

RECORDS
of the
INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XXXIX, Part I

MARCH, 1937

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Calcutta :
PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA

1937

Price Rupees Three and annas eight or six shillings

ZSL.5.XXXIX.
440.

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Price As. 8 or 10d.

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DESCRIPTION OF TWO NEW SPECIES OF *SYMPHYLURINUS*
(*DICELLURA*, FAMILY PROJAPYGIDAE) FROM INDIA AND
CHINA.

By FILIPPO SILVESTRI, *Portici, Italy.*

In a collection of Thysanura and Dicellura kindly submitted to me for study by the Zoological Survey of India I found a specimen of *Symphylurinus*, the first collected in India, which appears to belong to a new species and is described in this note together with another new species collected by me in China.

The genus is represented in Africa and in Central and South America by a few species.

***Symphylurinus indicus*, sp. nov.**

(Text fig. I).

♀ Corpus ochroleucum ; caput supra setis brevioribus parum numerosis et nonnullis brevibus, setis postantennalibus sublateralibus μ 70 longis ad apicem vix barbulatis ; labri seta postica mediana sat longa submedianis subaequali ; antennae 23-articulatae, articulo 2° quam lum c. $\frac{1}{4}$ longiore, setis et sensillis consuetis *vide* fig. I, 1 ; palpo labiali c. $\frac{3}{4}$ longiore quam latiore.

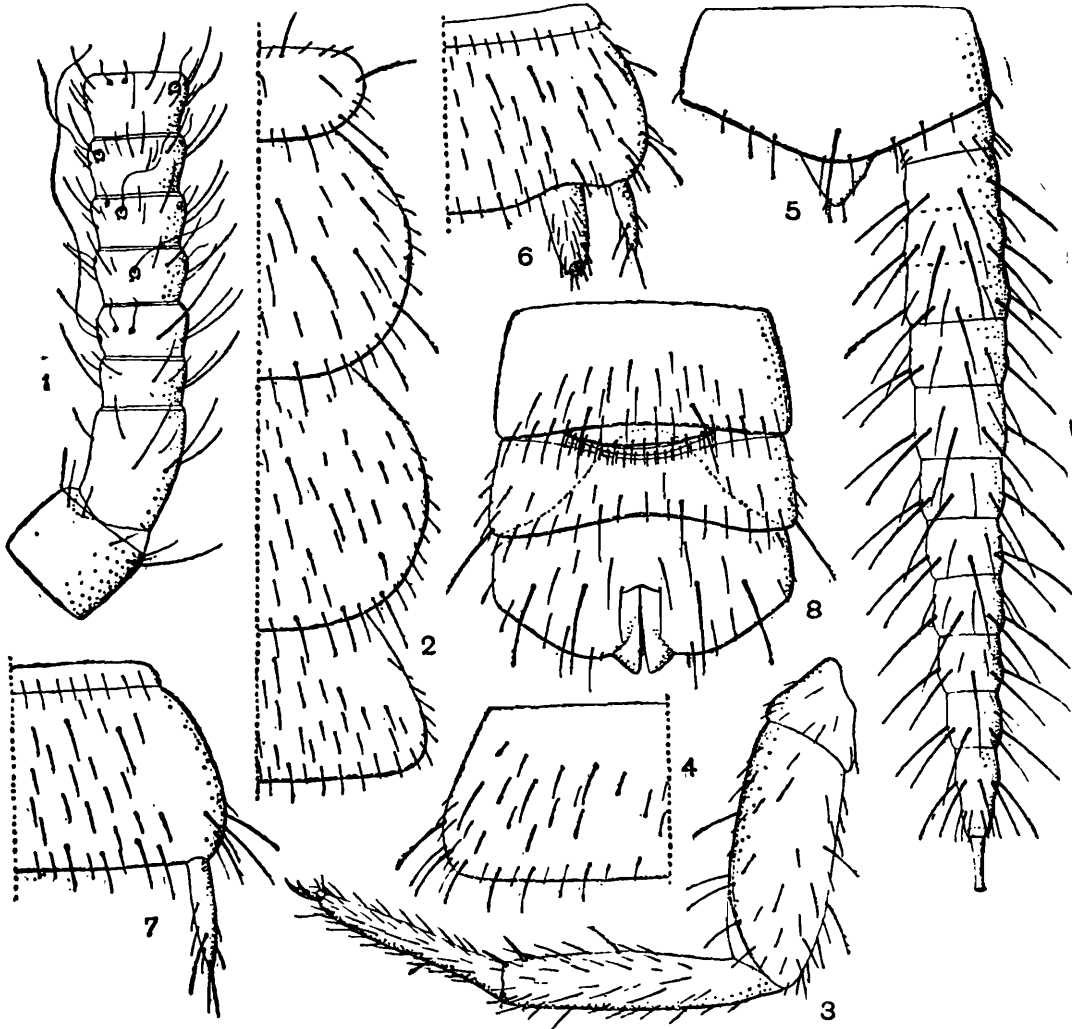
Thorax : pronotum macrochaetis 4+4 barbula minima auctis, lateralibus μ 75 longis, superficie cetera praeter setas marginales subnuda, (tantum setis brevibus duabus) ; mesonotum macrochaetis 7+7, quarum 1+1 subanticis, submedianis dispositione consueta, superficie cetera setis paucis instructa ; metanotum macrochaetis 5+5 cetero mesonoto simili.

Sterna setis consuetis maioribus barbulis 1—2 auctis instructa.

Pedes primi paris tibiae strigili apicali setis spatuliformibus 6 composita ; tertii paris trochanthero macrochaetis brevibus inferis 2, femore macrochaetis 2 superis, macrochaetis inferis submediana et apicalibus 2 longis barbulis 1—2 auctis, tibia macrochaeta ventrali submediana brevi barbula minima aucta, calcaribus apicalibus attenuatis, integris, praetarsi ungue postico quam anticus c. $\frac{1}{5}$ longiore.

Abdomen : tergum lum macrochaetis anticis submedianis 1+1 et 1+1 posticis etiam submedianis ; tergum 2um macrochaetis anticis 1+1 et 2+2 posticis ; 3um macrochaetis anticis 3+3, posticis 4+4 brevibus et barbula minima auctis, superficie cetera setis brevioribus parce numerosis et nonnullis brevibus marginalibus ; tergita 4—7 macrochaetis subanticis 4+4 (lateralis inclusa et a prima ad quartam gradatim a margine antico remotis), et 4+4 posticis, quarum lateralis μ 78 longa est ; tergum 8um macrochaetis posticis 4+4, 9um 3+3 ; tergum 10um setis minimis anticis 2+2, macrochaeta subpostica mediana quam setae marginales submedianae breves aliquantum longiore, setis marginalibus sublateralibus-submedianis, quam submedianae paullum longioribus, ceteris quam submedianae gradatim minoribus.

Urosternum primum macrochaetis anticis 3+3, posticis 4+4 barbulis 1—2 instructis, processibus subcoxalibus gradatim parum attenuatis quam stili, μ 68 longi, parum longioribus; urosterna 2—7 macrochaetis anticis 1+1, posticis 4+4, plerisque barbula minima auctis, superficie cetera setis brevibus et brevioribus parce numerosis, stilis consuetis; urosternum 8um macrochaetis posticis submedianis 1+1.



Text-fig. 1.—*Symphylurinus indicus*, sp. nov. 1. antennae laevae pars proximalis prona; 2. thoracis et urotergiti primi dimidia pars prona; 3. pes paris tertii; 4. urotergiti quinti dimidia pars prona; 5. urotergite decimum cum lamina supranali et cerco dextero; 6. urosterni primi dimidia pars; 7. urosterni quinti dimidia pars; 8. urosterna 8um ad 10um prona.

Apertura genitalis setis anticis 12 et 14 posticis instructa.

Cerci 13-articulati, articulis a tertio ad penultimum setis brevibus proximalibus etiam instructis.

Long. corporis mm 2.10, lat. capitis 0.48, long. antennarum 1.30, pedum paris tertii 1.10, cercorum 0.80.

Habitat. Exemplum vidi ad Helvak, Koyna Valley, Satara District a F. H. Gravely lectum.

***Symphylurinus orientalis*, sp. nov.**

(Text-fig. 2).

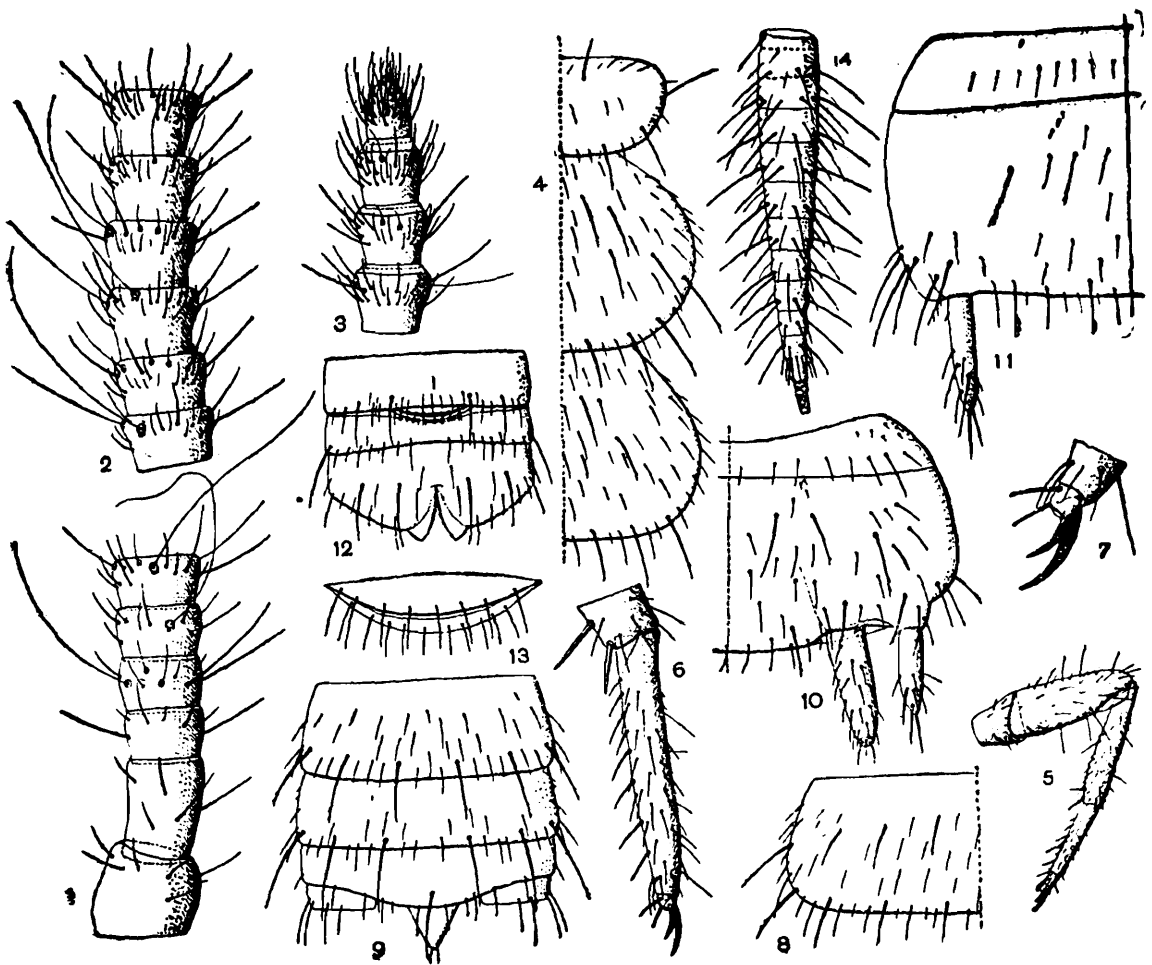
♀ Corpus cremeum; caput setis paucis brevioribus et nonnullis brevibus, omnibus integris vel setis majoribus barbula vix auctis;

antennae 23-articulatae, sensillis consuetis et setis *vide* fig. 2, 1—3; palpo labiali c. $\frac{1}{3}$ longiore quam latiore.

Thorax. Pronotum macrochaetis 4+4 subtilibus sat longis, lateralibus μ 110 longis, barbula minima auctis, superficie cetera setis paucioribus brevioribus et brevibus instructa; mesonotum macrochaetis 8+8, quarum 2+2 subanticae, 3—3 transverse submedianae, 3+3 posticis, superficie cetera setis paucioribus brevioribus et brevibus; metanotum macrochaetis 5+5, quarum 1+1 subanticae, 1+1 transverse submedianae et 3+3 posticae cetero metanoto submile.

Sterna praesternis et furcosternis macrochaetis consuetis.

Pedes setosuli, primi paris tibiae apicis strigili setarum spatuliformium 5—6 serie instructa, tertii paris trochantero subtus macrochaetis brevibus subtilibus integris 2, femore macrochaetis superis 3 et duabus inferis parum longis integris vel barbula minima tantum auctis, tibia macrochaetis duabus superis et macrochaeta ventrali submediana subtilibus brevibus, calcaribus attenuatis simplicibus, praetarsi unguibus parum arcuatis, postico quam anticus c. $\frac{1}{4}$ longiore.



Text-fig. 2.—*Symphylurinus orientalis* sp. nov. 1. antennae laevae pars proximalis prona; 2. antennae laevae articuli 7us ad 11um proni; 3. antennae laevae pars distalis; 4. thoracis dimidia pars prona; 5. pes paris tertii; 6. eiusdem tibiae apex, tarsus et praetarsus; 7. tarsi apex et praetarsus magis ampliati; 8. urotergiti quinti dimidia pars; 9. corporis pars postica a segmento octavo prona cum cercorum articulo basali; 10. urosterni primi dimidia pars; 11. urosterni quinti dimidia pars; 12. urosterna 8um ad ultimum; 13. valvulae genitales magis ampliatae; 14. cercus laevus pronus.

Abdomen. Tergitum 1um macrochaetis anticis 1+1 et 1+1 posticis submedianis, 2um macrochaetis anticis 1+1, posticis 2+2, tergita 3—7

subsimilia macrochaetis anticis 4+4 et 4+4 posticis, barbulis minimis 1—3 auctis, superficie cetera setis brevioribus et brevibus paucis instructa; tergum 8um macrochaetis posticis 3+3, 9um etiam 3+3, 10um macrochaeta subpostica mediana quam setae marginales submedianae breviores duplo vel parum magis longiore.

Urosternum primum macrochaetis anticis 3+3, posticis 4+4, processibus subcoxalibus elongatis paullum attenuatis, quam stili (μ 90 longi) aliquantum longioribus; urosterna 2—7 macrochaetis anticis 2+2 et 4+4 posticis, stilis elongatis setis simplicibus; urosternum 8um macrochaetis posticis 2+2, 9um macrochaetis 1+1 sublateralibus, 10um macrochaetis 2+2 transverse submedianis.

Cerci 13-articulati (semper primo anuliformi et ultimo tubiformi inclusis) articulo secundo brevissimo a 3° male distincto et tantum seta nonnulla sat longa instructo, 3° etiam a 4° parum distincto sed serie setarum completa, ceteris bene distinctis setis consuetis *vide* fig. 2, 14.

Long. corporis mm 3.10, lat. capitis 0.50, long. antennarum, 1.30, pedum paris tertii 1.10, cercorum 0.78.

Habitat. Exemplum typicum ad Canton in humo et paratypum ad Tungshan (Canton, China) legi.

Observatio. Species haec ad *S. grassii* Silv. perproxima est, sed cercorum articulorum numero et articulo antepenultimo etiam setis brevibus destituto saltem distincta est.

NOTES ON FISHES IN THE INDIAN MUSEUM.

XXVIII.—ON THREE COLLECTIONS OF FISH FROM MYSORE AND COORG, SOUTH INDIA.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.*

The three collections of fish which form the subject matter of this note were made by three different collectors from varied types of habitats. Mr. B. S. Bhimachar's material was collected mainly from the Tunga river at Shimoga, but he also obtained specimens from tanks, other rivers and torrential streams in the Mysore State. Dr. H. S. Rao's collection mainly consists of pool-, surface- and mud-living species from the Shimoga and Kadur Districts, whereas Prof. C. R. Narayan Rao's material was obtained from the headwaters of the Cauvery river in Coorg where it is a sluggish stream with a sandy or muddy bed.

From a zoo-geographical point of view the Mysore plateau is of exceptional interest, as it is on the borderland between the 'Deccan tract' and the 'Carnatic or the Madras tract' of Blanford. Blanford included it in the Carnatic tract but remarked: "Perhaps the Mysore plateau, from Bellary to Bangalore and the Nilgiris, should have been included in this tract [Deccan] rather than in the Carnatic."¹ It is fortunate, therefore, that I have been afforded an opportunity to examine extensive material from this region.

Our knowledge of the freshwater fishes of South India is mainly derived from the works of Jerdon² and Day,³ but unfortunately Jerdon was not quite familiar with the specific limits of the species described by Hamilton⁴ from the Ganges and, in consequence, the correct definition of the species recorded by him is a matter of considerable difficulty, and in the absence of the type material his species can only be identified by studying fresh collections made from type localities. In his earlier work, such as on the "Fishes of Malabar", Day also suffered from precisely the same handicap as Jerdon and later, when he became familiar with the fishes of other parts of India, he changed his views regarding taxonomy of a number of species so radically that only a confusing mass of literature is left behind which can only be sorted and sifted by an examination of material from type localities.

The earlier naturalists, such as Bloch,⁵ Cuvier and Valenciennes⁶ described a large number of Indian species from specimens collected in Malabar. Some of these species have now proved to be widely distributed, while others are restricted to the Peninsula. The fauna of

¹ Blanford, *Phil. Trans. Roy. Soc. London* (B), CXCIV, p. 345 (1901).

² Jerdon, *Madras Journ. Litt. & Sci.*, XV, pp. 139-149, 302-346 (1848).

³ Day, *Faun. Brit. Ind. Fish.* 2 vols. (1889).

⁴ Hamilton, *Fish. Ganges* (1822).

⁵ Bloch, *Naturges. ausländ. Fische*, 3 vols. (1784-95).

⁶ Cuvier & Valenciennes, *Hist. Nat. Poiss.*, 22 vols. (1828-49).

the Western Ghats extends not only all along the range but spreads over to the hills of the Peninsula. In consequence, several species described by Sykes¹ from Poona and the adjoining country have been found in the Mysore plateau; the material under report has thus enabled me to define the precise specific limits of some of Sykes' species.

In recent years Prof. C. R. Narayan Rao² contributed two papers on the fish of Mysore and last year I³ reported on a small collection of fish from the Chitaldrug District. Here I propose to describe the three collections of fish separately, noting in each case the ecological conditions under which the specimens were collected. Three new species are described, while notes are added on a number of rare forms. As the taxonomy of the large-scaled Barbels of South India (fish of the *Mahseer* or *Barbus tor* type) is considerably involved, the treatment of the few specimens of this type in the collections under report is deferred till a monographic study of these fishes is undertaken.

My grateful thanks are due to Prof. C. R. Narayan Rao and Mr. B. S. Bhimachar for their kindness in presenting very valuable collections to the Zoological Survey of India.

1. MR. B. S. BHIMACHAR'S COLLECTION FROM THE MYSORE STATE.

Mr. B. S. Bhimachar of the Zoology Department, Intermediate College, Bangalore, made a collection of fish in the Tunga River at Shimoga (December, 1935), in the Western Ghats (May, 1936) and several other places in the Mysore State. The material, which contains a number of rare forms and a new species of *Nemachilus*, has now been presented to the Zoological Survey of India. At my request Mr. Bhimachar has very kindly sent to me the following observations on the ecology and bionomics of some of the species represented in his collection :—

“The majority of forms in my present collection were obtained from the Tunga river, about half a mile from the railway bridge upwards, near Shimoga. The Tunga River takes its origin in the Western Ghats and flows north-east till it joins the Bhadra at Kudali, a village 9 miles from Shimoga. The Tungabhadra, thus formed, is the main tributary of the river Krishna.

The Tunga River has a wide bed with perennial water and mostly flows over a rocky basin. It is a fast flowing stream like the other South Indian rivers. In the rainy season the river swells up considerably and the water is then muddy. In all other parts of the year the water is crystal clear and is well known for its sweet taste. Though there are some shrubs on the sandy islands in the bed of the river there is really no vegetation in the river itself, except for a good growth of algae on the rocks over which a strong current of water flows.

I have observed *Garra* attached to these rocks. They move very slowly on the rocks without completely detaching themselves from the substratum. As they move they scrape the surface of the rock and devour the algae which form their main food. *Glyptothorax* is scarce in number and is occasionally seen attached to the rocks. Both *Garra* and *Glyptothorax* are difficult to spot out since their upper surface is dark like the rocks. The loaches (*Nemachilus* and *Nemachilichthys*) are found on gravelly bed in shallow water. They do not swim about like other fishes and it is rather difficult to observe them even in clear, shallow water, unless disturbed. The stripes on the body, no doubt, make them conspicuous from the side but viewed from above these

¹ Sykes, *Trans. Zool. Soc. London*, II, pp. 349-378 (1841).

² Rao, *Ann. Mag. Nat. Hist.*, (9) VI, pp. 45-64 (1920); Rao & Seshachar, *Half-yearly Journ. Mysore Univ.*, I, No. 2, pp. 1-29 (1927).

³ Hora, *Rev. Ind. Mus.*, XXXVIII, pp. 1-7 (1936).

fishes are difficult to make out because the colour matches with the gravelly bed of the river. The other forms, particularly the Cyprinoids, are confined to the deeper pools in the bed of the river and avoid the rapid current of water.

The western part of the Mysore State is known as 'Malnád', which means hilly-country. The hills of this region form the spurs of the Western Ghats. There are thick forests in this area, with a number of rapidly flowing streams, the smaller ones of which dry up in summer. The physical conditions of the country (the slopes of the hills and the climate) are well suited for the growth of coffee and cardamom. In one of the streams flowing in a coffee plantation I have collected *Bhavana annandalei* and *Nemachilus striatus*. This particular stream is on the road-side between Kottigehar and Balehonnur."

Mr. B. S. Bhimachar's material contains a specimen of *Ophicephalus gachua* with an abnormal dorsal fin collected by Dr. B. Thirumálachar in a tank near Mysore and a specimen of *O. punctatus* without the ventral fins. The latter abnormality was noticed in the practical classes by Mr. T. Ramachandra Rao.

Besides the two localities mentioned in Mr. Bhimachar's note fishes were also collected from (i) stream near Kottigehar village, (ii) a tank at Taluguppe village near Sagar, Shimoga District, (iii) Bangalore, (iv) Bhadra river, (v) Bethmangala tank, and (vi) Sulekere tank. The entire collection is listed below according to the localities.

Tunga River at Shimoga.

1. <i>Mastacembelus armatus</i> (Lacép.)	2 specimens.
2. <i>Garra bicornuta</i> Rao	3 specimens.
3. <i>Garra jerdonii</i> (Day)	6 specimens.
4. <i>Labeo porcellus</i> (Heckel)	4 specimens.
5. <i>Barbus pinnauratus</i> (Day)	2 specimens.
6. <i>Barbus</i> sp. (Large-scaled Barbel)	1 specimen.
7. <i>Barbus dorsalis</i> (Jerdon)	2 specimens.
8. <i>Barbus kolus</i> Sykes	1 specimen.
9. <i>Barbus ticto</i> (Ham.)	1 specimen.
10. <i>Barbus sophore</i> (Ham.)	1 specimen.
11. <i>Cirrhina fulunjee</i> (Sykes)	4 specimens.
12. <i>Scaphiodon nashii</i> (Day)	4 specimens.
13. <i>Rasbora daniconius</i> (Ham.)	3 specimens.
14. <i>Esomus barbatus</i> (Jerdon)	3 specimens.
15. <i>Danio strigillifer</i> Myers	5 specimens.
16. <i>Danio malabaricus</i> (Jerdon)	1 specimen.
17. <i>Barilius bendelisis</i> Ham.	2 specimens.
18. <i>Barilius barila</i> Ham.	1 specimen.
19. <i>Barilius barna</i> Ham.	6 specimens.
20. <i>Labauca atpar</i> (Ham.)	4 specimens.
21. <i>Chela argentea</i> Day	9 specimens.
22. <i>Nemachilus bhimachari</i> , sp. nov.	1 specimen.
23. <i>Nemachilus anguilla</i> Annandale	1 specimen.
24. <i>Nemachilus denisonii</i> Day	2 specimens.
25. <i>Nemachilichthys shimogensis</i> Rao	5 specimens.
26. <i>Lepidocephalichthys thermalis</i> (C. & V.)	9 specimens.
27. <i>Glyptothorax dekkanensis</i> (Günther)	1 specimen.
28. <i>Xenentodon cancila</i> (Ham.)	1 specimen.
29. <i>Ophicephalus gachua</i> Ham.	4 specimens.
30. <i>Ambassis ranga</i> (Ham.)	5 specimens.
31. <i>Glossogobius giuris</i> (Ham.)	2 specimens.

A stream on the road-side between Kottigehar and Balehonnur, Western Ghats.

- | | |
|-----------------------------------|---------------|
| 1. <i>Bhavana annandalei</i> Hora | 4 specimens. |
| 2. <i>Nemachilus striatus</i> Day | 10 specimens. |

A stream near Kottigehar Village, Western Ghats.

- | | |
|------------------------------------|---------------|
| 1. <i>Barbus ticto</i> (Ham.) | 11 specimens. |
| 2. <i>Barbus melanampyx</i> Day | 6 specimens. |
| 3. <i>Brachydanio rerio</i> (Ham.) | 6 specimens. |

A tank at Taluguppe Village near Sagar, Shimoga District.

- | | |
|---|--------------|
| 1. <i>Nemachilus dayi</i> Hora | 3 specimens. |
| 2. <i>Lepidocephalichthys thermalis</i> (C. & V.) | 5 specimens. |
| 3. <i>Panchax lineatus</i> C. & V. | 2 specimens. |

Round about Bangalore.

