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STUDIES ON INDIAN ITONIDIDAE (CECIDOMYIDAE: DIPTERA)[1].

V Descriptions and Records of Midges in the Pusa Collection[2].

By M. S. Mani, *M.A., Assistant to the Imperial Entomologist, New Delhi.*

Recent studies on the gall midges in the Pusa collection have brought to light three interesting new forms, one of which, *Anjeerodiplosis peshawarensis*, gen. *et* sp. nov., bred by my colleague Mr. H. L. Bhatia, is a pest of the cultivated country fig in the North-West Frontier Province. It has also been possible to establish the identity of the *Tamarix* shoot gall midge. Notes on the distribution of some little-known species are also added.

The writer's thanks are due to Dr. Hem Singh Pruthi, Imperial Entomologist, New Delhi, for facilities in connection with his work.

Tribe LASIOPTERARIAE.

Neolasioptera cephalandra Mani.

1934. *Neolasioptera cephalandrae*, Mani, *Rec. Ind. Mus.* XXXVI, pp. 397-399, figs. 8-9, ♀.
1936. *Neolasioptera cephalandrae*, Mani, *Rec. Ind. Mus.* XXXVIII, p. 193, ♂.

This species was originally described from specimens bred from the shoot galls of *Coccinia indica* Naud. in the Madras and Bengal Presidencies. It is being recorded here for the first time from Pusa, Bihar and Delhi on the same plant. The species thus appears to have a wide distribution in India.

Tribe OLIGOTROPHIARIAE.

Rhabdophaga mangiferae, sp. nov.

Female.—1 mm. long. First palpal segment short, subglobose; second segment slightly longer, stout; third segment nearly as long as the second but somewhat more slender; fourth segment about one and a half times the third, more slender. Antennae nearly as long as body, segments 14; stems gradually growing longer towards apex; third, fourth and fifth segments with a distinct constriction in the middle; third and fourth subequal, each longer than the rest of the segments; fifth with a stem about one fifth the enlargement. Mesonotum dark brownish in spirit specimens. Empodium nearly as long as claws or somewhat shorter. Abdomen with dense black setae. Ovipositor short, terminal

[1] Parts I-IV of this series were published in *Rec. Ind. Mus.* XXXVI, pp. 371-451 (1934); *op. cit.* XXXVII, pp. 425-454 (1935); *op. cit.* XXXVIII, pp. 193-197 (1936); *op. cit.* XXXIX, pp. 281-286 (1937).

[2] "Pusa Collections" means the insect collections of the Imperial Agricultural Research Institue, New Delhi.

lamellae oval, somewhat longer than broad, rounded apically, with a short ventral lobe at base.

Holotype.—One female dissected on a slide.

Paratypes.—Three females in spirit.

Both in the collections of the Imperial Entomologist, New Delhi.

This species was bred from shoot galls of *Mangifera indica* Linn. by Venkitasubayyar, Cochin State Entomologist, Central Farm, Trichur, 6th June, 1937. The genus *Rhabdophaga* Westw. has not been recorded so far from India.

Misospatha Kieffer.

1856. *Cecidomyia*, Amblard, *Ann. Soc. Ent. France* XXV, pp. 169-172 (*Partim*).
1912. *Oligotrophus*, Kieffer, *Ann. Soc. Ent. France* LXXXI, p. 129 (*Partim*).
1912. *Amblardiella*, Kieffer, *Marcellia* XI, p. 169 (*syn. nov.*).
1913. *Misospatha*, Kieffer, *Gen. Ins., Dipt.* (*Cecidomyid.*), p. 44.
1913. *Amblardiella*, Kieffer, *Gen. Ins., Dipt.* (*Cecidomyid.*), p. 84.
1913. *Misospatha*, Kieffer, *Bull. Soc. Hist. Nat. Metz* XXVIII, p. 48.

Recent studies have convinced me that *Amblardiella* described by Kieffer from larvae and pupae only taken from shoot galls of *Tamarix* spp. is identical with *Misospatha* Kieff. Full synonymy is given above.

Misospatha tamaricum (Kieffer) Mani.

1909. *Perrisia tamaricina*, Kieffer, *Bull. Soc. Hist. Nat. Metz* XXV, p. 2 (*syn. nov.*).
1912. *Oligotrophus tamaricum*, Kieffer, *Ann. Soc. Ent. France* LXXXI, p. 129.
1913. *Amblardiella tamaricum*, Kieffer, *Gen. Ins., Dipt.* (*Cecidomyid.*), p. 84.
1935. *Misospatha tamaricis*, Mani, *Rec. Ind. Mus.* XXXVII, p. 432.

In 1909 Kieffer described *Perrisia tamaricina* only from galls on the branches of *Tamarix gallica* from Africa. In 1912 he described from Egypt the same gall and the larvae producing it under the name *Oligotrophus tamaricum.* Again in 1913, he erected the genus *Amblardiella* from larvae and pupae only from the same galls and from the same locality, with *O. tamaricum* as the type. He did not, however, describe the adult midges. Recently I examined some specimens labelled *Oligotrophus tamaricum*, in the Pusa collection and found them to be identical with my species *Misospatha tamaricis*, described from adult midges bred from shoot galls of *Tamarix dioica* at Dehra Dun and later also from similar galls of *Tamarix gallica* at Pusa. The larval and pupal characters of *Misospatha tamaricis* and *Amblardiella tamaricum* are also identical.

The following observations are recorded on Cage Slip No. 2806 in the files of the Imperial Entomologist, New Delhi: Several maggots are found in a single gall, each maggot forming a cavity, in which it feeds and pupates. The full-grown pupa is about 4 mm. long and 1 mm. broad, brownish red in colour in the beginning, gradually becomes darker and just before the adult emerges it is black. The pupal period was found to be 8-10 days at Pusa in January. Large numbers of the Chalcid parasite *Eutelus tamaricum* Ferr. (previously known only from Algeria) were also bred from the galls.

The cervical armature of the pupa is strong, red and composed of two slightly curved, pointed spines. Antennal armature is much longer. Frontal armature short and stout. Anal cerci prominent.

Tribe ASPHONDYLARIAE.

Asphondylia lantanae Felt.

1920. *Asphondylia lantanae*, Felt, *Mem. Depart. Agric. Ind., Ent. Ser.* VII, p. 2.

I refer to this species two females and three males in the Pusa collection, labelled as having been bred from flowers of *Lantana*. Terminal clasp segment of male genitalia is minutely bidentate ; one tooth is larger than the other.

Tribe ITONIDIDINARIAE.

Anjeerodiplosis[1], gen. nov.

This genus belongs to the Bifila group. In Felt's[2] key it runs to the genus *Thorodiplosis* Felt, from which it is easily distinguished by the relatively longer, heavily chitinised and subaciculate ovipositor, uniformly binodose male antennal segments, absence of lobes on the basal clasp segment and by the slender terminal clasp segment.

The following is a full description of the genus :

Palpi quadriarticulate. Antennae with 14 segments ; third and fourth segments fused together ; segments in the female subcylindrical, stemmed ; in the male all binodose, circumfila two, loops longer than the stems. Wings nearly three times as long as broad ; third vein reaching margin at apex ; costa not thickened basally. Claws simple on all legs. Ovipositor subaciculate, lobes not fleshy, long, chitinised. Dorsal plate truncate apically, emarginate. Ventral plate and style as long as dorsal plate. Basal clasp segment elongate, simple ; terminal clasp segment slender, unidentate. Eyes not separated above in both the sexes.

Genotype.—Anjeerodiplosis peshawarensis, sp. nov.

Anjeerodiplosis peshawarensis, gen. *et* sp. nov.

Female.—1·25-1·50 mm. long. Brownish fuscus. First palpal segment short, subglobose ; second nearly twice the length of the first ; third segment about one and a half times the length of the second, slender ; fourth segment about one and a half times the third, more slender, fusiform. Antennal segments with an apical and a basal whorl of setae, basal band of circumfila at about the middle, the apical band subapical ; third segment longest ; fourth segment about three fourths the length of third ; enlargment of fifth segment with a length nearly twice its diameter, stem about one third the length of enlargement ; terminal segment with a cylindrical prolongation about half the length of the segment. Mesonotum brownish. Scutellum lighter. Claws about twice the length of empodium, stout.

Male.—Basal stems of basal antennal segments somewhat shorter than the apical stems, subequal elsewhere. Circumfila loops somewhat

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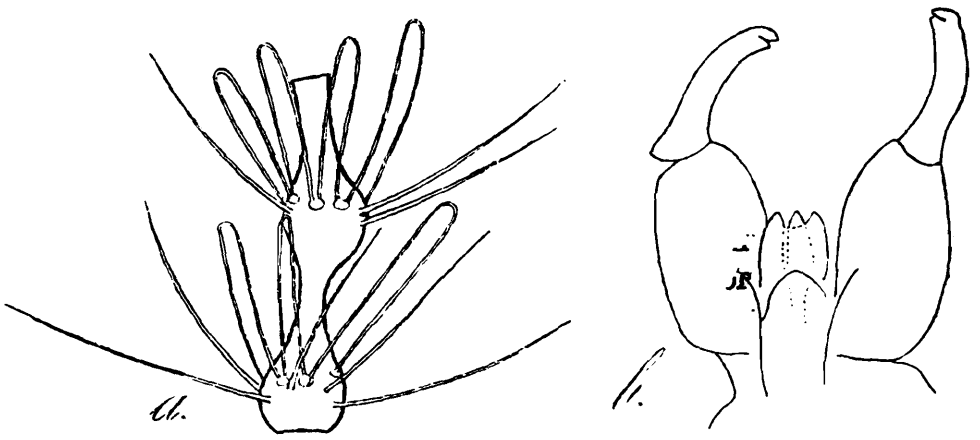
[1] *Anjeerodiplosis* from *anjeer*, the Hindustani name for the cultivated country fig., *Ficus carica*, from which the midges were bred.

[2] Felt, E. P., *Bull. N. Y. State Mus.* No. 275, p. 155 (1925).

longer than stems. Basal enlargement of the third segment oval, apical enlargement subglobose. Fifth segment with the basal stem



TEXT-FIG. 1.—*Anjeerodiplosis peshawarensis*, gen. *et* sp. nov. *a*. Fifth antennal segment of male ; *b*. Genitalia of male.

about three fourths the basal enlargement, apical stem equal to apical enlargement. Terminal segment with an apical prolongation nearly half the length of the apical, oval enlargement ; basal enlargement globose, length three fourths its diamater. Dorsal plate broadly and deeply truncate apically, broadly emarginate. Basal clasp segment subrectangular. Terminal clasp segment about four fifths the basal segment, elongate, slender, slightly curved, unidentate apically ; tooth large, chitinised. Style as long as dorsal plate.

Holotype.—One female dissected on two slides.

Allotype.—One male dissected on two slides.

Paratypes.—One female and three males in spirit.

Bred from the figs of *Ficus carica*, the cultivated country fig, Peshawar, H. L. Bhatia, May-July, 1937. In the collections of the Imperial Entomologist, New Delhi.

Lobopteromyia prosopidis, sp. nov.

Female.—About 1·75 mm. long. General colour of body pale yellow or white. First segment of palpus short, second segment nearly equal or slightly longer, terminal segment about one and two thirds the length of third segment. Fifth antennal segment : enlargement with a length about one and a half times its diameter, stem less than one fourth the length of enlargement ; terminal segment with an apical prolongation about one and two thirds the enlargement. Mesonotum dark brown. Scutellum white. Postscutellum darker. Claws slender, equal to empodium. Abdomen white, ovipositor subaciculate, long.

Male.—About 1·50 mm. long. White. First segment of palpus short, stout apically ; second segment a little longer or nearly equal but distinctly stouter than first ; third segment one and a half times the second, more slender ; terminal segment slightly longer and more slender than third. Fifth antennal segment : basal enlargement subglobose, basal stem with a length equal to its diameter, apical enlargement with a length about one and one fifth its diameter, apical stem twice its diameter in length. Terminal antennal segment : basal enlargement

ovate, basal stem shorter than the basal enlargement, apical enlargement elliptic-ovate, about one and a half times the basal enlargement and with an apical prolongation over half its length. Mesonotum brown. Genitalia : ventral plate longer than dorsal plate, deeply bilobed ; harpes simple, short ; basal clasp segment much longer than the inner parts, broad basally, cordate, simple ; terminal clasp segment slender, only slightly thicker basally than apically, three fourths the length of basal clasp segment, with one chitinous tooth apically.

Holotype.—One female dissected on a slide.

Allotype.—One male dissected on a slide.

Paratypes.—One female and one male in spirit.

All in the collections of the Imperial Entomologist, New Delhi. Bred from galls on leaf of *Prosopis spicigera* Linn., M. S. Mani, New Delhi, 30th September, 1937.

Specimens of this species were bred by the author[1] from galls on the rachides of *Prosopis spicigera* as early as 1931 in Tanjore, S. India but owing to the unsatisfactory nature of the material the species was not then described. The genus *Lobopteromyia* Felt itself has not been recorded from India so far.

TEXT-FIG. 2.—*Lobopteromyia prosopidis*, sp. nov. *a*. A leaf showing some galls ; *b*. A single pinna with galls magnified showing surface details.

The galls appear in Delhi about the month of June and adult midges emerge in August-September. Galls form on rachides of leaves and are solid, globose, woody structures measuring up to about 7 mm. in

[1] Mani, M. S., *Rec. Ind. Mus.* XXXVII, p. 449 (1935).

diameter, usually brownish in colour and containing one to two midges. Sometimes galls form crowded together resulting in a compound moniliform production. Several examples in formalin in Imperial Entomologist's collection and Zoological Survey of India collection, Calcutta.

Odinadiplosis Mani.

1935. *Odinadiplosis,* Mani, *Rec. Ind. Mus.* XXXVII, p. 435.

Since this genus was erected by me in 1935 with *O. odinae* Mani as the type, Barnes[1] has transferred to it another interesting species *Cecidomyia amygdali* Anagnos., which is a serious pest of almonds in Greece. *Odinadiplosis amygdali* (Anagnos.) produces galls on the buds of almond trees and thus seriously affects its growth and fruit production. The genus thus appears to have a wide range of distribution extending from the Palaearctic to the Indian regions.

Diadiplosis indica Felt.

1934. *Diadiplosis indica,* Mani, *Rec. Ind. Mus.* XXXVI, p. 424.

I refer to this species one female and one male in the Pusa collection labelled as having been bred from the scale insect *Phaenococcus hirsutus* at Pusa, October-November, 1918.

Basal clasp segment of male genitalia broad; terminal clasp segment short, about three fourths the length of the basal; moderately stout, slightly curved, apically armed with a long, sharp, curved spine.

Raodiplosis orientalis Felt.

1920. *Raodiplosis orientalis,* Felt, *Mem. Depart. Agric. Ind., Ent. Ser.* VII, p. 6.

To this species are referred several males and females in the Pusa collection labelled as having been bred from maggots found under the bark of a mango tree in Thaton, Burma.

Orseoliella apludae Felt.

1920. *Orseoliella apludae,* Felt, *Mem. Depart. Agric. Ind., Ent. Ser.* VII, p. 8.

I refer to this species three specimens in the Pusa collections labelled as having been bred from galls on *Apluda varia* at Coimbatore by Y. R. Rao.

Pachydiplosis oryzae Mani.

1934. *Pachydiplosis oryzae,* Mani, *Rec. Ind. Mus.* XXXVI, p. 433.

I refer to this species one female and one male in the Pusa collection labelled as having been bred from the silver-shoot gall of *Oryza sativa* at Coimbatore by Y. R. Rao, 31st July, 1916.

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[1] Barnes, H. F., *Journ. South-Eastern Agric. Coll., Wye, Kent* XXXVIII, pp. 75-77 (1936).

ON A NEW GENUS OF AMPHISTOMES (TREMATODA) FROM A SILUROID FISH OF RANGOON.

By R. C. CHATTERJI, *Helminthological Institute, University of Rangoon.*

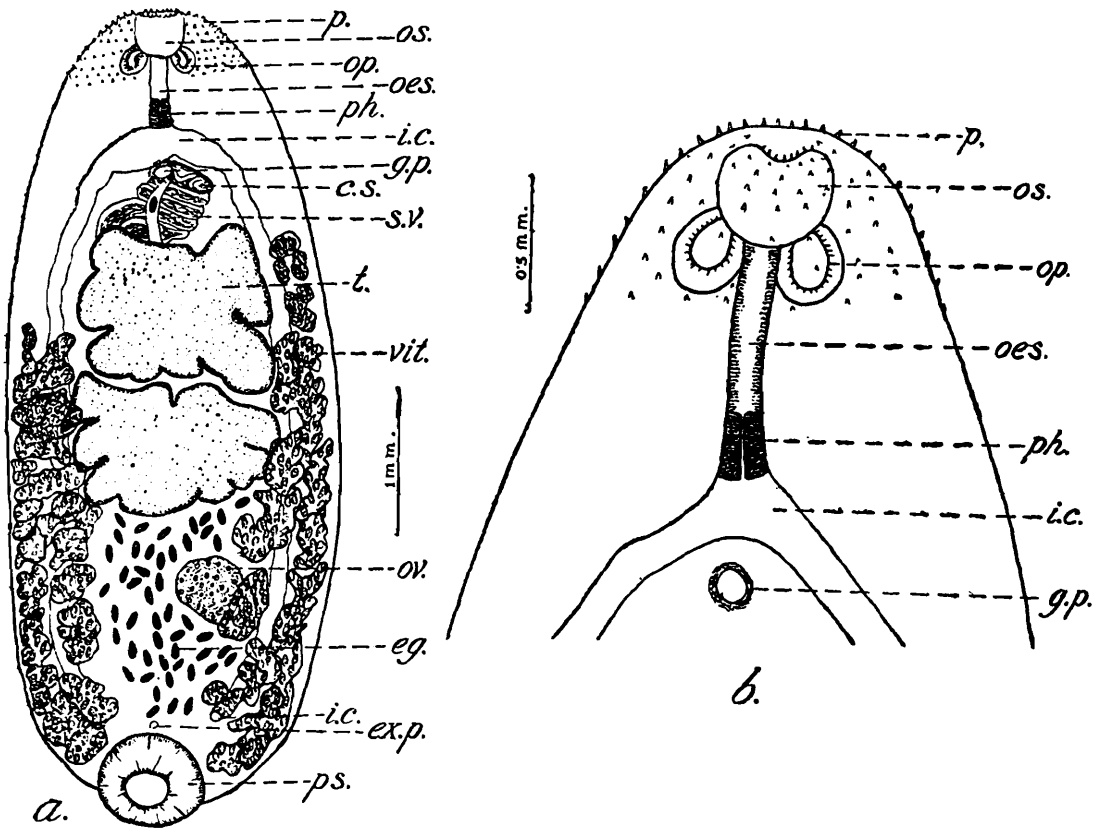
Four specimens of the 'siluroid' fish—*Pangasius pangasius* (Ham.) on being examined for helminth parasites gave the following results: first had two nematodes in the intestine—one, a larval form of *Ascaris capsularia* Rudolphi 1802, and the other a male *Cucullanus* (species undetermined on account of the scarcity of the material); second and third free from infection and the fourth infected with seven amphistomes and one young female nematode (*Paranisakis* sp.) from the intestine and nine nematodes (*Goezia* sp., probably new, but as all were females a specific diagnosis is held in abeyance) from the stomach. The present paper deals with the amphistomes obtained from the last fish. All the anatomical details except those of excretory system, which were studied in the live specimens, are from prepared slides.

Maccallumia burmanica, gen. *et* sp. nov.

Body oval and flattened, more attenuated anteriorly than posteriorly. Mature specimens 3·5-7·2[1] long and 1·43-2·7 in maximum breadth. Anterior extremity of body to just posterior to oral pouches surrounded by transverse rows of papillae, those in the anterior rows being more condensed than those in the posterior: rest of body smooth. Mouth small, terminal, surrounded by a row of papillae. Oral sucker strong, subspherical, deeply embedded in the tissue, 0·217-0·334×0·24. Posterior sucker terminal, almost spherical, slightly raised from body surface, 0·4-0·835×0·45-0·9. Two lateral muscular evaginations slightly smaller than oral sucker, measuring 0·15-0·27 in diameter, arising from postero-lateral aspect of the latter organ and lying dorsally. Between and below them runs the oesophagus, 0·132-0·62 long: the great variation in length being due to the extreme power of expansion and contraction of this organ. It is surrounded externally by deeply stained nuclei while the inner wall is provided into irregular glandular outgrowths. Posteriorly it continues into a peculiar elongated muscular pharynx, 0·14-0·25 long, in which the lumen is narrowed to a very fine tube surrounded by many dense concentric layers of muscles, closely applied to which are a large number of cells with deeply stained nuclei. Immediately anteriorly to the genital pore—which lies 0·55-1·65 from the anterior extremity of the body—the pharynx passes into the intestine, which in its turn almost immediately divides into more or less sinuous caeca, that closely approach the body margin and finally reach the posterior end of the body and end blindly a short distance anterior to the posterior sucker. The body parenchyma is soft and spongy, being composed of (1) ramifying cells, whose nuclei are very conspicuous and small, and

[1] All measurements in millimetres.

(2) large spaces between the cells which are filled with a coagulable fluid, the density of which differs in different places, being either slightly granular and staining quite lightly or denser and staining deeply. Nervous system consists of lateral ganglia near the oesophagus joined by a transverse commissure which passes over the dorsal surface of the latter organ a little posterior to the oesophageal pouches. Longitudinal nerve cords run, as usual, forward and backward along the sides of the body. Testes deeply lobed, one behind the other, more or less equal



Maccallumia burmanica, gen. *et* sp. nov.

a. Ventral view of the entire animal; *b*. Ventral view of the anterior end.
c. s. cirrus sac; *eg.* egg; *ex. p.* excretory pore; *g. p.* genital pore; *i. c.* intestinal caeca; *oes.* oesophagus; *op.* oral pouch; *os.* oral sucker; *ov.* ovary; *p.* papillae; *ph.* pharynx; *ps.* posterior sucker; *s. v.* vesicula seminalis; *t.* testis; *vit.* vitelline gland.

in size; anterior testis 0·768-1·2×0·87-1·7, posterior testis 0·8-1·34 ×0·87-1·7: some specimens showing anterior testis slightly larger than the posterior whereas in others the reverse is the condition. They occupy more or less one-third body length lying partly in middle third and partly in anterior third. Vas deferens usually thick and filled with spermatozoa and arises from the anterior dorsal portion of the testis, uniting with one another dorsal to anterior margin of anterior testis to continue forward as an elongated, thin-walled, much-folded vesicula seminalis. This communicates with the thick-walled, oval cirrus sac enclosing a parsprostatica and a coiled ductus ejaculatorius; the latter opens into the genital atrium, the external opening of which is provided with elastic fibrils to which are closely applied a large number of cells with deeply stained nuclei. Ovary almost spherical, 0·267-0·46 in diameter more or less median, sometimes pressed slightly to left or to right side of body during fixation, lying rather towards ventral surface, posterior to testes and slightly anterior to posterior sucker. Dorsally it gives off a short

oviduct which opens into an ootype, situated at the posterior margin of ovary. Vitellaria of lateral lobulated masses, consisting chiefly of granules and extending from a little posterior to anterior margin of anterior testis to end of caeca or slightly beyond : sometimes the glands on one side extending further anteriorly than those of the opposite side. Uterus very much convoluted, coils lying transversally and extending posterior to ovary, most tortuous in posterior part of body behind testes where they are closely packed with eggs. Ova oval, smooth, thin-walled, numerous, 0·08-0·097 × 0·056-0·06, becoming dark-brown and thick-walled when fertilized. Excretory pore on mid-ventral line, immediately anteriorly to posterior sucker and leading into a small spherical excretory bladder into which open two ducts from both sides, each forming an arm of an U-shaped structure. The two arms on each side run laterally and anteriorly upto the anterior margin of posterior testis, where they bend and then descend as far back as the level of ovary. The descending branch runs internal to the ascending branch and forms a loop at the level of ovary, from where it turns forward running as far as the level of the genital pore. Then, descending again upto the level of the posterior margin of anterior testis, it turns forward and runs upto the oral pouch. Further details regarding the finer branches were not studied.

Remarks.—The form agrees closely with the genus *Dadaytrema* Travassos 1931, the chief points of resemblance being the shape and the relative position of the testes, presence of a cirrus sac, spherical nature of the ovary and its position a little anterior to posterior sucker. It differs, however, chiefly in the extent of the vitellaria—these being more profusely developed and not confined only to post-testicular region of the body— and in the shape of the pharynx— it being a long cylindrical structure with strong musculature instead of a mere thickening. In the shape of the pharynx the present form resembles *Nematophila* Travassos 1934 but this similarity does not extend to other characters. MacCallum (1905, pp. 668-673) described under the name *Cladorchis pangasii*, an amphistome from the intestine of *Pangasius nasutus* from Sumatra, which greatly resembles the present form. The differences are, however, the absence of papillae on the body of the former, the restriction of vitellaria to a more limited field in the latter and in both the difference in the degree of development of the uterus and the number of eggs contained therein. Other minor differences are the relative size of the testes, position and size of the ovary, position of the nerve commissure and details of the excretory system. An important point of difference from the present form—the structure of the cirrus sac, which MacCallum (1905, p. 671) mentions as " very thin-walled, very long, and much folded upon itself, and is usually filled with spermatozoa "—can easily be eliminated, as what he has described as a cirrus sac is in reality the vesicula seminalis. Travassos (1934, p. 81) was justified by the important differences between MacCallum's species and *Cladorchis* in removing it from that genus. In assigning it to the genus *Dadaytrema* Travassos expressed doubts : these, in view of the present material, seem well founded. On account of vital differences in the structure of oesophagus and the disposition of the vitellaria between MacCallum's

species and *Dadaytrema* it would appear advisable to separate the former with the present form in a new genus for which I propose the name *Maccallumia*, in honour of the late Dr. W G. MacCallum with the following diagnosis :—

Maccallumia, gen. nov.

Cladorchinae : Body oval. Posterior sucker terminal, strong. Oral sucker with a pair of strong diverticula. Oesophagus present. Pharynx long, cylindrical. Genital pore median, near intestinal bifurcation. Intestinal caeca extending to posterior sucker or slightly anterior to it. Cirrus sac present. Vesicula seminalis much coiled, external to cirrus sac. Testes much lobed, one behind the other in median field, in intercaecal zone. Vitelline gland consisting of lateral lobulated masses and extending from intestinal bifurcation or a little posterior to it to end of caeca or slightly beyond. Uterus extending posterior to ovary. Excretory pore median, just anterior to posterior sucker.

Type-species.—Maccallumia burmanica, gen. *et* sp. nov.[1]

Other species.—Maccallumia pangasii (MacCallum 1905) ; synonyms : *Cladorchis pangasii* MacCallum 1905, *Chiorchis pangasii* (MacCallum 1905) Fukui 1929, *Dadaytrema pangasii* (MacCallum 1905) Travassos 1934.

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Vaz, Z., 1932.—Contribuicao ao conhecimento dos trematoides de peixes fluviaes do Brasil. *Thesis, Fac, Med. São Paulo,* pp. 1-47.

[1] Type-specimen (No. W-3421/1) in the Collection of the Zoological Survey of India, Indian Museum, Calcutta.

NEURO-MUSCULAR STUDY OF THE MOUTH-PARTS OF *COCCINELLA SEPTEMPUNCTATA*, WITH A COMPARISON OF THE MOUTH-PARTS IN CARNIVOROUS AND HERBIVOROUS COCCINELLIDS.

By S. PRADHAN, *D.Sc., Department of Zoology, Lucknow.*

(PLATE VI.)

CONTENTS.

INTRODUCTION.

Smith (1893) was the first to compare the mouth-parts in carnivorous and herbivorous Coccinellids. He was curious to know just what, if any, differences in the mouth-structures accompanied this divergence in habit, and dissected out the parts "in *Coccinella 9-notata* and *Epilachna borealis*" He gave a very brief description of the mouth-parts in these two species and concluded by saying, "I have made no detailed comparison between the parts preferring to let the figures speak for themselves but it gives an indication of differences *remaining to be studied*[1] and contradicts a generalisation which I had been inclined to make that compound mandibles would be rarely found in predaceous forms" It is surprising that this suggestive remark of Smith did not prompt any worker during the last half a century to take up a detailed investigation of this subject. I took up this suggestion of Smith and have already obtained interesting results by a study of the alimentary canals of these beetles (Pradhan, 1937) and have compared their mouth-parts in this paper.

Coccinella septempunctata was the first form to be studied both on account of its economic importance and its abundance at the time, when the studies began.

[1] The italics are mine.

The first important result in the study of the mouth-parts of this species was the discovery of well-developed labial glands, a short note on which has already been published (Pradhan, 1937). Encouraged by this result I worked out all the structures associated with the mouth-parts, *i.e.*, muscles, nerves and glands. The present paper embodies the results of my studies of the neuro-muscular system of the mouth-parts, the work on glands having been incorporated in a separate paper on account of their special importance.

The studies incorporated herein have been carried out under the direct guidance and supervision of Prof. K. N. Bahl. His helpful criticism throughout, painstaking correction of manuscripts, and in short his constant watchful interest in the progress of this work have been indispensable for these investigations. It has also been my privilege to receive valuable instructions, criticism and help from Dr. H. S. Pruthi, Imperial Entomologist to the Government of India. I am greatly indebted to Mr. M. L. Bhatia, University Lecturer in Zoology, who has always been ungrudgingly ready to help me in various ways.

My appreciative thanks are due to the University of Lucknow for encouragement in the form of a research fellowship during the course of these investigations.

MATERIAL AND TECHNIQUE.

The insects used during these studies were either brought fresh from the fields or reared in the laboratory, the species which were kept in the laboratory for fairly long periods being *E. indica*, *E. vingintioctopunctata*, *C. septempunctata*, and *Chilomenes sexmaculata*. The former two of these species were fed on the solanaceous and cucurbitaceous leaves while the latter two flourished well on every available species of aphids.

The points worthy of mention in the technique employed during these studies are as follows :—

Free-hand sections.—The strong chitin of the head-capsule of these beetles offers almost insurmountable difficulties in getting microtome sections. In order to get over this difficulty I began trying to cut free-hand sections of the ordinary paraffin blocks which were prepared exactly as if they were to be sectioned with a microtome. After a little practice I could get fairly good sections for anatomical studies. Further treatment of these sections was as in the case of microtome sections, although sometimes they were not fixed to the slide but treated further in a watch glass with much advantage. With these modifications the study of the internal structure of the hard head of these beetles became fairly easy.

Bleaching of chitin.—Strongly sclerotised and densely pigmented structures like the mandibles ordinarily do not show any of their internal structures. In order to examine the interior of such structures I have been bleaching the whole head of these beetles in Hydrogen peroxide. By this treatment the opaque chitin becomes almost transparent and the soft structures inside not only remain absolutely undamaged but begin to take specially brilliant stain with Borax carmine.

Dissection of muscles and nerves.—For the dissection of muscles and nerves of the mouth-parts I have used specimens which have been kept

in 90 per cent. alcohol for some months. These specimens become specially suitable for dissection after soaking in water for 12–24 hours or more.

MOUTH-PARTS OF *COCCINELLA SEPTEMPUNCTATA*.

The mouth-parts of *Coccinella septempunctata* include as usual: (1) an unpaired *labrum-epipharynx*, (2) a pair of *mandibles*, (3) a pair of *maxillae*, (4) an unpaired *labium*, and (5) an unpaired *hypopharynx*.

Labrum-epipharynx.—As in other generalised insects, the labrum-epipharynx in *C. septempunctata* forms the anterior or the upper lip of the extra-oral cavity. It is transversely elongate as shown in Plate VI, figure 1; when cleared in KOH solution it looks like a hollow bag, continuous with the general haemocoel; its anterior or upper flap is comparatively much more chitinised and forms the labrum proper (*lbr.*), and is connected above with the clypeus; the posterior or the lower flap is quite membranous and forms the epipharynx which is continuous with the roof of the fore-gut. At the junction of the epipharynx with the fore-gut there is, on either side, a chitinised hook-shaped structure called the *torma*. The labrum is densely fenestrated, the fenestrae (not shown) being distributed in irregular groups some of which lie at the bases of the long bristles. The bases of the bristles are comparatively less chitinised and appear like large fenestrae. The epipharynx, on the other hand, is comparatively smooth, there being only a few bristles along its anterior border and only a few about the middle of its surface.

Mandibles.—These are, as usual, the strongest of the mouth-parts (Pl. VI, figs. 2 and 3). Each mandible is strongly chitinised and is hollow, with a more or less triangular basal part and a bifid hook-shaped pointed tip. One angle of the basal part is directed inwards and is situated adjacent to the oral orifice, while the other two point outwards, each of them bearing a condyle for articulation with the head-capsule. The posterior or the ventral of these two condyles (*co.*) is much stronger and larger and is much more chitinised than the anterior or dorsal condyle. A little *distal* to the inner angle of the base there are two pointed teeth (*b. t.*), of which the antero-dorsal is distinctly larger than the postero-ventral. Arising a little distally to the postero-ventral tooth is the *prostheca* (*prs.*), a very small and frail chitinous structure fringed mesially with minute bristles. When examined in refracted light, the mandibles show innumerable minute pores on their thick chitinous surface but there are no pores on the teeth, condyles, the rim of the basal opening and the prostheca. A few bristles arise distally to the outer angles of the basal part and there are also a few on the inner angle of the base proximally to the basal teeth, where the chitin is rather membranous. There are two chitinised tendons (*md. abd.* and *md. add.*) associated with the mandibles for the attachment of the muscles; of these, the mesial one arises from the inner angle of the basal part, while the outer one arises between the two condyles. Thus the two condyles form the fulcrum-line and the two tendons represent the points of application of forces in a lever-like arrangement. It is thus clear that the mesial arm of the lever is extremely long, while the outer one is extremely small.

Maxillae.—The maxillae are (Pl. VI, figs. 4 and 5) too complicated in structure for a final interpretation of their parts from a study of their chitinous structures alone. They are, therefore, described here as they appear in a cleared specimen.

The maxilla generally consists of the cardo (*ca.*), the stipes (*st.*), the lacinia (*lc.*), the galea (*ga.*), and the palpus. The cardo (*ca.*), in this species as seen from inside, *i.e.*, antero-dorsally, looks like a deep cup-like structure lodged like a condyle into a shallow external depression on either side of the labium (*vide infra*). The proximal rim of the cardo bears three pointed apodemes projecting into the head-capsule; two of them are directed mesially while the third which is the longest is directed outwards. The two mesial apodemes are situated more or less dorso-ventrally to each other. These apodemes provide surfaces for the attachment of muscles. Distally the rim of the cardo is rather low and is connected with the stipital portion of the maxilla.

The stipital portion forms a hollow, drum-shaped structure which opens proximally into the head capsule, the opening lying in common with that of the cardo; distally the stipital portion is continued into the two lobes of the maxilla. The stipes consists of three separate sclerotised pieces, namely, dorso-lateral (*d.l.*), ventro-lateral (*v.l.*) and ventro-mesial (*sg.*).

From the dorso-mesial side of the stipes arises the lacinia which is hollow and sabre-shaped; its distal portion is fringed mesially with long bristles. Only the dorsal wall of the lacinia is well sclerotised and forms the lacinia proper.

The galea arises from the distal margin of the stipes ventrally to the lacinia, and consists of two segments; the proximal segment is small and tubular and appears neck-like as compared with the bigger head-like distal segment bearing long bristles.

The palpus arises from the distal margin of the stipes at the level of the galea. It consists of four segments which become wider and wider towards the distal end, the distalmost segment forming a big triangle, only one angle of which articulates with the penultimate segment.

Almost the whole of the body of maxilla is covered with bristles while the pores are rather rare.

Labium.—The labium (Pl. VI, figs. 6 and 7) is very much simplified. The pre-labium is a hollow, more or less triangular structure with a pair of palpi, there being no separate glossae and para-glossae. In a cleared specimen, one can sometimes distinguish a faint suture (not shown) on the ventral chitinised flap of the pre-labium running obliquely and just mesially to the origin of each palpus, thus demarcating the median pre-mentum from the lateral palpiger. The dorsal (inner) flap of the pre-labium is quite membranous and spreads out like a cushion to form the ventral (posterior) lip of the extra-oral cavity. This lip, which is the only representative of the ligula, is furnished with very minute bristles and pores. Proximally the ventral (outer) chitinised flap is continued dorsalwards into a pair of curved chitinous processes which meet dorsally in the middle line. Each palpus is three-jointed, the proximal joint being the smallest.

