

THE PROTERGUM

The protergal sclerite, the protergum or the pronotum is saddle-shaped; it is broader than its length, curved downwards at the sides and entirely covering the neck region. It measures about 5 mm. along its mid-dorsal



Text-Fig. 3. The Prothorax. (Dorsal view)

length. It bears almost throughout its length, on its dorsal surface, a median notch, the dorsal notch which divides it into two parts. The dorsal notch corresponds with a well developed ridge on the ventral side. The

pronotum is truncate anteriorly and posteriorly. Its dorsal surface is granulate and pubescent. Each half of the pronotum is again divided into two parts by means of a transverse suture on the dorsal side with a corresponding ridge on the ventral side. The transverse suture, from a little distance posterior to the anterior extremity of the dorsal notch, runs laterad of the pronotum where it becomes obsolete at its distal end and does not reach upto the lateral side of the notum. The anterior narrow and the posterior large parts of each half are the prozona and postzona respectively.

The prozona or prezona (Crampton, 1918) is the smaller part without any ridge or sulcus on any of its surfaces and appears a single region.

The large posterior part—the postzona or metazona (Karandikar, 1939) unlike the prozona bears a single ridge, the transverse ridge. The transverse ridge is very short and runs from the posterior end of the dorsal notch and is slightly curved outwards. The posterior margin of the postzona bears a well developed marginal ridge all along its breadth.

THE PROPLEURON

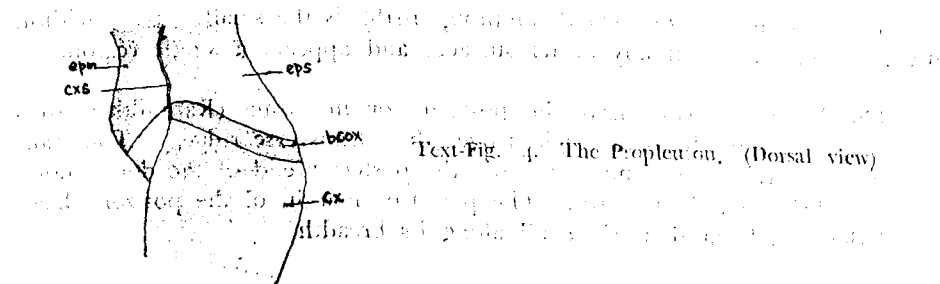
The propleuron consists of two parts, an anterior large episternum and the posterior small epimeron. The two parts of the propleuron are separated from each other by a vertical suture, the pleural suture on the dorsal side with the corresponding pleural ridge (Crampton, 1908; Snodgrass, 1909; Martin, 1916) on the ventral side. The pleural ridge forms a large pleural apophysis on its under side which extends inward towards the body axis. Internally, the pleural ridge projects into the coxal corium and forms a distinct process, the coxal process which fits into the coxal notch and also serves as a chief pivot for the coxa in the movement of the leg. The episternum is connected with the prosternum by a distinct oblique suture, the sterno-pleural suture. The coxal corium is chitinised along the pleural region, to form a distinct basicoxite.

THE PROSTERNUM

The prosternal region in *Schizodactylus* is made up of three typical sclerites, the basisternite or verasternite (Martin, 1916) or eusternite (Snodgrass, 1935), the furcasternite and the spinasternite.

The presternite is absent in the case of the prosternum, and the basisternite forms the anteriormost sclerite. It does not bear the prosternal spine. Crampton (1918) points out that this region generally bears a prominent prosternal spine. Antero-laterally the basisternite forms a precoxal with the proepisternum by an oblique suture, the sterno-pleural suture. In front of the basisternite is situated the ventral neck membrane from which it is separated by a suture, with a strong internal ridge.

Behind the basisternite is situated the furcasternite which in *Schizodactylus* is in the form of two triangular lobes surrounded on all sides by the furcasternal sutures with the corresponding furcasternal ridges on the ventral side. At the lateral end of each triangle is present a large furcal pit which internally gives insertion to a prominent furca-sternal apophysis. The furcasternite is connected posteriorly with large spinasternite by means of a transverse suture, the furcasternal suture with the corresponding ridge on the ventral side.



Text-Fig. 4. The Propleuron, (Dorsal view)

The spinasternite forms a large posterior sclerite of the prosternum. It also does not bear any spina or apophysis on its inner side. Karanlikar (1939) and Crampton (1914) have stated that spina or apophysis is generally present on the ventral side of the spinasternite in majority of Orthoptera. Laterally the spinasternite borders the coxal corium, while posteriorly it is marked off from the intersegmental membrane by a well developed suture, the spinasternal suture.

In the prosternum of *Schizodactylus* the lateral ends of the furcasternal lobes and the spinasternite have become adnate to each other, and from this junction on the ventral side are given out the well developed, long and bifurcated apophyses. These apophyses accordingly are termed as the furca-spinasternal apophyses instead of furcasternal apophyses, or, I would interpret that the furcasternal and the spinasternal apophysis have united with each other to form a single large and bifurcated apophysis, one on either side.

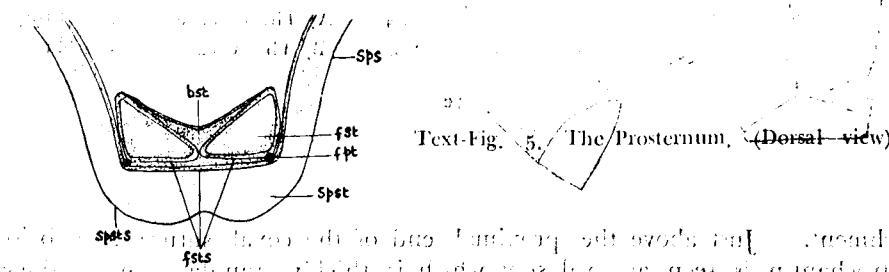
THE PROTHORACIC LEGS

Each of the two prothoracic legs is made up of two parts; (1) the basipodite, consisting of the trochantin and coxa, and (2) the telopodite, consisting of the trochanter, femur, tibia, tarsus and pretarsus.

The coxa of each leg is planted in an oval membranous area known as the coxal corium. The latter is bordered mesially by the sternal region, laterally by the ventral margin of the pleural wall, anteriorly by the precoxal bridge (formed by the junction of the ventral arm of the pleural and lateral

arm of the sternal regions on each side) and posteriorly by the inter-segmental membrane. The coxal corium of each coxa is chitinised along its sternal margin to form the pericoxite.

The coxa in the prothoracic leg is quite large and has the appearance of a short cylinder which is broad proximally and narrow distally. The chief articulating pivot of the coxa is the coxal process of the pleuron, formed by the downward projection of the pleural region at the base of the pleural

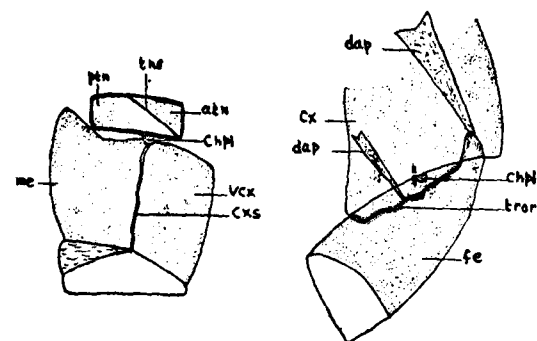


Text-Fig. 5. The Prosternum, (Dorsal view)

suture. The coxal process fits into the coxal notch in the antero-dorsal border of the coxa. The coxa is divided into two parts, an anterior *meracoxa* and the posterior *meron* by a suture, the coxal suture. The coxal suture runs along the preaxial border of the coxa and corresponds with the coxal ridge on the ventral side. Crampton (1923) termed the coxal suture as the *meral suture* and accordingly the two parts of the coxa as the *meracoxa* and *eucoxa*. The proximal margin of the coxa bears an internal ridge, the *basicosta* with the external suture, the *basicoxal suture*. The basicosta gives insertion to three apodemes, a tendon like apodeme—the *abductor apodeme*, a large and chitinous *tergal remotor apodeme* from its distal margin, and a long *tergal promotor apodeme* from its anterior margin just below the distal end of the trochantin. The basicosta in addition to the shallow coxal notch has two deep notches. Of these one lies immediately posterior to the coxal notch and gives insertion to the *abductor apodeme*. The other or the *trochantinal notch* is situated on the ventral part of the basicosta and receives the distal end of the trochantin. In *Schizodactylus* the trochantin does not form a second coxal articulation with the body as it does not reach upto the pronotum. The coxa has, therefore, a single articulation with the body. This arrangement thus gives the coxa the freedom of movement both in the vertical and horizontal planes.

Embedded preaxially within the coxal corium is a distinct sclerite the *trochantin* or *trochantinus* (Crampton and Hasey, 1915). It is articulated with the coxa by means of a small condyle fitting into the notch at the anterior corner of the coxa. The trochantin is a narrow rectangular sclerite

surrounded by ridges on all its sides. It is divided by an oblique suture into two parts, the ante-trochantin and the post-trochantin (Crampton, 1923). The oblique suture corresponds to an endotrochantin, a ridge for muscle

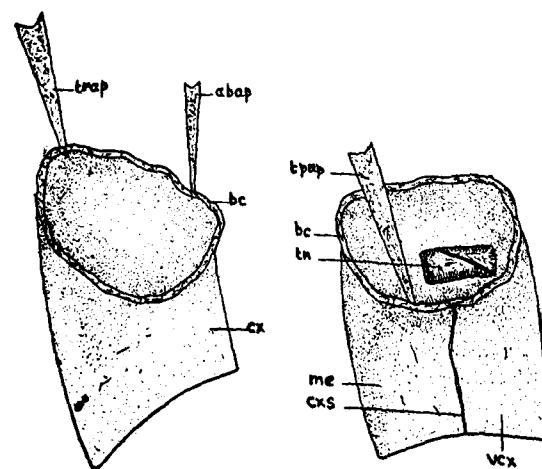


Text-Fig. 6.
A. The Coxa and Trochantin.
B. The Coxa and Trochanter.

attachment. Just above the proximal end of the coxal suture and below the trochantin is seen an oval spot which is thickly granulate on its dorsal surface.

The trochanter is some what triangular piece longer than coxa but less in width. All along its proximal submargin there runs a prominent ridge, the trochanteral ridge. The proximal end of the trochanter is produced into a condyle which fits into the veracoxa, and bears as a strong apodeme, the depressor apodeme. The depressor apodeme is long, narrow shaft like

Text-Fig. 7.
The Coxa showing basicosta.



at the lower end and broad and chitinous at the upper end. Another small narrow apodeme which runs in the coxal cavity is given out from the middle of the trochanteral ridge. This apodeme is also termed as the depressor apodeme. Below the meron and between it and the proximal submargin

of the trochanter is present a well developed coxo-trochanteral corium. Near the proximal border of the trochanter, the coxo-trochanteral corium has an oval chitinous plate which is thickly granulate on its dorsal surface. The distal border of the trochanter bears two short condyles which articulate with the femur.

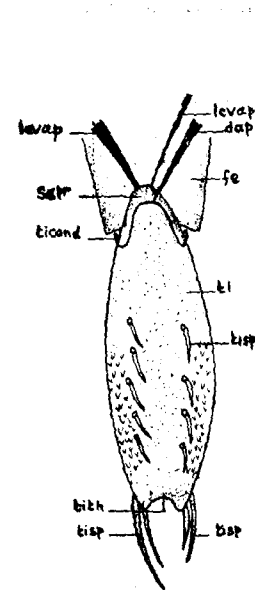
The femur is the longest segment of the prothoracic leg. It is a large cylinder, broad anteriorly and tapers gradually towards the distal end. Proximally it articulates with the trochanter by two small notches, the preaxial and the postaxial notch, into which fit the two articulatory condyles of the distal margin of the trochanter. The intervening area between the two notches is covered over by the coria. Distally the femur is articulated with the tibia, and the articulating surface of the femur is known as the gonytheca (Crampton, 1923).

The tibia which is slightly shorter than the femur is rounded in cross section and lies in the vertical plane at right angles to the latter. The head of the tibia, the tibiaput is recieved in the distal end of the femur called the femur cup or gonytheca. The proximal end of the tibia at its dorsal part is thick and cuticularised and projects forward beyond its ventral part into a prominent process, the saggital process (Misra, 1946) which lies telescoped within the distal end of the femur. The lower margin of the saggital process is produced into two condyles which fit into the respective articulatory notches on the distal margin of the femur. Crampton (1923) termed these articulatory condyles as the tibiacondyles. The ventral part of the proximal end of the tibia is less cuticularised, is more or less flaplike in shape and gives out a long depressor tendon at its anterior end. Two tendons, one thick, broad and short, and the other long and narrow are given out from the anterior end of the saggital process. These tendons are known as the levator tendons. The dorsal surface of the tibia is slightly granulate. The ventral side of the tibia bears two rows of five to six very long and pointed spines. Each spine has a well developed condyle at its proximal and which fits into the concavity in the ventral wall of the tibia. These spines are known as the tibial spines. Distally the lateral sides of the tibia are also be set with numerous small spines. The large and small spines are directed downward. The distal end of the tibia is produced into a cup, the tibiatheca, into which fits the proximal condyle of the basal segment of the tarsus. Four spines are present at the distal end of the tibia. Out of these, two attached to the preaxial border are very long and the rest two attached to the postaxial border are small. These spines also termed as the tibial spines are directed distad.

The tarsus consists of three proximal sub-segments and a terminal claw bearing portion, the pretarsus. Leveault (1935) stated that the most generalised Orthopterans have the tarsus with six sub-segments and the fewer number of the segments might be a primitive feature. The three sub-segments are known as the tarsomeres by Crampton (1923) and are referred as

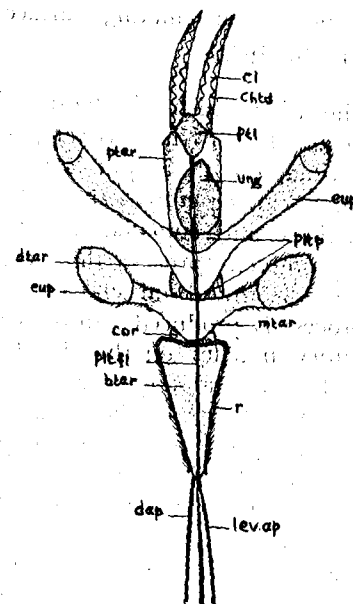
the basal, middle and the distal tarsomere. Crampton (1923) preferred the term basitarsus for the basal tarsomere instead of metatarsus which is used for the entire tarsus of the metathoracic leg.

The basal tarsomere is long, cylindrical, narrow proximally and broad distally. Proximally it is produced into a condyle, the tarsocaput, which is received in the tibiatheca. The tibio-tarsal articulation is surrounded by the corium. Just distad to the tarsocaput there are two small conical projections on the lateral sides of the basitarsomere. These conical processes also help in the articulation of the tarsus. The lateral borders of the basitarsomere are strengthened by the marginal ridges, while the ventral surface of it is beset



Text-Fig. 8.

Distal end of Femur and whole of Tibia.



Text-Fig. 9.

The Tarsus and Pretarsus. (Ventral view)

with numerous small setae and small soft hair are present on its lateral sides. The basitarsomere gives insertion to two long tendon-like flexors, the levator and the depressor flexors from its proximal end. The middle tarsomere is to some extent semicircular in outline and is produced proximally into a condyle which fits into concavity at the distal end of the preceding segment. This articulation of the two tarsomeres is also surrounded by the corium. The middle tarsomere gives out two long, globular, soft and membranous structures from its ventral side. These lobes—the euplantulae, extend laterally outward, are beset with numerous small setae on the ventral surface and with small soft hair on the lateral sides. At the distal end of the middle tarsomere, on the ventral side, below its articulation with the distal tarsomere, is present a small semicircular thickly cuticularised plate which is gran-

ulate on its dorsal surface. As this plate is raised above the tarsal surface it touches the ground while the insect walks, hence, it is termed as the plantar plate. The distal tarsomere is longer than the middle one and articulates with the later at its proximal end. The corium being absent in the case of above joint. The distal tarsomere also gives rise to two euplantulae, one on either side. The euplantulae in the distal tarsomere are very long, tube like and rounded at the distal ends. They are also pubescent on their ventral surfaces while small soft hair are present on their lateral sides. On the distal end of the distal tarsomere is present the plantar plate similar to that of the middle one. The pretarsus or distitarsus (deMeijeres, 1901) is long, somewhat rectangular in shape, and consists of three pieces, the unguitractor, the planta and the claws. The proximal condylar end of the pretarsus lies within the distal concavity of the distal tarsomere, and the articulation is surrounded by a distinct corium. The unguitractor is a median plate on the ventral side of the pretarsus, and is somewhat oval in outline. Just distad to the unguitractor is another large sclerite, the planta on the ventral side of the pretarsus. The planta gives insertion to a very long thread-like tendon, the plantar flexor from its proximal end. The plantar flexor extends backward into the tibial cavity. The claws arise from the dorso-distad end of the pretarsus. The claws are also termed as the ungula, unguicula, onyches, etc. by various investigators, but the term unguis or claw is preferred. Each claw is a long, hollow, and pointed organ with its cavity continuous with the lumen of the pretarsus. Below and at the lateral side of each claw is present a stiff corium known as the pulvicornium. On the ventral side of each claw on either side are present, two darkly colored thickly cuticularised threads arranged in a zig zag manner. Dashman (1953) while describing the terminology of pretarsus, does not mention any structure similar to these threads. He has only referred, the pseudonychia as lateral teeth on the claws of the Collembola. Levereault (1935) also fails to describe any structure similar to the above threads. The arolium is absent in *Schizodactylus* which is otherwise, present in the majority of insects and particularly in the group Orthoptera.

Summary

There has been so far no detailed account of the morphology of the cervical and thoracic sclerites of *Schizodactylus monstruosus* Don. The present work deals with the morphology of neck and prothorax of this. The following are noteworthy features.

1. The neck is only visible on the ventral side; the dorsal and the lateral sides being covered over by the pronotum. Only the lateral cervical sclerites are well developed which serve for the attachment of the neck with the head capsule. The dorsal cervical sclerites are in the form of pockets.

2. The pronotum is very much developed and entirely covers the neck. It does not bear many ridges or sulci, excepting a transverse ridge which is present at the distal end of the postzona.

3. The propleuron is distinguished into an episternum and epimeron by a well developed pleural suture and the pleural ridge. The pleural ridge forms a coxal process at its proximal end.

4. The prosternum consists of basisternum, furcasternum and spinasternum. The furca and the spinasternal apophysis on the ventral side have fused with each other to form a single apophysis.

5. The coxa is quite large, surrounded by the coxal corium and articulating with the coxal process of the pleural ridge which also serves as its chief pivot in the movement of the leg. The trochantin is also well developed and divided into two parts. It does not form a second coxal articulation with the body as it does not reach upto the pronotum. The trochanter is somewhat triangular in shape and gives insertion to two depressor apodemes. The femur forms the longest segment in the prothoracic leg. The tibia is rounded in cross section and bears spines at its disto-lateral sides. It gives insertion to one depressor and two levator tendons from its proximal margin. The tarsus consists of three sub-segments and a pretarsus. The middle and the distal tarsomere bear the euplantulae and plantar plates on their ventral surfaces. The pretarsus consists of an unguitactor, planta and two claws. Planta gives out a very long plantar flexor from its proximal end. Each claw bears two thick and chitinous threads, one on either side.

Acknowledgements

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Explanation of figures (To be written below the respective figure).

Abbreviations

ab.ap	...	abductor apodeme
ant.r	...	anterior ridge
a.tn	...	ante-trochantin
bc	...	basicosta
b.cox	...	basicoxite
bst	...	basisternite
b.tar	...	basal tarsomere
ch.p	...	chitinous part
ch.pl	...	chitinous plate
ch.td	...	chitinous thread
ci	...	claw
cond	...	condyle
cor	...	corium
cx	...	coxa
cx.s	...	coxal suture
d.ap	...	dorsal apodeme
dn	...	dorsal notch
d.scl	...	dorsal sclerite
d.tar	...	distal tarsomere
epm	...	epimeron
eps	...	episternum
eup	...	euplantula
fe	...	femur
f.pt	...	furcal pit
fst	...	furcasternite
fts	...	furcasternal suture
lev.ap	...	levator apodeme

i.sel	...	lateral sclerite
mar.r	...	marginal ridge
me	...	meron
mem.p	...	membranous part
mes.ap	...	mesial apodeme
m.scl	...	mesial sclerite
m.tar	...	middle tarsomere
ptl	...	planta
plt.p	...	plantar plate
poz	...	postzona
prz	...	prezona
p.tar	...	pretarsus
ptl.fl	...	planta flexor
p.tn	...	post-trochantin
r	...	ridge
sg.pr	...	sagittal process
s.p.s	...	sterno-pleural suture
spst	...	spinasternite
spst.s	...	spinasternal suture
td	...	tendon
ti	...	tibia
ti.cond	...	tibia-condyle
ti.sp	...	tibial spines
tith	...	tibia theca
tn.s	...	trochantinal suture
t.p.ap	...	tergal promotor apodeme
t.r.ap	...	tergal remotor apodeme
tro.r	...	trochanteral ridge
tr.r	...	transverse ridge
tr.s	...	transverse suture
ung	...	unguitractor
v.cx	...	veracoxa

Correlative Cyclical Changes in the Pituitary and Gonads of *Mystus seenghala* (Sykes) and *Barbus stigma* (Cuv. & Val.)

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Introduction

Much work has been done on the general morphology, histology and cytology of the teleostean pituitary (Herring, '08; de Beer, '26; Bock, '28; Matthews, '36, '38; Bell, '38; Evans, '37; Charipper, '37; Levenstein, '39; Woodman, '39; Scruggs, '39; Lee, '42; Potts, '42; Kerr, '42, '43, '48; Miller, '44; Atz, '53 and Stolk, '50). The pituitary-gonad interrelationship has been variously assayed by hypophysectomy (Matthews, '39) injection of pituitary extracts (Houssay, '30, '31; Cardoso, '34) and implantation experiments (Matthews, '40). The correlative seasonal histological changes of the pituitary and gonads of teleosts are available only in isolated instances (Bretschneider and de Wit, '47; Scruggs, '51 and Stolk, '50). Oliverau's studies on the histophysiology of the pituitary of *Salmo salar* is outstanding. This subject has been extensively reviewed by Pickford and Atz recently (1957).

Experiments on the induction of spawning by pituitary extracts in Indian species were attempted by some workers (Khan, '38) with appreciable degree of success (Alikunhi and Chaudhuri, '57 and Ramaswamy, '58). Informations on the structure and histology of the pituitary of *Chanos chanos* (Tampi, '51, '53), *Chela bacaila*, *Ophicephalus punctatus* *Barbus stigma* (Sathyanesan '57, '59), *Hilsa ilisha* (Misra and Sathyanesan, '58) are also available. Seasonal histological changes in the pituitary of *Cirrhitina reba* is reported by Sathyanesan ('58).

It has been observed by investigators that though the pituitary-gonad interrelationship in fishes has been demonstrated by some workers, many of the details, however, remain to be studied (Hoar, '55). Also, the lack of sufficient knowledge regarding the evolution of the physiological mechanism governing vertebrate reproduction is severally felt by workers. The pattern of reproduction of fishes inhabiting tropical and sub-tropical inland waters are little known. This work is an attempt to further our knowledge of the correlative seasonal changes of the pituitary and gonads in some Indian freshwater fishes.

Material and Methods

Specimens were collected for this investigation from the river Ganges at Banaras throughout each month for a complete year. The fishes were killed by severing the head. The pituitary and portions of gonads from the anterior, middle and posterior regions were fixed in appropriate fixatives without loss of time. Every month the entire gonads of few specimens were dissected out and preserved in 5% formalin to study the gross morphological changes. Zenker's fixative, Dawson-Friedgood's formol sublimate and Bouin's fluid were used as fixatives and Anderson's modification of Mallory's triple stain and modified Heidenhain's azan stain were used in the routine work. Sections were cut at 4 to 6 μ thick in paraffin. Gonads were fixed in Bouin's fluid and Zenker's fixative and stained with Heidenhain's haematoxylin and Ehrlich's haematoxylin.

Terminology of the components of the teleostean pituitary.

It is generally accepted by workers that the arrangement and organisation of the components of the teleostean pituitary varies greatly in different species (Hoar, '57) and many structural and histological features are peculiar to themselves rendering homologies difficult (Kerr, '42). The terminologies so far used by workers are too many (vide Table I). The desirability of simplifying and bringing them in line with that of the higher vertebrates is also stressed by investigators.

The pars intermedia and übergangsteil are homologised with the posterior and anterior lobes of the pituitary of higher vertebrates respectively. But authors differ in their opinion as to the homology of the pars anterior of the teleost. Some have found it comparable with the pars tuberalis (Miller, '44; Stolk, '51; Bretschneider and de Wit '47). Potts ('42) and Scruggs ('39) identified the tongue like portion found in the pars anterior of some teleosts with the pars tuberalis. Kerr ('43) does not find any homologue for the tuberal lobe in the pituitary of teleost, since there is no lateral lobe during its development. Hoar ('57) has rightly pointed out that one should wait for drawing conclusion till more is known about its physiology.

TABLE I
Terminology of the components of the teleostean pituitary (modified after Olivereau, 1954)

Stendell, Bock, Von Hagen, Buchmann, *de Beer, Bell, Kerr, Potts, Lee, Scruggs, Kerr, Levenstein, Rasquin, D'Ancona, Bretschneider & de Wit, Stolk, Miller, Olivereau **Pickford & Atz.	'14 '28 '36 '40 '26 '38 '40 '41 '42 '51 '42 '39 '49 '51 '47 '50 '44 '54 '57	Hauptlappen Hauptlappen Vorderlappen Lobe Principal Pars anterior do. Pars anterior do. do. do. Anterior glandular region Pars anterior Anterior lobe do. Lobus tuberalis do. Pars tuberalis Partie folleculaire Pro-adenohypophysis	Übergangsteil do. Übergangsteil do. do. do. do. do. do. do. Middle glandular region Transitional lobe do. do. Lobus anterior do. Pars distalis (pars anterior + transitional zone) Region glandulaire moyenne Meso-adenohypophysis	Zwischencappen do. Zwischencappen do. Pars intermedia do. Pars intermedia do. do. do. do. Posterior glandular region Pars intermedia Intermediate lobe do. Lobus intermedia do. Pars intermedia do. do. Partie folleculaire Meso-adenohypophysis	Hirnteil do. Hirnteil do. Pars nervosa do. Pars nervosa do. do. do. do. Nervous lobe Pars nervosa do. do. Lobus posterior do. Neurohypophysis Pars nervosa do. Meso-adenohypophysis
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*de Beer has drawn a list of synonyms of the pituitary components.

**A complete review of terminology is provided by Pickford & Atz.

General morphology and histology of the pituitary of Mystus seenghala, in correlation with gonadal changes.

The pituitary is an oval body situated ventral to the brain behind the optic chiasma, attached to the infundibulum by means of a slender stalk (Pl. III, Fig. 1.) Unlike *Polypterus* (deBeer, '26), *Epiceratodus* (Griffiths, '38) and *Hilsa ilisha* (Misra and Sathyanesan, '58) a well defined sella turcica is conspicuous by its absence. The pituitary of a well grown fish measures $1.8 \times 2 \times 1.9$ mm. It is divided into a nervous component, the pars nervosa or neurohypophysis and a glandular component pars glandularis or adenohypophysis. The latter is made up of three distinct parts; the pars anterior, ubergangsteil and pars intermedia. The components are demarkated by their distinct cell types (Pl. III, Fig. 1).

The infundibular stalk enters the pars glandularis and arborises into its substance as pars nervosa, which is constituted by loose fibrous strands with the nuclei of the neuroglia cells interspersed in their interices. The arrangement of the pars nervosa in relation to the glandular components is typical of the teleosts described by earlier workers (Scruggs, '39, '51; Kerr, '42; Bell, '38). Infundibular funnels which have lost their connection with the main cavity are often present in the pars nervosa. Apart from the smaller blood vessels penetrating into the pituitary through the surface, larger ones are seen entering along the stalk. Kerr ('42) observed that the main supply of blood to the pituitary is through its surface.

Three types of cells are distinguished in the pars anterior—the acidophils, bluish-pink cells, and chromophobes. The bluish-pink cells may be the amphiphils described in *Carassius auratus* (Bell, '38; Levenstein, '39) and *Xiphias gladius* (Lee, '42). But according to Scruggs ('51) the amphiphils of the above authors are nothing but acidophils. In their affinity to stain these cells appear different from the acidophils in *Mystus*. Hence to avoid confusion the term amphiphil of the previous workers is retained. Basophils, acidophils and chromophobes are the constituent cell types of the ubergangsteil. Of all the components of the pituitary the ubergangsteil exhibits outstanding quantitative and qualitative seasonal variations. Chromophobes, acidophils and basophils are the types of cells present in the pars intermedia.

Different spawning phases of the gonads and their duration.*

Prespawning phase	...	January and February.
Spawning phase	...	March to May.
Regression phase	...	June and July.
Resting phase	...	August to December.

*The late spawners are not taken into consideration.

Prespawning phase (January and February).