- | | |
|-------------------------------------|--------------|
| 1. <i>Barbus kolus</i> Sykes | 1 specimen. |
| 2. <i>Chela clupeoides</i> (Bloch). | 2 specimens. |
| 3. <i>Nemachilus denisonii</i> Day | 1 specimen. |
| 4. <i>Nemachilus striatus</i> Day | 9 specimens. |

Sulekere tank.

- | | |
|------------------------------------|-------------|
| 1. <i>Barbus ticto</i> (Ham.) | 1 specimen. |
| 2. <i>Chela clupeoides</i> (Bloch) | 1 specimen. |

Bethmangala tank.

- | | |
|------------------------------------|---------------|
| 1. <i>Nemachilus denisonii</i> Day | 13 specimens. |
|------------------------------------|---------------|

Bhadra river.

- | | |
|--------------------------------------|--------------|
| 1. <i>Barbus sophore</i> (Ham.) | 1 specimen. |
| 2. <i>Rasbora daniconius</i> (Ham.) | 1 specimen. |
| 3. <i>Esomus barbatus</i> (Jerdon) | 1 specimen. |
| 4. <i>Barilius bendelisis</i> (Ham.) | 2 specimens. |

As has been indicated above there is only one new species in Mr. Bhimachar's collection, but the material has enabled me to add notes on a few rare and interesting forms, such as *Labeo porcellus*, *Barbus pinnauratus*, *Scaphiodon nashii*, *Danio strigillifer*, *Bhavana annandalei*, *Nemachilus striatus*, *N. anguilla*, *Glyptothorax dekkansensis* and two abnormal specimens of *Ophicephalus*. Attention may specially be directed to the nature of the gill-openings in *Bhavana* which are small and restricted above the base of the pectoral fins. Among the Homalopterinae, as a rule, the gill-openings are fairly wide; but in *Bhavana* the form of these structures corresponds with that found in several genera of the Gastromyzoninae, such as *Gastromyzon*, *Neogastromyzon*, *Beaufortia*, *Sewellia*, and *Pseudogastromyzon*. The discovery of *Danio strigillifer* from S. India deserves special mention, as the species was only recently described by Myers from Upper Burma and has not so far been found in India proper. The occurrence of abnormal forms among the Ophicephalidae is not rare, but the two cases reported here

are of exceptional interest, firstly because the abnormality of the dorsal fin is rare and secondly because the absence of the ventral fins, though common in *O. gachua*, is of rare occurrence in the other species.

***Labeo porcellus* (Heckel).**

1877. *Labeo porcellus*, Day, *Fish. India*, p. 539, pl. cxxviii, fig. 1.

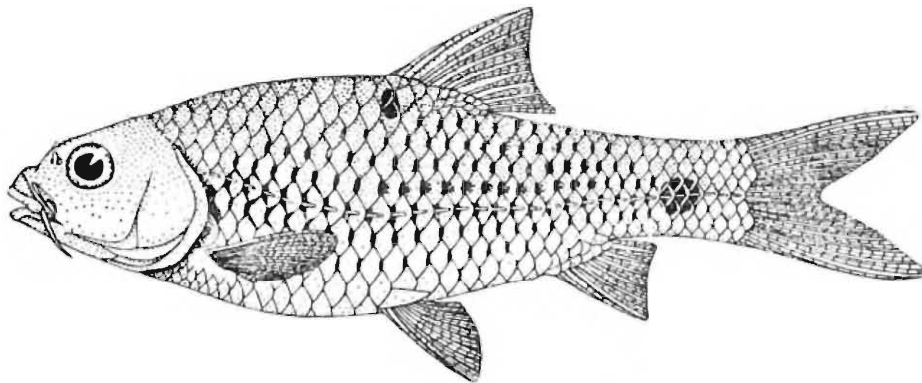
Labeo porcellus has hitherto been known from Bombay and Poona. Mr. Bhimachar obtained 4 specimens, 92-119 mm. in total length, from the Tunga river at Shimoga. It is evidently a small species, as no specimen over 7 inches in length has been found so far.

The upper lip and the rostral fold are slightly fimbriated, whereas the lower lip is strongly papillated. The papillae are long and slender and cover the entire exposed part of the lip. Such a condition of the lip seems to be antecedent to that found in *Labeo dero* (Ham.)¹ and some other Himalayan species. A transverse groove and a number of open pores on the snout are also present in *L. porcellus*.

***Barbus pinnauratus* (Day).**

1877. *Barbus pinnauratus*, Day, *Fish. India*, p. 561, pl. cxxxix, fig. 3.

Barbus pinnauratus is represented by two young specimens, 85 and 94 mm. in total length respectively, collected from the Tunga river



TEXT-FIG. 1.—Lateral view of a specimen of *Barbus pinnauratus* (Day) from the Tunga River. Nat. Size.

at Shimoga. Besides the characteristic colouration of the species as described by Day, in the specimens under report there is a short, somewhat oblique, deep black mark below the dorsal spine.

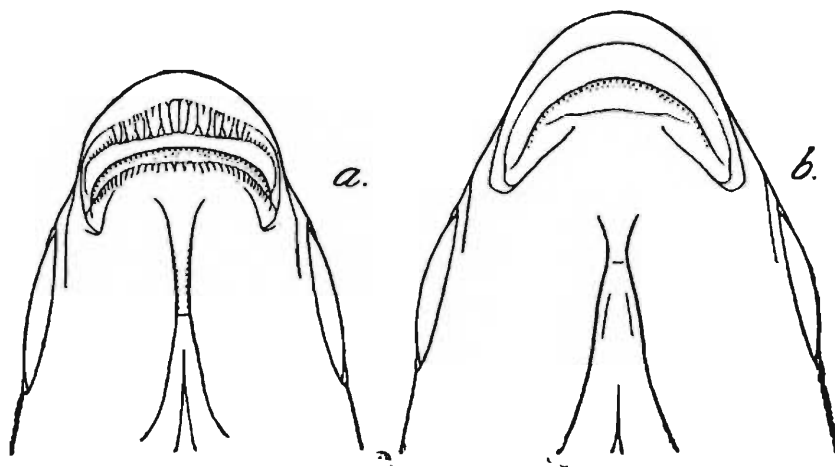
***Scaphiodon nashii* (Day).**

1931. *Scaphiodon nashii*, Mukerji, *Journ. Bombay Nat. Hist. Soc.*, XXXV, p. 169, fig. 3.

Mr. B. S. Bhimachar collected 4 specimens of *Scaphiodon nashii* from the Tunga river at Shimoga; they are from 84 to 104 mm. in total length. The structure of the mouth, lips and jaws is more or less similar to that described and figured by Mukerji in 3 specimens, 92, 95 and 104 mm. in length respectively; while in the smallest specimen

¹ Hora & Mukerji, *Rec. Ind. Mus.*, XXXVIII, p. 142 (1933); Hora, *ibid.*, p. 320.

the mouth is broad and is very much like that of an *Osteochilus*. According to Day "In the young the jaws are compressed, each with a cartilaginous covering: the lips at the angle are thick and continuous, not



TEXT-FIG. 2.—Ventral surface of head of a young and a half-grown specimen of *Scaphiodon nashii* (Day), showing changes in the nature of mouth, jaws and lips. $\times 3\frac{1}{2}$.

a. From a specimen 65 mm. in length without the caudal.

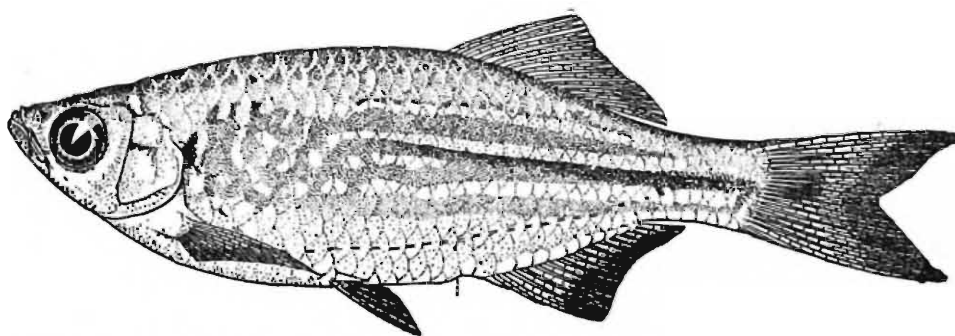
b. From a specimen 82 mm. in length without the caudal.

continued across the chin. As age increases the mouth widens, the cartilaginous covering becomes more horny, and the colours of the fish alter." It seems probable that in writing up his note Day erroneously attributed the structure of the young to the adult specimen. One of the specimens of *Scaphiodon nashii* examined by Day is stated to have been 4 inches (approximately 100 mm.) in length. The other two specimens noted to have been collected in South Canara were probably smaller as they showed characters of "*Osteochilus malabaricus*" The structure of the mouth and associated parts of the two stages is figured here for future reference.

Danio strigillifer Myers.

1924. *Danio strigillifer*, Myers, Amer. Mus. Novitates, No. 150, p. 1.

Danio strigillifer was described by Myers from two specimens collected at Myaing in Upper Burma. The South Indian specimens, which I now



TEXT-FIG. 3.—Lateral view of a specimen of *Danio strigillifer* Myers from the Tunga river. $\times 1\frac{1}{2}$.

refer to this species, agreed so closely with Myers' description that they could not be separated from it by any well marked character. Since the occurrence of precisely the same form in such widely separated

localities was a matter of considerable significance I sent a specimen to Dr. J. T. Nichols, Curator of Recent Fishes at the American Museum of Natural History, and requested him to compare it with the type-specimen of Myers' species. He has replied as follows :—

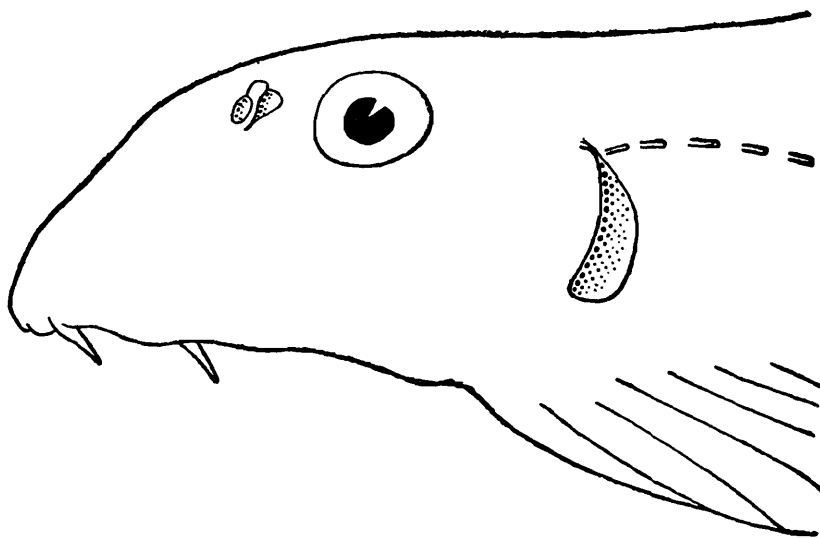
"I have just compared the specimen that you sent with Myers' *D. strigillifer*, American Museum No. 8351, and believe they are the same thing. The specimens are not in a very good state of preservation with colour almost entirely faded out, and I was unable to make out the barbels satisfactorily, but notice that Myers described them as in your fish."

There are a number of genera, such as *Silurus*, *Thynnichthys* and *Homaloptera* (s. l.), which are common to Burma, Assam Hills, Eastern Himalayas and South India, but, so far as I am aware, there is no record of any Indian species with such a discontinuous range of distribution.

***Bhavaniania*¹ *annandalei* Hora.**

1920. *Bhavaniania annandalei*, Hora, *Rec. Ind. Mus.*, XIX, p. 203, pl. x, figs. 1-3 ; pl. xi, figs. 5-7.

The South Indian members of the family Homalopteridae had been so much confused with those occurring in the Darjeeling Himalayas and the hill ranges of Assam that considerable difficulty was experienced in separating them. Finally, however, Homalopteridae of India² were grouped into three genera, viz., *Balitora* Gray from the Darjeeling Himalayas, the Assam hill ranges and Upper Burma, *Homaloptera* van Hasselt from Tenasserim and *Bhavaniania* Hora from the hill ranges of the Peninsula. The description of the last genus was based on immature specimens of two species which differed from *Balitora* in the form of the pectoral



TEXT-FIG. 4.—Lateral view of head and anterior part of body of *Bhavaniania annandalei* Hora, showing the position and extent of its gill-opening. $\times 4\frac{1}{2}$.

fins and the number of rays in them. When material of extra Indian species of *Homaloptera* became available in the Indian Museum for

¹ Prashad & Mukerji (*Rec. Ind. Mus.*, XXXI, p. 186, footnote, 1929) have already pointed out that my choice of the name *Bhavaniania* was rather unfortunate, for a similar name had been used by Schmarda for a Polychaete *Bhawania* in *Neue Wirbellose Thiere*, I, ii, p. 164, 1861. The different spellings of the two names, however, permit of *Bhavaniania* being retained as a valid genus.

² Hora, *Rec. Ind. Mus.*, XIX, pp. 195-215 (1920).

examination, it was found that in this genus the snout is either broad and rounded, as in *Bhavana*, or long and pointed, as in the Tenasserim species of *Homaloptera*. The great variation in form and structure of the pectoral fins in different species of *Homaloptera* made me¹ abandon the genus *Bhavana*, unfortunately without a careful study of the poor material even then available from S. India.

In Mr. B. S. Bhimachar's collection there are four well preserved specimens of *Bhavana annandalei* from 35 to 83 mm. in length. They agree with my description, but I omitted to record in the original account that in *Bhavana* the gill-openings are small and are situated entirely above the base of the pectoral fins. This feature is of exceptional interest, for in no other genus of the Homalopterinae the gill-openings are restricted above the base of the pectoral fins. This feature alone is of sufficient merit to distinguish *Bhavana* from the rest of the Homalopterinae.

In the Gastromyzoninae,² however, the gill-openings are restricted in quite a number of genera—*Pseudogastromyzon*, *Sewellia*, *Beaufortia*, *Neogastromyzon* and *Gastromyzon*. It was indicated by me³ that though the specialisation of form shows parallel evolution in the two subfamilies of the Homalopteridae, the modification of the gill-openings had not undergone similar changes in the two series, although they are used for the same purpose in a similar environment. The discovery of small gill-openings in *Bhavana* supplies a further proof of the parallelism in evolution, and shows that the causes that brought about this condition were probably the results of some divergent modifications in the original stock.

***Nemachilus striatus* Day.**

1877. *Nemachilus striatus*, Day, *Fish. India*, p. 617, pl. cliii, fig. 8.

Mr. Bhimachar collected a fine series of 10 specimens of *Nemachilus striatus* from a rapid stream in a Coffee Plantation, Western Ghats. These specimens vary in length from 25—50 mm., while Day's largest specimen was 2½ inches. The form and colouration shown in Day's figure probably represent these features in an adult specimen. In the young individuals before me colouration varies considerably. In a specimen about 25 mm. in length there are only 8 vertical bands on the body, some of which show clear indications of splitting up vertically. These bands go on increasing in number and in a specimen about 50 mm. in length there are 12 bands. The bands in the anterior region become indistinct but the increase in their number continues behind the dorsal fin. According to Day the number of bands is from 12—16 in the part of the body behind the commencement of the dorsal fin.

One constant feature of colouration, to which Day makes no reference, is the presence at the base of the anterior dorsal rays of a jet black spot; this is very prominent in the young individuals.

¹ Hora, *Rec. Ind. Mus.*, XXXIII, pp. 67-69 (1931); *Mem. Ind. Mus.*, XII, p. 274 (1932).

² Hora, *Mem. Ind. Mus.*, XII, p. 304 (1932).

³ Hora, *Mem. Ind. Mus.*, XII, p. 326 (1932).

According to Day the lateral line passes direct from the centre of the orbit to the middle of the base of the caudal fin. In the specimens before me the lateral line is marked only for a short distance in the anterior region.

Both Day and Mr. B. S. Bhimachar collected specimens of *N. striatus* in association with *Bhavana annandalei*.

***Nemachilus anguilla* Annandale.**

1919. *Nemachilus anguilla*, Annandale, *Rec. Ind. Mus.*, XVI, p. 127, pl. i, fig. 3; pl. iii, fig. 1.

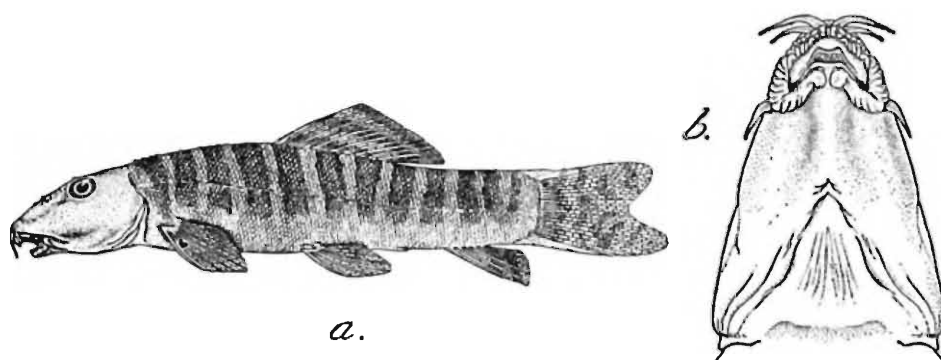
Nemachilus anguilla was described from 3 specimens collected in the Yenna River at Medha, Satara District, Bombay Presidency. Mr. Bhimachar obtained a young specimen, about 42 mm. in total length, from the Tunga River at Shimoga. This species can be readily distinguished by the presence of two short, stout, digitiform processes in front of the upper lip.

In the specimen under report the row of large, rectangular spots running along the mid-lateral line is more prominently marked.

***Nemachilus bhimachari*, sp. nov.**

D. 2/12; A. 2/5; P. 11; V 7; C. 18.

Nemachilus bhimachari is a stoutly built species in which the dorsal profile is moderately arched while the ventral profile is straight and horizontal throughout. The head is pointed; its length is equal to the length of the caudal fin and is contained about 5 times in the total length of the fish. The width of the head is slightly greater than its height at the occiput which is about half the length of the head. The eyes are situated in the posterior half of the head and are placed dorso-laterally; they are not visible from the ventral surface and are one



TEXT-FIG. 5.—*Nemachilus bhimachari*, sp. nov.

a. Lateral view of type-specimen Nat. Size. b. Ventral surface of head of same. $\times 2\frac{1}{2}$.

diameter apart. The diameter of the eye is contained about 5 times in the length of the head and 2.5 times in the length of the snout. The mouth opening is small, crescentic and horizontal. The lips are fleshy and fimbriated; they are continuous at the angles of the mouth, but the lower lip is interrupted in the middle. The lips do not cover the anterior portion of the jaws which are sharp and horny. The upper jaw is produced into a beak-like process in the middle while the lower jaw has a broad, rasping edge. The barbels are small; the inner rostrals

and maxillaries are subequal and are as long as the diameter of the eye while the outer rostrals are considerably shorter. The gill-openings are mostly lateral and extend to just below the base of the pectoral fin.

The depth of the body is contained about 6.5 times in the total length of the fish. The caudal peduncle is considerably higher than long. The body is covered throughout with small distinct scales which are somewhat faintly marked on the ventral surface. The lateral line is distinctly marked up to the base of the anal fin. There are small fleshy appendages at the bases of the paired fins.

The dorsal fin commences considerably in advance of the ventrals and its commencement is equally distant from the tip of the snout and the base of the caudal fin; its base is slightly shorter than the head and its upper border is truncate. The longest ray of the dorsal is not as high as the depth of the body below it. The pectoral fin is pointed in the middle; its length equals the head in front of the posterior margin of the orbit; it is separated from the ventral by a distance equal to about half of its length. The ventral fin is almost as long as the pectoral and is similarly pointed in the middle; it just misses the anal opening. The anal fin, when laid flat, reaches the base of the caudal fin which is emarginate with rounded lobes; the lower lobe is longer than the upper.

The colouration is very characteristic of the species. There are about a dozen black bands which are vertical in the posterior region and obliquely directed forward in the anterior region; these bands are wider than the pale-olivaceous interspaces between them. The dorsal fin is marked with three broad bands, the outermost forms a black edge to the fin. The caudal fin is marked with a number of incomplete bands. A black streak runs from the eye to the tip of the snout.

Locality.—Tunga River at Shimoga (December, 1935).

Type-specimen.—F12178/1, *Zoological Survey of India (Ind. Mus.)*, Calcutta.

Remarks.—*Nemachilus bhimachari* represents an intermediate form between *Nemachilus* and *Nemachilichthys*, and it seems questionable whether the latter genus, which is distinguished from the former by the length of its dorsal fin and the elongated snout, is really distinct from *Nemachilus*. Attention may here be directed to the fact that in several species of *Barbus*, such as *B. curmuca*, *B. dobsoni*, *B. kolus*, etc., occurring in the Western Ghats and the hill ranges of the Peninsula the snout is also somewhat cylindrical and elongated.

In its general facies *N. bhimachari* is abundantly distinct from all other species of *Nemachilus* known from India; its most salient features are (i) elongated snout, (ii) fimbriated lips, (iii) oblique, vertical bands; (iv) colouration of dorsal and caudal fins and (v) form of caudal fin.

***Glyptothorax dekkanensis* (Günther).**

1923. *Glyptothorax dekkanensis*, Hora, *Rec. Ind. Mus.*, XXV, p. 24, text-fig. 3

In Mr. Bhimachar's collection there is a fine example of *Glyptothorax dekkanensis*, about 140 mm. in total length. The specimen agrees with Günther's description and my observations on this species.

The body is covered with small, longitudinally arranged tubercles of unequal size ; those along the lateral line are of a somewhat larger size and form a regular series. These tubercles are absent along the dorsal surface, at the base of the dorsal fin and on the head.

TWO ABNORMAL SPECIMENS OF *Ophicephalus* spp.

The absence of the ventral fins is a fairly common abnormality in the members of the genus *Ophicephalus* but amongst Indian species such a condition is usually associated with *O. gachua*.¹ Mr. B. S. Bhimachar has sent an undoubted specimen of *O. punctatus* Bloch, about 169 mm. in total length, in which both the ventral fins are wanting. Unfortunately there is an incision in the mid-ventral line, but, so far as can be ascertained, there does not seem to be any abnormality in lepidosis in the region of the ventral fins. In all other respects the specimen is quite normal.

Of unusual interest is the abnormal condition of the dorsal fin in a young specimen of *O. gachua* Ham., 93 mm. in total length. The dorsal fin is divided into two portions, the anterior smaller, consisting of 2 or 3 rays and commencing about the 6th scale behind the upper angle of the gill-opening. This portion is separated from the normal fin by a distance almost equal to twice the diameter of the eye and the intervening space is covered by about 5 scales. In other respects the specimen is quite normal.

2. DR. H. S. RAO'S COLLECTION FROM THE MYSORE STATE.

In November-December 1928, Dr. H. S. Rao of the Zoological Survey of India collected fishes in the Shimoga and Kadur Districts of the Mysore State. I give below a short description of the localities based on Dr. Rao's notes, with lists of species collected therefrom :

Sharavati River below the Jog Falls, 2 miles below the Mysore Bungalow.
26.xi.1928.

"The stream is over 500 feet below the point at which the falls begin and is strewn with huge granite boulders. In the course of the stream there are shallow pools with sandy bottom."

- | | |
|--|-------------|
| 1. <i>Barbus</i> sp. (Large-scaled Barbel) | 1 specimen. |
| 2. <i>Barbus filamentosus</i> (C. & V.) | 1 specimen. |

A hill-stream on the Jog-Sagar Road near the junction of the road leading to the ferry. 30.xi.1928.

"Bed strewn with large stones and boulders ; in places with gravel."

- | | |
|------------------------------------|-------------|
| 1. <i>Brachydanio rerio</i> (Ham.) | 1 specimen. |
| 2. <i>Panchax lineatus</i> C. & V. | 1 specimen. |

¹ Hora & Mukerji, *Rec. Ind. Mus.*, XXXVI, p. 137 (1934).

Stream north of Sagar Rest House, Shimoga Dist. 1-2.xii.1928.

“ Full of weeds and algae. Bed sandy in some parts, gravelly in others.”

1. <i>Mastacembelus armatus</i> (Lacép.)	1 specimen.
2. <i>Garra jerdoni</i> (Day)	1 specimen.
3. <i>Barbus ticto</i> (Ham.)	55 specimens.
4. <i>Rasbora daniconius</i> (Ham.)	11 specimens.
5. <i>Danio strigillifer</i> Myers	1 specimen.
6. <i>Brachydanio rerio</i> (Ham.)	87 specimens.
7. <i>Nemachilus denisonii</i> Day	1 specimen.
8. <i>Nemachilus sinuatus</i> Day	1 specimen.
9. <i>Lepidocephalichthys thermalis</i> (C. & V.)	72 specimens.
10. <i>Panchax lineatus</i> C. & V.	14 specimens.
11. <i>Macropodus cupanus</i> (C. & V.)	30 specimens.
12. <i>Ophicephalus gachua</i> Ham.	2 specimens.

Streams and pools on the Kalurkatte Road near Sagar, Shimoga Dist. 3.xii.1928.

“ Bottom covered with gravel in some parts and with sand and mud in other parts.”

1. <i>Barbus ticto</i> (Ham.)	7 specimens.
2. <i>Barbus vittatus</i> Day	2 specimens.
3. <i>Barbus cosuatus</i> (Ham.)	1 specimen.
4. <i>Rasbora daniconius</i> (Ham.)	1 specimen.
5. <i>Esomus barbatus</i> (Jerdon).	2 specimens.
6. <i>Brachydanio rerio</i> (Ham.)	59 specimens.
7. <i>Lepidocephalichthys thermalis</i> (C. & V.)	3 specimens.
8. <i>Panchax lineatus</i> C. & V.	52 specimens.
9. <i>Macropodus cupanus</i> (C. & V.)	19 specimens.