The post-labium is separated from the pre-labium by a wide membranous area which allows considerable flexion of the pre-labium upwards. The post-labium consists of two chitinised plates: (1) the proximal sub-mentum, and (2) the distal mentum. The sub-mentum is rigidly fixed to the median sclerotised plate extending between it and the foramen magnum ; each of its lateral sides forms part of the cavity which receives the cardo of the maxilla. The mentum is only slightly moveable on the sub-mentum ; its sides are curved upwards and the curved portions bend towards the median line and are then continued into the skeleton of the hypopharynx.

Hypopharynx.—The hypopharynx (Pl. VI, fig. 7) is a flat membranous fold of the dorsal flap of the post-labial region supported by a set of strong sclerites. The fold begins just proximally to the pre-labium and extends distally almost up to the middle of that structure. The skeleton of the hypopharynx consists of a pair of basal bars on the floor and a fork-shaped suspensorium in the roof of the hypopharynx. Distally each bar almost meets an arm of the fork and proximally the arms of the suspensorial fork are continued beneath the buccal cavity where they converge to form a small median rod. Ventrally the fork is connected through vertical chitinisations with the mentum, while dorsally it is connected with a pair of apophyses (*ap.*) which arise near the dorsal articulation of the mandible and lie along the lateral walls of the buccal cavity and the pharynx. The proximal ends of these basal bars lie within small curvatures of the vertical chitinisations between the suspensorial fork and the mentum.

MUSCULATURE OF THE MOUTH-PARTS.

Recent studies of Snodgrass (1935) have considerably enhanced the importance of musculature in determining the homology of the sclerotised parts, although Imms (1931) has given a warning that " too exclusive reliance upon this one criterion is undesirable" The study of the musculature is also helpful in understanding the functional significance of the various sclerites.

The musculature of the mouth-parts may be described under two heads, namely (1) the *intrinsic muscles*, and (2) the *extrinsic muscles*.

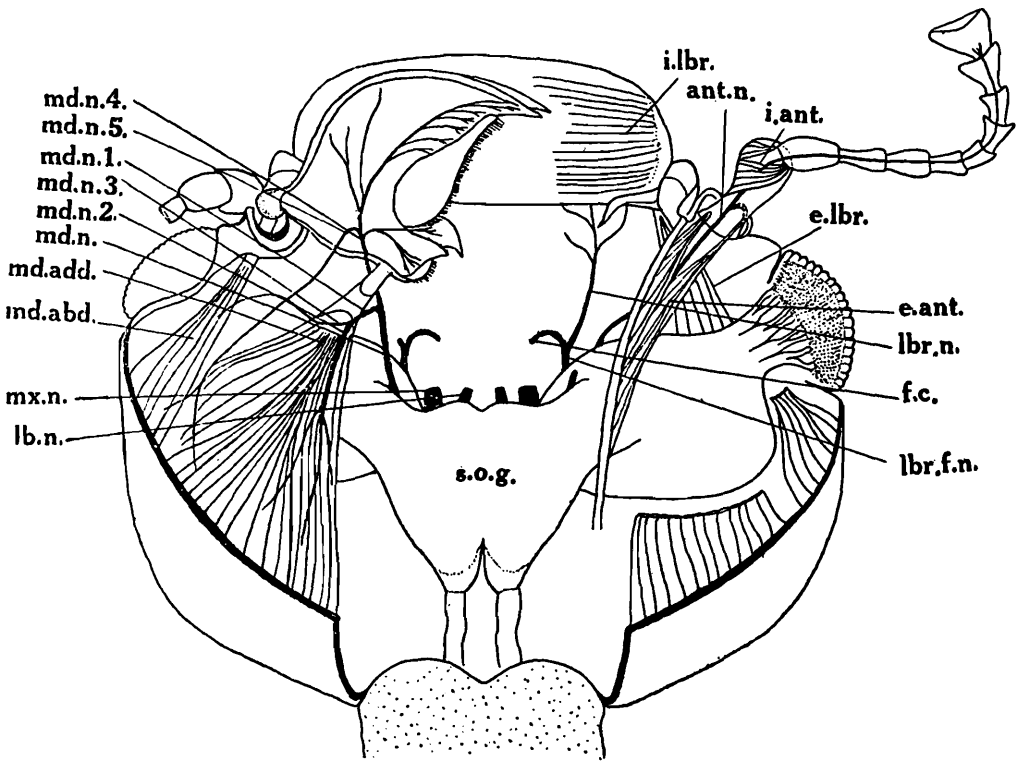
MUSCLES OF THE LABRUM.

The intrinsic labral muscles.—The intrinsic musculature of the labrum consists of two sets of fibres :—

(*a*) The first set of muscles, named as *Compressores labri* by Snodgrass, consists of small thin fibres running across and between the anterior and posterior walls of the labrum as sketched by Snodgrass in *Gryllus* or as described by Das (1937) in insect larvae in general. These muscles are so small that their contraction can hardly be effective in any way except in reducing the thickness of the labrum.

(*b*) The second set of muscles (text-fig. 1, *i*, *lbr.*) consists of fairly long fibres running almost parallel to the plane of the labrum. They arise from the epipharyngeal membrane about half the way between the median line and the lateral margin, and are inserted close to the lateral margin of the anterior sclerotised plate of the labrum. The contraction of these muscles brings about a curvature of the labrum inwards, thus keeping the *mandibles* steady while grasping the prey.

The extrinsic labral muscles.—The extrinsic musculature of the labrum (text-fig. 1, *e.lbr.*) consists of only a single pair of muscles. They originate



TEXT-FIG. 1.—Muscles and nerves of the mandible and labrum as seen from below after removing the labium and the maxillae (reconstructed from dissections and whole-mounts).

ant. n. antennal nerve; *e. ant.* extrinsic antennal muscles; *e. lbr.* extrinsic labral muscle; *f. c.* frontal connective; *i. ant.* intrinsic antennal muscles; *i. lbr.* intrinsic labral muscles; *lb. n.* labial nerve; *lbr. f. n.* labro-frontal nerve; *lbr. n.* labral nerve; *md. abd.* mandibular abductor muscle; *md. add.* mandibular adductor muscle; *md. n.* and *md. n. 1-5.* mandibular nerve and its branches; *mx. n.* maxillary nerve; *s. o. g.* sub-oesophageal ganglion.

from the frons and are inserted on the basal angles of the anterior sclerotised wall of the labrum. The contraction of these muscles is capable of effecting (1) an outward flexion, and (2) a lateral movement of the labrum, according as both the muscles of the pair contract simultaneously or each of them separately. The insertion of these muscles does not conform to Das's generalisation (1937) that the lateral muscles are always inserted on the tormae.

MUSCLES OF THE MANDIBLE.

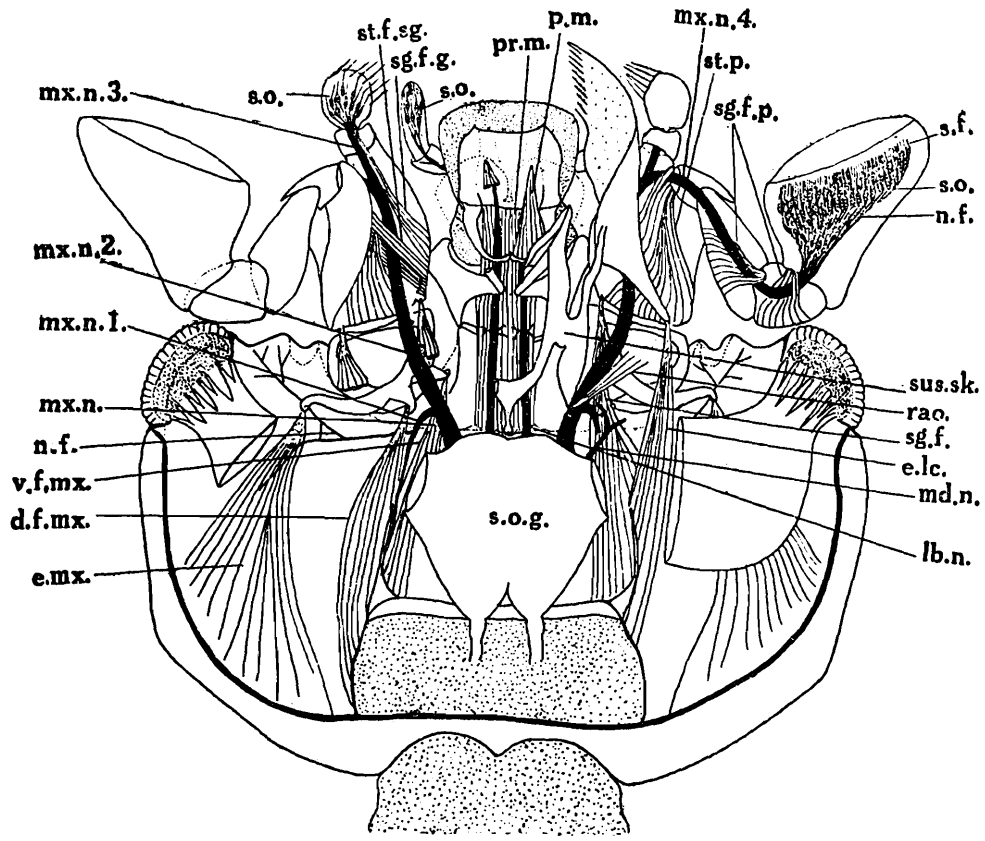
There are no *intrinsic muscles* in the mandibles (text-fig. 1).

The extrinsic muscles of the mandible.—These consist of a strong adductor and a comparatively small abductor muscle. The fibres of

the adductor muscle (*md. add.*) take their origin from the postero-lateral walls of the cranium and converge to form a chitinous cone-shaped tendon which is inserted on the inner angle of the basal triangle of the mandible. The origin of the abductor muscle (*md. abd.*) is antero-lateral to that of the adductor muscle and its insertion is on the outer side of the basal triangle, *i.e.*, between the condyles of the mandible, just a little outside the hinge-line. The distance of the abductor from the hinge-line is negligible in comparison with the distance between the adductor muscle and the hinge-line. Thus the adductor muscles are infinitely more effective than the abductor muscle.

MUSCLES OF THE MAXILLA.

(*a*) *The extrinsic muscles of the maxilla.*—There are five extrinsic muscles (text-fig. 2) associated with each maxilla ; three of these are



TEXT-FIG. 2.—Muscles and nerves of the maxillae and labium as seen from above after removing the dorsal wall of the cranium, labrum, mandible, etc.

d. f. mx. dorsal flexor of maxilla ; *e. lc.* extensor of lacinia ; *e. mx.* extensor of maxilla ; *lb. n.* labial nerve ; *md. n.* mandibular nerve ; *mx. n.* and *mx. n. 1-4*, maxillary nerve and its branches ; *n. f.* nerve ; fibre ; *p. m.* palpal muscle of the labium ; *pr. m.* premental muscle ; *rao.* retractores angulorum oris ; *s. f.* sense-fibre ; *s. o.* receptor organ ; *s. o. g.* sub-oesophageal ganglion ; *sg. f. g.* sub-galear flexor of galea ; *sg. f. p.* segmental flexor muscles of the palpus ; *st. f. sg.* stipital flexor of sub-galea ; *st. p.* stipital muscle of the palpus ; *sus. sk.* suspensorial skeleton ; *v. f. mx.* ventral flexor of maxilla.

inserted on the cardo and two on the stipital portion. The muscles of the cardo are not inserted into the interior of the cardo as is the case in Orthoptera and in the majority of other insects, but on long sclerotised hook-shaped apodemes, the direction and length of the apodeme

determining whether a muscle acts as an extensor or as a flexor. These muscles may be described as :—

1. *Dorsal (anterior) flexor of the maxilla.*—This muscle (*d.f.mx.*) takes its origin partly from the lateral rim of the foramen magnum, and partly from the posterior arm of the tentorium, and is inserted on the dorsal (anterior) apodeme of the cardo.

2. *Ventral (posterior) flexor of the maxilla.*—This muscle (*v.f.mx.*) also arises from the posterior arm of the tentorium and is inserted on the ventral apodeme of the cardo. It is situated mesially to the dorsal flexor.

3. *Extensor of the maxilla.*—This muscle (*e.mx.*) arises from the lateral wall of the cranium and is inserted on the longest apodeme of the cardo which begins from a place in between the dorsal and the ventral apodemes described above and extends outwards as shown in text-figure 2.

4. *Extensor of the lacinia.*—The fibres of this muscle also take their origin partly from the posterior arm of tentorium and partly from the rim of the foramen magnum. It is inserted on a long process arising from the outer angle of the base of the lacinia. Contraction of this muscle can serve only for the deflexion of the lacinia and not for its flexion. This muscle has not been named as an extensor before. Bauer (1910) calls this muscle as a superior flexor of the maxilla in *Dytiscus marginalis* (Coleoptera), but in his sketch, he does not show any definite proximal boundary of the lacinia and has probably not appreciated the distinct insertion of the muscle on the lacinia. Snodgrass (1935) does not mention any muscle with an extensor function associated with lacinia. He describes only a flexor muscle of the lacinia inserted on the mesial angle of the base of the lacinia. No such flexor muscle is present in *Coccinella septempunctata*, nor has any such muscle been described by Bauer in *Dytiscus*. Das (1937) describes only flexor (cranial and stipital) muscles of the lacinia and defines these muscles, like Snodgrass, as those having their insertion on the inner base of the lacinia, although in his sketches of *Rhagium*, *Tenebroides* (fig. 28)[1], and *Agriotes* (fig. 31), all three belonging to the order Coleoptera, he definitely shows that these muscles are inserted on the outer edges of the base of the lacinia. It appears, therefore, that the point of insertion of the lacinial muscle is not constant and that the muscle serves as a flexor or an extensor according as the insertion is near the inner or near the outer angle of the lacinia.

5. *Flexor of the sub-galea.*—This muscle (*sg.f.*), arises from the ventro-lateral rim of the foramen magnum and is inserted on the proximal corner of the sub-galea, *i.e.*, the ventro-mesial sclerite of the stipital region. Neither Snodgrass nor Das describes any muscle of this designation. Bauer (1910) describes a similar muscle under the name of anterior flexor of maxilla but he has studied this muscle as imperfectly as the extensor of lacinia described above. As already described, the anterior (dorsal) flexor of maxilla is inserted on the apodeme of the cardo in Coccinellid beetles.

[1] These figures refer to Das's diagrams.

(*b*) *The intrinsic muscles of the maxilla.*—The intrinsic musculature consists of :—

1. Sub-galear flexor of galea (*sg.f.g.*).
2. Stipital flexor of sub-galea (*st.f.sg.*).
3. Stipital muscle of palpus (*st.p.*).
4. Proximal segmental flexor of the palpus (*sg.f.p.*).
5. Distal segmental flexor of palpus (*sg.f.p.*).

1. *Sub-galear flexor of the galea.*—This muscle originates from the mesial margin of the sub-galea and runs distally to be inserted on to the base of the distal segment of the galea. This muscle has, in every case, been described to take its origin from the stipes proper, although Das (1937) has, most probably through inadvertence, wrongly named it as the cranial flexor of galea. As the sub-galea is distinctly separate from the stipes proper in Coccinellids, I have named the muscle as *sub-galear flexor of galea.*

2. *Stipital flexor of the sub-galea.*—This muscle takes its origin from two separate places, *i.e.*, along the small lengths of the mesial margins of both the anterior (dorsal) and posterior (ventral) walls of the stipes. The two sheets of muscle-fibres from the two margins converge towards each other and are inserted along the mesial margin of the sub-galea. A muscle of this nature has not been described before. It may be suspected that it might be the stipital flexor of the lacinia which has been mistaken for the flexor of sub-galea but I have definitely ascertained by repeated dissections and serial sections that the insertion is on the sub-galea and not on the lacinia which lies near by.

No muscular connection between the sub-galea and the stipes has been recorded before and the sub-galea has therefore been regarded as a secondary differentiation from the stipes. Snodgrass writes, " in some insects the area of the stipes supporting the galea is differentiated as a distinct lobe called the sub-galea, but the base of the true galea is to be determined by the point of attachment of its muscle." The presence of the stipital flexor of the sub-galea in these insects is very significant, as it renders the homology of the sub-galea an open question. If the musculature is at all a reliable criterion, the sub-galea should be regarded as a separate entity from the stipes.

3. *Stipital muscle of the maxillary palpus.*—This is a fairly strong muscle with its insertion along the proximal rim of the basal segment of the palpus. This muscle combines in itself both the levator and the depressor muscles described in other insects, the distinction between the two being difficult to make out, both at the origin as well as at the insertion. There is no doubt that the various movements of the palpus are possible by the contraction of some fibres and the relaxation of others.

4. *Proximal segmental flexor of the palpus.*—The fibres of this muscle arise from the second segment of the palpus and converge to be inserted on the third segment.

5. *Distal segmental flexor of the palpus.*—This muscle is an exact replica of the proximal segmental flexor, originating from the third segment and inserted on the fourth, *i.e.*, the last segment of the palpus.

Muscles of the Labium.

There are no *extrinsic muscles* in the labium of these insects. The *intrinsic musculature* consists of :—

1. Muscles of the pre-mentum (*pr.m.*).
2. Muscles of the palpi (*p.m.*).

1. *The muscle of the pre-mentum.*—These muscles originate from a median pointed fragma on the base of the sub-mentum and are inserted along the ventral rim of the base of the pre-mentum. Careful observation reveals a grouping of these fibres into four sets lying at the same level. This grouping probably represents two pairs of muscles which have been named by Das as median and lateral muscles of the pre-mentum in insect larvae. The contraction of these muscles serves to retract the pre-mentum, the retraction being made possible on account of the wide membrane between the pre-mentum and the mentum.

2. *The muscles of the palpi.*—These muscles originate from the proximal sclerotised rods of the pre-mentum and run above the pre-mental muscles to be inserted on the bases of the palpi. The action of these muscles like that of the palpal muscles of the maxillae is to give various movements to the palpi.

Muscles of the Hypopharynx.

The hypopharynx proper has no muscles but mention may be made of a pair of muscles (text-fig. 2, *rao.*) which arise from the dorsal wall of the cranium and are inserted on what has been described by Snodgrass as the oral branches of the suspensorial sclerites of the hypopharynx. A mention of these muscles at this place is justified on the ground that the contraction of these muscles raises the floor not only of the buccal cavity (post-oral) but also of the cibarium (pre-oral).

The Nerve-supply of the Mouth-parts.

A survey of the available literature shows that the nerve-supply of the insect mouth-parts has not been adequately studied. So far little effort has been made to homologise or even to name the various branches of the appendicular nerves of the insect head. Our knowledge of insect neurology being so deficient, hardly anything can be stated at present about the value of nerve-supply in determining the morphological relations of the mouth-parts. But this much is clear that much study is needed to fill up this gap in our knowledge of insect anatomy.

All the mouth-parts, except the labrum, receive their nerve-supply from the infra-oesophageal ganglion, the various nerves supplying the mouth-parts being (1) *labral nerve*, (2) *mandibular nerve*, (3) *maxillary nerve*, and (4) *labial nerve*, all of which are paired.

1. *Labral nerve.*—This nerve arises in common with the frontal nerve-connective from the tritocerebrum, the common stem being known as the labro-frontal nerve (text-fig. 1, *lbr.f.*). The labro-frontal nerve soon divides into its two components. The labral nerve, as shown in

text-fig. 1, gives off various minute branches to the roof of the cibarium before entering the labrum proper where it branches profusely.

2. *Mandibular nerve.*—The mandibular nerve (text-fig. 1, *md.n.*) arises from the infra-oesophageal ganglion near the circum-oesophageal connectives. About half-way between the brain and the mandible, the nerve gives off a branch the *ramus muscularis proximalis* (*md.n.1*), to the mandibular muscles. This branch of the mandibular nerve soon divides into two sub-branches, one of which (*md.n.2*) innervates the adductor and the other (*md.n.3*) the abductor muscle of the mandible. After giving off this branch, the mandibular nerve passes over the tendon of the adductor muscle and enters the cavity of the mandible wherein it divides into several branches innervating the entire body of the mandible (*md.n.4*). There is also a second branch supplying the muscles (*md.n.5*) which may be called the *ramus muscularis distalis*. It arises from the mandibular nerve after the latter enters the body of the mandible. It comes out of the mandible and reaches almost the origin of the mandibular muscles where it divides to innervate both the adductor and abductor muscles.

3. *Maxillary nerve.*—The maxillary nerve is the stoutest nerve (text-fig. 2, *mx.n.*) in the head-capsule and arises antero-laterally from the infra-oesophageal ganglion. At a little distance from its origin, it gives off a comparatively slender branch, the *ramus muscularis* (*mx.n.1*). This branch soon gives off a long but fine sub-branch to the extensor of the maxilla and then passes through the muscle-complex arising from the tentorium and the rim of the foramen magnum (*i.e.*, the dorsal and ventral flexors of the maxillae, the extensor of lacinia and the flexor of sub-galea). The branch to the extensor of the maxilla also gives minute branches to the glands in the region of the eye and the antenna as shown in text-fig. 2. There is a triangle formed by nerves in this region (*n.t.*). After giving off the ramus muscularis, the maxillary nerve (*mx.n.2*), enters the cavity of the maxilla as the most prominent nerve, passes through the stipital flexor of the sub-galea and reaches the level of the distal end of the stipital region. Here it gives off a branch to the galea (*mx.n.3*) and turns away into the maxillary palpus wherein (*mx.n.4*) it passes on through various muscles till it reaches the last segment of the palpus where its fibres spread out to form a prominent cone-shaped receptor organ (*s.o.*). The branch entering the galea also ends into a number of sense-cells situated in the distal segment of the galea. The maxillary nerve, during its course, gives off very minute branches to the various muscles within the maxilla through which it passes.

4. *Labial nerve.*—The labial nerve arises (text-fig. 2, *l.b.n.*) from the infra-oesophageal ganglion mesially to the maxillary nerve and passes over and along the labial muscles supplying them with very minute branches at the level of the mentum. On reaching the base of the labial palp, the labial nerve, after giving off very minute branches to the ligula, enters the labial palp and continues to its last segment to supply the sense-cells lodged therein.

Shortly after its origin, the labial nerve also gives off a small branch to the labial glands.

RECEPTOR ORGANS ON THE MOUTH-PARTS.

As referred to above, the chief centres at which the receptor-cells have accumulated on the mouth-parts are the distalmost segments of (1) the maxillary palpus, (2) the galea, and (3) the labial palpus (text-fig. 2).

Morphologically the sense-cells at all these centres are alike. They are fusiform in shape, and are supplied at their proximal ends with fine nerve-fibres (*n.f.*) while their distal ends are continued into still finer sensory fibres (*s.f.*). The receptor-cells of the maxillary palpus are, however, smaller than those of the galea. The receptor-cells in the maxillary palpus, in fact, are so small and so compactly crowded in spindle-shaped groups that their separate identity is made out with difficulty. Next to the eyes, the receptororgan of the maxillary palpus, is by far the most highly developed receptor organ in the head of these beetles. As shown in text-figure 2, it looks like a beautiful cone-shaped bouquet filling almost the whole of the distalmost segment of the palpus.

The sense-fibres in the galea enter the bases of long fine bristles, those in the maxillary palpus end at the bases of minute hollow pegs[1] whereas those in the labial palpus the sense-fibres end on a very thin chitinous surface although there are a few minute hollow pegs also present at the extremity.

The recognition[2] of these receptor organs is important as it fills up the gap left by McIndoo (1916) in his study of olfactory organs in Coleoptera. McIndoo searched for these organs in several parts of the body of Coleoptera (including Coccinellids) but omitted the mouth-parts where the sense-organs are best developed, at least in the Coccinellidae, although he suspected their presence on these parts.

In his experiments on *Epilachna borealis* in which he tested as to which parts of the body are affected by odor stimuli; McIndoo records, "They were extremely quiet and when tested they generally moved away slowly. They often vibrated the antennae and *mouth-parts*[3] and sometimes the legs." About the reaction of the same beetles after removal of antennae, McIndoo records "When tested with odors, most of them worked the *mouth-parts*; some moved away, a few vibrated one or more legs and some failed to respond." These observations clearly show that the mouth-parts are probably most sensitive in these beetles.

COMPARISON OF MOUTH-PARTS IN CARNIVOROUS AND HERBIVOROUS COCCINELLIDS.

Besides those of *Coccinella septempunctata*, the mouth-parts of six other species have been examined and sketched (text-figs. 3-6), two of these species are herbivorous, and four are carnivorous. This comparative study reveals the following significant differences which are probably

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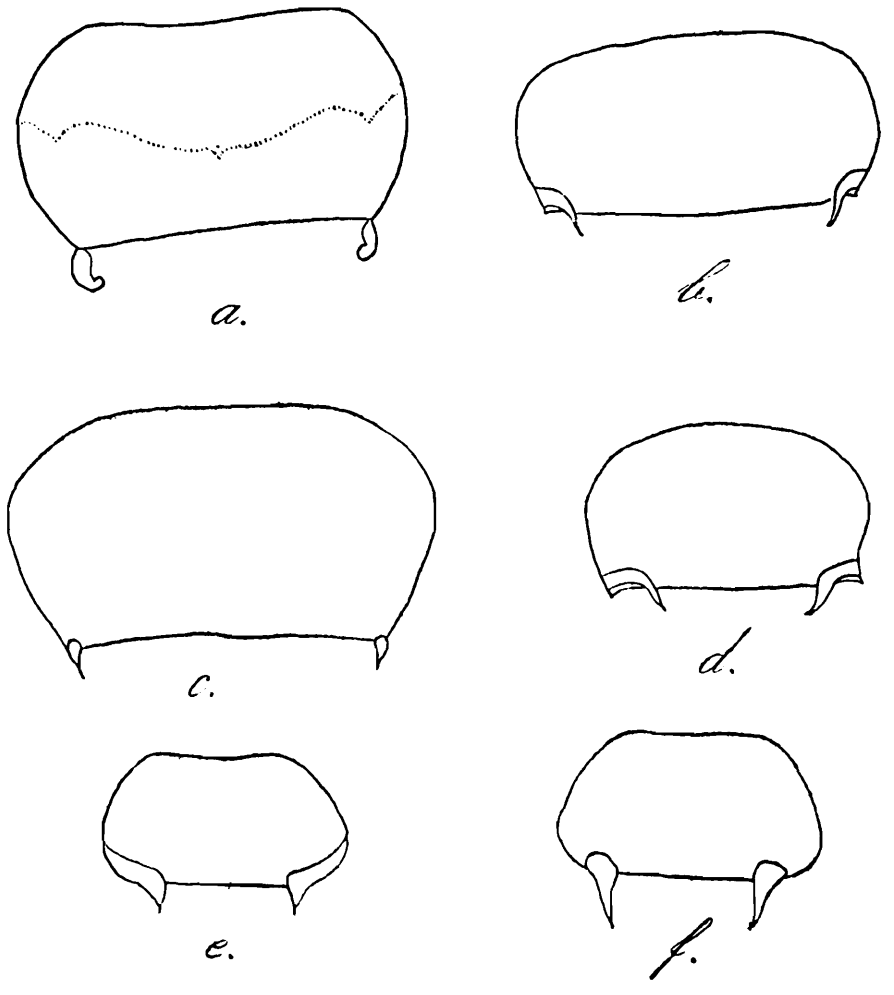
[1] These pegs are too small to be shown in the text-figure.
[2] Sense-organs have already been described on the palpi at least in *Dytiscus*.
[3] The italics are mine.

correlated with differences in feeding habits (carnivorous or herbivorous) of these beetles.

1. *Labrum.*—As text-fig. 3 brings out sufficiently the specific differences, a detailed account is hardly necessary.

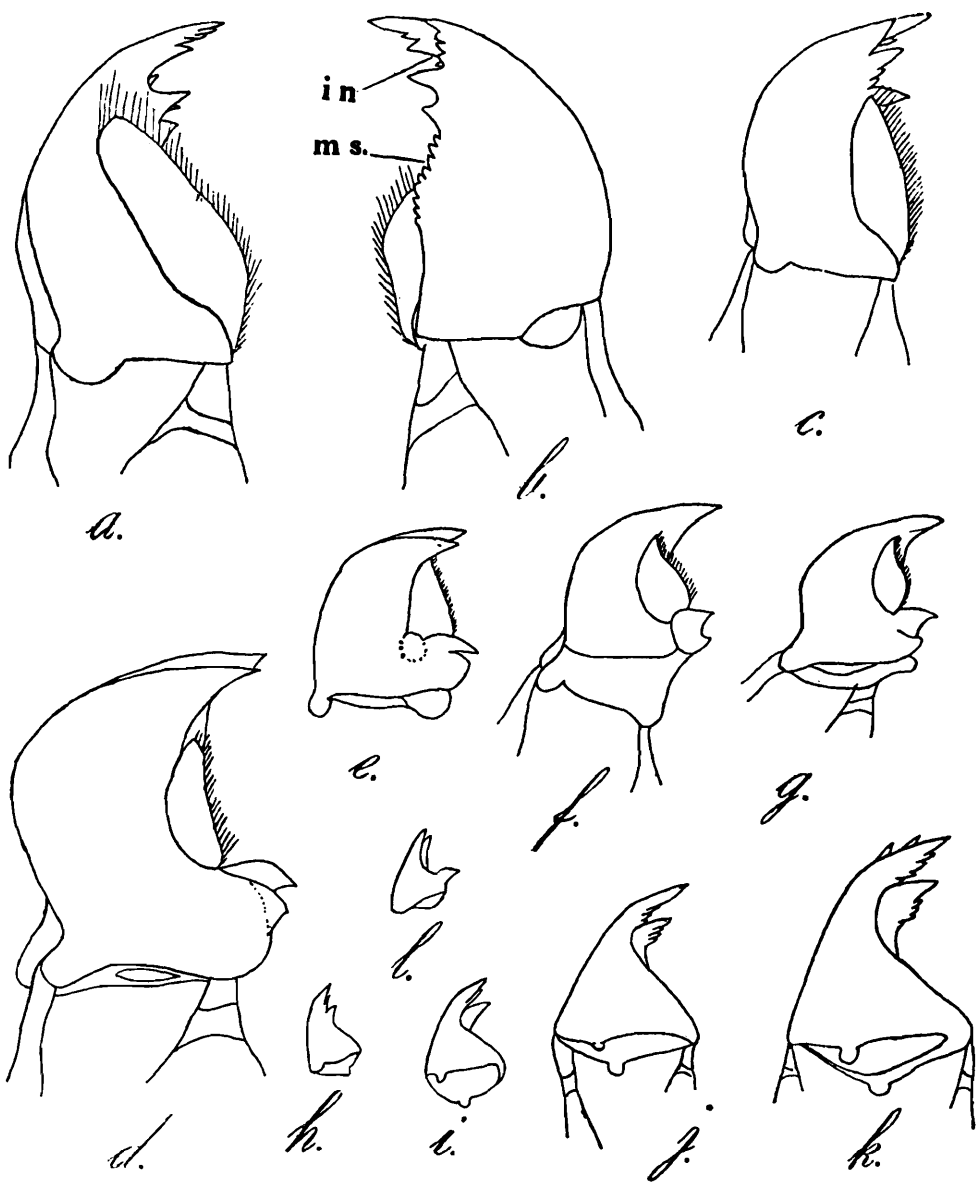


TEXT-FIG. 3.—Labrum of Coccinellids.

a. Epilachna indica; *b. E. vigintioctopunctata*; *c. Synia melanaria*; *d. Chilomenes sexmaculata*; *e. Chilocorus nigritus*; *f. Brumus suturalis.*

2. *Mandibles.*—The mandibles (text-fig. 4) show the most important and constant differences between carnivorous and herbivorous Coccinellids—differences which are probably more or less constant throughout the whole order Coleoptera. This, however, is not unexpected since mandibles are mechanically the most important of the mouth-parts. The mandibles of the herbivorous genus *Epilachna* (*E. indica* text-fig. 4, *a*, *b*), and *E. vigintioctopunctata* (text-fig. 4, *c*) are characteristically differentiated into (*a*) distal *incisor portion* (*in.*) meant for scraping the epidermis of the leaves on which these beetles feed, and (*b*) the proximal *molar area* (*m.s.*) where the scrapings are masticated. The incisor portion is provided with a large number of teeth of various sizes, whereas the molar surface is rather uniformly tuberculated with masticatory teeth. The mandibles of the carnivorous species examined are essentially similar to those of *C. septempunctata* with a strong bifid incisor portion and two pointed basal teeth, the molar area being entirely smooth, with no masticatory teeth. The mandibles of *Brumus suturalis* (text-fig.

4, *g*) and *Chilocorus nigritus* (text-fig. 4, *f*) are not even bifid at their distal extremity. The mandibles of the larval stages of *E. indica* (text-figs. 4, *h-k*) and of the first instar larva of *Chilomenes sexmaculata* (text-fig. 4, *l*) have also been examined. As shown in the sketches, the



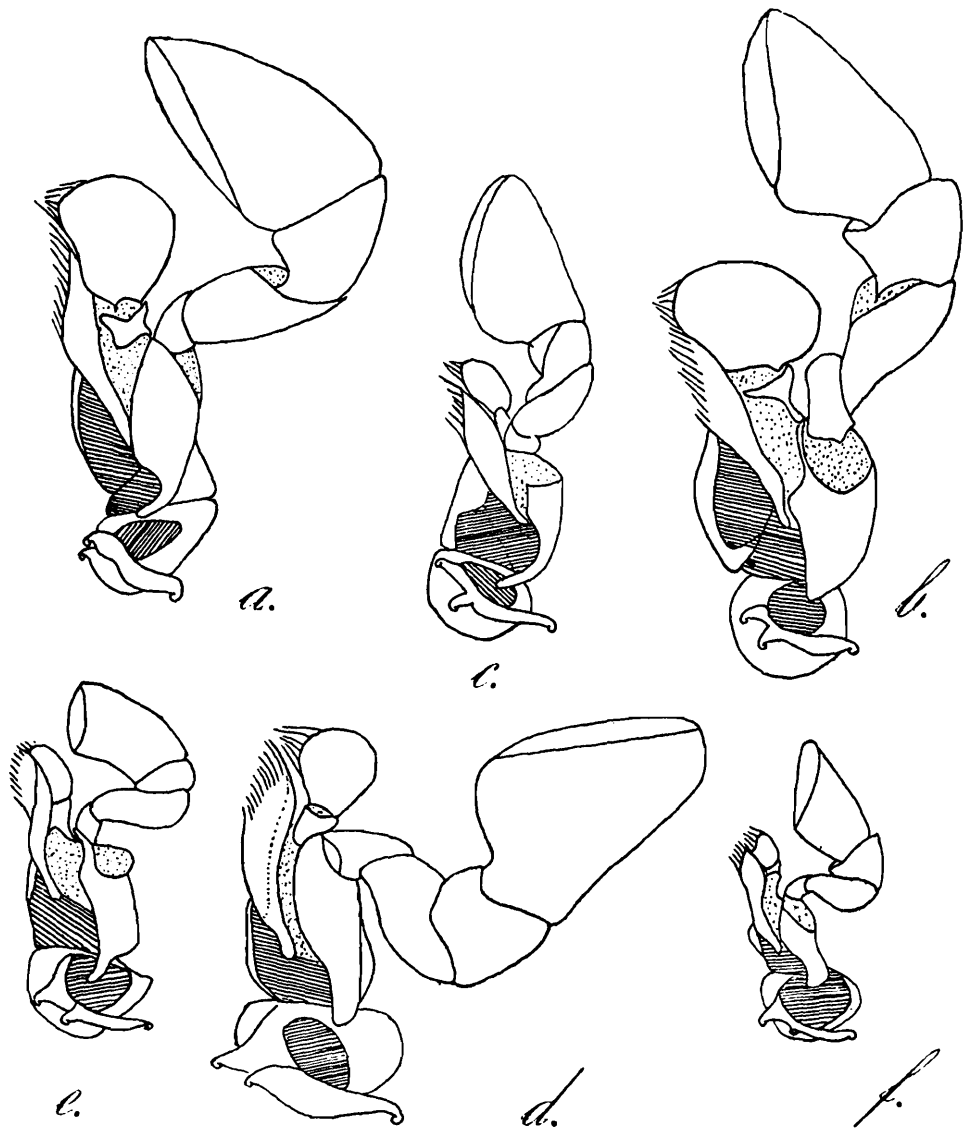
TEXT-FIG. 4.—Mandibles of Coccinellids.

a. Epilachna indica (ventral or posterior view); *b. E. indica* (dorsal or anterior view; *in.* incisor portion; *m. s.* masticatory (molar) portion, *c. E. vigintioctopunctata* (ventral view); *d. Synia melanaria* (ventral view); *e. Chilomenes sexmaculata* (ventral view); *f. Chilocorus nigritus* (ventral view); *g. Brumus suturalis* (ventral view); *h. E. indica* (1st instar); *i. E. indica* (2nd instar); *j. E. indica* (3rd instar); *k. E. indica* (4th instar); *l. Chilomenes* sp. (1st instar).

mandibles of the earlier instars of *E. indica* have simple incisor portions showing greater resemblance to those of carnivorous Coccinellids. This fact combined with the observation that the first instar larvae of *E. indica* show a carnivorous tendency in eating up the unhatched eggs of their own parents[1], throws some light on the ancestry of the herbivorous Coccinellids which have probably descended from carnivorous forms.