Large number of chromophils of the ubergangsteil are seen in different stages of migration towards the pituitary stalk along the branches of the pars nervosa (Pl. III, Fig. 3). Among them disintegrating basophils are not uncommon (Pl. III, Fig. 2). The quantitative variation of these cells at different periods of the year strongly suggests some specific function. Kerr ('42) did not find any clear indication of organised migration of chromophils. Occasionally acidophilic and basophilic colloid-like bodies are present in the pars nervosa (Pl. III, Figs. 2 and 5). These bodies resemble closely the disintegrated remnants of the immigrant chromophils of the ubergangsteil. Disintegration of migrated basophils in the pars nervosa is recorded in *Carassius* (Bell, '38). Stendell ('14) has interpreted the disintegration of the immigrant cells of the pars intermedia in the pars nervosa as a process of secretion. Amphiphils of the pars anterior are also seen in large numbers in the pars nervosa branches of the pars anterior in *Mystus*.

A few basophils are often found in the pars anterior and they closely resemble those of the ubergangsteil in their staining reactions and seasonal changes. Such basophils are reported in *Carassius* (Scruggs, '51) and *Cirrhinia* (Sathyanesan, '57). Scruggs ('51) states that those may be cells which are not segregated during the development of the gland. The acidophils are intensely granulated having prominent round nucleus and often with indistinct cell wall (Pl. IV, Fig. 4). The amphiphils are granulated and of the same size as that of the acidophils. They show distinct variation during different periods of the year. They are mainly located in and around the pars nervosa ramifications of the pars anterior. Chromophobes are few and appear like groups of nuclei with indistinct cell boundary. Pars anterior is well vascularised and is larger than the ubergangsteil during this phase of the cycle.

The basophils of the ubergangsteil are granulated and are prominent by their large size (Pl. III, Figs. 4 and 6). Some have vacuoles and liquefied cytoplasmic contents (Pl. III, Fig. 9). The acidophils are smaller, granulated and variously shaped. Apart from the basophils and acidophils there are cells which are lightly basophilic or acidophilic due to their sparsely distributed granules (Pl. 3, Fig. 6). These cells are few in number and show a numerical variation during different periods of the year. Such cells are considered as degenerating or regressive deeply staining cells by Scruggs ('51). The chromophobes are nonstaining and nongranular cells often resembling naked nuclei due to lack of proper cellular definition. During January the percentages of the basophils, acidophils and chromophobes are 45.1, 43.6 and 11.3 respectively (vide Table II, Graph I). In February the ubergangsteil expands at the cost of the pars intermedia and pars anterior and its basophils exhibit a noticeable increase in number and size. Basophils with partly or wholly liquefied contents are numerous than in January (Pl. IV, Fig. 1). Those of the basophils having globular secretory inclusions are termed as

globular basophils by some workers (Copeland, '43; Scruggs, '51). Very often the secreted products are not in the form of globules in *Mystus*, hence the term secretory basophil is appropriately used to describe such basophils in this investigation. These are also seen discharging their contents. The acidophils of the ubergangsteil show a numerical reduction and the basophil-acidophil percentage becomes 59.2 and 32.4 respectively. Lightly staining basophils apparently occur in large numbers.

The basophils of the pars intermedia are granulated and often arranged around blood sinuses. Patches of blue colloid-like bodies and disintegrating basophils are present in the lumina of some blood sinuses (Pl. III, Fig. 7 and 8). Acidophils are granular and much less in number than the basophils. The chromophobes are often without distinct cell boundary which form the predominant cell type. The pars intermedia is well supplied with blood vessels from the vascular meninges covering the pituitary.

Spawning phase (March to May).

Basophilic and acidophilic colloid-like matter is present in the pars nervosa. The migrated chromophils of the ubergangsteil still persist. Amphiphils are present in the pars nervosa branches of the pars anterior in large numbers (Pl. IV, Fig. 5). These show an increase in size and take more of the basic stain and are consequently slaty or dirty blue in colour.

During this period a reduction in number of the secretory basophils of the ubergangsteil is in evidence. An increase in the number of lightly staining basophils is observed. The ubergangsteil becomes the largest component of the pituitary and its basophil form the largest percentage of the cellular component (vide Table II, Graph I).

The pars intermedia does not show much variation from the pre-spawning phase. Lightly staining basophils occur in large numbers.

Regression phase (June and July).

Typical chromophils are totally absent in the pars nervosa. The colloid-like matter is present in small quantities.

In the pars anterior the prominent cell type is the polygonal or round chromophobes having definite cell boundary (Pl. II, Fig. 6). Acidophils are few. A large percentage of the amphiphils are degranulated and lose their definition (Pl. IV, Fig. 7).

The whole picture of the ubergangsteil is completely changed during this phase. Due to the degranulation and disappearance of the cytoplasmic content of a large number of basophils, the ubergangsteil presents a net-like appearance (Pl. IV, Fig. 2). These basophils are chromophobic and few show signs of pycnosis and degeneration. However, during July, basophils show a

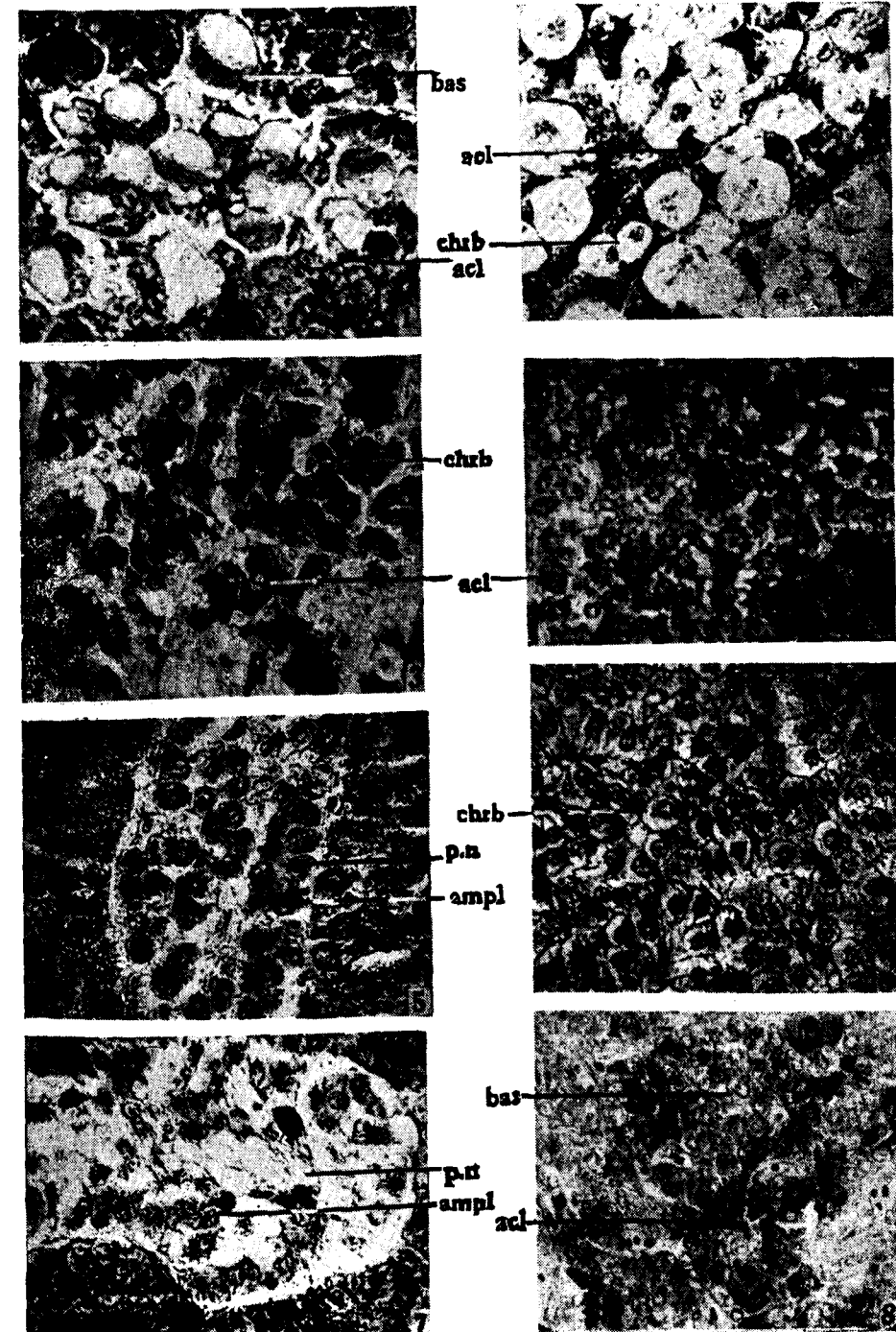
Explanation to Figures.

PLATE IV

- Fig. 1. Photograph showing a group of secretory basophils in the ubergangsteil ... February X 1060
- Fig. 2. Photograph showing the above secretory basophils denuded off their contents. ... June X 380
- Fig. 3. Photograph showing the acidophils and chromophobes of the ubergangsteil ... August X 360
- Fig. 4. Photograph showing the granulated acidophils of the pars anterior. ... January X 600
- Fig. 5. Photograph showing amphiphils in the pars nervosa branches ramifying the pars anterior. ... May X 580
- Fig. 6. Photograph showing a number of chromophobes of the pars anterior. ... July X 680
- Fig. 7. Photograph showing the amphiphils in the pars nervosa ramifying the pars anterior of *Mystus*. ... July X 680
- Fig. 8. Photograph showing the cellular components of the ubergangsteil, in *Barbus*. ... March X 600

Sathyanesan :

Plate IV



gradual increase in number. The acidophils are numerous and occur in groups between chromophobes, and form the chief cell type.

The percentage of acidophils in the pars intermedia exceeds that of March, April and May. Few scattered acidophilic globular bodies are often found in this region. Basophils are not seen in association with blood sinuses. The cell limits of the chromophobes are indistinct. In many cases the nuclei of the chromophobes show an increase in the acidophilic intranuclear contents.

Resting phase (August to December).

Colloid-like matter is rare in the pars nervosa during the early resting phase. However, in the later half limited quantity is present which sometimes gives polychromatic reaction to stain. The migration of the chromophils of the ubergangsteil into the pars nervosa becomes evident by the end of the resting period. The degranulated, ill-defined amphiphils which are abundant in the pars nervosa in August. They take a definite shape during the later half of the resting phase.

In August the pars anterior exhibits much similarity to the conditions obtained in June and July, but progressive granulation of the chromophobes is obvious. In the later part of this phase the dominant cell type is the acidophils showing different grades of granulation. Chromophobes are numerically insignificant. The amphiphils do not show its characteristic tinctorial differentiation in August and September, but the difference is sufficient to distinguish them from the acidophils. During October to December, they increase in size and give the typical amphiphilic colour reaction.

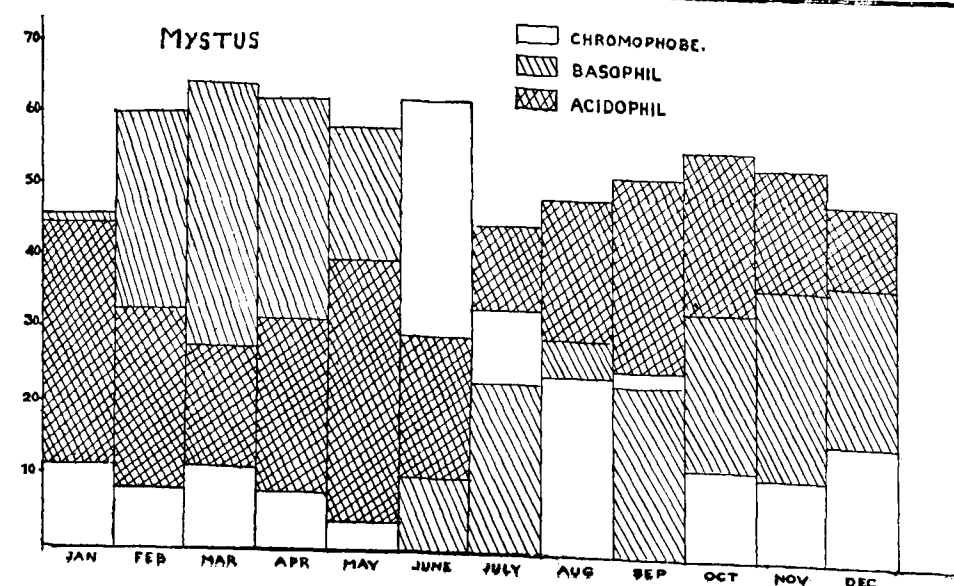
In the ubergangsteil the acidophils are the chief cell type (vide Table II, Graph I). The chromophobes are more compact and much reduced in number and size (Pl. IV, Fig. 3). Some of them may not show distinct cell wall. Acidophils with bluish tint and amphiphils of violet hue make their appearance for the first time in the ubergangsteil. They may be probably representing an intermediate condition between the two types of chromophils. The basophils show a gradual increase in their percentage. The secretory basophils are absent. Lightly staining chromophils are greatly reduced in their number.

Bright acidophilic globules are present in the pars intermedia in August as in the months of June and July. Some of these bodies are seen inside the lightly staining acidophils. These may be compared to the sphere cells of *Perca fluviatilis* (Kerr, '42). The presence of such acidophilic bodies is unusual in the pituitary during other months of the year. The acidophils of the pars intermedia show an increase in number and a corresponding numerical decrease is noted in the basophils. Lightly staining chromophils are also met with.

TABLE II

Percentage of the Chromophils and the chromophobes in the ubergangsteil of *Mystus seenghala* during different months of the year.

Month	Basophil		Acidophil		Chromophobe	
	No.	Percent-age	No.	Percent-age	No.	Percent-age
January	1225	45.1	1185	43.6	308	11.3
February	1590	59.2	869	32.4	227	8.4
March	1490	62.7	626	26.5	256	10.8
April	1945	60.5	1005	31.3	265	8.2
May	1973	57.4	1333	38.8	129	3.8
June	415	9.9	1227	29.3	2542	60.8
July	439	22.8	857	44.4	633	32.8
August	509	28.7	847	47.7	418	23.6
September	481	23.3	1058	51.4	522	25.3
October	703	32.8	1186	55.3	255	11.9
November	381	35.8	561	52.8	121	11.4
December	560	36.5	730	47.6	244	15.9



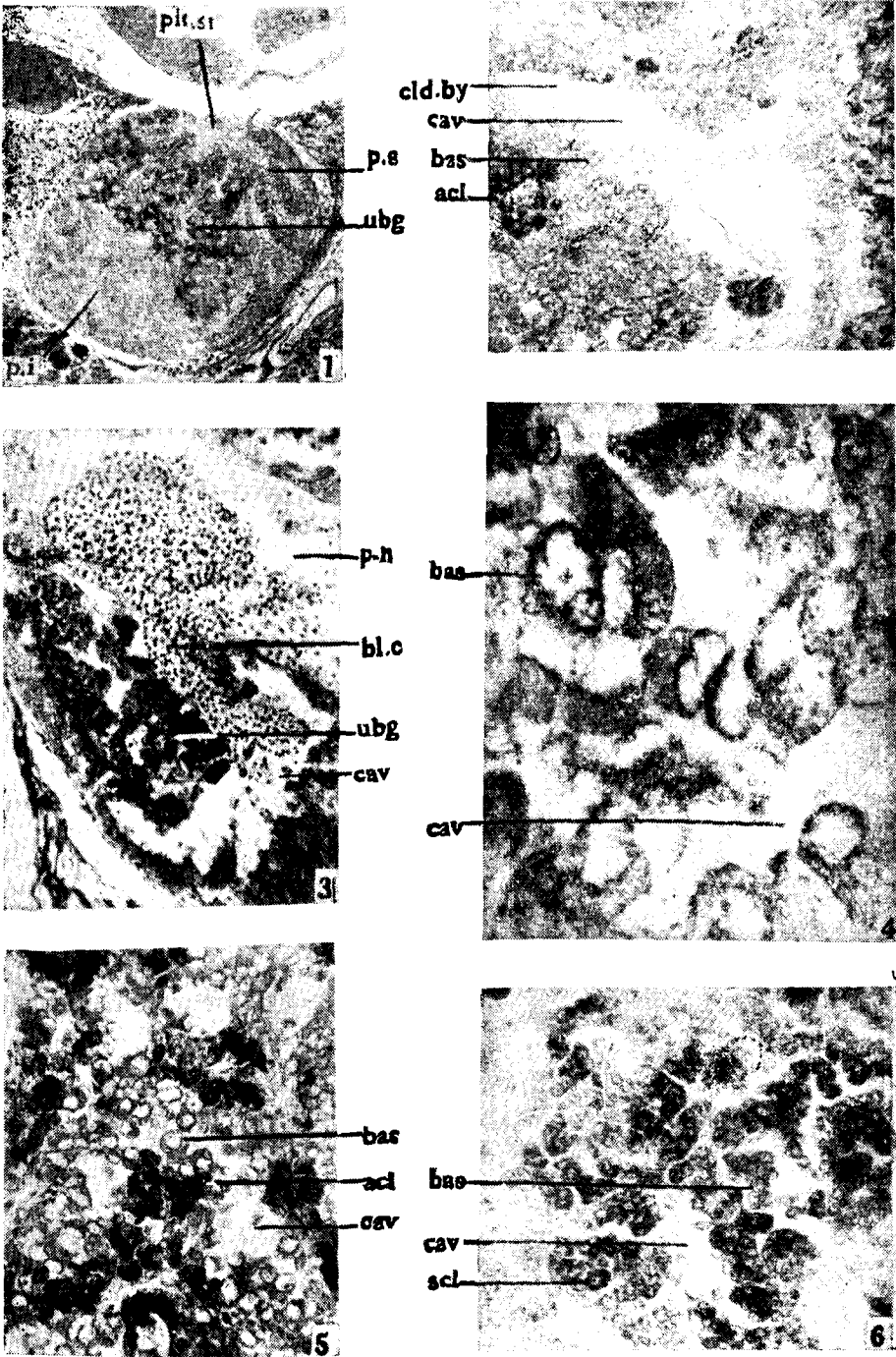
Explanation to Figures.

PLATE V

- Fig. 1. Median sagittal section of the pituitary of *Barbus* showing the arrangement of its various components. ... March X 80
- Fig. 2. Photograph showing the vesicle in the ubergangsteil containing basophilic colloid like material. A few basophils may be seen in the lumen. ... May X 420
- Fig. 3. Photograph showing infiltration of blood cells from the pars nervosa into the vesicle. ... April X 300
- Fig. 4. Photograph showing vacuolate basophils with small quantities of acidophilic granules in them. ... June X 1400
- Fig. 5. Photograph of the ubergangsteil showing acidophils vacuolated basophils and cavities containing varying quantity of colloid-like substance. ... June X 560
- Fig. 6. Photograph showing part of ubergangsteil during the resting phase. The basophils are devoid of vacuoles and narrowing out of vesicles also may be noted. ... January X 620

Sathyanesan:

Plate V



Correlative Cyclical changes in *Barbus Stigma*

Different spawning phases of the gonads and their duration:

Prespawning phase	...	February to April.
Spawning phase	...	April to July.
Regression phase	...	August to September.
Resting phase	...	September to January.

Structurally the pituitary of *Barbus* does not show much dissimilarity from that of *Mystus* (Pl. V. Fig. 1). Of all the components, the *übergangsteil* exhibits marked correlative seasonal changes. And the changes in the basophils, in particular, are more pronounced than those of the other cell types.

In the prespawning phase the *übergangsteil* is the smallest component and the acidophils form its chief cell type (vide Table III, Graph II). Both the basophils and acidophils are granulated. During the later half of this period the basophils show a numerical increase and the *übergangsteil* becomes larger in size (Pl. IV. Fig. 8).

During the spawning phase the *übergangsteil* stands out as the largest component of the pituitary having the basophils as its major cell type. Many basophils contain prominent acidophilic granules and globules in their cytoplasm. Some of the extruded globules are seen in between cells. A number of irregular cavities are formed in the *übergangsteil* during this phase. These cavities are chiefly lined by basophils. These vesicles may often contain basophilic colloid-like matter (Pl. V. Fig. 2). This may be the product of secretion of the basophils which are at times discernible among this secretory substance. In some cases infiltration of blood cells from the *pars nervosa* blood vessel is evident in these cavities (Pl. V. Fig. 3). These vesicles cannot be compared with those present in the *pars anterior* of trout, eel (Kerr. '42), *Chanos chanos* (Tampi, '51, '53) and *Hilsa ilisha* (Misra and Sathyanesan) because these are transitory and structurally different.

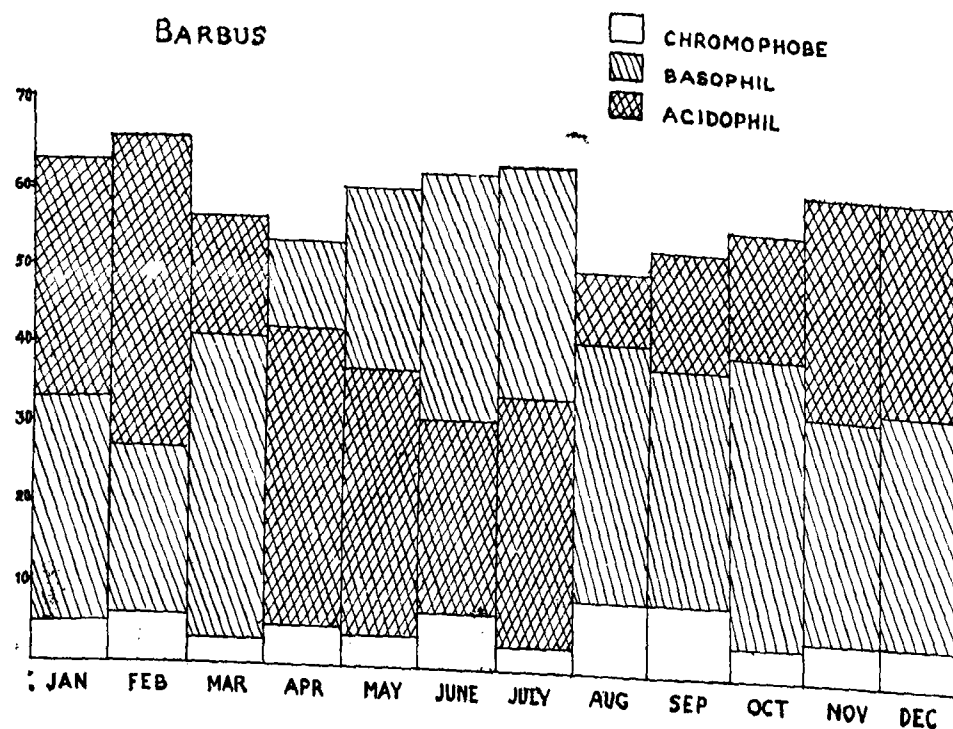
During the later part of the spawning period many basophils are denuded off their cytoplasmic contents and they become partly or wholly vacuolated. But unlike *Mystus* the basophils retain their identity (Pl. 5. Fig. 4). However, due to the vacuolated basophils the *übergangsteil* presents a net-like appearance as in the former species. The acidophil groups form islands amidst the basophils and do not show visible secretory activity (Pl. V. Fig. 5). Unlike *Mystus* at no stage the migration of chromophils into the *pars nervosa* could be evidenced.

In the resting phase, the basophils lose their vacuole and become compact and are finely granulated (Pl. 5. Fig. 6). The acidophils once again become the prominent cell type and *übergangsteil* is rendered smaller than the other components of the *pars glandularis*.

TABLE III

The percentage of the chromophils and chromophobes in the ubergangsteil of *Barbus stigma* during different months of the year.

Month	Basophil		Acidophil		Chromophobe	
	No.	Percent-age	No.	Percent-age	No.	Percent-age
January	164	32.5	316	62.7	24	4.8
February	97	27.4	235	66.4	22	6.2
March	344	41.0	469	55.8	27	3.2
April	467	53.1	372	42.2	42	4.7
May	947	60.3	567	36.9	57	3.7
June	569	62.3	284	31.0	61	6.7
July	798	62.6	434	34.1	42	3.3
August	134	40.7	166	50.3	29	8.9
September	178	38.0	246	52.6	54	9.4
October	196	39.8	276	55.9	21	4.3
November	135	33.3	248	61.2	22	5.4
December	130	33.9	236	61.4	18	4.7



Discussion

The pituitary of *Mystus* and *Barbus* are suspended from the floor of the infundibulum with a distinct stalk which ramifies into the pars glandularis as the pars nervosa. The pars glandularis is divided into three components, the pars anterior, ubergangsteil and pars intermedia. The homologies of all the components of the teleostean pituitary are not well established. The terminology of the pituitary components used by workers are no doubt little confusing (vide Table I). However, recent observations suggest the existence of a complete representation of the endocrine system of the higher vertebrates in teleosts (Hoar, '57). The presence of functional correlation between the pituitary and the gonads in teleosts has been variously assayed by workers. Studies reveal that the ubergangsteil in fishes exhibit maximum correlative variations.

Matthews reports (1936) the preponderance of acidophils in the ubergangsteil of *Fundulus* during the prespawning period whereas Scruggs ('51) records the basophil-acidophil percentage in *Carassius* at the corresponding stage to be 68 and 32. Bretschneider and de Wit ('47) report the characteristic change from acidophilicity of the 'anterior lobe' (ubergangsteil) to basophilicity and a return again to acidophilicity. The intermediate basophil stage according to them is "probably the actual working phase of the cell and represents the restitution phase of the products".

Mystus resembles *Carassius* (Scruggs, '51) in the occurrence of higher percentage of basophils and in the incidence of secretory basophils during the prespawning and spawning periods. In *Mystus* the phase in which the basophils preponderate is not so transitory as in *Rhodeus* (Bretschneider and de Wit, '47). During post-spawning period, in *Mystus*, a large percentage of the basophils of the ubergangsteil are rendered chromophobic due to degranulation and disappearance of their cytoplasmic contents. This may stand comparison with the shrunken chromophobes reported in the pituitary of *Fundulus* (Matthews, '36) and the net-like appearance of the ubergangsteil reported in *Xiphias* (Lee, '42) and *Cirrhinia* (Sathyanesan, '58). In *Barbus* though the ubergangsteil present a net-like appearance during the post-spawning phase the basophils retain their identity. Such a condition when the chromophobes predominate in the ubergangsteil does not obtain in the case of *Carassius* and *Cyprinus* (Scruggs, '51). He did not pay much heed to the chromophobes because of their negligible number. In *Mystus* soon after spawning the number of basophils gradually increase. But throughout the resting period acidophils form the major cell type (vide Table II, Graph I).

In *Triturus* Copeland, ('43) records that in the annual cycle of the male the 'globular basophils' increase with the testis growth and discharge with testis maturation. Aplington ('42) observed correlation between the testis and the pituitary during the growth period, by reason of the increase in the

number of granular basophils. According to him during the discharge of the sperms, it is the degranulation of the granular acidophils which furnishes evidence of correlation.

Herring ('08) suggested that the hyaline bodies are formed from the cells of the pars intermedia migrating into the pars nervosa. Stendell ('14) observed that disintegration of the immigrant cells of the pars intermedia in the pars nervosa and release of droplets of colloid from the cells of pars intermedia into the pars nervosa as two methods of secretion of that lobe. Potts ('42) supported the findings of Stendell ('14) in Poeciliid fishes. In *Mystus*, besides the secretory basophils described elsewhere disintegration of the migrated chromophils of the ubergangsteil takes place in the pars nervosa in the prespawning and the spawning phases. However, such a migration is not obvious in *Barbus*. During the period of gonadal regression migrated chromophils are apparently absent in *Mystus*. The other kinds of secretions seem to be the "sphere cells" which appear during the period of regression in the pars intermedia. These bodies are acidophilic and globular and do not appear in the other phases of growth. Kerr ('42) records the presence of 'sphere cells' and globular basophils in the ubergangsteil of *Perca fluviatilis*. He suggests that the herring material of the pars nervosa is formed from the droplets extruded from the sphere cells. Matthews ('36) compares the acidophilic colloid found in the pars nervosa of *Fundulus* with the secretory matter present in the cells of the pars intermedia to which it bears resemblance. Scruggs ('51) has suggested that the acidophilic contents of the globular basophils may be convertible into herring material. Bargmann ('58) opines that the herring bodies of the vertebrates belong to the nerve fibres of the diencephalon. Since the present work deals only with the pituitary a discussion on the neuro-secretory ganglion cells of the diencephalon is beyond the scope of this paper. The terms herring material, colloid-like bodies and hyaline bodies are used as synonyms by workers to denote the secretory matter lodged in the pars nervosa.

During the prespawning and spawning periods some of the blood sinuses of the pars intermedia and ubergangsteil contain basophilic colloid-like material and disintegrating basophils. Thus this matter appears to come in direct contact with the blood sinuses which may facilitate their transfer. Apart from these colloid-like bodies are seen along the main stalk of the pars nervosa, the possible formation of which is already described. In *Barbus* the vesicles containing colloid-like substance in the ubergangsteil during the spawning phase strongly suggests its secretory activity. And the infiltration of the blood cells into these vesicles may be inferred as one of the possible means by which the secretion is conducted into the general circulation. Sathyanesan ('58) reported the presence of acidophilic globules in the pars nervosa blood vessels of the pars intermedia of *Cirrhinus*.

The teleostean ubergangsteil has been compared to the pars anterior of higher vertebrates. Two views are current on the relationship of cells in the pars anterior of higher vertebrates. According to the first view the basophils, acidophils and the chromophobes are considered to be distinctly different cell types. The second view regards these cells as representing different physiological phases of a single type. An excellent review of this literature is given by Severinghaus ('33).