Tank near Sagar Rest House, Shimoga Dist. 3-5.xii.1928.

“ Surface covered with abundant growth of aquatic vegetation.”

1. <i>Rasbora daniconius</i> (Ham.)	4 specimens.
2. <i>Panchax lineatus</i> C. & V.	23 specimens.
3. <i>Macropodus cupanus</i> (C. & V.)	4 specimens.

Stream near Kugve, 4 miles west of Sagar, Shimoga Dist. 4.xii.1928.

“ Muddy with lot of vegetation.”

1. <i>Mastacembelus armatus</i> (Lacép.)	1 specimen.
2. <i>Barbus dorsalis</i> (Jerdon)	4 specimens.
3. <i>Rasbora daniconius</i> (Ham.)	4 specimens.
4. <i>Esomus barbatus</i> (Jerdon)	1 specimen.
5. <i>Ophicephalus gachua</i> Ham.	4 specimens.

Streams on the Sagar-Shimoga Road, Shimoga Dist. 5.xii.1928.

1. <i>Garra jerdoni</i> (Day)	2 specimens.
2. <i>Rasbora daniconius</i> (Ham.)	1 specimen.
3. <i>Labauca atpar</i> (Ham.)	3 specimens.
4. <i>Nemachilus denisonii</i> Day	2 specimens.

Tunga River at Shimoga. 8-10.xii.1928.

"Rocky in the middle, sandy or full of gravel near the banks. Mostly shallow, but with deep pools in the middle. Small, sandy pools near the bank overgrown with weeds."

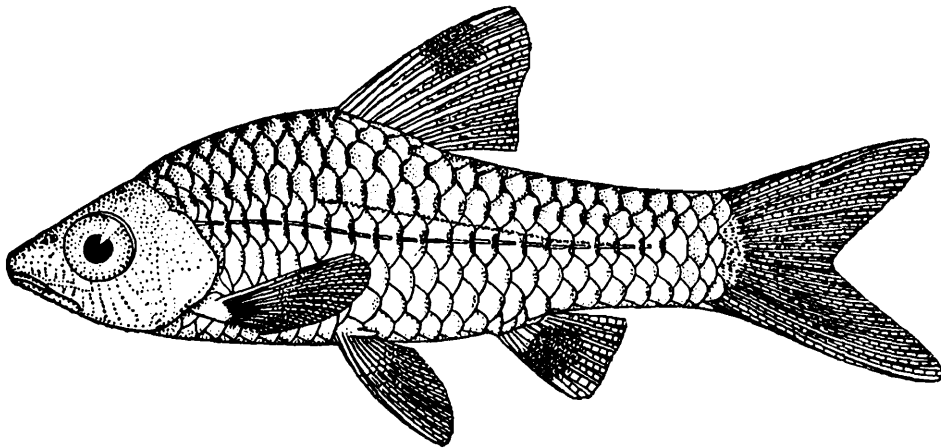
1. <i>Garra jerdoni</i> (Day)	2 specimens.
2. <i>Barbus pinnauratus</i> (Day)	2 specimens.
3. <i>Barbus sophore</i> (Ham.)	7 specimens.
4. <i>Barbus dorsalis</i> (Jerdon)	2 specimens.
5. <i>Barbus pulchellus</i> (Day)	1 specimen.
6. <i>Cirrhina fulungee</i> (Sykes)	2 specimens.
7. <i>Rasbora daniconius</i> (Ham.)	8 specimens.
8. <i>Esomus barbatus</i> (Jerdon)	3 specimens.
9. <i>Rohtee duvaucelli</i> (C. & V.)	1 specimen.
10. <i>Labauca atpar</i> (Ham.)	1 specimen.
11. <i>Nemachilichthys shimogensis</i> Rao.	1 specimen.
12. <i>Mystus cavasius</i> (Ham.)	11 specimens.
13. <i>Ophicephalus punctatus</i> Bloch.	1 specimen.
14. <i>Ambassis ranga</i> (Ham.)	1 specimen.

Bhadra River at Bhadravati, Shimoga Dist. 12-14.xii.1928.

"Bottom rocky in places but mostly covered with thick layer of silt. At the sides the bed consists of large gravel or coarse sand. Vegetation rather scanty, except for small shrubs in sandy part. Filamentous and other algae in abundance."

1. <i>Barbus dorsalis</i> (Jerdon)	2 specimens.
2. <i>Barbus ticto</i> (Ham.)	13 specimens.
3. <i>Rasbora daniconius</i> (Ham.)	20 specimens.
4. <i>Esomus barbatus</i> (Jerdon)	28 specimens.
5. <i>Danio strigillifer</i> Myers	1 specimen.
6. <i>Labauca atpar</i> (Ham.)	43 specimens.
7. <i>Lepidocephalichthys thermalis</i> (C. & V.)	15 specimens.
8. <i>Panchax lineatus</i> C. & V.	15 specimens.
9. <i>Macropodus cupanus</i> (C. & V.)	3 specimens.

From the description of the localities it is clear that Dr. Rao collected fishes from pools and puddles and, in consequence, the fish-association in this lot mostly consists of small, surface-living or mud-living species. Only a few rapid-water forms are present and the larger species are represented by young specimens only.



TEXT-FIG. 6.—Lateral view of a specimen of *Barbus cosuatus* (Ham.), to show the colour spots on the dorsal and anal fins and sensory folds on the head. $\times 3\frac{2}{3}$.

Most of the species represented in this lot do not call for any comments, but attention may here be directed to the presence of an apodal

specimen of *Ophicephalus gachua*, 63 mm. in total length, and of specimens of *Danio strigillifer* Myers. In the specimen of *Barbus cosuatus* the lateral line is only absent on the last 3 or 4 scales and the black bands on the dorsal and anal fins are represented by well defined patches which become diffuse on the neighbouring rays. The most remarkable feature of this species appears to be the presence of numerous, fine, parallel sensory folds on the sides of the head. This feature it shares with the fishes of the genus *Cyclocheilichthys* Bleeker, but in other respects it is quite different.

3. PROFESSOR C. R. NARAYAN RAO'S COLLECTION FROM THE CAUVERY RIVER IN THE COORG STATE.

Professor C. R. Narayan Rao of the Central College, Bangalore (University of Mysore) has presented to the Zoological Survey of India 211 specimens of fish collected over 10 years ago from the headwaters of the Cauvery River in the Coorg State. Unfortunately the locality labels have been destroyed by the formalin solution in which the specimens had been kept, and the collection also has suffered considerably by a long immersion in this fluid.

Professor Narayan Rao informs me that the fish were collected at 4 places along the Cauvery River—Bhagamandla, Siddapur, Fraserpet, and Dubari. Of these places he writes :—

“ The Cauvery takes its source in Bhagamandla where it is a narrow stream with even current of water flowing over soft earth—mostly loamy soil. At Siddapur the stream is still slender and sluggish and there is not much difference in the character of the soil. At Dubari, the river widens out into a fast stream flowing over small boulders and sand. It is still wider at Fraserpet but the current is slow, flowing over a sandy bed.”

Of the 54 species represented in this collection, 33 belong to the Cyprinidae, 11 to the Siluroidea (families : Heteropneustidae, Bagridae, Sisoridae, Schilbeidae, and Clariidae), 1 to the Mastacembelidae, 2 to the Cyprinodontidae, 1 to the Xenentodontidae, 3 to the Ophicephalidae, 1 to the Osphronemidae, 1 to the Ambassidae and 1 to the Gobiidae. The fish association fully bears out the nature of the localities as described in Professor Narayan Rao's note ; most of the species are sluggish-water forms.

Besides the two new species of *Barbus*, which belong to the group *Puntius*, there are representatives of several rare forms. Special mention may be made of the fact that *B. filamentosus* and *B. mahecola* are definitely proved to be conspecific, the former represents male individuals and the latter either young or female specimens. *Rasbora caverii* (Jerdon) is redescribed from a large number of specimens ; this species was imperfectly known and had not been recognised as distinct from *B. daniconius*. The precise generic and specific limits of *Pseudeutropius taakree* (Sykes) will be discussed elsewhere.

The following is a complete list of the species represented in Professor Narayan Rao's collection. Most of the forms do not call for any

comments, but the two new species are described below and notes are added on *Barbus filamentosus* and *Rasbora caverii*.

	No. of specimens.
MASTACEMBELIDAE.	
1. <i>Mastacembelus armatus</i> (Lacép.)	2
CYPRINIDAE.	
2. <i>Carassius vulgaris</i> Nilsson	1
3. <i>Garra mullya</i> (Sykes)	8
4. <i>Garra jerdonii</i> Day	1
5. <i>Garra stenorhynchus</i> (Jerdon)	2
6. <i>Labeo bogut</i> (Sykes)	3
7. <i>Labeo dussumieri</i> (C. & V.)	3
8. <i>Barbus chrysopoma</i> C. & V.	3
9. <i>Barbus pinnauratus</i> Day	7
10. <i>Barbus dubius</i> Day	1
11. <i>Barbus micropogon</i> C. & V.	2
12. <i>Barbus cauveriensis</i> , sp. nov.	2
13. <i>Barbus sophore</i> (Ham.)	5
14. <i>Barbus lithopidos</i> Day	2
15. <i>Barbus dorsalis</i> (Jerdon)	17
16. <i>Barbus kolus</i> Sykes	2
17. <i>Barbus filamentosus</i> (C. & V.)	2
18. <i>Barbus ticto</i> (Ham.)	1
19. <i>Barbus melanampyx</i> Day	1
20. <i>Barbus narayani</i> , sp. nov.	2
21. <i>Cirrhina fulungee</i> (Sykes)	1
22. <i>Cirrhina reba</i> (Ham.)	2
23. <i>Scaphiodon thomasi</i> (Day)	1
24. <i>Aspidoparia morar</i> (Ham.)	1
25. <i>Rohtee ogilbii</i> Sykes	1
26. <i>Rohtee neilli</i> Day	?
27. <i>Amblypharyngodon microlepis</i> (Bleeker)	4
28. <i>Rasbora daniconius</i> (Ham.)	3
29. <i>Rasbora caverii</i> (Jerdon)	21
30. <i>Esomus barbatus</i> (Jerdon)	1
31. <i>Danio malabaricus</i> (Jerdon)	8
32. <i>Barilius gatensis</i> (C. & V.)	7
33. <i>Nemachilus denisonii</i> Day	9
34. <i>Nemachilus dayi</i> Hora	3
HETEROPNEUSTIDAE.	
35. <i>Heteropneustes fossilis</i> (Bloch)	12
BAGRIDAE.	
36. <i>Mystus aor</i> (Ham.)	2
37. <i>Mystus punctatus</i> (Jerdon)	1
38. <i>Mystus cavasius</i> (Ham.)	10
39. <i>Mystus vittatus</i> (Bloch)	12
40. <i>Mystus montanus</i> (Jerdon)	9
41. <i>Mystus malabaricus</i> (Jerdon)	4
SISORIDAE.	
42. <i>Nangra viridescens</i> (Ham.)	1
43. <i>Glyptothorax madraspatanus</i> (Day)	1

	No. of specimens.
SCHILBEIDAE.	
44. <i>Pseudeutropius taakree</i> (Sykes)	1
CLARIIDAE.	
45. <i>Clarias batrachus</i> (Linn.)	2
CYPRINODONTIDAE.	
46. <i>Panchax blochii</i> (Arnold)	5
47. <i>Panchax lineatus</i> C. & V.	1
XENENTODONTIDAE.	
48. <i>Xenentodon cancila</i> (Ham.)	4
OPHICEPHALIDAE.	
49. <i>Ophicephalus marulius</i> Bloch.	1
50. <i>Ophicephalus punctatus</i> Bloch.	2
51. <i>Ophicephalus gachua</i> Ham.	4
OSPHRONEMIDAE.	
52. <i>Macropodus cupanus</i> (C. & V.)	2
AMBASSIDAE.	
53. <i>Ambassis ranga</i> (Ham.)	2
GOBIIDAE.	
54. <i>Glossogobius giuris</i> (Ham.)	3

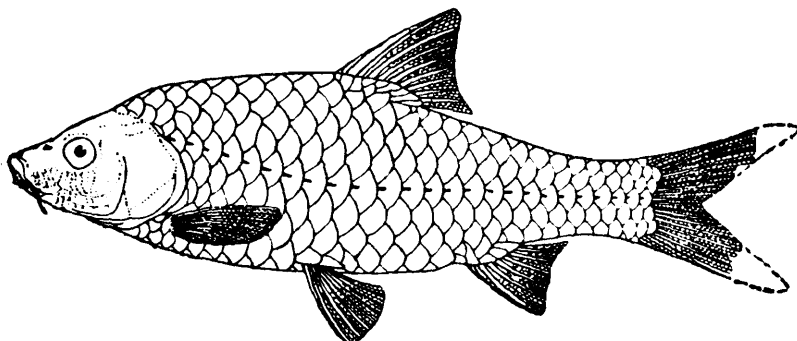
***Barbus cauveriensis*, sp. nov.**

D. 3/8-9; A. 2/5-6; P. 15-16; V 7; C. 18.

In *Barbus cauveriensis* the dorsal profile of the head rises sharply from the tip of the snout to the occiput and thereafter gently to the dorsal fin beyond which it gradually slopes down to the base of the caudal fin. The ventral profile is evenly arched throughout. The head is somewhat pointed and the snout considerably produced. In these respects the species corresponds very closely with forms like *B. dubius*, *B. thomassi*, *B. curmuca* and *B. kolus*, all of which are found in South India.

In the two specimens before me the head is proportionately larger in the smaller individual; it is contained from 3.6 to 3.8 times in the length without the caudal, its width is contained 1.7 times and its height at occiput 1.4 times in its length. The greatest depth of the body is contained from 2.8 to 3.2 times in the length without the caudal; the body is considerably deeper in the smaller specimen and is almost as thick as the width of the head. The eyes are small and situated almost entirely in the anterior half of the head; the diameter of the eye is contained from 4.6 to 4.8 times in the length of the head, 1.6 times in the length of the snout and from 1.6 to 1.8 times in the interorbital width. The mouth is small, somewhat oblique, sub-inferior and horse-shoe-shaped; the maxilla does not extend to the anterior border of the orbit; the lips are thick, somewhat papillated, and continuous. The post-labial groove is interrupted in the middle. There is a pair of small maxillary barbels which are as long as the diameter of the eye. On the sides of the head there are numerous, fine, parallel sensory folds similar

to those present in fishes of the genus *Cyclocheilichthys* Bleeker. The suborbital ring of bones is narrow.



TEXT-FIG. 7.—Lateral view of the type-specimen of *Barbus cauveriensis*, sp. nov. $\times \frac{1}{2}$.

The scales are large and firmly fixed ; there are from 25 to 26 scales along the lateral line and 9 longitudinal series between the bases of the dorsal and ventral fins. Between the lateral line and the base of the ventral fin there are $3\frac{1}{2}$ rows of scales. The number of scales round the caudal peduncle is 12 and in front of the dorsal fin 9. The scales at the base of the dorsal fin form a tile-like row. The lateral line is complete. The caudal peduncle is from 1.3 to 1.4 times as long as high.

The dorsal fin commences almost midway between the tip of the snout and the base of the caudal fin ; its free border is slightly concave. The dorsal spine is osseous and smooth ; it is three-fourths of the length of the head. The pectorals are considerably shorter than the head and do not extend to the bases of the ventrals which are separated from the anal-opening by a distance almost equal to half of their length. The body between the ventrals and the anal is somewhat keeled. The anal fin is short and is separated from the caudal by a considerable distance. The caudal fin is deeply forked.

The specimens under report are greyish brown, but on account of long immersion in a formalin solution appear to have lost all natural colour.

Locality.—Cauvery River, Coorg State.

Type-specimen.—F 12179/1, Zoological Survey of India (Ind. Mus.), Calcutta.

Remarks.—This is a remarkable species of the genus *Barbus* and can be distinguished by (i) two barbels, (ii) osseous, smooth spine, (iii) large scales, (iv) small eyes, (v) greatly produced snout, (vi) nature of dorsal profile, and (vii) sensory folds on the head. I am not aware of any other species of the genus *Barbus* in any way closely allied to this species, unless any of Jerdon's species, which are very little known, may prove to be this form.

Measurements in millimetres.

Total length without caudal	.	.	.	.	105.0	124.0
Length of head	.	.	.	.	28.9	32.5
Width of head	.	.	.	.	17.0	19.0
Height of head at occiput	.	.	.	.	20.0	22.5
Depth of body	.	.	.	.	37.0	39.0
Width of body	.	.	.	.	16.0	19.0
Diameter of eye	.	.	.	.	6.0	7.0
Interorbital width	.	.	.	.	11.0	11.3

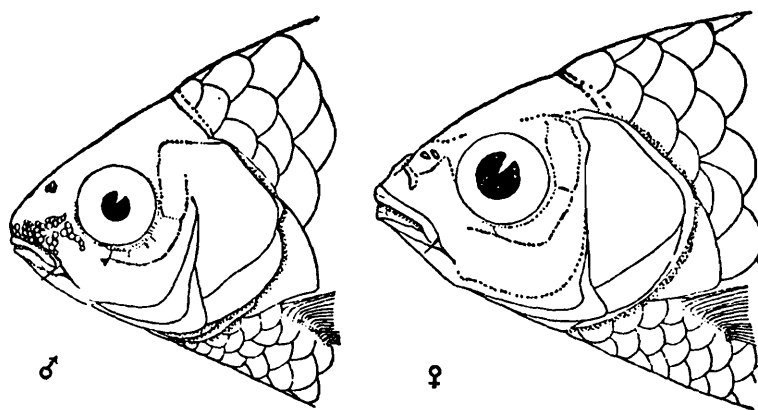
Length of snout	10.0	11.0
Length of dorsal spine	22.0	24.0
Longest ray of anal	14.0	16.5
Length of pectoral	21.0	22.5
Length of caudal peduncle	18.0	22.0
Least height of caudal peduncle	14.0	15.2

***Barbus filamentosus* (Cuv. & Val.).**

1844. *Leuciscus filamentosus*, Cuvier and Valenciennes, *Hist. Nat. Poiss.*, XVII, p. 96, pl. cccxcii.

Of the very large number of species of the genus *Barbus* (*s. l.*) known from India, *B. filamentosus* can be readily distinguished by its large scales and characteristic colouration. Identically the same features distinguish *B. mahecola* (C. & V.).¹ In his account of the former species Day² stated that "It is so similar to *B. Mahecola* (except in wanting barbels) that I have not figured it." When considering the utility of barbels in separating species of *Barbus* Day (*op. cit.*, p. 556) remarked :

"It is remarkable how very similar the *Barbus Mahicola*, C. V which has two barbels, is to the *B. filamentosus*, C. V with none. If a number of examples are examined it will be found that in some these appendages are very minute, the barbels being, as a rule, smallest in specimens obtained furthest from the hills. In South Canara, the Wynaad, and base of the Neilgherries, where the barbels are large, the *B. Mahicola* abounds: towards Cochin and up the Coromandel coast as far as Madras they are small or absent, and *B. filamentosus* is the type. Here, undoubtedly, the question must force itself on one's notice, are we dealing with two distinct species, or one in a state of transition? If the latter, which is the original form?"



TEXT-FIG. 8.—Lateral view of head and anterior part of body of a male and a female specimen of *Barbus filamentosus* (C. & V.). Nat. Size.

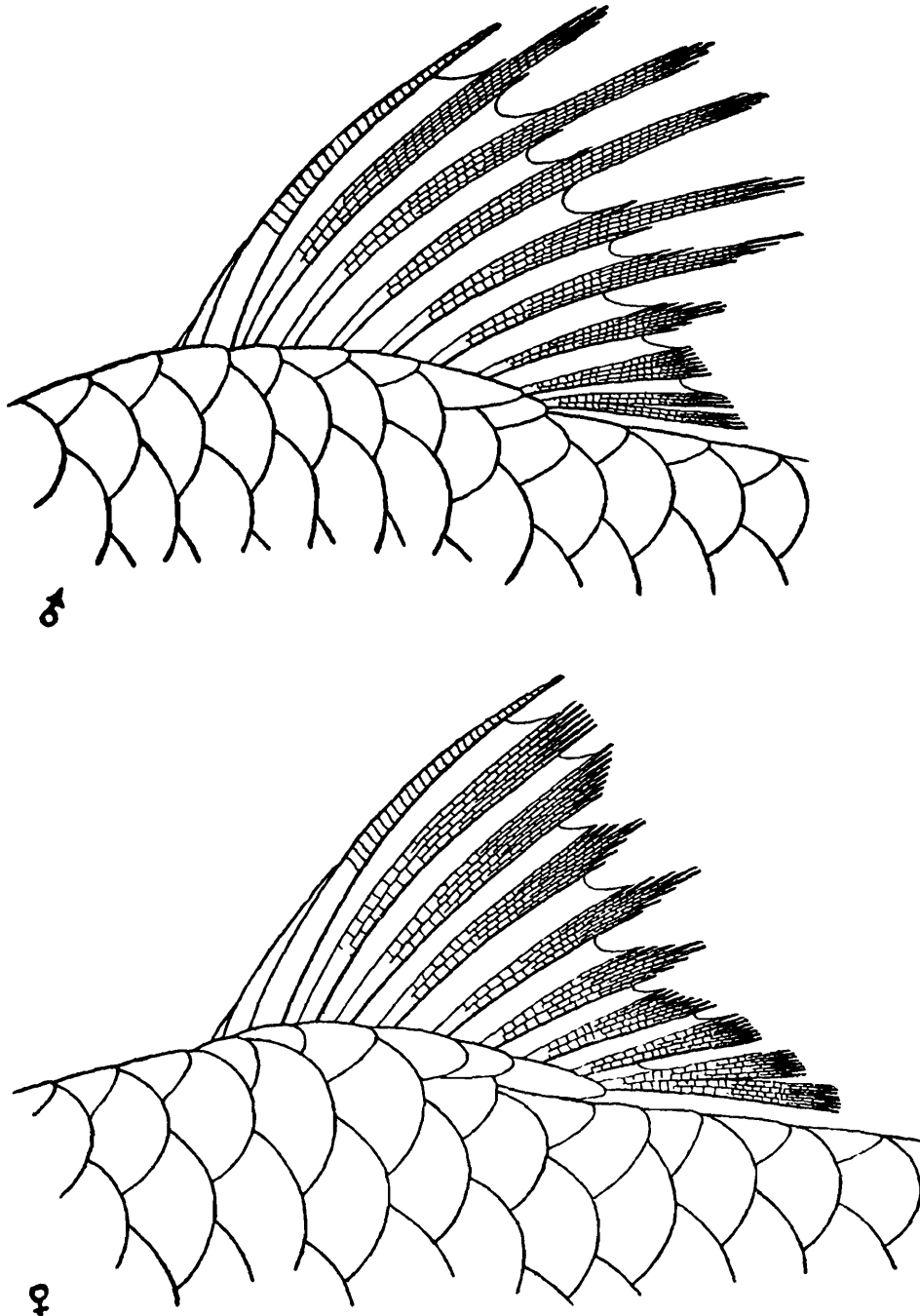
In his "Fishes of Malabar" Day had considered *Puntius filamentosus* as the adult of *P. mahecola*, but Günther³ did not agree with his view and remarked, "I hesitate to adopt this opinion, because the black caudal spot is more advanced in *B. filamentosus* than in the figure of *L. mahecola*." From an examination of the material in the collection of

¹ Cuvier & Valenciennes, *Hist. Nat. Poiss.*, XVII, p. 305. pl. 502 (1842).

² Day, *Fish. India*, pp. 582, 556 (1877).

³ Günther, *Cat. Fish. Brit. Mus.*, VII, p. 146 (1868).

the Indian Museum I am convinced that Day was fully justified in his views regarding the identity of the two species referred to above. In



TEXT-FIG. 9.—Lateral view of dorsal fin of a male and a female specimen of *Barbus filamentosus* (C. & V.). $\times 1\frac{2}{3}$.

the adult condition, especially at breeding time, secondary sexual characters appear so that in the males the anterior 4 or 5 branched rays of the dorsal fin are prolonged and the snout is covered by a patch of large tubercles on either side in front of the eyes. The male in this condition represents the *filamentosus*-type and the female *mahecola*-type. It was pointed out by Mukerji and myself¹ that more or less similar sexual differences were responsible for *Barbus chagunio* and *B. spilopholus* being recognised as two distinct species. Quite recently Misra and I²

¹ Hora & Mukerji, *Journ. As. Soc. Bengal* (N. S.) XXVII 1931, p. 137 (1933).

² Hora & Misra, *Rec. Ind. Mus.*, XXXVIII, p. 341 (1936).

described the sexual differences in *Labeo dero*. From the above it is abundantly clear that *B. filamentosus* and *B. mahecola* cannot be regarded as distinct species; the former name has page priority over the latter.

Attention may here be directed to the fact that Jerdon¹ described this species under three names—*Systomus filamentosus*, *S. assimilis* and *S. madraspatensis*, and the descriptions show that he must have had specimens of different sizes and sexes before him. He also included *Leuciscus mahecola* in his list but had no specimen of the species for examination. Day² also described the young of this species as *Puntius (Capoeta) lepidus*, but in his "Fishes of India" he included it in the synonymy of *Barbus mahecola*. Sundara Raj³ in his account of the freshwater fish of Madras listed both the species but remarked as follows under *B. filamentosus*:

"It is very doubtful if the present species is really distinct from *B. mahecola* (C. & V.). Both forms, those with a pair of minute maxillary barbels (*B. mahecola*) and those without them (*B. filamentosus*), occur in Madras and are identical in all other respects."

I have found minute barbels even in the specimens referred by Day to *mahecola*. On account of their small size, however, they are liable to be overlooked sometimes.