[1] Pradhan, S., *Proc. Ind. Sc. Cong.*, (1936).

Maxillae.—The chief visible difference in the chitinous structure of the maxillae (text-fig. 5) lies in the galea which is comparatively much larger in species of *Epilachna* (text-fig. 5, *a*, *b*) than in the carnivorous



TEXT-FIG. 5.—Maxillae of Coccinellids, (dorsal or anterior view).

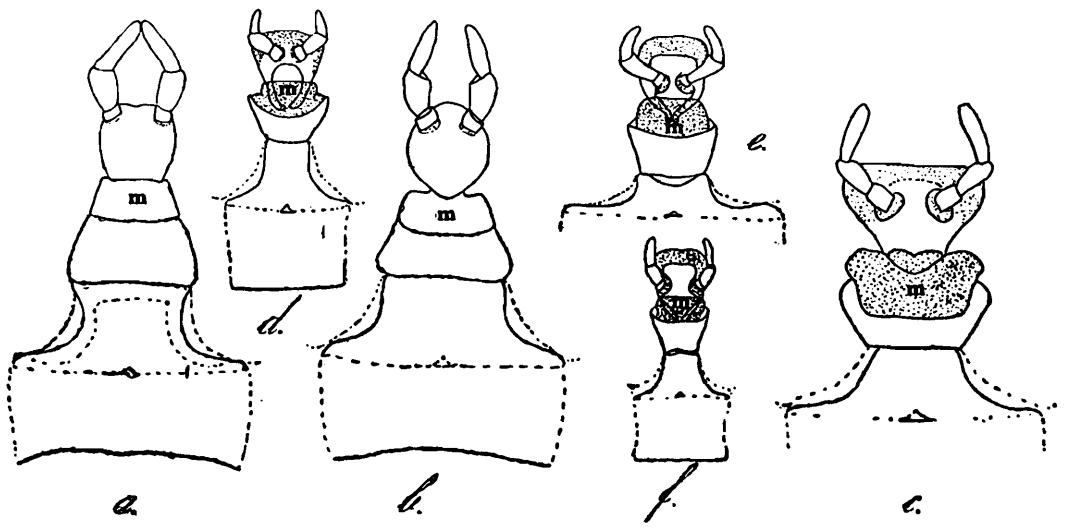
a. Epilachna indica; *b. E. vigintioctopunctata*; *c. Chilomenes sexmaculata*; *d. Synia melanaria*; *e. Chilocorus nigritus*; *f. Brumus suturalis.*

forms. The study of the nerve-supply indicates that this structure is chiefly sensory in function. It may be conjectured that as the *Epilachna* beetles remain scraping the epidermis, the galeae are in constant contact with the leaf-surface and serve, on account of their sensory nature, to guard against scraping that portion of the epidermis on which some harmful substance may be lying. Thus the galea may have become better developed in the herbivorous forms.

Labium.—The study of the labium (text fig. 6) shows two important differences between the carnivorous and herbivorous Coccinellids :—

1. The pre-labium in carnivorous forms (text-fig. 6, *c-f*) is comparatively larger and more expanded than in the herbivorous genus *Epilachna* (text-fig. 6, *a*, *b*) as is clear from the diagrams. I am not able to explain this difference on the basis of their dietetic deviation.

2. The membranous connection (*m*) between the pre- and the post-labium which allows the pre-labium to be inflected upwards in carnivorous forms has become fairly strengthened in herbivorous forms in which the pre-labium is not inflected



TEXT-FIG. 6.—Labium.

a. Epilachna indica; *b. E. vigintioctopunctata*; *c. Synia melanaria*; *d. Chilomenes sexmaculata*; *e. Chilocorus nigritus*; *f. Brumus suturalis*; *m.* membrane between mentum and sub-mentum.

upwards. This difference is probably correlated with the mode of feeding in this way : *Epilachna* remains continuously scraping the epidermis with its mouth-parts almost at right angles to the leaf-surface while the carnivorous Coccinellids pick up their prey and suck its juice while keeping the prey raised above the surface. The pre-labium, thus, has to be often inflected upwards in carnivorous forms, a need for which seldom arises in the herbivorous *Epilachna*.

SUMMARY.

This paper embodies :—

1. A description of the chitinous structures of the mouth-parts of *C. septempunctata*.
2. A description of both the extrinsic and intrinsic musculature of the mouth-parts of the same species, with the function of the muscles in each case.
3. A description of the nervous supply of the mouth-parts of the same species.
4. A comparison of the chitinous structures of the mouth-parts in seven species of Coccinellidae.
5. A short description of the sense-organs situated on the mouth-parts.

These studies have brought to light some facts of morphological importance. Thus, for example, the muscles of the designations *Extensor of Lacinia*, *Cranial Flexor of Sub-galea*, and *Stipital Flexor of Sub-galea* do not exist in literature, the first two being recorded but differently interpreted, while the last one not being recorded at all.

The study of nervous supply has revealed prominent aggregations of sensory cells in the labial and maxillary palpi and the galea. These sense-organs appear to be olfactory in nature. Thus, these findings fill up the gap left by McIndoo (1916) in his study of olfactory sense-organs in several parts of the body of Coleoptera. McIndoo searched for these organs in several parts of the body of Coleoptera (including Coccinellidae) but omitted to examine the mouth-parts where they are best developed in Coccinellidae at least.

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EXPLANATION OF PLATE VI.

Mouth-parts of Coccinella septempunctata.

FIG. 1.—Labrum.

FIG. 2.—Mandible (posterior or ventral view). *b.t.* basal teeth; *co.* condyle; *md. abd.* tendon of abductor muscle; *md. add.* tendon of adductor muscle; *prs.* prostheca.

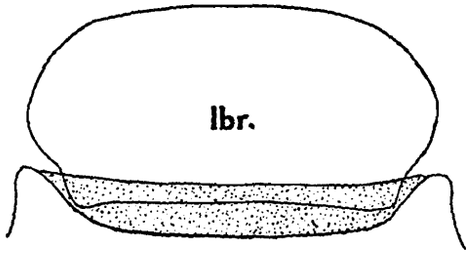
FIG. 3.—Mandible (anterior or dorsal view).

FIG. 4.—Maxilla (dorsal or anterior view).
ap. 1-3. apodemes; *ca.* cardo; *dl.* dorso-lateral sclerite of the stipital portion; *ga.* galea; *lc.* lacinia.

FIG. 5.—Maxilla (ventral view).
sg. sub-galea (ventro-mesial sclerite of stipital portion); *v. l.* ventro-lateral sclerite.

FIG. 6.—Labium (ventral or posterior view).
h. p. hypostomal plate; *m.* membrane between mentum and pre-mentum; *mt.* mentum; *p.* palpus; *prmt.* pre-mentum; *smt.* sub-mentum.

FIG. 7.—Lateral view of the labium and hypopharynx.
ap. apophysis; *b. b.* basal bar; *rao.* retractores angulorum oris; *sus. f.* suspensorial fork. Rest of the lettering as in figure 6.



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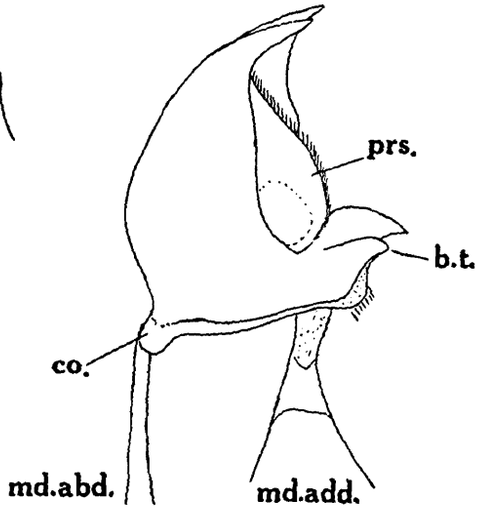

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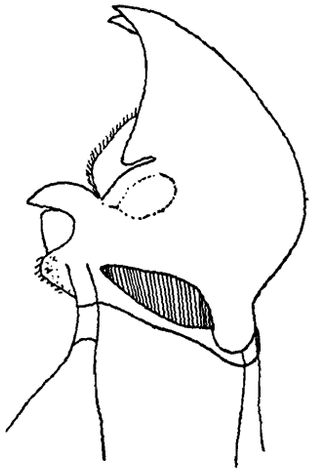

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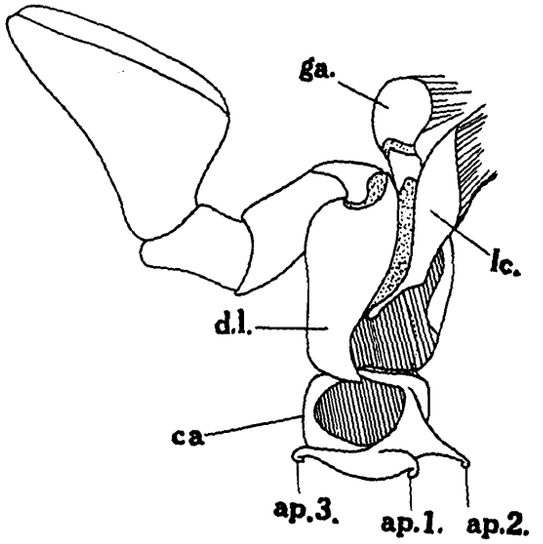

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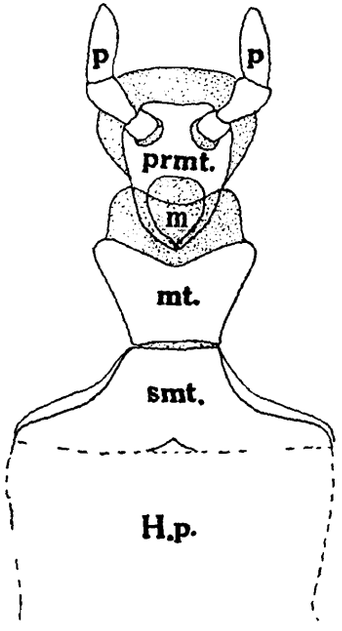

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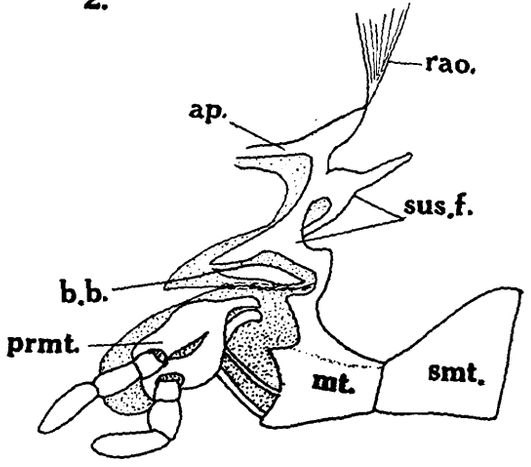

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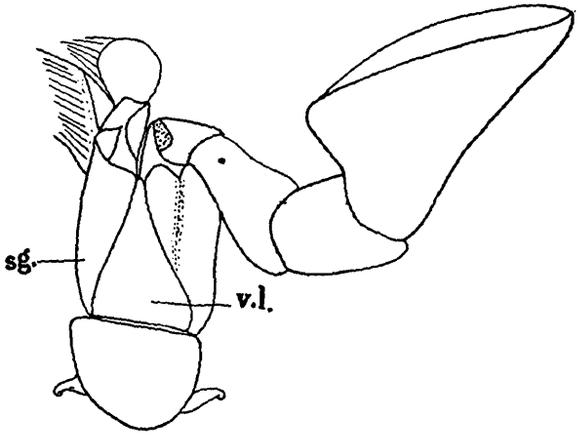


5.

Mouth parts of *Coccinella septempunctata*.

THE EARLY STAGES OF *AEDES LOPHOVENTRALIS* (THEOBALD).

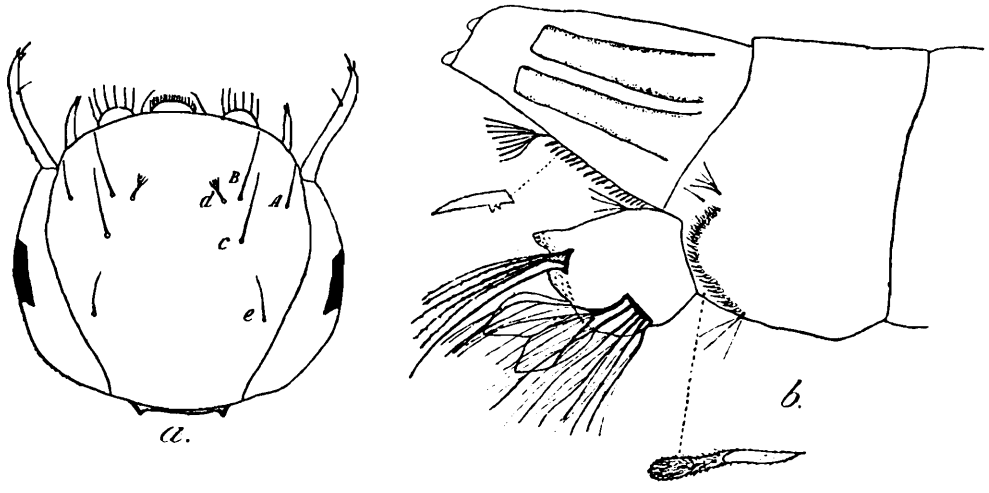
By PURNENDU SEN, *M.Sc. (Cal.), Ph.D. (Lond.), D.I.C., Entomologist, Bengal Public Health Department, Calcutta.*

The early stages of *Aedes lophoventralis* (Theobald) have so far been unknown. Barraud[1] had "no specimens available for description" The species was found breeding intensively in the village Madhyamgram near Barasat (24-Parganas, Bengal) in tree-holes, and this finding afforded me ample opportunities of studying its early stages. In Bengal the species was previously recorded from Chittagong, Eastern Bengal, only (*vide* Barraud, *op. cit.*, p. 168).

LARVA.

Larva large, dark in colour when living. Length of mature larva about 8 mm.

Head.—Head dark brown, nearly as broad as long, length 0·9 mm., breadth 1·0 mm. (text-fig. 1*a*). Antenna (0·5 mm. long), about half



TEXT-FIG. 1.—Larva of *Aedes lophoventralis* (Theobald).
a. Head (dorsal view); *b.* terminal segments of abdomen.

the length of head, somewhat tapering towards the tip and pale in colour, not covered with spines at base. Antennal tuft small consisting of a single hair or branch situated at nearly $\frac{2}{3}$rds from base of the shaft; bristles short, consisting of five simple terminally placed branches. Clypeal spines long, slender, bent inwards. Clypeal tufts A simple; B and C also simple, but stout, long and approximated, arising almost from the same plane; *d* 4 or 5-branched, inconspicuous; *e* also simple or rarely bifid, of about same size as A. Mentum triangular, with about 15 or 16 subequal, strong teeth.

Thorax.—Thorax 1·1 mm. long, 1·7 mm. broad. Lateral tufts of moderate size, simple in case of prothorax, plumose or branched on

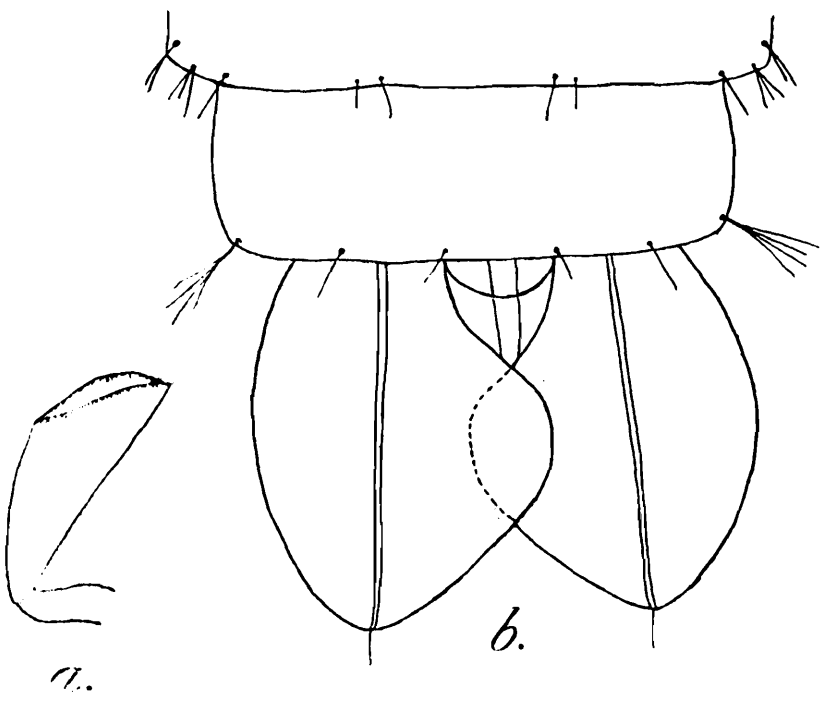
[1] Barraud, P. J., *Fauna of British India, Diptera* V., Culicidae (Megarhinini & Culicini). London (1934).

meso- and meta-thorax. All the tufts show fine frayings. The tufts of metathorax arise from well-developed chitinous plates. Very small spines present at the base of tufts in meso- and meta-thorax.

Abdomen.—Body distinctly dark. Abdominal third segment 0·9 mm. broad, 0·6 mm. long. Abdominal tufts of considerable size, eighth segment with the uppermost tuft four-rayed and stout. The comb consists of about 28 broad, obtuse scales on either side (text-fig. 1*b*) ; the scales are delicately fringed. Anal segment well chitinised on dorsum and sides, with narrow dark basal rings. The inner dorsal hair forms a strong tuft of about five simple branches with slender frayings on either side. The outer dorsal hair long, stout and simple. The lateral hair also simple, with fine frayings and situated close to the margin of the segment. The ventral brush with six pairs of many-branched tufts. Towards the hind end the surface bears numerous small teeth or spines, best developed dorsally. Anal gills short, about ⅔rds the length of anal segment. Siphon nearly 0·7 mm. long, tapering slightly towards the tip, darker than body. Pecten extends nearly half-way along the siphon and consists of about 22 (as few as 18 and a maximum of 26 noted) sharply pointed, strong teeth almost equidistantly placed ; each with 2 or 3 blunt serrations on the lower margin. The tuft well developed, having eight to ten branches with frayings, situated just beyond the pecten.

PUPA.

Pupa large and dark in colour. Respiratory trumpets dark, of moderate length ; orifice at 45° to axis of trumpet which is slightly dis-



TEXT-FIG. 2.—Pupa of *Aedes lophoventralis* (Theobald).
a. pupal trumpet ; *b*. terminal segments of abdomen (dorsal view).

tended apically (text-fig. 2*a*). Tuft on first abdominal segment fairly well developed and composed of dendritic hairs. Sub-lateral hair or

seta simple and long up to segment VI, on segment VII this is considerably reduced in length. The lateral tuft of segment VIII with about four strong plumose branches, the inner seta simple and delicate (text-fig. 2*b*). Paddles at their widest parts about two-thirds of their length, colourless, margin without teeth; midrib distinct, ending in a rather long, slender seta. Outer buttress distinct but narrow.

Habitat.—Breeding in tree-holes.

Locality.—Madhyamgram (24-Parganas, Bengal).

NOTES ON FISHES IN THE INDIAN MUSEUM.

XXXVIII. On the Systematic Position of *Bagrus lonah* Sykes, with Descriptions of and Remarks on other Glyptosternoid Fishes from the Deccan.

By Sunder Lal Hora, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

(Plate VII.)

In his account of the *Fishes of the Dukhun*, Sykes (1841, p. 371) described a Glyptosternoid fish as *Bagrus lonah* and characterised it as follows :—

"A *Bagrus*, with 8 small *cirri*; flat, granulated head; first dorsal fin of 7 rays, and pectoral of 10 rays, the first ray of which is furnished on the posterior edge with long sharp teeth; anal fin of 10 rays."

As the above synopsis and even Sykes's detailed description of the species are, as judged by modern standards, too generalised, it is not possible to define the precise specific limits of the species. It may, however, be noted that in Sykes's species the head is stated to be "granulated" Fortunately, Sykes preserved some fishes and along with his account presented them to the Court of Directors of the East India Company in June 1831. For a time, the specimens remained in the Museum at the India House, but were later transferred to the British Museum. In his *Catalogue*, Günther (1864, p. 187) records two Glyptosternoid fishes "From the collection of Colonel Sykes," 6 inches and $3\frac{1}{2}$ inches long respectively. The former is described as *Glyptosternum lonah* (Sykes) and the latter as a new species *G. dekkanense*. As judged from their descriptions the two species differ from each other in the following characters.

G. lonah (Sykes).	*G. dekkanense* (Günther).
1. Head as long as broad.	Head rather longer than broad.
2. Free portion of tail twice as high as long.	Free portion of tail two-thirds as high as long.
3. Dorsal fin higher than body.	Dorsal fin as high as body.
4. Dorsal spine not quite half as long as head.	Dorsal spine half as long as head.
5. Pectoral spine moderately broad, with a fine outer and strong inner serrature.	Pectoral spine very broad and strongly serrated interiorly.

Dr. Trewavas, who very kindly compared the types of the two species for me, noted that "The condition of the outer edge of the spine is similar in both, but in *G. lonah* the skin has been removed, leaving the serrations visible" The differences in the proportions of the various parts, noted by Günther, seem to fall within the range of individual variation, especially as the two types are of very different sizes and are also in different states of preservation. In view of the above it appeared to me that the two species may be identical, and on this point also Dr. Trewavas agreed and wrote "my conclusion is that *G. dekkanense* may be

identical with *G. lonah*"[1]. A thorough examination of the Glyptosternoid specimens from Peninsular India in the collection of the Zoological Survey of India has also shown that the two forms must be regarded as conspecific.

In 1871, Day (p. 714) extended the range of *G. dekkanense* to the Jumna river " near where it emerges from the Siwalik hills ", but later in his *Fishes of India* he combined the two species from Deccan under *G. lonah*, and noted " I have taken this species at Poona, and also in the head waters of the Jumna " In the collection of the Indian Museum there was no named specimen of either of the species from Deccan when I (1923, pp. 8-30) revised the Indian members of the genus *Glyptothorax*. Day's specimen of *G. lonah* from the Jumna was referred to *G. conirostre* (Steind.) and a specimen from the Satara District identified by Annandale (1919, p. 126) as *Euglyptosternum saisii* was described as *G. dekkanense*. Quite recently, however, the Zoological Survey of India received several examples of *Glyptothorax* from Poona and adjacent hill ranges and doubts arose as to the precise specific limits of *G. lonah* (Sykes) and *G. dekkanense* (Günther). A specimen of a species of *Glyptothorax* with smooth skin from Motha Mola river, Poona, was sent to Mr. J. R. Norman for comparison with the types of *G. lonah* and *G. dekkanense*. Dr. E. Trewavas very kindly attended to this enquiry and replied as follows :—

" Your problem is made more difficult of solution by reason of the poor state of preservation of the type of *Glyptosternum lonah*. But the type of *G. dekkanense* is well preserved, and my conclusion is that *G. dekkanense* may be identical with *G. lonah*, and that in *any* case your Motha Mola R. specimen belongs to neither species for the following reasons :—

(*a*) The skin of the body in *G. dekkanense* is tuberculated, that of the head is finely granular. It is difficult to judge the nature of the skin in the emaciated type of *G. lonah*, but there appear to be signs of tuberculation. The skin of Motha Mola fish is smooth.

(*b*) The adhesive apparatus in *G. lonah* and *G. dekkanense* is longer than broad. In the Motha Mola fish it appears to be broader than long.

(*c*) The caudal, twice as long as deep in the Motha Mola fish is $1\frac{5}{12}$ times as long as deep in the type of *G. dekkanense*. That the ratio is also 2 in *G. lonah* may be partly due to emaciation ;—the ends of both dorsal and haemal spines project.

(*d*) The shape of the supracleithrum, as seen or felt through the skin, is of one sort in *G. lonah* and *G. dekkanense* and of another in the Motha Mola fish, in Day's Jumna R. fish and in three (coll. Day) from Poonah.

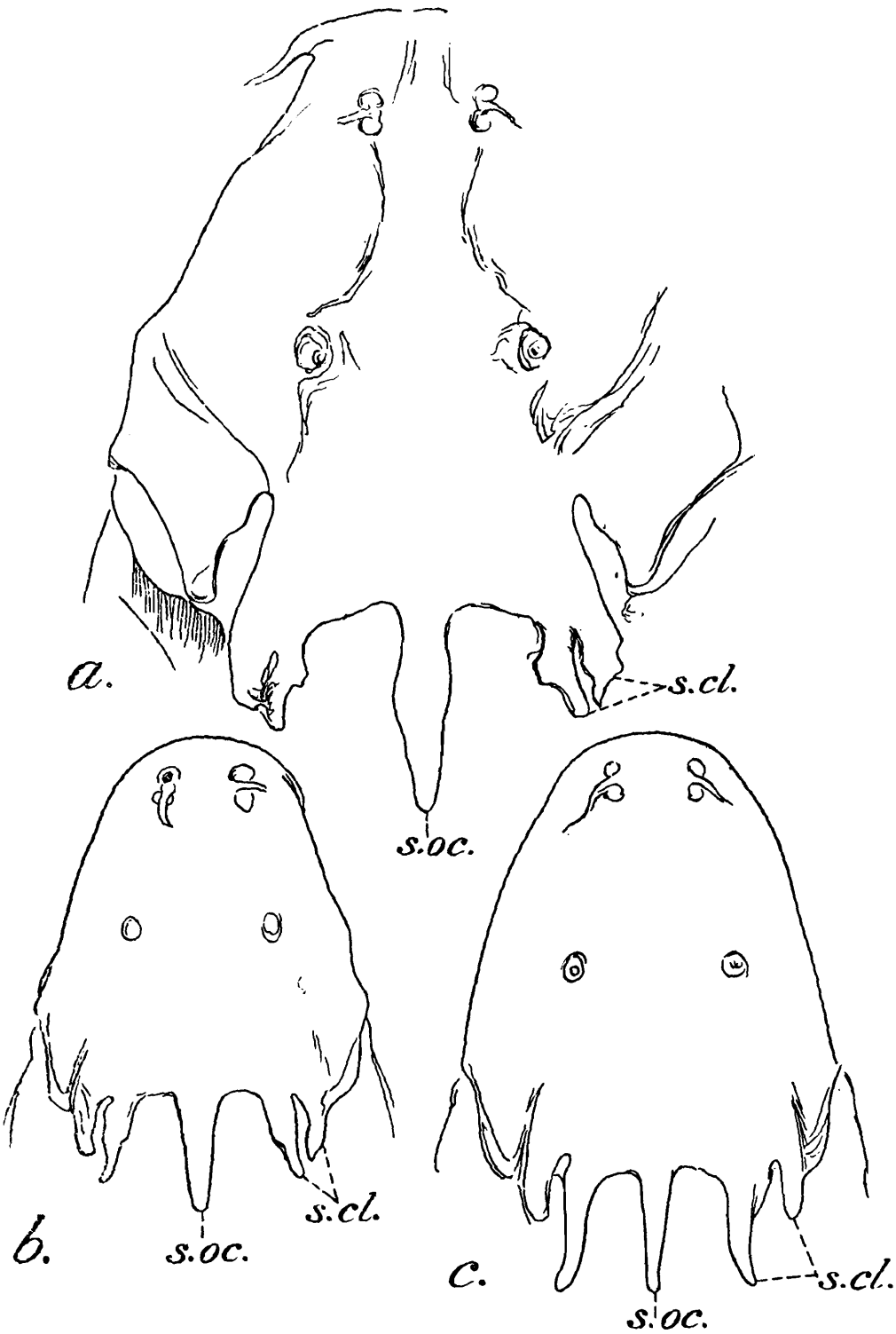
The inner limb of the forked supracleithrum is much longer than the outer and as long as the supraoccipital spine in the Motha Mola fish, whereas in *G. dekkanense* it is not much longer than the outer limb and is considerably shorter than the supraoccipital spine. I send herewith sketches drawn to scale to illustrate this.

Three specimens, 39 to 52 mm. in standard length collected by Day at Poonah, seem to agree very well with the Motha Mola fish. They are labelled *G. lonah*. Another labelled *G. dekkanense*, from the Jumna R. (coll. Day) looks to me to be also very much like your fish. It is very much emaciated. The pectoral spine is relatively longer and more coarsely serrated."

---

[1] On a request being made to give reasons for her conclusions Dr. Trewavas very kindly supplied the following information :—" The type of *G. lonah* resembles that of *G. dekkanense* in all characters (tuberculation of skin, shape of adhesive apparatus, shape of head and shape and proportions of supracleithrum) except size of fish (*G. lonah* 128 mm., *G. dekkanense* 68 mm. standard length) and proportions of caudal peduncle. The apparent slenderness of *G. lonah* is partly due to extreme emaciation but also the relative length of the caudal peduncle is greater in *G. lonah* than in *G. dekkanense* ($5\frac{1}{3}$ times in standard length in *G. lonah*, $5\frac{2}{3}$ times in *G. dekkanense*, measured from base of anal to end of last vertebra. Whether or not this can be accounted for by the difference in size I cannot say, and I believe that only the examination of large numbers of specimens from the Deccan can really decide whether these represent two species or one."

From Dr. Trewavas's remarks it appears that the smooth-skinned specimens of the Motha Mola river are similar to those which Day (1871,



TEXT-FIG. 1.—View of the dorsal surface of head in three specimens of *Glyptothorax* from Deccan, showing the shape of the surpacleithrum. Only the bases of the nasal barbels are shown. (From sketches supplied by Dr. E. Trewavas.)

a. Type of *G. lonah* (Sykes). ×2⅔ ; *b.* Type of *G. dekkanense* (Günther). ×2⅔ ; *c.* Motha Mola river specimen of *G. conirostre* var. *poonaensis*, nov. ×2⅔ *s. cl.* Supracleithrum ; s.oc. Supraoccipital process.

G. 714 ; 1877, p. 496) had collected in the Jumna river and referred to p. *lonah* and *G. dekkanense.* In my earlier work (1923, p. 30) I indicated

that one of Day's specimens of *G. lonah* from the headwaters of the Jumna river, now preserved in the collection of the Indian Museum, was referrable to *G. conirostre* (Steind.), but as there is a close similarity between the Jumna river form and the smooth-skinned form from Poona, the range of *G. conirostre* must be extended to Deccan. A more detailed comparison of the specimens from the two localities shows that the head is proportionately broader and the dorsal fin shorter in the Deccan examples.

Owing to the inadequacy of the material of *Glyptothorax* from the headwaters of the Jumna in the collection of the Indian Museum, a specimen of the Deccan form of *G. conirostre* was sent to Dr. Trewavas for comparison with Day's material from Poona and the Jumna river. Her report is as follows :—

"Specimen F $\frac{12126}{1}$ labelled 'Deccan form of *Glyptothorax conirostre* (Steind.)' agrees well with Day's '*G. lonah*' from Poonah. Compared with Day's '*Glyptosternum dekkanense*' from Jumna R. (which I think you are right in referring to *G. conirostre*) it has, as you point out, a somewhat broader head and lower dorsal fin. These two fishes are of approximately the same size. If now Day's '*Glyptosternum lonah*' from Poonah are compared with specimens of *G. conirostre* of their size from Simla the same difference in width of head is observed. The difference in height of dorsal seems less constant. Therefore, it seems certain that the Motha Mola fish and Day's '*G. lonah*' from Poonah are conspecific, and are distinct from *G. conirostre*; whether specifically or subspecifically only more material can show."

The Poona specimens of *G. conirostre* would thus seem to represent a geographical race of the Jumna form, and to indicate the differences between the two types I propose to describe the Poona race as a distinct variety (*vide infra*, p. 368).

The extension of the range of *G. conirostre* from the headwaters of the Jumna river to the Western Ghats is of considerable interest. In one of my (1938, p. 169) recent contributions the probable route along which the species from the Eastern Himalayas seem to have migrated to the Western Ghats and thence to the hills of Peninsular India was indicated. *G. lonah* (=*G. dekkanense*), which has recently been obtained from the Bastar State[1], Central Provinces, (Hora 1938 *b*, p. 241) would thus appear to have migrated along the Satpuras to the Western Ghats.

The Western Ghats had also a connection with the Western Himalayas in the direction from Gujrat to Delhi through the intermediation of the Aravalli Mountains (Heron 1938, p. 119). The distribution of *G. conirostre* to the Deccan may thus have been effected along the Aravalli range.

It is probably due to these two routes of migrations of the hill-stream fauna from the north to the south that in the South Indian fish-fauna both the Eastern and the Western Himalayan forms are represented.

The specimen of Annandale's (1919, p. 126) *Euglyptosternum saisii* from the Satara District, as indicated above, was referred by me (1923,

[1] A specimen, about 3·5 inches in length, from the Bastar State was sent to Dr. Trewavas, under the title *Glyptothorax dekkanense*, for comparing it with the type of Günther's species. She found the two specimens identical in every respect.

p. 24) to *Glyptothorax dekkanense*, and later another specimen from the Tunga river at Shimoga (No. F 12435/1), owing to its strong resemblance to the Satara specimen, was assigned to the same species (Hora 1937, p. 14). The latter example, under the title *G. lonah*, was sent to Dr. Trewavas for comparison with the types of *G. lonah* and *G. dekkanense* and she has kindly favoured me with the following report :—

" Comparison of the type of *G. lonah* and your specimen so labelled is less satisfactory as both are in a poor state. What strikes me is that although your fish (F $\frac{12435}{1}$) is shorter than the type it has a longer head, and also stronger inner serrae on the pectoral spine. The depth of its caudal peduncle is only $\frac{2}{3}$ of that of the type, which is less than one would expect even if the type were not emaciated. The maxillary barbel in your fish barely reaches the base of the pectoral, in the type it extends beyond it. I am satisfied that F $\frac{12435}{1}$ is distinct from *G. lonah* but not that it is identical with *G. dekkanense*."

These specimens are quite different from the other species found in India, and in view of the above opinion it seems necessary to separate them as a new species.

Misra and I (1938, p. 36) referred a specimen of *Glyptothorax* from the headwaters of the Godavari river to *G. annandalei* Hora, but I am of opinion that it should be referred to *G. lonah*. As Günther had included both *G. lonah* and *G. dekkanense* under the division characterised by " Ventral and pectoral rays not plaited below ", the close association of *G. annandalei*, in which the outer pectoral and ventral rays are plaited on the ventral surface, with *G. lonah* never occurred to me. I now find that the plaited condition of the rays of the paired fins may be an ecological character depending upon the rapidity of the water in which the fish may be living. Similar ecological races were indicated by me in the case of *Garra mullya* (Hora 1921, p. 659) and by Day (1871, p. 714) in the case of *Glyptothorax*. I think, however, that one should recognise local races based on geographical or ecological considerations. In view of the above, I am of the opinion that *G. annandalei* Hora, with a much longer and narrower caudal peduncle, probably represents a torrential race of *G. lonah* (Sykes), but in the present state of our knowledge it may be retained, for the time being at least, as a separate species. In *G. annandalei* the outer border of the pectoral spine is finely serrated and the caudal peduncle is at least twice as long as high. In all the fresh specimens of *G. lonah* that I have examined the outer rays of the paired fins are faintly or distinctly plaited below.

Besides the species referred to above, *G. madraspatanus* (Day) is the only other species of *Glyptothorax* found in South India. It agrees with *G. lonah*, the new species from Satara, and *G. annandalei* in possessing a tuberculated body, but differs in having relatively longer fins and stronger spines. In *G. madraspatanus* the pectorals are as long as or slightly longer than the head and the dorsal spine is serrated along both the borders near the apex ; the serrae are, however, more pronounced along the posterior border.

From the above it is clear that at present five species of *Glyptothorax* can be recognised from Peninsular India, *viz.*, *G. lonah* (Sykes), *G. madraspatanus* (Day), *G. annandalei* Hora, *G. conirostre* (Steind.) var.

poonaensis nov. and *G. trewavasae*, sp. nov. They may be distinguished by the following key :—

1. Skin smooth	*G. conirostre* var. *poonaensis*, nov.
2. Skin tuberculated	
I. Pectoral spine almost as long as head, or somewhat longer; dorsal spine strong and serrated near the apex	*G. madraspatanus* (Day).
II. Pectoral spine not as long as head, generally considerably shorter; dorsal spine moderately developed and smooth throughout	
A. Maxillary barbels extending considerably beyond commencement of pectoral	
i. Caudal peduncle about 1½ times as long as deep	*G. lonah* (Sykes).
ii. Caudal peduncle at least 2 times as long as deep	*G. annandalei* Hora.
B. Maxillary barbels barely reaching base of pectoral	*G. trewavasae*, sp. nov.