The basophil-chromophobe cycle in *Mystus* partly agrees with the scheme formulated by Kraus ('14 reviewed by Severinghaus '33). The reversion of the granular basophils to chromophobes do occur in this species by degranulation and loss of cytoplasmic contents. In conformity with Trautmann's view ('09) one finds in *Mystus* that few of the degranulated basophils undergo degeneration during the regressive period while some others show signs of regranulation. Those cells undergoing regranulation contain varying amounts of basophilic granules and may be representing the 'übergangszelle' of Kraus ('14) which according to him represent the transitional stage between the chromophobe and the basophil. Though the occurrence of acidophils with bluish tint and violet cells in the ubergangsteil of *Mystus* during August appears to be an intermediate stage between acidophil and basophil, it does not explain the numerical increase of the basophils during February; since such types of cells are met with only during August and are absent during the rest of the year. So it is evident that there is some other mode of conversion of one specific type into another but the details of which are obscure. No intermediate stage was observed during January or February suggestive of a gradual change over of the acidophils into basophils as postulated by Saint Remy (1892), Benda (1900), Collin ('33, reviewed by Severinghaus, '33) and more recently by Bretschneider and de Wit ('47). Since mitotic divisions are very rare in the ubergangsteil, the increase in the percentage of basophils during prespawning and spawning period cannot be attributed to division of the already existing cells.

The correlated seasonal changes in the pars intermedia in *Mystus* is not well manifested. However, the changes occurring in the amphiphils and the acidophils of the pars anterior appear to have definite seasonal significance.

Summary

The terminology of the components of the pituitary of teleosts is reviewed.

The general morphology and histology of the pituitary of *Mystus senghala* and *Barbus stigma* are described.

The ubergangsteil is the component of the pituitary which exhibits qualitative and quantitative seasonal variations that are correlated with the different growth phases of the gonads in both species.

The occurrence of granules, globules, liquefied cytoplasmic content, and the total disintegration of chromophils resulting in the formation of colloid-like matter are considered as signs of secretory activity.

The possible channels of conduction of the secretory product is suggested.

Chromophobe-chromophil relation is discussed.

Acknowledgments

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Key to Lettering

acl.	—	acidophil
bas. I	—	amphiphil
bas.	—	lightly staining basophil
ble.	—	basophil
ampl.	—	blood cell
cav.	—	cavity
chrb.	—	chromophobe
cll. by	—	colloid-like body
pa.	—	pars anterior
pi.	—	pars intermedia
pn.	—	pars nervosa
pit. st	—	pituitary stalk
ubg.	—	übergangsteil

Studies on The Life History and Feeding Habits of the Indian Thread-Fin *Polynemus indicus* (Shaw)

BY M. D. K. KUTHALINGAM*

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Introduction

The present account deals with part of the results of the investigations carried out by the author at the Madras University Zoological Research Laboratory for a period of five years (1953-1957) on the life histories and feeding habits of certain important marketable marine food fishes. Our knowledge of the life history and feeding habits of the Polynemids is confined to the work of Jones and Menon (1953) who described the eggs and some larval stages of *Polynemus paradiseus* and Sarojini and Malhotra (1952) on the larval development of *Eleutheronema tetradactylum*. Malhotra (1953) has given an account of the food and feeding habits of the young and adults of *Eleutheronema tetradactylum*. Though the present author (1955a) has already dealt with the food and feeding habits of juveniles and adults of *Polynemus indicus* it was considered worthwhile to present a complete life history together with the food and feeding habits during the different stages of growth. A general remarks on the bionomics and migrations are offered at the end of this section.

Material and Methods

The material for the study consists of 239 eggs and 92 larvae collected when townetting in the off-shore area about 25 miles north-east from Madras Harbour. They were brought to the laboratory in a porous mud pot and transferred to a glass trough. In such a process the delicate larvae were subjected to mechanical shocks which may account for most of the larvae not surviving for more than four hours in the laboratory; however, a few slowly recovered and were able to continue their development. But almost all the

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eggs so transported were unaffected and underwent normal development and were reared upto identifiable juveniles.

A high rate of mortality among the larvae was recorded when the yolk is absorbed and the digestive system of the pro-larvae becomes modified to take in food in the post larval stage. The pro-larvae hatched from the pelagic fish eggs retain the yolk for as long as three days and they do not feed. Even before the yolk is absorbed and the post larvae begin to feed, different items of food were supplied continuously in order to determine the earliest diet of the fish and to prevent the larvae from starving owing to lack of food they are partial to. Hence cultures of different planktonic organisms were maintained and replenished from daily hauls. A detailed account of the method of rearing the marine fish eggs and larvae has been already dealt with by the author in an earlier paper (Kuthalingam, 1959).

Eggs :

In a single plankton haul made in November 1956, 239 eggs were collected at 8-30 A.M. They were perfectly spherical with an average diameter of 1.3 mm. They were transparent and contained a large oil globule (about 0.5 mm. in diameter) as well as a clear unsegmented yolk. Development had proceeded to the stage in which a distinct embryo with unpigmented eyes, auditory vesicles, and pulsating heart could be made out. A few myotomes were also visible. The anterior portion of the body of the embryo was sunk in the yolk mass. Pigmentation was noticeable round the auditory vesicles, as well as the anterior end of the head region and in the caudal region—the rest of the body being unpigmented (Fig. 1). The larvae were seen turning and twisting inside the egg membrane. The eggs which were brought to the laboratory at 10 A.M. hatched by 1 P.M.

Larvae just hatched (Fig. 2):

These were found to rest on the bottom of the glass trough and darted about only when disturbed. They had an average length of 2.2 mm. The yolk mass was noticed as a bulge at the front end of the body with the oil globule on its posterior side. The larvae showed the same type of pigmentation as the embryo. Twelve pre-anal and eleven post-anal myotomes were observed. Paired fins were absent, the median fin-folds were continuous. A few chromatophores too faint to give any colouration were noticed on the part of the body swollen by the yolk.

Larvae 20 hours after hatching (Fig. 3):

The larvae were 2.4 mm. long. As the yolk had shrunk in bulk, the head was more prominent and the larvae swam with the yolk facing downwards. There was no change in the number of pre-anal myotomes, but four more post-anal myotomes were noticed and the mouth appeared as a small depression. The crowded black pigment cells on the tail region of the larvae which were noticed in the embryo and in the previous stage disappeared

completely, whereas they were more conspicuous on the head region. Numerous black pigment spots were scattered irregularly all over the body. The eyes were yet without any pigmentation. The auditory vesicles had enlarged in size and the dark patches of pigment cells which were seen crowded around the auditory vesicle also disappeared.

Larvae 24 hours after hatching (Fig. 4):

Eight larvae were found dead on the second day after hatching. The larvae continued to be transparent though they had increased in length to 2.8 mm. The eyes were pigmented and the iris was brown in colour. Four gills began to make their appearance. The mouth was formed and opened into the alimentary canal which was translucent and contained a smaller mass of yolk and oil globule. Rudiments of the pectoral fins appeared as prominent membranous folds. There was no change in the number of pre-anal myotomes, but nineteen post-anal myotomes could be made out at this stage. The larvae were unpigmented except in the ventral region of the head.

Larvae 48 hours after hatching (Fig. 5):

The larvae had increased to 3.8 mm. in length; as the yolk was not noticeable externally, they can be described as post-larvae. Of the 231 larvae, 32 larvae were found dead on the third day morning. The gape of the mouth was very wide extending far behind the eye. Numerous sharp curved teeth were present on the jaws. The four gills became more prominent and the general shape of the head was definitely polynemid. Thick black chromatophores were more or less regularly arranged in broken chains along the ventral side of the myotome and a few were also present in the ventral fin fold. Owing to the heavy pigmentation the gut was obscured, but about twenty-three pre-anal myotomes could be made out with difficulty. The pectoral fins were semi-circular in shape and were attached by their broad bases.

Twenty of the post-larvae were supplied with different articles of food from the plankton such as nauplii and adults of copepods, molluscan larvae, diatoms, cirripede larvae, larval polychaetes and ostracods, and larval *Penaeus*. The post-larvae did not feed on any of these food items for about four hours. It is probable that during this period the species did not feed owing to the presence of some yolk which these post-larvae retained within their guts. After four hours, fifteen of the larvae were seen feeding actively, and five larvae which were found inactive resting at the bottom of the vessel were found dead by the evening. Examination of their gut contents showed that traces of yolk still persisted inside the stomach; hence it may be inferred that owing to some failure of functional co-ordination of internal organs, the larvae perished. The rest of the larvae fed more on copepod eggs, nauplii and adults than on other food. The copepods were identified as *Macrosetella gracilis*, *Temora* sp., *Oithona rigida*, *Paracalanus parvus*, *Euterpina achutifrons*, *Acartia erythraea*, *Pseudodiaptomus* sp., and *Corycaeus* sp. Another lot of twenty post-larvae were supplied with a large

number of diatoms and copepods. It was observed that these larvae rejected diatoms. When fresh unsorted plankton samples were given to another lot of twenty larvae, and after about four hours they were killed and the stomach contents teased on to a slide, it was found that 79.8% of the total food consisted of nauplii and adult copepods and 20.2% constituted cirripede larvae. It was concluded that the post-larvae were purely carnivorous in their feeding habits and that they preferred small sized prey to the larger penaeid larvae.

There was no change in the diet for another six days.

Larvae 10th day after hatching (Fig. 6).

The larvae had now attained an average length of 9.2 mm. There was no change in the number of pre-anal myotomes, but there were twenty-three

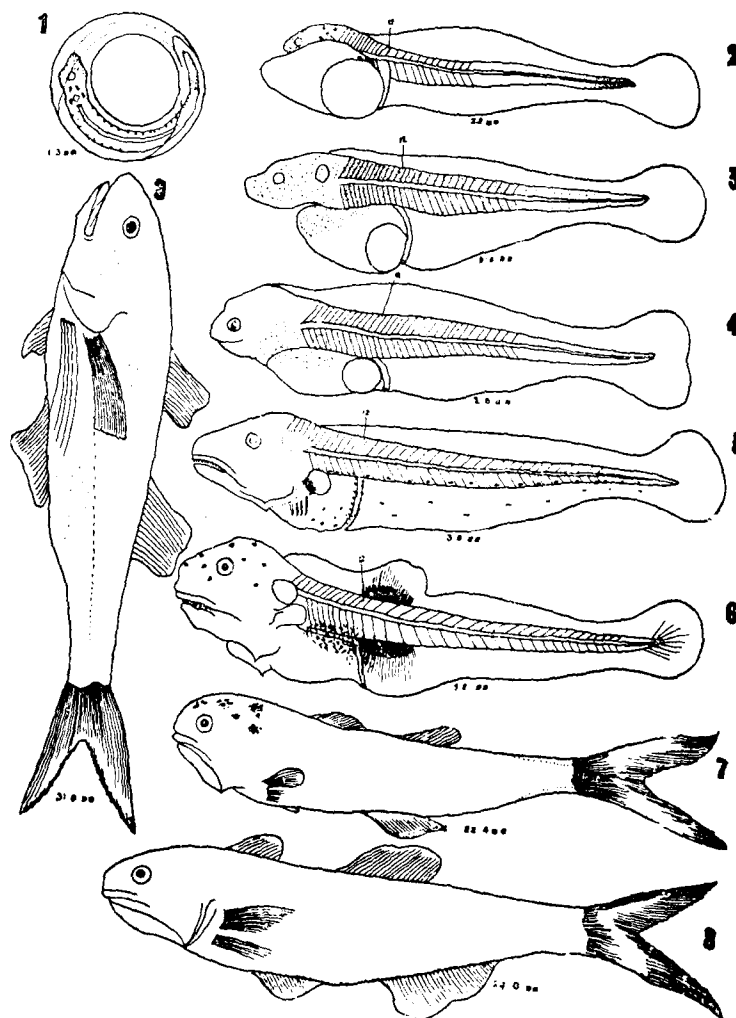


Fig. 1 Egg. Fig. 2-4 Pro-larvae. Fig. 5-8 Post-larvae. Fig. 9 Juvenile.

post-anal myotomes which appeared to have increased in height and breadth. There was an increase in width at the anterior half of the trunk. The abdomen had become opaque due to the intensity of the black pigmentation, and the rest of the body also became less transparent and the myotomes could be made out only after fixing and clearing in cedar wood oil and staining in Boraxcarmine. Anterior portion of the head had increased in breadth and height and gained the shape characteristic of the species. The mouth was sub-ventral. Though the median fins were continuous still, the rudiments of the fin rays were differentiated. Fin-rays were noticed in the caudal region also. Pectoral fins were large with a lower lobe, whereas the pelvics were still absent. Isolated black chromatophores were present on each side of the dorsal aspect of the head in front and behind the eyes.

Though different items of planktonic food were supplied to these post-larvae, the larvae did not feed on any food except larval *Penaeus sp.* and very few copepods. As in later life this fish shows a selective partiality for *Penaeus sp.*, it was considered worthwhile to see if it does so at this stage. Equal number of penaeid larvae and copepods were left in a dish containing twenty post-larvae. The fish larvae were carefully watched under a binocular and it was found that they ate up the penaeid larvae first before going for the copepods. After four hours a few copepods were still left suggesting that this fish manifests its habits of selective feeding even on the 10th day after hatching. Ten post-larvae reared separately and fed with only adult and nauplii of copepods, cirripede larvae, molluscan larvae, diatoms and polychaete larvae died after the fourth day, though they fed liberally on this diet. It is possible that the body requires a penaeid diet. There was no change in diet till another ten days except the growth in size of these larvae.

Larvae 21st day after hatching (Fig. 7):

The post-larvae had grown to a length of 22.4 mm. and had become completely opaque. Both the dorsal fins were formed. The caudal fin was distinctly forked. The pelvic fins appeared as small buds. The lower lobe of the pectoral fin was very conspicuous and rudiments of free fin filaments were seen. Patches of dark black pigment cells were noticed over the eyes and in the head region.

Feeding experiments conducted during the next two days showed no change in diet but the fish preferred larger sized prey to smaller ones.

Larvae 24th day after hatching (Fig. 8):

The larvae had grown to 24.8 mm. in length. The median fin-folds had completely disappeared and all the fins had fin-rays and were separate from each other. Pelvic fins were well developed. This is practically the last phase of the post-larval stage. The characteristic large eyes were also noticed at this stage and the free pectoral fin-rays grew beyond the upper lobe of the

pectoral fin. The rudiments of the scales were also indicated. The general shape of the dorsal and anal fins resembled those in the adult but were extremely soft and partially transparent.

On the morning of the 24th day a batch of twenty larvae were supplied with different species of *Penaeus* (*Penaeus carinatus* and *P. indicus*) together with copepods and were observed under the binocular. It was found that these post-larvae which supplemented their *Penaeus* diet with a few copepods now fed exclusively on *Penaeus spp.* To verify this another lot of twenty larvae were supplied with only a definite number of copepods. These larvae did not feed on any of them, but starved for eight hours till *Penaeus spp.* were introduced. After about four hours, these fish larvae were killed and their stomach contents examined. It was found that of the twenty larvae, eighteen had taken only prawns whereas the other two larvae had prawns as well as four copepods in each.

No change in diet and structure was noticed for another five days.

Ninety-eight post-larvae measuring 8 mm. — 24.8 mm. were collected from the plankton as well as from the fishermen's net during the month of December. The examination of the stomach contents showed that 72.8% of the stomachs were filled with *Penaeus sp.* and the rest 27.2% consisted of copepod adults and nauplii. The copepods were identified as *Pseudodiaptomus sp.*, *Temora sp.*, *Acartia sp.*, *Oithona sp.*, *Paracalanus sp.*, *Eucalanus sp.*, and *Corycaeus sp.* which are the commonest in the Madras plankton.

Larvae 30th day after hatching:

Though the post-larvae had grown to a length of 28.3 mm. there was not much difference in its external features. But during the next nine days, growth became slack though all the features of the juvenile stage came into prominence.

Larvae 40th day after hatching (Fig. 9):

Except for the shortness of the free filaments of the pectoral fins, the juveniles which measured 31.8 mm. exhibited all the adult characters including the pattern of pigmentation. The juveniles were identified as belonging to *Polynemus indicus*. The following fin formula was recorded D. 8/1/13. P. 15. A. 3/12. L. 1, 72. Pectorals were complete with five articulated free rays, the upper of which was the longest reaching nearly the anal. The caudal was deeply forked with pointed lobes, the lower being longer than the upper. All the fins were well developed, but still partially transparent. The young fish was black purplish at the back and the abdomen was silvery white dashed with gold.

To determine the diet of these juveniles, twenty of them were supplied with fresh unsorted plankton. After two hours they were killed and were

found to have fed exclusively on larval and young forms of penaeids particularly *Penaeus carinatus*. Since the adults showed a definite preference for this species of *Penaeus* (vide paper 1955a) a lot of twenty juveniles were supplied with equal number of *Penaeus carinatus* and *P. indicus*. It was observed that the juveniles fed 73.8% of *Penaeus carinatus* and 26.2% of *P. indicus*. This experiment was repeated several times and the results obtained were found to be the same.

A total number of 118 juveniles measuring 28.5 mm. 41.8 mm. collected from the fishermen's nets during January, showed that 76.2% of the total food consisted of *Penaeus carinatus*, 15.7% of copepod adults (*Temora sp.*, *Acartia sp.*, *Oithona sp.*, *Paracalanus sp.*, *Pontella sp.*, and *Eucalanus sp.*) and 8.1% consisted of nauplii of different species of copepods.

General Remarks

From the above study of the food and feeding habits of the species and from the statistics of fish landings at Madras a few general conclusions may be hazarded.

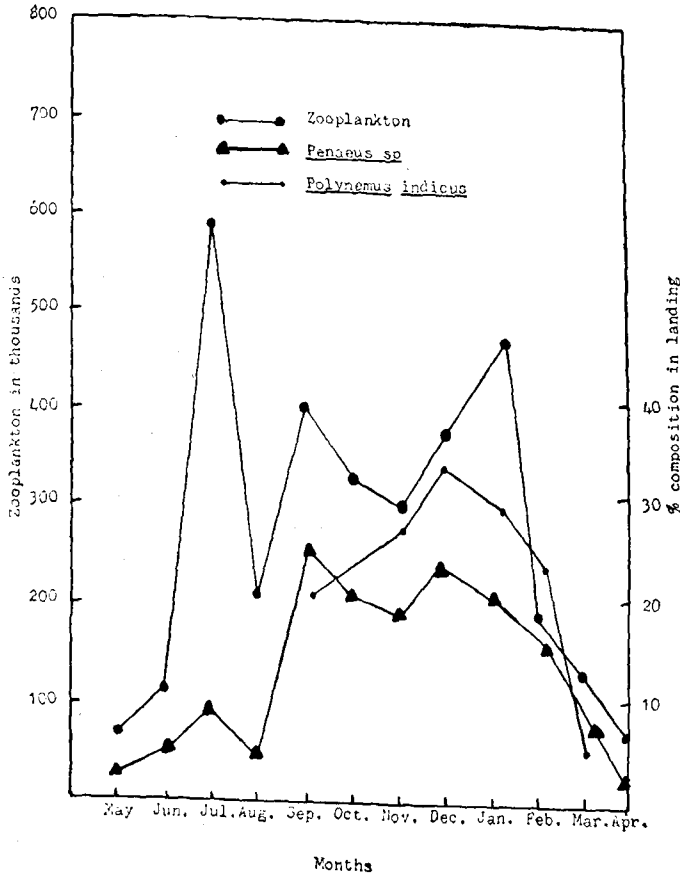
This carnivorous fish appears in Madras in-shore area in September. Landings during the next two months contained a maximum number of spawners. This fact taken together with the occurrence of eggs in the plankton, suggests that the fish returns to the in-shore waters of Madras for breeding. This conclusion is further supported by the fact that a large number of fish caught in December were spent fishes. As would be evident from the study of the life history and the occurrence of post-larvae ranging in length from 8 mm. 24.8 mm. during December and of juveniles ranging in size from 28.5 mm. 41.8 mm. during January and February, this species uses the in-shore waters as a nursery for its young.

Statistics of fish landing in September indicate that this fish moves in shoals when it migrates. Random samples from each day's landings showed that in some nets the species formed 25—33% of the total catches while others were almost free of them. During October and November no such predominance of the species was noticed in the catches suggesting a scattering. But in December again there was a marked increase in the percentage of this fish in the catches with the difference that all the adults were mostly spent ones suggesting the reformation of the shoals and the commencement of migration to off-shore feeding grounds, for in February the species became scarce, and disappeared from Madras waters in March.

If we plot the number of this fish and prawns landed in the different months in the in-shore area of Madras along with the volume of zooplankton (vide Graph No. I), we are impressed by the fact that during the period (September to February) when this fish sojourns in Madras waters, there is also an abundance of young and adult penaeids which constitute its food,

It is equally significant that when the prawn population becomes less abundant—probably because most of the adult prawns migrate to deeper off-shore waters—this fish also becomes scarce in March and totally absent till September.

Several authors like Peterson (1894), Dannevig (1897), Lebour (1919), Russel (1929), and Shelbourne (1953) have emphasized the capacity of some fish for selective feeding and restricting their diet to one or a few species of



Graph No. 1 showing the occurrence of *Polynemus indicus* correlated with the seasonal variation in the zooplankton and the landing of *Prawn spp* during 1956-'57.

prey. *Polynemus indicus* is remarkable in limiting its diet to only one species, viz., *Penaeus carinatus* during its adult life. The stomach contents of larvae, juveniles, and adults collected from the sea as well as experiments on feeding in the laboratory, showed that larvae ten days after hatching begin to show a partiality for penaeid larvae. From the time the fish attains the juvenile stage the entire diet is made up of young prawns belonging to *Penaeus carinatus* and *Penaeus indicus* with a definite preponderance of the

former species. When the fish becomes adult it feeds on larger individuals of *Penaeus carinatus* even though fishermen's landing showed that other species of prawns also occur in the area.

The spent fishes appear to feed more voraciously than the matured fish and the spawners (vide Table No. 2).

Table (No. 2) showing the total number of fishes examined and the percentage average volume of food consumed during the three different stages of *Polynemus indicus* :—

Stage of maturity	No. of fishes examined from 1955—57	Percentage average volume of stomach contents in cc.
Nature	218	2.2
Spawning	204	2.9
Spent	228	4.3

All these three categories of the adult fish, the post-larvae and the juveniles take a heavy toll of young and adult prawns (*Penaeus sp.*). Therefore it is to be inferred that these fishes are harmful to the prawn fishery of this area. It must however be remembered that this fish is of higher economic value than the prawns.

Summary

- (1) The various stages in the life history of *Polynemus indicus* are described with the composition of the earliest diet of the post larvae, the later changes in diet during the subsequent stages are described fully on the basis of the experiments conducted on their feeding. The data gathered regarding their larval diet are compared with those of the adults diet.
- (2) Feeding begins invariably when the prolarvae is transformed into post larvae. *Polynemus indicus* begins on a diet of copepod eggs, nauplii and adults during the early larval period gradually changes over to larger organisms and *Penaeus sp* in particular as it grows and finally subsists on *Penaeus spp*. It is all the more significant that even amongst the different species of *Penaeus* occurring in mid-waters, the fish preferred only *Penaeus carinatus*.
- (3) The heavy mortality noted in the pro-larvae just metamorphosed into post-larvae, not being due to physico-chemical factors or lack of food but due to physiological defects is suggested.

(4) Feeding migrations, selective feeding during the life history of the fishes studied are commented on.

Acknowledgment

I am thankful to Dr. C. P. Gnanamuthu, the Director Zoology Research Laboratory, Chepauk, Madras for suggesting the problem and for his guidance throughout the course of investigation. I am indebted to Dr. G. A. Steven, the Laboratory Citadel Hill Plymouth and Dr. M. V. Lebour for offering their valuable suggestions. In conclusion I wish to thank the syndicate of the Madras University for the award of a Research Fellowship during the tenure of which the present investigation was conducted.

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Incidence of Opalinid⁽¹⁾ Infections in Certain Monitor Lizards

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Introduction

After working for over three years on the problem of opalinid infection in *Varanus monitor* Linn., Misra (1943), very briefly, indicated about the occurrence of *Opalina* and *Cepedea* in this lizard. Since then, wherever opportunities permitted, he has tried to collect further data on this topic. Recently, he had the opportunity of examining the preserved specimens of monitors in the collections of the Zoological Survey of India. The purport of this paper is to place on record the data availed in regard to the incidence of opalinid infections in certain monitors.

The writer wishes to express his sincere thanks to Dr. M. L. Roonwal, Director, Zoological Survey of India, for kindly extending facilities for work, and also to the authorities of his Reptilia Section for their kind cooperation.

Observations

During the course of several years, 90 specimens of monitors were collected from various parts of India, and observations on their opalinid parasites (commensals) were made. Certain specimens of *Varanus monitor* Linn., showing opalinid infections in their faeces, were starved for months together, at Lucknow, before being destroyed. Survival of opalinid infections was noted even in such specimens of this lizard as were kept starving for over seven months. In the starved host specimens, the opalinids were usually found to occupy greater areas of the alimentary canal, and in some cases the entire gut was found infected with them. This abnormality may, possibly, be due to the inactivity of the gut during the starvation period, as has been suggested by Ratcliffe and Geiman (1938) for entamoebic infection in the stomach and intestine of the water snakes, *Natrix rhombifer*, etc.

As for the observations on the opalinids in the preserved specimens of monitors, out of 70 such specimens examined, the guts of 15 were found already removed (probably before preservation); of the remaining 55 specimens, 51 had Reg. Nos. of the Z.S.I., while 4 (1 *Varanus monitor* and 3 *V. flavescens*) were not numbered, but had their guts intact. For the sake of convenience, the data regarding the incidence of opalinid infections in monitors are being dealt with below separately under two headings, viz., data from (i) freshly killed hosts (Table 1), and from preserved hosts (Table 2).

(1) Previously, the opalinids were classified as ciliated protozoa (Protociliata, Ciliophora), but, of late, the trend in vogue is to regard them as flagellated protozoa (Zoomastigina, Mastigophora). The writer, however, is reluctant, at least for the nonce, to uphold the view that the opalinids "are excluded entirely from the hierarchy of ciliated protozoa". Corliss, 1956).

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TABLE 1.—Incidence of Opalinid infections in freshly killed specimens of monitors :—

Name	Locality	Number of specimens examined	Number of specimens infected	Approximate percentage of infection	Intensity and site of infection
1. <i>Varanus monitor</i> Linn.	Lucknow (U.P.)	53	21	39.6%	(i) 5 specimens showed very heavy infection throughout the gut; (ii) 12 were heavily infected in the region of the small intestine, but less so in the rectum; and, (iii) 4 showed moderate infections in the small intestine and rectum.
	Nautanwa Gorakhpur, (U.P.)	14	4	28.5%	(i) 3 specimens showed heavy infections, and (ii) 1 revealed light infection in the small intestine and rectum.
	Agra (U.P.)	6	Nil	—	—
	Bhagalpur (Bihar)	8	2	25.0%	Both specimens showed moderate infections in the small intestine and rectum.
2. <i>Varanus flavescens</i> (Gray).	do	7	Nil	—	—
3. <i>Varanus griseus</i> (Gray).	Saugor (M.P.)	2	Nil	—	—

TABLE 2.—Incidence of Opalinid infections in preserved specimens of monitors in the collections of the Zoological Survey of India :

Name	Z.S.I. Reg. Nos.	Locality	Date of Collection	Collector/Donor	Intensity and site of infection
1. <i>Varanus monitor</i> Linn.	2136	Sibsagar (Assam)	-10-1872	S. E. Peal	Negative
	18369	Ishapur, Barrackpur, Calcutta (West Bengal)	-5-1916	Dr. Matley	do
	16428	Nainital Dt. (U. P.)	—	R. Hodgart	do
	19897	Central Jail Jabbalpur (M. P.)	—	Major R.T. Rodgers	do
	20735	Bikaner, (Rajasthan)	5-4-1957	Dr. S. D. Gupta	Moderate infection; small intestine and rectum.
	20736	do	do	do	Negative
	20737	do	do	do	Very heavy infection; throughout the gut.
	20738	do	do	do	Negative
	20739	do	do	do	Very heavy infection; throughout the gut.

TABLE 2.—(Contd.)

Name	Z.S.I. Reg. Nos.	Locality	Date of Collection	Collector/ Donor	Intensity and site of infection
	20740	Bikaner (Rajasthan)	do	Dr. S. D. Gupta	Light infection; small intestine and rectum.
	20741	do	do	do	Negative
	20742	do	do	do	Very heavy infection; throughout the gut.
	20743	do	do	do	Negative
	4664	Pishri Persian Beluchistan)	- - 1872	W. T. Blanford	do
	2105	—	—	—	do
	2129	Calcutta (West Bengal)	2-6-1870	Purchased	Negative
2. <i>Varanus flavescens</i> (Gray) 1.	2149	do	-1-1867	Dr. Anderson	do
	2170	do	-2-1870	do	do
	20693	do	-4-1957	—	do

(1) Smith (1932) writes about *Varanus flavescens* (Gray) as follows: "The rarest of all the Indian species, only a few specimens being known in Museum Collections". His remark was based upon his experience of the collections of this monitor in the British Museum (Natural History), the Indian Museum, Calcutta, and the Museum of the Bombay Natural History Society. It may be remarked that it is not a safe criterion to judge the frequency of occurrence of an animal by the numbers it is represented in a Museum or Museums. However, Smith (1935) again writes about this species: "Apparently common in many places, but poorly represented in Museums". On the contrary, the writer finds this species well represented in the collections of the Zoological Survey of India.