***Barbus narayani*, sp. nov.**

D. 3/9; A. 3/6; P. 14; V. 9; C. 18.

Barbus narayani is a small, well-built species in which both the dorsal and the ventral profiles are greatly arched, the former more so than the latter. The head is short and blunt; its length is contained about 4 times in the total length without the caudal. The head is almost as high at the occiput as its length, while its width is about two-thirds of the length. The depth of the body is contained about 2.5 times in the length without the caudal while its width is somewhat less than that of the head. The eyes are large and are situated considerably nearer to the tip of the snout than to the posterior border of the operculum. The diameter of the eye is contained about 2.9 times in the length of the head. The snout is shorter than the diameter of the eye while the interorbital width is almost equal to it. The mouth is small and somewhat oblique. The lips are fleshy and continuous; they are studded with minute spines. The labial groove is interrupted in the middle. The barbels are totally absent.

The scales are well developed; there are about 22 scales along the lateral line and 9 rows between the bases of the dorsal and ventral fins, 4 rows above the lateral line and 4 rows below it. There are 12 scales round the caudal peduncle and 8 before the dorsal fin. The caudal peduncle is almost as high as long.

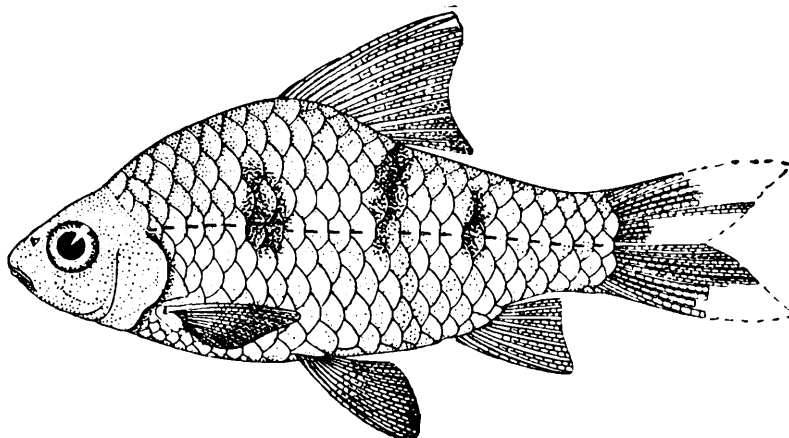
The dorsal fin commences slightly in advance of the ventral; its commencement is nearer the tip of the snout than the base of the caudal. It possesses a feeble and articulated spine which is considerably longer

¹ Jerdon, *Madras Journ. Lit. Sci.*, XV, pp. 318, 319, 322 (1848).

² Day, *Proc. Zool. Soc. London*, p. 196 (1868).

³ Sundara Raj, *Rec. Ind. Mus.*, XII, p. 258 (1916).

than the head ; its free border is slightly concave though rounded at the top. The pectoral fin is slightly shorter than the head, but it extends



TEXT-FIG. 10.—Lateral view of the type-specimen of *Barbus narayani*, sp. nov. $\times 1\frac{1}{2}$.

to the commencement of the ventral fin which is as long as the pectoral. The ventrals just reach the anal-opening. The anal fin is short. The caudal fin is forked.

Due to a long immersion in a formalin solution the original colour has disappeared in the specimens before me ; the general colour at present is greyish-brown. Three vertical black marks on the body are faintly indicated, the first below the commencement of the dorsal, the second below or just behind the dorsal and the third above the posterior half of the anal.

Locality.—Cauvery River, Coorg State.

Type-specimen.—F 12180/1, Zoological Survey of India (Ind. Mus.), Calcutta.

Remarks.—This small species may be distinguished by the following combination of characters : (i) absence of barbels, (ii) smooth, articulated dorsal ray longer than the head, (iii) complete lateral line ; (iv) 22 scales along lateral line and 9 rows between the bases of dorsal and ventral fins, and (v) three vertical marks on the body.

I have great pleasure in associating the name of this species with that of Professor C. R. Narayan Rao through whose generosity the Zoological Survey has received a valuable collection from the Cauvery River.

Measurements in millimetres.

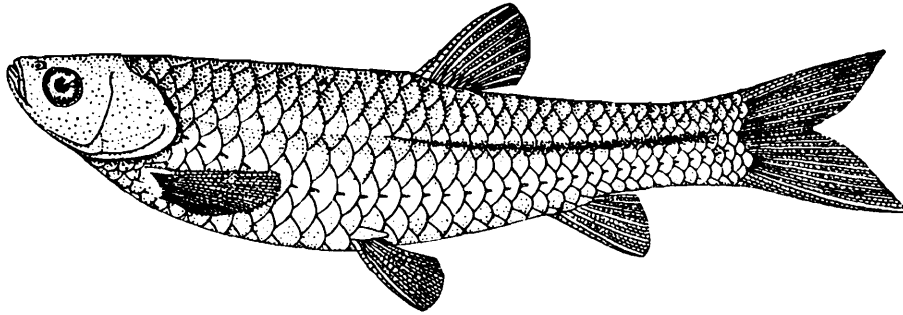
Total length without caudal	46.0	47.0
Length of head	11.5	11.5
Width of head	8.0	8.0
Height of head at occiput	11.3	11.4
Depth of body	18.0	19.0
Width of body	7.0	7.0
Diameter of eye	4.0	4.0
Interorbital width	4.0	4.3
Length of snout	3.6	3.6
Length of dorsal spine	13.5	13.6
Longest ray of anal	9.0	9.0
Length of pectoral	11.0	11.0
Length of caudal peduncle	8.0	8.0
Least height of caudal peduncle	7.5	7.6

Rasbora caverii (Jerdon).

1848. *Leuciscus Caverii*, Jerdon, *Madras Journ. Lit. & Sci.*, XV, p. 320.

Jerdon's *Leuciscus caverii* has not been recognised as a distinct species both by Günther¹ and Day², the former listed it among the species insufficiently described for their systematic position to be ascertained from the accounts given, while Day included it in the synonymy of *Rasbora daniconius* (Ham.) without any comments. In Professor C. R. Narayan Rao's collection there are 21 specimens of a species of *Rasbora*, which are abundantly distinct from *R. daniconius* and *R. rasbora*, and seem to agree with the meagre and inadequate description of *Leuciscus caverii*, which, according to Jerdon, is very common in the Cauvery and all its branches. Jerdon's description of *L. caverii* is as follows:—

“Head about one-fourth length of body; height one-fifth of length; eye nearly one-fifth of length of head; dorsal placed a little behind the middle of back, nearly opposite to anal; 30 scales along the side in 7 rows—D. 9, A. 6—green above, silvery beneath; cheeks golden; a blue stripe from operculum to tail, with a narrow yellow one above it; lateral line concave—usually about 3 inches long.”



TEXT-FIG. 11.—Lateral view of an adult specimen of *Rasbora caverii* (Jerdon). Approximately natural size.

The above description agrees more particularly with the smaller individuals before me, while the proportions, etc., of the adult specimens are quite different. Jerdon also noted that—

“I possess a sketch of another *Leuciscus* from the Cauvery of which I have lost my specimen, which appears to differ from any of these. It is nearly allied to *L. Caverii* in form, but has a much larger eye, and the depression in the crown more marked, muzzle in front of the depression continuing straight, parallel with the back; profile of abdomen good deal arched; lateral line much curved. I am unable to give the number of rays or scales.”

In the case of Jerdon it is known that he very often recognised the young and adult specimens of a fish as distinct species and the above two descriptions seem to refer to the different stages of growth of the same species. The description of the dorsal and the ventral profiles as also of the lateral line agree with the same features in the adult specimens before me.

As to the precise systematic position of Jerdon's *Leuciscus malabaricus*, and *L. flavus*, which Day included in the synonymy of *Rasbora daniconius* along with *L. caverii*, it is very difficult to express an opinion without examining fresh material from the type-localities.

¹ Günther, *Cat. Fish. Brit. Mus.*, VII, p. 5 (1868).

² Day, *Fish. India*, p. 584 (1877).

Rasbora caverii may now be redescribed as follows :—

D. 2/7 ; A. 1/5 ; P. 14 ; V 7 ; C. 19.

In the adult specimens the dorsal profile is almost straight and horizontal while the ventral profile is greatly arched. In the young individuals, however, both the dorsal and the ventral profiles are only slightly arched. The head is bluntly pointed ; it is relatively large in young individuals, its length being contained from 5.1 to 5.6 times in the total length and from 4.2 to 4.6 times in the length without the caudal. The width and height of head increase with growth, the former is contained from 1.9 to 2.6 times and the latter from 1.4 to 1.8 times in the length of the head. The depth of the body is contained about 5 times in the total length and from 3.9 to 4.2 times in the length without the caudal. The eye is situated entirely in the anterior half of the head ; its diameter is contained from 3.5 to 3.6 times in the length of the head. The snout is somewhat shorter than the diameter of the eye. The interorbital space is narrower in the young individuals, being less than the diameter of the eye. In adults the space between the orbits is flat and about $1\frac{1}{3}$ times the diameter of the eye. The mouth is small and obliquely directed upwards ; the maxilla does not extend to below the anterior margin of the orbit. The lower jaw bears a prominent knob in the middle and there is a corresponding emargination in the upper jaw. The lips are moderately fleshy and continuous ; the post-labial groove is interrupted in the middle. The pharyngeal teeth are curved and sharp ; they are situated in 3 rows : 4, 3, 2. The barbels are totally absent. The gill-membrane is well developed.

The scales are thin but firmly adherent ; their exposed portions are marked with a large number of radii. The lateral line is complete and curved ; there are about 32 perforated scales. The number of scales from the upper angle of the gill-opening to the base of the caudal is about 36-37. There are 7 series of scales between the bases of the dorsal and ventral fins and $1\frac{1}{2}$ to 2 between the lateral line and the base of the ventral fin. The number of predorsal scales is 16-17, while there are 14 scales round the caudal peduncle, which is almost twice as long as high. There is a scaly appendage in the axil of the ventral fin.

The dorsal fin commences considerably behind the commencement of the ventral but does not extend over the anal fin. Its longest ray is equal to the head behind the middle of the eyes, and its free border is rounded ; its commencement is considerably nearer to the base of the caudal than to the tip of the snout. The pectorals are small and do not extend to the ventrals, which are separated from the anal-opening by a distance equal to three-fourths of their own length. The anal fin is small and commences midway between the base of the caudal and the commencement of the ventrals. The caudal fin is forked with both the lobes pointed ; the lower lobe is longer and better developed than the upper.

The general colour of the spirit specimens before me is olivaceous with a faintly marked lateral streak on the sides ; this lateral band is more prominent in the posterior half of the body.

Locality.—Cauvery River, Coorg State.

Measurements in millimetres.

Total length excluding caudal		54.0	71.0	79.0
Length of caudal	.	12.0	20.0	17.0
Length of head		13.0	16.5	17.0
Width of head		5.0	7.5	8.8
Height of head at occiput		7.2	10.8	11.5
Depth of body		13.0	18.0	19.0
Width of body		6.0	8.6	10.0
Diameter of eye		3.7	4.5	4.7
Length of snout		3.3	4.4	4.3
Interorbital width	.	3.0	5.7	5.8
Longest rays of dorsal	.	9.8	14.0	12.0
Longest ray of anal	.	9.2	11.0	11.0
Length of pectoral	.	9.8	13.0	13.0
Length of ventral	.	8.0	11.0	11.8
Length of caudal peduncle	.	13.0	15.0	19.0
Least height of caudal peduncle		7.0	8.0	9.0

DESCRIPTIONS OF THREE NEW HYDROPHILIDAE FROM INDIA.

By A. D'ORCHYMONT, *Brussels.*

***Helochares (Agraphydrus) exedis*, sp. nov.**

Type : No. $\frac{3802}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Bombay Presidency, Poona District, Khandala, alt. ca. 2,500 feet ; 6-10.iii.1918 ; among damp algae on cliff at edge of waterfall (Annandale), ♂, 2×1 mm.

Paratypes : Nos. $\frac{3803-3805}{H4}$. Same locality ; same collector ; a few specimens.

Distinguished from all previously described *Agraphydrus* by its unpolished, somewhat eroded, nearly unpunctate upper surface. Under a very high power, however, it is possible to detect very fine and small punctures, separated from one another by about five times their diameter. The eroded appearance of the upper surface (head, prothorax, scutellum and wing cases) is due to an extremely fine, microscopical reticulation, which is difficult to see even under the microscope.

Of an obscure testaceous colour, obscured on the labrum, middle of forehead, between the eyes faint and indefinite in places, apparently owing to transparency, upon the disc of prothorax, very faintly on the disc of elytra. On the head the Y-suture is blackish with a row of coarser punctures behind the anterior branches of the Y. Eyes small. Antennae 9-jointed, joints 4 and 5 very short. Palpi entirely yellow.

Anterior and posterior angles of prothorax rounded, posterior ones more so ; anterior margin narrower than the posterior, anterior and postero-lateral systematic series distinct, composed of moderately coarse punctures.

Elytra not $1\frac{1}{2}$ times as long as wide, suture very narrowly blackish, systematic series of coarser punctures not well developed but there are two basal punctures on each side of scutellum.

Mentum shining, with some very minute punctures on the side and a semi-circular shining excavation in the middle of anterior margin. Mesosternum minutely protuberant in the middle before intermediate coxae. Emargination of the last ventral segment very shallow and wide. All femora except the knees pubescent. Tibiae very spinulose. Tarsi yellow.

Aedeagus at its end V-shaped ; the parameres being widened at their apex to an oblique foot-like appendage, which is minutely toothed or hooked at its outer and anterior edge ; at their apices the appendages are rounded. The median lobe is not protruding but embedded in between the two parameres, shorter and much narrower, parallel-sided and rounded at the apex.

***Pelthydrus similis*, sp. nov.**

Type : No. $\frac{3806}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Nerbudda Survey, sta. 56, Rewa State, Machrar Nala

tributary at Chapra, 2,625 feet ; March 1927 (H. S. Pruthi) ; 2.6×1.3 mm.

Paratypes : Nos. $\frac{3807-3811}{H4}$. Same locality, date, altitude and collector ; sta. 51, same Survey, the river opposite the camp at Kachratola, 2,625 feet ; March 1927 (H. S. Pruthi) ; a few. Sta. 38, the river about 3 miles (east) from Koilari, Rewa State ; February 1927 (H. S. Pruthi) ; a single specimen.

This is the 12th *Pelthydrus* discovered ; it comes very near *vitalisi* d'Orchymont, being of about the same size (2.5-2.6 mm.), 8-jointed antennae, not punctate-seriate elytra, not very small eyes, carinate prosternum, in the middle of body not much widened and not of navicular shape, with also close and coarse punctation on the wing cases. The colouration of the upper surface is the same : deep blackish, with the disc of prothorax and elytra bordered more widely with clearer brown or even yellow. The palpi are uniformly reddish as also the feet with only the tibiae more or less infuscate. The anterior side of the forehead is widely and more deeply emarginate, as in *vitalisi*, with the outer angles more sharply protruding. The prothorax is moderately convex, very distinctly narrowed behind with the posterior margin distinctly narrower than the anterior (in *vitalisi* more convex and nearly of same width before and behind). The anterior angles are entirely rounded. The sculpture of the prothorax is also somewhat different : under a high power the large punctures seem preceded by a much finer one which has a tendency to coalesce in the longitudinal direction, so that the punctures seem more distinctly geminate than in *vitalisi*. The elytra are more parallel-sided, less attenuate posteriorly and less convex than in that species, without the faintest trace of a serial arrangement of some of the otherwise nearly as dense and strong punctures.

On the under side the mesosternal process is not arrow-head shaped as in *vitalisi*, but the longitudinal carina is only limited before by a half circular and obscurely raised line. Seen from the side the process is not so protuberant before as in *vitalisi*. The first ventral segment is, therefore, less distinctly carinate.

***Berosus (Enoplurus) fallax*, sp. nov.**

Type : No. $\frac{3812}{H4}$. In the Zoological Survey of India (Indian Museum), Calcutta. Nerbudda Survey, Central Provinces, sta. 83 ; small pools near the river channel at Mandla ; ♂, 4.9×2 mm. ; November 1927 (H. S. Pruthi).

Paratypes : Nos. $\frac{3813-3819}{H4}$ Same locality, date and collector ; ♂♂♀♀. Same Survey, the Taba tributary at Babai, Central Provinces, sta. 103 ; 17th December 1927 ; still water ; 1 ♂ (H. S. Pruthi) ; the river at Hoshangabad (Central Provinces), sta. 104 ; December 1927, 1 ♀ (H. S. Pruthi).

Nearest to *fairmairei* but on an average somewhat smaller and more coarsely sculptured, with the elytral striae, especially at base and along suture, deeper impressed and the interspaces more densely and more coarsely punctured, the sutural angle of elytra of ♂ more produced than in the ♀, the parameres of aedeagus very long, rounded at extremity

(very acutely pointed in *fairmairei*) and the median lobe not abruptly widened at the end, which is coated with dense, very short, microscopical setae; median orifice distal (median lobe in *fairmairei* strongly arcuate but only in one direction—convexity ventral—the end abruptly widened, coated also with very short setae and with median orifice nearly distal).

Upper side of a yellow testaceous colour, very obscurely darkened by brown spot-like markings: two on the postfrons, sometimes two geminated ones towards the anterior side of prothorax, one along the suture of elytra beyond the middle and two others more exterior ones before and another behind the sutural one. These elytral markings are rather darkenings of a short portion of the 2nd to 4th, 7th to 9th and 5th to 7th striae.

Head and prothorax more densely and more regularly punctured than in *fairmairei*, otherwise very similar in general form and disposition. Each elytral puncture of interstices bears a short yellow procumbent hair. Exterior spine long and slender, a trifle more so than in *fairmairei*.

Mesosternum with a low median elevated carina. Metasternal median process triangular and advanced towards posterior coxae and deeply unifoveolate below. First ventral segment obscurely carinate at base. Fifth abdominal segment with a wide and very shallow emargination, not toothed at the bottom, inconspicuously more abrupt at the sides as in *fairmairei*. Claws of tarsi long as in that species.

♂. Anterior tarsi tetramerous, the basal joints enlarged, elytral interspaces not reticulate between punctures. Fifth ventral segment with a shallow emargination as remarked above, nearly 4 or 5 times as wide as deep.

♀. Anterior tarsi pentamerous, basal joints not enlarged, elytral interspaces very distinctly reticulate, 5th abdominal segment not emarginate at the end but widely and inconspicuously truncate at the end, the truncate portion being nearly twice as wide as the emargination of ♂.

COLEOPTERA PALPICORNIA FROM THE KHEWRA GORGE, SALT RANGE, PUNJAB.

By A. D'ORCHYMONT, *Brussels.*

Some time back I received from Dr. H. S. Pruthi some Coleoptera Palpicornia collected by him and Dr. S. L. Hora of the Zoological Survey of India during a survey of the Khewra Gorge, Salt Range, Punjab. According to Dr. Pruthi there is a small stream at the Khewra Gorge, the water of which is fresh three miles above the Khewra village, but gradually becomes saline nearer the village. It is a stream only during and just after the rainy season, and for the most part of the year it consists of only a chain of pools, more or less connected with one another, in some cases by under-ground water channels. As noted above, the salinity increases on approaching the Khewra village and near the village itself is more than twice that of the sea¹. Of course under such uncertain conditions the salinity must be very variable according to the period of the year at which investigations are carried out.

The stations from where Palpicornia were submitted to me are the following ; the numbers of the stations follow the course of the stream upwards :

Sta. 2 ; 12.x.1930². Stream about a quarter mile beyond station 1. Salinity : 91.273. Species collected : *Ochthebius flumineus*, sp. nov., *O. explanatus*, sp. nov., *Enochrus (Lumetus) sinuatus*, sp. nov., *Berosus (s. str.) nigriceps* (F.), and *B. insolitus*, sp. nov.

Sta. 3 ; 13.x.1930. A couple of hundred yards beyond station 2 and near the first sharp turning of stream. Salinity : 42.357. Species collected : *Enochrus (Lumetus) sinuatus*, sp. nov., *Berosus nigriceps* (F.)

Sta. 4 ; 13.x.1930. A small highly saline streamlet flowing on the side of station 3. Salinity : 143.889³. Species collected : *Enochrus (Lumetus) sinuatus*, sp. nov., *Berosus nigriceps* (F.), *Berosus insolitus*, sp. nov.

Sta. 5 ; 9.iv.1931. A large deep pool in the course of the stream at the turning about 50 yards beyond stations 3 and 4. Salinity : not indicated (fresh water ?). Species collected : *Laccobius gracilis* Mots., *Enochrus (Lumetus) sinuatus*, sp. nov., *Sternolophus rufipes* (F.), *Berosus (s. str.) nigriceps* (F.)

Sta. 7 ; 31.iii.1931. A large pool in the course of the stream between stations 6 and 8. Salinity : 6.366. Species collected : *Laccobius gracilis* Mots., *sinuatus* d'Orchymont, *Helochaeres (Agraphydrus) stagnalis*, sp. nov., *Sternolophus rufipes* (F.)

¹ H. S. Pruthi—"An Ecological Study of the Fauna of the Khewra Gorge and some other Salt Waters in the Salt Range, Punjab" *Rec. Ind. Mus.*, XXXV, pp. 87-119, with one text-figure (1933).

² Some of the labels bear the date 30.x.1930.

³ About 4½ times as much as the salinity of the Indian Ocean.

Sta. 9 ; 10.iv.1931. A series of small pools and rapids in the course of the stream, 50 yards beyond station 8. Salinity : 1.979. Species collected : *Coelostoma horni* (Régimbart).

Sta. 10 ; 2.iv.1931. A small pool in the course of the stream near the place where the water-pipe crosses the stream. Salinity : 0.608. Species collected : *Enochrus* (*Methydrus*) *tetraspilus* (Régimbart).

Of the eleven species represented in the collection, five are new to science. Some of them (*Ochthebius flumineus* and *O. explanatus*, *Enochrus sinuatus* and *Berosus insolitus*) appear as if they were at least halophilous, if not halobiont, although the third (*Enochrus sinuatus*) was also collected at station 5, where the salinity seems to have been so low, on the 9th of April 1931, as to be not worth recording. At stations 2 to 5 with these four species specimens of *Berosus nigriceps* (F.) were also collected ; this species is widely distributed throughout India. In spite of Knisch's statement in his catalogue, it is specifically distinct from the cafrarian *punctulatus* of Boheman. Most of the species studied are rather of a Palaearctic character, but *Coelostoma horni* and *Sternolophus rufipes* are certainly Indo-Malayan. The sub-genus *Helochares* (*Agraphydrus*) has an extensive range of distribution, from tropical Asia over Sumatra, Java and Bali as far as Madagascar and even continental East Africa.

The table on the opposite page shows the exact localities from which the various species were collected.

***Ochthebius* (*Hymenodes*) *flumineus*, sp. nov.**

Type : No. $\frac{3820}{H4}$. Indian Museum ; ♂ ; Station 2 ; 12.x.1930 ; 2×0.8 mm.

Paratypes : Nos. $\frac{3821-3826}{H4}$. ♂♂♀♀. Same locality and date (Station 2) ; few specimens.

This new species can be distinguished from the closely allied species (*difficilis* Mulsant, *schneideri* Kuwert, *aeneocupreus* J. Sahlberg) by its smaller prothorax as compared with the hind body, by the labrum being conspicuously notched in the middle of its anterior margin, by the elytra of the ♀ gradually and widely expanded behind the shoulders to nearly the sutural angle, the expanded margin having its greatest width just before the middle. The aedeagus differs from that of *aeneocupreus* by the extremity of the median lobe being much more smaller and less widely spatuliform.

Upper side black with a cupreous or purpuraceous hue and fine recumbent hairs. Palpi and legs testaceous brown, with the extremity of 5th joint of tarsi somewhat infusate. Forehead shining, sparsely and finely punctate, the clypeal suture transversely deepened in the middle. Space between the inter-ocular foveae and before the posterior one also shining, sparsely and finely punctate. Labrum notched in the middle but not very deeply.

Sclerified portion of prothorax irregularly hexagonal, much more narrowed towards the base than towards the apex, lateral angulation being on the first third ; behind this angulation the sides are not serrate and nearly straight or but little curved inwards to the posterior angles, and bordered with a pellucid narrow membrane. The fore side is also

Stations.	1 ¹		2		3		4		5		7		9	10	11
Date.	11.x.30.	27.iii.31.	12.x.30.	9.iv.31.	13.x.30.	9.iv.31.	13.x.30.	9.iv.31.	14.x.30.	9.iv.31.	14.x.30.	31.iii.31.	10.iv.31.	2.iv.31.	3.iv.31.
Salinity.	78.529	166.830	91.273	123.961 ²	42.357 ³	51.057 ⁴	143.889 ⁵	130.82 ⁶	38.856 ⁵	?	5.174 ³	6.366	1.979 ⁶	0.603 ⁴	0.192 ⁶
Hydraenidae.															
1. <i>Ochthebius</i> (<i>Hymenodes</i>) <i>fluminus</i> , sp. nov.			×												
2. <i>Ochthebius</i> (<i>Hymenodes</i>) <i>explanatus</i> , sp. nov.			×												
Hydrophilidae.															
3. <i>Coelostoma horni</i> (Régimbart)													×		
4. <i>Laccobius</i> (<i>s. str.</i>) <i>gracilis</i> Mots.										×		×			
5. <i>Laccobius</i> (<i>s. str.</i>) <i>simulans</i> d'Orchymont.												×			
6. <i>Helochaeres</i> (<i>Agraphydrus</i>) <i>stagnalis</i> , sp. nov.												×			
7. <i>Enochrus</i> (<i>Lumetus</i>) <i>sinuatus</i> , sp. nov.			×		×		×			×					
8. <i>Enochrus</i> (<i>Methydrus</i>) <i>tetraspilus</i> (Régimbart).														×	
9. <i>Sternolophus</i> (<i>s. str.</i>) <i>rufipes</i> (F.)										×		×			
10. <i>Berosus</i> (<i>s. str.</i>) <i>nigriceps</i> (F.)			×		×		×			×					
11. <i>Berosus</i> (<i>s. str.</i>) <i>insolitus</i> , sp. nov.			×				×								

¹ According to Dr. Pruthi's report *Ochthebius* sp., *Berosus nigriceps* and *Berosus* sp. (larvae) were present, but no specimens were submitted for identification.