An analysis of the geographical distribution of the above mentioned 5 species is of some interest. *G. conirostre* var. *poonaensis* has so far been recorded only from the waterways near Poona, but as its closely allied form is found in the Jumna river, it is likely to be met with in the intermediate regions. *G. lonah* is known from the Godavari watershed (Nasik and Bailadila range) and the Kistna watershed (Poona). *G. trewavasae* is found only in the Kistna watershed, while the remaining two species, *G. madraspatanus* and *G. annandalei*, occur in the Cauvery watershed. So far, *G. lonah* is the only species that is known to occur in the two adjacent watersheds and over a much wider area.

Glyptothorax conirostre var. **poonaensis**, nov.

(Plate VII, figs. 5 and 6.)

1877. *Glyptosternum lonah*, Day (in part, *nec* Sykes), *Fish. Ind.*, p. 496, pl cxiii, fig. 5.

D. 1/6|0 ; A. 10 ; P. 10 ; V 6 ; C. 17.

The head and the anterior part of the body are moderately depressed, and the tail region is compressed from side to side. The skin, both on the head and the body, is smooth. The snout tapers broadly towards the anterior end. The head is distinctly longer than broad ; its length is contained from 4·2 to 4·3 times in the standard length. The eyes are small, dorso-lateral in position, and situated in the posterior half of the head. The occipital process is long and narrow ; it is almost twice as long as broad at its base ; it is separated from the basal bone of the dorsal fin by a short distance. The nasal openings are situated slightly behind the tip of the snout and are separated by small barbels, which do not extend as far as the eyes. The mouth is ventral, transverse and crescentic ; its gape is almost equal to half the width of the head. The lips are thin, slightly papillated and continuous at the angles of the

mouth. The labial groove is widely interrupted. The posterior jaw is almost truncate in the middle. A portion of the upper jaw and dentition are bare. The teeth are small and villiform. The gill-openings are wide, and the gill-membranes meet the isthmus in the mid-ventral line. The thoracic adhesive apparatus is considerably longer than broad, but the ridges are only developed in the peripheral region. The maxillary barbels possess broad bases, and extend considerably beyond the commencement of the pectoral fins. The two pairs of mandibular barbels are considerably shorter.

The height of the body varies considerably : it is contained from 5·8 to 7·0 times in the standard length. In the case of mature females (Pl. VII, fig. 5) the body is considerably distended with gonads. The caudal peduncle is short, but narrow ; its least height is contained about 2 times in its length. The rayed dorsal fin commences above the pectorals ; its commencement is almost equidistant between the tip of the snout and the adipose dorsal. The dorsal fin is slightly higher than the depth of the body, but in fully mature females the body is somewhat deeper ; its spine is strong, smooth, and almost half as long as the length of the head. The pectoral fin is shorter than the head ; its spine is strong and pectinated internally ; it is somewhat roughened along the outer edge. The pectoral fin is separated from the ventral fin by a considerable distance. The ventrals are considerably shorter than the pectorals and extend as far as or slightly beyond the anal opening, but are separated from the anal fin by a considerable distance. In the specimens examined by me the paired fins are devoid of the usual adhesive pads on the ventral surface of their outer rays. The anal fin is short and situated below the adipose dorsal. The caudal fin is deeply forked and both the lobes are of equal length.

In the material before me the general colour is light dusky above and dirty white below. The whole of the dorsal surface of the head and body is studded with minute, black dots. In some specimens there are three, saddle-shaped bands across the dorsal surface ; the first across the occipital process and the basal bone of the dorsal fin, the second at the base of the dorsal fin and the third across the base of the adipose dorsal. There is generally a band at the base of the caudal fin. The distal part of the caudal fin is infuscated with black, as also the distal portion of the anal fin.

Locality.—Poona and its environs.

Type-specimen.—Holotype No. F 12126/1 Zoological Survey of India (*Ind. Mus.*), Calcutta.

Remarks.—I have examined 5 specimens of the new variety, 4 from Motha Mola river near Poona collected by Mr. C. V Kulkarni, Department of Fisheries, Bombay and 1 from the Motha Molla R. near Kharadigaon, Poona, collected by Mr. A. G. L. Fraser. According to Mr. Fraser this species is locally known as *Phather Chatoo*, in which reference is made to the stone-licking habits of these fishes.

Reference has been made above (*vide supra*, p. 366) to the great resemblance of this fish to *G. conirostre* from the Jumna river, and the characters by which it may be distinguished from the typical form.

To facilitate reference, measurements of the two specimens from the Jumna river are also included in the table given below.

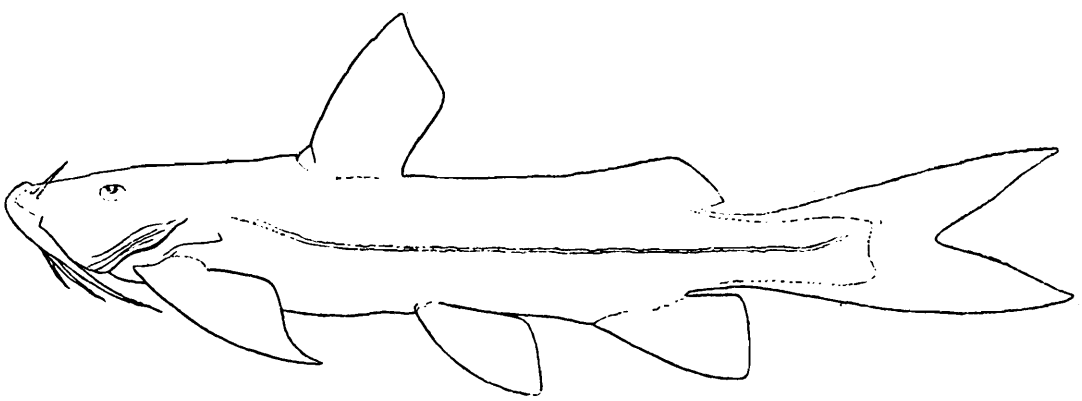
Measurements in millimetres.

	G. conirostre var. *poonaensis.*			*G. conirostre.*	
Total length excluding caudal	81·0	79·5	79·0	107·0	74·5
Length of caudal	17·3	21·5	18·2	28·0	
Length of head	19·0	18·6	19·0	24·8	16·5
Width of head	15·0	16·6	16·7	18·0	12·3
Height of head	9·8	11·2	10·0	13·0	9·0
Length of snout	10·2	8·3	9·0	12·0	8·9
Interorbital width	5·0	5·4	5·0	5·0	4·5
Depth of body ..	12·0	14·0	11·2	17·0	10·6
Height of dorsal fin	13·5	14·2	12·6	21·0	15·0
Length of pectoral fin	18·5	17·3	16·0	26·0	18·0
Length of ventral fin	13·0	13·6	11·2	18·0	14·0
Longest ray of anal fin	10·4	13·0	10·5	20·0	14·2
Length of dorsal spine ..	10·0	10·0	10·0	14·5	11·0
Length of caudal peduncle	14·0	13·2	13·8	21·8	16·5
Least height of caudal peduncle ..	6·8	6·7	6·2	9·8	6·8

Glyptothorax madraspatanus (Day).

1867. *Glyptosternum lonah*, Day (*nec* Sykes), *Proc. Zool. Soc. London*, p. 285.
1873. *Glyptosternum madraspatanum*, Day, *Journ. Linn. Soc. London* XI, p. 526.
1877. *Glyptosternum madraspatanum*, Day, *Fish. India*, p. 498, pl. cxvi, fig. 4.
1889. *Glyptosternum madraspatanum*, Day, *Faun. Brit. Ind., Fish.* I, p. 200.
1923. *Glyptothorax madraspatanus*, Hora, *Rec. Ind. Mus.* XXV, p. 29.
1937. *Glyptothorax madraspatanus*, Hora, *Rec. Ind. Mus.* XXXIX, p. 19.

Since 1923, when I made some remarks on *Glyptothorax madraspatanus*, the species has also been reported from the Cauvery river in the



TEXT-FIG. 2.—Lateral view of a specimen of *Glyptothorax madraspatanus* (Day) from the Cauvery river, Coorg State. × ⅔.

Coorg State. The skin is coarsely tuberculated in all the 8 specimens now represented in the collection of the Zoological Survey of India and the pectoral and the dorsal fins are proportionately much longer in this species. The dorsal and the pectoral spines are also longer and stronger. Further, the dorsal spine is serrated near the apex along both the borders.

Glyptothorax lonah (Sykes).

(Plate VII, figs. 1 and 2.)

D. 1/610 ; A. 11 ; P. 9 ; V 6 ; C. 16.

1841. *Bagrus lonah*, Sykes, *Trans. Zool. Soc. London* II, p. 371.
1864. *Glyptosternum lonah*, Günther, *Cat. Fish. Brit. Mus.* V, p. 187.
1864. *Glyptosternum dekkanense*, Günther, *Cat. Fish. Brit. Mus.* V, p. 187.
1937. *Glyptothorax lonah*, Hora & Misra, *Journ. Bombay Nat. Hist. Soc.* XXXIX, p. 513.
1938. *Glyptothorax annandalei*, Hora & Misra (*nec* Hora), *Journ. Bombay Nat. Hist. Soc.* XL, p. 36, pl. iii, figs. 3, 3a.
1938. *Glyptothorax dekkanensis*, Hora, *Rec. Ind. Mus.* XL, p. 241.

Glyptothorax lonah is a stoutly-built species, in which both the dorsal and the ventral profiles are slightly arched. The head and the anterior part of the body are somewhat depressed and the ventral surface is flattened ; the body is compressed in the tail region. The skin, particularly on the head, is distinctly granulated. The head is somewhat longer than broad ; its length is contained from 4·1 to 4·4 times in the standard length. The eyes are small, dorso-lateral, and situated in the posterior half of the head. The snout is broad and rounded ; it is equal to half the length of the head. The inter-orbital width is equal to one-third the length of the head. The occipital spine is long and narrow ; it almost extends to the basal bone of the dorsal fin. The nasal openings are well-marked and situated slightly behind the tip of the snout ; they are separated by the nasal barbels which do not extend to the eyes. The mouth is ventral, transverse and crescentic ; its gape is almost equal to half the width of the head. The anterior lip is thickly beset with papillae, which are indistinctly marked on the posterior lip. The two lips are continuous at the angles of the mouth. The labial groove is narrow and widely interrupted in the middle. A portion of the anterior jaw and dentition is not covered by the posterior jaw. The teeth are small and villiform. The gill-openings are wide and the gill-membranes are united to the isthmus which is half as wide as the gape of the mouth. The adhesive apparatus on the chest and the ventral surface of the outer rays of the paired fins is fully developed ; the thoracic apparatus is longer than broad and is almost filled with ridges to the mid-ventral line. The maxillary barbels possess broad bases, and extend considerably beyond the commencement of the pectoral fins. The two pairs of mandibular barbels are considerably shorter.

The height of the body is contained from 5·1 to 5·8 times in the standard length. The least height of the caudal peduncle is contained from 1·5 to 1·7 times in its length.

The dorsal fin commences above the pectorals and considerably in advance of the ventrals ; it is almost equidistant between the tip of the snout and the origin of the second anal ray. It is as high as the length of the head behind the nostrils, and is either equal to or slightly shorter or longer than half the length of the head and is usually clothed in thick skin. The pectoral fin is almost as long as the head ; its spine is strongly pectinated internally and finely serrated along the outer border. Usually the spine is covered by thick skin and the outer serrations cannot be made out without dissection. The pectoral fin is separated

from the ventral by a distance equal to the distance between the eye and the nostrils. The ventrals are considerably shorter than the pectorals, but extend beyond the anal opening and miss the anal fin by a very short distance. The anal fin is short and a part of it is situated below the adipose dorsal. The caudal fin is deeply forked ; the upper lobe being somewhat more developed than the lower.

The general colour of the spirit specimens is greyish above and dirty-white below. There is a white streak along the lateral line, and the bases of the fins are generally of a dark colour. The ventrals, anal and caudal fins are provided with black patches in their distal portions. In the smaller individuals, the general colouration is somewhat lighter, but the dark markings are better pronounced.

Localities.—The precise locality of Sykes's specimens is not known, but in the British Museum Catalogue they are noted to have been collected in " Dekkan" The above description is based on the 4 specimens collected by Mr. H. Crookshank from the Galli Nalah near Loa, Bailadila range, Bastar State, Central Provinces. One of these specimens was compared by Dr. Trewavas with the type of *G. dekkanense* and found to be identical with it. Besides these example, 6 more, somewhat smaller, specimens were collected by Mr. Crookshank from another part of the Bailadila range. There are three more specimens of *G. lonah*, collected by Mr. A. G. J. Fraser, one from the Godavari river near Nasik and two from the section below Fitzgerald Bridge, Poona ; these specimens are of small size.

Remarks.—The precise systematic position of the species has been fully discussed above (*vide* p. 367). It can be readily distinguished by its broad caudal peduncle.

Measurements in millimetres.

Total length excluding caudal	83·0	78·0	71·0	70·0
Length of caudal	21·0	21·0	Damaged	20·6
Length of head	19·0	18·5	17·1	17·1
Width of head	16·7	16·0	14·0	14·0
Height of head ..	12·0	11·5	10·5	9·5
Length of snout ..	10·0	8·2	8·6	8·7
Interorbital width ..	6·2	5·8	6·3	5·6
Depth of body ..	15·0	13·9	12·3	13·8
Height of dorsal fin	15·0	16·1	12·5	12·5
Length of pectoral fin	20·0	18·0	17·0	16·1
Length of ventral fin	15·5	14·5	13·5	13·9
Longest ray of anal fin	14·0	14·5	13·0	14·2
Length of dorsal spine ..	11·2	10·8	9·5	8·2
Length of caudal peduncle ..	15·0	14·6	12·2	11·4
Least height of caudal peduncle	10·0	8·7	7·5	7·3

Glyptothorax annandalei Hora.

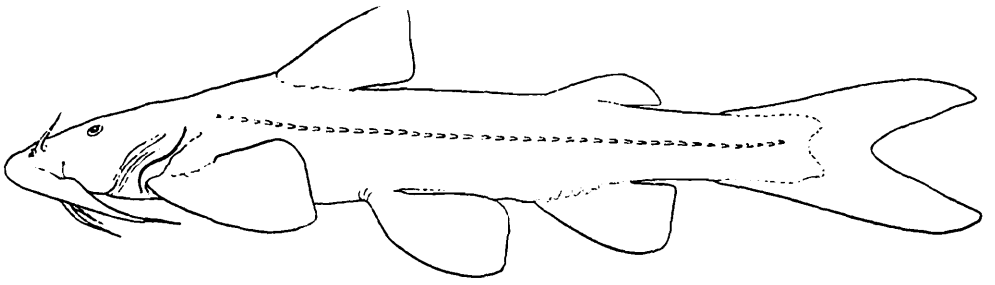
1923. *Glyptothorax annandalei*, Hora, *Rec. Ind. Mus.* XXV, p. 14, pl. i, fig. 3.

In 1923, I included a reference by Day[1] to *Glyptosternum lonah* from the Bhavani river in the synonymy of *Glyptothorax annandalei*,

[1] Day, F., *Proc. Zool. Soc. London*, p. 285 (1867).

but now it seems that the record may refer to *G. madraspatanus* which was described later by Day[1] from the same locality.

G. annandalei is closely allied to *G. lonah*. Its pectoral and the dorsal spines are enveloped in skin, but on dissection the outer border



TEXT-FIG. 3.—Lateral view of a specimen of *Glyptothorax annandalei* Hora. Nat. size.

of the pectoral spine was found to be finely serrated. The head and body distinctly tuberculated, and the skin in the region of the lateral line is raised as a ridge.

In the depressed form of its body, the development of the adhesive pads on the chest and the ventral surface of the outer rays of the paired fins, and the form of the caudal peduncle *G. annandalei* appears to be the most highly specialised torrential species of *Glyptothorax* in Peninsular India.

Glyptothorax trewavasae, sp. nov.

(Plate VII, figs. 3 and 4.)

1919. *Euglytosternum saisii*, Annandale (*nec* Jenkins), *Rec. Ind. Mus.* XVI, p. 126.
1923. *Glyptothorax dekkanensis*, Hora (*nec* Günther), *Rec. Ind. Mus.* XXV, p. 24, fig. 3.
1937. *Glyptothorax dekkanensis*, Hora (*nec* Günther), *Rec. Ind. Mus.* XXXIX, p. 14.

In *Glyptothorax trewavasae* the dorsal profile is almost straight and horizontal and the ventral profile is slightly arched. The head and the anterior part of the body are depressed, and the ventral surface is somewhat flattened. The tail region is only compressed. The skin is finely granulated. The head broadly tapers anteriorly, and the snout is rounded. The head is considerably longer than broad ; its length is contained from 3·8 to 4·0 times in the standard length. The eyes are small, dorso-lateral, and situated in the posterior half of the head. The interorbital space is somewhat greater than half the length of the snout. The occipital process is rectangular ; it is almost 3 times as long as broad at its base and does not extend to the basal bone of the dorsal fin. The nostrils are well-marked and are situated slightly behind the tip of the snout. The nasal barbels are small and do not reach the anterior margins of the eyes. The mouth is ventral, transverse and horizontal ; its gape is equal to half the width of the head. The lips are thin and slightly tuberculated. They are continuous at the angles of the mouth. The

[1] Day, F., *Journ. Linn. Soc. London* XI, p. 526 (1873).

labial groove is quite extensive and is only interrupted for a short distance in the middle. A portion of the anterior jaw and dentition are not covered by the posterior lip. The teeth are small and villiform. There are sharp, horny tubercles on the palate but no teeth. The gill-openings are wide and the isthmus is very narrow. The adhesive apparatus on the chest is almost as wide as long, and extends forwards to a point in between the union of the gill-membranes to the isthmus. The ventral surface of the head is ridged, grooved and papillated, and probably helps in adhesion. The outer rays of the paired fins in the preserved material before me are not provided with adhesive pads. The maxillary barbels barely extend to the roots of the pectoral fins, while the two pairs of the mandibular barbels are considerably shorter.

The height of the body is contained from 6 to 7 times in the standard length. The least height of the caudal peduncle is contained from 1·7 to 2·6 times in its length ; the caudal peduncle becomes narrower with growth.

The dorsal fin commences above the termination of the pectorals ; its commencement is almost equidistant between the tip of the snout and the base of the adipose fin. The dorsal fin is longer than the depth of the body below it ; its spine forms a strong, smooth prickle, which is almost equal to the length of the snout. Except in a young specimen, the pectoral fin is shorter than the head ; it possesses a broad, strong spine which is strongly pectinated internally and is distinctly serrated along the outer border. The pectorals are separated from the ventrals by a distance almost equal to half of their lengths. The ventrals extend beyond the anal opening but are separated from the anal fin by a considerable distance. The anal fin is short and commences slightly in advance of the adipose dorsal. The caudal fin is deeply forked.

The colouration is uniformly light grey with the bases of the pectoral, dorsal, adipose and caudal fins dark. Portions of certain rays in the dorsal, anal and ventral fins are infuscated with black. The distal portion of the caudal fin is dark, it is tipped with a lighter colour.

Localities.—Yenna and Koyna valleys in the Satara District, Bombay Presidency ; and the Tunga river at Shimoga in the Mysore State. The waters from these regions drain into the Kistna river.

Type-specimen.—Holotype No. F 9723/1, Zoological Survey of India (*Ind. Mus.*), Calcutta.

Remarks.—The above description is based mainly on the type-specimen from the Yenna Valley collected by the late Dr. N. Annandale. In a smaller specimen from the Koyna Valley the proportions of the various parts are different, as is also their structure, but in all essential features it seems to represent the species described above. The thoracic adhesive apparatus is considerably longer than broad and the labial grooves are not so extensive. The isthmus is also fairly wide, and the barbels are proportionately longer. The tuberculation on the skin is very faintly marked.

The Tunga river specimen, which I refer to *G. trewavasae*, is partly damaged as Mr. Bhimachar took out the brain of the fish for his studies.

Measurements in millimetres.

	Koyna Valley.	Yenna Valley, Type.	Tunga River, Shimoga.
Total length excluding caudal	44·1	97·0	113·0
Length of caudal	13·9	24·0	27·0
Length of head	11·0	25·0	29·7
Width of head	9·0	20·0	24·0
Height of head	6·0	13·0	13·0
Length of snout	5·7	12·0	17·2
Interorbital width	3·5	6·7	8·4
Depth of body	6·2	15·1	19·1
Height of dorsal fin	9·5	16·8	22·0
Length of pectoral fin	11·2	18·1	25·0
Length of ventral fin	7·9	15·5	19·0
Longest ray of anal fin	9·1	15·5	18·1
Length of dorsal spine	5·7	12·4	16·2
Length of caudal peduncle	7·7	16·7	21·2
Least height of caudal peduncle	4·5	8·2	8·1

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EXPLANATION OF PLATE VII.

Glyptothorax from South India.

FIG. 1.—Lateral view of a specimen of *Glyptothorax lonah* from the Bailadila range, Bastar State, Central Provinces. $\times 1\frac{1}{2}$.

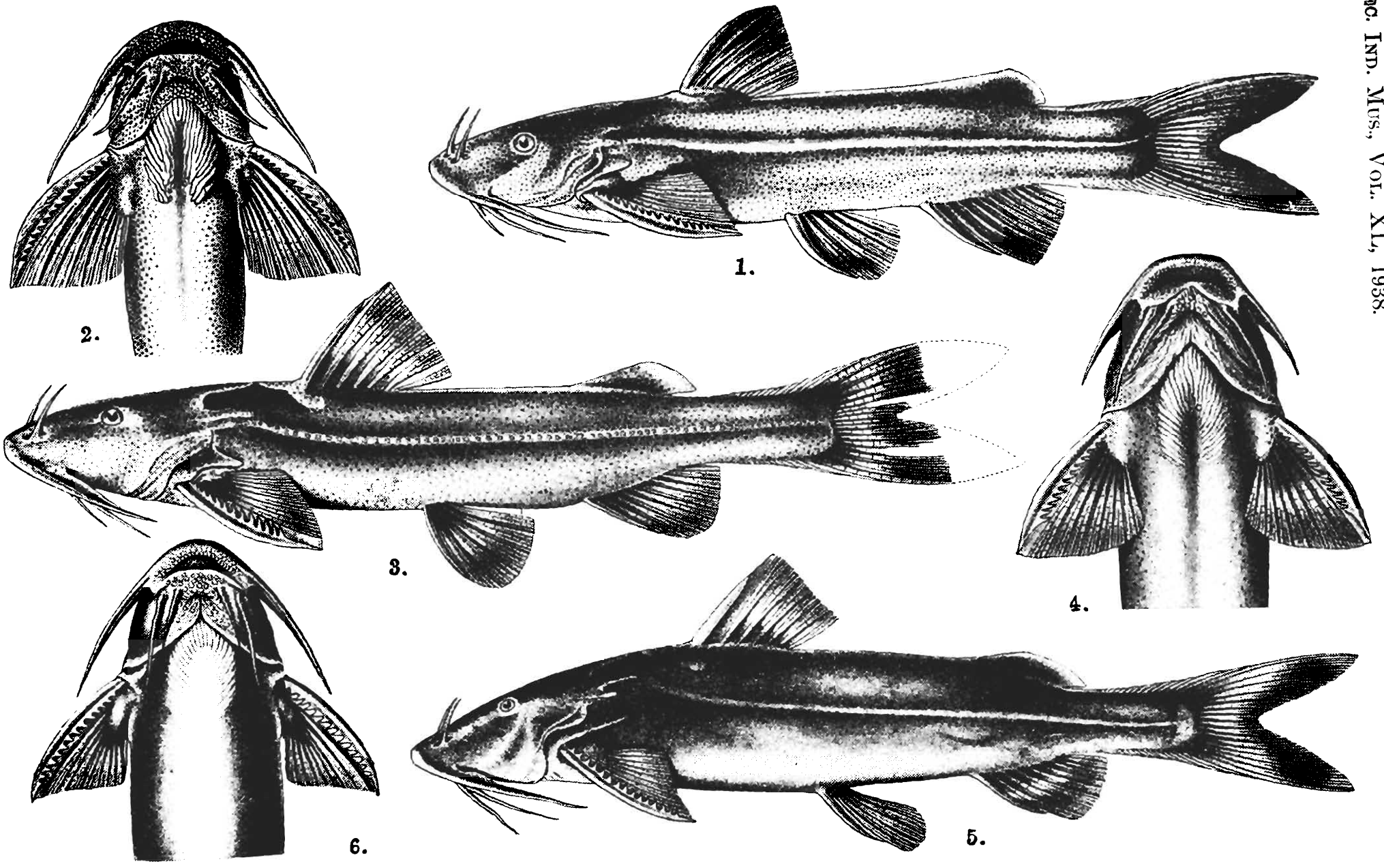
FIG. 2.—Ventral surface of head and anterior part of body of the same. $\times 1\frac{1}{2}$.

FIG. 3.—Lateral view of the Holotype of *Glyptothorax trewavasae*, sp. nov. $\times 1\frac{1}{4}$.

FIG. 4.—Ventral surface of head and anterior part of body of the same. $\times 1\frac{1}{4}$.

FIG. 5.—Lateral view of the Holotype of *Glyptothorax conirostre* var. *poonaensis*, nov. $\times 1\frac{1}{2}$.

FIG. 6.—Ventral surface of head and anterior part of body of the same. $\times 1\frac{1}{2}$.



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Glyptothorax from Peninsular India.

ON THE ECOLOGY, BIONOMICS AND SYSTEMATICS OF THE BLENNIID FISHES OF THE GENUS *ANDAMIA* BLYTH.

(Plates VIII-X.)

By H. Srinivasa Rao, *M.A., D.Sc., F.A.Sc., F.N.I.*, and Sunder Lal Hora, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendents, Zoological Survey of India, Calcutta.*

I.—Ecology and Bionomics.

By H. Srinivasa Rao.

Contents.

Introduction.

In a study of the Andaman fluviatile fish-fauna published some years ago Annandale and Hora[1] (1925) remarked that this fauna was derived mainly from adaptable marine species in recent times. While working along the coasts of the Andaman Islands in connection with the *Trochus* fishery investigation, the common occurrence of an abundant population of the Blenniid fish, *Andamia heteroptera,* only on the rocks subject to the pounding action of the breakers and nowhere else reminded me of the remarks of these authors, and induced me to record my observations on these animals not only in the field but also in aquaria in the Laboratory. As Mukerji[2] (1933), who had previously made some observations on the fish of the Andamans and published some notes on them, was keenly interested in the problem of the origin of the freshwater fauna of the Andamans, I gladly placed my collections of fish and my notes on them in his hands for study. Unfortunately, owing to his untimely and lamented death last year, the notes and the materials remained untouched. The Blenniid fishes of the genus *Andamia* collected in the Andamans have since been studied by my colleague, Dr. Hora, and his conclusions on the systematic position of the species known from the Andamans are published in the second part (*infra,* pp. 393-400). In view of the scanty observations on the habits of *Andamia,* which is so widely

[1] Annandale, N. and Hora, S. L., *Rec. Ind. Mus.* XXVII, pp. 33-41, pl. ii (1925).
[2] Mukerji, D. D., *Rec. Ind. Mus.* XXXV, pp. 121-123 (1933).

distributed in the Indo-Pacific region, Dr. Hora urged me to publish my field notes on the species observed. My thanks are due to him for this encouragement which has enabled me to bring together my scattered notes on the subject in the form of a more or less connected account.

My observations on the rock-skippers of the Andamans inclined me to the view that, sexual dimorphism apart, there were at least two distinct species within the limits of Port Blair where, mainly, observations were made. The re-examination by Dr. Hora of the material collected by me and my predecessors in charge of the *Trochus* fishery has convinced him that my surmise was correct, and in the following article he has fully described *A. heteroptera* and what, in our opinion, constitutes a hitherto undescribed species of *Andamia*.

Andamia heteroptera and *Andamia raoi* have been observed in the vicinity of Port Blair, and in Rutland I., Cinque Is., and at Port Bonington in North Andaman. My observations in the field are based mainly on the fish occurring on the rocks and piers around Ross I., and on the rocky coasts near North Point, South Point, South Corbyn's Cove (Plate VIII), and Brookesabad, all within the jurisdiction of the Port Blair settlement. The rocky shores at these places are subject to the direct action of breakers. The rocks which are found between tide-marks are uncovered by the sea at low tides, but are kept moist by a more or less constant spray from the dashing waves. The fish obtained from the coasts of Ross I., were also kept under observation in large bell-jars of sea-water in the Laboratory, and were experimented upon variously. The results of these observations and experiments are detailed in these notes.

HABITATS OF *ANDAMIA*.

The general nature of the environment in which *Andamia heteroptera* and *Andamia raoi* live does not, at first sight, appear to differ very much, but the latter species seems to prefer situations exposed to the breakers which strike with full force on the vertical face of the rocks. Under laboratory conditions *A. raoi* appears to be more active than *A. heteroptera*, more particularly the males which frequently dive to the bottom of the jar where they stay for several minutes attached to the stone and often feed on the algae growing on it. *A. heteroptera* is much less active, and rarely stays under water for long periods, but its young ones are as active as those of *A. raoi* and behave in the same way in the aquarium. It would thus appear to be far more terrestrial than *A. raoi*, and the divergence from the aquatic habitat of the closely allied species of the genus *Salarias* appears to have gone on much further in *A. heteroptera* than in *A. raoi*. It lives in groups of not less than 4 or 5, often in larger groups of 10 or more, in the fissures, crevices and pits of large massive rocks facing the surf, or on isolated rocks swept by every wave or constantly covered by the spray of dashing waves. It is found in still larger numbers on the vertical sides of deep gullies (formed by cleavages in rocks) which are within reach of the swell from the sea which rises and falls rhythmically every few seconds. Environments like those described above are common on the shores near Port Blair (Plate X, figs. 5 and 7), Port Bonington, and Cinque Is. On the Rutland I.,

however, the environment is somewhat different. At the time of my landing on the west coast of this island at 5 P.M., the tide was rising on the sandy beach. Between the beach and the jungle close by were several isolated rocks which were kept moist by the gentle rush of the ripples. On these rocks were found several young specimens of *A. heteroptera.* At low tide the following day, the inter-tidal region, which is a sandy stretch of several hundred yards in width with no rocks jutting above the sand, was without a trace of these rock-skippers. When the tide is low, the fish seem to live in crannies and pits in the rocks where, presumably, collections of sea-water are left by the previous high tide. It is probable that they lie quietly in these crevices where the moisture is sufficient to keep them alive, and come out on the surface of the rocks with the next high tide. I was, however, unable to discover any of these small fish at low tide either on or at the base of the rocks. Although cracks in the rocks were evident, I could not find the hiding places of the fish. It is not likely that the fish keep moving with the tides, as at low tide there are no rocks jutting out of the water on which they could skip about ; and experiments with *A. heteroptera* in the Laboratory show that they cannot live immersed in water for more than a few hours at a stretch.

On the western side of Ross I. there are no rocks, isolated or massive, but there is a wall of granite slabs against which the wharf and the pier rest. On this wall *A. heteroptera* occurs in fairly large numbers. When the tide is high and the wall is bathed by spray from the waves, the fish skip about on the granite slabs, resting always a few inches to 3 feet, above the water-level. When the tide is low, and the wall is not covered by a column of water, the fish seem to hide themselves in the crevices between the slabs which contain sufficient moisture to keep the fish alive till the next rise of the tide. This device of concealing themselves in fissures and crevices observed on the west coast of Rutland and Ross Is. seems to be adopted by the fish as the inter-tidal region does not provide an environment suitable for their active life when the tide is low. Their behaviour on the rocky coasts and in open bays studded with isolated rocks or massive dead corals is different. A dozen or more of the fish occupy the surface of the rocks or corals, and when disturbed they dodge cleverly from the seaward face of the rocks to the landward and *vice versa.* But when continually disturbed and cornered they skim the surface of water or swim through water to a distant rock more than a yard or so away. If the distance from one rock to another is less than a yard they jump directly from the surface of one rock to that of the other employing the tail to propel themselves in the air, and thus avoid getting into the water. As far as my observations go, these fish never seem to jump deliberately into the water, or swim, or seek food under water in their natural surroundings. When a wave suddenly strikes the rocks on which they live, the fish stick firmly to the rock-surface by means of the labial sucker and the pectoral fins which are fully spread out in the form of an open fan (Plate IX, figs. 3-5). If they are on the vertical face of a rock the head is directed upwards when sticking to it. When the sea water has completely streamed down the sides of the rock, the fish begin to move about, and continue as usual to keep well within the

area constantly kept moist by the spray. On the vertical walls of deep gulleys into which the sea water rushes in and out with every rise and fall of the wave, the fish are found in much larger numbers, often more than a hundred or so, quietly sticking to the surface of the walls and moving slowly up and down with every rise and fall of the level of sea water. When disturbed they jump into the water and swim to a more distant part of the rock-surface or skip off from one face of the gulley to the other on the opposite side. The behaviour of the fish is very similar to that of the mud-skippers, *Periophthalmus* and *Periophthalmodon.*

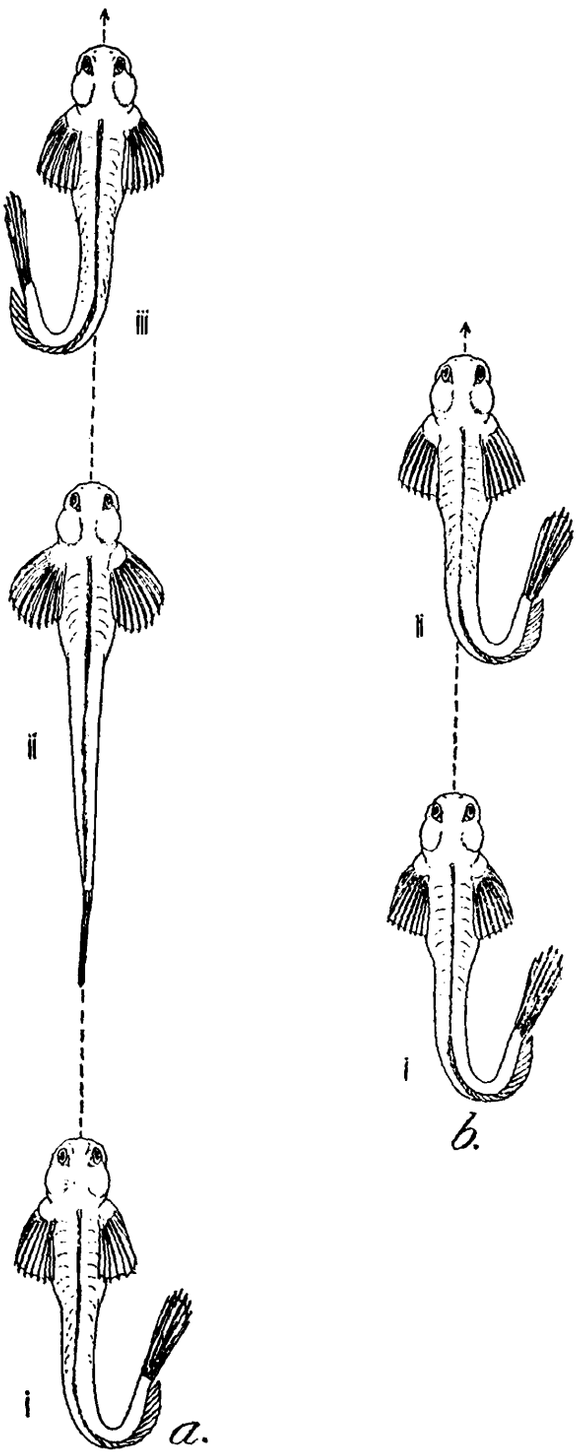
LOCOMOTION.

The locomotion of *Andamia* is of various types according to the circumstances in the environment in which they find themselves. Their active movements such as skipping, skimming the surface of water, or swimming, when disturbed by waves, by the rise of the tide, or by human beings have been referred to above. In the absence of disturbances their movements are quite different. They often adopt a shuffling gait which curiously resembles that of some of the larger reptiles or mammals. In this movement the whole of the tail takes part, and enables the fish to move either from side to side or forward. Forward progression may be effected by the flexure of the tail either on one side only (text-fig. 1*b*), or on both the sides alternately (text-fig. 1*a*), but this flexure does not involve any zig-zag movement on the part of the fish, that is to say, the new positions reached in this kind of progression are nearly always in a straight line in front of them. The pectoral and ventral fins and the ventral sucker probably assist the fish in holding on to the new positions attained, but they seem to come into full action when there is a rush of water from the sea washing the rocks or a strong surf breaking on them. This must result in dislodging them from their positions were it not for the powerful action of the fins and sucker as adhesive organs. These probably also serve as a leverage for the body of the fish in the act of skipping from place to place. Annandale and Hora (*loc. cit.*) rightly believed that the structure of the fish as a whole is modified as in hill-stream fishes to resist the swift and violent movements of water.