TABLE 2.—(Contd.)

Name	Z.S.I. Reg. Nos.	Locality	Date of Collection	Collector/ Donor	Intensity and site of infection
	20695	Calcutta (West Bengal)	do	—	do
	16008	Pakur (Bihar)	—	R. Hodgart	do
	2173	Agra (U. P.)	17-7-1870	Agra Museum	do
	2138	Ambala (Punjab)	-1-1873	Sogin Esqr.	do
	2139	—	—	—	do
	2114	Moulmein (Lower Burma)	27-9-1870	I. Craw- ford	Negative
3. <i>Varanus nebulosus</i> (Gray)	2168	—	—	—	do
	2169	—	—	—	do
	2172	—	—	—	do
	2188	Colombo	-10-1872	H. Fergu- son	do
4. <i>Varanus griseus</i> (Daudin) 1.	20697	Bikaner (Rajasthan)	—	Dr. S. D. Gupta	Negative

(1) Corkill (1928) writes about *V. griseus*: "It is said not to hibernate, and as a fact is seen much more frequently in winter all day long than in summer when it is seen in early morning and late evening only." Smith (1935) also mentions, "they are said not to hibernate. Recently, Khalil and Abdel-Messeih (1959) have written about this species: "It usually hibernates during the months of October, November, December and January". These contradictory statements regarding the hibernating behaviour of this monitor deserves elucidation.

TABLE 2.—(Contd.)

Name	Z.S.I. Reg. Nos.	Locality	Date of Collection	Collector/ Donor	Intensity and site of infection
	20723	Bikner (Rajasthan)	5-4-1957	Dr. S. D. Gupta	Moderate infec- tion; small in- testine and rectum.
	20724	do	—	do	Negative
	20725	do	—	do	Moderate infec- tion; small in- testine and rectum.
	20726	do	—	do	Negative
	20727	do	—	do	do
	20728	do	—	do	do
	20729	do	—	do	Very heavy in- fection through- out the gut.
	20730	do	—	—	Negative
	20731	do	—	do	do
	20732	do	—	do	do
	20733	do	—	do	do
	20734	do	—	do	do

TABLE 2.—(Contd.)

Name	Z.S.I. Reg. Nos.	Locality	Date of Collection	Collector/ Donor	Intensity and site of infection
5. <i>Varamus salvator</i> (Laurenti) 1.	4670	Bhamo (Upper Burma)	—	T. C. Cooper	Negative
	2115	Samagooting (Assam)	-10-1872	Capt. Butler	do
	2183	—	—	—	do
	2190	Calcutta (West Bengal)	do	Dr. King	do
	4669	do	—	O. S. Fraser	do
	12604	Narcondam Islands (Bay of Bengal)	—	F. R. Mallet	do
	13743	Andaman Islands	—	C. Casey	do
	11914	Brisbane (Australia)	—	Queens- land Museum exchange	do
	11916	do	do	—	do

(1) Regarding the Common Water-Monitor (*V. salvator*), Smith (1930) writes: "The food of the Water-Monitor consists mainly of fish and frogs."

Conclusions

1. The percentage of opalinid infections in *Varanus monitor* Linn. was found to be nearly 31.0% and in *V. griseus* (Daud.) 23.0%.
2. The specimens of *V. flavescens* (Gray), *V. nebulosus* (Gray), and *V. salvator* (Laurenti) were found negative for opalinid infections.
3. It is interesting to note that the Common Water Monitor (*V. salvator*), which mostly feeds upon fish and frogs (Smith, 1930), proved negative for opalinid infection, whereas some specimens of the Desert Monitor (*V. griseus*)—a xerophytic species, which has little chances to come across frogs in nature (Mertens, 1942)—were found to harbour certain opalinids.

4. Contrary to Metcalf's (1940) view, the writer feels that the opalinid infections in monitor lizards are not adventitious or temporary.

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Studies in the Ecology of the Vellar Estuary : I. A preliminary Survey of the Estuarine Bottom and its Fauna conducted on 11-9-59.

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(Communicated by Prof. R. V. SESHAIYA, F.Z.S.I.)

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Introduction

Annandale (1907) and Annandale and Kemp (1915) conducted what have come to be regarded as classic investigations of the ecology of Gangetic Delta and Chilka Lake. Panikkar and Aiyar (1937) made a faunal investigation of the brackish water areas near the city of Madras. Recently Kuriyan (1955) made a preliminary survey of the bottom fauna and the bottom deposits of the Travancore coast within 15 fathom line.

The concept of bottom communities has formed the subject of extensive study in Europe and U.S.A. Intensive work has been carried out by Jones (1950, '51 & '56 in U.K., Sanders (1956 & '58) in U.S.A. and Thorson (1958) in Denmark. In India some attempts have been made recently to study the bottom fauna of the sea, as pointed out above. But comparatively little is known of the estuarine bottom communities in India. The present account is the report of a preliminary quantitative survey of the macrofauna associated with the bottom deposits of the Vellar estuary. It was undertaken to determine the species composition of the animal communities and the sediment composition. The survey was made on 11th September 1959.

The Vellar estuary is situated on lat $11^{\circ} 29'N$ and long. $79^{\circ} 47'E$ at Porto Novo, S. India where it flows into the Bay of Bengal. The bar of the estuary is always open and the estuary is relatively shallow averaging six feet in depth before the monsoon period. Seven survey stations were established as being representative of different faunal assemblages in the estuary.

Methods

Petersen dredge and Ekman dredge were used for collection of bottom samples. After picking out the larger organisms, the bottom samples were washed through a sieve with 1 mm. circular holes under water tap. The organisms retained in the sieve were collected and examined. After identification and counting they were preserved in 4% formalin. From each haul a little quantity of mud sample was taken, dried and later subjected to the method of grade analysis used by Holme (1954).

TABLE 1

Number of organisms per square meter in various stations

Station number	...	1	2	3	4	5	6	7
Depth (meter)	...	1.824	1.524	1.824	3.353	2.134	1.824	1.829
Species	...							
Polychaeta								
<i>Pisionidens indica</i> Alikunhi	...	2	-	-	-	-	-	-
<i>Ancistrosyllis constricta</i> Southern...	...	15	-	5	-	-	-	-
<i>Lycastis indica</i> Southern	...	-	-	-	-	2	-	-
<i>Tylonereis fauveli</i> Southern	...	-	-	-	-	3	-	-
<i>Nereis chilensis</i> Southern	...	-	-	2	-	-	-	-
<i>Nephtys polybranchia</i> Southern	...	20	-	-	-	-	-	-
<i>Lumbriconereis polydesma</i>								
Southern	...	-	2	8	10	4	-	-
<i>Lumbriconereis simplex</i> Southern...	...	-	-	-	-	5	2	-
<i>Glycera alba</i> Rathke	...	8	-	-	-	-	-	-
<i>Heteromastus similis</i> Southern	...	-	-	3	4	-	-	-
<i>Paraheteromastus tenuis</i> Monro	...	-	4	-	3	-	-	-
<i>Branchiocapitella singularis</i>								
Fauvel	...	-	-	4	-	-	-	-
<i>Euclymene annandalei</i> Southern...	...	-	-	3	3	-	-	-
<i>Nerine cirratulus</i> Delle Chiaje	...	5	-	-	-	-	-	-
<i>Spio bengalensis</i> Willey	...	2	-	2	3	-	-	-
<i>Prionospio polybranchiata</i> Fauvel...	...	-	-	4	4	5	2	-
<i>Cossura delta</i> Reish	...	-	-	-	96	5	-	-
<i>Ammotrypane aulogaster</i> Rathke	...	4	-	-	-	-	-	-
<i>Pectinaria crassa</i> Grube	...	4	-	-	-	-	-	-
<i>Laonome indica</i> Southern	...	-	-	-	7	-	-	-

TABLE 1—(Contd.)

Number of organisms per square meter in various stations

Station number	...	1	2	3	4	5	6	7
Depth (meter)	...	1.824	1.524	1.824	3.353	2.134	1.824	1.829
Species	...							
Isopoda								
<i>Apseudes gymnophobia</i> Brnrd	...	-	-	-	-	-	18	8
<i>Apseudes chilensis</i> Chilton	...	-	2	2	-	-	-	-
<i>Apanthura sandalensis</i> Stebb	...	-	-	2	-	-	-	-
<i>Synidotea variegata</i> Collinge	...	-	-	1	-	-	-	-
Amphipoda								
<i>Niphargus chilensis</i> Chilton	...	-	-	3	-	-	-	-
<i>Paracalliope fluviatilis</i> Thomson	...	-	-	-	-	-	-	4
Decapoda								
<i>Alpheus malabaricus</i> Fabricius	...	-	-	1	-	-	-	-
Phoronida								
<i>Phoronis architecta</i> Andrews	...	-	-	24	-	-	-	-
Mollusca								
<i>Meretrix meretrix</i> Linn	...	-	106	4	-	-	-	-
<i>Arca granosa</i> Linn	...	-	5	-	-	-	-	-
<i>Solen aquae-dulcioris</i> Ghosh	...	-	-	-	1	-	-	-
Pisces								
<i>Trypauchen vagina</i> Bl & Schn	...	-	-	-	1	-	-	-
Total numbers	...	60	119	68	132	24	22	12

Station I is situated near the mouth of the Vellar estuary. The maximum depth here is 1.824 meter. Salinity at the bottom is 29.61‰. The bottom deposit consisted of coarse sandy loam (Table. II). The density of the organisms is 60 per square meter. (Table I). Eight species of animals, all of them Polychaetes, were found at the bottom. They are *Ancistrosyllis constricta*, *Nephtys polybranchia*, *Glycera alba*, *Nerine cirratulus*, *Pisionidens indica*, *Spio bengalensis*, *Pectinaria crassa* and *Ammotrypane aulogaster*.

Station II is situated about 1.5 kilometers from Station I. The maximum depth at this place is 1.524 meter. Salinity at the bottom is 27.57‰. The bottom deposit consisted of loamy sand. The density of the organisms is 119 per square meter. Seven species were collected. The polychaetes *Lumbriconereis polydesma* and *Paraheteromastus tenuis*, the Isopod, *Apseudes chilensis* and bivalves, *Meretrix meretrix* and *Arca granosa* were found. *Meretrix meretrix* formed 89.1% of the total number.

Station III is situated about 200 meters from Station II. The maximum depth at this place is 1.824 meter. Salinity at the bottom is 26.98‰. The bottom deposit consisted of sandy loam. The density of the organisms is 68 per square meter. Polychaetes, Isopods, Amphipods, *Meretrix*, *Alpheus* and *Phoronis* were collected. *Phoronis architecta* formed the dominant species in the community being 35.3% of the total number.

Station IV is situated opposite to the Biological Station and is about 0.6 kilometers from Station III. The maximum depth at this place is 3.353 meters. Salinity at the bottom is 26.36‰. The bottom deposit consisted of silty clay. The greatest concentration of animals per square meter was found in this station. The density of the organisms is 132 per square meter. *Cossura delta*, a cirratulid Polychaete was the dominant species in the population forming 72.7% of the total. The gobiid fish *Trypauchen vagina* was dredged at this station.

Station V is situated about 0.6 kilometers from Station IV. The maximum depth at this place is 2.134 meters. The salinity at the bottom is 22.64‰. The bottom deposit consisted of loam. The density of the organisms is 24 per square meter. Six species, all of them Polychaetes, *Cossura delta*, *Prionospio polybranchiata*, *Lumbriconereis polydesma*, *Lumbriconereis simplex*, *Lycastis indica* and *Tylonereis fauveli* were present.

Station VI is situated about 1.5 kilometers from Station V. The maximum depth at this place is 1.824 meter. The salinity at the bottom is 16.43‰. The bottom deposit consisted of silty clay. Three species are present in the bottom deposits. The density of the organisms is 22 per square meter.

TABLE 2

Percentage of each grade in deposit samples

Particle size (mm)	>2.0	2.0 1.0	1.0 0.5	0.5 0.25	0.25 0.125	0.125 3.0313	<0.0313	shell
Station								
1	1.67	10.24	28.51	21.02	11.45	6.13	20.98	-
2	-	5.46	11.38	32.99	19.05	14.31	16.81	1.6
3	-	1.22	5.26	10.84	20.16	17.18	46.34	1.2
4	-	-	-	1.89	4.63	15.45	78.03	-
5	-	-	3.14	7.55	10.26	20.32	58.73	-
6	-	-	-	1.14	6.28	11.76	80.92	-
7	-	-	-	1.59	2.85	6.92	88.64	-

TABLE 3

Hydrological data for various stations on 11-8-59

Station	1	2	3	4	5	6	7
Temperature °F Surface ...	84	83	83	83	82	82	82
Bottom ...	83	83	83	83	83	83	83
Salinity ‰ Surface ...	19.26	14.78	14.66	10.83	8.81	5.87	5.12
Bottom ...	29.61	27.57	26.98	26.36	22.64	16.43	14.63
Oxygen ppm. Surface ...	6.0	6.0	6.0	6.0	6.0	6.4	6.6
Bottom ...	5.2	5.0	5.0	4.8	5.2	5.0	5.4
Carbonate ppm. Surface ...	20	20	20	30	20	20	20
Bottom ...	20	20	20	30	20	20	20
Bicarbonate ppm. Surface...	140	160	160	180	190	180	180
Bottom ...	110	150	150	160	150	160	160
Phosphate mg/m ³ . Surface...	2.0	2.4	2.4	2.4	3.0	3.0	3.0
Bottom ...	2.0	3.0	3.2	3.2	3.2	3.8	3.8
Interstitial Phosphate mg/gm. silt ...	13.2	15.8	17.9	21.4	14.0	16.2	16.8

Station VII is 1.8 kilometers from Station VI. The maximum depth in this place is 1.829 meter. The salinity at the bottom is 14.63‰. The bottom deposit consisted of silty clay. The density of the organisms is 12 per square meter. Two species, the Isopod *Apseudes gymnophobia* and the Amphipod *Paracalliope fluviatilis* were present.

Station IV has the maximum number of 132 organisms per square meter and Station VII has the minimum number of 12. Station VII is situated farther upstream where the bottom salinity is very low. Further down, the salinity increases progressively reaching the maximum at Station I (Table III) which is situated near the mouth of the Vellar estuary. Because of the low salinity prevailing at the bottom, Stations V, VI and VII have a thin population of organisms 24, 22 and 12 respectively per square meter. The greater fluctuation in salinity due to tidal flushing might also account for the sparse distribution of the organisms in these stations. Stations I to IV have a greater density of organisms per square meter being respectively 60, 119, 68 and 132.

As mentioned already, some of the stations have a predominant species in the community *Meretrix meretrix* in Station II, *Phoronis architecta* in Station III and *Cossura delta* in Station IV. In stations I and V two or three species are the major members of the community. Some species like *Cossura delta*, *Apseudes gymnophobia* and *Lumbriconereis simplex* occur in more than one station and others like *Phoronis architecta*, *Pectinaria crassa* and *Laonome indica* are restricted in one station only.

Summary

The paper is a report of the survey of the bottom communities in the Vellar estuary made on 11-9-59. Altogether 32 species of animals were collected from the bottom deposits.

The maximum density of organisms per square meter is 132 in Station IV and the minimum is 12 in Station VII.

The grade analysis of the bottom deposits and the hydrological conditions of the various stations are given. The dominant species in each station are described.

Acknowledgments

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Studies on the Ascorbic Acid Content of Fish Tissues—II.

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(Communicated by Prof. R. V. Seshaiya, F.Z.S.I.)

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Introduction

The ascorbic acid content of the tissues of only a few species of fish is known. Love (1957) lists about 50 species of fish, in which the ascorbic acid content has been reported. Most of these analyses were published before 1940. It is difficult to judge the reliability of these data, since there does not seem to have been any uniformity or standardisation of the procedures adopted for the determination of ascorbic acid and the presentation of the data. This makes it difficult to properly evaluate the data and form an idea of the variability for each species and for the different tissues. It may also be noted that not all the tissues have been examined, especially blood and skin.

The present authors have reported elsewhere (1960) the ascorbic acid content of the integument and muscle of a few fish. In the present study the ascorbic acid content of the blood, and also of the liver, kidney and brain in three species of fish has been determined.

Material

For the determination of ascorbic acid specimens of *Liza dussumieri* (Val) (= *Mugil dussumieri*), *Boleophthalmus boddarti* Pallas, *Tachysurus venosus* (Val) (= *Arius malabaricus*) were obtained in fresh condition and the tissues were fixed for analysis immediately after catching. The specimens for each species were more or less of the same size.

Analytical Procedure

The modified Roe and Kuether (1959) method, as described by Hawk et al. was adopted as in the previous communication. This method—Hastings and Spencer (1952) believe—gives values of ascorbic acid that are more in line with actual *in vivo* levels. The tissues were analysed in samples of eight specimens for each of the three species.

Results

The results are shown below in the tabulated form. The mean values for eight determinations are shown in mg. per 100g. of wet weight of tissue.

Table I—Ascorbic acid content in blood

	m.g. per 100g.	Range
<i>Liza dussumieri</i>	1.1950±0.1060	1.02—1.60
<i>Boleophthalmus boddarti</i>	0.2936±0.0894	0.06—0.57
<i>Tachysurus venosus</i>	0.7794±0.1385	0.12—1.30

Table II—Ascorbic acid content in liver

	m.g. per 100g.	Range
<i>Liza dussumieri</i>	4.999±0.2511	3.14—6.04
<i>Boleophthalmus boddarti</i>	2.088±0.4527	0.59—3.57
<i>Tachysurus venosus</i>	4.627±0.8116	2.38—7.50

Table III—Ascorbic acid content in Kidney

	m.g. per 100g.	Range
<i>Liza dussumieri</i>	5.3968±0.2334	4.84—6.93
<i>Boleophthalmus boddarti</i>	8.7300±1.064	6.01—11.60
<i>Tachysurus venosus</i>	5.2135±0.9550	2.14—10.72

Table IV—Ascorbic acid content in Brain

	m.g. per 100g.	Range
<i>Liza dussumierii</i> ...	15.635±0.1875	14.57—16.66
<i>Boleophthalmus boddarti</i> ...	14.600±0.2971	13.60—15.70
<i>Tachysurus venosus</i> ...	14.150±0.2917	13.30—15.32

The ascorbic acid content varies in the three species of fishes and also in the different tissues.

The brain has a much higher content than the other tissues, and blood has the lowest content among the tissues investigated. The kidney has a relatively higher content than the liver.

The values for the ascorbic acid in the brain do not differ much in the three species. *Liza* and *Tachysurus* are more or less similar in the ascorbic acid content in the liver and kidney. The values for the ascorbic acid in the blood are quite distinctive in the three species.

The ascorbic acid values for the tissues of *Boleophthalmus* stand out distinctly from those of the other two species. The blood ascorbic acid content is the lowest in *Boleophthalmus*. In the liver it is lower, and in the kidney higher than in the other two species.

The range of variation of ascorbic acid in the samples of the different tissues also shows some interesting features. In the blood the ascorbic acid content is more or less consistent, with relatively less variation than in other tissues. In the brain also the variation is not very much, but in the liver and kidney the range of variation is greater.

Conclusion

The ascorbic acid values differ in the different tissues in the three species studied. Haurowitz (1959) points out that it has been suggested by several investigators that ascorbic acid is involved in oxidation reduction processes probably acting even as a catalyst or a coenzyme. But very little is definitely known regarding the metabolic reactions for which ascorbic acid is necessary. It is difficult, therefore, to interpret in precise terms the differences in the ascorbic acid levels in the different tissues, and state how far they reflect metabolic differences.

Acknowledgements

Our thanks are due to Prof. R. V. Seshaiya for guidance and to the University Grants Commission for the award of research scholarships to us.

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Embryonic Nutrition in *Lychas tricarinatus*

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Introduction

The development of scorpions has been studied by many authors. Kowalevsky and Schulgin (1886), Laurie (1890), Brauer (1894 and 95), Percyaslowiczwa (1907), Pavlovsky (1924 and 25), studied the scorpions with heavily yolked eggs "Apoikogenic" of Laurie while Laurie (1891), Poljansky (1903), Pflugfelder (1930), Mathew (1948 and 1956), and Vachon (1950) have studied those with comparatively yolk free eggs "Katoikogenic" of Laurie. These studies have shown that the Buthid scorpions have heavily yolked eggs whereas the others like the Ischnurida and Scorpionida have comparatively little yolk in the eggs, and so a secondary feeding mechanism is developed in all these to enable the intra-uterine embryo to complete its development.

Pavlovsky (1923, 1925) referred to a singular exception to this, namely *Lychas tricarinatus*, one of the Buthid scorpions with only a small quantity of yolk but with a compensatory feeding mechanism. He, however, obtained only one or two stages, and so his account is only fragmentary. No attempt has since been made to complete these studies, but the present author confirmed the findings of Pavlovsky in 1956.

In 1958 the study of this type was resumed by the author and the results of these investigations form the subject matter of this paper.

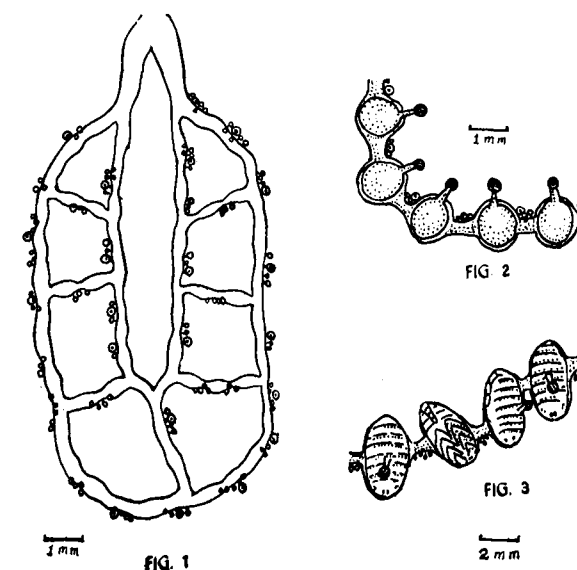
Material and Methods

The scorpions for the present investigation were collected chiefly from south Travancore; a few specimens have also been obtained from different

parts of South India including Tambaram in Madras State. The dissected ovaries were fixed in Bouin's fluid, Smith's Dichromate-acetic-formol and Picrosulphuric. Sections were stained with Heidenheim's haematoxylin.

Female reproductive system

The ovarian network in *Lychas* differs from that in other scorpions in that here there are practically four longitudinal tubes, the union between the median tubes being confined to a small portion behind the penultimate pair of transverse arches—thus approximating very much to the condition of the male reproductive system (Text fig. 1). The ova are seen in small follicles arranged irregularly along the tubes. The ova arise from the germinal layer but soon they are seen pushed out and lying in tiny little bubble like follicles. Fertilisation takes place here. Since after fertilisation the segmenting eggs pass into the ovarian tubes (or uterine tubes) in which they undergo



Text-fig. 1. Female reproductive system of *Lychas tricarinatus* when the fertilised eggs have sunk into the uterine tubes causing the swellings. Inside each swelling is the segmenting embryo. A section through one of these swellings is seen in fig 2. Plate VI.

Text-fig. 2. Part of the ovarian tube where the embryos have developed to about the middle stage. The feeding mechanism is clearly seen capped with the corpus luteum.

Text-fig. 3. Part of the ovarian tube where the embryos have developed fully and are about to be extruded. The small spherical bodies seen in all these figures attached to the ovarian tubes are the follicles with eggs.

further development, the ovarian tubes gradually become beaded, as the embryos enlarge, till the young are ready to be born. This beaded appearance of the ovarian tubes is characteristic of the Buthidae contrasting with the pendant diverticula of the scorpionida. Yet the beads in *Lychas* differ from those in all other Buthids in having a tiny conical process with a globular

egg-like body attached to the tip of each bead. This makes the ovarian tubes of *Lychas* so different from those of all other scorpions and, as will be shown later, these conical processes are really the feeding apparatus formed in relation to each developing embryo. Because of these developmental changes, the external form of ovarian tubes presents differences corresponding to the stage of development of the embryo; some of these stages are shown in Text figs. 2 and 3.

The ovarian tube has the typical structure that is so well known in all scorpions (Fig. 1 Plate VI) and the ova arise from the germinal layer lining these tubes.

Feeding mechanism as seen in a mature embryo

When the embryo has grown to a fairly advanced stage, it is seen forming an oval bead like swelling of the ovarian tube. (Text figs. 2 & 3). It is a stout oval structure and in its envelopes is 4.1 mm. long and 2 mm. broad. The metasoma is tucked on the ventral side of the mesosoma in typical Buthid style. On the dorsal side of the embryo is a conical process terminating in a globular body, 260 microns in diameter. The stalk itself is 325 microns in length externally. Study of transverse and longitudinal sections shows that the core of this structure pierces through the 3rd or between the 3rd and 4th terga of the mesosoma and enters the midgut of the embryo. (Fig. 5, Plate VI.) The internal lumen of the stalk extending into the gut is $39\ \mu$ in diameter. It can also be seen that this globular mass contains a secreted fluid with a few floating cells and these are passed directly into the gut for the nourishment of the embryo. The duct contains a homogeneous granular material which fills also the lumen of the gut. The endoderm cells show characteristic inclusions representing metabolic products of this secreted material.

Based on these observations, it is assumed that this conical structure on the back of the embryo is a feeding mechanism, secreting a nutritive substance at the globular free end, which is passed along distinct ducts into the lumen of the midgut.

Some stages in the development of the feeding mechanism

The origin and development of this nutritive mechanism show some features which are as interesting as its structure and physiology. The follicular ova are seen to be of different sizes, the largest measuring 54 microns in diameter with a nucleus of 18 microns while the more common ones were 28.5 microns in diameter with a nucleus of $10.5\ \mu$. The ovum is surrounded by a distinct thin membrane. The immature ova are pushed out into the follicles but they soon enlarge as nutritive material collects in them.

The mature ova get fertilised in these follicles and immediately after, they are surrounded by a thick pigmented membrane (fig. 1, Plate VI). What is

Explanation to Figures.

Fig. 1. T. S. of an ovarian tube with a fertilised ovum still in its follicle.

Fig. 2. L. S. of an ovarian tube in which the embryo has sunk into it. Segmentation has produced a blastoderm which is clearly visible.

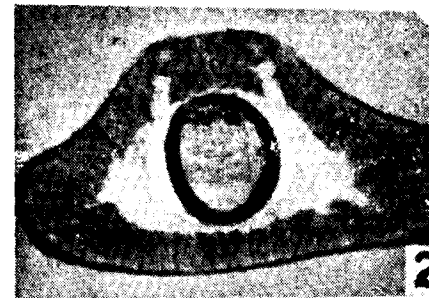
Fig. 3. L. S. of an ovarian tube where the chorion is being pushed on towards and the "embryonic vesicle" has been ejected from the egg shell. Notice the continuity of the "Vesicle" and the egg shell and of the cavity of the egg shell with the cavity of the "Vesicle" which latter is full of nutrient materials.

Fig. 4. T. S. of an embryo of medium stage of development passing through the feeding mechanism.

Fig. 5. T. S. of a mature embryo passing through the feeding mechanism. The canals from the stalk of the feeding mechanism can be seen joining the midgut of the embryo.

A. P. Mathew :

Plate 6



the nature of this membrane? It is apparently a uniform envelope, but in many sections appears composed of a number of similar plates. It takes a deep stain with iron haematoxylin. It is possible that it is a cellular envelope formed by the cuticularisation of the follicular cells. The zygote nucleus is very clear and the surrounding cytoplasm is loaded with granular food-material, amongst which numerous vacuoles are visible. As segmentation begins, the egg descends into the ovarian tube, and at these sites the tubes are slightly swollen, and have a beaded appearance. Between the swollen parts, the ovarian wall is tucked in and forms inverted cup-like cushion in close contact with the upper pole of the egg (Text fig. 2).

Segmentation results in a small blastoderm on the upper pole of the egg where it is in contact with the intucked ovarian wall. This orientation of the egg appears to be constant as in all the eggs of this stage the blastoderm is confined to this pole which may easily be distinguished as the animal pole. The embryo has now enlarged considerably—the pigmented envelop appears to enlarge side by side with the growth of the embryo in these early stages. Now it is 172.8μ in diameter. The cells of the blastoderm are large with very clear nuclei. The blastoderm is about 70μ across and the cells are already arranged in two layers—the outer layer spreading so as to line the chorion (?). The inner layer sinks into the "yolk". This sinking in is median and so it may correspond to the median keel noticed in *Euscorpius*. These insinking cells multiply and form lumps of cells floating in the "yolk".

When the outer layer has spread all beneath the chorion, the wall of the chorion in the middle of the vegetal pole becomes softened and finally gives way, allowing the "yolk" with the cells in it to protrude out into the space of the ovarian tube. As this happens, the chorion or the egg shell is seen to be drawn upwards by the eversion of the intucked wall of the ovarian tube which appeared to be gripping it. As the "yolk" protrudes out, the contained cells arrange themselves around its periphery surrounding it. This forms the endoderm. At the same time the outer layer which lines the chorion spreads around the extruded endoderm layer, (Plate VI Fig. 3).