² According to the same report *Ochthebius* sp., *Enochrus* sp., *Enoplurus* sp. and ? *Berosus* sp. (larvae) were present, but no specimens were submitted for identification.

³ According to the same report *Ochthebius* sp. present, but not submitted for identification.

⁴ According to the same report *Ochthebius* sp. and *Enochrus* sp. present, but not submitted for identification.

⁵ According to the same report *Palpicornia* were captured, but not submitted for identification.

⁶ According to the same report ? *Berosus* sp. present, but not submitted for identification.

bordered with such a narrow membrane, and is only faintly emarginated behind the normally convex eyes; the anterior angles do not project forwards. Immediately behind these angles the lateral border has 3-4 very small tooth-like asperities. The disc is shining and sparsely punctured but more strongly than on the head. There is a deep and narrow median furrow, on each side of this furrow are the lateral foveæ, the anterior ones somewhat smaller and shorter than the posterior, and the lateral ear-like projections of the disc are very finely reticulate-granulate.

Elytra wider at the base than at the base of prothorax, widest a little beyond the middle, separately rounded at the extremity. They are provided with ten regular not striated rows of moderately impressed and not very large punctures. The interspaces of rows are wider than the punctures, and wider also than the space separating two succeeding punctures of the same row. Out of each puncture a recumbent hair arises, and as a result the pubescence of elytra appears to be arranged in regular distanced rows. The external, not serrate but entire border, seen from above is not expanded in the males, but is widely so in the females, as described above. One of the females has its elytra particularly widened.

The pygidium protrudes somewhat in both sexes, between the median emargination at the sutural angle of elytra.

Ochthebius (Hymenodes) explanatus, sp. nov.

Type: No. $\frac{3827}{H4}$ Indian Museum; ♂; Station 2; 12.x.1930; 1.47 × 0.6 mm.

Paratypes: Nos. $\frac{3828-3839}{H4}$. ♂♂♀♀; same locality and date (Station 2): numerous specimens.

The ♀ has its elytra expanded as in females of *flumineus*, but the latter species is larger, much more shining, without reticulation upon the elevated parts of the disc of the head and prothorax.

Also the aedeagus is different: in *explanatus* the terminal mobile piece is only gradually and not greatly, more or less triangularly widened at the extremity, while in *flumineus* it is abruptly widened at the end into a more or less rounded spatuliform flattened plate.

O. explanatus by its long legs and widened elytra, especially in the ♀, recalls somewhat the subgenus *Doryochthebius*, but the anterior angles of the prothorax do not protrude forwards like finger-like processes and the anterior border near those angles is not emarginate behind the eyes (deeply excised in *Doryochthebius*). *O. andraei* Breit (Mesopotamia: Hit) and *reflexus* Sahlberg (Transcaspia: Mulla Kara) differ by their size (2 mm.) and in other particulars, *vide* their descriptions.

Of a black colour with greenish metallic hue, the legs and palpi, with the exception of their last joint which is clear yellowish, of a brownish colour. Head and prothorax even on the elevated parts are microscopically reticulated. The labrum is somewhat deeper notched in the middle as in *flumineus*. The clypeal suture is transversely deepened in the middle and the posterior fovea of head is much smaller than the two interocular ones.

Prothorax narrower behind than in front, but with no conspicuous angulation on the sides. The sclerified disc is widest in the anterior third, wider here than the head with the eyes, with the anterior angles completely rounded and provided with some very small tooth-like asperities, gradually attenuated in the two last thirds with the lateral borders nearly straight or only feebly arcuated inwards, not serrate. A delicate and narrow membrane is to be observed along the anterior and posterior borders and along the hind lateral attenuation. Median longitudinal groove not very narrow, with the two foveae on each side of this groove—the anterior smaller than the posterior—rather shallow and still more reticulated. The same may be said of the lateral ear-like expansions.

Elytra much wider at the base than the base of the prothorax, having their greatest width beyond the middle. At the extremity they are separately rounded, leaving a small common emargination on the sutural angles. No serration at the sides. They are covered with ten not so conspicuously separated rows of punctures as in *flumineus*, the punctures are also nearer to one another, more shallow and not so well defined. Interspaces are also less wide. The superficial pubescence is less conspicuous than in the allied species. The females with their more depressed, shield-like elytra, and widened more or less brownish more expanded lateral margins look very peculiar.

Seen from above the pygidium is somewhat protruding between the sutural angles of the elytra.

Coelostoma horni (Régimbart).

♂♀; Station 9; 10.iv.1931. The aedeagus of ♂ has been compared. Described from Ceylon but recorded also from continental India and even, but very sparingly, from tropical Africa.

Laccobius (s. str.) gracilis Motschulsky.

(Syn. *L. orientalis* Knisch).

A few specimens, ♂♂ and ♀♀, from Station 5 (9.iv.1931) and Station 7 (31.iii.1931). A typical Palaearctic species.

Laccobius (s. str.) simulans d'Orchymont.

A single ♀ from Station 7 (31.iii.1931). Described from Yunnan and North India.

Helochares (Agraphydrus) stagnalis, sp. nov.

Type: No. $\frac{3840}{H4}$. Indian Museum; Station 7; 31.iii.1931; 2.4×1.2 mm.

Paratypes: Nos. $\frac{3841-3842}{H4}$. Same locality and date (Station 7); both sexes.

This *Agraphydrus* has distinctly 9-jointed antennae. It differs from all the described species, except *kempi* d'Orchymont, by its more parallel-sided, narrower and more elongate shape; from *coomani* d'Orchymont by the preocular spots smaller, the almost entirely obscure

prothorax, narrowly bordered at the sides by a band of a testaceous colour, by the more slender median lobe of the aedeagus, by the more broadly truncate extremity of parameres (attenuate and more narrowed at the end in *coomani*) ; from *kempi* by the larger, less elongate shape, the less dense punctation of the head, the more rounded posterior angles of prothorax, the less strong, less dense, nearly obsolete punctation of wing cases ; from *orientalis* d'Orchymont by the not reticulate forehead which is distinctly but finely punctured, of the same type as on the postfrons, by the prothorax more obscure, less broadly margined by testaceous colour at the sides, a trifle more strongly punctured, by the median lobe of aedeagus which is very slender, elongated, cylindrical (wide, flattened and nearly truncate at the end in *orientalis*) ; from *pauculus* Knisch by the less obscure elytra, the finer and more sparse punctation of head, prothorax and especially of the wing cases ; from *punctatellus* Régimbart by the different colouration (eyespots not so large, prothorax more obscure, etc.), and by the parameres of aedeagus more broadly truncate at the end, their outer margin nearly straight, not rounded ; finally from *pygmaeus* Knisch by the much finer punctation of the upper side, especially of the wing cases, and by the much less obscure colouration.

Head, including labrum, and prothorax shining black, with small preocular testaceous spots and the prothorax at the lateral sides not widely bordered with the same colour. Wing cases more brown, narrowly bordered with testaceous at the sides and the suture very narrowly black. Entire palpi and tarsi yellow. Punctation very fine and of the same form on fore- and hind head, nearly of the same shape and density on the prothorax, very much more obsolete on the wing cases. On these the two coarse punctures on each side of the scutellum are easily observed ; the inner series of coarser punctures are very sparsely furnished, the inner one not so widely separated from its basal puncture as the second ; the third series has also only a few widely separated punctures ; the outer one (4th) has more punctures and reaches nearly the base of wing cases.

Mentum with an anterior rounded emargination, with some coarse punctures and oblique ridges at the sides. Emargination of 5th ventral segment minute and not very distinct.

***Enochrus (Lumetus) sinuatus*, sp. nov.**

Type : No. $\frac{3843}{H4}$. Indian Museum. Station 5 ; 9.iv.1931 ; ♂ ; 4.6 × 2.2 mm.

Paratypes : Nos. $\frac{3844-3854}{H4}$. Same locality and date : a few ♂♀ ; Station 2 : 12.x.1930 : ♂♂♀ ; Stations 3 and 4 : 13.x.1930 : ♂♂, ♀♀.

A halophilous *Enochrus* representing in the Salt Range our common also halophilous *bicolor* Fabricius. It is at once distinguished from that species by the very obsolete sculpture of the upper surface, by the (in both sexes) deep black labrum and by the bordered lateral margin of elytra which is not regularly rounded in its second half, but distinctly curved in and then again curved out on its third fourth, more so in several females than in males. The portion of elytra just near the lateral margin is distinctly turned up. Both sexes are of the same colour ;

yellow testaceous with the exception of the black labrum, a variable transverse anterior blackish spot on the forehead, joined to the equally obscured Y-suture by a longitudinal obscure band, four black punctures on the disc of prothorax and an obscure humeral spot. The elytra are ordinarily more or less tinged with clear brown. Palpi, including the last and pseudo-basal joints, entirely yellow; antennae of the same colour, the club (joints 7-9) more obscure; legs testaceous, only the base of femora and the claws obscured.

From *fragilis* Sharp and *fretus* d'Orchymont it is distinguished at a glance by the much larger claws, the different and more testaceous colouration, the reduced sculpture of the upper surface, reduction of femoral hydrofugal pubescence, the aedeagus otherwise built, etc.

Upper side oily shining, head not very densely and finely punctulate, with some larger punctures behind labrum and along the transversal suture. Palpi not very long, nevertheless longer than the head and with the last joint much shorter than the foregoing. Eyes of moderate size, not very convex.

Prothorax on the disc still more finely punctulate than the head, with antero-external and postero-lateral systematic punctures of same form as on the head.

Scutellum and front side of elytra finely bordered with black. Elytra highly polished, with very obsolete punctation, so that the two inner irregular rows of larger systematic punctures, though not much larger than on the prothorax, are more conspicuous; along the lateral margin there are also such punctures but irregularly placed. On the disc one can count 9 series and the beginning of a juxta-scutellar supplementary short series of black, not closely placed punctures, which are only seen by transparency.

Under side black; mentum shining, in the ground with some punctures of medium strength. Prosternum not carinate, not toothed on the middle of its anterior margin. Mesothorax with a roof-like carinate protuberance anteriorly very minutely toothed. Fifth (last) ventral segment without ciliated emargination. Basal half of anterior and median femora infusate and pubescent; only basal third of posterior femora pubescent and more or less infusate. Claws very large; inner and outer claws of ♂ identical, all tarsi hooked and minutely lobbed at base. Claws of ♀ not hooked, somewhat longer than in ♂, obscurely toothed at base. Onychium in both sexes much shorter than the claws.

Median lobe of aedeagus parallel-sided, band-like as in *fragilis*, but less short with more protruding terminal dorsal strut. Parameres longer than the median lobe.

***Enochrus (Methydrus) tetraspilus* (Régimbart).**

One specimen; Station 10; 2.iv.1931; salinity only 0.608. Not halophilous.

***Sternolophus (s. str.) rufipes* (Fabricius).**

One specimen: Station 5; 9.iv.1931; another: Station 7; 31.iii.1931, Not halophilous.

Berosus (s. str.) nigriceps (Fabricius, 1801).*Berosus aeneiceps* Motschulsky, 1861 (Ceylon).? *Paraberosus melanocephalus* Kuwert, 1890 (Arabia).? *Paraberosus nigriceps* Kuwert, 1890 (Persia, Mesopotamia).*Berosus immaculicollis* Fairmaire, 1892 (Obock).

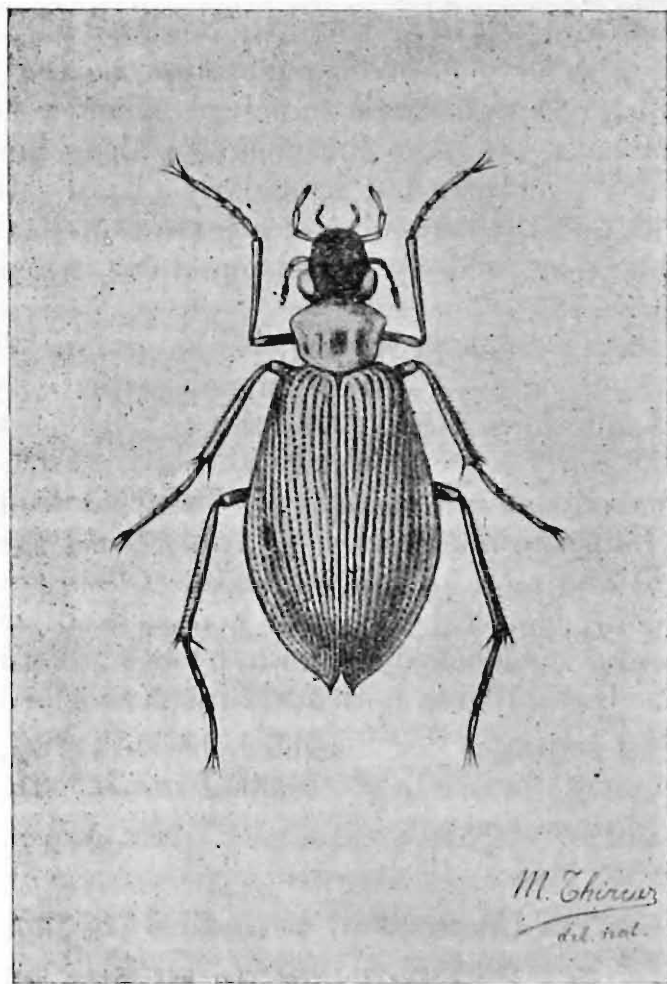
Stations : 2 (12.x.1930), 3 (13.x.1930), 4 (13.x.1930) and 5 (14.x.1930) ; several ♂♂ and ♀♀. Species described from "India orientalis". Not halophilous.

Berosus (s. str.) insolitus, sp. nov.

Type : No. $\frac{3855}{H4}$. Indian Museum. Station 4 ; 13.x.1930 ; ♂ ; 4 × 1.9 mm.

Paratypes : Nos. $\frac{3856-3863}{H4}$. Same locality and date ; Station 2 ; 12.x.1930 ; a few ♂♂ and ♀♀.

This species stands unique among the European and Asiatic species of *Berosus* and can readily be distinguished by the elytra which in both sexes are unispinose at the sutural angle. In both sexes the elytra are also much widened beyond the middle.



Berosus (s. str.) insolitus, sp. nov. × 10.

Upper side including palpi, antennae and legs of a general yellow colour, only head with labrum and base of mandibles black and metallic, of a green and purple hue ; the apex of mandibles more or less reddish,

the prothorax and elytra here and there only very faintly infuscated, the punctures of elytral series each surrounded by infuscation.

Head with Y-suture very conspicuous, placed in a depression, the disc (fore- and hind head) covered with not very closely placed and rather coarse and deep punctures. Eyes globose and prominent. Vertex (after the postfronto-vertical suture) obscure, shining and without punctation. Last joint of maxillary palpi very faintly obscured round the apex.

Prothorax distinctly wider than long, fringed with long hairs on the lateral sides which in the middle are gently curved in, distinctly narrowed behind ; the anterior angles much rounded, the posterior also but less and more obtuse ; anterior and posterior margin curved out, the former towards the head, the latter towards the scutellum ; disc with rather fine punctures in the middle, coarser and denser at the sides where they are not all of one size.

Scutellum more or less obscure. Elytra, in both sexes, very conspicuously inflated at the sides, the inflation having its maximum in the middle ; they are divaricate at the apex and each sutural angle is prolonged into a triangular and acute expansion or tooth. The ten normal and the eleventh shortened (juxta-scutellar) series are composed of punctures of moderate strength, nearly three times smaller as the intervals are wide. These interspaces are flat, more shining in the ♂, obscurely alutaceous in the ♀. The rather long juxta-scutellar series of punctures is often individually irregular.

Claws in both sexes long. In the ♂ the second joint of anterior tarsi is much inflated.

Mesosternum with a very obscure raised longitudinal line in the middle. Metasternum in the middle before the hind coxae with a small and ovate excavation. First ventral segment with a longitudinal median and basal carina. Fifth segment in both sexes without emargination.

NOTES ON FISHES IN THE INDIAN MUSEUM.

XXIX.—ON A COLLECTION OF FISH FROM NEPAL.

By SUNDER LAL HORA, D.Sc., F.R.S.E., F.N.I., Assistant Superintendent,
Zoological Survey of India, Calcutta.

Nepal is generally regarded as a closed country to travellers and it is no wonder, therefore, that very little is known about its fauna. The lack of knowledge about the ichthyology of the Nepal Himalayas is a great handicap in any discussion concerning the geographical distribution of fishes that have been recorded from the eastern and the western parts of this great mountain chain. In 1907, Regan¹ reported on a small collection of fish obtained from Nepal and recorded the following species :—

1. <i>Oreinus richardsonii</i> Gray	Soondrijal hills above Katmandu.
2. <i>Diptychus annandalei</i> Regan	Pharping (Katmandu Valley).
3. <i>Saccorbranchus fossilis</i> (Bloch)	Katmandu.
4. <i>Euchiloglanis blythii</i> (Day)	Pharping.
5. <i>Ophiocephalus punctatus</i> Bloch	Pharping.

In 1923, I² pointed out that the Nepal specimens referred by Regan to *Euchiloglanis blythii* (Day) did not belong to that species and had to be referred to a new species which I designated as *Glyptosternum hodgarti*. This species is fairly common in the rivers below Darjiling and in the hill ranges of Assam. In 1931, Mukerji³ discussed the generic position of *Diptychus annandalei* and came to a tentative conclusion that it should be referred to the genus *Schizothorax* or, if the absence of scales turns out to be a constant feature of the adults, to a new genus intermediate between *Schizothorax* and *Diptychus*.

From the beginning of 1935 Colonel F. M. Bailey, Resident at the British Legation, Nepal, has at my request sent four lots of fish from the Nepal territory and these form the subject matter of this note. Though no new species of fish is represented in this valuable collection, I have been enabled to extend the range of the remarkable genus *Semiplotus* Bleeker which had hitherto been recorded from Burma, the Assam hills and the Darjiling Himalayas and to record variation in colour in the case of *Barilius vagra* Ham. The occurrence of *Labeo dyocheilus* (McClelland) is also of some interest as the species had hitherto been known from the Assam hills on the one hand and Hardwar and Simla on the other.

In all 158 specimens belonging to 22 species were sent by Col. Bailey, but those from Devighat were not in a good condition to be preserved. The remaining specimens have been incorporated in the collection of

¹ Regan, *Rec. Ind. Mus.*, I, p. 157 (1907).

² Hora, *Rec. Ind. Mus.*, XXV, p. 38 (1923).

³ Mukerji, *Rec. Ind. Mus.*, XXXIII, p. 63 (1931).

the Zoological Survey of India (Indian Museum). I take this opportunity to offer my sincerest thanks to Col. F. M. Bailey for his kindness in collecting fishes from this interesting area and presenting the same to the Zoological Survey.

The entire material is listed below according to the localities :

Devighat (Lat. 27° 50', Long. 85° 5'), 2 days march west of Katmandu (April, 1935).		
1. <i>Barilius vagra</i> Ham.		14 specimens.
2. <i>Crossochilus latius</i> (Ham.)		1 specimen.
3. <i>Barbus</i> sp. (juvenile)		3 specimens.
Hulchok (on Gandak River near Lat. 28° 15', Long. 84° 50'), 2,500 ft. (10.viii.1935).		
1. <i>Oreinus richardsonii</i> Gray		8 specimens.
Mangning (about Lat. 28° 10', Long. 85° 10'), 5,000 ft. (13.viii.1935).		
1. <i>Oreinus richardsonii</i> Gray		6 specimens.
Nagarkot, (Lat. 27° 40', Long. 85° 30') 5,500 ft. (20.ix.1935).		
1. <i>Oreinus richardsonii</i> Gray		14 specimens.
2. <i>Nemachilus rupicola</i> var. <i>inglisi</i> Hora		5 specimens.
Sundarwal (Central Nepal), 5,500 ft. (20.ix.1935).		
1. <i>Oreinus</i> sp. (juvenile)		6 specimens.
Katmandu, 4,500 ft. (29.ix.1935).		
1. <i>Ophicephalus punctatus</i> Bloch		37 specimens.
Tribeni (Lat. 27° 26', Long. 83° 56'), Nepal Terai (5.xii.1935).		
1. <i>Chela baicala</i> (Ham.)		1 specimen.
2. <i>Laubuca laubuca</i> (Ham.)		1 specimen.
3. <i>Barilius bendelisis</i> (Ham.)		5 specimens.
4. <i>Barilius tileo</i> Ham.		9 specimens.
5. <i>Barilius shacra</i> Ham.		3 specimens.
6. <i>Barilius vagra</i> Ham.		5 specimens.
7. <i>Barilius (Opsarius) bola</i> Ham.		1 specimen.
8. <i>Aspidoparia jaya</i> (Ham.)		4 specimens.
9. <i>Aspidoparia morar</i> (Ham.)		6 specimens.
10. <i>Labeo dero</i> (Ham.)		1 specimen.
11. <i>Crossochilus latius</i> (Ham.)		7 specimens.
12. <i>Barbus putitora</i> (Ham.)		1 specimen.
13. <i>Nemachilus scaturigina</i> (McClell.)		1 specimen.
14. <i>Ailia coila</i> (Ham.)		10 specimens.
15. <i>Clupisoma garua</i> (Ham.)		2 specimens.
16. <i>Xenentodon cancila</i> (Ham.)		4 specimens.
Nepal Terai, near Tribeni (February, 1936).		
1. <i>Labeo dero</i> (Ham.)		1 specimen.
2. <i>Labeo dyocheilus</i> (McClell.)		1 specimen.
3. <i>Semiplotus semiplotus</i> (McClell.)		1 specimen.

***Barilius vagra* Hamilton.**

In 1872, Day¹ described *Barilius modestus* from the Indus in Sind and the Ravi River at Lahore. So far as can be judged from its description, he distinguished it from the common *B. vagra* Ham. by the absence of the vertical colour bars. I have examined a typical specimen of the species in the collection of the Indian Museum and have compared it with specimens of *B. vagra*. There are no morphological features on which the two species can be recognised from each other. In Col. Bailey's collection there are 5 specimens from Tribeni which I have referred to *B. vagra*; they lack any colour markings on the body, except that the dorsal surface is grayish and strongly marked off from the silvery sides. The examination of these specimens has convinced me that Day's *B. modestus* is only a colour variant of *B. vagra* and not a distinct species.

¹ Day, *Journ. As. Soc. Bengal*, p. 4 (1872); *Fish. India*, p. 589, pl. cli, fig. 3 (1878).

To facilitate reference in future I give below a table of measurements of the Nepalese specimens :

Measurements in millimetres.

Total length	59.0	67.0	69.0	84.0	92.5
Length of caudal	10.0	13.5	13.5	18.0	21.3
Length of head	11.0	13.0	13.0	14.3	15.5
Height of head	7.0	8.5	8.8	10.0	11.3
Width of head	5.0	6.0	6.0	7.0	8.0
Diameter of eye	3.0	3.5	3.9	4.0	4.5
Interorbital width	3.3	3.3	4.0	4.3	5.0
Length of snout	3.0	3.8	3.8	3.8	4.0
Height of body	10.0	12.0	11.3	14.0	15.8
Width of body	5.0	6.0	6.0	6.3	7.0
Length of caudal peduncle	7.0	8.0	8.0	8.0	8.5
Least height of caudal peduncle	5.0	6.0	5.5	7.0	7.5
Longest ray of dorsal	9.0	10.0	10.0	11.5	14.0
Longest ray of anal	8.0	8.5	8.5	8.5	12.0
Length of pectoral	9.5	10.0	10.0	13.0	13.4

***Labeo dyocheilus* (McClelland).**

Recently I¹ pointed out the distinguishing features of *Labeo dyocheilus* and showed the characters in which it differs from *Labeo dero* (Ham.). At the same time it was indicated that the collection of the Indian Museum contained only 4 specimens of this species—1 from Simla, 1 from Hardwar and 2 from Assam. The addition of one more specimen to the collection from an intermediate region is, therefore, of great value.

***Semiplotus semiplotus* (McClelland).**

Semiplotus semiplotus was described by McClelland² from Assam and placed in the genus *Cyprinus* with only one other Indian species *Catla catla* (Ham.). Bleeker³ proposed a new genus *Semiplotus* for it and this he defined as follows, presumably without examining any specimen of the species :

“Rostrum integrum lateribus non lobatum. Maxilla superior non protractilis. Ossa nasalia et suborbitalia cum maxilla superiore coalita. Labia continua nec crenata nec fimbriata. Cirri nulli. Pinna dorsalis elongata spina edentula armata, supra analem desinens. Squamae magnae.”

Günther⁴ recognised Bleeker's genus without any emendation, but he had only one bad skin for examination. In 1870, Day⁵ described another species—*S. modestus*—in this genus from the hill-ranges of Akyab and remarked :

“This species appears intermediate between the genera *Semiplotus* and *Cyprinion* ; for it nearly agrees with the former in the slight motion

¹ Hora, *Rec. Ind. Mus.*, XXXVIII, p. 320 (1936).

² McClelland, *As. Res.* (Ind. Cyprinidae), XIX, pp. 274, 346, pl. xxxvii, fig. 2 (1839).

³ Bleeker, *Atl. Ichth.*, III, p. 25 (1863).

⁴ Günther, *Cat. Fish. Brit. Mus.*, VII, p. 204 (1868).