FEEDING HABITS.

The mode of feeding in *Andamia heteroptera* and *Andamia raoi* is of some interest. The rocks on which they live are usually covered with growths of algae. When the fish applies the mouth to the surface of the rock, it appears to expand the fleshy lips to their fullest extent so as to permit the rows of very fine golden yellow teeth in each jaw to come into contact with the algal growth. It raises its head, when the opposing rows of teeth come together holding between them a small quantity of algae which is taken into the mouth. The head is thus repeatedly moved up and down as the fish moves along on the surface of the rock. The curious movements of the head of the fish in the act of feeding suggest those associated with cattle grazing on a meadow and moving

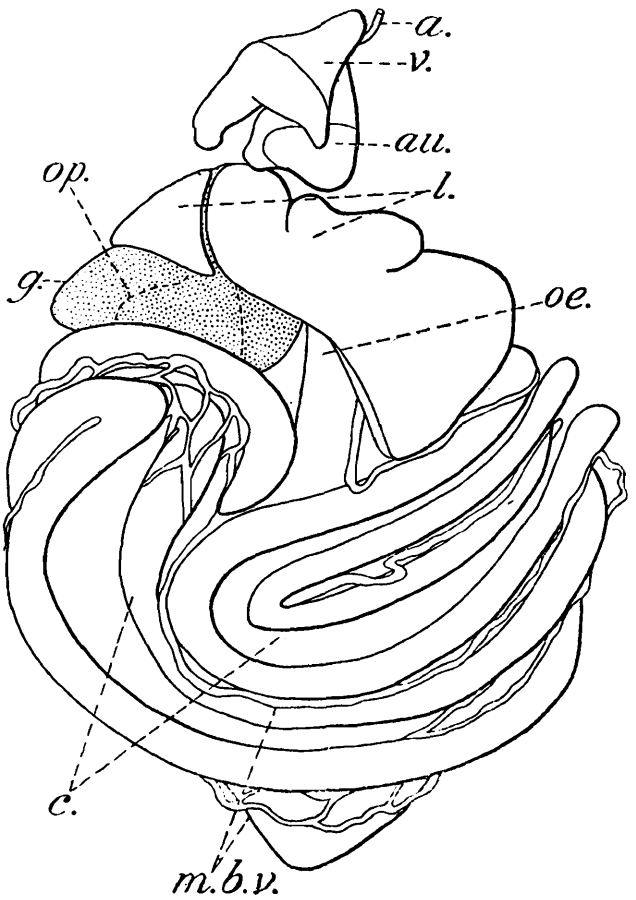
slowly along pulling wisps of grass. Another voluntary movement of these fish is also of considerable interest. While the fish are resting on



Text-fig. 1.—Sketches to show the positions assumed by *Andamia* in forward progression on rocks washed by the spray or waves from the sea. *a* (i to iii). Progression by flexure of the tail on the right and on the left alternately; *b* (i and ii). Progression by flexure of the tail on one side only.

the rocks they occasionally hold firmly the rock-surface by the tail, and roll the anterior part of the body from side to side so that the sides of the head come into close contact with the rock. This rolling movement is repeated twice or thrice in quick succession before the position of rest

is resumed. This action has again a curious resemblance to the act of scratching which one observes in mammals, and probably represents a process of cleaning or of scratching.



TEXT-FIG. 2.—View of the viscera of *Andamia heteroptera* (Bleeker) *in situ* dissected from the ventral surface. (Diagrammatic).

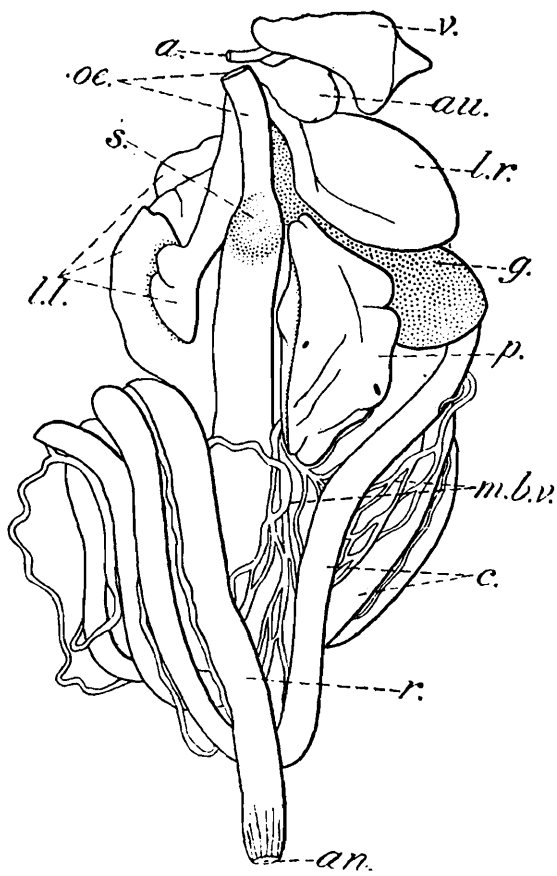
a. aorta ; *au.* auricle ; *c.* coils of the intestine ; *g.* gall-bladder ; *l.* lobes of the liver, *m.b.v.* mesenterial blood-vessels ; *oe.* oesophagus ; *op.* outline of pancreas seen through the transparent wall of gall-bladder ; *v.* ventricle.

The fish, which should be classed as a scraper, seems to feed mainly on minute algae, but microscopic animals which are found in association with the algae are also taken in while feeding. Thus among the gut-contents of several fish examined were found filamentous or lamellar algae of green, brown or pink colour, minute particles of sand, tests of Foraminifera, spicules of sponges, small Gastropod shells, small Crustacea, and worms.

While dealing with the feeding habits of the fish it will be appropriate to mention some features of the visceral organs which I have been able to observe by dissection of the freshly captured fish. The relationship of the various organs forming part of the viscera is shown in text-figures 2-5. As in all vegetable-feeding vertebrates the intestine is very long, about 3 times the body-length of the fish, and forms a complicated coil overlying the oesophagus and the rectum.[1] The heart and the aorta

[1] Ishida, J. (*Annot. Zool. Japon.* XV, pp. 158-160, 1935) records the occurrence of a band of ciliated epithelium lining a part of the intestine of the Blenniid fish, *Salarias enosimae* of Japan. The function of the ciliated part is not known. I have not been able to study the histology of *Andamia* to institute a comparison with this author's observations.

are seen immediately in front of the lobes of the brownish liver, while there are much-branched mesenterial blood-vessels lying on and between the coils of the intestine. The gall-bladder, which is a transparent green conical sac, lies concealed by the lobes of the liver and the coils of the intestine. The pancreas is a reddish body lying concealed below the gall-bladder. The stomach is a small rounded dilatation of the oesophageal part and is not seen when the fish is dissected from the ventral



Text-fig. 3.—View of the viscera of *Andamia heteroptera* (Bleeker) as seen when dist sected from the dorsal surface. (Diagrammatic).

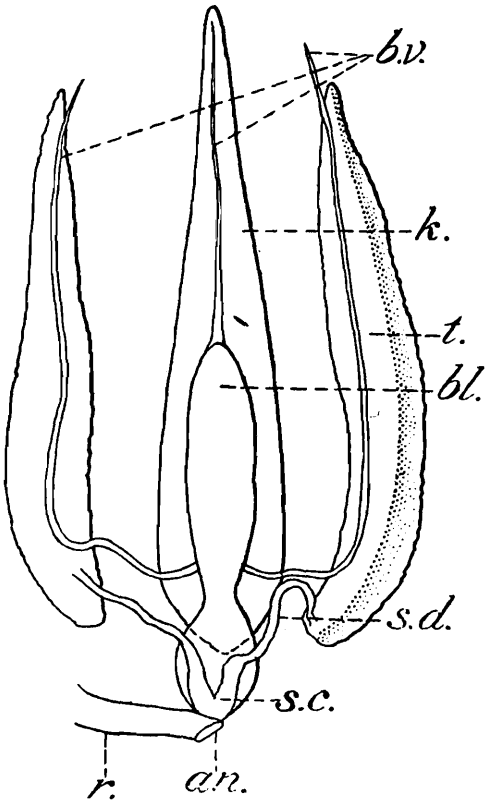
a. aorta ; *an.* anus ; *au.* auricle ; *c.* coils of the intestine ; *g.* gall-bladder ; *l. l.* left lobe of the liver ; *l.r.* right lobe of liver ; *m.b.v.* mesenterial blood vessels ; *oe.* oesophagus ; *p.* pancreas ; *r.* rectum ; *s.* stomach ; *v.* ventricle.

surface. The kidney and the gonads are lanceolate bodies lying closely packed near the vertebral column at the lower end of the peritoneal cavity. The gonoducts and the ureters are adherent to each other and to the bladder and seem to open into a small common chamber which opens into the rectum very near the anal opening. In the gravid female the ova bulge out from within on the surface of the ovary. The kidney, gonads and bladder are well supplied with blood-vessels.

Longevity, and Habits under Laboratory Conditions.

The behaviour of the rock-skippers when kept in ordinary bell-jars full of sea water was studied in the laboratory. As there were no supports for them to perch on they all repeatedly tried to adhere to the smooth, curved surface of the jar, but nearly all of them slipped

down and dropped into the water in which they swam and came back to the sides. It seemed at first that the fish congregated on the lighted

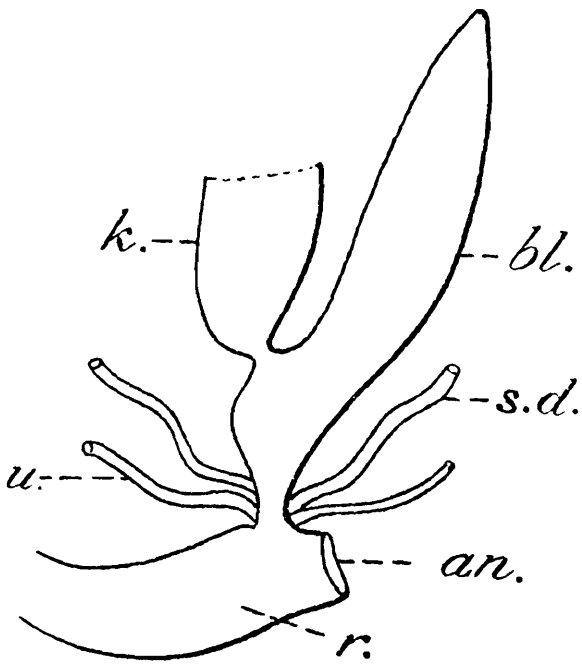


TEXT-FIG. 4.—The urino-genital system of the male *Andamia heteroptera* (Bleeker) as seen when dissected from the dorsal surface. (Diagrammatic).

an. anus ; *bl.* bladder ; *b.v.* blood-vessels ; *k.* kidney ; *r.* rectum ; *s.c.* common chamber into which spermduct and ureters open ; *s.d.* spermduct ; *t.* testes.

side of the aquarium, but on hanging a piece of wet cheese-cloth on the darker side all the fish jumped on to the cloth which presented a rough surface facilitating adhesion by means of their pectoral fin and the labial sucker. The action of the pectoral fin and the sucker when the fish were trying to stick to the glass surface was more pronounced than when the fish were perched on the cheese-cloth. The cloth was removed and small pieces of wood about 2″-3″ square were floated on the water, and small masses of algae scraped from rocks were placed on them and at the bottom of the jar. The fish promptly jumped on to the floating pieces of wood and settled in such a way that the water was just touching the anterior end of the body. They began to suck in the water by the mouth and let it out by the gill-aperture. When the cheese-cloth was hung on the sides again many of them left their positions on the wood and jumped on to the cloth. After a while they wriggled slowly and reversed their position on the cloth so that the head was again touching the surface of water. One or two of them occasionally dived to the bottom of the aquarium and nibbled at the algae. When the fish were not near the surface of water they usually lifted their head and kept it at an angle to the rest of the body. In that position the opercular chamber ceased its rhythmic pulsating movements and was bulged with air, and the fish remained quiet for several hours. In aquaria with a large mass of coral covered with algae kept in the centre with a portion

projecting above the water, the fish usually preferred to sit on the coral mass at the edge of the water, but a few occasionally jumped into the



Text-fig. 5.—The terminal portion of the rectum of the male *Andamia heteroptera* (Bleeker) showing the relationship of the various parts of the urinogenital system to one another and to the rectum. (Diagrammatic). The structures are shown slightly displaced to one side.

an. anus; *bl.* bladder; *k.* kidney; *r.* rectum; *s.d.* spermduct; *u.* ureter.

water and swam to the sides of the jar apparently in an attempt to escape from confinement, where they stuck to the glass sides by their labial sucker and pectoral fins. When exhausted by the effort of sticking to the glass they returned to the coral mass again. Some occasionally scraped the algal growth on the coral. Under the temperature and atmospheric conditions in the laboratory, the fish did not seem to live for more than a month. What the longevity of these fish is in their natural environment on the rocks washed by the spray and waves is not known. In May 1932 twenty-four large and small fish were kept in bell-jars full of sea-water and provided with an abundant supply of algae growing on pieces of coral mass, and the sea-water was changed daily. The bell-jars were placed near open windows where plenty of light and air was available. Within a fortnight they all looked famished and thin, and one by one began to die until the last survivor was found dead exactly a month later. This experiment of keeping the rock-skippers in aquaria in the laboratory was continued till the first week of August 1932, and as a rule, all the fish died within three weeks to a month.

Effect of Desiccation.

The observation of Mukerji (*op. cit.*) that *Andamia heteroptera* bask in the sun on the rocks on which they live led me to try the effect of desiccation. A fairly large specimen was kept in a dry bell-jar at 11 A.M. The fish stuck to the sides for several minutes with the opercular chamber

pulsating fairly quickly. After 3 hours the mucus on the head of the fish had dried up, and the fish slowly began to relax its hold on the sides until it dropped down to the bottom of the jar. It was gently removed to a petri-dish where it showed signs of feeble movement of the tail and the body. On placing a few drops of sea-water on the head and body, the opercular chamber began to pulsate again, but after a few minutes the fish showed signs of collapse. Immersion of the fish in a jar of fresh sea-water failed to revive it, and death ensued at 2·30 P.M., that is, after $3\frac{1}{2}$ hours of the commencement of the experiment. Probably, the process of desiccation within that period had gone on so far that recovery to normal conditions was impossible. Whatever the purpose of the basking habit observed by Mukerji, basking cannot be prolonged too long, for moisture seems to be an essential condition for all air-breathing species of fishes.

The minute ridges and grooves which form a meandrine pattern on the head, operculum, and parts of the body of *Andamia* are a characteristic feature, and it seems to me that these grooves serve to hold moisture for a much longer period than if the skin were smooth (Pl. IX, fig. 6, Pl. X, fig. 6). For fish living always outside water in the inter-tidal region, it would be a disadvantage to have a smooth skin over which the water will flow down and leave it dry in a much shorter time. These grooves and ridges are best seen, in fact, in preserved fish when the skin has been allowed to dry. The nature of these grooves in *A. heteroptera* and *A. raoi* seems also to differ. In the former species the ridges are thick and the grooves narrow, whereas in the latter the ridges are thin and the grooves broad. The skin of *A. heteroptera* seems, therefore, better fitted for holding water for a longer period, and this condition should be regarded as an advanced stage in adaptation for terrestrial life. Curiously enough, the grooves and ridges which are so characteristic of *Andamia* are absent in the closely allied Blenniid fish *Salarias* which nearly always lives in pools of sea-water.

The much-branched superficial blood-vessels forming a kind of plexus on each side of the operculum, which may be seen on the surface even in preserved specimens, suggest the possibility of a certain amount of skin respiration as well. As interchange of gases can take place only in the presence of moisture, the retention of water in the grooves would serve to maintain a certain degree of moisture on the skin of the head and operculum and assist in the process of respiration.

AERIAL AND AQUATIC RESPIRATION.

A series of simple experiments was conducted to observe the behaviour of the fish when confined in small or large quantities of sea-water in closed jars, then in open jars, and when prevented from coming up to the surface of the water. Six specimens of rock-skippers, three large and three small, were confined in a closed jar (7 lb. capacity) of sea-water. The three small ones died in one and a half hours, one large fish in three hours and 40 minutes, the second in five hours and ten minutes, and the third in five hours and fifty minutes. A specimen of *Andamia heteroptera* was kept in a large jar (7 lb. capacity) full of sea-water and the mouth of the jar was closed with a piece of mosquito-netting. This jar

was lowered into a plunger jar (18″ high and in 18″ diameter) containing sea-water which was changed every day. The fish which had gone down to the bottom of the jar did not make any attempt to come up to the netting, but remained at the bottom vigorously taking in water through the mouth and letting it out through the opercular opening. In the afternoon the fish was observed to come up to the net and attach itself by the pectoral fins and the ventral sucker. In this position it remained till late in the evening when it descended to the bottom again. On the following morning, however, the fish was found dead. In a similar experiment with three examples of fish the following were observed : The fish made several excursions from the bottom of the jar to the netting and descended to the bottom immediately, finding exit impossible. One of them, after several attempts, seemed exhausted and dropped down passively to the bottom of the jar. In all of them the movements of the operculum in the act of drawing water through the mouth and opercular chamber were unusually rapid. After seven hours of confinement in the jar the fish were removed to an open jar containing sea-water and a large piece of coral was placed in the centre with a portion projecting out of the water. The movements of the operculum had then become less rapid and finally ceased, but occasional reversion to the habit of pulsating the opercular chamber was observed in some of them. After some time the fish found convenient positions of rest on the coral mass, and the opercular movements were no longer observed. The same fish were confined in a jar on the following day. The rapid opercular movements were renewed, and after a lapse of $8\frac{1}{2}$ hours two fish died, while the third one died in the course of the night. It seems to me that in the circumstances detailed above the fish can tolerate atmospheric air normally dissolved in sea-water only for a short time, probably not exceeding 24 hours. As to what would be the behaviour of the fish if the water inside the 7 lb. jar were kept well aerated can only be conjectured. Presumably it would be similar to that observed by Hora (1935, p. 9) in the case of *Periophthalmodon schlosseri* (Pallas). The intake of atmospheric air through the medium of a moist skin and the inner vascular lining of the mouth and the pharynx does not involve any physical exertion like that observed in fish confined under water, and the aerial mode of respiration being physiologically the more advantageous, owing to the richness of oxygen in air, seems to have been adopted. In their natural habitat, atmospheric air is, therefore, another essential condition of life for these rock-skipping fish in addition to moisture that has already been mentioned.

The simple experiments of Ghosh[1] (1934) on the asphyxiation of various air-breathing fishes of Bengal show that the prevention of access to free atmospheric air was not the actual cause of the death of the fish, but the insufficiency of the volume of water containing an optimum quantity of dissolved air. Those that have retained the aquatic mode of respiration to a considerable extent survived in his experiments, although they had at the same time become adapted for aerial respiration by the development of accessory respiratory organs which enable them to live out of water for considerable periods. Fishes of the genus

[1] Ghosh, E., *Journ. As. Soc. Bengal*, (N. S.) XXIX, pp. 327-332, 1933 (1934).

Andamia, being almost terrestrial in their habits, are fully adapted for aerial respiration in the presence of moisture, but under adverse conditions can remain alive for short periods through aquatic respiration, as detailed in the above experiments. In the latter case the organs of aerial respiration presumably subserve aquatic respiration also. The spaciousness of the opercular chamber and the extraordinarily well-developed discrete gill-lamellae and pseudobranch appear to be factors concerned in this increased capacity for aerial respiration. A comparative morphological study of the opercular chamber and its structures in the Blenniid fishes would probably explain the considerable differences in the modes of respiration in different species which live in slightly varying habitats on the rocky coasts of the Indo-Pacific seas.

Hora's[1] (1935) observations support Ghosh's conclusions, but Das[2] (1937) seems to think that deprivation of the free atmospheric air is the primary cause of asphyxiation. In this connection Howell's[3] observations (1915) on the Ophicephalid fishes in the Punjab are of great interest. He has shown that the *Murral* need not come to the surface of the water to take in air if the temperature of the water remains sufficiently cold, for it is well known that water areas are saturated with air when exposed to the atmosphere and the degree of absorption varies inversely with temperature.

The buccal cavity, gill chambers, and gills in the marine and estuarine air-breathing Gobioid fishes of the genera *Apocryptes*, *Pseudapocryptes*, *Taenioides*, *Periophthalmus* and *Periophthalmodon*, and in the Blenniid fish *Andamia* act as organs of aerial respiration. Hora (*loc. cit.*, 1935) thinks that the air-breathing habit in these fish has been induced not because of the lack of oxygen in the inshore waters but by the action of the tides. The closely allied Blenniid fishes of the genus *Salarias* of which a number of species occurs on the coasts of the Andamans, seem to be in a state of transition between the aquatic and aerial modes of respiration. On the same rocks on which *A. heteroptera* live, species of *Salarias* are found in small pits on the vertical face of the rocks, in large rock-pools in which the range of temperature is between 30° C. to 33°C. in the months of March and April, and in sandy pools between coral rocks from which they never seem to come out to the exposed surface of rock masses on the shore. So, among species of *Salarias* there are those which never leave the water and consequently have aquatic respiration, and others which, although they come out of water and live in crannies, crevices and pits constantly bathed by spray from the sea, are still to be classed among fishes having aquatic respiration. The difference between these species and *Andamia*, if any, in the mode of respiration, can only be a matter of degree. No experiments have been made with these species of *Salarias*, but presumably they will suffer no ill-effects under water as do species of *Andamia*, provided it is well aerated. The fishes of the latter genus seem to have developed to a higher stage in the evolution of the air-breathing habit, and their capacity to tolerate insufficiently aerated water is distinctly inferior to that

[1] Hora, S. L., *Trans. Nat. Inst. Sci. India* I, p. 13, pl. i (1935).
[2] Das, B. K., *XIIth Congr. Internat. Zool.* II, pp. 888, 889 (1937).
[3] Howell, G. C. L, *Journ. Bombay Nat. Hist. Soc.* XXIV, pp. 195, 196 (1915).

of *Salarias*. The members of the Blenniidae are generally inhabitants of rock-pools or sandy pools in the intertidal region. The increasing deficiency of dissolved air in these pools, especially at the high temperatures which prevail during the low-tide periods, must have been a powerful factor in inducing some species to leave their stable environment in the pools for the unstable but better aerated conditions of the spray and surf which beat the rocks on the coasts. The two species of *Andamia* and one or two species of *Salarias* appear to be the few Blenniids which have left their original environment in the inter-tidal pools. In the reference cited Hora (1935) has, I believe, rightly surmised " that the conditions in the rock pools may, however, necessitate aerial respiration at times as is the case with torrential fishes"

The curious habit of *Andamia* lying passively in groups on rocks with the opercular chamber bulging out prominently on the sides suggested to me the possibility of atmospheric air being confined in the chamber and used up by the fish when they are not active at all and make no movements of the operculum such as are observed when they are confined in water. Two examples of fish freshly obtained from the rocks on Ross I. were brought to the laboratory, and with a sharp, sterilised mounted needle a tiny hole was made through the opercula on both sides of the fish. A large bell-jar with fresh sea-water was set up on a bench in the open air under the shade of a tree. Small masses of coral with growths of algae on them were heaped in the centre of the jar so that a portion of the mass was projecting above the water. The fish with the punctured opercula were left in the jar. They took up convenient positions on the coral mass facing the surface of water and made no effort to escape or to swim in the water. One of them died after an hour and a half, while the other died 4 hours after it was put into the jar. Examination of the dead fish showed that the pricking of the hole in the opercula had not caused any haemorrhage, but the bulging of the opercular chamber was not so prominent at their death as it was when they were introduced into the aquarium. Death might have ensued as a result of the escape of air from and the non-retention of fresh air in the opercular chamber. The proximity of the sea-water in the jar from which the fish, in their emergency, could have obtained their supply of dissolved air for respiration by gills was apparently no inducement for a species of fish which deliberately avoids submergence under water.

Respiration in Diluted Sea-water and in Freshwater.

The capacity of *Andamia* to tolerate dilutions of sea-water and to live in freshwater was tested by experiment. Six individuals of fish collected from the rocks on Ross I. were thrown into a bell-jar containing freshwater from the tap. All except one went down to the bottom of the jar where the pulsating action of the opercular chamber was observed. The one that remained above the surface of water made repeated attempts to stick to the sides of the jar. Pieces of wood thrown into the water did not serve as an inducement for the fish to cling to Later, a piece of cheese-cloth was hung on the sides of the jar. After a few more futile attempts to stick to the jar the fish jumped on to the cheese-cloth. Two gravid females which went down to the bottom of

the jar showed signs of exhaustion after ten minutes. The pre-anal portion of the body of the fish was observed to have swollen, and both the fish died exactly half an hour after they were in freshwater. The other three fish also indicated distress as the opercular movements were getting visibly slower, and they ceased all activity 35 minutes after being in freshwater. When the fish were touched or the water in their neighbourhood stirred, the reactions seemed to be of a reflex kind, only a few twitchings of the body being observed. All the fish under experiment were removed to a jar of sea-water. Within 5 minutes the opercular movements were resumed, and in an hour and a half the fish were able to come up to the surface and remain attached to the sides of the jar. When they had revived completely in the sea-water they were again transferred to a jar of freshwater. In about an hour the two gravid females began to show signs of distress and did not revive on retransference to fresh sea-water. One male specimen died in two hours. The last survivor, a male, was transferred to a jar of sea-water and left there over-night, but was found dead on the following morning. The specific gravity of the coastal waters of the Bay of Bengal is known to be about 1·0270 but in the Andamans which receive considerable rainfall during both the monsoons, it may vary from 1·015 to 1·027.

In the next experiment with five more individuals the effect of gradual dilution of a known quantity of sea-water with freshwater was observed. Three litres of sea-water were taken in a bell-jar and a coral rock with algal growth was placed in the centre so that a portion was projecting above the water. The experiment was commenced on November 4, 1932 and concluded on December 10, 1932. The volume of sea-water was kept constant, but that of the freshwater added everyday was increased as shown below :—

Dates of Experiment.	Quantities of freshwater in cubic centimetres.	Remarks.
NOVEMBER.		
4	20	
5	30	The volume of freshwater added was increased by 10 c. c. everyday.
6	40	
7	50	
8	70	The volume of freshwater added was increased by 20 c. c. everyday.
9	90	
10	110	
11	130	
12	150	
13	170	
14	190	
15	210	
16	230	
17	250	
18	270	Colour of fish paler than usual.
19	300	The volume of freshwater added was increased by 30 c. c. everyday.
20	330	
21	360	

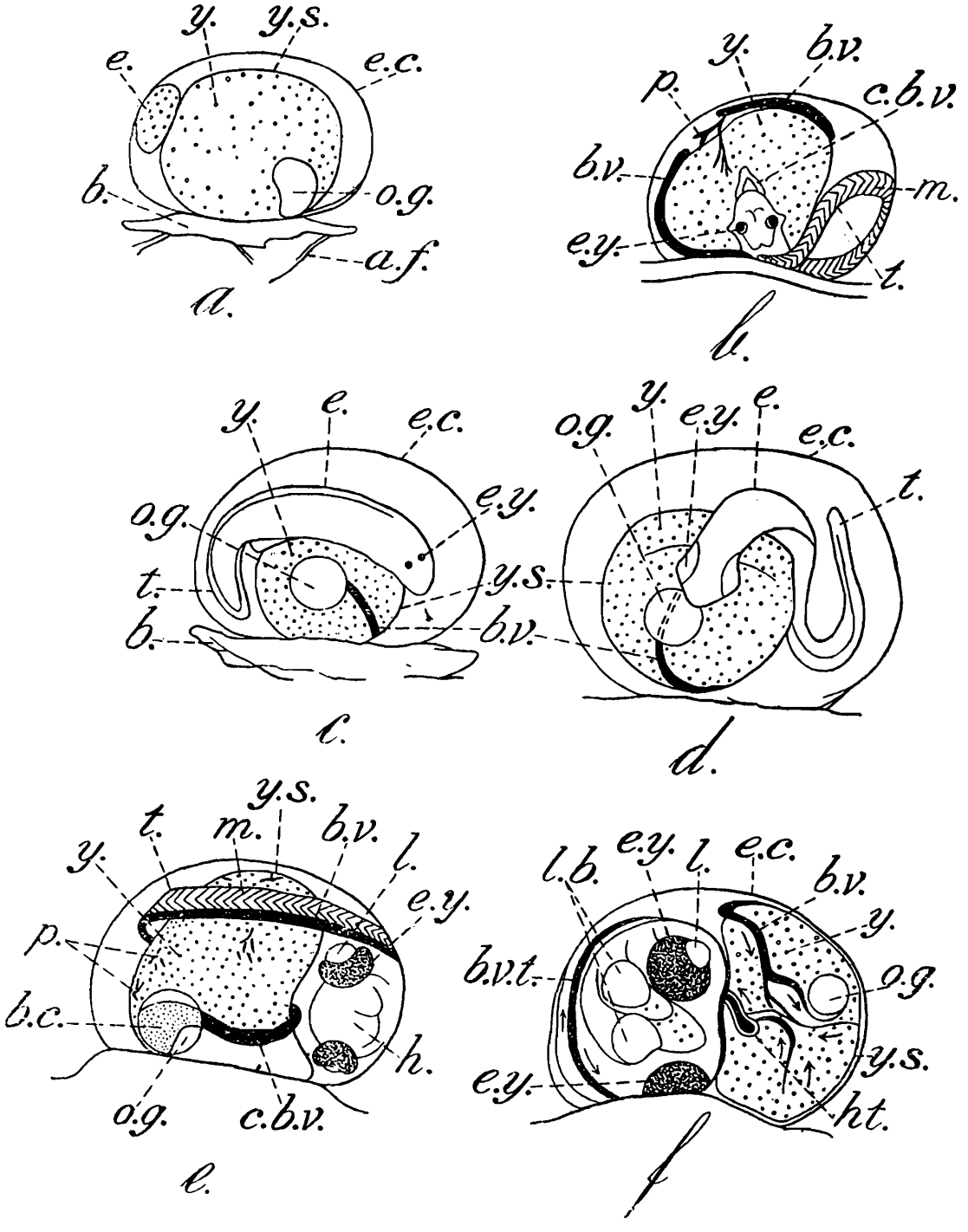
Dates of Experiment.	Quantities of freshwater in cubic centimetres.	Remarks.
NOVEMBER.		
22	400	The volume of freshwater added was increased by 40 c. c. One fish died.
23	450	The volume of freshwater added was increased by 50 c. c.
24	500	Second fish died.
25	560	The volume of freshwater added was increased by 60 c. c. Third fish died.
26	630	The volume of freshwater added was increased by 70 c. c. everyday.
27	700	
28	780	The volume of freshwater added was increased by 80 c. c.
29	880	The volume of freshwater added was increased by 100 c. c.
30	1,000	The volume of freshwater added was increased by 120 c. c.
DECEMBER.		
1	1,100	The volume of freshwater added was increased by 100 c. c. everyday.
2	1,200	
3	1,300	
4	1,400	
5	1,500	
6	1,600	
7	1,700	
8	1,800	Fourth fish died.
9	1,900	
10		Last fish found dead.

After two weeks in the gradually diluted sea water in the jar, the fish had turned paler in colour, and grown appreciably thinner. After 18 days the fish began to die one after the other, the first after 18 days, the second and third after 20 and 21 days respectively. The fourth fish died on the 34th day and the fifth on the 36th day. The normal activities of the fish of seeking food on the coral mass, or of splashing into the water at intervals, presumably, to moisten the opercular chamber, and of the assumption of a quiescent attitude for longer intervals did not seem to have been in any way interfered with by the dilution of sea-water, and two at least of the five fish with which the experiment was started lived for over a month which is the normal period of the life of this species under laboratory conditions.

Breeding and Development.

The breeding season of *Andamia* seems to be fairly extended. I have observed eggs being laid in the laboratory from September to December, gravid females from December to March, and young ones of various sizes practically throughout the year. It is quite probable that *Andamia* is a continuous breeder. Eggs laid in the laboratory in the months of September and October failed to develop. In November 1932 several freshly caught *Andamia heteroptera* from the rocks on Ross

I. were kept in laboratory aquaria. On the day following their confinement in jars several small groups of eggs, two to twelve or more in a group,



TEXT-FIG. 6.—Diagrams of the developing embryos of *Andamia heteroptera* (Bleeker) inside eggs.

The eggs were laid on 23.xii.32, and the embryos were sketched on the 5th and 6th days after the eggs were laid. Stages *a*, *b* and *e* were sketched on 28.xii.32, and stages *c*, *d* and *f* on 29.xii.32.

a. f. algal filaments attached to the basal chitinous plate of the egg; *b.* basal chitinous plate by which the egg is attached to the rocks; *b.c.* blood-corpuscles; *b.v.* blood-vessel; *b.v.t.* blood-vessel of the tail; *c.b.v.* contractile portions of blood-vessel; *e.* embryo; *e.c.* egg-case of chitinous material; *e.y.* eye; *h.* head; *ht.* heart; *l.* lens of the eye; *l.b.* lobes of the brain; *m.* myotomes; *o.g.* oil globule; *p.* branching streaks of black pigment; *t.* tail; *y.* yolk granules; *y.s.* yolk sac.

were found deposited amongst the algal growths on the coral mass. They were firmly sticking to the algal strands by a broad basal chitinous plate. Each egg was enveloped by an outer tough minutely sculptured membrane

and an inner thin covering within which yolk granules and a large yellow oil-globule were present. Four days after the laying of the eggs, development was noticed in some of them. One was apparently an early stage : the large oil-globule in the egg had been broken up into finer globules and the yolk granules had turned opaque ; the other was a more advanced stage in which the embryo had fully developed head and tail, large eyes, and the yolk granules were greatly reduced in number and occupied only half the space inside the ovum. In the month of December 1932 again the fish kept in the laboratory laid 30-40 eggs in groups of three or more. The embryos were in different stages of development (text-fig. 6). In the more advanced stages the eyes were prominent, the heart was tubular and contractile, the veins and arteries on the tail could be distinguished by the direction of the flow of blood, and the lobes of the brain were prominent. Streaks of black pigment were found here and there on the body. Some embryos were seen to turn occasionally over the yolk sac. Some of the stages observed are shown in text-figure 6.

II.—Systematics.

By Sunder Lal Hora.

Contents.

Introduction.

In 1858, Blyth described a small collection of fish made at Port Blair, Andaman Islands, and remarked that among the fishes " the most remarkable is a curious new genus of the Blenny group, with broad expanded pectorals, thrown out as in the loaches of the genus *Homaloptera* " The new genus was christened *Andamia*, and characterised as follows :—

" Form elongated, with large expanded pectorals and caudal, and a long serrated anal which is also permanently expanded ; the ventrals short, even with the pectorals, and consisting each of an outer simple ray and an inner divided ray, which are separated nearly to the base. Head depressed, with rather small eyes, placed vertically, and distantly apart ; the mouth opening downward, and furnished with a remarkable labial apparatus : in front it is covered by a thin overflapping upper lip, which is connected laterally by a plicature with a fold or flap of membrane underneath, at a short distance from the mouth behind it : minute marginal teeth in both jaws, which are perceptible to the touch as a slight asperity. Dorsal fin extending the whole length of the back, becoming higher on its posterior half ; its spinous and soft rays not easily distinguishable, and the second and third rays are a little elongated in the males (at least of the species described, which also has a small palmated appendage over each eye)."

Günther (1861, p. 294) recognised *Andamia* as a distinct genus among the Blenniidae, but he characterised it after Blyth and remarked that he had no opportunity of seeing any specimens of this genus.