Thus we get a queer embryo, partly projecting out of the egg shell (chorion) as a vesicle lying in the ovarian tube and partly inside the chorion. In the embryo that has thus developed we can recognise the outer layer as the ectoderm and the inner layer that surrounds the "yolk" as the endoderm. Again from subsequent development we see that the "vesicle" outside the chorion alone gives rise to the embryo while the part inside the chorion is extra embryonal, giving rise to the feeding device. It will be clear that the ectoderm of the "external vesicle" alone gives rise to the embryonic ectoderm while the rest of the ectoderm which still lines the chorion is the extra embryonic ectoderm and would represent the amnion and serosa of other Buthid and Centruroid scorpions. Similarly the endoderm cells lining the external "vesicle" alone forms the embryonic endoderm contributing to the body of

the embryo proper, while the endoderm cells that line the chorion would represent the extraembryonic endoderm. This extra embryonic endoderm inside the egg shell is seen to bud off cells into its internal cavity which is filled with a secreted nutrient matter. These cells appear to have some connection with the formation of this food substance which is passed on into the gut of the embryo and there gets converted into yolky material. Thus we are able to recognise an embryonic part—the embryonic vesicle—and an extra embryonic part lying in the egg shell. The embryonic vesicle rapidly grows and gives rise to the embryo while the extra embryonic part, still mostly retained in the chorion develops into a feeding device by which nourishing material is passed directly into the gut on its dorsal side. The cavity of the vesicle which is the embryonic gut is in free communication with the cavity of the egg shell. (Plate VI, Fig. 4).

The growth of the embryo is rapid and as it grows, the chorion is pulled farther and farther outwards surrounded by the evaginating uterine wall. At the next stage as shown in (Fig. 4 Plate VI), the evagination of the uterine wall is complete and the chorion is exposed at the animal pole. As this takes place the junction of the chorion and the embryo proper is drawn out into a conical hollow stalk which places the now distinct gut of the embryo in free communication with the cavity of the chorion. This stalk is covered over by the uterine wall which has become considerably thickened and modified. The cells have enlarged and elongated and the large vacuoles suggest that they have become glandular in nature.

As the stalk gets marked out in this way, its basal portion narrows and at the same time an increase in the size of the embryo clearly demarcates the dorsal surface of the embryo to which the stalk is seen attached. This stalk serves as the channel for the nutrient materials elaborated in the "chorion" to pass into the gut of the embryo. (Plate VI Fig. 4).

Fate of the Embryonic Feeding structures after the birth of the young

At birth the feeding mechanism is completely separated from the embryo and left in the maternal body cavity while the embryo alone passes out. Prior to parturition the base of the canals in the stalk become constricted and the whole extra embryonic apparatus lying in the stalk loses connection with the embryo proper so that the embryo can freely pass out. During parturition or immediately after, when there is considerable shrinkage of the uterine wall, the entire feeding mechanism consisting of the chorion and the extra embryonic stalk which has now torn itself away from the uterine wall and has its surface smoothened into a tiny club, is cast off into the maternal body cavity. If a recently delivered female is opened and examined, we see many of these club shaped structures capped by the chorion lying in the body cavity. If the examination is made some days later the chorion is seen still in tact but the soft club shaped 'stalk' has disappeared. Evidently these

structures which are cast off into the body cavity at parturition are gradually broken down there and absorbed.

Discussion

The queer feeding device described above raises certain interesting questions of homologies and analogies. One of the structures playing a major role in this is the so called "chorion". What does it really represent? It has been mentioned above that this structure develops after fertilisation and from its structure it was suggested that it might represent the follicular cells which have become culticularised.

The movements of this "chorion" present a unique phenomenon. As segmentation begins it sinks into the ovarian tube. But when the blastoderm has been established we find an outward movement again—but this time the embryo proper is passed out of the chorion and it is the partially empty shell that is pushed outwards. Inside this shell are the extra embryonic cell layers which soon give rise to a feeding mechanism. When we recollect that this structure itself, quite likely, represents the follicular cells and that it takes up an important role in the subsequent development of the embryo, we may conclude that this represents a "*corpus luteum*."

Study of sections of the corpus luteum shows that it consists of two regions:

1. the chorion or the follicular shell which gives rise to the feeding mechanism; and
2. the uterine wall around it, which has developed into a thick glandular structure. The latter may correspond functionally to the typical *corpus luteum* inhibiting growth of new embryos. When a female with well developed embryos is examined one comes across a few zygotes and well developed blastoderms held in arrested development, which may be by the inhibitory action of the corpus luteum.¹

In the development of *Euscorpius*, Laurie has described a *corpus luteum* formed as the zygote leaves the follicle and enters the ovarian tube, but this has nothing to do with the nutrition of the embryo and is believed to be only inhibiting formation of new embryos.

Comparison of this feeding mechanism with what is already known in the scorpionida would be of interest. In the Scorpionida, *Heterometrus Pandinus*, *Hormurus*, *Opisthophthalmus*, *Iomachus*, *Ischnurus* and *Opisthocentrus* have all embryonic feeding mechanisms of the same fundamental pat-

¹ This question is being dealt with in another paper on the breeding biology of *Lychas*.

tern consisting of a secreting tubule which is fitted directly into the mouth of the embryo—bottle feeding mechanism, as I have termed it elsewhere—with of course generic and specific variations. Attempts have been made to homologise this with the “umbilical cord” but this structure merely opening into the mouth of the embryo without any organic connection cannot be said to have even a superficial resemblance to the umbilical cord.”

But when we consider the feeding mechanism of *Lychas* the position is different. Here is a feeding device that is not only connected with the midgut but has actually arisen as a part of it and supplies nourishment direct; the analogy with the yolk sac will be obvious. Of course there is no suggestion of any parallel between nutrition through blood capillaries that we see in the higher vertebrates and the simple mechanism here whereby nutritive material is secreted and passed directly into the midgut. But leaving these details the nearest comparison we can make of this strange mechanism is to the yolk sac of some of the lower vertebrates.

However, it may be pointed out that the yolk sac in vertebrate embryos is attached on the ventral side of the embryo; here it is on the dorsal side. This is only what can be expected if we bear in mind the fundamental contrast in the organisation of the vertebrate and invertebrate body.

Again, turning to the comparison of the feeding mechanisms in the scorpions it may be noticed that whereas in the scorpionida feeding mechanisms are usual, their eggs being deficient in yolk, in Buthidae none with a feeding mechanism is known, with the exception of *Lychas*. All Buthids have heavily yolked eggs; but *Lychas* is poor in yolk. An when a Buthid develops a feeding mechanism it has nothing to do with the general pattern in Scorpionida but is in a different pattern of its own!

It may also be noticed that in the Scorpionida the feeding mechanism is developed during fertilisation; but in *Lychas* the mechanism is formed only after the completion of segmentation and the embryo is developed with distinct ectoderm, endoderm and gut.

And lastly in the fate of the feeding mechanism also, there is a strong contrast to what happens in the Scorpionida. In the latter group when parturition has taken place, the feeding mechanism released from the mouth of the young still hangs on at the end of the empty diverticula which are gradually absorbed later. This permits two or three successive generations being represented by vestiges of the feeding mechanism in various grades of degeneration. This is possible however, since the feeding tubes are attached only to the diverticula and not directly to the ovarian tubes (Mathew, 1948, 1956 and 1959). In *Lychas*, however, the feeding mechanism is directly on the ovarian tube and its presence all along in series on the ovarian tube would seriously tamper with the development of the next brood. So it is necessary that at parturition these “appendages” are got rid of from the ovarian

tube; and we find that they are actually separated off and left in the body cavity.

Summary

It is generally regarded that in Scorpions the Buthidae have heavily yolked eggs, so that there is no need of a secondary feeding mechanism for their growing embryos whereas in the other families, where yolk is insufficient for the full development of the embryo, different types of secondary nutritional methods are present. In this paper, however, a queer feeding mechanism is described as seen in *Lychas tricarinatus*, a typical Buthid Scorpion. The egg being deficient in yolk, the embryos after the early stages of development are nourished by this mechanism. The mechanism itself is developed out of the empty egg shell corresponding to a *Corpus luteum*. Cells of the extraembryonal layers of the developing embryo are retained inside this egg shell, and it develops into a food elaborating organ. It is connected with the gut of the embryo on its dorsal side and nourishment is passed directly into the latter. The early stages of development of the embryo and feeding mechanism are traced to show how the direct connection of the mechanism with the gut of the embryo is established. A comparison is made with the feeding devices already well known in the other Scorpions. At parturition the feeding mechanism is cast off into the body cavity of the mother to be gradually absorbed. So no trace of this is left on the ovarian tubes themselves.

Acknowledgments

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On the Eggs and Early Development of Eels off Waltair Coast

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Introduction

Our present knowledge of the eggs and early development of the eels in the Indian Seas is very meagre. The accounts available are largely restricted to a description of the different types of leptocephali, collected from the plankton, both from the west and the east coasts of India. Among these may be mentioned the publications of Gopinath (1949), Nair (1952) Jones and Pantulu (1954, 1955).

The first record of the eggs of the eel from Indian waters seems to be that by Aiyar, Unny and Varkey (1944). Nair and Bhimachar (1950) described three types of eggs and two types of eel larvae from the plankton collected from the Gulf of Mannar, but the authors could not establish the identity of either the eggs or larvae. From the available description it would appear that eggs I and II where the oil globule is absent and the oesophageal pouch poorly developed may be Muraenid eggs while the third type may be that of an Ophichthyid. The Larva I and Larva II resemble the three and four days old Muraenid and Ophichthyid larvae respectively described by us. But the number of preanal myotomes is more in both the larvae described by them. Bapat (1955) collected a few Muraenid eggs from the Gulf of Mannar and Palk Bay. The measurements of the eggs are not given but from the general appearance of the embryo and the number of preanal myotomes of the larvae, they correspond to Stage V of the Muraenid embryo described in the present paper.

Delsman (1933) gave an account of seven kinds of eel eggs and their hatchlings from the Java Sea. While one had no oil globule the others showed a varying number of oil globules ranging from one to several. Two

of the larvae that hatched from eggs having a single oil globule were assigned by Delsman to the Ophichthyid group. He suggested that the eggs with numerous oil globules probably belonged to the eel *Venefica procera*. The identity of the other eggs and larvae could not be established. The characters of the Ophichthyid eggs and larvae described in this article agree with those described by Delsman in many characters such as size, presence of oil globule, serial arrangement of pigment spots and the number of preanal myotomes.

Material and Methods

The eggs were collected from the tow-net plankton samples at about the 10 fathom line off Lawson's Bay.

A single Muraenid egg was obtained on 19th February 1959 and seven more on 23rd March 1960. One Ophichthyid egg was collected on 24th January 1960 and another three on 23rd March 1960. It is interesting that as many as 7 Muraenid and 3 Ophichthyid eggs were collected from the same sample of plankton which contained in addition a few clupeoid eggs and swarms of Salpids.

The live eggs were washed in clean sea water and kept in large glass troughs containing filtered sea water. Whatman 42 filter paper was used for filtering the water which was changed three or four times a day. The above precaution helped to keep down the growth of ciliates. The frequent stirring with a glass rod helped in the proper aeration of water and to prevent the eggs and larvae from settling at the bottom.

The larvae failed to feed on living microplanktonic organisms as well as powdered egg yolk and ultimately died due to starvation.

The single Muraenid and the Ophichthyid egg obtained in 1959 were kept for hatching in a temperature controlled room at 23°C. While the Ophichthyid egg hatched in 72 hours the Muraenid egg failed to hatch even after 6 days and ultimately died. The eggs of both kinds collected in March 1960 were reared at room temperature which was about 26°C. The Ophichthyid eggs hatched out after 36 hours and the Muraenid eggs in 3½ days. It is interesting to observe that even a 3°C. rise in temperature reduced the hatching time by half, of the Ophichthyid egg.

Early Development of *Muraena* sp.

Stage I (3 hours) Fig. 1:

The eggs collected on 23-3-1960 were presumably spawned in the early hours of the morning and when they were observed at 10 a.m. on the same day the blastodermic cells had covered about a third of the surface of the yolk. The age of this stage may tentatively be fixed at 3 hours. The eggs

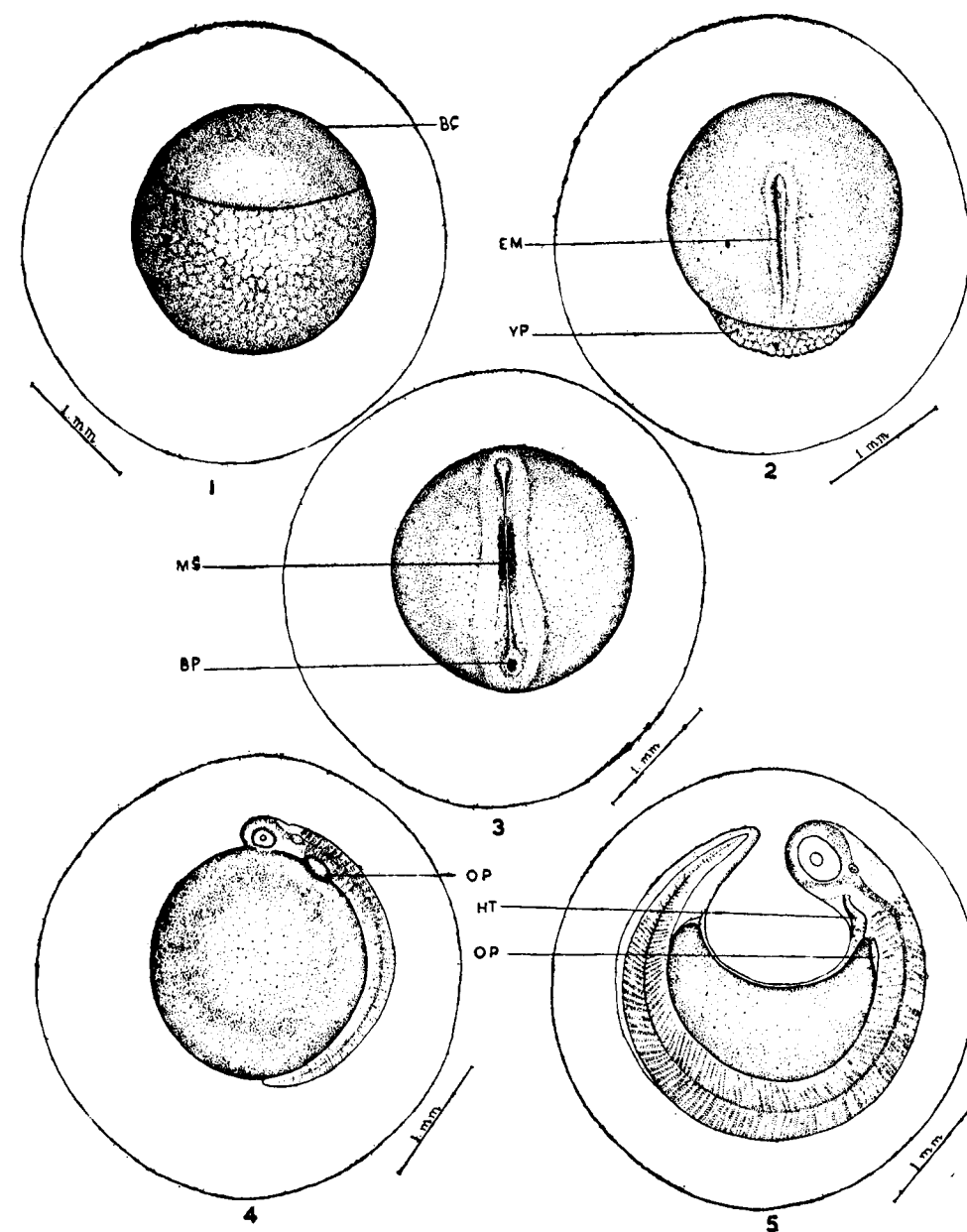


Fig 1-11 Early development of *Muraena* sp.:

- Fig. 1. Stage I (3 hours) of Muraenid egg.
 - Fig. 2. Stage II (6 hours) of Muraenid egg.
 - Fig. 3. Stage III (10 hours) of Muraenid egg.
 - Fig. 4. Stage IV (30 hours) of Muraenid egg.
 - Fig. 5. Stage V (60 hours) of Muraenid egg.
- (Segmentation of yolk is not shown in Fig. 3, 4 and 5.)

are large measuring 3.25 to 3.6 mm. in diameter. The yolk is clearly segmented and measures 2.0 mm. in diameter. An oil globule is absent. There are no chromatophores. The perivitelline space is very large.

Stage II (6 hours) Fig. 2:

In another three hours the blastodermic cells have overgrown three fourth of the yolk. The embryo is in the form of a longitudinal ridge with the anterior end slightly bulged and the posterior end gradually merging with the blastoporal region, where the yolk appears as a large plug.

Stage III (10 hours) Fig. 3:

At this stage the gastrulation is complete with the blastopore just closing. The embryo has grown longer with six completely formed mesodermal somites. The eyes are not yet formed. In one of the seven eggs the blastopore was still very large at this stage.

Stage IV (30 hours) Fig. 4:

In about 30 hours, the embryo occupies nearly half the circumference of the yolk. The eyes are completely formed with the lenses but no pigment is yet developed. The auditory vesicles are also formed but the otoliths have not appeared. The number of myotomes has increased to 48. The oval oesophageal pouch so characteristic of the eel embryo is developed behind the auditory vesicles between the embryo and the yolk. The pouch is not, however, as pronounced as that of the *Ophichthyid* embryo. The segmented yolk is still large.

Stage V (60 hours) Fig. 5:

In about sixty hours the embryo has grown over almost the entire circumference of the yolk. The eggs at this stage sank to the bottom perhaps owing to the absorption of most of the yolk the specific gravity of which is less than that of sea water. The posterior part of the alimentary canal extends behind the yolk. The embryo is ring-like the coiling being in one plane and the yolk appears as a crescent. Two otoliths make their appearance in each auditory vesicle. The oesophageal pouch appears compressed between the yolk and the embryo. In front of the oesophageal pouch a tubular heart is formed which beats about 150 times a minute.

Stage VI (96 hours) Fig. 6:

In about 4 days the embryo has assumed the shape of a typical fish larva. The yolk is completely absorbed. The disposition of the larva inside the egg is quite characteristic in that it lies coiled in a plane like a girdle. The larva makes frequent jerking movements and changes its orientation from time to time. No chromatophores are present. The mouth and anus are not yet visible although the alimentary canal is completely formed. The rate of the heart beat has increased from 150 to 175 times per minute.

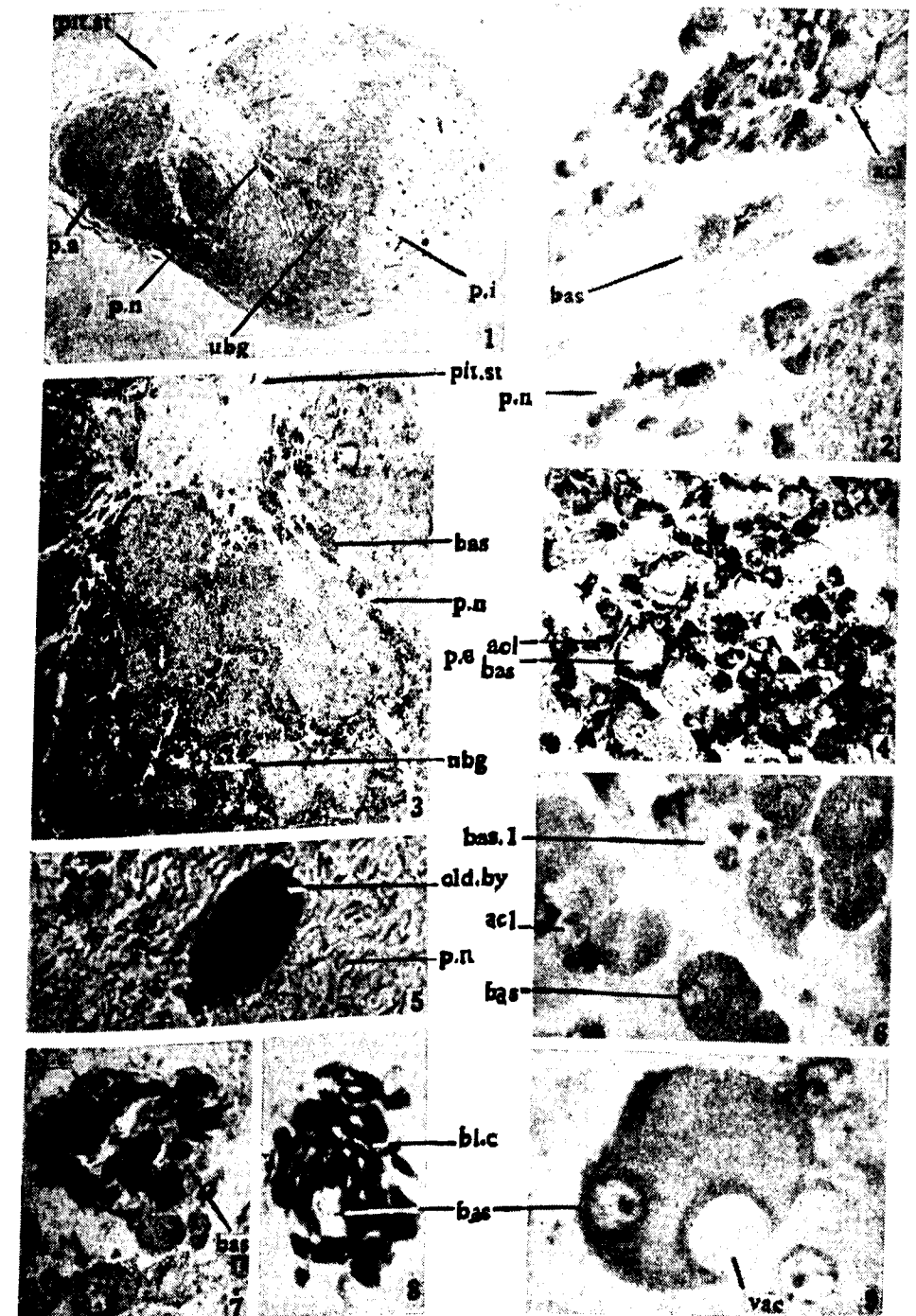
Explanation of Plates

PLATE III

- Fig. 1. Median sagittal section of the pituitary of *Mystus* showing the arrangement of the pars glandularis and pars nervosa. January X 25
- Fig. 2. Photograph showing the disintegration of the immigrant basophils of the ubergangsteil in the pars nervosa. ... January X 500
- Fig. 3. Photograph showing the migration of the chromophils from the ubergangsteil into pars nervosa. ... January X 70
- Fig. 4. Photograph showing the cellular components of the ubergangsteil. ... January X 400
- Fig. 5. Photograph showing a droplet of colloid-like matter in the pars nervosa. ... January X 500
- Fig. 6. Photograph showing heavily and sparsely granulated basophils of the ubergangsteil. ... May X 1060
- Figs. 7 & 8. Photographs of the basophils inside the blood sinuses in the pars intermedia. ... January X 760 & X 720
- Fig. 9. Photograph of a secretory basophil showing liquefied cytoplasmic content. A vacuole and a part of the granular cytoplasm may also be seen. ... January X 1200

Sathyanesan :

Plate III



Newly hatched larva (Fig. 7A and 7B).

The eggs began hatching in the evening, at 7 p.m. on the fourth day and all the seven hatched out by 9 p.m. The hatchlings remained curved for some time and became straight very soon. They were sluggish in the beginning but became very active after a time. The newly hatched larva measured 9.5 mm. in length. The head is conical and the mouth open. The rudiments of teeth on the jaws are seen as small elevations. The alimentary canal is a straight tube without any chromatophores or swellings. It extends as far as the 59th myotome but does not open to the exterior. Very close to the posterior end of the alimentary canal is a very small urinary vesicle below the 62nd myotome. The eyes are transparent without any pigmentation. The dorsal finfold is very narrow and the caudal finfold is very broad and round. The rudiments of the pectoral fins are formed just below and behind the auditory vesicles. After swimming for some time the larvae were observed to sink to the bottom and rest on one side of the body.

One day old larva (Figs. 8A and 8B):

The larvae were found to be actively swimming with a characteristic wriggling movement like that of a snake. The anterior portion of the alimentary canal has become very narrow with a bulging at its end. The eyes have become brown. The two jaws have also grown forwards with the upper jaw longer than the lower. The former is produced into a beak-like structure. The rudiments of the teeth have become more prominent. The anus has shifted posteriorly from the 59th to the 63rd myotome.

Two days old larva:

At this stage the two jaws have grown still longer. There are four well defined peg-like teeth in each half of the jaw. The anterior teeth are longer than the posterior ones. The eyes have become black. The alimentary canal has further extended from the 63rd to the 66th myotome where it opens to the exterior by the anus. The larvae were found in a coiled position like the letter 'C' at the bottom and were moving the tail gently.

Three days old larva:

At this stage the jaws are completely formed and the teeth have become needle-like structures. It was observed that the larvae kept their mouth continuously open after the complete formation of the jaws and the teeth. Colourless blood corpuscles are seen circulating in the blood vessels below the notochord. Two of the seven larvae died on the third day.

Four days old larvae:

Some of the larvae actively swimming, two of them were reduced in length probably due to starvation. There were no important changes at this stage. Three larvae died on the fifth day.

Six days old larva (Figs. 11A and 11B):

Only two larvae were alive on the sixth day. The anterior portion of the body has become more linear than the posterior. There is a golden

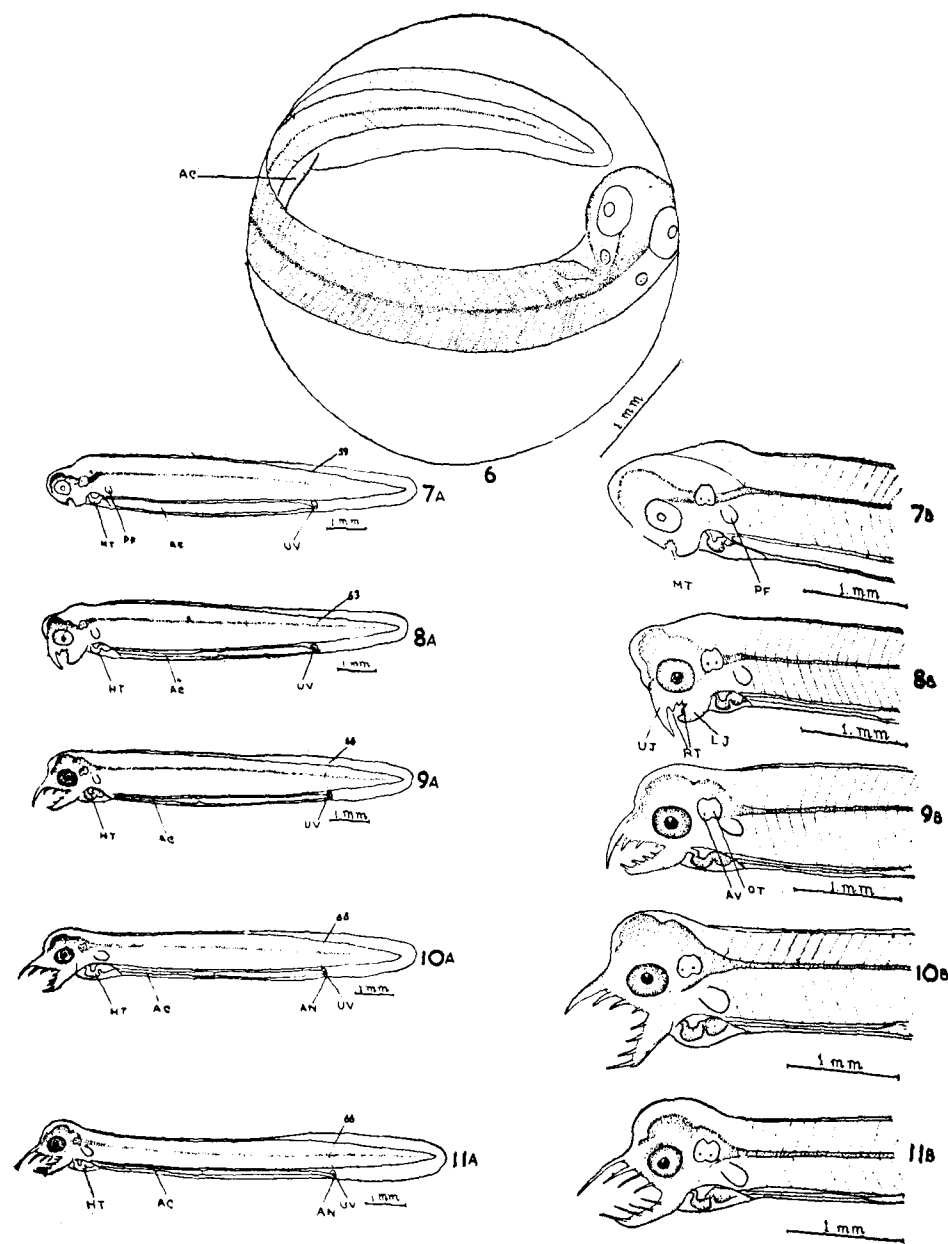


Fig. 6. Stage VI (96 hours) of Muraenid egg.
Fig. 7A and 7B. Newly hatched larva of *Muraena* sp.
Fig. 8A and 8B. One day old larva of *Muraena* sp.
Fig. 9A and 9B. Two days old larva of *Muraena* sp.
Fig. 10A and 10B. Three days old larva of *Muraena* sp.
Fig. 11A and 11B. Six days old larva of *Muraena* sp.

yellow pigment round the eye. There is no further shifting of the anus from the 66th myotome. Towards the end of the 6th day these larvae showed signs of death. The body appeared shrunk and the tail curved. A number of ciliates were also observed attacking them and they were fixed in formalin.