⁵ Day, *Proc. Zool. Soc. London*, p. 101 (1870).

of the upper jaw, absence of barbels, etc., whilst it likewise resembles the latter in having a serrated dorsal spine, although it has no bony edge to the lips or barbels."

Chaudhuri¹ described a third species of *Semiplotus*—*S. cirrhosus*—from very young specimens and distinguished it from the other two species by the possession of two small maxillary barbels and by the absence of a knob at the symphysis of the lower jaw. Col. Bailey's specimen from Nepal was identified as *Semiplotus semiplotus* but was found to possess two small maxillary barbels in the groove at the corner of the mouth. This led me to examine other specimens of the species in the collection of the Indian Museum and in every case the maxillary barbels were found to be present. In young individuals they are relatively much longer and project outside the groove whereas in half-grown and adult specimens they are more or less concealed, but it is not very difficult to make them out. Similar barbels are also present in Day's *S. modestus*. It is clear, therefore, that the presence of small, maxillary barbels is a constant feature of the genus. I am of opinion that Chaudhuri's unique specimen of *S. cirrhosus* is only a young of *S. semiplotus*. Day's species with the serrated dorsal spine is, however, quite distinct.

¹ Chaudhuri, *Rec. Ind. Mus.*, XVI, p. 280 (1919).

ON THE HABITAT AND HABITS OF *TROCHUS NILOTICUS* LINN. IN THE ANDAMAN SEAS.

By H. SRINIVASA RAO, M.A., D.Sc., Assistant Superintendent, Zoological Survey of India, Calcutta.

(Plate I.)

Trochus niloticus Linn., one of the largest species among the Trochidae, has a fairly wide distribution in the Indo-Pacific seas. Its range extends from Ceylon, Mergui and the Andamans and Nicobars to Samoa in a west to east direction, and from the coasts of Queensland and Western Australia through New Caledonia, Philippine and Fiji islands to Lu Chu islands in Japan in a south to north direction.¹ It probably also occurs in the Laccadive islands in the Arabian sea but the shells found there have not been identified as *T. niloticus*.²

Before proceeding to describe the habits of *T. niloticus* it is important to consider whether amongst the large populations of *Trochus* in the Andaman waters there are not forms, varieties, and species resembling *Trochus niloticus* in form, shape, colouration, and sculpture of the shell. On the same beds with *T. niloticus* occur commonly *T. pyramis* Born (= *T. obeliscus* Gmelin) and *T. maculatus* Linn. which are easily distinguished from *T. niloticus* by the general outline, colour and sculpture of the shell. There are, however, certain forms of shells amongst *T. niloticus* differing slightly in their outline, convexity of the base and whorls of the shell, thickness, disposition of the last whorl in relation to the penultimate and other whorls, colour, pattern, and sculpture. In the very large series of full-grown *T. niloticus* shells from various localities in the Andamans and Nicobars which I have been able to examine, there were two common types of shell (pl. I, figs. 11 and 12) (1) the broad, short-spined shell with the outlines of the last whorl curved and its periphery thickened, and with convex base, and (2) the regularly conical, long-spined shell with the outlines of the whorls more or less straight and its base flat. A third and rather uncommon type (pl. I, fig. 13) resembling the second in general facies but with a distinct broad, somewhat convex ridge along the periphery of the base of the last whorl seems also to occur, but only one example of this type was found in several thousands of shells examined. Also among young shells with a diameter upto 5 centimetres the first two types of shell occur, but with a number of intermediate forms which grade imperceptibly one into the other; and in very young shells below 3 cms. in diameter the outlines of the whorls are masked by the peripheral hollow spinous processes on the suture. The regularly conical straight-sided type seems, however, to prevail amongst the very young shells. That the differentiation in shell-outlines was not a manifestation of sex differences was ascertained by examining the gonads of a large number of adult shells of the two types. The proportions of the two types of

¹ Hedley (1917).

² Ramaswami Ayyangar (1922).

shells in large samples of collections from various localities differed widely, sometimes one type predominating over the other in numbers. von Martens (1867) was of the opinion that types 1 and 2 were distinct species, namely, *T. niloticus* Linn. and *T. maximus* Koch, and that the Indian Ocean was the common home of both the species. While the latter statement inclined Pilsbry (1889) to agree with von Martens, the very slight differences in shell-form or sculpture led him to express the opinion that *T. maximus* was an arrested and primitive form of *T. niloticus* resembling an immature specimen of the latter in its "conic form, flat lirate base and sculptured spire", but retaining these characters in the adult stage. The differences in the environment,¹ and the changes in shell-form as a result of growth would seem to account for the occurrence of the various types of shell. Moorhouse (1933) found that in the Low Isles on the Queensland coast, retarded growth in shells of *T. niloticus* was characterised by "an extremely thick shell which is correspondingly heavier than a shell of the same diameter taken from an area of normal growth, as, for instance, from the outer surf-beaten zone of the reef", and by "a curved base, for all shell found on the outer edge of the reef are flat-based". In the course of my observations on growth of *T. niloticus* in the Andamans over a period of about three years, I had the opportunity to observe the changes in the form of the shell of a certain number of marked shells. These changes were usually associated with the exaggeration of the curvature of the sides of the last two or three whorls and of the base of the shell brought about, presumably, by the increased deposition of shell-substance in the region of the growing parts of the last whorl. In shells above 10 cms. in diameter these changes are more marked than in those of smaller dimensions.² It would appear that changes in shell-form may partly represent changes due to senescence (*vide infra*, p. 69). The proportion of the height of the shell to the maximum diameter seems also to undergo a change with the growth of the shell. In random samples of shells above 7 cms. in diameter collected from the same locality, it was observed that the difference between the height and the maximum diameter showed a tendency to increase with the size of the shell. Russell (1909) showed for *Patella vulgata* that changes in the ratios of dimensions of the shell during growth were merely "the expression of the laws of growth, and not due to natural selection". It, therefore, seems probable that in the Andaman waters, at any rate, the various forms of *Trochus niloticus* represent either plastic phases of this species or changes in shape and outline of the shell due to differences in the rate of growth at various ages.

Although *Trochus niloticus* has been commercially exploited for over 35 years, very little is known of its habitat and habits. It lives amidst coral reefs and under rocky ledges covered with growths of green and brown algae from between tide-marks to depths upto 12 fathoms.³ In

¹ The Japanese divers who are licensed to fish *Trochus* in the Andaman seas have informed me that flat-based shells are more common in the Nicobar Islands than in the Andaman Islands.

² Moorhouse (1932) observed that in Low Isles only shells above 8 cms. in diameter had their last whorl expanded.

³ See Watson (1886) where *T. niloticus* is reported to have been dredged in 12 fathoms off Levuka, Fiji.

the Andaman sea it is most abundant on the reefs in the inshore waters, not more than half to one mile from the rocky or sandy shore of most of the islands comprising the Andaman and Nicobar groups. The depth of the sea-floor in the reef area 'round the islands is usually between 1 to 5 fathoms, but rarely exceeds 7 fathoms. The Japanese Fishery Companies of Singapore which have been licensed to fish *Trochus* shells in the Andamans and Nicobars since 1929 employ Japanese naked divers for the purpose who are brought over to the Andamans every year in their own motor boats. The divers, with their simple but efficient hand-made water-goggles well-adjusted to their nose-bridge and eyes by elastic rubber-tubing secured to the outer ends of the goggles, swim at the surface looking down on the sea-floor, and as soon as a shell or group of shells has been sighted, dive down and bring them up.¹ Where the bottom is covered with large masses of Madreporarian coral with overhanging ledges which cast deep shadows and render the finding of shells from the surface of the sea rather difficult, the divers swim near the bottom passing in and out amongst the meandering narrow corridors and lanes at the bottom, examining the crevices and the under-surface of ledges for specimens of *Trochus*.

At the commencement of the *Trochus*-fishery in October 1929 when the beds were virgin ground, it was comparatively easy to pick up shells in very shallow water. The results of the Fishery at the end of 3 months showed that approximately 500 tons of shells had been gathered from what, presumably, were overstocked shell-beds. After 3 seasons of fishing, the shell-populations in the shallower regions between 3 to 5 fathoms were so greatly diminished in numbers that the Japanese had to extend their operations to the fishing grounds at depths of 7 fathoms. It appears that naked diving would be impossible at depths exceeding 7 fathoms, and the Japanese were soon driven to the necessity of applying for licenses for the use of diving apparatus. Actually, however, no diving apparatus was employed, presumably because of the difficulty of securing the services of special divers at Singapore for the purpose. The Japanese assert that there is still an abundant shell-population in depths beyond 7 fathoms, from which apparently the shallower regions are replenished from time to time. However, continued fishing for *Trochus* since 1929 has reduced quantities of shell fished from 500 tons to less than 40 tons in a fishing season, although the period of fishing has been doubled. There is no doubt that the shell-population has suffered considerable depletion, as may be seen from the fact that the rate of collection per diver per hour has fallen from over 20 in 1933 to 2—3 in 1935.

Moorhouse's (1932, p. 147) observation that despite a tendency for zoning of the animals in the Low Isles there was a frequent mixing of forms of various sizes does not appear to be quite in accord with mine in the vicinity of Port Blair. The young forms below 5 cms. in diameter appear to be rather scarce in depths between 2 and 7 fathoms² as the

¹ For a more detailed account of the Japanese Fishing methods, boats, equipment etc., see Setna (1932).

² It is quite possible that the young forms occur in greater abundance at depths beyond 7 fathoms and creep gradually into shallower waters, but no evidence of such occurrence in the Andamans has been obtained,

Japanese divers in the Andamans testify, but amongst the coral shingle and under coral slabs between spring tides they are usually found at all times of the year. The type of locality in which they commonly occur is shown in fig. 1, pl. I, of the present note and in fig. 1, pl. xiv (Rao, 1936). The older forms above 5 cms. generally occur below the low-water mark of spring and neap tides.

Moorhouse (1932) also observed that *T. niloticus* was gregarious in the Low Isles of the Great Barrier Reef, as many as 15 individuals having been taken from one slab or boulder of coral on several occasions. My observations on the reefs round the Andaman and Nicobar groups of islands with the help of a water-glass, while the Japanese divers were working in those areas, showed that the individuals of the shell population on the reefs were greatly scattered, and that in consequence the divers were unable to obtain more than 2 or 3, or at the most, 5 shells at a time from a chosen spot on the reef. This may have been due to the fact that the shell-beds were, at the time of my investigation, more or less depleted of their normal stock of shells by heavy and continuous fishing. On one occasion, however, in October 1932, looking for shells in a small bay south of the South Corbyn's Cove, Port Blair, 36 specimens ranging from 5.0 cms. to 12.5 cms. in diameter were picked up either singly or in twos and threes in an area 10 yards square. Some of them were attached to the under surface of rocks, others to coral shingle, while a few were crawling on coarse coral sand in crevices under stones. A few were found on wet ground some distance below the high-water mark. The lowest tide on this day was 0.2 feet at 4.42 P.M. and the highest 6.5 feet at 10.38 A.M. (I. S. T.). The congregation of such a large number of individuals in a small area between tide-marks is no doubt exceptional, and may have resulted from the action of strong currents or some adverse weather conditions. But in comparison with other species of Gastropods such as *Nerita polita*, *N. albicella*, *N. chameleo*, *Acmaea saccharina* var. *stellaris*, and *Littorina scabra* which are found in large numbers in the Andaman and Nicobar Islands on rocks between tide-marks, *Trochus niloticus* cannot be said to be really gregarious. On several occasions when marked shells were on purpose massed together round boulders under which there were adequate shelter and abundant food in the form of growths of algae, the individuals were found to have scattered within a fortnight to considerable distances from their original shelter. The tendency to wander about seems to be a feature of this species which, therefore, does not admit of its being classed among the strictly gregarious species of Gastropods.

Trochus niloticus does not seem to thrive under artificial conditions of the laboratory. Attempts to keep the animals alive in glass aquaria in which sea water was constantly kept circulated after renewal everyday proved a complete failure.¹ The longest period for which a specimen was kept alive in the aquarium was 5 days, during 3 out of which the animal was in a semi-comatose condition; but usually individuals did not survive the conditions in laboratory aquaria after 48 hours,

¹ Small reservoirs on a higher level than the aquaria were constantly filled with fresh sea-water which was led through rubber tubing into the aquaria. There were no facilities at Port Blair for a higher grade of aeration than mere renewal of sea-water,

some dying even within 24 hours. The very high degree of aeration which is maintained on the reefs is extremely difficult to imitate under the artificial conditions of the laboratory.¹ During the first three or four hours of immersion in aquaria *T. niloticus* crawls about on the small stones and shingle placed at the bottom, but in a partially expanded state in which the head and tentacles of the animal are barely visible (pl. I, fig. 2). The mouth is, however, closely applied to the surface of the stone on which it crawls in the act of browsing on the algae and the vegetable and mineral debris which constitute its food. After this period, the feeding activities of the animal cease altogether, but the foot and the columellar muscles continue to expand and contract giving the shell a partial rotary motion with the columellar muscles as the fulcrum. The epipodial lobe which in conjunction with the mantle forms the siphon for the intake of the respiratory current is observed to be mobile. After 6-8 hours in the aquarium, the animal is overcome by a state of torpor which is maintained unless disturbed. The renewed activity following any disturbance is, however, for a very short period, and the animal falls into a comatose condition again. During the first few hours of activity the animal feeds and defaecates constantly, leaving pellets of faecal matter $\frac{1}{2}$ to 1 inch long in its trail. Later, it stops feeding but continues to throw out faecal pellets a little longer. Finally it withdraws itself into the shell, but with the movements of the epipodial siphon continued until the animal is actually in a comatose state. The animals seem to survive suspension in the sea for several hours or days even though they are crowded in a net bag and deprived of food.² They are also able to survive dessication for a little over 48 hours. On several occasions it was found convenient to transport live animals from distant beds to Port Blair by carrying them in a dry state. When exposed to the sun and wind on the open deck of the Japanese fishing boats, the live animals do not withdraw themselves into the shell and remain inactive, but protrude the whole or part of the foot gradually and withdraw it with such suddenness and force as to eject jets of sea-water from within the shell to a distance of 3 to 5 feet. This movement of the animal goes on at short intervals until the water contained in the whorls of the shell and in the tissues is dried up when the animal becomes inactive and finally dies. Some of the animals which had ceased their movements two days after their removal from the reefs were revived on immersion in the sea, and observed to grow.

It is difficult to observe the details of movements of the animals in their natural haunts between tide-marks. The quick succession of waves which dash against the coral boulders renders continuous observation impossible. At depths of about one or two fathoms the animals can be observed with the help of a water-glass³ from a small boat

¹ Stephenson (p. 491, 1923-25), Moorhouse (p. 147, 1932), and Weymouth (p. 9, 1923) have observed that in the case of *Halotis tuberculata*, *Trochus niloticus*, and *Tivela stultorum* respectively ordinary laboratory conditions in aquaria are unsuitable for keeping them alive in captivity.

² Some animals have been observed to browse on the algae growing on the shells of other animals confined in the bag.

³ A pyramidal trumpet-shaped wooden structure with plate-glass fixed to the broader side acting as the window.

anchored at the place of observation, but the details of their movements except when they are crawling on the vertical sides of a coral mass are obscured. Sometimes an individual may be seen crawling on a rock projecting above the surface of the water and bathed by the spray from the waves.

Although *T niloticus* is extremely slow in its movements, it moves about a great deal in search of food and shelter. In exposed positions between tide-marks it is rarely found, but is common in holes and crevices amidst or under rocks and coral masses where algae grow in abundance. In the course of observations on growth of marked individuals (Rao, 1936) considerable difficulty was experienced in recovering them every month from the reefs, as with every ebb and flow of the tides they seemed to crawl slowly backwards and forwards. The younger individuals below 5 cms. in diameter are far more active, and move about a great deal more than the older ones above this size. Except in places protected against strong currents and waves by natural barriers provided by large masses of coral rock or by artificial piers, the recovery of the smaller animals was extremely difficult, and instances of marked shells recovered after an interval of 3 or 4 months were not uncommon. These observations show that *T niloticus* wanders about a great deal, assisted by tides in search of food and shelter. It seems, however, improbable that it travels long stretches of the sea-bottom, particularly those between two distant islands, devoid of continuous reefs. In the Andaman and Nicobar Islands, subject to the rough weather of the south-west and the north-east monsoons, the species is found along the east and west coasts of these islands, but where the coasts are protected from the effects of the monsoons by large inlets of the sea and hills in the path of the monsoons the species is rather rare. The islands of the Nicobar group which receive a heavier rainfall than those of the Andaman group have a relatively denser population of *T niloticus*. Even after six continuous years of fishing the Nicobars are still the more prolific area than the Andamans, and have yielded a bigger tonnage of shells. As has been observed by Moorhouse (1932, pp. 146-147) in the Low Isles, the species avoids sandy and muddy places along the coasts.

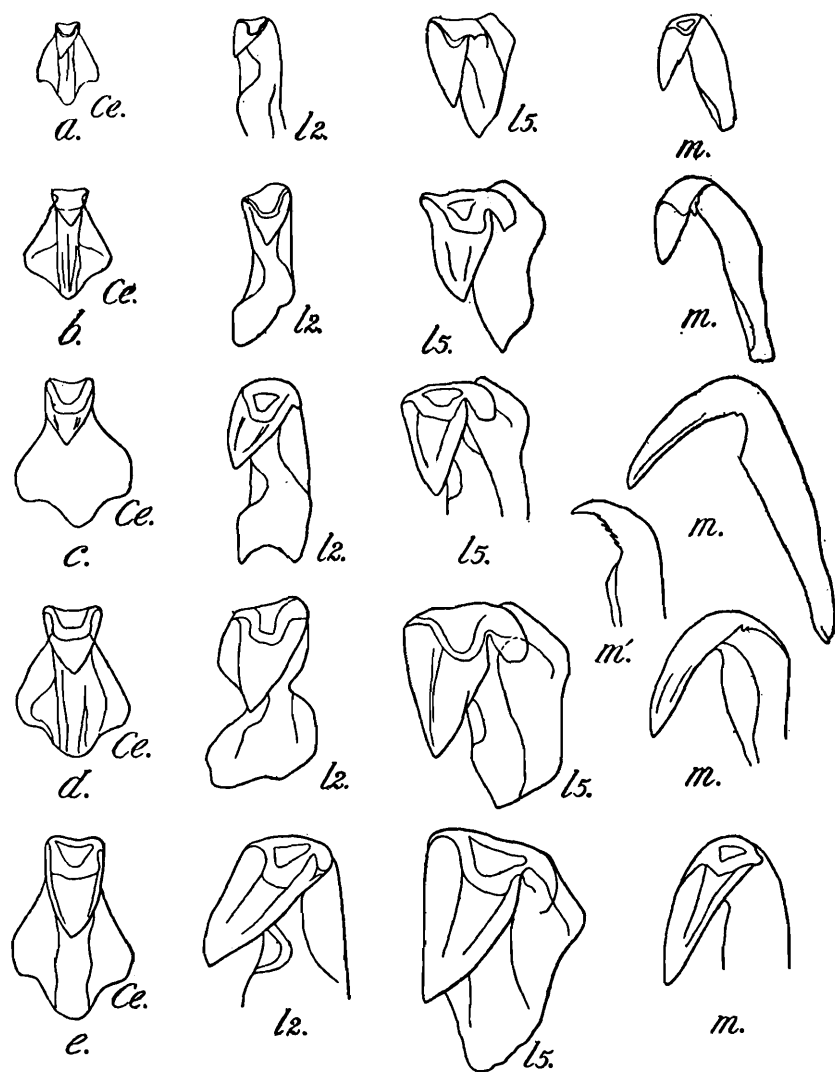
The difficulties of observing the habits of this animal both in its natural haunts and when kept in captivity in aquaria have been explained above. On one occasion (8-1-35) while searching for examples of small size on a wide stretch of coral shingle in Murdakhari Bay, Port Blair (pl. I, fig. 1) a specimen was found crawling slowly on a branch of coral covered with growths of algae, and on observing with a magnifying lens was found to be feeding. The contractions and movements of the foot are extremely slow and suggest those seen in slow-motion films.¹ The respiratory siphon, which is partially closed while in water, seems to open out when the animal is removed from water so that the pallial cavity is in communication with the outside atmosphere. The proboscis-like part of the head which is mobile is extended slowly downwards over the front part of the foot to the surface on which the animal

¹ Robert, A. (1903) described the undulatory movements of the integument of the foot in *Trochus*.

crawls until the aperture of the mouth is closely applied to it. Moorhouse's observation that a small, very short, and non-retractile muzzle is present is not in accord with mine. Then the parts surrounding the aperture are presumably depressed to form a shallow cup in which a partial vacuum may be formed. The contractions of the integument round the aperture and the adjoining parts suggest the formation of a partial vacuum. All the particles of sand and disintegrated coral, and the minute growths of algae on the branch of coral are presumably sucked into the buccal cavity. At the same time the radular teeth appear to assist in rooting out the algal filaments from their attachment. At brief intervals the proboscis-like part of the head is removed from the surface of the coral on which the animal crawls, and on the slightest disturbance in its vicinity, is withdrawn into the shell, followed by the foot, the two sides of which fold along the median line. Examination of the gut contents of a large number of individuals of *Trochus niloticus* from various localities shows that brown and green algae, chiefly the minute species, form part of its food. As the animal feeds by scraping the rocks and coral masses on which it lives, the contents of the gut include a large proportion of inorganic and organic debris, and a variety of organisms which live amidst the algal vegetation. Thus, in the course of the examination of the gut-contents, remains of small Crustacea such as Copepods, Ostracods and Isopods, tests of Foraminifera and Radiolaria, spicules of Sponges and Alcyonaria, fragments of Hydroid colonies, small Polychaete worms, Nematodes, small Molluscs (soft parts as well as shells), Pycnogonids, Insect-larvae (Chironomidae) and demersal eggs of fish have been found in addition to bunches or fragments of leaf-like or filamentous algae including young and immature forms of *Ulva*, *Polysiphonia*, *Chaetomorpha*, *Turbinaria*, *Hypnea*, *Lyngbia*, *Neomeris*, etc.¹ The commonest alga found in the gut of *T. niloticus* was a *Hypnea* sp., pink in colour. According to Yonges's (1928) classification of the feeding mechanisms in the Invertebrates, *T. niloticus* should belong to his section B of group II in which the feeding mechanism is intended for scraping and dealing with large particles or masses, but judging from the contents of the gut, *T. niloticus*, which seems to swallow large quantities of bottom deposits also, may therefore be included in his section A as well. In the rectal portion of the hind-gut, in addition to the inorganic debris in the faecal matter algae in a more or less undigested state are also found. The anterior loop of the rectum contains a soft muddy mass including a few algal filaments and inorganic matter, while the posterior loop contains a somewhat friable mass of debris consisting of large grains of sand and other inorganic material, bunches of undigested algae, and the hard remains of Foraminifera, Sponges, Hydroids, Crustacea, and Mollusca. This fact coupled with that of the absence of food material in the oesophageal part of the fore-gut seems to indicate that the passage of the food through the entire gut is fairly rapid and that digestion is only partial. In some specimens dissected soon after capture the stomach

¹ I have to thank my friend, Prof. M. O. P. Iyengar, Director of the University, Botanical Laboratory, Madras, for the identification of the algae.

was found to be empty, while the loops of the hind-gut were full of partially digested matter. The weight of the stomach-contents including the algae and the inorganic and organic debris is very small in proportion to the weight of the entire animal excluding the shell. In fresh specimens of *Trochus niloticus* examined, the weight of the algae alone (separated from the debris) was 6-10 per cent. of the weight of the stomach contents while the organic and inorganic debris constituted over 90 per cent. of the total weight. The weight of the entire animal (including a large quantity of sea-water in the tissues and amongst the internal organs) was 32 times the weight of the contents of the stomach, while that of the shell (usually varying from 3 to 14 ounces) was 2.25 times



TEXT-FIG. 1.—Radular teeth of individuals of *Trochus niloticus* with shell-diameter not exceeding 5.0 cms. (The entire teeth have not been drawn in all cases owing to the high magnification).

a. 1.74 cms. ; b. 2.32 cms. ; c. 3.27 cms. ; d. 4.30 cms. ; e. 5.00 cms.

ce. central ; l_2 . second lateral ; l_5 . fifth lateral ; m. marginal ; m^1 . marginal slightly tilted to a side.

the weight of the animal. It would appear that *T. niloticus* extracts its nourishment mainly from the bottom deposits consisting of organic and inorganic material but supplements it with nutriment derived

from an inconsiderable proportion of vegetable matter.¹ This species may therefore be classed as a "selective deposit-feeder".² Although species of *Trochus* are known to be herbivorous and selective deposit-feeders, they occasionally seem to adopt carnivorous habits. Robert (1903, p. 10) recorded that in an aquarium at Roscoff in which *Trochus conuloides* and two specimens of *Palmipes membranaceus* L. Agassiz (slightly injured by the fishing gear) were kept, the former had attacked and devoured the latter in about two days.