Day (1869) also recognised Blyth's genus and species as valid, and redescribed the latter from " Many specimens, up to $3\frac{1}{2}$ inches in length,

exist in the Calcutta Museum. All were received from the Andaman Islands" Later he (1870, 1873) extended its range to the Nicobar Islands, but in his *Fishes of India* (1876, p. 336) he assigned Günther's (1861, p. 253) *Salarias aequipinnis* to the synonymy of *Andamia expansa* Blyth, and thus further extended the range of the genus from "Andamans and Nicobars to Amboina" Day also noted that Blyth's species "appears to be nearly related to *Salarias* or *Alticus heteropterous*, Bleeker, which however is said to have D. 14/21, A. 26-27, and no mention is made of the labial sucker. There are specimens from Amboina both in the British and Berlin Museums. Some of those in the former are the types of *Salarias aequipinnis*, Günther." In the *Fauna* volume, however, he (1889) definitely recognised Bleeker's species and assigned both Blyth's *expansa* and Günther's *aequipinnis* to its synonymy. Weber (1909, 1913), in his description of the new species, *Andamia cyclocheilus* from West New Guinea, refers to the systematic position of Bleeker's *Salarias heteropterus* and agrees with Day that it is synonymous with *Andamia expansa* Blyth. He distinguished his new species from that of Blyth mainly on the form of the disc, but Mukerji (1933) showed that Weber's species is identical with the Andaman form. Annandale and Hora had previously, on the authority of Mr. J. R. Norman, combined *Salarias heteropterus* Bleeker, *Andamia expansa* Blyth and *Salarias aequipinnis* Günther into one species. It would thus appear that *Andamia*, as recognised at the present day, is a monotypic genus.

Mr. Norman has very kindly re-examined the typical specimens of *Salarias aequipinnis* Günther with the help of the key given below and favoured me with the following report :—

"Unfortunately the matter is not too easy as the two type specimens of *Salarias aequipinnis* Gthr. are in a very soft condition and any measurement of the eyes or interorbital region is therefore quite impossible. I am able to give the following information, however, about these two specimens of which I should be inclined to select the larger, slightly better preserved, one as the type. This is 70 mm. in total length and 56 mm. standard length, all the dorsal spines are more or less produced beyond the membrane of the fin, the second spine being definitely prolonged. There is no trace of a crest on the head ; the anal fin has a dark brown longitudinal band running along the whole of its length with a pale basal area below it and above it. Testing this specimen on your key there seems to be very little doubt that it runs down to a ♂ *Andamia expansa*. The second specimen has a total length of 64 mm. and a standard length of 53 mm. The dorsal fin membrane is very much damaged and broken but it is perhaps possible that the spines were more or less produced beyond the membrane, although it is quite impossible to be certain about this. There is no crest on the head and the anal fin is uniformly pale. Thus this specimen is most likely to be a ♀ *Andamia expansa* but might possibly be the ♀ of your other species.

In the light of this report it seems that the previous conclusion was correct and that *Salarias aequipinnis* Gthr. is a synonym of *Andamia expansa*."

During the period from 1930 to 1935, when the Zoological Survey of India was in charge of the *Trochus*-shell fishery investigations in the Andamans, large collections of marine animals were made by the successive parties of the Department, and at my request special attention was paid to the ecology and biology of *Andamia*. Consequently, a great deal of material was also collected, mainly from the Ross Island. Dr. H. S. Rao, who was in charge of the Fishery for a little over three years, and had thus opportunities to observe the Blenniid fishes in various environments in different parts of the Andaman Islands, found that he could group the *Andamia* of the Andaman waters into two species,

but for a considerable time it was found difficult to separate them by any well-marked morphological characters. A systematic detailed study of the material has, however, revealed that Dr. Rao's surmise was correct and that the two species may be differentiated by the following characters :—

I. Dorsal spine not forming filamentous prolongations beyond the membrane (Anal fin without extensive black spots or colour in its middle or basal half)	*A. heteroptera* ♀.
II. Dorsal spines, especially the second, forming filamentous prolongations beyond the membrane.	
A. Anal fin without extensive black spots or colour in its middle or basal half ..	*A. raoi*, sp. nov. ♀.
B. Anal fin with extensive black marks in its middle or basal half, or whole fin black with only tips of spines white.	
1. A prominent crest on head (dorsal spines greatly produced) ..	*A. raoi*, sp. nov. ♂.
2. No crest on head (dorsal spines moderately produced)	*A. heteroptera* ♂.

In the above key use is made of only the secondary sexual characters of the two species and in consequence these diagnostic features are not applicable to very young specimens. It has, however, been found that as a rule the interorbital space of *A. heteroptera* is about four-fifths of the diameter of the eye, while it is half or less than half of the diameter of the eye in *A. raoi*. Another character by which the two species may sometimes be separated is the presence of small rounded or oval white spots on the head and anterior part of the body in *A. raoi* ; sometimes two white broad streaks also radiate from the eye to the maxillary groove in *A. raoi*. Such colour markings are absent in *A. heteroptera*. In view of abundant fresh material, *A. heteroptera* is also described here along with the new species.

In the earlier accounts no mention is made of the precise habitat of *Andamia* and for this reason Annandale and Hora (1925, p. 41) could only surmise, after a study of the adhesive organs of the fish and the convergence they show to the similar structures found in fishes of torrential streams, that " It is probably a fish of rocks in the surf-line or of the shores of islands and is evidently modified for resistance to rapid-flowing water of marine waves."

In February 1930, Dr. Baini Prashad and myself went to the Andamans in connection with the *Trochus*-shell fishery, and observed for the first time the actual habitat and behaviour of *Andamia*. The results of these observations were communicated to the Ordinary Monthly Meeting of the Asiatic Society of Bengal in August 1932 (*vide* Hora 1932), and a somewhat more detailed account of its bionomics and habitat was published a year later (Hora 1933). Mukerji (1933, p. 123) also published a short note on the habits of the fish, and in 1935 I commented on the aerial respiration of the species. The observations so far recorded are of a sketchy nature, but in the preceding pages (pp. 377-393) Dr. H. S. Rao presents a detailed study of the bionomics of the two species of the Andaman Islands. Further work on the morphology of the respiratory and adhesive organs of this remarkable Blenniid is likely to throw considerable light on the probable mode of evolution of the various adaptations found in these fishes.

The systematic position of *Andamia* was discussed by Annandale and Hora (1925, p. 39), who disagreed with Jordan (1923, p. 233) and retained the genus in the family Blenniidae. Observations on the living fish have clearly indicated that the immediate ancestors of *Andamia* were probably *Salarias*-like forms. In fact, the inclusion of the specimens of *Andamia* by Bleeker (*Salarias heteropterous*) and Günther (*Salarias aequipinnis*) in the genus *Salarias* shows its great similarity to the members of the latter genus. The limits of the two genera, as already noted by Day (1876), can be demarcated by the presence or absence of the labial disc.

The two species of *Andamia* are described below from the extensive fresh material now available.

Andamia heteroptera (Bleeker).

(Plate IX, figs. 1-6.)

1857. *Salarias heteropterous*, Bleeker, *Act. Soc. Sci. Indo-Neerl.* II, pp. 65, 66.
1857. *Salarias heteropterous*, Bleeker, *Nat. Tijdschr. Ned. Ind.* XIII, p. 372.
1858. *Andamia expansa*, Blyth, *Journ. As. Soc. Bengal* XXVII, p. 271.
1861. *Salarias aequipinnis*, Günther, *Cat. Fish. Brit. Mus.* III, p. 253.
1861. *Andamia expansa*, Günther, *Cat. Fish. Brit. Mus.* III, p. 294.
1869. *Andamia expansa*, Day, *Proc. Zool. Soc. London*, p. 518.
1870. *Andamia expansa*, Day, *Proc. Zool. Soc. London*, p. 695.
1873. *Andamia expansa*, Day, *Rep. Sea Fish & Fisheries India and Burma*, p. ccli.
1876. *Andamia expansa*, Day, *Fish. India*, p. 336, pl. lxxi, fig. 2.
1889. *Andamia heteroptera*, Day, *Faun. Brit. India*, Fish. II, p. 323, fig. 104.
1909. *Andamia cyclocheilus*, Weber, *Notes Leyden Mus.* XXXI, p. 143.
1913. *Andamia cyclocheilus*, Weber, *Siboga-Expeditie Monograph.* LVII, p. 538, pl. iii, fig. 3.
1925. *Andamia heteroptera*, Annandale & Hora, *Rec. Ind. Mus.* XXVII, p. 39.
1933. *Andamia heteroptera*, Mukerji, *Rec. Ind. Mus.* XXXV, p. 121.

D. 35 ; A. 26-27 ; P. 14-15 ; V 3 ; C. 14-15.

The body is elongated and narrow ; the head and the anterior part of the body are somewhat depressed while the tail region is compressed. Both the profiles are almost straight ; the body only tapering slightly towards the posterior end. The head is relatively short and broad ; the snout is rounded and overhangs the mouth. The length of the head is contained from 5·2 to 5·8 times in the length of the body without the caudal ; the width of the head is only slightly less than its length. The eyes are dorsolateral in position and are not visible from the ventral surface. The supraorbital rim is provided with a small, palmate appendage. The eyes are somewhat smaller in the males and larger in the females ; the diameter of the eye is contained from 3·0 to 3·3 times in the length of the head in the females and from 4·0 to 4·3 times in the males. The interorbital space is usually equal to four-fifths of the diameter of the eye, but in some cases it may be equal to it. There are some open pores round the eyes and in the interorbital space. The nostrils are small, separate and situated in front of the inner border of the eyes ; the anterior nostril is the larger of the two and is provided with a small, almost indistinguishable, unbranched appendage ; the posterior nostril is much smaller and is represented by a shallow circular pit. There is no appendage at the nape and the males are not

provided with a crest. The mouth is large, extending across the entire width of the snout ; it is almost straight and horizontal. The anterior lip and jaw are overhung by the rostral flap which is distinctly fringed. The lower lip is fleshy and coarsely fringed. The lips are continuous and folded at the angles of the mouth forming a sort of a frenulum to permit the distension of the mouth. Behind the posterior lip the skin is hardened to form a labial disc which is oval in outline and free at the posterior end. At the angles of the mouth there is a deep V-shaped groove. The jaws are provided with a series of closely-set, small, golden coloured, elongated teeth. As a rule, the gill-chambers form conspicuous bulgings outwards. The gill-openings are extensive and the gill-membranes are united across the isthmus. The membranous flaps of the gill-covers are short, but well-marked.

The body is apparently smooth, but under a magnifying glass it appears to be finely grained. The depth of the body, which is a very variable character and suffers greatly through preservation, is contained from 8·5 to 10·8 times in the standard length. The lateral line is absent, but anteriorly it may be represented by a few small open pores on the head above the gill-openings.

The dorsal fin commences above the base of the pectoral and extends almost to the base of the caudal from which it is, however, distinctly separated. There are no branched rays in the fin and in most cases it is difficult to separate the two portions of the dorsal fin. The tips of the spines are usually produced beyond the membrane to a very slight extent, but in the males these spines are produced into filamentous prolongations some of which may even exceed the length of the head. The second spine is usually the longest. Leaving the prolongations aside, the anterior portion of the fin is lower than the posterior part. The anal fin is also extensive ; it is much lower than the dorsal and extends to the base of the caudal from which it is distinctly separated ; its rays, in which the tips are free, increase in length posteriorly. The pectoral fin is broad and fan-shaped ; it is considerably longer than the head and can be divided into a horizontal and a vertical portion. The rays of the horizontal portion are thickened and flattened and are no doubt used for adhesion. The fin possesses a well developed muscular base. The ventrals, though small, are somewhat fleshy and thickly padded for adhesive purposes ; they are composed of two broad and flexible spines and a ray which is divided to the base. The bases of these fins are only slightly behind the commencement of the pectoral. The caudal fin is provided with unbranched rays which project beyond the membrane ; it is almost rounded, but the central rays are sometimes considerably longer than the outer rays.

Colouration.—In young specimens the colour is plumbeous above and the body is marked with somewhat pale mottled vertical bands on the sides. The sides of the head and the anterior part of the body are studded with minute dusky specks. The dorsal fin is dusky with the anterior 2 or 3 rays dark ; the anal fin is whitish with a dark spot on each ray. The rays of the caudal fin are much darker than the interspaces between them. In very small specimens the colours are considerably lighter, but in adult specimens there is well marked

sexual dimorphism as regards colouration. In a male specimen, about 87 mm. in length, the body is still distinctly banded but the markings are very irregular and diffuse. The anal fin, with the exception of the tips of spines, is deeply stained with black. The dark colour of the anal fin is continued on to the lower portion of the tail fin. The dorsal fin is also dusky but its anterior half is much darker than the posterior half. In the females the colour is more uniformly grayish and the vertical bands are not so clearly marked. The anal fin continues to exhibit the juvenile colouration. The lower portion of the caudal, and the edges of the pectoral and dorsal fins are whitish.

Sexual Dimorphism.—In the case of the males attention has been directed to the prolongation of the rays by all the earlier authors, but the dark colour of the basal portion of the anal fin is also an important character of ripe males. In fact, the development of these two characters is very closely correlated. Besides these two principal characters, the males possess relatively smaller eyes and longer snout.

Distribution.—Andamans, Nicobars, Amboina and New Guinea. In the preceding section Dr. Rao has indicated the types of habitat in which the fish lives (*see* pls. IX, fig. 5, and pl. X, figs. 5 and 7). As surmised by Annandale and Hora (1925) it lives on rocks in the surf-line where it is constantly washed by spray or by breakers.

Measurements in millimetres.

	♂	♂	♂	♂	♀	♀	♀	♀
Total length without caudal	76·0	68·0	67·0	64·0	56·0	55·0	52·0	50·0
Length of head	13·0	12·0	12·0	12·0	10·0	10·0	10·0	9·0
Width of head	12·5	11·0	11·0	10·8	9·0	9·0	8·5	8·5
Depth of body	7·0	6·5	6·5	7·5	6·0	6·0	5·0	5·0
Diameter of eye ..	3·0	3·0	3·0	3·0	3·0	3·0	3·0	3·0
Length of snout ..	4·0	3·5	4·0	3·0	3·0	3·0	3·5	3·0
Interorbital width ..	3·0	2·5	2·5	2·5	2·5	2·2	2·5	2·0
Length of pectoral	16·0	15·5	15·5	14·5	14·0	13·0	11·0	10·5
Length of ventral ..	6·0	5·0	5·0	5·0	4·5	4·5	4·0	4·0

Andamia raoi, sp. nov.

(Plate X, figs. 1-4, and 6.)

D. 34 ; A. 25-26 ; P. 15 ; V 3 ; C. 13.

In its general facies and proportions the new species of *Andamia* is very similar to *A. heteroptera*. The length of the head is contained from 5·3 to 5·7 times in the standard length ; the width of the head is almost equal to its length. The eyes are much more approximated dorsally and project in sockets more prominently. The supraorbital rim is provided with a small, fleshy, palmate appendage. In the males there is a thick, triangular, fleshy crest which commences behind the eyes and extends to the termination of the head. The eyes are somewhat smaller in the males than in the females ; the diameter of the eye is contained from 3·6 to 3·7 times in the length of the head in the males and from 3·0 to 3·2 times in the females. The interorbital space is about half the diameter of the eye. The open pores on the head and

nostrils are similar to those of *A. heteroptera*. The form and structure of the mouth, lips, teeth and gill-openings are similar to those found in *A. heteroptera*; the lips, however, are not so distinctly fimbriated. The body is somewhat more robust ; its depth being contained from 8 to 9 times in the standard length.

The general form and disposition of the fins are more or less similar to those of *A. heteroptera*. In *A. raoi*, however, the second dorsal spine is elongated in both the sexes, and, as a rule, the dorsal spines are greatly produced in the males but less so in the females.

Colouration.—In very young specimens the body is very distinctly banded, but in the grown-up specimens the body is indistinctly marked or is uniformly grey. The anterior half of the dorsal is darker ; base of anal fin and the lower edge of the caudal fin are intensely black in the males. In the interspaces between the rays of the dorsal fin, on the head and the anterior part of the body there are usually a number of white spots. In some specimens these markings are wanting. Two white, broad streaks, usually radiate from the eye and extend obliquely to the side of the head. In the female examples, which are generally smaller, the vertical bands on the body are somewhat more distinct.

Dr. Rao made the following observation on the colouration of the living specimens :—

" The female of *Andamia raoi* is generally smaller than the male[1]. The dorsal surface is of a dark-gray colour, while the ventral is of a much lighter shade, and the sides are a pale steel-blue in colour. Seven to nine indistinct broad vertical bands of a deeper shade than the ground colour of the body are present on the sides. A row of white spots commencing from each external nares and round the front part of the eye is continued between the eyes up to the base of the anterior part of the dorsal fin. This, however, does not appear to be a constant feature in all the specimens examined.

" A similar row on each side commencing from the side of the operculum is continued up to a point some distance below the 9th or 10th dorsal ray. A semi-circular orange-coloured band commencing from the base of the cockscomb-like ocular process surrounds the outer margin of the eye. A series of small sensory pits is present round the eye, and also on each side commencing opposite the corner of the mouth and the sucker, and running along the middle of the operculum to the upper part of the base of the pectoral fin. The ventral fin has 3 rays, the innermost bifid near the tip. The second dorsal ray is elongated and reddish in colour. The male of *Andamia raoi* is relatively large and stout, and the ground colour of the body of a slightly deeper shade than that of the female. The dorsal, anal and caudal fins are of a darker shade, the membrane between the rays being pale yellow or white. The reddish rays of these fins are all prolonged beyond the membrane, the second dorsal being the longest of the series. The white spots on the head are confined to the front portion of the eye and the middle of the operculum. A white band runs obliquely from behind each eye skirting the orange band and ends behind the fold of the skin of the upper jaw at the corner of the mouth. A stout and prominent crest with its extremity of a steel-blue colour extends from behind the eyes to the posterior margin of the head. The crest is proportionately small in the younger males. The sensory pits on the head and the operculum are smaller. The male is more active than the female, and often erects the front half of the dorsal fin while perched on a rock which is not within reach of the surf."

Sexual Dimorphism.—Besides the characters showing sexual dimorphism as in the case of *A. heteroptera*, attention must here be directed to the possession of a well-developed crest by the males. The development of the crest, the prolongation of the dorsal rays and the intensity of the black colour at the base of the anal fin are closely correlated features. The males possess relatively small eyes and a long snout as compared with the females.

[1] Mukerji (*loc. cit.*) observed that the females of *A. heteroptera* were also smaller than the males.

Distribution.—The majority of the specimens in the collection are from the east side of the Ross Island in the Andamans. There are also a few specimens from North Bay and S. Corbyn's Cove in the Andamans.

As explained above by Dr. Rao (*vide supra*, pp. 378,379) this species lives on rocks which are either actually beaten by the waves or washed by the swell of the sea, and are in consequence more difficult to collect. *A. heteroptera* is thus more terrestrial in its habits than *A. raoi*.

Type-specimen.—Holotype No. F 12933 /1, *Zoological Survey of India, Indian Museum, Calcutta.*

Measurements in millimetres.

	♂	♂	♂	♂	♀	♀	♀	♀
Total length excluding caudal ..	73·0	69·0	67·0	65·0	60·0	55·0	54·0	48·0
Length of head	13·0	12·0	12·0	12·0	10·5	10·0	10·0	9·0
Width of head ..	13·0	12·0	12·0	11·0	10·0	9·5	9·0	8·5
Depth of body ..	8·5	8·5	7·0	7·5	7·0	6·0	6·0	6·0
Diameter of eye	3·5	3·3	3·3	3·3	3·3	3·3	3·3	3·0
Length of snout	5·0	4·0	4·0	4·0	3·5	3·5	3·5	3·0
Interorbital width	2·0	1·5	1·5	1·6	1·5	1·5	1·5	1·4
Length of petoral	16·0	15·5	15·0	15·0	11·5	13·0	12·5	11·0
Length of ventral	7·0	6·0	6·0	5·3	6·0	5·0	5·0	4·0

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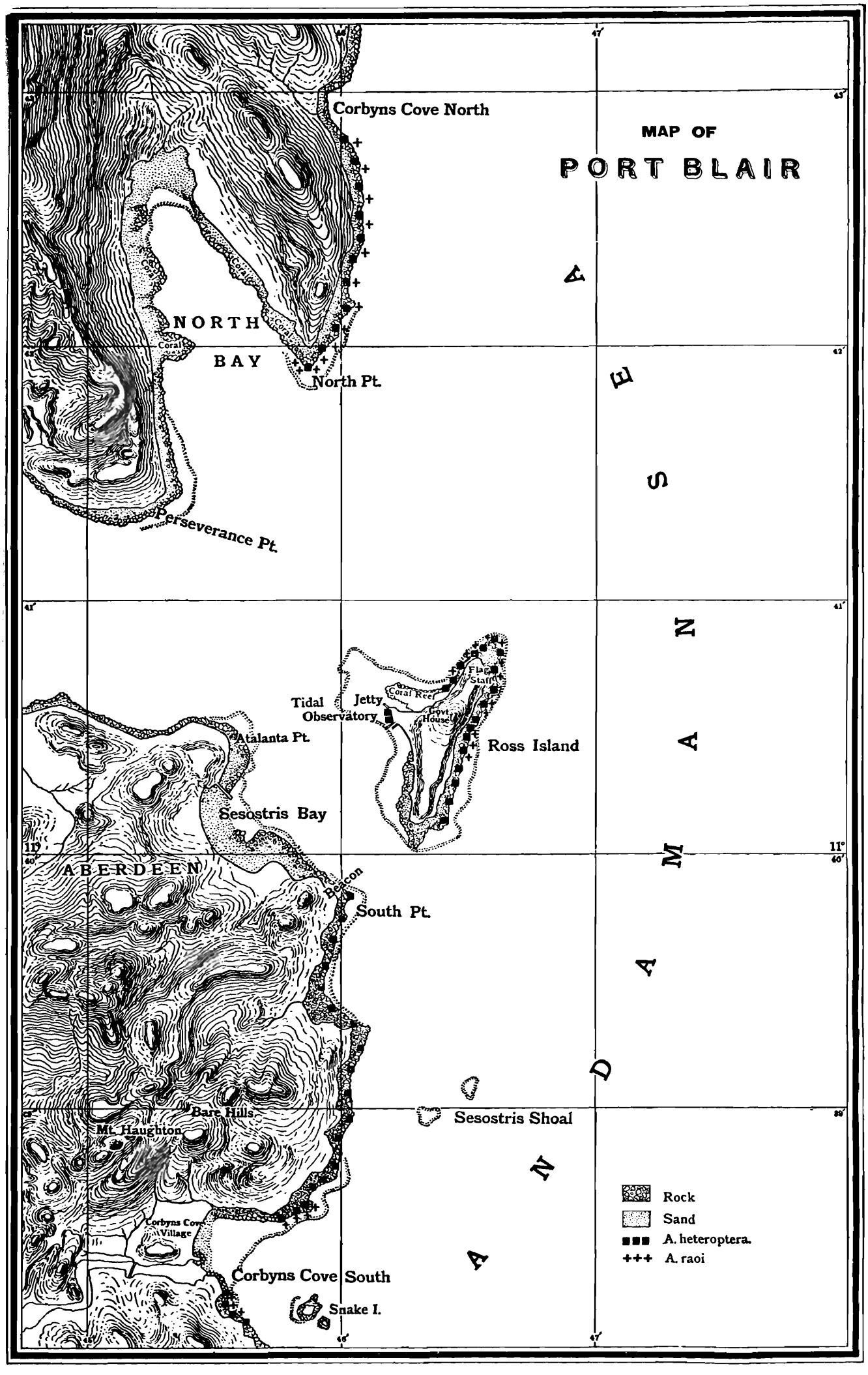
EXPLANATION OF PLATE VIII.

Map of the coastal region of Port Blair.

This map shows the configuration of the coast-line with the rocky and sandy portions marked, and the positions in which the two species of *Andamia* occur.

Square solid blocks (■) indicate the observed distribution of *A. heteroptera* (Bleeker) and plus signs (+) that of *A. raoi*, sp. nov.


MAP OF
PORT BLAIR
Corbyns Cove North
NORTH
BAY
North Pt.
Perseverance Pt.
Flag Staff
Coral Reef
Tidal Observatory
Jetty
Govt House
Ross Island
Atalanta Pt.
Sesostris Bay
ABERDEEN
Beacon
South Pt.
Bare Hills
Mt. Haughton
Corbyns Cove Village
Corbyns Cove South
Snake I.
Sesostris Shoal
ANDAMAN SEA
Rock
Sand
A. heteroptera.
A. raoi

EXPLANATION OF PLATE IX.

Andamia heteroptera (Bleeker).

FIG. 1.—Lateral view of a female specimen. × 1·6.

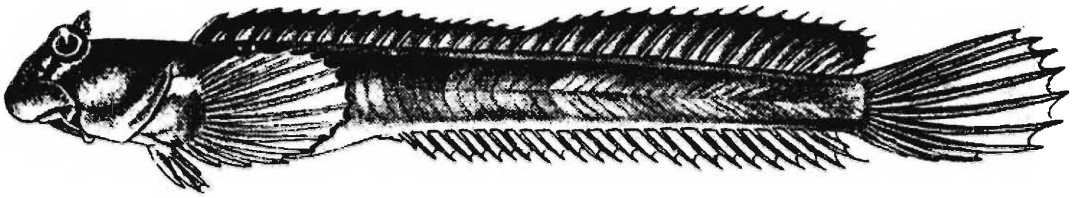
FIG. 2.—Lateral view of a male specimen. ×1·6.

FIG. 3.—Ventral view of the anterior portion of a male specimen. ×2.

FIG. 4.—Dorsal view of the anterior portion of the same. ×2.

FIG. 5.—View of a group of *Andamia heteroptera* sticking to the stone slabs of the wharf on the west coast of Ross Island, Andamans, washed by the spray from the sea (*see* p. 379 of text).

FIG. 6.—Photograph of a portion of the skin of the head between the eyes of *Andamia heteroptera* showing the ridges and grooves (*see* p. 386 of text).



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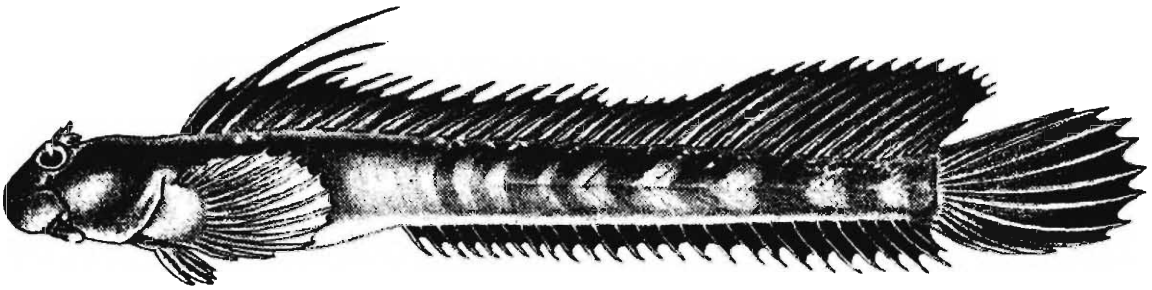

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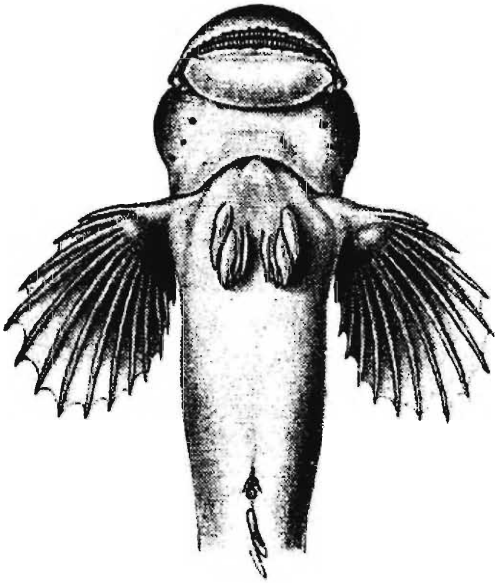

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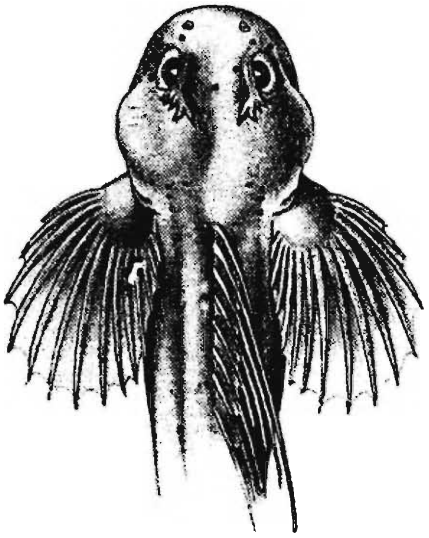


4.

5.

6.

S. B. Setna Photo
A. Mondal del.

Andamia heteroptera (Bleeker).

EXPLANATION OF PLATE X.

Andamia raoi, sp. nov.

FIG. 1.—Lateral view of the Holotype (female). ×1·6.

FIG. 2.—Lateral view of the Holotype (male). ×1·6.

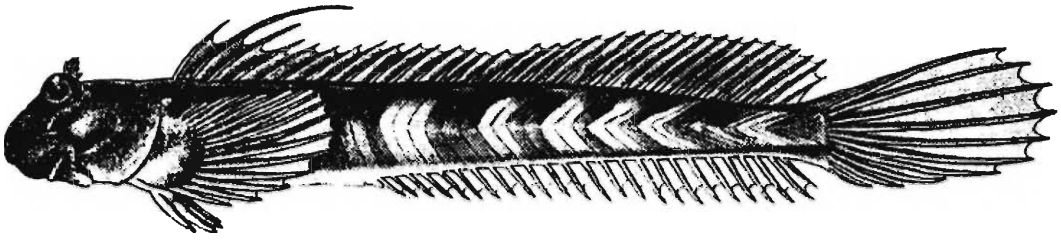
FIG. 3.—Ventral view of the anterior portion of the Holotype (male). ×1·6.

FIG. 4.—Dorsal view of the anterior portion of the same. ×1·6.

FIG. 5.—View of rocks on the North-West coast of Ross I., Andamans, where *Andamia heteroptera* (Bleeker) occurs. The white cross in the back-ground shows the observed limit up to which it occurs on this coast. The coral masses in the fore-ground exposed at low tides were not inhabited by the species.

FIG. 6.—Photograph of a portion of the skin of the head between the eyes of *Andamia raoi* showing the ridges and grooves (*see* p. 386 of text).

FIG. 7.—View of rocks on the North-east coast of Ross I., Andamans, where both species of *Andamia* occur. The black cross indicates the habitat of *A. raoi*, and the white cross that of *A. heteroptera* (*see* p. 378 of text).



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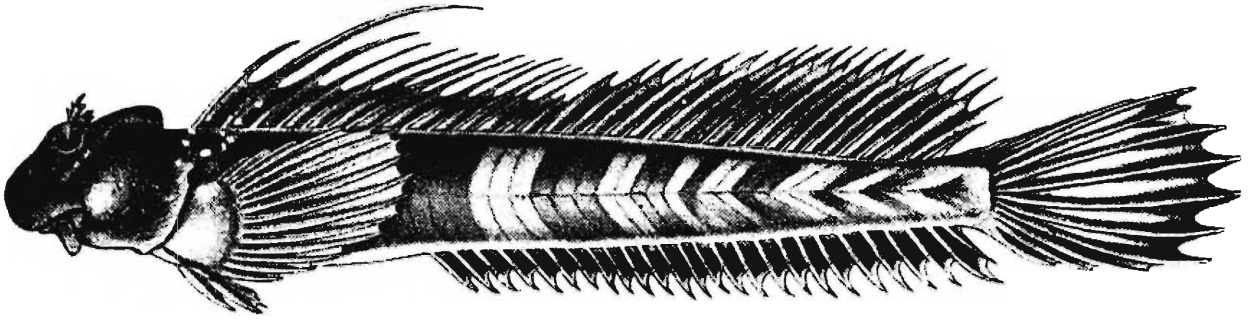

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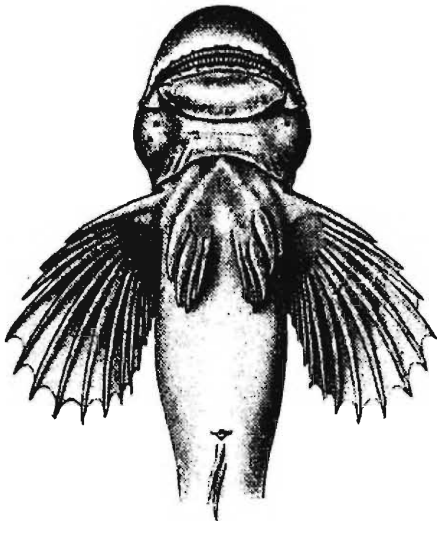

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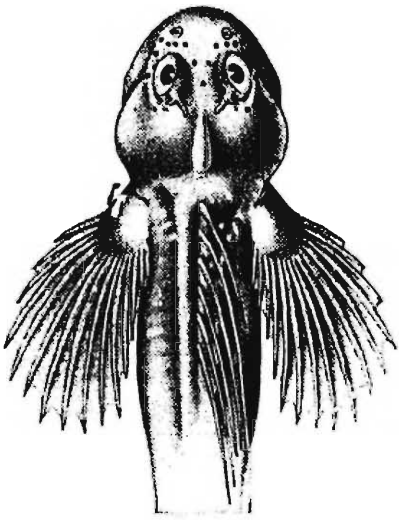

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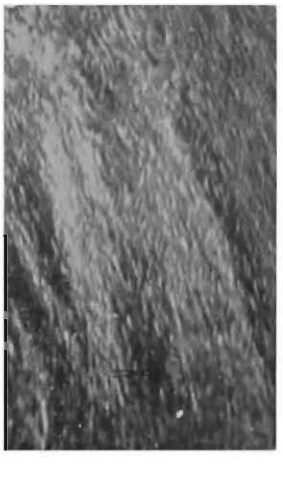

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H. S. Rao Photo
A. Mondal del.

Andamia raoi, sp. nov.

INDIAN EARTHWORMS.

By G. E. GATES, *Judson College, Rangoon, Burma.*

IV. THE GENUS *LAMPITO* KINBERG.

CONTENTS.

INTRODUCTION.

The present contribution and those to follow in this series are outgrowths of a study, begun several years ago, on the classification of the Megascolecidae and in particular of the Megascolecinae. To avoid repetition of past mistakes, such a project has to be based on a careful investigation of worms themselves rather than on literature. Yet repeated attempts to secure the necessary material have been fruitless or nearly so, and without the co-operation of Dr. B. Prashad the effort would have been abandoned. Although all material in the Indian Museum has been available for examination, this is quite insufficient for the purposes in view and accordingly results hitherto obtained can only be presented somewhat tentatively and with a very definite proviso as to the necessity for confirmation when more and better material is available.

In the genus with which we are now concerned there are seven species. One of these is markedly peregrine. Aside from that form, all other (and of course the more interesting) species are known only from the type localities, while three, *kempi*, *palniensis* and *sylvicola*, are known only from single specimens. Of the types of a fourth species, *marianae*, all but one are juvenile. The types of *kempi*, *palniensis* and *sylvicola* are probably postsexual aclitellates, that of *kempi* in poor condition. Although Michaelsen had 36 specimens of *vilpattiensis*, only two clitellate individuals of this species are in the Indian Museum. Important structures, removed from the types of *marianae*, *palniensis* and *sylvicola* in

previous dissections, have been lost. In view of the status of the specimens examined, as types in the national collection, further drastic dissection is inadvisable, even though such dissection would enable definite statements with regard to important characteristics such as the location of the spermathecal pores.

As before, Dr. B. Prashad, Director of the Zoological Survey of India, has unreservedly made available the resources of the Indian Museum for which the author's heartiest thanks are again extended. Thanks are also due to Mr. L. W Trueblood for assistance with matters geographical, and in addition to Prof. K. S. P. Aiyer for the gift of specimens from his own collections, and to Dr. F. H. Gravely for information regarding the location and elevation of Vilpatti.

Genus **Lampito** Kinberg.

1867. *Lampito*, Kinberg, *Öfv. Ak. Förh.* XXIII, p. 103. (Genotype, *L. mauritii* Kinberg 1867.)
1869. *Megascolex* (part), Vaillant, *Hist. nat. Annel.* III, (2), p. 62.
1895. *Megascolex* (part), Beddard, *Monog.*, p. 370.
1900. *Megascolex* (part), Michaelsen, *Das Tierreich*, X, p. 212.
1907. *Megascolex* (part), *Fauna S. W. Austral.* I, p. 163.
1907. *Lampito*, Michaelsen, *Mitt. Mus. Hamburg* XXIV, p. 159.
1909. *Lampito*, Michaelsen, *Mem. Ind. Mus.* I, p. 178.
1916. *Megascolex* (part), Michaelsen, *K. Svensk. Vet. Handl.* LII, (13), p. 57.
1923. *Megascolex* (part), Stephenson, *Oligochaeta* in *F. B. I.*, p. 222.
1928. *Megascolex* (*Lampito*), Narayan Rao, *Half Yearly Mysore Univ. J.* II, (1), p. 6.
1930. *Megascolex* (part), Stephenson, *The Oligochaeta*, p. 837.