Early Development of *Ophichthys* sp.

All the three eggs, obtained on 23rd March 1960 were already in an advanced stage of development (Stage I, Fig. 12). They might have been spawned in the early hours of the previous night and the eggs may represent a development of about 15 hours.

These three eggs were smaller than the Muraenid eggs and measured 2.4 mm, 2.5 mm, and 2.7 mm, respectively in diameter. The yolk is frothy and segmented. It measured 1.8 mm. in diameter. An yellow oil globule of 0.4 mm. in diameter was present opposite to the embryo in the yolk. The perivitelline space is very large. All the three eggs were at the same stage of development. The embryo was completely formed with well developed eyes.

Stage II (24 hours old, Fig. 13):

The embryo has grown considerably in size and lies coiled irregularly inside the egg. Most of the yolk is absorbed. The yolk retains its oval shape until its complete absorption unlike the crescentic yolk in Muraenid eggs at the same stage of development. The oesophageal pouch, is well developed. A tubular, functional heart is present with a large pericardial space. The auditory vesicles with the two otoliths are fully formed. The eyes are still transparent. The embryo made occasional twitching movements with its tail.

Stage III (38 hours old, Fig. 14):

At this stage the tail of the embryo is coiled on itself. The body has taken the form of the typical leptocephalus of the eels. The yolk is diminished in size. The round oil globe has become oval and small. The alimentary canal takes its origin behind the oil globule. A few stellate melanophores are present in the posterior part of the body and at the tip of the tail.

Newly hatched larva (Figs. 15A and 15B):

All the 3 eggs had hatched out between 7 and 8 p.m. on the second day. The larvae remained in the curved position immediately after hatching but became straight after a few minutes. The larva measured 10 mm. in length. The eyes have not developed any pigment. The tail is pointed unlike that of the Muraenid larva. The pectoral fins are not developed. The alimentary canal appears swollen at intervals and at each swelling a group of pigment spots is found. These two characters are characteristic of the Ophichthyid larva which are not present in the Muraenid larva. The alimentary canal ends at the 75th myotome while in Muraenid hatchling it ends at 59th myotome. There are 36 clearly differentiated postanal myotomes.

One day old larva (Figs. 16A and 16B):

At this stage the mouth is formed. The two jaws have developed small protuberances which are the rudiments of the future teeth. The eyes have

developed a few dendritic pigment cells. Some yolk is drawn into the alimentary canal and the rest is distributed along the alimentary canal in the form of small hemispherical bodies. The alimentary canal does not open to the exterior. The pigment spots on the alimentary canal have become branched.

Two days old larva:

The jaws and the teeth have grown larger and the alimentary canal opens to the exterior. There is no other marked change. One of the larvae died on the second day.

Three days old larva (Figs. 17A and 17B):

The larva has increased in size and measures 12 mm. in length. The hemispherical yolk bodies of the alimentary canal are completely absorbed. The mouth and jaws are well developed. The teeth have assumed the form of slightly curved needles. There are four teeth in each half of the jaw. The anterior teeth are longer than the posterior ones in both the jaws. The eyes have become completely black. They were found lying at the bottom on one side after swimming for some time. The two pectoral fins have developed. The larvae were found dead on the fourth day.

The differences in the characters of the Muraenid and Ophichthyid development are tabulated below:

<i>Muraena</i> sp.	<i>Ophichthys</i> sp.
1. Spawning probably in the early hours of the morning ...	Spawning probably in the early hours of the night.
2. Diameter of the egg 3.25 to 3.6 mm. ...	Diameter of the eggs 2.4 mm. to 2.7 mm.
3. Yolk assumes crescentic shape during development ...	Yolk retains oval shape
4. Oil globule is absent ...	Yellow oil globule is present
5. The embryo lies coiled in the form of a ring ...	The embryo lies coiled more or less irregularly.
6. Oesophageal pouch is small ...	Oesophageal pouch is very pronounced.
7. Chromatophores developed even before hatching ...	No chromatophore either in the egg or in the hatchling.
8. Yolk is completely absorbed in the hatchling. ...	Yolk and oil globule are not completely absorbed in hatchling.
9. The alimentary canal has neither swellings nor chromatophores. ...	Alimentary canal has swellings with chromatophores.
10. Alimentary canal ends at 59th myotome in the hatchling. ...	Alimentary canal ends at 75th myotome in the hatchling.
11. The head is conical in hatchling. ...	Head is blunt.
12. The tail of hatchling is blunt. ...	Tail is pointed.

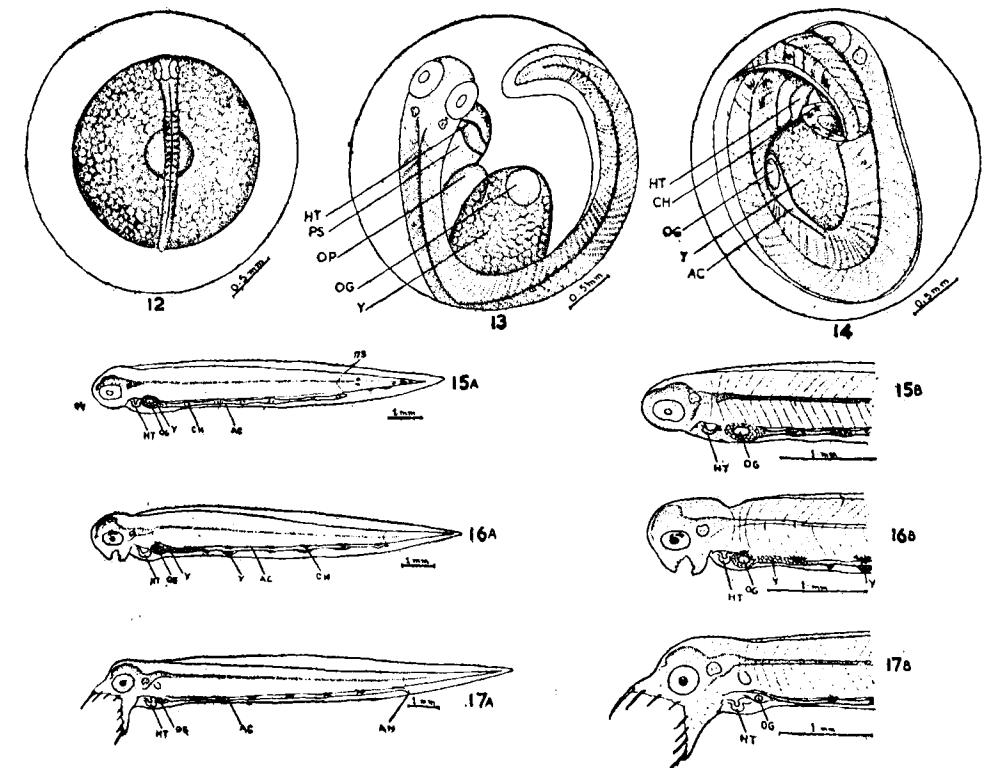


Fig. 12-17. Early development of *Ophichthys* sp.:

- Fig. 12. Stage I (15 hours) of Ophichthyid egg.
 Fig. 13. Stage II (24 hours) of Ophichthyid egg.
 Fig. 14. Stage III (38 hours) of Ophichthyid egg.
 Fig. 15A and 15B. Newly hatched larva of *Ophichthys* sp.
 Fig. 16A and 16B. One day old larva of *Ophichthys* sp.
 Fig. 17A and 17B. Three days old larva of *Ophichthys* sp.

Summary

1. A detailed account of the eggs and early development of a few Muraenid and Ophichthyid eggs is given.
2. The Muraenid eggs take about 96 hours to hatch. The eggs of the Ophichthyid were already in an advanced stage of development and as such it was not possible to fix the exact time required for its hatching.
3. The hatchlings of Muraenid take about 3 days to develop the typical pre-leptocephaline characters such as the development of jaws, teeth and the pigmentation of the eyes.

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Key to the lettering of figures

AC: Alimentary canal; AN: Anus; AV: Auditory vesicle; BC: Blastodermic cells; BP: Blastopore; CH: Chromatophores; EM: Embryo; HT: Heart; LJ: Lower Jaw; MS: Mesodermal somites MT: Mouth; OG: Oil globule; OP: oesophageal pouch; OT: Otoliths; PF: Pectoral fin; PS: Pericardial space; RT: Rudiments of teeth; UJ: Upper jaw; UV: Urinary vesicle; YP: Yolk plug; Y: Yolk.

The Proper Generic names for some common Indian Fishes of Commercial Importance

BY K. C. JAYARAMAN,

Central Inland Fisheries Research Substation, Allahabad

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Introduction

Nomenclature is the language of Zoology and the rules of nomenclature are its grammar. We cannot speak of objects if they do not have names. To be a useful tool it must be widespread and the same words must have the same meaning to everyone. Universality and stability are the principal objects of any nomenclature. In zoological research, notably in systematics, there are two classes of name changes: (1) changes necessitated by scientific progress and (2) changes dictated by rules of nomenclature, such as the Law of Priority.

Strict application of the Law of Priority is not much liked by some zoologists, particularly the non-systematists. The only alternative to Law of Priority is the Principle of Continuity, but in this case the objectivity and stability which are so essential for any nomenclature are lost. Every law is a living law, which affects the surrounding situation and in turn is affected by it. It is no argument that old and forgotten names should not be re-introduced as a substitute name again, if otherwise they conform to the Rules. Every name when first proposed remains obscure, and only with persistent usage becomes common. The earlier preoccupied or invalid name gradually fades from current literature and the substitute name gains currency with usage. Failure to use the proper names for taxa results in confusion and sometimes even wrong identifications.

Such confusion in respect to certain common fish generic names exists among Indian fishery workers due to non-conformity to the various rules of nomenclature by ichthyologists. The ordinary fishery worker, particularly the field staff, not aware of the various rules and provisions of Zoological

Nomenclature and of Systematics in general is oftentimes too perplexed to decide which name to use. The present article deals with certain generic names of some common fishes of Indian waters which are used almost daily in various reports, catch statistics and landing returns. With consistent usage of these proper generic names, it is hoped, greater accuracy and uniformity would result.

THE COMMON GENERIC NAMES

Ophicephalus or *Channa*

The snake-headed fishes are conspicuous in the Indian fishery by their availability throughout the year in most areas. There are several species, but the designation *murrel* is applied usually to *marulius* and *striatus* only. In the Punjab, Madhya Pradesh and Andhra Pradesh, murrels are considered as excellent table fish.

The name *Ophicephalus* was proposed by Bloch in 1797 and the name *Channa* by Scopoli in 1777. Each of these names was proposed independently. For a number of years Scopoli's generic names were considered unavailable for Nomenclatural purposes, but by a recent ruling of the International Commission on Zoological Nomenclature (opinions and declaration of the International Commission 9 (23), p. 309, 1955, Scopoli's names are acceptable and valid. *Channa* Scopoli being an earlier valid available name, it should replace *Ophicephalus*. The proper generic name for these fishes is therefore *Channa*.

Macrones or *Mystus*

These bagrid catfishes are of routine occurrence in any fishery. Their abundance and low price value are mainly responsible for their demand and consumption.

Originally called *Macrones*, these fishes for a few years were also described under *Aoria*. The name *Mystus* which is of Scopoli (1777) is the proper generic name to be used. Details are published elsewhere (Jayaram, 1959, 1960), but suffice to point out that the main reason for the change is the same as applied to *Ophicephalus* or *Channa*.

Callichrous or *Ompok*

Considered as one of the predatory fishes in nursery ponds, these are of wide distribution in Indian waters. The common species is *bimaculatus*.

The generic name *Callichrous* was proposed by Hamilton in 1822 with *Callichrous pabda* Hamilton as the type-species. *Ompok* was established by Lacepede in 1803 with *Ompok siluroides* Lacepede as the type-species. *C. pabda* has been synonymized with *O. siluroides*.

Lacepede's diagnosis of *Ompok* is zoologically poor, but otherwise conforming to the provisions of the Rules of Nomenclature. Whereas Lacepede's genus is the one proposed earlier and nomenclaturally valid, there is no

justification in using *Callichrous* which is a later name. The confusion arose because Bleeker (1862, p. 85) assuming *Ompok* to be a mutilated form of the Malay name *Limpok* substituted *Callichrous* in its place, which action was subsequently followed by most ichthyologists.

The generic name *Ompok* Lacepede therefore unquestionably supplants *Callichrous* and is the proper one to be used.

Saccobranchius or *Heteropneustes*

These air-breathing fishes constitute an important part in the live-fish trade and are much sought after in many parts. They inhabit ponds, ditches, swamps and marshes and also muddy rivers.

The genus *Saccobranchius* was proposed (November, 1840) by Cuvier and Valenciennes with *Silurus singio* Hamilton as the type-species. *Heteropneustes* was also proposed in the same year 1840, but a few months earlier than Cuvier and Valenciennes' paper. The type-species of *Heteropneustes*, *Silurus fossilis* Bloch is a synonym of *Silurus singio*. Inasmuch as *Heteropneustes* was established earlier, which fact Muller himself (1841) pointed out, *Saccobranchius* published a few months later has to fall as a subjective synonym as per provisions of the Law of Priority.

The proper generic name for these fishes is *Heteropneustes*.

Rhyncobdella or *Macrognathus*

Common in brackish waters within tidal influence in the deltas of Indian, Burmese and Sind rivers, these fishes are frequently obtained when fishing for other species of greater importance.

Rhyncobdella was established by Bloch (1801) with *R. orientalis* Bloch as the type-species, which is however a synonym of *Ophidium aculeatum* Bloch (1787). *Macrognathus* was proposed in 1800, but included a heterogeneous assemblage of species. Cuvier and Valenciennes (1831) restricted *Macrognathus* to *M. aculeatus* which in turn is synonymous with *R. orientalis* = *R. aculeatum*. According to the Law of Priority, *Macrognathus* Lacepede being earlier replaces *Rhyncobdella* Bleeker.

Macrognathus is the proper name to be used for these fishes.

Trichogaster or *Colisa*

Characterised by their long pectoral filaments, these small fishes are of some importance in that they occur not infrequently along with other miscellaneous fishes.

Trichogaster was proposed by Bloch in 1801. Cuvier and Valenciennes in 1831 indicated *Labrus trichopterus* Pallas as the type-species of *Trichogaster*.

er. *Colisa* was proposed by Cuvier and Valenciennes in the same year (1831) with *Colisa fasciata* Bloch as the type-species. Thus it will be seen both these genera were proposed with different type-species which are separate valid species not synonymous with each other. The name *Colisa* should be used only to indicate similar fishes represented by *Colisa fasciata* and the name *Trichogaster* to indicate fishes represented by *Trichogaster trichopterus*. The three species: *chuna*, *fasciatus* and *lalius* and the Burmese *labiosus* should only bear the proper generic name *Colisa*.

Summary

The following are the correct generic names that are to be used:—

- Channa* instead of *Ophicephalus*.
Mystus instead of *Macrones*, *Aoria*.
Ompok instead of *Callichrous*.
Hetropneustes instead of *Saccobranchus*.
Macrogathus instead of *Rhyncobdella*.
Colisa instead of *Trichogaster*.

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Studies on Indian Freshwater Copepoda I. On a new species of *Heliodiaptomus* Brehm (Calanoida : Diaptomidae) from Orissa*

BY K. L. SEHGAL,

Central Inland Fisheries Research Sub-Station, Cuttack.

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Introduction

The genus *Heliodiaptomus* was created by Brehm in 1953 and five species of this genus are now known from India. In the course of a study of freshwater copepods from fish ponds several specimens of an unusually large-sized *Heliodiaptomus* were encountered. On a closer examination, these specimens appeared to be undescribed and are therefore assigned to new species which is described below in detail.

Heliodiaptomus alikunhii sp. nov.

Female: Total length 2.50 — 2.64 mm.

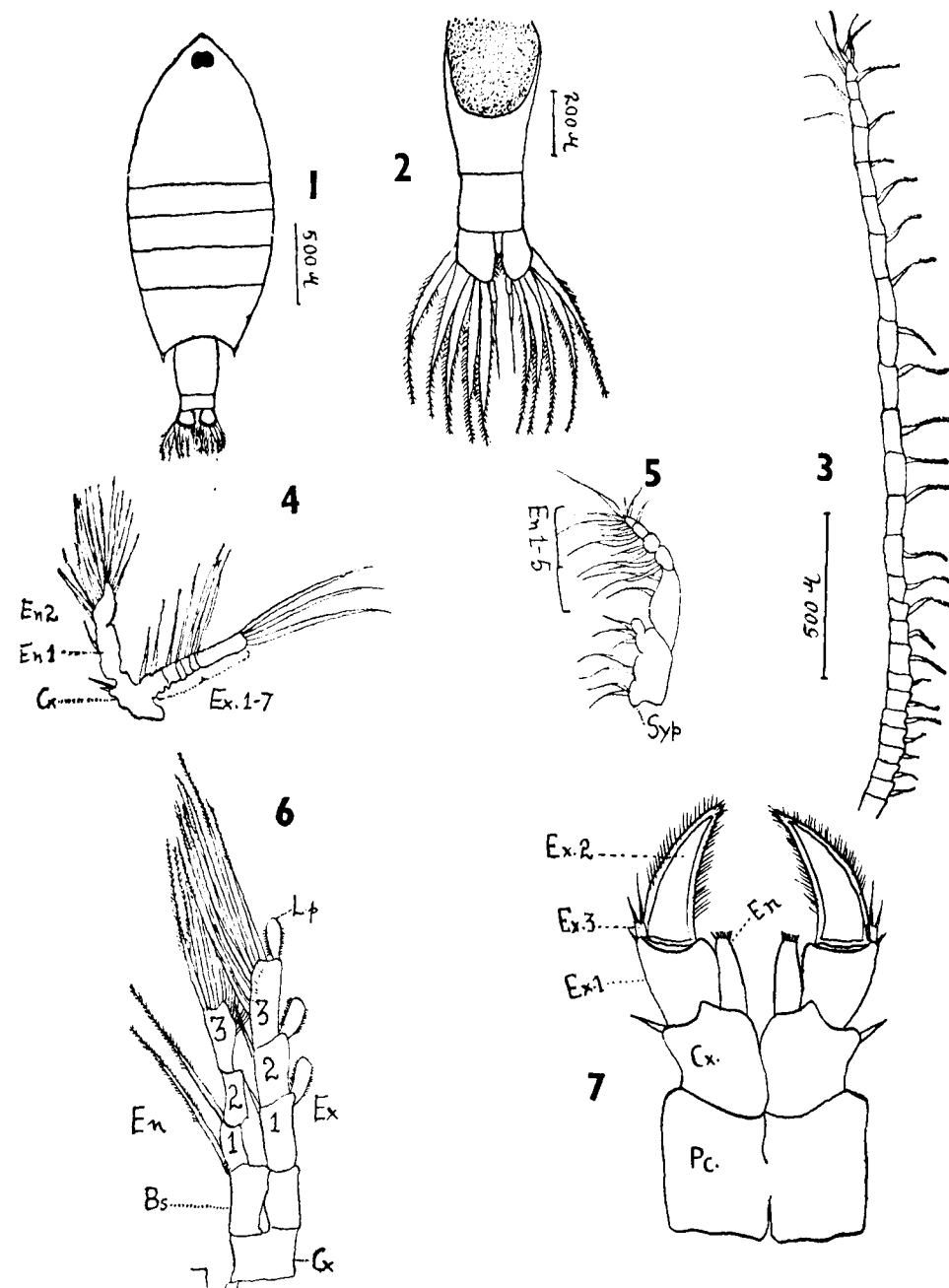
Body: The robust, well built body tapers anteriorly to a point. The last thoracic segment is symmetrical with the postero-lateral corners produced into short subacute spines (Fig. 1). Cephalothorax is 3.20 times longer than the abdomen including furcal rami. Abdomen is 2-segmented and the genital segment is devoid of lateral spines (Fig. 2). Relative lengths of the abdominal segments are as follows:—

$$\frac{\text{Segs.} \quad \quad \quad -1 \quad \quad \quad -2 \quad \quad \quad \text{Furca}}{\quad \quad \quad 60 \quad \quad \quad 22 \quad \quad \quad 18} = 100$$

Appendages: Antennule is short and reaches upto the posterior end of the second abdominal segment (Fig. 3).

The coxa of antenna has two setae at its distal external angle. The first segment of endopod is provided with one seta on its distal outer margin

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Text Figs. 1 to 7 *Heliodiaptomus alikunhii*, Female.

1. Dorsal view, appendages not shown. 2. Abdominal segments and caudal furci. 3. Antennule. 4. Antenna. 5. Maxillipede. 6. Second pair of swimming legs (only the left leg is shown). 7. Fifth pair of swimming legs.

Abbreviations:

BS, Basis; Cx, Coxa; En, Endopod; En. 1-5 Five segments of endopod; Ex, Exopod; Ex. 1, Ex. 2 and Ex. 3 First, Second and third segments of exopod; Ex. 1-7. Seven segments of exopod; L.P. lappet-like process, Pc, Pre-coxa; Syp. sympod.

(Fig. 4), while the terminal segment has 6-7 and 8-9 setae on its outer and inner edges respectively. The first six segments of the exopod have one seta each and the seventh has one seta at the base and three at its distal extremity.

Mandibles, maxillules and maxillae are similar in structure to those of *Diaptomus castor* (Gurney 1931).

Maxillipede is not very strong. Its first two basal segments have two setae each. Tip of the third basal segment is produced into a rounded prominence and bears three setae (Fig. 5). On the five segmented endopod, the first four segments carry two setae each, while fifth segment has two basal setae one on either side and five terminal setae.

The first four pairs of swimming legs have no seta or spine on the coxa. Segments 1 and 2 of exopod have each an inner spine and an outer lappet like structure fringed with small bristles. Segment 3 has six to seven setae at the tip and a lappet as in other segments (Fig. 6). Segments 1 and 2 of endopod are provided with a single outer spine each, whereas segment 3 has eight apical setae.

Fifth leg is stout. Precoxa is devoid of any spine. Coxa has a sensory spine (Fig. 7). First segment of exopod is almost as long as broad, and bears a short seta on its outer antero-lateral corner; the second or sinuate claw is fringed with long bristles on either side, while the third segment is distinct and small having an inner longer and an outer shorter setae. Endopod is long, reaching upto the distal end of the first segment of the exopod.

Male: Total length 2.04 — 2.32 mm.

Body: The body is similar to that of the female with the last thoracic segment symmetrical. Cephalothorax is 1.89 times longer than the abdomen including furcal rami (Fig. 8). Abdomen is five segmented. The first abdominal segment is devoid of any lateral spine. Relative lengths of the various abdominal segments are as follows:—

Segs.	—1	—2	—3	—4	—5	Furca	
	21	17	18	20	9	15	= 100

Appendages: Prehensile antennule consists of 25 segments. Segments 13 and 14 have each a stout process and a seta, segments 16 and 17 have each a spine a distal seta, and segment 22 a plumose spine and a distal short seta. The hyaline process on segment 23 extends beyond the distal end of segment 24 (Fig. 10).

In the fifth pair of legs, the left leg is shorter reaching only half way to the tip of the right one. Endopod of the left leg is short, reaching upto

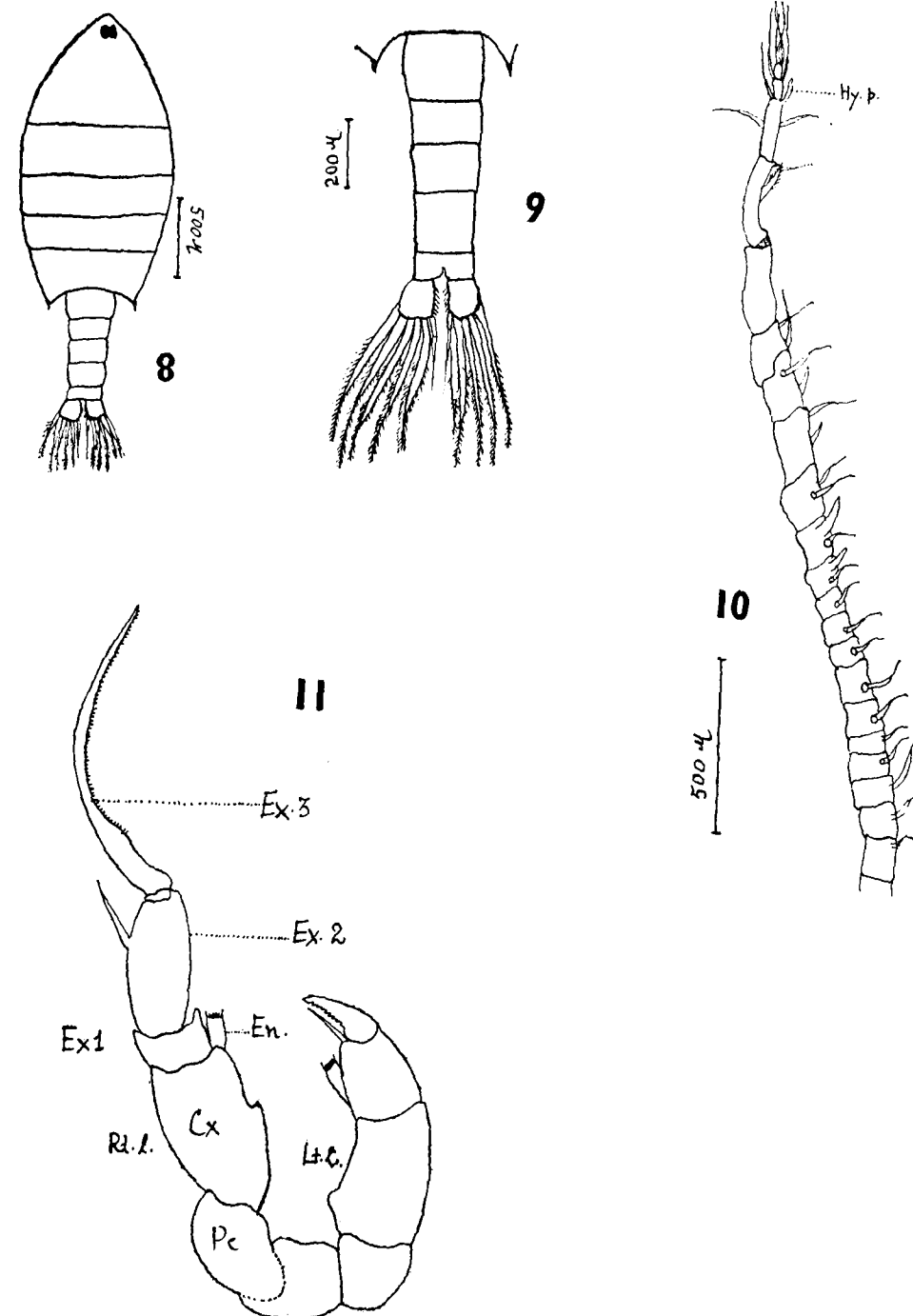
the distal end of the first segment of the exopod. In the left leg, the terminal joint of the exopodite has a chela like shape, owing to the long spine borne by it, opposing itself to the much produced and serrated joint itself (Fig. 11). Coxa of the right leg is produced into a small projection in the upper half of that segment on its inner margin. First segment of the right exopod is produced into a conical projection on its inner angle. Second segment of the exopod has a lateral spine inserted in the distal half of the segment, while the third segment or claw is sickle-shaped. Right endopod is short reaching upto the distal end of the first segment of the exopod.

Taxonomic Remarks: The genus *Heliodiaptomus* Brehm at present is known by five species in India described from time to time by Gurney (1916), Sewell (1924, 1934) and Brehm (1950, 1953). The five species are *H. elegans* Kiefer, *H. pulcher* Gurney, *H. viduus* Gurney, *H. contortus* Gurney and *H. cinctus* Gurney. The present species largely resembles *H. viduus* in its large size and well built robust body and the presence of a spine at distal end of the left fifth leg of the male, but differs from the latter in the absence of lateral spines on the genital segment of the female. The endopodite of the right fifth leg of the male is short as in *H. pulcher* but the presence of serrated hyaline process on 23rd segment of the prehensile antennule of the male and the lateral spines on the genital segment of the female are features in which *H. pulcher* differs from the present form.

These differences appear sufficient to separate the present form as a new species for which the name *H. alikunhii* is proposed. The accompanying table gives some of the major differences between *H. alikunhii* and *H. viduus*.

Major differences between H. alikunhi sp. nov. and *H. viduus* Gurney

<i>H. alikunhii</i> sp. nov.	<i>H. viduus</i> Gurney.
1. Endopod of the right fifth leg of the male does not reach beyond the distal end of first segment of exopod.	Endopod reaches upto the middle of the second segment of exopod.
2. Second segment of exopod of the fifth leg of the female has numerous long bristles on both outer and inner margins.	Second segment of exopod has 6-8 teeth on the inner margin only. (In a few of the specimens a similar number of teeth are present on the outer margin also of the right leg.)