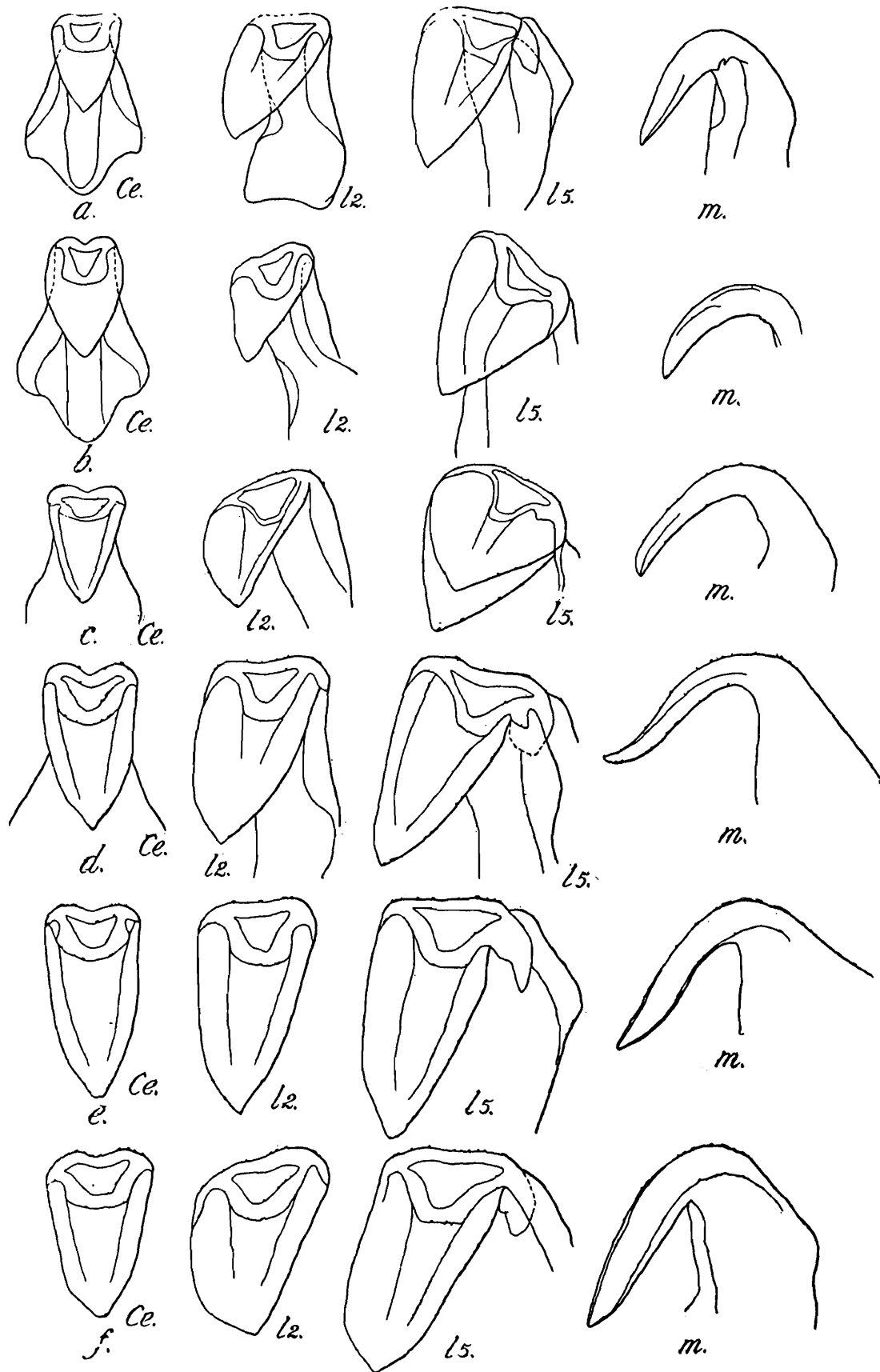
The nature of the food of *Trochus niloticus* and the manner of feeding involve a considerable wear and tear of the radular teeth, and the very long radular sac and ribbon seem to meet the constant need for replacing the worn out teeth. The features of the radular teeth of *T. niloticus* are figured by Troschel (1879), but his figures seem to represent those of a much worn series. The marginals, however, seem to be from a different row in that the main cusp and the denticulations are fairly sharp and well-defined. In the series of camera lucida drawings of radular teeth (text-figs. 1 and 2) (central, 2nd and 5th laterals, and the marginal) from approximately the middle region of the ribbon of individuals with shell of diameter 1.74 cms. to 11.14 cms., the features of the radula are shown. The proportions in dimension between the cusps and the basal part remain the same except for slight individual variations. In older individuals there is a tendency for the cusps of the central to become blunt, and for the reduction in the number of small cusps on the marginals. The radular sac is bifid in its terminal portion as in *T. lineatus* (Da costa), *T. magus* (Linn.) and the other species of the sub-genus *Gibbula*, and the radular teeth resemble in structure those of *T. lineatus* (*vide* Randles, 1905), the first marginal not being different in size and structure from the rest of the marginals.

It is a well-known fact that the sexes are separate in *Trochus niloticus*, but no feature in the external form of the shell or in the visible soft parts of the animal when extended gives a clue to the sex of an individual. The differences in the curvature of the whorls and the basal part and in the thickness of the shell met with in the three types of shell-form mentioned above (p. 47) led me to examine the gonads of several individuals belonging to the three types, but no correlation between sex and type of shell was found to exist, that is to say, all three types of shell had male and female elements, thereby establishing that the sex of a given individual cannot be determined at a glance by examining its external features. Moorhouse (1932, p. 146) found no difference in shell-form in the two sexes. Amirthalingam (1932, pp. 72-73) claimed, however, that the outlines of the cavities inside the shell of over 7 cms. diameter as revealed by longitudinal sections "passing through the extreme end of the suture of the outer lip to the bodywhorl and the columella" showed significant differences in the two sexes. In the

¹ Several specimens of *Turbo marmoratus* from the Andamans showed that their feeding habits were similar to those of *Trochus niloticus*.

² Hunt (1925) in the course of his study of the food of the bottom fauna of the Plymouth Fishing grounds found that *Turritella communis* and *Aporrhais pes-pelicanis* (among the various Gastropods present) had roughly sorted bottom material in their stomach.

determination of the sex of a shell at a glance his claim, if confirmed, will have little practical application. No accessory organs indicative



TEXT-FIG. 2.—Radular teeth of individuals of *Trochus niloticus* with shell-diameter above 6.0 cms. and below 12.0 cms. (The entire teeth have not been drawn in all cases owing to the high magnification).

a. 6.79 cms.; b. 7.29 cms.; c. 8.72 cms.; d. 9.69 cms.; e. 10.12 cms.; f. 11.14 cms.
ce. central; l_2 . second lateral; l_5 . fifth lateral; m. marginal.

of sex are present in the animal, but when the latter is extracted from the shell, or the spire of the shell is broken exposing the visceral coil, the colour of the gonads in sexually mature individuals, which is dark-green in the female, white or cream in the male, helps in the identification of sex. In immature individuals the portion of the visceral coil representing the gonad is of a more or less uniform gray colour which renders identification of sex difficult, but examination under the microscope of the contents of the gonad either in fresh smears or in sections usually reveals spermatozoa or oocytes in various stages of development. In examples with a shell diameter of less than 3 cms. in which the gonads are still in an undifferentiated state even microscopic examination may often fail to reveal the sex (see text-fig. 6, p. 63). Moorhouse (1932, p. 153) in stating that "in no case were sperm and eggs found together" apparently expected to find sex-change in *T. niloticus*, at any rate, in moderately young *Trochus*. From an examination of a large number of microtome sections of the gonads of both sexes of all ages, I consider that no sex-change is probable, although as Moorhouse suggests the matter requires further examination. A practicable method of examining the sex-products at different stages of the growth of individuals without causing material injury to the animal may help to solve the question of sex-change in *T. niloticus*. At a point three or four whorls below the apex of the shell a tiny hole was made on a few shells with the help of a drill, and the sex-products drawn into a hypodermic syringe through a small puncture in the integument of the gonad were examined on a slide. The specimens thus punctured were returned to the sea, but were recovered dead after a few weeks. A second attempt to examine sex-products by this method resulted again in the death of the animals under observation. A satisfactory method of closing hermetically the puncture in the shell after a sample of the sex-products has been drawn would perhaps eliminate the chance of death of the animals. In the course of the examination of the gonads of several hundred examples of *T. niloticus*, there was no single instance in which sex could not be determined in microtome sections of the gonad of examples with a shell-diameter exceeding 3 cms., and no case of hermaphroditism comparable to that of *Patella vulgata* (see Orton, 1928, pp. 853-857) was observed in *Trochus niloticus*. Even in the former species instances of hermaphroditism appear to be the exception rather than the rule.

Samples of *T. niloticus* having a shell-diameter above 5 cms. from various localities in the Andamans from which smears of the gonads were examined microscopically showed that those having a shell-diameter under 7.0 cms. were usually immature, and that the sexes, were present in almost equal numbers. Shells having a diameter of 7.0 cms. and above were therefore considered adult. The records of the frequency distribution of shells of various adult size- or age-groups of both sexes from various localities in the Andamans lend support to the view that the proportions of males and females are about equal. For the purpose of the investigation of sex-ratio in *T. niloticus*, the records of sizes and sexes of shells collected from two separate groups of islands in the Andamans were selected for study. Dr. K. C. K. E. Raja

to whom I am indebted for the statistical treatment of the records, has kindly furnished the following note :—

Ritchie's Archipelago.

A sample of 806 shells of *T niloticus* was obtained. Of these 309 were picked up at random and were examined for sex giving the following frequency distributions :—

Age. (Size in centimetres.)	Frequency.	
	Male.	Female.
7— 7.99	42	40
8— 8.99	64	57
9— 9.99	25	30
10—10.99	14	16
11—11.99	10	11
	155	154

Taking these two samples of 155 and 154 shells as random samples,

$\chi^2=1.086$
 $N=4$, P lies between 0.8 and 0.9.

Hence there is no reason to assume that the numbers of males and females at each size- or age-group are different from each other.

The same problem may be approached from another point of view. We have a larger sample of 806 shells and the assumption that the sexes are equally represented may be tested by comparing the actuals for males and females given above with the expected numbers at each age period, if the totals of 155 and 154 are distributed in the proportions given by the sample of 806.

Age. (Size in centimetres.)	Male.		Female.	
	Observed.	Expected.	Observed.	Expected.
7— 7.99	42	39.61	40	39.36
8— 8.99	64	70.58	57	70.12
9— 9.99	25	25.77	30	25.60
10—10.99	14	13.46	16	13.37
11—11.99	10	5.58	11	5.55

Males.— $\chi^2=4.303$, $N=4$, P lies between 0.5 and 0.3.

Females.— $\chi^2=9.091$, $N=4$, P lies between 0.1 and 0.05.
Hence, in both cases, no significant difference between the expected and observed distributions has been made out.

Cinque, Passage, Sister, Brother and Little Andaman Islands.

In the case of these islands a larger sample of 2,031 shells was available. From this sample a smaller sample of 363 was taken at random

and an examination for the sexes was carried out. The distributions are given below :—

Age.		Male.	Female.
7— 7.99	.	17	21
8— 8.99	.	36	30
9— 9.99	.	33	40
10—10.99	.	30	41
11—11.99	.	30	27
12 and over	.	25	33
		171	192

For the sake of comparability of these figures with those for Ritchie's Archipelago, we leave out the last group (12 and over). A comparison between these two distributions shows that there is no significant difference.

$\chi^2=2.952$, $N=4$, P lies between 0.7 and 0.5.

Further, a comparison between the observed and expected frequencies on the proportions given at each age by the large sample of 2,031 also brings out that there is no significant difference in the case of both sexes.

Males.— $\chi^2=1.596$, $N=4$, P lies between 0.9 and 0.8.

Females.— $\chi^2=10.076$, $N=4$, P lies between 0.05 and 0.02.

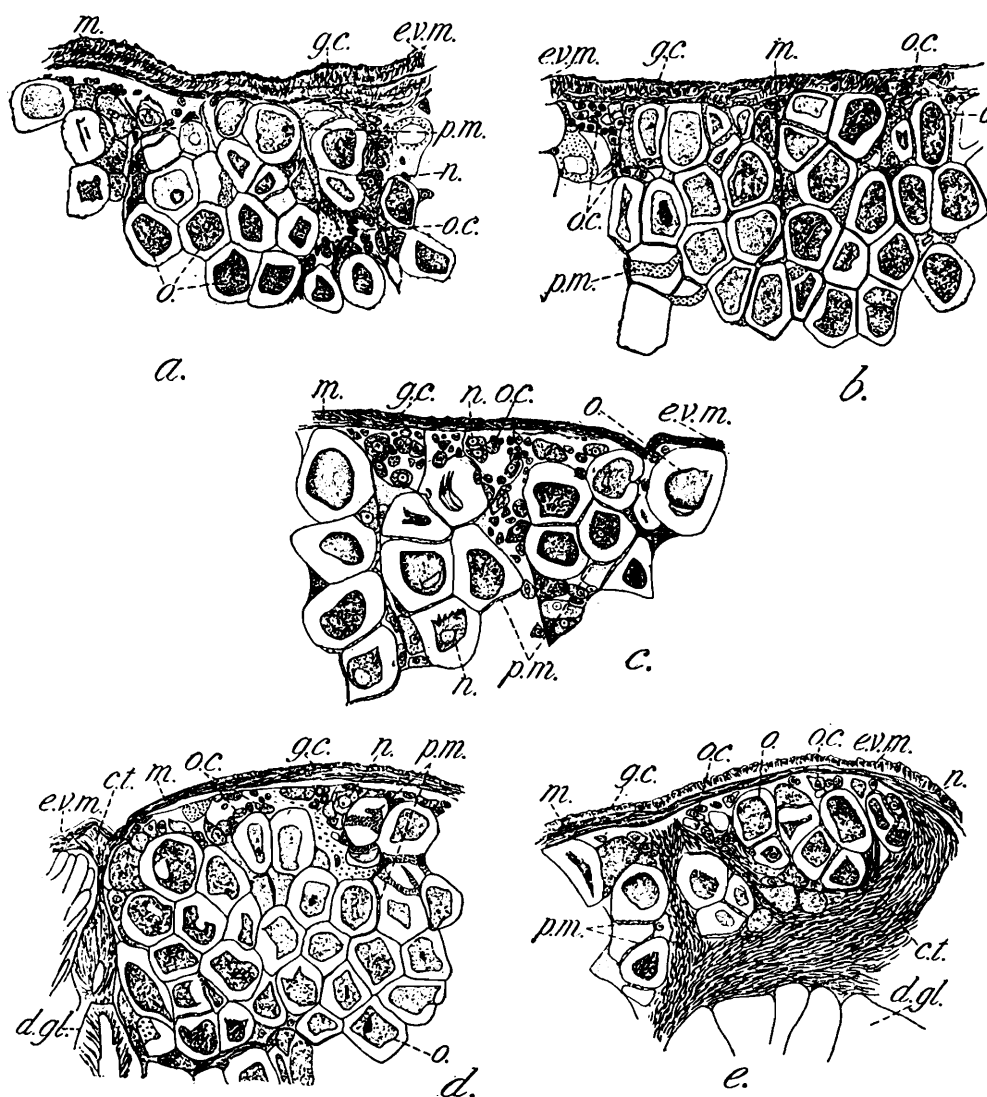
The last result suggests that the difference between the two distributions is just emerging into significance. Taking all the tests into consideration it may be said that males and females appear to be present in about equal numbers at the respective ages. It may be remembered that we have confined ourselves to the ages represented by the sizes from 7—7.99 to 11—11.99. At the later age groups the divergence between the sexes seems to be significant.

In the two samples the bulk of the shells fell into these groups. In both, shells below 7.0 cms. do not come into consideration, as the sex elements are immature at this stage. Above 11.99 cms., there were in the first sample only 0.25 per cent. shells and in the second only 9.80 per cent. The samples represent almost complete collections of the shells in two separate areas and they may be taken to be representative samples of the adult population of *T. niloticus* of these islands. On the information afforded by these samples the inference is that, within the age groups indicated, males and females may be present in about equal numbers.

The conclusions of Moorhouse in regard to the sex-ratio of *T. niloticus* in the Low Isles are thus corroborated by my own observations in the Andamans.

The correlation between age and size in *Trochus niloticus* as indicated by the maximum diameter of the shell has been referred to in a previous paper (Rao, 1936). The determination of the criterion for maturity in both sexes, and of the minimum size or youngest age at which such maturity is reached must precede that of the breeding period. After examining the smears of the sex elements of a large series of examples of all ages from different localities, it was decided that the presence of active

spermatozoa in the male and the size of ova with a diameter between 0.20 and 0.25 mm. (excluding the pitted gelatinous outer cover-



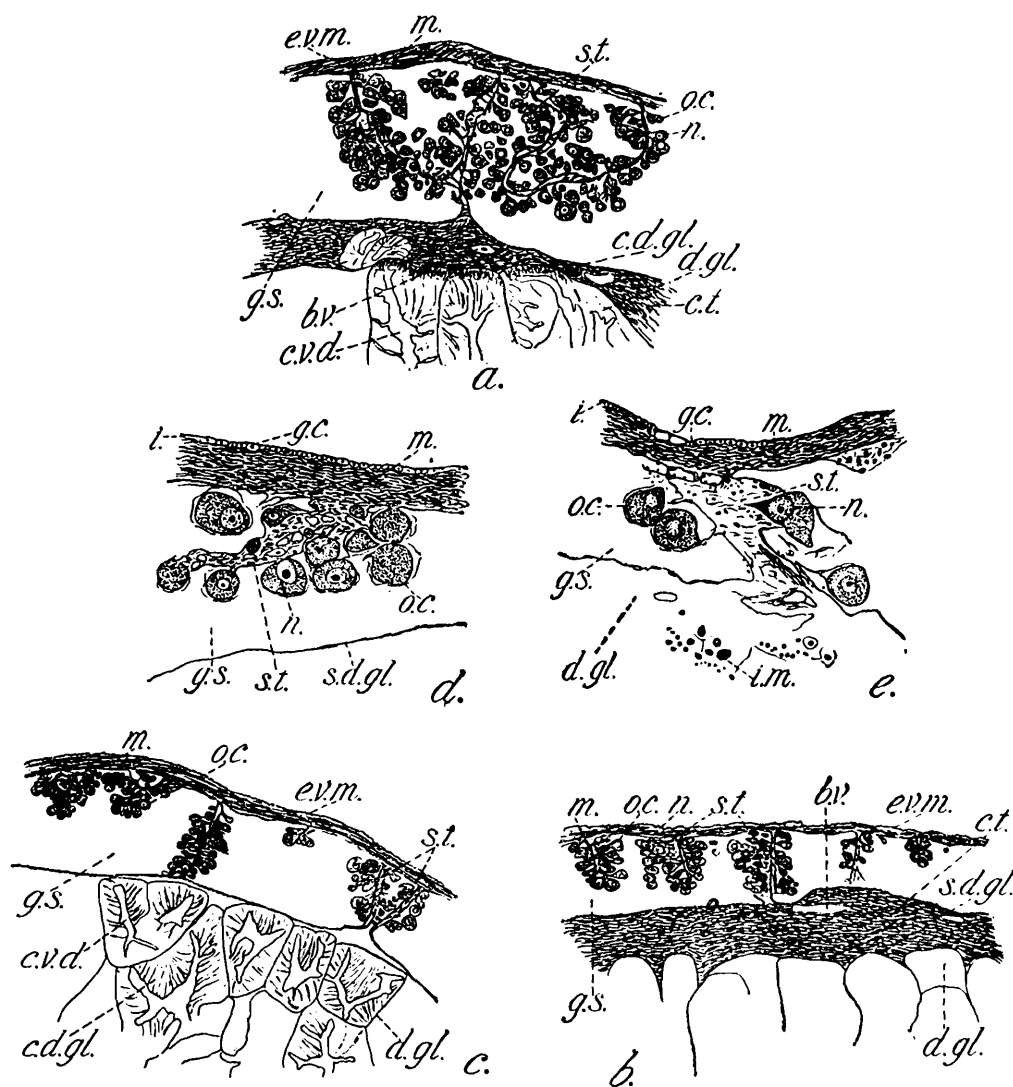
TEXT-FIG. 3.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 9.0 cms. and 12.5 cms.

a. 12.25 cms. (March); b. 11.72 cms. (January); c. 10.38 cms. (November); d. 9.93 cms. (November); e. 9.02 cms. (January). (Drawn under low power and eye-piece $\times 10$).

bv. blood-vessel; c. d. gl. cells of the digestive gland; c. i. cellular inclusions tinted blue by Mallory's stain; c. t. connective tissue; c. v. d. cavity of the tubule of the digestive gland; d. gl. digestive gland; d. p. dark pigment; e. v. m. epithelium of visceral mass; g. c. globular or cubical mucus cells of the integument; g. s. coelomic space between the gonadial layer of the epithelium of the visceral mass and the digestive gland; i. integument; i. m. irregular masses in cells of the digestive gland which take a deep blue tint in Mallory's stain; m. muscles of the integument; n. nucleus of oocytes; o. ova fully developed; o. c. oocytes; o. g. spherical inclusions (with granules) which stain olive-brown or olive-green in Mallory's stain; p. m. pitted membrane; s. d. gl. gonadial surface of the digestive gland; s. t. branching trabeculae of the coelomic epithelium (lying between the integument and the connective tissue of the digestive gland) with developing oocytes; t. d. gl. tubules of the digestive gland; t. s. transparent spherical inclusions with olive-yellow granules.

ing) in the female should be the criteria for sexual maturity. In the latter sex the presence of developing oocytes with a diameter ranging from 0.05 to 0.20 mm. rendered the determination of sexual maturity somewhat difficult. It was, however, found later that the development of a pitted membrane round the ova roughly coincided with their maturity, and that in sexually mature females of all sizes there was always

a varying number of oocytes also. For the purposes of a rough and ready method of determining the state of maturity of females smears in which a majority of the number of ova had a diameter exceeding 0.20 mm. were taken as samples representing mature females, and those in which the majority of ova had diameter above 0.05 mm. and below 0.20 mm. were treated as samples representing immature females.



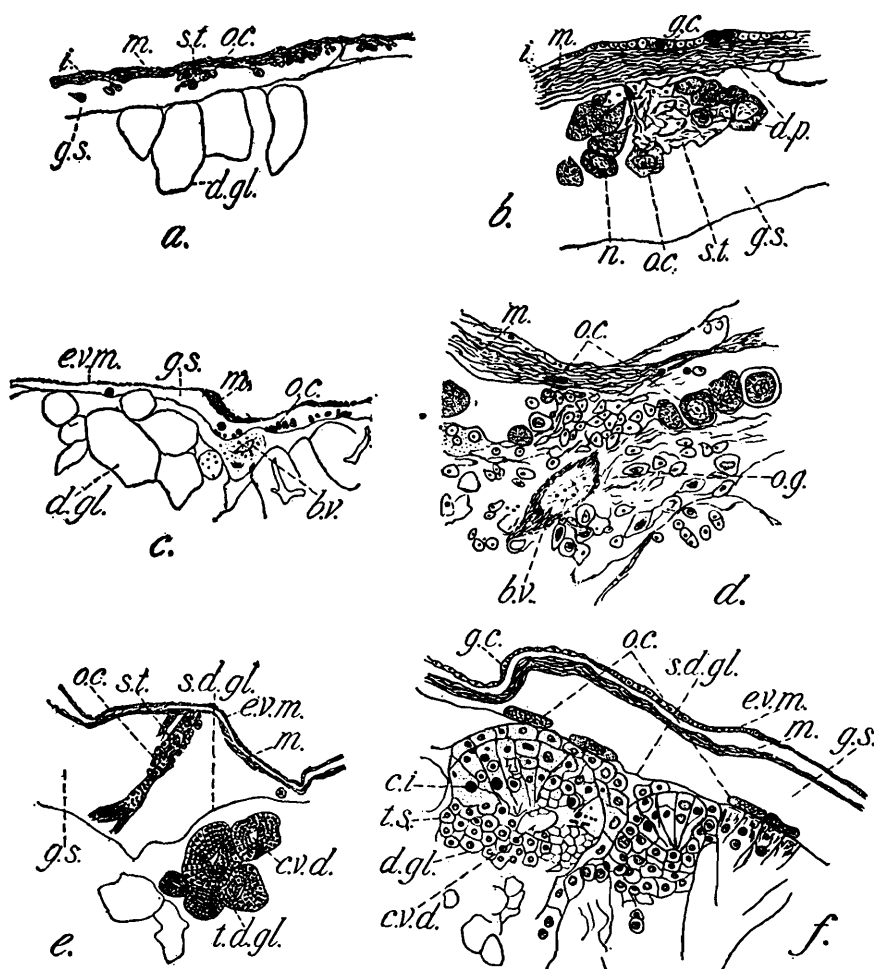
TEXT-FIG. 4.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 6.0 cms. and 8.5 cms.

a. 8.11 cms. (February) ; b. 7.25 cms. (January) ; c. 6.87 cms. (February) ; d. and e. (from different regions of the section) 6.52 cms. (February).

a. to c. drawn under low-power and eye-piece $\times 10$, d. & e. drawn under high power and eye-piece $\times 10$. For explanation of lettering see under Text-fig. 3, p. 60.