Diagnosis.—Male pores on xviii. Female pores paired on xiv. Clitellum annular. All septa from 4/5 or 5/6 present. Gizzard in v. Calciferous tissue in longitudinally placed, more or less lamelliform ridges on the inner wall of the oesophagus in x-xiii. Intestine begins in xv-xvi, typhlosole present. Hearts four pairs, in x-xiii, latero-oesophageal. Excretory organs: paired rosettes or vertically flattened clusters of micronephridia on the anterior faces of the septa in v-xiii (or xiv), integumentary, closed exonephric micronephridia from xv posteriorly, in broad bands (in xv-xvii) or single rows just behind the septa ; 1 pair of open, enteronephric meganephridia with preseptal funnels, from xx-xxi posteriorly. Prostates racemose, strap-shaped or compact. Spermathecae with small, paired, median and lateral diverticula.

Remarks.—Reproductive apertures are ventral and superficial in all species, and except for the spermathecal and male pores of *mauritii*, also minute.

Lampito is distinguished from all other Indian Megascolecinae, except *Nellogaster* (and possibly *Tonoscolex*), by the presence of paired enteronephric meganephridia with preseptal funnels along with closed integumentary and pharyngeal micronephridia, and from *Nellogaster* by the absence of integumentary micronephridia in the first thirteen segments, the presence of paired spermathecal diverticula, and the location of the gizzard in v.

Lampito was separated off from *Megascolex* by Michaelsen in 1909 after finding two South Indian species with a combination of mega-

and micronephridia like that of *mauritii.* In 1916 *Lampito* was suppressed as Michaelsen had come to believe that a combination of the two types of nephridia arose sporadically in widely diverse groups and hence was of no importance. With this Stephenson agreed (1923, p. 223) mentioning as further evidence the many varieties of nephridial arrangement in the genus *Megascolex* (and in particular *M. escherichi* Michaelsen 1910 which is purely micronephridial while *M. e.* var. *papillifer* Stephenson 1915 has the *Lampito* arrangement) and the lack of common origin of the " *Lampito* " species.

Lampito dubius Stephenson 1916 from Kurseong in the East Himalayas is a *Perionyx* and the holotype is possibly only an aclitellate specimen of *P. m'intoshii. (vide* Gates 1934). *Lampito trilobata* Stephenson 1914 from Baroda and Bombay, is a synonymn of *mauritii.* The " lack of common origin " objection is no longer true.

Michaelsen's argument as to the sporadic occurrence of the mega- and micronephridial combination scarcely seems valid. The " sporadic occurrence " of racemose prostates or perichaetine setae has not been considered an objection to the use of those characteristcs in generic definition, in fact quite the contrary. *M. escherichi* and its variety *papillifer* are of no importance in this connection as the nature of the supposed " meganephridia " of variety *papillifer* is unknown,—the larger tubules, having no connection with the septa, may only be enlarged micronephridia. Even if the " meganephridia " of papillifer are enteronephric as in *Lampito*, other evidence of similarity to the *Lampito* species is lacking.

Michaelsen refrained from using the paired condition of the spermathecal diverticula as a generic characterisation in 1909 " as the finding of a single spermathecal diverticulum can only be regarded as of specific value " It scarcely seems necessary to worry about what the future may reveal as to the spermathecal diverticula. All that is of importance for the present is the material now available for study. All such material is without exception characterised by paired diverticula, on all spermathecae, of all specimens, in each species. A characteristic that is uniform in a group of species otherwise entitled to separate generic ranking is regarded as of generic and diagnostic value.

Furthermore paired spermathecal diverticula are very rare in other Indian Megascolecinae and especially those which are closely related to *Lampito.* Aside from *Perionyx*[1] which certainly need not be taken into consideration in any discussion of *Lampito* relationships, only two Indian species, *Plutellus palniensis* Michaelsen 1907 and *Megascolex curgensis* Michaelsen 1921, have paired diverticula.

In the first species the spermathecae are unpaired and median, the paired condition of the diverticula accordingly capable of interpretation as the result of incomplete fusion of a pair of spermathecae. In the

[1] Four species of *Perionyx, fossus* Stephenson 1920, *himalayanus* Michaelsen 1907, *minimus* Stephenson 1920, and *shillongensis* Stephenson 1920, have paired diverticula on the spermathecae but diverticula are often quite variable intraspecifically in *Perionyx* and may be rather indefinite,

other species the supposedly paired diverticula open into the duct through a common basal region so that the paired condition can be regarded as the result of an incomplete bifurcation of a single diverticulum. The ramshorn-shaped bifurcations are further quite different from the *Lampito* diverticula.[1]

Phylogenetic seriation of the known species of *Lampito* is impossible. An ancestral form, in addition to the generic characteristics probably had lumbricine setae with *a* and *b* of xviii modified to penial setae, and two pairs of spermathecae opening to the exterior on 7/8-8/9. *L. mauritii* which retained the penial setae is derived from the ancestral form by a marked increase in the number of setae and the development of a third pair of spermathecae belonging to vii. Later a common ancestor of the remaining species lost its penial setae while the spermathecal pores were slightly dislocated onto the anterior margins of viii and ix. From such a form *palniensis* is derived by special development of the calciferous lamellae and the appearance of lymph glands. The next stage was the development of perichaetine setae but less extensively than in *mauritii* and the loss of the anterior pair of testes and male funnels. *L. vilpattiensis* with spermathecal pores fairly close to 7/8 and 8/9 may represent an offshoot at this stage. In the remaining species the chief development is merely a continuation of the posterior dislocating of the spermathecal pores. In *marianae* both pairs of pores have reached a position in *ab* just in front of the transverse setal lines. In *kumiliensis* the pores are shifted just median to *a* and into the transverse setal lines, in *sylvicola* the shift still further behind to a point about halfway between the transverse setal lines and the posterior intersegmental furrows. *L. kempi* retained a *marianae* location for the posterior pores but along with a shift of the anterior pores into a *sylvicola* position.

Distribution.—South India, northern half of the Cardamom Hills and the Palni Hills (endemic species only). One species is widely peregrine but its original home must have been in the lowlands round about the region where its nearest relatives are endemic.

The non-peregrine species are only known from two localities about 75 miles apart, *kumiliensis* from Kumily near Lake Periyar in the northern half of the Cardamom Hills and the others from the vicinity of Kodaikanal in the Palni Hills.

The endemic species are restricted to the hills: *kempi* found at an elevation of 4,200 feet, *kumiliensis* at 1,500 feet, *marianae* at 7,000 feet, *palniensis* at 7,000 feet, *sylvicola* at 5,500 feet, *vilpattiensis* at 6,000 feet. The other species, *L. mauritii* is a lowland form, found but rarely above the 500 foot level, and then only up to 2,500 feet.

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[1] Of Ceylonese Megascolecinae only three species are said to have paired diverticula. In one of these, *Notoscolex ceylanensis* (Michaelsen) 1897, one of the diverticula is said to be rudimentary or lacking, or at best smaller than the normal diverticulum. In another species, *Notoscolex crassicystis* (Michaelsen) 1897, "In manchen Fallen war nur ein einzige Divertikel vorhanden". The third species, *Megascolex leucocyclus* (Schmarda) 1861, has paired diverticula but here again the spermathecae are unpaired and median so that the paired condition is presumably the result of incomplete fusion of a pair of spermathecae. The diverticulum also has multiple seminal chambers rather than a single chamber as in *Lampito*.

Key to species of Lampito.

1.	*a.* Quadrithecal	2
	b. Sexthecal	*mauritii.*
2.	*a.* Holandric, setae lumbricine throughout ..	*palniensis.*
	b. Metandric, setae perichaetine posteriorly ..	3
3.	*a.* Male pores on an unpaired genital shield ..	*marianae.*
	b. Male pores not on an unpaired genital shield, on small paired porophores	4
4.	*a.* Anterior spermathecal pores postsetal, posterior spermathecal pores presetal	*kempi.*
	b. Both pairs of spermathecal pores similarly located with relation to the setae	5
5.	*a.* Genital markings paired, on xviii	*vilpattiensis.*
	b. Genital markings unpaired and not on xviii ..	6
6.	*a.* Spermathecal pores on transverse setal line and just median to *a*, genital markings on xvii ..	*kumiliensis.*
	b. Spermathecal pores postsetal, genital markings on xix	*sylvicola.*

As in previous papers, negative statements are omitted from specific diagnoses. If a species lacks genital markings no mention of such markings is made. If however nothing is known of certain characteristics of specific importance attention is drawn to this gap in our knowledge by inclusion of the name of the particular structure followed by an interrogation mark. Location of the first pair of meganephridia as well as characteristics of the spermathecae and prostates may prove, on further study, to be of diagnostic value.

Lampito kempi, sp. nov.

Material examined.—From the Indian Museum: 1 sexual (?), dissected specimen labelled, "*Megascolex sylvicola* (Mich.) var. nov. ? Under stone in dense jungle, Palni Hills, near Neutral Saddle, 4,200 ft. 14 Sept. 1922. S. Kemp. W 1158/1".

External characteristics.—The minute and superficial spermathecal pores have not been seen but the anterior pores are probably on viii, about half way between the transverse setal line and 8/9, the posterior pores on ix slightly in front of or close to the transverse setal line, the pores on or close to *a*. The spermathecae are in viii and ix, the anterior pair passing into the parietes slightly in front of the parietal attachment of 8/9, the posterior pair passing into the parietes behind 8/9 and close to the setae of ix.

The male pores are minute and superficial, each pore probably at or near the centre of a small, transversely placed area of elliptical outline, possibly located on an anterior portion of xviii. Ventral setae of xviii apparently lacking.

Genital markings, if present, are unrecognizable.

Internal anatomy.—Septum 5/6 is membranous, 6/7-10/11 muscular or thickly muscular.

The gizzard is in v.

A large tuft of nephridial tubules is attached to the oesophagus on each side, in front of the gizzard. Integumentary micronephridia are first visible in xv, meganephridia present from xx posteriorly.

Metandric, one pair of male funnels in xi, one pair of seminal vesicles (?) in xii. The prostates which extend through three segments, are flattened, broad in a lateromesial direction, the median portion thick and with smooth margin, the lateral margin thin and with two incisions marking off three lobes. The ducts are 1-1½ mm. long, slender, with slight muscular sheen, emerging from a cleft in the median margin of the anterior lobe.

The spermathecal duct appears to be much shorter than the ampulla, the diverticula joining the entalmost portion of the duct just below the ampulla which is only slightly wider than the duct.

Remarks.—The type is in poor condition as a result of maceration or improper preservation. A slight iridescence of the spermathecal diverticula indicates that the worm may have been sexual but a clitellum is unrecognizable.

The prostates look somewhat like the strap-shaped glands of certain species of *Tonoscolex* but are shorter, broader and more deeply incised laterally.

The label in the tube appears to be in Stephenson's writing but no reference to this specimen has been found in the 1924 paper in which other worms from the same locality are considered.

L. kempi is distinguished from all other species of the genus by the location of the spermathecal pores.

Diagnosis.—Quadrithecal, spermathecal pores on or close to *a*, postsetal on viii and about half way between the transverse setal line and 8/9, posterior pores presetal on ix and close to the transverse setal line. Male pores at or near centres of small, transversely placed porophores of elliptical outline. Genital markings ? Female pores ? Clitellum ? First dorsal pore ? Setae perichaetine ; numbers ? Pigmentation ? Length ? Diameter ?

Intestine begins ? Typhlosole ? Metandric ; seminal vesicles in xii.

Distribution.—Known only from the type locality, Neutral Saddle, Palni Hills, South India.

Lampito kumiliensis (Aiyer).

1929. *Megascolex kumiliensis*, Aiyer, *Rec. Ind. Mus.* XXXI, p. 70. (Type locality Kumily, Travancore. Types in the Indian Museum.)

Material examined.—From the Indian Museum: 2 clitellate, undissected specimens labelled, "*Megascolex kumiliensis* Aiyer. Kumily. K. S. P. Aiyer. Types. W 1522/1."

From Prof. K. S. P. Aiyer: 4 clitellate, undissected specimens labelled, "*Megascolex kumiliensis sp. nov.* 26/12/26. K. S. P. Aiyer".

External characteristics.—The setae begin on ii. The setal numbers are shown below. As might be suspected from these numbers the setae are usually paired though any particular seta may be lacking or displaced while extra setae may be present between the pairs. In the posterior

portion of the body the mid-dorsal interval, wide anteriorly, is gradually reduced though without increase in number of setae (8-9 pairs posteriorly).

ii	iii	iv	vii	xii	xxi
9	10	11	11	12	14*
8	13	12	12	12	16*
4	6	11	12	12	15
8	9	10	12	12	16
6	7	10	12	12	16
5	3	9	12	12	16

* Setal pits in which no setae are visible have been counted as setae on these worms.

The first dorsal pore is on 10/11 (4), on 11/12 but with a pore-like and possibly perforate marking on 10/11 (2).

The clitellum extends from a posterior portion of xiii onto the anterior margin of xix, conspicuously protuberant except at the anterior and posterior extremities where it is not sharply demarcated ; dorsal pores (except on 13/14 and 18/19) lacking, intersegmental furrows lacking or only slightly indicated ventrally, setae present except the ventral pairs of xviii.

The spermathecal pores are minute and superficial, on the transverse setal lines of viii and ix, just median to *a* (6), nearer to *a* than the latter is to *b*.

The female pores are paired, anterior and slightly median to *a* (6).

The male pores are minute, diagonally placed slits, each pore on a small, raised, transversely placed porophore of shortly elliptical outline that extends from slightly lateral to *b* or just at *b* nearly to the mid-ventral line, the pore on or median to *b* and hence on the lateral portion of the porophore (6).

The genital markings are conspicuously raised, on the presetal portions of xvii and xx (6), occasionally bulging 16/17 (slight trace only) and 19/20 anteriorly, each marking with a small, slightly depressed, grayish translucent central portion.

Internal anatomy.—The gizzard is in v (6). The oesophagus in ix-xiii is moniliform, septally constricted, heavily vascularized, the inner wall provided with low but slightly lamelliform ridges which are sharply zigzagged and interrupted or almost so septally. At first glance the appearance is as of numerous V-shaped ridges which are lacking across the mid-dorsal and mid-ventral lines. The intestine begins in xvi (6), but the oesophageal valve is clearly recognizable (in the posterior portion of xv and the anterior part of xvi) only in one specimen, possibly slightly relaxed in the other worms. The typhlosole begins in xxvii (3) and is a low, simple ridge, slightly irregular, decreasing in height passing posteriorly but broadened slightly towards the hind end, unrecognizable behind cvii (1) or cviii (1 worm with 134 segments).

The dorsal blood vessel (single) is continued onto the pharyngeal bulb to the region of the supra-oesophageal ganglia. The ventral trunk has not been traced anterior to ix. The supra-oesophageal trunk is present in ix-xiii terminating posteriorly by dividing into two branches which pass laterally and then ventrally on the coelomic face of the gut nearly to the ventral side. Extra-oesophageal trunks are first visible

close to the circumoesophageal nervous commissures from where they pass ventrally and then posteriorly, parallel to the nerve cord. Only one trunk was found in this region in each specimen and this receives just behind the suboesophageal ganglia 3 commissures from a vessel close to the nerve cord which appears to be an anterior continuation of the ventral trunk, (this latter bifurcating anteriorly at the front margin of the suboesophageal ganglia). The extra-oesophageal passes dorsally between the hind end of the pharyngeal bulb and the large nephridial cluster of iv, and then turns to run posteriorly at a level just beneath the gizzard, both trunks recognizable from the nephridial clusters posteriorly and with a transverse connective immediately behind the clusters. Posterior to this connective each trunk receives a fairly large vessel from the lateral face of the pharyngeal bulb. In vi-viii the trunks pass onto the ventral face of the gut close to the midventral line where they can be traced posteriorly into xiii. No subneural. The hearts of x-xiii bifurcate dorsally, the anterior bifurcation large and filled with blood, the posterior slender and white. The anterior branches of the hearts of xiii pass into the bifurcations of the supra-oesophageal quite some distance lateral to the supra-oesophageal trunk while the anterior branches of hearts of ix and xii pass into transvere vessels that open into the supra-oesophageal. In x and xi the anterior branches of the hearts appear to pass directly into the supra-oesophageal. A fairly large, longitudinally placed parietal vessel is visible on each side in xiv-xviii. Just anterior to 13/14 this vessel turns dorsally to open into the posterior bifurcation of the supra-oesophageal just lateral to the junction with anterior branch of the heart, no connective to the extra-oesophageal found. The last pair of hearts is in xiii (6). Paired commissures from the dorsal blood vessel are present in ix-vi. No commissures have been found in v but at the anterior end of the gizzard two large branches from the dorsal trunk pass ventrally into the cluster of nephridial tubules of iv. Commissures and hearts of ix-xiii pass into the ventral trunk.

The nephridia are as in *mauritii* except as follows : each transverse integumentary micronephridial band of xv-xvii is separated into three to five fairly large clusters or rosettes of nephridial tubules which only rarely are so closely crowded as to produce a somewhat band-like appearance ; the long and slender meganephridia reach nearly to the mid-dorsal line. The funnels of the meganephridia have not been seen but the ducts are well preserved and can be traced dorsally nearly to the region of the dorsal blood vessel.

The rather strap-shaped prostates are fully developed only in one specimen where they reach posteriorly to 24/25, the lateral margins incised and thin, the median margins thick and smooth. In other worms the prostates appear to be juvenile or rudimentary, restricted to xviii or xviii-xix or xvii-xviii, the incisions of the lateral margin, in part at least, independent of the septa. Associated with the posterior end of a prostate there may be a compact, rather brittle body distinguished from the whitish gland proper by brown colouration, greater thickness and non-lobed condition. This outgrowth (?) may be smaller or larger than the gland, and when present is to be found only on one prostate,

(on the right side, 3 specimens). The vas deferens has not been traced throughout but is recognizable in xviii where it is rather thick, adherent to the parietes, passing into the prostate gland and not into the duct. There is no spermatozoal iridescence on any of the male funnels (four specimens from Prof. Aiyer).

The spermathecal duct and ampulla are not marked off externally. Ental to the diverticular junction the lumen is large and transversely elliptical in section and into this chamber the diverticula open, the diverticular lumen turning entally at the diverticular junction. Ectal to the junction the lumen of the duct is narrow and the wall thick, the duct gradually narrowing ectally, very slender within the parietes. The diverticula are not marked off externally into seminal chamber and stalk but a stalk portion may be recognized in cleared spermathecae by the thicker wall and narrow lumen. There is no spermatozoal iridescence (5 specimens).

The longitudinal musculature is uninterrupted over sites of the genital markings. In sections the male porophores and genital markings are obviously areas of epidermal thickening, the thickening greatest on the genital mrkings.

Remarks.—One of the Indian Museum worms appears to be sexual; all others, lacking spermatozoal iridescence on male funnels and in spermathecal diverticula, are presumably not sexual. The juvenile or rudimentary condition of the prostates, in view of the complete or nearly complete clitellar development, may be evidence for some abnormal interference with development.

Calciferous lamellae appear to be less well developed in *kumiliensis* than in other species.

Diagnosis.—Quadrithecal, spermathecal pores just median to *a* and on the transverse setal lines of viii and ix. Male pores on or median to *b*, each pore on the lateral portion of a small, transvesely placed porophore of elliptical outline, extending from the region of *b* nearly to midventral line. Genital markings unpaired, presetal, in *bb*, on xvii and xx. Clitellum from posterior portion of xiii to anterior portion of xix. First dorsal pore on 10/11. Setae perichaetine: 8-9/ii, 10-13/iii, 10-12/iv, 11-12/vii, 12/viii, 14-16/xxi. Pigmentation ? Length 100-120 mm. Diameter 3 mm.

Intestine begins in xvi. Typhlosole, a very low, simple, slightly irregular ridge; beginning in xxvii and terminating in cvii-cviii. Metandric; seminal vesicles in xii.

Distribution.—Known only from the type locality Kumily, Travancore.

Lampito marianae (Stephenson).

1924. *Megascolex sylvicola* var. *marianae* Stephenson, *Rec. Ind. Mus.* XXVI, p. 336. (Type locality Marian Shola, Palni Hills, S. I. Types in the Indian Museum.)

Material examined.—From the Indian Museum: 1 clitellate and 3 juvenile specimens labelled, "*Megascolex sylvicola* (Mich.) var. *marianae*, nov. Under wood in jungle, Marian Shola, *ca.* 7,000 ft. Palni Hills, S. I. S. Kemp. 24 Aug. 1922. Types. W 1121/1".

External characteristics.—Unpigmented (? alcoholic preservation). The prostomium is retracted into the buccal cavity, prolobous.

Determination of setal numbers is difficult as a result of the presence in the setal circles of gaps and markings that look somewhat like the setae, as well as eroded areas in the epidermis, the numbers noted herewith possibly not quite correct; 8/ii, 13/iii, 19/iv, 16+/viii, 20+/xii, 26/xx, 26/xxx. On the posterior preclitellar and the anterior postclitellar segments *ab* and *cd* are paired, but posteriorly this condition disappears.

The clitellum is clearly marked, on xiv to the setal circle of xviii, annular.

The spermathecal pores are unrecognizable possibly as a result of damage to the epidermis but are located on viii and ix, in *ab*, and either on the transverse setal line or just in front of the line (confirmed by dissecting the spermathecal ducts out of the parietes).

The female pores were not found (possibly unpaired).

The genital shield is crescentic, transversely placed with the concave side anteriorly, reaching laterally into *ef*, sharply demarcated on each side by a slight but definite groove which passes into 17/18 at *e* and 18/19 at *c*. An anterior portion of the shield is protuberant and on this raised portion there is a very slight, somewhat irregular but rather crescentic groove, concave anteriorly, reaching laterally on each side at least to *c*. Behind the elevation and only a slight distance from 18/19 mesially there is a more definite though slight groove which runs anterolaterally nearly to the margin of the shield. On this latter groove, in *ab*, there is a tiny, whitish, somewhat conical protuberance on which the male pore is probably located. The ventral setae of xviii appear to be lacking.

Internal anatomy.—The inner wall of the oesophagus in xi-xiii is provided with lamelliform longitudinal ridges. An oesophageal valve is in the anterior part of xvi and possibly also the posterior part of xv, the intestine accordingly beginning in xvi (2). The typhlosole begins gradually in xxiii-xxiv, and while small is definitely larger than in other species. Anteriorly the typhlosole in section has an inverted T-shape, the smaller horizontal lamella forming the ventral margin of the typhlosole with a dark red appearance as if gorged with blood. Passing posteriorly the horizontal lamella is gradually reduced and finally lost but the ventral margin of the typhlosole still continues to be dark red.

The hearts of xii and xiii are latero-oesophageal (2). Paired mid-segmental, vertical vessels to the supra-oesophageal trunk are present as in *mauritii*. Parietal vessels are visible in xvii-xiii, in the latter segment rising from the body wall to pass to the gut. No subneural vessel.

There is a large cluster of nephridial tubules on each side of the gut just in front of the gizzard, and attached or connected to the oesophagus by a stalk or band containing muscle fibres. Additional paired, vertically flattened clusters of nephridial tubules are present in each of vi-x, possibly xi (none found in xii), and xiii, the clusters on the anterior faces of the septa near the gut. In xiv, on each side, there is a small, rosette-like cluster of tubules, on the ventral parietes, or base of 14/15. The integumentary micronephridia of xv, xvi and xvii are in wide, transverse bands as in *mauritii*, from xviii posteriorly in vertical rows close to the bases of the septa (posterior faces).

The prostates are slightly longer than wide, compact, lobed though not so much as in *mauritii*.

The prostatic duct is 2-3 mm. long, slender but with muscular sheen.

In xiv, high up on the posterior face of 13/14 there is a pair of small structures that may be ovisacs.

Remarks.—The intestine of xvii-xviii of the type had been removed. A specimen on which the male shield seemed to be most developed was dissected for further information regarding the typhlosole. In this worm the prostates are confined to xviii and the spermathecae are obviously juvenile.

Diagnosis.—Quadrithecal, spermathecal pores in *ab*, on or just anterior to the transverse setal lines of viii and ix. Male pores in *ab*, on tiny conical protuberances from a transversely placed genital shield of crescentic outline with concave side anteriorly, reaching laterally into *ef*. Female pores ? Clitellum from 13/14 to setae of xviii. First dorsal pore on 9/10. Setae perichaetine: 8/ii, 13/iii, 19/iv, 16+/viii, 20+/xii, 26/xx. Unpigmented ? Length 110 mm. Diameter $2\frac{1}{2}$ mm.

Intestine begins in xvi. Typhlosole with a ventral, transversely placed lamella anteriorly so that the section is of an inverted T-shape; beginning in xxiii-xxiv and terminating in (?). Metandric; seminal vesicles in xii.

Distribution.—Known only from the type locality, Marian Shola, Palni Hills, South India.

Lampito mauritii Kinberg.

1867. *Lampito mauritii*, Kinberg, *Öfv. Ak. Förh.* XXIII, p. 103. (Type locality Mauritius. Type in the Stockholm Museum.)
1883. *Perichaeta armata*, Beddard, *Ann. Mag. Nat. Hist.* (5) XII, p. 216. (Type locality Calcutta. Types ?)
1887. *Perichaeta bivaginata* + *P. salettensis*, Bourne, *Proc. Zool. Soc. London*, 1886, pp. 666 and 669. (Type locality of both species Salem, 1,000 feet, South India. No types.)
1888. *Megascolex armatus*, Rosa, *Ann. Mus. Genova* XXVI, p. 159, and *Boll. Mus. Torino*, III, (50), p. 2.
1889. *Megascolex armatus*, Rosa, *Ann. Mus. Genova* XXVII, pp. 125 and 134, and *Boll. Mus. Torino* IV, (73), p. 2.
1889. *Megascolex armatus* + *M. Mauritii* Vaillant, *Hist. Nat. Annel.* III, (1), p. 70.
1891. *Perichaeta armata*, Bourne, *Quart. J. Mic. Sci.* XXXII, pp. 50 and 55.
1891. *Perichaeta madagascariensis*, Michaelsen, *Arch. Natg.* LVII, (1), p. 227. (Type locality N. W. Madagascar. Type in the Berlin Museum.)
1891. *Perichaeta Mauritii*, Michaelsen, *Jahrb. Hamburg. Wiss. Anst.* IX, p. 58.
1891. *Megascolex armatus*, Rosa, *Ann. Nat. Hofmus. Wien* VI, p. 404.
1893. *Megascolex armatus*, Horst, in Weber, *Reise Niederl. Ost-Ind.* III, pp. 29 and 71.
1895. *Perichaeta madagascariensis*, Michaelsen, in *Deutsch-Ost-Afrika* IV, Regenwurmer, p. 40.
1895. *Lampito mauritii*+*Megascolex armatus*+*M. madagascariensis*, Beddard, *Monog.* pp. 369, 384, 385.
1897. *Megascolex armatus*, Michaelsen, *Mitt. Mus. Hamburg* XIV, pp. 5 and 208.
1897. *Megascolex armatus*+*M.* (?) *mauritii*, Michaelsen, *Abh. Senck. Ges.* XXXI, pp. 224 and 225.
1898. *Megascolex armatus*, Michaelsen, *Zool. Jahrb. Syst.* XII, p. 144.
1898. *Megascolex armatus*, Rosa, *Ann. Mag. Nat. Hist.* (7) II, p. 290.
1899. *Megascolex armatus*, Michaelsen, *Mitt. Mus. Hamburg* XVI, p. 10.
1899. *Megascolex mauritii*, Michaelsen, *Öfv. Ak. Förh.* LVI, p. 441.

1900. *Megascolex mauritii* (part), Michaelsen, *Das Tierreich* X, p. 227. (Excluding *Perichaeta coerulea* and *P. luzonica* Perrier 1875, *Megascolex perrieri* Vaillant 1889, and *Perichaeta mauritiana* Beddard 1892.)
1902. *Megascolex mauritii*, Michaelsen, *Die Geogr. Verbr.* p. 93.
1903. *Megascolex mauritii*, Beddard, *Fauna Laccad. Archipel.* p. 375.
1905. *Megascolex mauritii*, Michaelsen, *Zeit. Wiss. Zool.* LXXXII, p. 290.
1907. *Megascolex mauritii*, Michaelsen, in Voeltzkow, *Reise Ostafrika 1903-05*, II, p. 44.
1909. *Megascolex mauritii*, Cognetti di Martiis, *Boll. Mus. Torino* XXIV (602), p. 2.
1909. *Lampito mauritii*, Michaelsen, *Mem. Ind. Mus.* I., p. 179.
1910. *Lampito mauritii*, Michaelsen, *Abh. Nat. Ver. Hamburg* XIX (5), p. 62.
1911. *Lampito mauritii*, Cognetti di Martiis, *Ann. Mag. Nat. Hist.* (8) VII, pp. 494 and 498.
1913. *Lampito mauritii*, Michaelsen, *Mitt. Mus. Hamburg.* XXX, p. 79.
1913. *Lampito mauritii* var. *zeylanica*, Stephenson, *Spolia Zeylanica* VIII, p. 263. (Type locality Anuradhapura, Ceylon. Type in the Indian Museum.)
1914. *Lampito barodensis* (*lapsus* for *trilobata*)+*L. mauritii*+*L. trilobata*, Stephenson, *Rec. Ind. Mus.* X, pp. 323 and 340. (Type locality of *trilobata* Baroda. Types in the Indian Museum.)
1915. *Lampito mauritii*, Stephenson, *Mem. Ind. Mus.* VI, p. 75.
1916. *Lampito mauritii*, Michaelsen, *Ark. Zool.* X, (9), p. 9.
1916. *Megascolex mauritii*, Michaelsen, *Kungl. Svensk. Vet. Handl.* 52, (13), p. 52.
1916. *Lampito mauritii*, Prashad, *J. Bombay Nat. Hist. Soc.* XXIV, p. 504.
1916. *Lampito mauritii*, Stephenson, *Rec. Ind. Mus.* XII, p. 315.
1917. *Lampito mauritii*, Stephenson, *Rec. Ind. Mus.* XIII, p. 385.
1920. *Lampito mauritii*, Stephenson, *Mem. Ind. Mus.* VII, p. 222.
1921. *Megascolex mauritii*, Stephenson, *Rec. Ind. Mus.* XXII, p. 759.
1922. *Megascolex mauritii*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 432.
1922. *Megascolex mauritii*, Michaelsen, *Cap. Zool.* I, (3), p. 22.
1923. *Megascolex mauritii*+*M. trilobatus*, Stephenson, *Oligochaeta* in *F. B. I.* S., pp. 259 and 279.
1924. *Megascolex mauritii*+*M. trilobatus*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 335.
1924. *Lampito mauritii*+*L. trilobata*, Bahl, *Quart. J. Mic. Sci.* LXVIII, p. 72. (Nephridia).
1925. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXVII, p. 473. (Luminescence).
1925. *Megascolex mauritii*, Stephenson, *Rec. Ind. Mus.* XXVII, p. 56.
1926. *Megascolex mauritii*, Gates, *J. Bombay Nat. Hist. Soc.* pp. 182-185, *J. Burma Res. Soc.* XV, p. 207, *Ann. Mag. Nat. Hist.* (9) XVII, p. 440, and *Rec. Ind. Mus.* XXVIII, p. 151.
1926. *Megascolex mauritii*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 256.
1928. *Megascolex mauritii*, Michaelsen, *Treubia* X, p. 291 ; and *Ark. Zool.* XX, (3), p. 10.
1928. *Megascolex* (*Lampito*) *trilobatus*+*M.* (*L.*) *mauritii*. Narayan Rao, *Half-yearly Mysore Univ. J.* II, (1), p. 6.
1929. *Megascolex mauritii*, Aiyer, *Rec. Ind. Mus.* XXXI, p. 63. (Cerebral ganglia and prostomial nerves.)
1929. *Megascolex mauritii*, Gates, *Proc. U. S. Nat. Mus.* LXXV, (10), p. 7.
1929. *Megascolex mauritii*, Michaelsen, *Lingnan Sci. J.* VIII, p. 158.
1930. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXXII, pp. 301 and 355.
1930. *Megascolex mauritii*+*M. trilobatus*, Stephenson, *The Oligochaeta*, pp. 206, 207, 212, 215, 237, 423, 550, 635, 662, 666, and 837.
1930. *Megascolex mauritii*, Stephenson, *J. Fed. Malay States Mus.* XVI, p. 273.
1931. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXXIII, pp. 361 and 435.
1931. *Megascolex mauritii*, Michaelsen, *Peking Nat. Hist. Bull.* V, (3), p. 1.
1932. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXXIV, p. 374 ; and *Lingnan Sci. J.* XI, p. 509.
1932. *Megascolex mauritii*, Stephenson, *Bull. Raffles Mus. Singapore* VII, p. 42.
1933. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXXV, p. 491.
1933. *Megascolex mauritii*, Stephenson, *Proc. Zool. Soc. London*, 1932, p. 914.
1935. *Megascolex mauritii*, Gates, *Bull. Raffles Mus. Singapore* X, p. 91.
1936. *Megascolex mauritii*, Gates, *Rec. Ind. Mus.* XXXVIII, p. 388.
1937. *Megascolex mauritii*, Hla Kyaw and Gates, *J. R. As. Soc. Bengal, Sci.* II, pp. 166-169. (Populations and castings.)

Notes on the synonymy.—Bourne's *bivaginata* and *salettensis* are known only from very inadequate preliminary descriptions which were never supplemented. Bourne himself later considered that both were to be treated as synonyms of *armatus* (=*mauritii*). The types were not preserved. *L. mauritii* has not been recorded from the type locality of Bourne's species, which is 1,000 feet up the hills. There is no reason to suspect that *bivaginata* is other than *mauritii* and this disposition of Bourne's species may accordingly be accepted. But *salettensis*, according to Bourne, lacks penial setae and has a single female pore. The unpaired female pore occurs as a rare variation in *mauritii* (*vide infra*, also noted on *madagascariensis* by Michaelsen) and accordingly is not of importance. Since apenisetal individuals of *mauritii* have not been found some doubt may be expressed as to *salettensis*. Metandric species of *Lampito* have no penial setae but are all quadrithecal. Should a sexthecal, apenisetal species of *Lampito* be discovered at or near the type locality of *salettensis* the possibility that such a worm may be Bourne's species will have to be considered.

Material examined.—From the Indian Museum :—1 dissected clitellate and 1 undissected juvenile specimen labelled " *Lampito zeylanica.* In rotten wood. Anuradhapura (Low Country) Ceylon. 18.x.11. ZEV 6063/7 ", 2 dissected, 21 undissected clitellate and 2 undissected aclitellate specimens labelled, " *Lampito trilobata* Stephenson. Baroda. Lt.-Col. J. Stephenson. 'Type' W 28/1." 1 clitellate specimen labelled, " On the ground near the cistern of Extension Filter bed No. 7 Pulta Waterworks. Pulta Waterworks Survey." 4 clitellate and 2 aclitellate specimens labelled, " On the banks of the New Filter Bed No. 3. Pulta Waterworks. Pulta Waterworks Survey." 1 clitellate specimen labelled, " Between new Filter Bed 4 and Settling Tank. Pulta Waterworks. Pulta Waterworks Survey ", 11 clitellate specimens (and probably 12 juveniles) labelled, " On ground just outside the cistern of New Filter Bed No. 16. Pulta Waterworks. Pulta Waterworks Survey ". From the Fisheries Reserve Officer, Madras :—27 clitellate specimens labelled " Ennur. 21-2-36 ", and 21 clitellate specimens labelled, " West Hill. Feb. 1934 ". From the Bombay Natural History Society :—6 juveniles labelled, " Andheri, Salsette Isl. Thana dist. 14-8-38 ".

External characteristics.—As an occasional variation the paired female pores may be replaced by a single median pore, (28 out of 429 Burmese specimens).

Internal anatomy.—The gizzard is in v (all dissected specimens). On the inner wall of the oesophagus in vii-xiii except at the mid-dorsal and midventral lines, there are longitudinal, regularly zigzagged, prominent ridges, especially well developed in ix-xii, so much so that the ridge designation scarcely does justice to the lamelliform, shelf-like appearance. The ridges are interrupted or nearly so at the oesophageal constrictions in the region of attachment of the septa, and may also be interrupted or nearly so at the midlongitudinal point in each segment. Each ridge slopes dorsally from the septal region to the midsegmental point and then slopes ventrally to the next region of septal attachment. Small calcareous granules have been observed between the ridges. The oesophageal valve is in the posterior portion of xiv and the anterior part of xv, the intestine accordingly beginning in xv. In several specimens the gut is narrowed in the prostatic region. The typhlosole is a very low, simple, slightly zigzagged ridge, extending

from xv to the region of lxxiii behind which it is unrecognizable, possibly slightly higher posterior to xviii than anteriorly.