Text Figs. 8 to 11 *Heliodiaptomus alikunhii*, Male.

8. Dorsal view, appendages not shown. 9. Abdominal segments and caudal furci. 10. Prehensile antennule. 11. Fifth pair of swimming legs.

Abbreviations:

Hy. p. Hyaline process; Lt. l. Left leg; Rt. l. Right leg; other abbreviations are the same as in figs. 1 to 7.

Major differences between H. alikunhi sp. nov. and *H. viduus* Gurney—(Contd.)

<i>H. alikunhi</i> sp. nov.	<i>H. viduus</i> Gurney.
3. Exopodite segments of the first four pairs of swimming legs have lappet like structure on the antero-lateral margins.	Exopodite segments have outer spines on the antero-lateral margins.
4. Antennule in the case of female reaches upto the posterior end of the second abdominal segment.	Antennule reaches beyond the tip of the furcal rami.
5. Genital segment is devoid of lateral spines.	Genital segment with lateral spines.

Ecological Notes:—This species was encountered only in a few of the collections, made from nursery ponds at Lingipur Fish Farm in Puri District, Orissa during July and August 1956. They were unusually large forms having pink body colour. The collections made during the two months consisted of all developmental stages and several females with 16-21 eggs in a sac. This may suggest the breeding of the species during those two months. The collections made from the same farm during the other months of that year contained only stray specimens of the species. During July-August the water in the ponds was turbid having a pH range of 7.5-7.9. There were no weeds of any type in them. The ponds get dried up in April-May every year and the bottom was sandy. In a few of the collections the present species was found in association with *H. viduus* Gurney and *Neodiaptomus strigilipes* Gurney.

Acknowledgments

The author wishes to express his sincere thanks to Sri K. H. Alikunhi, Research Officer (Pond Culture), Central Inland Fisheries Research Sub-Station, Cuttack for placing the collections containing the new species at the author's disposal and for his guidance and encouragement. Thanks are also due to Dr. S. Krishnaswami of the University Zoological Laboratory, Madras, for kindly checking up the validity of the new species.

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International Termite Symposium

An International Symposium on Termites in the Humid Tropics was held in New Delhi from 4th-12th October, 1960, under the joint auspices of the Zoological Survey of India and UNESCO. The Symposium was inaugurated by the Union Minister of Scientific Research and Cultural Affairs, Professor Humayun Kabir, and was presided over by Dr. M. L. Roonwal, Director, Zoological Survey of India, Calcutta. Dr. S. Pradhan, Professor of Entomology at the Indian Agricultural Research Institute, New Delhi, was the General Rapporteur. About sixty delegates from nine different countries, viz., Burma, Ceylon, India, Indonesia, Pakistan, U.K., U.S.A., U.S.S.R., and West Germany, attended.

A total of about forty papers were presented and discussed in the six Sections, each with its Chairman, thus:—

- (1) Systematics and Morphology (Chairman: Prof. A. E. Emerson of Chicago).
- (2) Physiology and Development (Chairman: Dr. J. N. Misra of Kanpur).
- (3) General Biology (Chairman: Dr. W. V. Harris of London).
- (4) Ecology (Chairman: Prof. M. S. Ghilarov of Moscow).
- (5) Intestinal Cellulose-digesting Symbionts (Chairman: Dr. J. N. Misra of Kanpur).
- (6) Termite Control and Termite-proof Constructions (Chairman: Prof. K. Gosswald of Wurzburg).

A Termite Exhibition was also held as a part of the Symposium. Among the more interesting exhibits were the soldiers which have recently been discovered in India in the genus *Speculitermes* (hitherto regarded as devoid of the soldier caste), nests of the genus *A. picotermes* and techniques for breeding fungus-growing termites in the laboratory. A day's excursion to the forests of Dehra Dun was also organized.

The Proceedings of the Symposium will be published in full by the UNESCO.

New Tubuliferan Thysanoptera from India

BY T. N. ANANTHAKRISHNAN,

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The present paper is based on a collection of Thysanoptera kindly forwarded by Dr. R. N. Mathur, Chief Research Officer, Forest Research Institute, Dehra Dun, to whom the author's grateful thanks are due. Two new genera, *Paxillothrips* and *Aesthesiothrips* and two new species—*Barythrips mathuri* and *Gigantothrips gardneri*, are described.

Paxillothrips gen. nov.

Antenna 8-jointed; head elongate, little produced in front of eyes; cheeks behind eyes distinctly concave, set with conspicuous spines. Mouth-cone broadly rounded. Prothorax shorter than head; prothoracic bristles moderately long, pointed. Forefemur and tibia without teeth, but with conspicuous spines all over; foretarsus with a well developed tooth in both sexes. *Foreangles of mesothorax with a well developed peg-like process in the male*, feebly developed in the female. Wings evenly wide, with double fringes. Tube evenly conical, longer than head.

Genus Type : *Paxillothrips longicauda* gen. et. sp. nov.

This genus is most closely related to *Dinothrips* Bagnall in having the process at the foreangles of the mesothorax. In *Dinothrips* the process is found only in the male and is forked, but in this genus it is present in both the sexes but more conspicuous in the male and is not forked. *Phasmothrips* Priesner has in some cases a small backwardly directed tooth, but the shape of the head and the 6—8 rigid spines at the foreangles of the prothorax are characteristic. *Tetracanthothrips* Bagnall has two digitiform spines at each foreangle of the mesothorax, but is different from this genus in every other respect.

Paxillothrips longicauda gen. et. sp. nov.

Macropterous female:—Total body length, 5.86—6.16 mm. General colour dark blackish brown. All antennal joints except joint 3, dark; joint 3 clear yellow except at extreme apex, where it is pale to dark brown; apex of foretarsus yellowish brown, rest dark.

Head 700—728 μ long, 434—448 μ wide across eyes, little produced in front, 28 μ long and 238 μ wide. Cheeks concave behind eyes, 392 μ wide and 406—420 μ wide beyond middle. Cheeks with 5—8 well developed pointed spines, the longest below the eyes 84—112 μ long. Eyes large, 196—210 μ long, 112—126 μ wide, occupying a third of the head length. Interocular space as wide as

an eye. Median ocellus from posterior ocelli 84 μ apart; posterior ocelli 28 μ in diameter, 140 μ apart. A pair of setae on either side of median ocellus, very conspicuous, 252 μ long. Postoculars one pair, 252—280 μ long, pointed, placed 84 μ from cheeks and 70 μ below eyes. Mouth cone broadly rounded, 294 μ long.

Antennal joints with short, thin sense cones; joint three with little rugged margins. Antennal joints, length (width) in μ : 126 (84); 98 (56); 336 (70 at apex); 280 (63); 224 (56); 182 (42); 126 (35); 112 (21).

Prothorax, shorter than the head, 392 μ long at middle, 476—504 μ wide at anterior margin, 910 μ wide at posterior margin, inclusive of coxae. Anterior angulars short and pointed, 70 μ long; epimerals 210—266 μ long; coxals 154 μ long; forefemora 308 μ wide at middle, moderately stout, outer and inner margins and surface with conspicuous spines. Foretarsus with a well developed tooth, 112 μ long.

Mesothorax at anterior angles with a small protuberance, 28 μ long. Pterothorax, 952—994 μ wide at anterior margin, inclusive of the projection and 882 μ at middle. Wings well developed, uniformly wide; forewings 2.59 mm. long and with 54—58 accessory setae or double fringes.

Abdomen at base, 1036 μ wide, 490 μ across segment VIII and 308 μ across IX. Setae on IX long and thin, outer 504 μ long, inner 778 μ long. Tube 840 μ long, about 1.2 times as head, evenly conical, 196 μ wide at base, 140 μ at middle and 84 μ wide at apex. Tube setae small, inconspicuous, 140 μ long.

Holotype female (measurements in μ unless otherwise specified): Total body length, 5.58 mm. Head length 700; width across eyes 420; width below eyes 392; width at middle, 420; head production, width 238; eyes, length 210 width 210; postocular setae, length 252; mouth cone, length 224; width at base 350; at apex, 238 antennal joints length (width):—126 (84); 98 (56); 336 (70); 280 (63); 224 (56); 182 (42); 126 (35); 112 (21).

Prothorax, length 420; width across anterior margin, 504; width across posterior margin, inclusive of coxa, 882; coxals 126; epimerals 210; forefemur, width at middle, 294.

Pterothorax, anterior width inclusive of process, 966; abdomen, width at base, 840; across VIII 518; across IX 308; tube, length 812; width at base, middle and apex, 182, 154 and 84 μ respectively.

Macropterous male:—Like the female in all aspects, but with well developed mesothoracic processes.

Total body length: 5.60 mm.

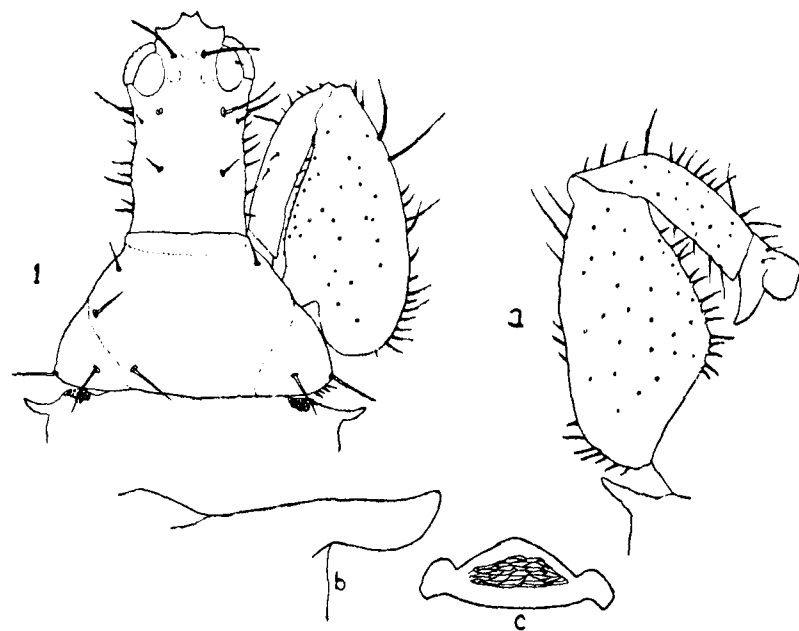


Fig. 1. *Paxillothrips longicauda* gen. et. sp. nov., head and Prothorax of male; a—foreleg of male; b—peg-like process of mesothorax; c—pelta.

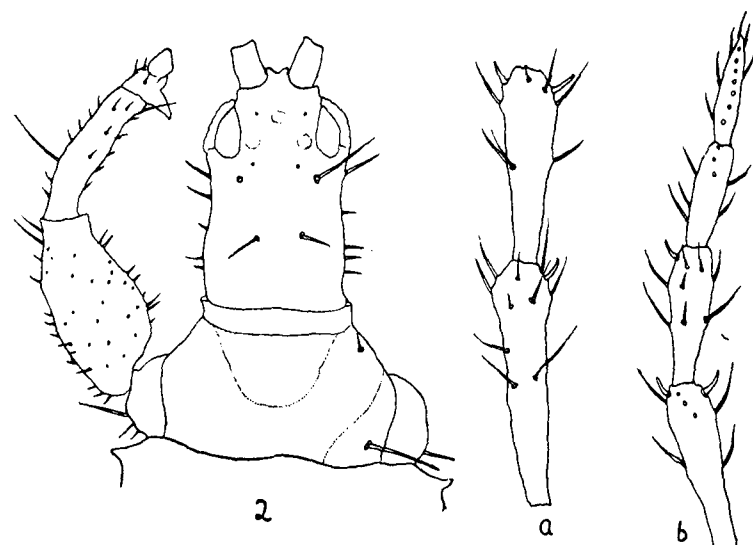


Fig. 2. *Paxillothrips longicauda* gen. et. sp. nov., head and Prothorax of female; a—antennal joints 3 & 4; b—antennal joints 5-8 of female.

Head, 658μ long, $420-434\mu$ wide across eyes, 364μ below eyes and 392μ at base. Head production, 28μ long and 218μ wide. Eyes 210μ long; postoculars $182-210\mu$ long; anterior ocellus from posterior ocelli 84μ apart and posterior ocelli 112μ apart. Antennal joints, length (width) in

μ :—126 (84); 98 (54); 322 (63); 238 (70); 210 (56); 168 (56); 126 (42); 126 (21).

Prothorax, 510μ long at middle, 498μ wide across anterior margin and 980μ wide at base inclusive of coxae. Forefemur $364-420\mu$ wide at middle; foretarsus with a well developed tooth, stouter than in the female, 126μ long. Mesothorax at foreangles with a well developed process, 140μ long; pterothorax at anterior margin, $1162-1288\mu$ wide inclusive of the processes. Abdomen 406μ wide across segment VIII, and 280μ across segment IX. Tube 700μ long, 154μ wide at base, 126 and 84μ wide at middle and apex respectively.

Habitat:—Four females and 2 males, in hollow of Bamboo; Ramangulli, Bombay, 28-1-1949; collection of the forest research Institute, Dehra Dun. (Holotype in T.N.A. Colls. No. 420).

Aesthesiothrips gen. nov.

Head very long, parallel sided, without conspicuous setae on warts; eyes small, occupying one-fifth the head length; antenna 8-jointed, joint 3 asymmetrical, shorter than 4; sense cones very long, thin and flagelliform. Prothorax strongly transverse, shorter than half the head length. Forefemora and tibia without teeth; wings widened beyond middle, anterior margin almost straight, posterior margin bent upwards to meet the anterior; with double fringes. Tube more than three times as long as segment IX, longer than head, not hairy. (Females only).

Genus Type: *Aesthesiothrips jatrophae* gen. et. sp. nov.

The long tube, strongly transverse prothorax and the position of the antero-lateral prothoracic setae close to the anterior margin of the prothorax, suggest *Megalothrips* affinities; but the asymmetrical third antennal joint, the very long sense cones and the lack of a hairy tube separate this genus.

Aesthesiothrips jatrophae gen. et. sp. nov.

Macropterous female:—Total body length, 4.62 mm. General colour dark blackish brown, except joint 3 of antenna, pale brown.

Head 742μ long, 322μ wide across eyes and equally so at middle; parallel sided; cheeks practically smooth except for 3 or 4 minute setae, not situated on warts. Eyes 154μ long, occupying one-fifth the length of the head. Mouth cone, broadly rounded. Antennal joint 3 shorter than 4, asymmetrical; sense cones long and thin, 140μ long; sense cone formula.—

$$\begin{array}{cccc} 2+2 & 2+2 & 1+1 & 0+1 \\ 3 & 4 & 5 & 6 \end{array}$$

Measurements of antennal joints—length (width) in μ :—84 (70); 98 (56); 154—168 (70); 210—224 (70); 210 (56); 140 (56); 112 (56); 84 (42). Fig. 3.

Prothorax, 350μ long at middle, 420μ wide at anterior margin and 798μ wide across posterior margin, inclusive of coxae. Antero-angulars very short, 42μ long, placed close to anterior margin of prothorax. Epimerals one pair, 210μ long, and almost setaceous. Coxals 84μ long. Forefemora not much enlarged, $210\text{--}224\mu$ wide at middle.

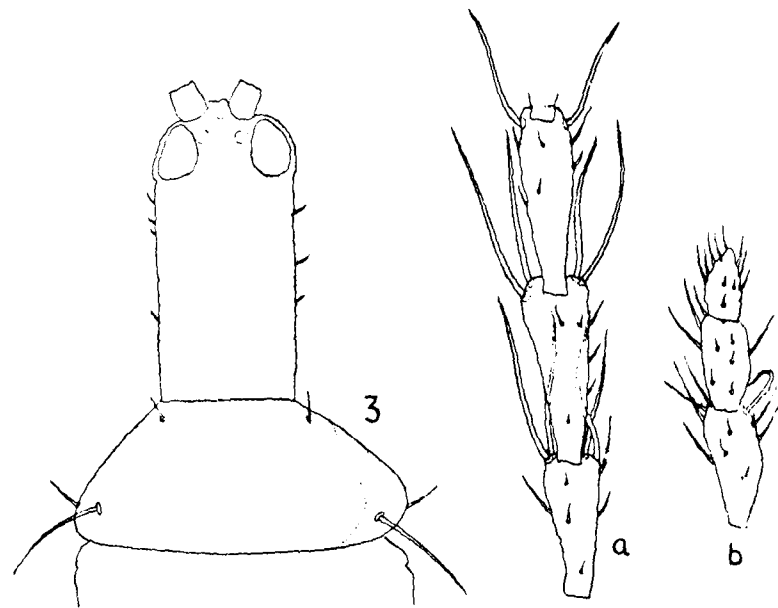


Fig. 3. *Aesthesiuthrips jatrophae* gen. et. sp. nov., head and prothorax of female; a—antennal joints 3—5; b—joints 6—8.

Pterothorax 700μ long and 840μ wide across mesothorax and 770μ across metathorax. Wings widened beyond middle, anterior margin almost straight, posterior margin bent upwards to meet the anterior. Forewings 2.590 mm long, 196μ wide at base, 196μ at middle, 252μ beyond middle and 168μ at tip. Basal wing bristles rather short, 80 , 144 and 128μ long respectively; forewings with 35 duplicate cilia.

Abdomen 840μ wide at base, 420μ wide across segment VIII and 308μ across IX. Tube $780\text{--}840\mu$ long, 196 , 150 and 70μ respectively wide at base, middle and apex, and $5\frac{1}{2}$ times the length of IX segment, distinctly longer than head; surface not setose. Setae on IX long, thin and fine, outer 840 , inner 700μ long.

Habitat:—Two damaged females, Nakronda, Dehra Dun on *Jatropha curcas* flowers, 22-3-1934. S. Bahadur's collection Holotype in T.N.A. Colls. No. 421.

Genus *Barythrips* Hood & Williams

1915. Hood, J. D. Jour New Y. Ent. Soc., XXIII (2): 134.

1957. Stannard, L. J. Ill. Biol. Mon., 25: 94.

Hood and Williams erected this genus for a single apterous male, with a rectangular head, longer than wide, small eyes, mouth cone broadly rounded; pronotum longer than head, with a prominent medial thickening, short pterothorax and large and broad abdomen.

The following are the additional characters of the genus: Both sexes with or without distinct ocelli; maxillary stylets inserted oculad; stylets distended apically (Megathripine); female with tube longer than head; male with tube shorter than head.

Barythrips mathuri sp. nov.

Apterous female:—Body brown; joint 2, and bases of 4 and 5 more yellowish, rest brown. Tibiae lighter brown; setae yellow.

Head, $308\text{--}322\mu$ long, $238\text{--}252\mu$ wide across eyes, $280\text{--}294\mu$ behind eyes, constricted at base. Eyes small, $70\text{--}84\mu$ long, $56\text{--}70\mu$ wide. Ocelli distinct, median ocellus 28μ in diameter placed 42μ from lateral ocelli, 32μ in diameter and 56μ apart. Postoculars thin, fine and curved, 126μ long. Mouth cone, $154\text{--}210\mu$ long, 266μ wide at base, and $140\text{--}168\mu$ wide at apex.

Prothorax, $308\text{--}350\mu$ long at middle, 350μ long at middle, 350μ wide at anterior margin and $616\text{--}700\mu$ wide at base inclusive of coxae. Prothoracic setae pointed; midlaterals 84μ & epimerals 140μ postangulars 126μ long; forefemora 154μ wide; foretarsus with a small tooth, 42μ long.

Pterothorax, $350\text{--}490\mu$ long, $616\text{--}672\mu$ wide across mesothorax. Abdomen, at base 840μ wide, $840\text{--}1120\mu$ at middle, $490\text{--}560\mu$ across VIII and $252\text{--}294\mu$ wide across IX. Tube $350\text{--}378\mu$ long, 126 , 98 and 70μ wide respectively at base, middle and tip, little constricted before apex and feebly longitudinally grooved.

Total body length: $3.780\text{--}4.900\text{ mm}$. Fig. 4.

Apterous male:—General colouration as in the female. Head, 294μ long, 224μ wide across eyes, 252μ at middle. Eyes 70μ long and 56μ wide. Postoculars 84μ long, pointed. Ocelli clear, posterior ocelli 42μ apart; median ocellus from posterior ocelli 28μ apart; mouth-cone broadly rounded, 196μ long. Antennal joints, length (width) in μ :—63 (56); 84 (42); 126 (56); 112 (42); 112 (42); 98 (42); 70 (28); 70 (14).

Prothorax, heavy, 462μ long at middle, 448μ wide across anterior margin and 602μ wide at posterior margin inclusive of coxae. Prothoracic setae fine and pointed; anteroangulars 56μ , midlaterals 70μ , postangulars 126μ and epimerals 112μ long. Forefemora 182μ wide at middle; foretarsus with a straight tooth, 56μ long.

Pterothorax, 420μ long and 630μ wide at anterior margin. Abdomen at base, 868μ wide, 896μ across III segment at middle, 420μ wide across

VIII and 210μ wide across IX. Setae of IX short, inner 70μ and outer 126μ long. Tube 280μ long, shorter than head, 112μ wide at base, 84μ at middle and 70μ across constricted region before apex and 84μ at apex.

Total body length, 3.458 mm .

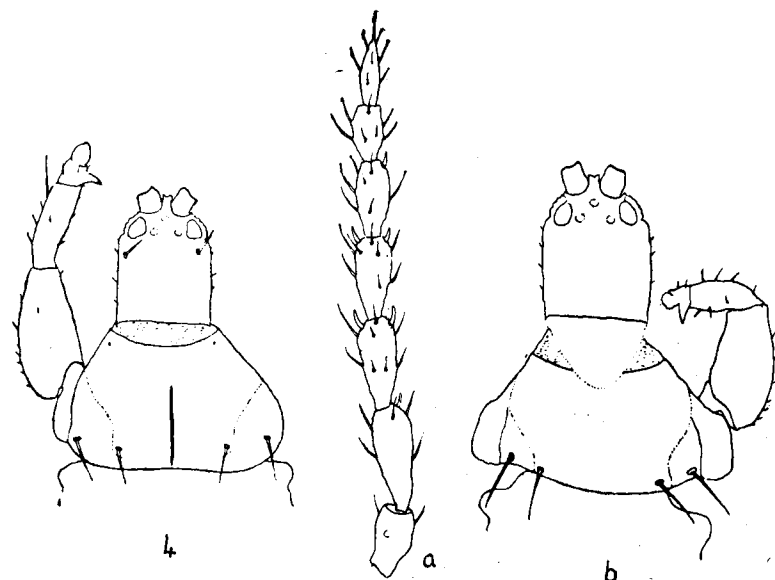


Fig. 4. *Barythrips mathuri* sp. n., head and prothorax of male; a—antenna of male; b—head and prothorax of female.

Habitat:—5 females and one male, Mussoorie, IX. 1936. (J. C. M. Gardner Collections). Holotype in T.N.A. Colls. No. 422.

This species is named after Dr. R. N. Mathur, due to whose kindness, was examination of this material possible.

Three species of *Barythrips* are known—*B. grandicauda* Priesner, *B. sculpticauda* Hood and Williams, and *B. heterocerus* Hood. The present species is very closely related to *sculpticauda*.

***Gigantothrips gardneri* sp. nov.**

Macropterous female:—

Total body length $4.62\text{--}4.79\text{ mm}$.

Body brownish, mid- and hind-tibiae yellowish brown, at base, rest yellow; antennal joints, 1, 2 and 8 brown, rest almost yellow. Wings cloudy, fringes brown.

Head $434\text{--}490\mu$ long, $280\text{--}308\mu$ wide across eyes, $266\text{--}280\mu$ at middle, clearly constricted behind eyes. Cheeks rugose, with 2–3 sharp spines, with no prominent warts. Eyes 154μ long and 84μ wide; ocelli, median and lateral, 28μ in diameter, median ocellus placed 42μ apart from posterior

ocelli, also 42μ apart. Postoculars wanting. Mouth-cone broad and bluntly rounded, 266μ wide at base, 182μ at apex and 210μ long. Antennal joints, length (width) in μ :—

56 (56); 84 (56); 210 (42); 182 (56); 154 (56); 126 (56); 84 (42); 42 (28). Sense cones long and thin.

Prothorax, 280μ long at middle, $308\text{--}336\mu$ wide at anterior margin, $560\text{--}602\mu$ across posterior margin, inclusive of coxae. Prothoracic setae pointed, epimerals 98μ long. Forefemora, $140\text{--}154\mu$ wide at middle; outer margin strongly setose; foretarsus with a small, forwardly directed tooth.

Pterothorax, $588\text{--}644\mu$ long, $630\text{--}700\mu$ wide across mesothorax. Forewings 1.904 mm long, with 33–34 duplicate cilia.

Abdomen $560\text{--}588\mu$ wide at base, $490\text{--}504\mu$ wide at middle, $280\text{--}336\mu$ across IX. Setae on IX, outer and inner subequal, $140\text{--}168\mu$ long. Tube setose $1.058\text{--}1.134\text{ mm}$ long, 2.4 times as long as head and $98\text{--}126$, $84\text{--}98$ and $63\text{--}70\mu$ respectively wide at base, middle and apex. Fig. 5.

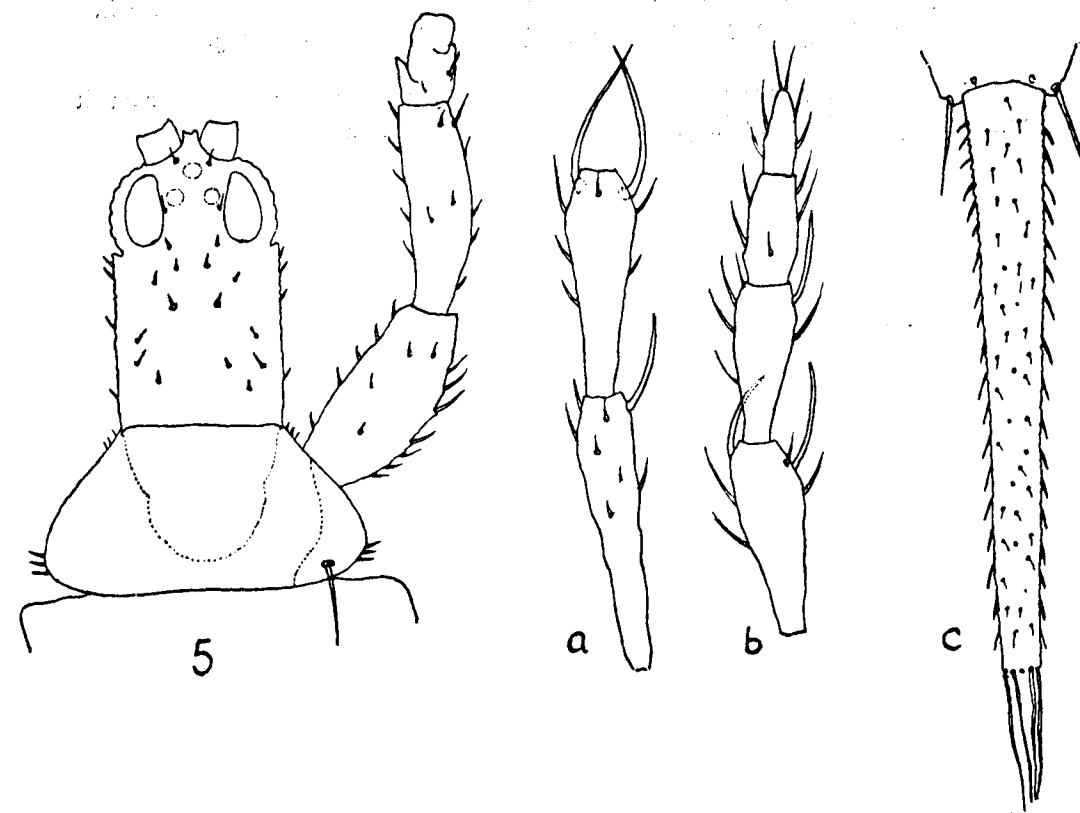


Fig. 5. *Gigantothrips gardneri* sp. nov., head and prothorax of female; a—antennal joint 3 & 4; b—joints 5–8; c—Tube.

Macropterous male:—

Total body length, 4.48 mm.

General colouration, as in the female.

Head $448\ \mu$ long, $280\ \mu$ wide across eyes, and $266\ \mu$ wide at middle. Eyes $140\ \mu$ long, $98\ \mu$ wide. Median ocellus $28\ \mu$ apart from posterior ocelli, $38\ \mu$ apart. Prothorax, $280\ \mu$ long at middle, and as wide across anterior margin and $560\ \mu$ across posterior margin. Forefemora as wide as that in the female, $140\ \mu$ wide; foretarsus with a small tooth.

Pterothorax, $560\ \mu$ long and $630\ \mu$ wide across mesothorax; forewings 1.720 mm. long, with 33 duplicate cilia.

Abdominal segment IX $210\ \mu$ long and $252\ \mu$ wide. Tube $980\ \mu$ long, 126, 84 and $60\ \mu$ wide respectively at base, middle and apex.

Habitat:—

Four females and one male. Mussoorie, on leaves of an unidentified plant, IX 1936. (J. C. M. Gardner Coll). T.N.A. Colls. No. 423.

This species comes very close to *G. baculifer* Priesner differing from it particularly in the very large number of duplicate cilia.

A Note on the Chromosomes of *Forcipula quadrispinosa* Dohrn

BY N. RAMALINGAM,

Department of Zoology, Presidency College, Madras.

(Communicated by Prof. P. K. Menon).

With 6 Text-figures

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Introduction

Though Dermaptera have attracted the attention of many cytologists, only 11 species belonging to 6 genera have been studied cytologically. (Goldschmidt '53; Callan, H.G. '41). At the same time the cytology of the group has presented many interesting features. (Morgan '28; Callan '41; Goldschmidt '53; Schrader '41). As far as the author is aware no account is available relating to the cytology of the Indian Dermaptera. In view of this a cytological study of the Indian Dermaptera was undertaken by the author. The present account relates to the chromosomes of *Forcipula quadrispinosa* Dohrn. A preliminary examination has also been made of the chromosomes of four other species of Labidurinae, viz. *F. aspinosa*, *F. decolyi*, *F. lurida* and *F. trispinosa*.

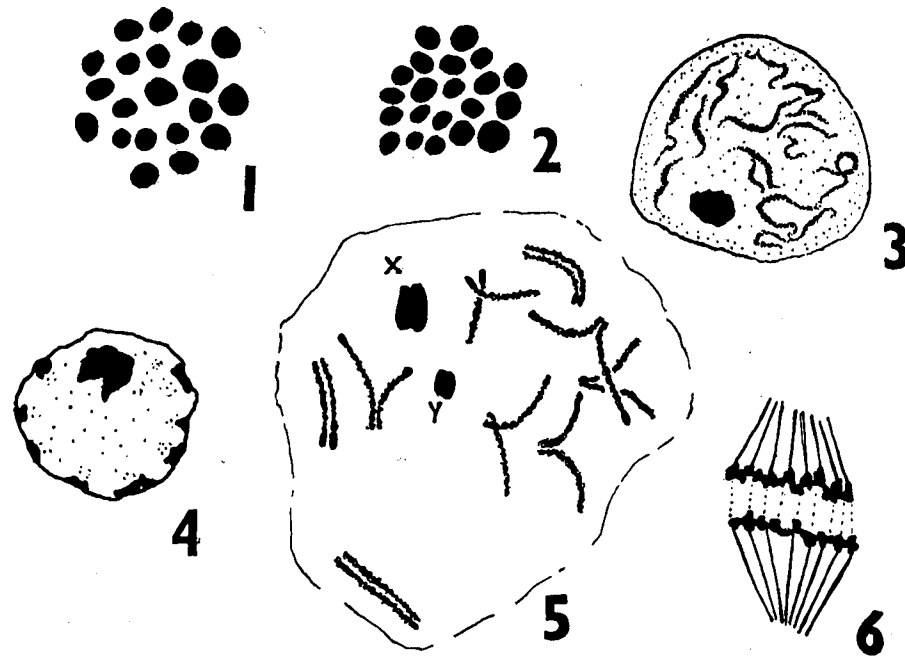
Material and Methods

Specimens of *F. quadrispinosa* were collected from the banks of Poondi Reservoir, about 45 miles from the city of Madras. The testes were fixed in La Cours' 2 BD, Bouin's and Carnoy's fixatives. After dehydration through graded series of alcohol and embedding in paraffin wax at $59-60^{\circ}\text{C}$, sections $8\ \mu$ to $10\ \mu$ thick were cut. The sections were then stained in Heiden-

hain's iron-alum haematoxylin or Feulgen stain. Aceto-orcein squash preparations of the testes were also made for comparison.

Observations

The spermatogonia are packed closely at the apices of the two follicles of each testis. In the majority of a large number of well spread metaphase plates the diploid number of chromosomes was observed to be 20. (Text fig. 1). However plates with 21 chromosomes were frequently found. (Text fig. 2). The sex-chromosomes could not be made out with certainty as they do not exhibit any



Text figures (1-6)

All the figures are drawn with the help of camera lucida, using x 90 objective and x 25 eye piece, at the table level.

1. Spermatogonial Metaphase, polar view, 20-type.
2. Spermatogonial Metaphase, polar view, 21-type.
3. Early Prophase showing positively heteropycnotic sex-chromosomes.
4. "Diffuse stage" showing the heteropycnotic sex-chromosome mass and the heteropycnotic ends of the autosomes abutting against the nuclear-membrane.
5. Diplotene stage with 9 bivalents + X + Y.
6. Anaphase I exhibiting synchronous movements of all the chromosomes.

Figures 1, 2 and 4 are drawn from Section and the rest are from aceto-orcein squashes.

staining peculiarity at this stage; but they become apparent, being positively heteropycnotic during the prophase stages of meiosis. (Text fig. 3). A stage intervenes between pachytene and diplotene when the sex-chromosomes con-

tinue to appear as a single well stained mass but the autosomes, except at their heteropycnotic ends do not take the stain. These stained ends are seen abutting against the nuclear membrane. (Text fig. 4). This stage is described as 'diffuse stage' by some workers. (Schrader '41b; Rao '55a, '55b, '56 and '57).

During diplotene, when the autosomes are paired, the sex-chromosomes are separate from each other, and each appears to have a bipartite structure. (Text fig. 5). The autosomes generally show one chiasma per bivalent and the chiasmata are terminalized at diakinesis. The bivalents are highly condensed and are distributed along the periphery of the nuclear membrane.

At metaphase the arrangement of all the chromosomes is regular and during Anaphase I, all the chromosomes move synchronously to the poles. (Text fig. 6). There is a slight difference in size between the sex-chromosomes, the X chromosome being slightly larger than the Y. Telophase is normal.

A distinct interphase intervenes between the two meiotic divisions.

Discussion

The species described herein shows 20 chromosomes with an XY type of sex-determining mechanism. As already stated plates with 21 chromosomes are frequently found. The identity of this extra chromosome is under investigation. A similar variation in the number of chromosomes has been observed by previous workers on Dermaptera (Morgan '28; Callan '41). So far the chromosomes of 11 species have been studied. (Goldschmidt '53; Misra '37). Bauer '47 puts these into 2 series, a lower one ($2n = 12-14$) and a higher one ($2n = 24-25$).

Forcipula quadrispinosa Dohrn seems to belong to the higher series.

In the other four species also, studied by the present author, the sex-chromosomes appear to be of the 'XY' type in the male.

Summary

Spermatogenesis in *Forcipula quadrispinosa* Dohrn is described. A preliminary examination of the chromosomes has also been made in four other species of Labidurinae, viz. *F. aspinosa*, *F. decolyi*, *F. trispinosa* and *F. lurida*. In all these species the sex-chromosomes in the male appear to be of the 'XY' type. A detailed study of the cytology, including spermatogenesis, cytotaxonomy, and cytogenetical aspects of the species mentioned is in progress.

Acknowledgments

My sincere thanks are due to Prof. H. Enoch, Head of the Department of Zoology, Presidency College, Madras, for giving me facilities to carry out the investigation and to Prof. P. K. Menon of the same department for suggestion and criticism. My thanks are also due to Dr. S. R. Venkatasubbha Rao, Cytogeneticist, Cancer Institute, Adyar, Madras for help. Mr. V. T. John, University Botany Laboratory, Madras, helped me in taking photomicrographs.

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Address of the President

To the Annual General Meeting of the Zoological Society of India, held at Bombay on the 4th and 5th January, 1960*

BY

M. L. ROONWAL,

President, Zoological Society of India.

AND

Director, Zoological Survey of India, Calcutta.

(With 3 Tables)

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PART 1**THE PROGRESS OF THE SOCIETY DURING 1959.****General**

This is my third and last year of service to the Society as its President, and I wish to take this opportunity of expressing my gratitude to all the

*The Presidential Address was delivered on the 5th January, 1960.

Office-bearers and Members for unstinted and valued co-operation during the entire period of three years. I venture to think with some satisfaction and a little pride that during this period the Society has made satisfactory progress, and even a little history, particularly by the sponsorship and successful holding of the First All-India Congress of Zoology, but all this would not have been possible without unity and co-operation. I wish all the Members of the Society a Happy and Prosperous New Year.

Membership

New Additions

The total number of Members on our rolls, as on 30th November, 1959, is 572, and the effective membership, that is, those that are in good standing, 234 as against 194 last year—an increase of 40. The total number of Ordinary Fellows on the rolls is 62 of which 49 are in good standing. There is thus a steady increase in the membership-strength of the Society.

I am glad to say that we have lost no member by the hand of death.

Finances

The Treasurer has already given you a detailed account of the finances of the Society. The total permanent reserves of the Society, as on 15th December, 1959, stand at Rs. 39,460-81 as against Rs. 36,989 last year, i.e., there is an increase of about Rs. 2,471. The reserve funds are built up as follows:—

	Rs.	nP.
1. Permanent Reserve Fund	...	23,586—87
2. Exhibition Fund	...	5,816—00
3. Dr. Bhalerao Memorial Fund	...	3,855—96
4. Late Prof. K. N. Bahl Memorial Fund (less amount paid to Lucknow University for Bahl Medal)	..	101—98
5. Publications Fund	...	5,600—00
6. Building Fund	...	500—00
Total	...	39,460—81

The total income from 1st April to 15th December 1959 was Rs. 12,756-02 nP. and the expenditure Rs. 17,163-35 nP. and we are thus in deficit by Rs. 4,407-33 nP.

Donations from the following sources were received and are gratefully acknowledged:—

	Rs.	nP.
(i) National Institute of Sciences of India (for 1958-59) ...	2,000—00	
(ii) Indian Council of Agricultural Research (for 1957-58 and 1958-59) ...	2,414—00	
(iii) University of Madras (for 1958-59) ...	150—00	
(iv) Kerala University (for 2 years) ...	100—00	
(v) M/s Burma Shell Oil, Storage & Distribution Co. (Private) Ltd. ...	100—00	
(vi) Bombay Natural History Society (for 1st All-India Congress of Zoology) ...	100—00	
(vii) Dr. G. S. Thapar (for the Bhalerao Memorial Fund) ...	144—50	
Total	...	5,008—50

As in previous years, I would like to pay tribute to our Honorary Treasurer, Dr. B. S. Chauhan, for his wise and careful husbanding of the resources of the Society.

Publications

(a) *The Journal*

Thanks to the energy and zeal of our Editor, Professor R. V. Seshaiya, and our Manager of Publications, Professor P. K. Menon, the issues of the *Journal of the Zoological Society of India* have come out regularly. All the past arrears have been made up, and the general printing and get-up have also been greatly improved. The following volumes were issued during the year:—

Vol. 10 (Nos. 1 and 2) for 1958 and Vol. 11 (No. 1) for 1959. It is expected that No. 2 issue of Vol. 11 will be out shortly.

(b) *The Year-Book*

Members will recall that the first *Year-Book*, covering the period 1956-57 (1st April, 1956 to 31st March, 1957) was issued in December, 1957, and the second one (for 1957-58) in February, 1959. The third one, the *Year-Book* for 1958-59, was issued during the year under report (in September, 1959).

(c) *The Indian Zoological Memoirs*

Steady progress was maintained regarding the publication of the "*Indian Zoological Memoirs on Indian Animal Types*" (initiated by the late Professor

- (i) Memoir No. 7, on *Salmacis* (the Indian Sea Urchin), by Professor R. Gopala Aiyar, has been under revision by Dr. P. N. Ganapati for the last two-and-a-half years, and I hope Dr. Ganapati will not delay the revision any further. Members will recall that the author has given the sole rights for this memoir to the Society.
- (ii) Memoir No. 3, on *Ostrea* (the Bombay Oyster), by Professor P. R. Awati, is also on our reprinting programme and final decision about it is expected to be taken in the near future.
- (iii) A memoir on *Schistocerca gregaria* (the Desert Locust), whose manuscript was under the Society's consideration last year, was, after careful scrutiny, not found suitable for publication in this series.
- (iv) A memoir on the fish *Ophiocephalus punctatus* (Bloch has been allotted to Dr. Har Swarup of the Saugar University, Sagar.
- (v) A memoir on the common Indian rat, *Rattus rattus*, has been assigned to Dr. D. R. Sharma of Raigarh (M.P.).
- (vi) It is hoped that the final decision about the publication of Memoir No. 9, *Dasyatis* (the Indian Sting Ray), by Dr. M. Chandi, which was under dispute with Dr. M. L. Bhatia of Delhi (*vide Year-Book for 1957-58*, p. 36), will be taken soon.

The *Who's Who* of the Society, which had been under preparation for the last two years, is now ready to go to the press, and we hope that it will be published soon. Its publication was delayed in part due to other and more pressing work.

Like the *Who's Who* mentioned above, the *National Register*, which, it may be added, is complementary to the *Who's Who*, is also ready to go to the press.

You already know that the First All-India Congress of Zoology, which the Society has been planning for quite sometime and which I had referred to in my two previous Annual Addresses (see *Year-Book* for 1957-58, pp. 20 and 38; and *Year-Book* for 1958-59, pp. 19 and 27) was held at Jabalpur

I would, however, like to take this opportunity of expressing, on behalf of the Society, our gratitude to all those who helped in organizing the Congress and making it the success that it was. In particular our thanks go to the following persons and institutions:—To the University of Jabalpur, for inviting the Congress to Jabalpur; to the Principal (Professor U. Mukerjee) and staff of the Mahakoshal Mahavidyalaya, Jabalpur, in whose buildings the Congress was held; to the Chairman and Members of the Local Reception Committee; to the Local Secretaries (Professor S. B. Singh Thakur and Professor G. W. Vaidya) for their indefatigable care and attention; to the Volunteers; to the organizations which provided the evening variety entertainments; and finally, to all the office bearers of the Congress for their ready and enthusiastic co-operation, and particularly to the following upon whom fell, most of all, the heaviest burden of the day to day work and who bore it unflinchingly: Dr. B. S. Chauhan, the indefatigable General Secretary who, as I said in my Presidential Address to the Congress, we may well regard as “the Quartermaster-General and the Master of Ceremonies of the Congress, rolled into one”; and Messers G. Ramakrishna and A. K. Bose, the Assistant General Secretaries.

The *Proceedings* of the Congress, which, besides official matters, will contain all the papers in full, are in the process of active editing for publication.

We may well regard the Congress as a milestone in the history of Indian zoology. Never before has such a galaxy of Indian zoologists, both old and young, assembled in such strength, and many veterans, some of whom had retired fifteen or twenty years earlier, took the trouble to travel long distances and grace the Congress; they gave it dignity, weight and wisdom. About 100 papers were received, and were classified into eleven Sections, each with its own Chairman and Recorder. Besides these, three Symposia were held for which about 18 papers were received. An Exhibition was organized, and four popular lectures on zoological topics were delivered.

The Plenary Sessions passed a series of important resolutions which have already been placed before you for approval and action. It was decided to hold the Congress periodically once every three years, the Second Congress to be held in the year 1962.

The second symposium organised under the Society's auspices was on "Modern Trends in Zoological Research in India", and was held in New

Delhi on the 20th January, 1959. Contributions to this symposium were published in October, 1959, as No. 3 Bulletin of the *Zoological Society of India*.

The Society's Awards

The second award of the Bhalerao Medal for meritorious contributions to Helminthology in India for the three-year period 1955-57, which was under consideration last year, has been awarded jointly to Dr. G. S. Thapar of Lucknow and Dr. H. D. Srivastava of Izatnagar. On behalf of the Society, and on my own behalf, I congratulate these worthy scientists most heartily upon the honour which they richly deserve.

Representation of the Society on Outside Bodies

Indian Board for Wild Life.—Dr. B. N. Chopra was elected as the Society's representative on the Indian Board for Wild Life in place of Dr. H. Srinivasa Rao who had expressed a wish to be relieved of this work.

Professor K. N. Bahl Memorial Fund

The Professor K. N. Bahl Memorial Fund, subscriptions to which were closed recently, now stands at Rs. 1653-98 nP. Out of this sum an amount of Rs. 1552/- has been paid as an endowment to the Lucknow University, Lucknow (where Professor Bahl served for the major portion of his service career), for the annual award of a gold medal, to be known as the "Zoological Society of India K. N. Bahl Medal" to the student who secures the highest number of aggregate marks in both the M.Sc. Previous and Final Examinations in zoology at that University. Negotiations in this respect with the Lucknow University have been finalised.

Register of Signatures, the Scrolls, etc.

- (i) *Register of signatures of Members*:—This Register made of special high-quality paper and suitably bound in leather, was started during this year, and I would request the Members to kindly sign their names in it for permanent record with the Society.
- (ii) *Album of Photographs*:—The album is under active preparation, and I hope it will be ready in the next few months.
- (iii) *Scrolls to Members and Fellows*:—These Scrolls, which will be presented to all Members and Fellows, are now in the press, and will, it is hoped, soon be ready for distribution.

The Society's Library

The Society's Library, which is maintained at Calcutta, received during 1959 an addition of 84 volumes, including books, periodicals and reprints, and the total number now stands at 1,835 volumes.

Permanent Building Reserve Fund

In my Address to you last year I had recommended that we should start a Permanent Building Reserve Fund for the erection of a permanent building of our own. I am glad to say that the Treasurer has been able to put a sum of Rs. 500/- in this fund.

PART II

THE EMPLOYMENT AND EMOLUMENTS OF ZOOLOGISTS IN INDIA

(Tables 1—3)

(a) Present Position

In my Presidential Address to the Annual General Meeting of the Zoological Society of India held at Madras on the 7th January, 1958, I had called attention (Roonwal 1959) to some problems relating to the proper utilization of zoological talent in India. Owing to lack of proper employment the young zoologist has often to accept posts in purely temporary Schemes of Research on the termination of which he is left on the streets so to speak. If he has put in say five or ten years work in the Schemes, he is by now rather too old to compete on favourable terms with comparative freshers, and if he does find a permanent post he usually does not have enough years left to qualify for full pension and thus loses heavily compared to those who may be lucky enough to enter service at a younger age. One obvious solution of this difficulty is the creation, under the various bodies which sponsor the research schemes, of a permanent cadre of zoologists who could be transferred from one scheme to another as the need arises without loss of security and of prospects of promotion.

Recently the National Register Division of the Council of Scientific and Industrial Research (C.S.I.R., 1959), has published an interesting analysis of the employment of scientific personnel in India based on the entries in the National Register of scientists.* Out of a total of only about 7,948* scientists employed in India by various agencies such as the Government, private industry, etc., the subject-wise distribution is as shown in Table 1. The zoologists are unfortunately at the lower end of the scale—only 683 zoologists as against 2,380 chemists and 1,608 physicists. Industry employs only 5 zoologists as against 321 chemists, 109 geo-scientists and 17 botanists. How-

*The term "scientist" is confined here to those having the M.Sc. (or equivalent) or higher degrees in science.

*In the United States in 1957, about 7,38,000 scientists and engineers were employed as follows:—Engineers 5,28,000; scientists 1,52,000; and administrators of scientific and engineering activities 58,000.

ever, in research and development work outside industry, the zoologists hold a relatively high position—212 zoologists as against 317 agri-scientists (highest), 209 geo-scientists and 46 botanists.

Table 1:—Employment of scientists in India in industry and research and development (R & D) work in India, based on the C.S.I.R. National Register. (From *Tech. Man power*, Vol. 1, No. 5, May, 1959, p. 2.)

Scientists (Post-graduate level)	Total employed	Type of Employment and Number Employed			
		Non- industrial	Govt. industry	Private industry	R & D outside industry*
1. Physicists	1,608	1,444	27	24	113
2. Mathematicians	1,078	980	15	41	42
3. Chemists	2,380	1,951	102	219	108
4. Foresters	69	57	1	2	9
5. Botanists	774	711	2	15	46
6. Geo.Scientists	696	378	32	77	209
7. Zoologists	683	466	3	2	212
8. Agri-Scientists	660	321	6	16	317
Total Number	7,948	6,308	188	396	1,056
Total percentage	100	79.4	2.4	5.0	13.2

*Research and Development work, e.g., in organizations like the National Laboratories of the C.S.I.R., the Scientific Surveys (Geological, Zoological and Botanical Surveys, etc.) etc.

The comparison of the pay-structure of the scientists is equally instructive (Table 2). At all age-levels, from 25 to 55 years, zoologists are about the lowest paid among the scientists, not to speak of the other services and professions, and this handicap is in no way lessened by the fact that botanists and chemists are not placed in a much better position. The highest paid are physicists, mathematicians and geo-scientists (pay per month at 25 years age, Rs. 345—400, versus Rs. 335 for zoologists; and at 55 years age Rs. 1,625—1,645, versus Rs. 1,270 for zoologists. This shows that zoological merit is not yet much appreciated in terms of emoluments.

Table 2:—Median pay, per month, in rupees, of scientists in India in the various sciences, as based on the data in the National Register. ("All" includes all scientists, whether holding a Ph.D., M.Sc. or equivalent degree.) (From *Tech. Manpower*, C.S.I.R., New Delhi, Vol. 1, No. 5, May 1959, p. 2.)

Age	Qualifications	Median Pay in Rupees per month					
		Physics	Mathe- matics & Statistics	Chemistry	Zoology	Botany	Geo- Sciences
25	Ph. D.	345	400	345	335	385	370
	All	260	250	250	235	245	320
30	Ph. D.	450	525	400	405	350	515
	All	320	310	310	280	275	385
35	Ph. D.	530	630	495	490	520	390
	All	440	450	400	370	330	505
40	Ph. D.	630	825	580	575	555	*
	All	540	560	505	515	485	705
45	Ph. D.	675	1,075	740	630	670	*
	All	575	620	565	560	575	1,016
50	Ph. D.	1,110	1,290	935	890	780	*
	All	635	627	710	770	655	1,337
55	Ph. D.	1,645	*	1,025	1,270	1,210	1,625
	All	1,030	665	740	1,044	775	1,580

*Denotes insufficient data.

It is interesting to note (Table 3) that the highest proportion of doctorate holders (Ph.D. and D.Sc.) occur in zoology and chemistry (19%) with botany a close second (18%), while the other sciences are far below. As may be expected, the per centage of doctorate holders among the employed scientists is higher among the zoologists and chemists (23%), with botany a close second (22%).

Table 3:—Proportion of doctorate holders (Ph.D. and D.Sc.) among scientists in India in various sciences, as based on the National Register. (From *Tech. Manpower*, C.S.I.R., New Delhi, Vol. 1, No. 5, May 1959, p. 1.)

Subject	Doctors among registrants	
	% of total	% of employed scientists
Physics ...	10	13
Mathematics & Statistics ...	6	8
Chemistry ...	19	23
Zoology ...	19	23
Botany ...	18	22
Geo-Sciences ...	8	10
Total ...	14%	17%

Our immediate problems, thus, are as follows:—(i) First, to increase the total number of zoologists from the present 683 to at least double this figure in the next few years. (ii) Secondly, to advance the industrial applications of zoology. (iii) And thirdly, to better their pay-scales.

(b) References

- COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW DELHI. 1959.—Scientists and industry—*Technical Manpower* (Bull. National Register, C.S.I.R.), New Delhi, 1 (5), May, 1959. 4 pp. (unnumbered).
- ROONWAL, M. L. 1959.—Address of President to the Annual General Meeting of the Zoological Society of India, held at Madras on the 7th January, 1958. *Year-Book zool. Soc. India, for 1957-58*, Calcutta, pp. 32-43. Also in *J. zool. Soc. India*, Calcutta, 10 (1), pp. 82-91, 1 pl.

REVIEW

The grasshoppers of the genus *Chrotogonus*, and their biogeography

KEVAN, D. K. McE. 1959. A study of the genus *Chrotogonus* Audinet—Serville, 1839 (Orthoptera: Acridoidea: Pyrgomorphae). V. A. revisional monograph of the Chrotogoni. VI. The history and biogeography of the Chrotogoni. *Compan. Diamant. Angola (Diam.)*, Mus. Dundo, Publ. Cult., Lisbon, No. 43, 246 pp. (quarto).

The Chrotogoni are a tribe of old world short-horned grasshoppers some of which are insidious crop pests of some severity. The group is distributed from Africa through West Asia and Iran to India and portions of central Asia. Because of difficulties of various kinds, its systematics have hitherto been in a hopeless state of confusion. In this sumptuous monograph, Dr. McE Kevan, Professor of Entomology at the McGill University, Canada, has, as a result of study covering many years, straightened out the systematics of this difficult group for which he is to be congratulated.

In the first portion of the monograph (pp. 15-199), the author, after giving a short account of the distribution, phylogeny, morphological variation and bionomics of the group, gives a key to the genera, of which there are six including the new genus *Maxicus*. The genus *Chrotogonus* is further divided into two subgenera—*Chrotogonus* s. str. and *Obbiacris*. Each of the six genera are dealt with in considerable detail, with full synonymies, keys to species and subspecies, systematic characters of the genera, species, etc., and detailed geographical distributions. Fortunately, so far as India is concerned the place names have been referred not only to their old Provinces but also to the new States as far as possible, although the reorganisation of States on 1st November, 1956, does not appear to have been taken into account. To give an example (p. 57): "Madhya Pradesh (Central Provinces)"; "Vindhya Pradesh (Central India, Eastern States)".

The second portion of the monograph (pp. 201-246) deals with the history and biogeography of the Chrotogoni. McE Kevan concludes that the genus *Chrotogonus* possibly dates from the early Miocene of tropical Africa but probably reached southern India soon afterwards.

The monograph is produced in quarto size and is printed on art paper throughout, and the publishers are to be congratulated on bringing out a fine production. A minor printing mistake which has come to my notice may be mentioned:

p. 17, line 15 from below: "Puna, India", should probably read "Pusa, India", Pusa (in Bihar, India) being a well known centre of entomological and agricultural research.

We would commend this monograph not only to the attention of all entomologists, both agricultural and systematic, but also to other zoologists as an example of careful, critical, patient and painstaking work not merely in the field of systematics but also for the study of wider problems of evolution and biogeography.

M. L. ROONWAL

FORTHCOMING PUBLICATIONS

The following papers will be published in Vol. XIII. No. 1.

- | | |
|--|--|
| Dominic, C. J. | Signs of Secretary Activity in Bursa Fabricius of Two species of Indian Birds. |
| Saxena, S. C. | Study on the Heritability of Thanatosis and Insecticide Tolerance of Selected Populations of <i>Catandra granaria</i> . L. |
| Menon, A. G. K. | <i>Bascanichthys deraniyagalai</i> , A new eel from the coromandel coast of India with a key to the Indian Ophichthyidae. |
| Kurup, N. G. | On the Digestive tract of <i>Cryptocerata</i> . (Insecta Hemiptera)—1. <i>Laccotrephes maculatus</i> . Fabr. (Fam Nepidae). |
| Kuttalingam, M. D. | Observations on the life-history and Feeding Habits of a Plankton & feeder (<i>Dussumieria acuta</i> Cuv and Val) |
| Kusumavati Kadam | Studies on the Morphology of an Indian Earwing <i>Ladidura riparia</i> Pall. var. <i>Inermes</i> Brunner. |
| Pasha, S. M. K. | On a collection of Rotifers from Madras. |
| Kannan, S. | Soil Nematodes from Madras city. |
| Seshadri, B. | Studies on the Distribution of the Exocrine Pancreas in <i>Ophicephalus striatus</i> Bloch and <i>Mugil speigleri</i> (Bleeker). |
| Ananthasubramanyam, K. S.
and
Ananthakrishnan, T. N. | } Biology of <i>Anastatus</i> sp. |
| Durve, V. S. and Bal, D. V. | Studies on the chemical composition of <i>Crassostrea gryphoides</i> Scholthen. |
| Dutt, S. | Biometrical studies of <i>Sardinella</i> spp. of Waltair coast. |
| David, A. | Notes on the Embryonic and Larval Development of <i>Bagarius bagarius</i> (Hamilton). |

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I, Sri R. V. Seshaiya, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Date, 31-3-61,

R. V. SESHAIYA,
Editor.

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The Govt. of India, Ministry of Scientific Research & Cultural Affairs, The National Institute of Sciences of India ; Indian Council of Agricultural Research ; Universities of Madras, Annamalai and Travancore ; Messrs. Burmah-Shell Oil Storage and Distributing Company of India, Ltd., etc.

The Hony. Treasurer,

NOTICE

Members of the Zoological Society of India are requested to send their membership subscription of Society for the year 1961-62 and arrears, if any, to the Hony. Treasurer at an early date.

The Journal of the Society as and when published, is mailed only to members in good standing.

Orders for publications of the Zoological Society of India, the *Indian Journal of Helminthology*, reprints of a few papers of the Indian Helminthologist, the late Dr. G. D. Bhalerao, Prof. G. S. Thapar 60th Birthday Commer. Vol. etc. could also now be placed with **Dr. B. S. Chauhan, Hony. Treasurer, Zoological Society of India, 34, Chittaranjan Avenue, Calcutta-12 (India)**

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Other Publications : Year-Book of the Zoological Society of India (1956-57 and 1957-58) Rs. 3.00 each; 1958-59 Rs. 5.00. Indian Zoological Memoirs (initiated by the late Prof. K. N. Bahl) Nos. 6 *Palaemon*, 7 *Salmacis* & 3 *Ostrea* available.

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2. No. 7. The Indian Sea-Urchin, *Salmacis* by Professor R. Gopala Aiyar, 1938. Rs. 2.50 plus packing and postage Rs. 1.00.
3. No. 3. The Bombay Oyster, *Ostrea cucullata* by Professor P. R. Awati, 1931. Rs. 3.00 plus packing and postage Rs. 1.00.
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