The dorsal blood vessel (single) is continued into the pharyngeal region as is the ventral vessel. The latter bifurcates over the sub-pharyngeal ganglian, the branches passing laterally and then dorsally along the circum-pharyngeal nervous commissures. An extra-oesophageal trunk is present under the pharynx on each side, with two connectives from the ventral trunk, rising to the ventral face of the gizzard and passing thence posteriorly along the gut till xiii is reached whence the trunk is no longer recognizable. A parietal vessel is usually present on each side in xviii-xiv ; from the body wall in xiii, passing directly into the extra-oesophageal ; or bifurcating, one branch to the extra-oesophageal, the other to the dorsal face of the gut or into the supra-oesophageal ; or only the dorsal branch visible, connection to the extra-oesophageal unrecognizable. In several specimens parietal vessels are quite unrecognizable. In one worm the two parietal vessels bend mesially to unite for a very short distance in xv under the nerve cord. A large supra-oesophageal is present in segments vii-xiii. In each of these segments there is a fairly conspicuous vessel on each side passing ventrally from the supra-oesophageal to the level of the extra-oesophageal trunk. Ventrally the vessels diminish in size, connections with the extra-oesophageal trunks if present have not been seen in any of the worms. The hearts of x-xiii bifurcate dorsally, the posterior bifurcation which passes from the heart to the dorsal blood vessel always slender and white while the anterior branch which passes to the supra-oesophageal is always distended with blood. Commissures of vi-ix connect the dorsal and ventral trunks. No subneural.

In v on each side of the oesophagus, in the space between the hind end of pharynx and the anterior end of the gizzard, there is a fairly large, rather, mop-like mass of nephridial tubules. A fairly strong cord, presumably the duct, can be traced from the nephridia to the ventral side of the posterior portion of the pharynx. In segments vi-xiii, there is on each side of the oesophagus and on the anterior face of the septum a vertically flattened cluster of nephridial tubules. From each of these clusters a translucent cord (duct ?) passes ventrally to the parietes from whence it can be traced anteriorly to or nearly to the septum. The size of these clusters decreases gradually passing posteriorly, those of xiii quite small. In xiv, on each side, there is a rosette-like cluster which is always ventral, but may be on the parietes over the parietal vessel, on the posterior face of 13/14, or on the anterior face of 14/15. A cord (duct ?) passes from the cluster to the parietes just behind 13/14. The integumentary micronephridia in xv, xvi and xvii are closely crowded to form conspicuous transverse bands on the parietes, each band with a width about half the length of the segment. From xviii posteriorly the bands of integumentary micronephridia are replaced by transverse rows, one row just behind each septum. The enteronephric meganephridia are present from xx posteriorly (20). In one worm the right nephridium of xx is lacking, in another both nephridia of xx are lacking, while in a third the meganephridia of xx and the left side of xxi are missing. In one specimen a nephridium is

present in xix on the left side. According to Bahl (1924) the tufts in v-ix are pharyngeal nephridia, ducts from the tufts opening into a ventral portion of the pharynx. Bahl failed to characterize the nephridia of x-xiv.

The prostatic duct is about 2 mm long, with muscular sheen, narrowed ectally and entally, straight, nearly straight, slightly bowed, slightly sigmoid or markedly sigmoid, usually in part surrounded by lobes of the prostate.

In a juvenile specimen of Stephenson's *zeylanica* two distinct penisetal follicles were noted on the median face of the prostatic duct and a similar condition has since been observed in other specimens. In clitellate worms both follicles though distinct appear to be enclosed in a common sheath from which a muscular band is continued dorsally. In each follicle there are two penial setae, of about the same size. On removing the follicle from the parietes one seta is exposed ectally while the other, presumably a reserve seta is not exposed, the tip some distance from the ectal end of the follicle. The two follicles presumably contain modified *a* and *b* setae. Teeth are so closely crowded that it is difficult to recognize distinct rows or circles, but (counting at the margins) there are 7-12 circles.

Notes on the types. Types of zeylanica.—A small central portion of the male porophore bearing the male aperture is depressed (clitellate specimen) but aside from this unimportant result of some peculiar contraction there is nothing to distinguish the porophores from those of typical forms. The single, median female pore is an occasional variation of no importance. The gizzard is in v. In the juvenile specimen there are rudimentary seminal vesicles in ix. No accessory prostates or glands with stalks can be found in either specimen. Presumably the supposed accessory prostates were nothing more than some unusual lobulation of the real prostate. The spermathecal duct is normal though the muscularity is not obvious. The anterior spermathecae and one of the second pair at first glance appear to have but a single diverticulum each, anterior rather than median or lateral. One such diverticulum examined microscopically is in reality two tubular diverticula without differentiation into stalk and seminal chamber, bound together by connective tissue, each tube with its own opening into the duct, obviously an abnormality. There are no differences from typical worms to justify a distinct form.

Types of trilobata.—On every specimen on which female openings can be definitely identified there is a pair of such apertures, the location slightly variable, the pores nearer to each other than to the setae or nearer to the setae. The pores which are unusually difficult to identify are on a transversely placed whitened area of shortly elliptical outline very clearly demarcated by a slightly more opaque but very narrow rim. I cannot recall ever having seen such regularly elliptical, clearly demarcated areas before. The male porophores do not differ from those of typical forms in any important characteristic.

The intestine begins in xv (4). It is true that the gut in xviii is unusually slender, but this is doubtless the result of the pressure on the intestine of the unusually large prostates. In xviii the inner wall of

the gut is longitudinally ridged, the gut in xv-xviii deeply constricted at the septal attachments, whitish and rather superficially resembling the calciferous portion of the oesophagus. There is however an oesophageal valve in the posterior portion of xiv and the anterior part of xv but no valve posteriorly.

In x-xiv the micronephridia are as described above.

There was a rudimentary seminal vesicle in ix on the right side of one of the dissected specimens but the septal attachment was fragile and the vesicle fell off on being touched. In the other dissected specimen there is a fairly well developed vesicle in ix on the left side. In one hitherto unopened specimen vesicles of ix are lacking while in another there is a vesicle in ix on the right side. The penial setae do not differ significantly from those of typical forms.

As was pointed out several years ago (Gates 1926, pp. 442-444) there are no valid reasons for maintenance of *trilobata* as a distinct form.

Diagnosis.—Sexthecal, spermathecal pores on 6/7-8/9, in region of *eg*, larger than the female pores. Male pores (common apertures of prostatic ducts and penisetal follicles) in *bc* or close to *b*, at or near centres of paired, nearly circular, slightly raised porophores, that extend from *a* into *ce*, and anteroposteriorly to and dislocating 17/18-18/19. Clitellum from 13/14 or a postsetal portion of xiii to 17/18. First dorsal pore on 11/12. Setae perichaetine: vii/10-15, viii/12-16, xvii/4, xviii/0, xix/4, 26-39/iii, 40-51/viii, 38-50/xii, 30-42/xx. Pigmentation slight, brown or grey. Length 95-155 mm. Diameter 3-5 mm.

Intestine begins in xv. Typhlosole a very low, simple, slightly zigzagged ridge; beginning in xv and terminating in lxxiii. Holandric; seminal vesicles in ix and xii. Penial setae with horseshoe-shaped to scoop-shaped tip, ornamented with closely crowded circles (7-12) of triangular teeth.

Remarks.—As was the case with certain species of *Pheretima* (*vide* Gates 1937, p. 177) the wide distribution of *L. mauritii* has been overemphasized to the neglect of certain important aspects of that distribution. "This worm is one of the commonest in India—absolutely the commonest in the present collections; and being so widely distributed it is scarcely necessary for the future to note the precise details of each capture." (Stephenson 1920, p. 222). "Very widely distributed, has been recorded from all parts of India, except apparently the United Provinces." (Stephenson 1923, p. 260). Actually *mauritii* is unknown from Coorg, Baluchistan, the Northwestern Frontier Province, Kashmir, Assam, Nepal, Sikkim, and Bhutan, while there is only one record each from Central Provinces, Orissa, United Provinces, Mysore, and Hyderabad Deccan, two each from the Punjab and Rajputana, and but three from Central India. Doubtless the species is much more common in some at least of these areas than the records indicate.

In Burma, *mauritii* is also widely distributed, and quite common especially in the dry season, but is restricted to the lowlands of the coastal districts and along the Irrawaddy, Sittang, Salween and Chindwin Rivers. Examination of the distribution of *mauritii* in India and Ceylon shows that a somewhat similar statement can be made for these areas also. All of the Indian and Ceylonese records are of localities

below the 500 foot level except the following :—Kapurthala and Lahore (750 feet), Gwalior (500-1,000), Banswara (1,000 or less), Salem (1,000), Joshachivir (1,200 or under), Jubbulpore and Dungapur (1,000-1,500), Hyderabad and Peradeniya (1,500-2,000), Dambulla (2,000), Bangalore (2,000-3,000), Kandlamadagu (2,500). (Elevations of Nemar Kheri and Katni in Central India are unknown.) The elevations just listed were determined from maps by Mr. Trueblood but the actual heights at which the worms were secured is usually unknown and may in some at least of the cases be lower than those mentioned. Twice only the actual elevations have been reported, 1,000 feet at Salem and 2,500 at Kandlamadagu. Accordingly in India and Ceylon as well as in Burma, and in particular in South India, *L. mauritii* appears to be a lowland species, quite unknown at present from elevations above 2,500 feet and but rarely found above the 500 foot level.

With one exception only all species of *Lampito* are, in accordance with Michaelsen's criterion—" Eine Art, die lediglich in einem eng begrenzten Gebiet vorkommt, ist als endemisch in demselben anzusehen."—endemic in South India. Presumably then *L. mauritii* is to be regarded as having also originated in South India somewhere in the vicinity of the region where its nearest relatives are today endemic. From this region it has migrated or been transported to other sections of India and other regions bordering the Indian Ocean.

The extra-Indian distribution is such that a large part of this distribution must be explained as a result of accidental carriage (either by man or animals or natural agencies) but how much of the Indian distribution is similarly to be explained is not yet clear. The wide distribution in Burma may indicate that the species is able to spread rapidly within a new region as a result of its own activities, once it has become established.

In view of the wide transference of several species of earthworms it scarcely seems likely that *mauritii* has been accidently carried only to tropical regions of the world. Hence it is necessary for the present to regard *mauritii* as a primarily tropical and lowland form that has been unable to adapt itself to non-tropical conditions or to penetrate into the higher hills in the tropical regions in which it is now established. (All of the localities, including Hong Kong, are south of the tropic of Cancer, except a very few in Bengal, United Provinces and the Punjab.)

Distribution.—Shasthancottah, Kerumaadi, Pallode, Trivandrum, Cape Comorin, Murukpuzha, Vazhote, Shertalay, in Travancore ; Trichur, Ernakulam, in Cochin ; Ramnad (Madura district), Pondicherry (South Arcot district), Madras, Ennur, Dowlaishweram and Agarru (Godaveri district), Kandlamadagu (Chittoor district), Salem, in the Madras Presidency ; Bangalore, in Mysore ; Hyderabad, in Hyderabad State, Deccan. Vareeg Island, in Portuguese India. Bombay, Salsette Island, Gujerat, Godhra, Broach, Surat, Ahmedabad, Nadiad, Dhanu, Sirvai Madhapur, Baroda, Palchar (=Palghar ?) and Joshachivir, in Bombay Presidency. Jubbulpore in the Central Provinces. Sur Lake, in Orissa. Nemar Kheri, Katni and Gwalior, in Central India. Dungapura and Banswara in South Rajputana. Benares in the United Provinces. Calcutta, Raniganj (Burdwan district), Bhogaon, Purneah,

Rajshahi, Saraghat, Betracona (Mymensingh district), and Siliguri, in Bengal. Lahore and Kapurthala in the Punjab.

Outside of India : Bentota, Vakvella, Peradeniya, Panadhure, Kanthalai, Dambulla, Trincomali, Jaffna, Belligame, Anuradhapura, and Colombo in Ceylon ; the Maldive and Laccadive Islands including Minicoy ; Mauritius, Seychelles, Comoro Islands, Madagascar, Zanzibar ; lowlands of the coastal districts and along the Irrawaddy, Sittang, Salween, and Chindwin Rivers of Burma ; Ross Island, Port Blair, Mt. Harriet, Jingighat, and Minnie Bay on the Andaman Islands ; Siam (Bawti and Not Theinko in Peninsular Siam), Malay Peninsula (Singapore and Kuala Lumpur) ; Sumatra (Padang and Poeloe-Weh) ; Christmas Island, Nordwachter (Java Sea), Sumba (Kambera), Kisser Island (north of Timor) Labuan and British North Borneo, Philippine Islands (Manila), Nias ; Kowloon, China, near Hongkong.

Michaelsen (1897, p. 208), erroneously included Naduvatam and Ootacamund in the distribution of *mauritii*, though the species is probably to be found at Naduvatam, a lowland locality. Beddard (1895, p. 384) included Labuan and the Seychelles in the distribution of the species, but no further evidence for this has been found. (Some of Beddard's papers are not available to the writer.)

Lampito palniensis (Stephenson).

1924. *Notoscolex palniensis*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 333. (Type locality Marian Shola, Palni Hills, South India. Type in the Indian Museum.)

Material examined.—From the Indian Museum : 1 aclitellate (?) specimen labelled " *Notoscolex palniensis*, sp. nov. Under wood in jungle. Marian Shola *ca.* 7,000 ft. Palni Hills. 24 Aug. 1922. S. Kemp. W 1120/1 ".

External characteristics.—Unpigmented (? alcoholic preservation). The prostomium is retracted into the buccal cavity, apparently prolobous. The setae begin on ii on which segment all are present ; on xxi *ab*<*bc*, but *bc*, *cd* and *aa* are about equal. Ventral setae of xviii apparently are lacking. Clitellar segments are distinguished from the neighbouring metameres only by the absence or indistinctness of the secondary annulation.

The spermathecal pores are minute and superficial, on or very close to *a*, at the anterior margins of viii and ix, just behind 7/8 and 8/9. The epidermis in the vicinity of the pores is wrinkled, the pores themselves rather difficult to find.

The female pores are probably paired, represented by minute, raised points on xiv, slightly anterior and just median to *a*, the actual apertures not seen.

The male pores are minute and superficial, about on *b*, at or near the anterior ends of a seminal (?) groove.

On xviii there is a sharply demarcated, transversely placed genital shield of elliptical outline, reaching antero-posteriorly to 17/18 and 18/19 and laterally to *c*. A central portion of this area is elevated, sloping gradually towards the posterior margin but just in front the slope is steep into a transverse depression. On the raised portion there is a

transversely placed, crescentic seminal (?) groove, with the concave side facing anteriorly, the ends of the groove about on *b*.

Internal anatomy.—Septa 5/6-12/13 are muscular to thickly muscular; 13/14-14/15 slightly muscular.

The gizzard is in v. The oesophagus is deeply constricted and very slender at the region of attachment of septa 8/9-14/15 and accordingly markedly moniliform. The calciferous ridges are high and lamelliform. What appears to be a characteristic oesophageal valve is present in the posterior part of xv and the anterior part of xvi, the intestine accordingly beginning in xvi. The typhlosole is a very low, slightly zigzagged ridge, practically unrecognizable posterior to lii.

The last pair of hearts is in xiii, the hearts of xii and xiii apparently latero-oesophageal. Parietal vessels are visible in xviii to xiii, in xiii probably passing to the ventral face of the gut. Extra-oesophageals probably as in *mauritii*, but distended with blood and readily recognizable only under the gizzard. In viii-xiv there is on each side a fairly large vertically placed mid segmental vessel on the wall of the oesophagus, passing into the supra-oesophageal trunk. No subneural. On the dorsal blood vessel and the anterior face of the septum in each intestinal segment there is a single, transversely placed, whitish ellipsoidal body, the so-called lymph gland.

On the anterior faces of septa 6/7-13/14, on each side and close to the oesophagus, is a vertically placed, flattened cluster of nephridial tubules, the size of the cluster gradually decreasing passing posteriorly. A large clump of nephridial tubules in v, on each side appears to be attached by a cord either to the gut just in front of the gizzard, or to the posterior face of 4/5 near the gut. In xiv and xv, on each side there is a small, rosette-like cluster of nephridial tubules. Transverse integumentary bands of nephridia are present in xvi and xvii. From xviii posteriorly the micronephridia are less obvious, as inconspicuous transverse rows at the bases of septa (posterior faces). Meganephridia are present from xxi (?) posteriorly.

The prostate at first glance appears to be like a *Pheretima* gland but when unfolded and straightened out is strap-shaped, the median margin thick and smooth, the lateral margin thin and incised. As in *Tonoscolex* which has similar glands the short and slender duct (*ca* 2 mm. long) emerges from the median margin of the gland almost at the anterior end.

The spermathecal diverticula are characterized by a slight spermatozoal iridescence. Diverticular junctions with the duct are slightly closer to the ectal than the ental end of duct but are certainly not at the ectal end of duct (even of the coelomic portion).

The male shield is an area of parietal thickening, the body wall in that region slightly raised into the coelomic cavity.

Remarks.—One prostate and duct, a portion of the intestine extending from xxvi to xxxviii, and a spermatheca had been removed in previous dissection, so that characterisation of the anterior portion of the typhlosole is impossible. As the specimen is unique the removal of further structures is undesirable, although this prevents adequate description of the spermatheca.

Calciferous lamellae appear to be more highly developed in this species than in the perichaetine forms and should be more accurately described than it now possible.

Diagnosis.—Quadrithecal, spermathecal pores, on or close to *a*, on the anterior margins of viii and ix, just behind the intersegmental furrows. Male pores about on *b*, at ends of a transversely placed, crescentic seminal (?) groove with the concave face anteriorly, on a transversely placed genital shield that reaches to *c* and anteroposteriorly to 17/18 and 18/19. Clitellum ? First dorsal pore on 10/11. Setae lumbricine; on xxi, *ab*<*cd*, *bc*, *cd* and *aa* about equal. Pigmentation ? Length 120 mm. Diameter 3 mm.

Intestine begins in xvi. Typhlosole a very low, slightly zigzagged ridge; beginning in (?) and terminating in lii (?). An unpaired lymph gland on the dorsal blood vessel posteriorly in each intestinal segment. Holandric; seminal vesicles in xi and xii.

Distribution.—Known only from the type locality, Marian Shola, Palni Hills, South India.

Lampito sylvicola Michaelsen.

1907. *Lampito sylvicola* Michaelsen, *Mitt. Mus. Hamburg.* XXIV, p. 161. (Type locality Tiger Shola, near Kodaikanal, Palni Hills, S. I. Type in the Indian Museum.)
1909. *Lampito sylvicola*, Michaelsen, *Mem. Ind. Mus.* I, p. 181.
1923. *Megascolex sylvicola*, Stephenson, *Oligochaeta* in *F. B. I.* S. p. 273.

Material examined.—From the Indian Museum: 1 aclitellate specimen labelled, "*Lampito sylvicola* Michlsn. Tiger Shola, near Kodaikanal, S. I. Dr. J. R. Henderson. Type. ZEV 2941/7".

External characteristics.—Unpigmented (? alcoholic preservation). The prostomium appears to be prolobous, possibly proepilobous, as there are two, very short, longitudinally placed furrows close to the mid-dorsal line on the anterior portion of i. Clitellum unrecognizable. The setae begin on ii; 7/ii, 11/iii, 14/iv, 14+/viii, 16+/xii, 28+/xx, *ca.* 28/xxx, gaps in the setal circles where setae would be expected apparently have no setal follicles, at least follicular apertures are unrecognizable.

The spermathecal pores have not been seen but are obviously minute and superficial, probably located on viii and ix, on *a*, about half way between the transverse setal lines and the posterior intersegmental furrows.

The female pores have not been identified definitely but are probably represented by protuberant spots just anterior and median to *a* on each side of xiv.

The sites of the male pores are probably indicated by very minute spots with marginal areas that are whitish and slightly iridescent, each pore located on a tiny, transversely placed area of oval outline in *ab* with the pointed end mesially, the pore towards the lateral margin on a slight protuberance, the median portion depressed and with a greyish translucent appearance. The dumb-bell shaped wall which, according to Michaelsen, surrounds the porophores, is only very slightly raised,

faintly demarcated and scarcely recognizable. Ventral setae of xviii are lacking, or invisible.

The presetal portion of xix is extended, as a result of the development of the genital marking and is more than twice as long as the postsetal portion. The transversely placed marking is presetal, extending laterally into *bc*, and anteriorly nearly to 18/19, a central area of greyish translucence slightly depressed, with a narrow, clearly demarcated opaque rim slightly raised, seta *a* and possibly also *b* included in the posterior margin.

Internal anatomy.—The typhlosole is a very low, simple, straight ridge.

In xiv-xvii on each side there is a parietal vessel as in *mauritii*. These vessels are invisible in xiii where they presumably pass to the gut wall. No subneural.

On the anterior face of a fragment of 12/13 there is a vertically placed, flattened cluster of nephridial tubules. On the posterior face of a right fragment of 13/14, close to the parietes, is a small rosette-like cluster of tubules. On left side, just lateral to the oviducal funnel a similar cluster, on anterior face of 13/14. There are broad, transverse bands of integumentary micronephridia in xv-xvii as in *mauritii*. From xviii posteriorly inconspicuous vertical rows at the bases of septa (posterior faces). Meganephridia present from xx posteriorly, on the ventral parietes behind the micronephridia but well in front of the posterior septa.

The vas deferens passes into the extreme ental end of the prostatic duct. The latter is slender, looped, about 2 mm. long.

The anterior spermatheca of the right side passes into the parietes just in front of a fragment of septum 8/9 while the other spermatheca of the same side passes into the parietes behind the setae of ix. The spermathecal diverticula are characterized by a slight iridescence.

The longitudinal musculature is uninterrupted over the site of the genital markings.

Remarks.—Most of the internal organs had been removed from the anterior end so that it is impossible to report on certain important structures. The iridescence of the spermathecal diverticula as well as of the male funnels probably indicates that the specimen was at least postsexual if not actually sexual, though Michaelsen considered the worm to be " half mature "

Diagnosis.—Quadrithecal, spermathecal pores on or close to *a*, postsetal on viii and ix, half way between the transverse setal lines and the intersegmental furrows. Male pores on slight protuberances from lateral portions of transversely placed porophores of oval outline in *ab*. Genital marking presetal, on xix, in *cc*. Clitellum ? First dorsal pore on 9/10. Setae perichaetine : 8/ii, 11/iii, 14/iv, 16/xii, 26/xx. Unpigmented ? Length 185 mm. Diameter $3\frac{1}{2}$ mm.

Intestine begins in xvi ? Typhlosole, a very low, simple, straight ridge ; beginning in (?) and terminating in (?). Metandric ; seminal vesicles in xii.

Distribution.—Known only from the type locality, Tiger Shola, Palni Hills, South India.

Lampito vilpattiensis Michaelsen.

1907. *Lampito vilpattiensis*, Michaelsen, *Mitt. Mus. Hamburg* XXIV, p. 160 (Type locality Vilpatti, Palni Hills, S. I. Types in the Indian Museum.)
1909. *Lampito vilpattiensis*, Michaelsen, *Mem. Ind. Mus.* I, p. 179.
1916. *Megascolex vilpattiensis*, Michaelsen, *Mjöberg's Austral. Exp.* p. 52.
1923. *Megascolex vilpattiensis*, Stephenson, *Oligochaeta* in *F. B. I.* S., p. 285.

Material examined.—From the Indian Museum : 13 aclitellate and 2 clitellate specimens labelled, " *Lampito vilpattiensis* Michlsn. Vilpatti, Palni Hills, S. I. Dr. J. R. Henderson. Types. ZEV 2934/1 ".

External characteristics.—The prostomium is retracted and appears to be prolobous, but two slight furrows near the mid-dorsal line at the anterior margin of i are recognizable. There is usually a pore-like but possibly imperforate marking on the mid-dorsal line at 9/10.

The setae are lumbricine on ii-viii, occasionally an extra seta or two present on one or more of segments iv-viii. The following numbers were noted : 8/ii, 8/iii, 8/iv, 8/viii, 12/xii, 22/xx ; 8/ii, 8/iii, 8/iv, 10/viii, 13/xii, 22/xx, 24/xxx ; 8/ii, 8/iii, 8/iv, 8/viii, 12/xii, 20/xx ; 8/ii, 8/iii, 8/iv, 8/viii, 10/xii, 20/xx. Ventral setae apparently are lacking on xviii.

The clitellum is protuberant, and extends from a posterior portion of xiii to or just behind the setae of xviii : intersegmental furrows lacking, setae present, dorsal pores present (clitellum not fully developed ? certainly not as protuberant as on other specimens) or represented by non-functional markings at 13/14 and 15/16-17/18.

The spermathecal pores are minute and superficial, two pairs, on the anterior secondary annuli of viii and ix, on *a* (14), the pores usually about equidistant from the anterior intersegmental furrow and the presetal secondary furrow (location confirmed by dissecting spermathecal ducts out of the parietes). The actual aperture identifiable only with high magnification and brilliant illumination, though the sites of the pores can usually be recognized as minute point-like elevations with lower magnification. On 7/8 and 8/9 and on *a* on each side there is a much more obvious, greyish translucent spot that looks as if it might contain a pore though no perforation has been recognized (several specimens). These are the markings which Michaelsen mistook for the spermathecal apertures.

The female pores are paired, anterior and very slightly median to *a* (2 clitellate and several aclitellate specimens).

The male pores are minute and superficial, in *ab*, each pore at or near the centre of a tiny, transversely placed porophore of elliptical outline reaching from *a* to *b*. Occasionally these porophores are sharply demarcated, with a greyish translucent central portion and a narrow, opaque rim, usually displaced posteriorly so that they are nearer to 18/19 than 17/18 but still about in line with or perhaps very slightly posterior to the transverse setal line.

The genital markings are one pair of fairly clearly demarcated areas on the presetal portion of xviii which is elongated. On the clitellate specimens 17/18 is not of course visible but on those clitellate specimens on which 17/18 is recognizable ventrally the furrow is dislocated anteriorly by the markings. The latter are of shortly elliptical outline, usually

slightly diagonal so that the posterior end is slightly nearer the mid-ventral line, with a central portion which may be greyish and translucent protuberant in a regularly convex fashion and clearly marked off from a very narrow, opaque rim that is not or only very slightly protuberant. On 4 specimens the rims are in contact midventrally but not united while on 10 specimens the markings are separated by a midventral strip of unmodified epidermis. On one specimen the markings are practically longitudinal and almost confined to *ab*, but on other worms the markings extend into *bc*.

Internal anatomy.—Septum 5/6 is membranous, transparent but slightly strengthened by a few muscle fibres.

The gizzard is in v (3). On the inner wall of the oesophagus there is on each side a series of longitudinal ridges lacking only at the mid-ventral and mid-dorsal regions. In x-xiii these ridges are especially protuberant and large enough relative to the size of the oesophagus in this worm to be termed lamellae. The arrangement of the lamellae is much the same as in *mauritii* except that here the ridges are interrupted (or very markedly decreased in height) midsegmentally rather than at the region of septal attachments so that there appears to be a deep vertical cleft or slit on each side of the oesophagus midsegmentally. In one worm tiny calcareous particles are visible between the lamellae. The intestine begins in xvi (2) with an oesophageal valve in the posterior portion of xv and the anterior part of xvi. The typhlosole begins rather gradually in xxv-xxvi but is at most only a very low, simple ridge, straight or very slightly zigzagged.

The last pair of hearts is in xiii (3). No subneural vessel and no lymph glands.

In v on each side and in the dorsal portion of the segment there is a rather spheroidal mass of nephridial tubules attached to the gut by a fairly strong cord. In vi-x at least there is a pair of smaller nephridial masses flattened in a vertical fashion against the anterior faces of the septa at the sides of the oesophagus, the size of the clusters gradually decreasing posteriorly. In vi-viii a rather translucent cord passes downwards on the septum from each cluster to the parietes and then anteriorly to the septum next in front. These cords which may be ducts of the nephridial clusters could not be traced, in the specimens studied, further than the anterior septum. Clusters of nephridia are probably present on the anterior faces of the septa in xi-xiii, the attachment to the septum becoming more ventral passing posteriorly. In xiv there appears to be a transversely placed row of integumentary micronephridia on each side, on the ventral parietes just in front of 14/15. From xv posteriorly there is a transversely placed band of integumentary micronephridia on the ventral parietes on each side, just behind the septum.

The prostates are shortly strap-shaped with thickened median margin and more or less deeply incised lateral margins, the duct arising from the median margin anteriorly. The duct is about 3 mm. long, looped, the ectal two-thirds with a strongly marked muscular sheen, the ental third with no sheen. The *vas deferens* passes into the ental end of the duct at the margin of the gland but cannot be traced anterior to the point at which it rises from the parietes in xviii.

The spermathecal duct is about twice as long and half as thick as the ampulla and is abruptly narrowed in the parietes. The duct lumen is abruptly narrowed in the region of the diverticular junctions and very small ectally. Each diverticulum has a seminal chamber and a stalk of about equal length, the lumen of the stalk very narrow. The diverticular junction is just ental to the parietes.

The longitudinal musculature is uninterrupted over the sites of the genital markings.

Diagnosis.—Quadrithecal, spermathecal pores on *a*, on the anterior secondary annuli of viii and ix, about half way between the intersegmental furrow and the presetal secondary furrow. Male pores at or near the centres of transversely placed porophores of elliptical outline in *ab*. Genital markings paired, presetal on xviii, reaching laterally into *bc* and into contact or almost so midventrally, slightly diagonal, the posterior ends nearer the midventral line. Clitellum from posterior portion of xiii to setae of xviii. First dorsal pore on 10/11. Setaeo perichaetine : 8/ii-iv, 8-10/viii, 10-13/xii, 20-22/xx. Unpigmented. Length 70-90 mm. Diameter 2-2½ mm.

Intestine begins in xvi. Typhlosole a very low, simple ridge, at most only slightly zigzagged ; beginning in xxv-xxvi, terminating in (?). Metandric ; seminal vesicles in xii.

Distribution.—Known only from the type locality, Vilpatti, Palni Hills, South India.

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V *Nellocaster*, gen. nov., with a note on Indian species of *Woodwardiella*.

Woodwardiella bahli Stephenson 1925 was assigned to the genus *Woodwardiella*, by definition meganephridial, in the belief that the anterior tufts are to be regarded as meganephridia rather than micronephridia, and also on a supposition that integumentary micronephridia

are lacking in the posterior portion of the body. But Bahl (1926) maintains that the clusters of integumentary tubules which Stephenson regarded as modified meganephridia are actually bunches of discrete micronephridia, each nephridium with its own duct and external aperture, and further that there are integumentary micronephridia along with the enteronephric meganephridia in the postclitellar segments of the body.

Since *Woodwardiella* is by definition "purely meganephridial", *W. bahli* must be transferred to some other genus. Transfer to *Notoscolex* would only serve to emphasize further the polyphyletic nature of that genus. Inclusion in *Lampito* which has a somewhat similar excretory system would be possible only by a repetition of the same sort of mistake that has produced the present polyphyletic Megascolecin genera. The only alternative therefore is erection of a new genus.

Nellogaster, gen. nov.

Diagnosis.—Bithecal (or quadrithecal), spermathecal pores on (7/8-8/9 or) 8/9, on or lateral to *b*. Female pores paired, on xiv, in *aa*. Male pores on xviii, on or lateral to *b*. Genital markings (when present) postclitellar. Setae lumbricine. Clitellum annular, on xiv-xvii. First dorsal pore on 9/10 (-10/11). Unpigmented.

All septa from 5/6 present. Gizzard in vi. (Calciferous tissue in more or less lamelliform ridges in x-xiii.) Intestine begins in (xvii-) xviii. Last hearts in xiii. Excretory organs; one pair of clusters of closed enteronephric (pharyngeal) micronephridia in iv[1]; one pair of clusters of discrete, closed, exonephric, integumentary micronephridia per segment from v posteriorly; one pair of open, enteronephric meganephridia with preseptal funnels from xxv posteriorly. Holandric (or metandric); seminal vesicles in xi and xii (or xii only). Prostates strap-shaped. Spermathecae with unpaired diverticula, at ental ends of spermathecal ducts. Ventral setae of xviii modified to penial setae.

Genotype.—*Woodwardiella bahli* Stephenson 1925.

Remarks.—Inasmuch as only one species, and that not too well known can now be definitely included in *Nellogaster*, the diagnosis must be provisional and subject to modification as further species are studied.

Several species now included in *Notoscolex* and *Woodwardiella* may have to be transferred to *Nellogaster* when more accurate or detailed information is available, especially with regard to the excretory organs. Inclusion of these species will require, except for the excretory organs, only slight modifications in the generic definition (already indicated in the definition above in the parentheses).

The nephridia of *Notoscolex gravelyi* Stephenson 1916 appear to be similar to those of *bahli*. The excretory system of *Woodwardiella hastata* (Stephenson) 1915 apparently differs from that of *bahli* only in the attachment to the parietes, at least anteriorly, of each cluster of tubules by a stalk, supposedly a common duct of all tubules in the cluster but possibly a group of separate ducts. Nothing is known of the nephridial system

[1] On pp. 115 and 120 (Bahl, 1926) and in figure 1 on p. 116, the pharyngeal nephridia are said or shown to be in iv, while on page 121 they are said to be in v. Presumably this latter statement is to be regarded as a misprint.

of *Notoscolex termiticola* Michaelsen 1910 except that it was described as micronephridial, but this species is similar in a number of respects to *bahli*. If the inclusion of all of these species in *Nellogaster* is possible the genus occupies a rather small area which includes a portion of Ceylon and a neighbouring part of south India : Colombo (*bahli*), Peradeniya (*termiticola*), Kandy (*gravelyi*), and Parambikulam, Cochin, South India (*hastata*). Each species has been found but once. All species are lowland (*bahli*, sea level) or from lower elevations in the hills : Peradeniya—1,500 feet, Kandy—1,600 feet, Parambikulam—1,700 to 3,200 feet.

Nellogaster is distinguished from *Lampito* by the presence of only one pair of clusters of pharyngeal micronephridia, presence of integumentary micronephridia in clusters in v-xiii, location of the gizzard in vi, more posterior location of the first intestinal segment, and the unpaired spermathecal diverticula.

Nellogaster bahli (Stephenson).

1925. *Woodwardiella bahli*, Stephenson, *Proc. Zool. Soc. London*, 1925, p. 888. (Type locality Colombo, Ceylon. Types in the British Museum.)
1926. *Woodwardia bahli*, Bahl, *Quart. J. Mic. Sci.* LXX, p. 114. (Nephridia.)

Material examined.—None (available).

Diagnosis.—Bithecal, spermathecal pores on 8/9, on *c*. Male pores at or near centres of longitudinally placed, widely paired porophores of elliptical outline that extend nearly to 17/18 and 18/19. Genital markings paired ; circular markings on 17/18 with centres about on *a* ; a diagonally placed marking with a central, slit-like depression on xviii between each circular marking and the male porophore. Setae : $ab<$ *cd*, $dd<\frac{1}{2}$C posteriorly. Length 96-98 mm. Diameter 2 mm.

Intestine begins in xviii. Typhlosole ? Holandric ; seminal vesicles in xi-xii. Penial setae 1·55-1·8 mm. long, thickness 0·01 near tip, 0·011 at middle, 0·012 near base ; shaft slightly bowed, ectal portion hooked in opposite direction from main curvature, unornamented.

Distribution.—Known only from the type locality, Colombo.

NOTE ON INDIAN SPECIES OF *WOODWARDIELLA*.

With the transfer of *W. bahli* to a new genus there remain for further consideration in our region (India, Burma and Ceylon) six species of *Woodwardiella ; burkilli* (Michaelsen) 1907, *hastata* (Stephenson) 1915, *sarasinorum* (Michaelsen) 1897, *uzeli* (Michaelsen) 1903, *kayankulamensis* Aiyer 1929, and *pumila* Stephenson 1931. Of these, *burkilli* is not a *Woodwardiella* and must be the type of a new genus closely related to *Tonoscolex ;* while *hastata* possibly should go into *Nellogaster. W sarasinorum* as defined by Stephenson in 1923, has " Micronephridia aggregated on each side of the middle line into compact tufts, attached to the body wall in line with *c*." and obviously should not be left in a " purely meganephridial " genus. In absence of meganephridia of one sort or another, transfer to *Notoscolex* is suggested. Should enteronephric meganephridia of the *Nellogaster* type be present in a posterior portion of the body, relationships to the *Nellogaster* species must be

considered. This leaves three species, one each in Burma (*pumila*), Ceylon (*uzeli*) and India (*kayankulamensis*). All three are much alike, possibly even specifically identical, and further are closely related to certain Australian species of *Woodwardiella*. Worms of the small size of these three species are easily and often transported. Possibly all three may eventually prove to be importations into the regions from which they are now only known.

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MGIPC—M—III-8-17—19-12-38—400.