In Table I (see p. 75) the number of individuals with ova and/or oocytes of the three categories of dimensions, and the total number of shells from each locality examined are shown at the bottom. The percentage frequency of individuals of each size or age-group under each of the three categories of ova-size is shown in the vertical columns of the table. A careful scrutiny of this table would show that in all the localities, 95—100 per cent. of the individuals with a shell-diameter above 10.00 cms. have a majority of fully mature ova, while over 50—90 per cent. of the individuals with a shell-diameter of 9—9.99 cms. have a majority of mature ova. In the individuals of the age-groups with a diameter below 9 cms. the percentage frequency of individuals with mature ova

is reduced to an average of about 33. The examination of the condition of the gonads in a large series of females of all age or size-groups as revealed by microtome sections also brings out the fact that individuals with the shell-diameter below 9.0 cms. have as a rule the gonad in the form of an arborescent racemose gland (Text-fig. 4) while those with the shell-diameter above 9.0 cms. have a relatively large majority of mature ova covered with a pitted gelatinous membrane and arranged in the form of a honey-comb (Text-fig. 3). The proliferation of oocytes on the branching trabeculae of the coelomic epithelium which lie between the integument and the connective tissue of the digestive gland seems to be an invariable feature of the gonads in individuals with a shell-diameter exceeding 9.0 cms. The text-figures (3 to 6) illustrate clearly what has



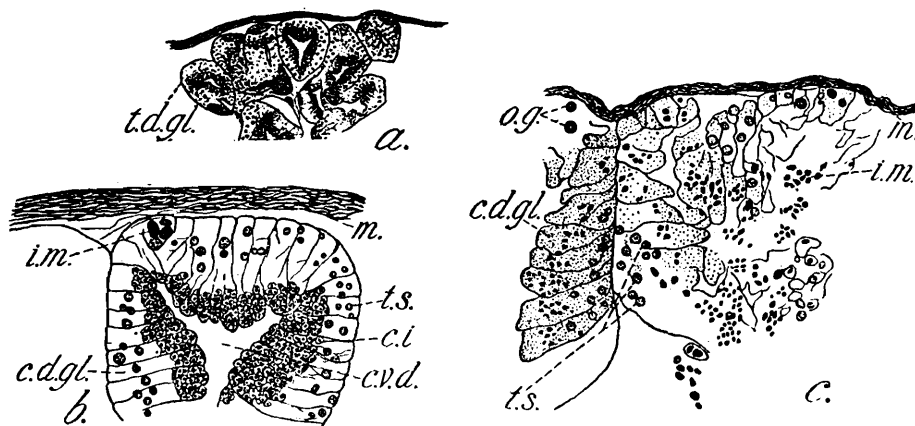
TEXT-FIG. 5.—Vertical longitudinal sections of ovary from specimens of *Trochus niloticus* (collected in various months) with shell-diameter ranging between 3.5 cms. and 5.7 cms.

a. 5.70 cms. (December); drawn under low power and eye-piece $\times 10$; b. same as a. but with the portion of the section marked s. t. and o. c. enlarged and drawn under high power; c. 4.47 cms. (December) drawn under low power and eye-piece $\times 10$; d. same as c. but with the portion of the section marked m., o. c., and b. v. enlarged and drawn under high power; e. 3.55 cms. (January) drawn under low power and eye-piece $\times 10$; f. same as e but from a different portion of the section and drawn under high power.

For explanation of lettering see under Text-fig. 3, p. 60.

been said above. The inference that in the Andaman waters the female of *Trochus niloticus* becomes sexually mature when it has attained a shell-diameter of 9.0 cms., which as stated in my previous paper (Rao, 1936, p. 482) will be in its third year of life, seems to be justified.

Although no detailed observations on the maturity of the male of *T. niloticus* were made, it was found that individuals with a shell-diameter of 6—7 cms. had generally mature or active sperms in their gonad. The age at maturity of *Trochus niloticus* does not appear to be uniform in all the regions in which the species has been studied. Montague (1915) concluded from his observations in New Caledonia that individuals of *T. niloticus* with shell-diameter above 8·5 cms. (about 3 years old) were mature, while Moorhouse (1932, pp. 154-155) basing his observations on *Trochus niloticus* of the Low Isles came to the conclusion that they were mature in their second year of life when the shell-diameter was generally between 5·00—6·25 cms. Moorhouse found that a few female specimens between 4·40 and 5·00 cms. in shell-diameter were also sexually mature. The range of shell-size for sexual maturity among males was according to him between 5·61 and 7·22 cms. in diameter. The results of my observations are more in accord with those of Montague. Whether the differences in the age at maturity in the three areas have anything to do with the differences in the environmental conditions such as temperature, food, salinity, etc., cannot be stated without further observations¹. Orton (1922, pp. 351-353) gives several instances of the attainment of sexual maturity at a very early age under suitable temperature conditions, and points out that size or age at maturity will depend on the duration of growth and breeding, and that in favourable breeding conditions development of the gonads at an early stage of growth takes precedence over mere increase in size. The comparatively early attainment of maturity by *T. niloticus* in the Low Isles is presumably to be attributed to favourable temperature or other conditions which in the case of New Caledonia and the Andamans seem to be lacking, or as Moor-



TEXT-FIG. 6.—Vertical transverse sections of the digestive gland of specimens of *Trochus niloticus* (collected in July) with shell-diameter ranging between 2·5 cms. and 3·5 cms. The sections indicate no trace of the ovary in the space between the integument and the digestive gland.

a 3·17 cms. (drawn under low power and eye-piece $\times 10$); *b*, a portion of the same section drawn under high power. *c*. 2·73 cms. (drawn under high power and eye-piece $\times 10$).

For explanation of lettering see under Text-fig. 3, p. 60.

house himself surmised, the occurrence of maturity in small-sized shells may indicate a retardation in the growth of the shell.

¹ The recent works of Newcombe (1936), and of Newcombe and Kessler (1936), on the relationship of growth and environment in the clam, *Mya arenaria* Linn. deal with these questions in some detail.

The rate of growth at different ages has been dealt with in a previous paper (Rao, *loc. cit.*). Despite the fact that shell-growth is very irregular even in the individuals of a given size-category, there is a definite falling off in the rate of growth as the shell increases in size. Moorhouse speaks of "a definite slackening off in the amount of shell deposited by the animals during the colder months", and of a period of "rest from shell-building" which he terms the "time of hibernating", but in the Andamans I have not been able to obtain any evidence to show that *T niloticus* has a slack season for growth of shell or a definite period of aestivation when the animal does not feed or move about. Amirthalingam's (1932, p. 98) observations on the growth of *T niloticus* at Port Blair led him to the conclusion that it "grows during the monsoon and 'winter' months, that is, July to March", a statement which seems to imply that the remaining part of the year from April to June constitutes a season of slow or no growth.

The determination of the breeding period or periods of *T niloticus* in the Andamans presented considerable difficulties. The main criterion for breeding is the discharge of eggs and spermatozoa at about the same time, and the fertilisation of the former leading to development. Observations in the field and in the laboratory of several hundreds of adult sizes of *T niloticus* during the years 1932 to 1935 failed to reveal any male or female in the act of discharging its sex-products. Artificial fertilisation experiments with the ripe sex-products obtained from individuals having a shell-diameter of 10.0 cms. during the months September to July proved a failure.¹ The mature state of the sex-products of the adults throughout the year seemed to show that at any time of the year individuals bearing ripe sex elements were not altogether absent. Amongst them were those with gonads full of ova or spermatozoa as well as individuals (with flabby gonads) which may be considered to have recently shed their sex-products in part. A second method of approach to the problem of the breeding season adopted was the periodical examination of the plankton of the inshore waters round about Port Blair and other localities to discover the occurrence of any advanced veligers with shell resembling the types common to Trochidae. Several forms allied to the Cerithidae, Rissoidae, Turbinidae, Neritidae, etc., were found in the plankton during the warmer months of the year, and it was thought that the occurrence of advanced larvae of Trochidae would give a clue to the breeding period. Unfortunately, none of the Trochoid forms was obtained during the months December to April when the weather conditions were suitable for the collection of plankton.

If breeding in *T niloticus* were confined to a short season in the year one would expect to find the shell-populations distributed in several sharp well-defined categories of sizes. Supposing that the breeding season was spread over a period of 2—3 months only commencing in April, and a random sample of the population in a given area measured, say in March of the following year, one would find only shells with a diameter

¹ The looseness of the ova in the gonads which washed freely when a jet of water was directed on it, and the presence of ova in the passages connecting the gonad with the kidney were taken as the criteria for judging the readiness of specimens to breed. The impurity of the sea-water in the shore area around Port Blair which had to be used for the experiment was probably responsible for the failure of artificial fertilisation,

of about 5 cms. in the first year of growth, of 8 cms. in the second year of growth, of 10 cms. in the third year of growth and so on exhibiting gaps in size between the various groups, but none amongst the size-ranges of 1—4 cms.¹ In fact, however, the data of shell-collection of *T. niloticus* round about Port Blair for a period of 4 years ending in July 1935 show no well-defined gaps in the distribution of shells amongst the various categories of sizes (see Table II, pp. 76-79). The absence of small-size shells of diameter upto 1.99 cms. in the years 1931-34 has no significance. Because of their cryptic habits and small-size, and the dull colour of the shell which so well harmonizes with that of its surroundings, the small shells may have been overlooked.² The intensive fishing for *Trochus* shells by the Japanese during the years 1929 and 1930, may have also been partly responsible for the scarcity of both the small and the very large shells with a diameter range of 1-3 cms. and 12-14 cms. respectively. A glance at Tables II and III (pp. 76-79 and p. 80) would seem to emphasise the point that intensive collection has made inroads on the large-sized shells as the frequency distribution of shells of various sizes in the four years 1931-35 shows. The mode of frequency seems to move gradually from 7.0 and 8.0 cms. categories in 1931-32 to 3.0 and 4.0 cms. categories in 1934-35.

Of the three types of evidence available for determining the breeding period, that provided by the larvae is negative. The mature and gravid condition of the gonads in adult individuals throughout the year leads one to the conclusion that breeding is not noticeably interrupted, while the samples of shells, collected throughout the twelve months of the four years in the same locality, which include shells of all ages amply support the conclusion that breeding is continuous (see Tables II and IV, pp. 76-79 and p. 81).

In the Low Isles, Moorhouse (1932, p. 154) observed that the spawning period was of some five months' duration at least, commencing in March, and that eggs were liberated not in great clouds but in small quantities at a time. He thought however that the egg-laying was protracted over a period longer than five months. In New Caledonia Montague (*loc. cit.*) found in the month of December several specimens (9 cms. in diameter) distended with eggs ready for deposition. In the Andamans, Amirthalingam (1932, p. 31) inferred that spawning would probably begin in April, presumably from the fact that females with spent gonads were observed from that month onwards, but did not mention whether he had seen any individuals actually spawning. If spawning is continuous over only a short period, one may expect to find a majority of individuals with spent gonads during that period. Actually, however, examples with full and spent gonads were obtained during the warm as well as the cold months of the year. These terms 'warm' and 'cold' have relatively less significance in the latitudes in which the Andamans

¹ The results of the rate of growth studies embodied in another paper (Rao & Raja, 1936) have been used to estimate the age-groups.

² It is also possible that the younger forms inhabit the deeper parts of the sea from which a few stray into the shallower parts and the intertidal region. Hedley (1917, p. 70) stated that the youngest stages of *T. niloticus* are passed in deep water on the reefs. Gopala Aiyar (1935) found that specimens of the Echinoid *Salmacis bicolor* of small size (3.4 cms. in diameter) were singularly absent amongst hundreds of large forms obtained from the Madras Harbour, and suggested that the young forms may probably be confined to the deeper parts, creeping up only after attaining maturity.

are situated where the annual range of the average monthly temperature of the surface-water does not exceed 2°C .¹ The influence of temperature on breeding is discussed below. It may be pointed, however, that in the Andamans there is no definite evidence to show that spawning is confined to any well-marked season, although spawning has probably a tendency to be more intensive in the warm months from February to May, than during the monsoon months June to November.

The temperature observations on the east coast of Ross I. were taken at various hours of the day from 6 A.M. to 6 P.M. in knee-deep water between the rocks constantly washed by the waves. The highest and lowest temperatures recorded during these nine months were 32.0°C . in May and 25.9°C . in December respectively, while (the daily average) high temperatures prevailed during the months of May and October. The average temperature for April would presumably be higher than that of May, but owing to other work no observations could be taken at Port Blair during the dry and warmer months of February, March, and April (see Table V, p. 82).

Amirthalingam in his note to *Nature* (p. 98, 1932) stated that *Trochus niloticus* "has a minimum temperature above which alone it would spawn" basing his conclusion presumably on the fact that individuals with spent gonads were found from the month of April onwards, and on the results of Sewell's temperature observations (*loc. cit.*) in the Andaman sea which indicate a double oscillation in temperature in the course of a year. He also stated that the observation that *T. niloticus* starts spawning in April when the first rise of temperature takes place emphasised "the idea that the marine invertebrates in tropical waters do not breed haphazardly but with a similar regularity to that observed in temperate waters" My observations in the Andamans for about 3 years do not establish any definite correlation between breeding in *T. niloticus* and the observed high temperature epochs of the Andaman sea, and the analogy of the correlation between these two phenomena in the temperate seas may not hold good in the tropics.² Recently Whedon (1936) studying the spawning habits of *Mytilus californianus* Conrad in the vicinity of San Francisco with reference to temperature doubted that the changes in temperature which occur in that region were severe enough to influence spawning. He found the sex products developing in the warmer months when food was most abundant, and the mussels spawning in the cooler months, while on the contrary *Mytilus edulis* of the Atlantic coast of America was observed to develop sex products in the coldest months and to spawn with the onset of warmer conditions. In the same manner the warmer periods during March and April and again in October in the Andamans may stimulate the activity of sex-glands in *T. niloticus* leading to a comparatively intensive spell of spawning at their end, or during the cooler months following the warm periods.

¹ The average daily range of temperature at Port Blair as given by Sewell (1927, pp. 104-118) seems to be much higher than the one given here. My observations at Port Blair during 1933 show that the difference in maximum and minimum temperatures attained in the course of the day is no more than 2°C .

² Adult specimens of *T. niloticus* kept in samples of sea-water the temperature of which was raised by artificial heat up to 35° to 40°C . did not show any signs of spawning, although active movements of the animal were observed.

Orton (1922) has shown that in marine animals of temperate regions sexual activity is induced under normal biological conditions by the stimulus of temperature, and that in the temperate regions the breeding temperature which is a physiological constant for each species of marine animal may be the minimum or the maximum attained in that particular locality. In regard to the tropics where constant or nearly constant temperature conditions prevail, he has stated that "there is apparently good evidence that breeding in marine animals is continuous, but a thorough investigation of this problem is desirable". The main problems in regard to the breeding of tropical marine animals may be stated in the form of a questionnaire : (1) does the small range of variation in the temperature of tropical seas admit of considering temperature as the main stimulus for breeding, (2) if the answer to this question is in the affirmative, do the maxima and minima of temperatures attained in various localities act as physiological constants in the breeding of marine animals, (3) do factors other than temperature have any correlation with breeding, and if so, to what extent. In the present state of our knowledge of the breeding of tropical marine animals the answers to the questionnaire would presumably be incomplete. Observations in the different regions of the tropical seas seem to have led to divergent conclusions. A short review of the opinions held in regard to the general question of the epoch and frequency of breeding in the tropical seas may not be out of place here. Mortensen (1921), while admitting that temperature has an important bearing on development which proceeds at a conspicuously quicker rate at the higher temperature of the tropics than in the colder regions, did not agree with the view that all tropical marine animals breed continuously throughout the year. From his experience of some species of tropical Echinoderms he could only concede that they have more than one breeding season in the year. He was able to confirm Orton's statement that "where biological conditions do not vary much marine animals will breed continuously" but "would only object to making this a general rule ; this it is certainly not, especially not in the tropics", by which Mortensen apparently meant that biological conditions do vary in the tropics and that therefore breeding cannot be continuous. Anne Stephenson (1934), as a result of her observations on the breeding of various marine Invertebrates such as Coelenterates, Echinoderms, Molluscs, and Crustaceans in the Great Barrier Reef in 1928-29, came to the conclusion that the breeding was by no means confined to any one part of the year, but occurred every month, in winter as well as in summer. She believed, however, that although spawning was going on all the year round, a majority of the species investigated "would be found spawning either exclusively or most actively in the warmer months". She also thought that "the actual breeding season of any one species would probably fluctuate considerably from one year to another, in the same place, not to mention its varying from one district to another". She observed four main types of breeding in the Great Barrier Reef, (1) a single breeding period not lasting the whole year round, (2) continuous breeding throughout the year but more active in one part of the year than during the remainder, (3) discontinuous breeding occurring in relation to lunar phases during a longer or shorter portion of the year, (4) two spawning periods

in the year with a quiescent phase between them. Moore (1934) observed considerable variation in the breeding periods of *Echinus esculentus* even in localities separated only by a few miles and at different depths. Gopala Aiyar (1931) found the Polychaete worm *Marphysa* breeding in Madras from January to September and again in December. The same author (1935) collected sexually ripe individuals of the Echinoid *Salmacis bicolor* in the Madras Harbour throughout the year at temperatures varying from 24° C. to 30° C., and found (1935) *Acentrogobius neilli* (Day) breeding at all times in the Adyar backwaters, Madras, at temperatures varying from 24°·4 C. to 29°·65 C., but with an intensive breeding period during the monsoon in October and November.¹ Subramaniam (1935) observed the brackishwater hermit-crab, *Clibanarius olivaceous* (Henderson) at the mouth of the Adyar River, Madras, breeding throughout the year but with a well-marked intensive period from September to March. Whedon (1936) found *Mytilus californianus* Conrad in the region of San Francisco spawning at all times of the year, but with a maximum period of spawning beginning early in October, followed by two other periods of lesser degree in January and February, and in May and June. This short review of recent work on breeding in tropical marine animals in relation to temperature changes seems to indicate that the evidence in support of the view that tropical marine animals breed continuously tends to gather weight. It does not seem to be clear, however, what, under the uniform biological conditions of tropical seas, constitute the stimulus for inducing marine animals to spawn. Whedon (*loc. cit.*) has "shown that spawning occurs at all times of the year, apparently irrespective of temperature or other external stimuli", and the observations of Anne Stephenson (*loc. cit.*) and Moore (*loc. cit.*) seem to lend support to that author's findings.

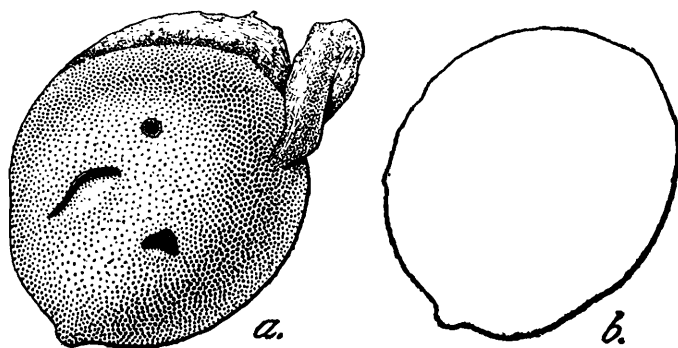
In regard to the factors which influence breeding in *T. niloticus* the observations of Montague (*loc. cit.*), Moorhouse (1932) and Amirthalingam (*loc. cit.*), and those recorded in the present paper tend to show that the physiological constant which induces spawning is not merely temperature or latitude or food. The optimum condition for spawning in a given region would probably be a combination of several factors which may include one or more of those mentioned. Without a detailed investigation of the physiology of *T. niloticus* it would be difficult to determine the factor or combination of factors which induces sexual activity throughout the year. On the whole the question of sexual maturity and spawning in individual species of tropical marine animals in relation to the physical and biological conditions at different latitudes cannot be settled satisfactorily without further knowledge of the habits of marine animals from various regions of the tropical seas.

The longevity of *Trochus niloticus* in the Andamans has been dealt with (Rao, *loc. cit.*) in another paper. Individuals with shell-diameter up to 15 cms. have occasionally been taken in collections from various islands of the Andaman and Nicobar groups. Under normal conditions an individual may live for well over 10 years attaining a diameter of

¹ In the Andamans I have observed the Blennioid fish *Andamia heteroptera* Bleeker on the rocks between tide-marks in the vicinity of Port Blair with fully developed eggs from September to the beginning of May, and young ones 1·2 cms. long practically throughout the year.

over 12 cms., but specimens with shell-diameter exceeding 14 cms. may be 12 years old.¹ Death in *T. niloticus* due to old age is very little known. Certain characters of the shell (in examples with diameter exceeding 11 cms.) observed in the course of the investigation seem to suggest their association with senility. The tendency of the upper margin of the last whorl to be discrete from the suture or the previous whorl, the irregularity of the oblique lines of growth on the last whorl, the thickening of the shell, and the tendency to the formation of blisters on the nacreous surface of the mouth of the shell are some of the features commonly observed in shells above 11—12 cms. in diameter and may be associated with the senile changes in this species. There may be other features of senility exhibited by the internal organs such as the digestive and the nervous systems,² but these have not been investigated.

The sheltered positions on the reefs in which *T. niloticus* occurs probably protect the species to some extent from predatory enemies, such as sharks, rays, Gymnodontid fishes, etc. In the more exposed parts of the reefs, however, the extremely thick and hard shell of the species seems to be of doubtful utility in protecting the species from the attacks of such enemies mentioned above, for fragments of shells of *Trochus* and *Turbo* have been found amongst the gut contents of these fish.³ The thin and weak operculum seems to provide inadequate protection against the attacks of large crabs which with the help of their powerful chelipeds seem to tear the soft parts of *Trochus* in the expanded state. On one occasion a large crab on the reef near South Point, Port Blair, was seen helping itself to morsels of the flesh of *T. niloticus* under a stone when the animal was in a partial state of expansion. The snail was found to be dead, but it was difficult to say whether the crab was merely feeding on the carcass of an individual, or had caused the death of the animal



TEXT-FIG. 7.—Calcareous concretion from the apex of the visceral coil of *Trochus niloticus* from Sister Is., Andamans (24.ii.1933).

a. In the investing membrane which is produced into a short twisted stalk at one end., *b.* The concretion removed from its investment.

prior to feeding on the flesh of its victim. A species of Gastropod (Purpurinae-Muricidae) was also found feeding similarly on the soft

¹ Hedley (p. 70, 1917) stated that according to native tradition in Fiji, *T. niloticus* lives for 4 years.

² For a detailed study of senility among Gastropods the works of Burnett Smith (1905), of I. and M. Szabó (1934) and of I. Szabó (1935) may be consulted with advantage.

³ Moorhouse (1932, p. 148) recorded that sting-rays, hermitcrabs (*Dardanus megistos*) and whelks were responsible for the destruction of live *Trochus niloticus* on the Low Isles.

parts of *T. niloticus* kept under a rock covered by the tide and examined 24 hours later. The incidence of mortality, due to diseased conditions, or to attacks by crabs, fish, molluscs, etc., as revealed by the number of empty shells or of those occupied by hermit-crabs in samples of shell collections made by divers in the course of a day, appears to be negligible i.e., less than 3 per cent.

The surface of the whorls of the shell is covered by growths of various brown and green algae, by growths of animal colonies such as Sponges, Hydroids, Polyzoa, small Madreporarian corals, barnacles, molluscs, etc. The smaller shells below 7 cms. in diameter are usually free from these growths on the whorls, but the larger ones, particularly those above 10 cms. in diameter, are invariably covered with plants and animal colonies. These presumably afford the animal some degree of protection from predatory enemies. Amongst the animals causing damage to the shell were observed the following: the bivalve molluscs *Lithophaga* (*Lithopaga*) *nasuta* (Philippi), *L. (L.) laevigata* (Quoy & Gaimard),¹ *Parapholas quadrizonata* Spengler, and *Rocellaria* sp. often boring into the nacreous layer of the shell; Gastropods like the Lepetellid *Saptadanta nasika* Prashad & Rao, the Patellid *Patella* (*Patellidea*) *tara* Prashad & Rao,² the Vermetid *Vermetus* (*Spirogyphus*) *andamanicus* Prashad & Rao³ which cause some damage to the periostracal and nacreous layers of the shell by excavating deep impressions of the outline of their respective shells; and the boring Sponge *Cliona* sp. which destroys the periostracal layer.⁴ Irritation caused by sand-grains or other foreign particles on the mantle inside the shell usually leads to the formation of rounded or irregular nodules of mother-of-pearl on the nacreous layer inside the mouth of the shell. In an adult shell from Sister I., Andamans, an oval mass of calcium carbonate (pl. I, fig. 17) about the size of a small pea was found in a small sac of mantle tissue (text fig. 7a.) in the top-whorls of the spire.⁵ This may also have been due to the irritation set up initially by a foreign particle, but resulting in the deposition of a calcareous amorphous mass instead of nacreous substance.

No internal parasites causing damage to the soft parts have been found in *T. niloticus*, but the Copepod, *Panaetis camerata* Stebbing, found living generally in the buccal cavity and oesophagus of the living *T. niloticus* appears to be a commensal rather than a parasite. No discernible damage has, at any rate, been done to the host by this Copepod. This species, known previously from a unique example (♀) taken from the pallial cavity of an unknown Gastropod from the Louisiade Archipelago off the south eastern coast of New Guinea, has been fully described

¹ Winckworth (1933) described *Acanthochitona penetrans* found living in the holes made by these two species of *Lithophaga*.

² *Rec. Ind. Mus.*, XXXVI, pp. 1-4, pl. i (1934).

³ *Rec. Ind. Mus.* XXXV, pp. 409-412, pl. x (1933).

⁴ A species of *Petrosia* Vosmaer found filling up the cavity in the apex of the spire above the white mass of amorphous calcareous deposit in certain specimens of *T. niloticus* does not appear to be harmful to its host, but it is difficult to understand how the sponge could have gained access to the interior of the apical part of the shell which was entire and without cracks or holes on the outside.

⁵ My friend, Dr. M. S. Krishnan of the Geological Survey, whom I have to thank for examining the mass, reported that its composition was almost pure calcium carbonate (Aragonite).

from several examples by Monod (1934), and is invariably found in the living state in the buccal cavity or oesophagus of *Trochus niloticus* of all ages known in the Andamans. This Copepod has recently been recorded by Yamaguti (1936) from the mouth cavity of *Turbo* (*Batillus*) *cornutus* Solander from the Sea of Japan. A closely allied *P. haliotis* Yamaguti from the Pacific Coast was found in the mouth cavity of *Haliotis* (*Sulculus*) *gigantea* Gmelin.

In conclusion I wish to take this opportunity to express my indebtedness to Dr. Baini Prashad for much encouragement in my investigations, to the authorities of the Andaman administration for the grant of laboratory and transport facilities on land and sea respectively, and to the representatives of the Japanese Fishery Companies of Singapore stationed at Port Blair, who rendered the most valuable assistance in my field-work by taking me in their motor-boats to nearly all the *Trochus* shell-beds in the Andaman and Nicobar groups of islands and permitting me to examine their collections of shells. To Mr. K. S. Misra, Laboratory Assistant at Port Blair, my best thanks are due for diligent and willing assistance rendered throughout the period of my investigations.

SUMMARY.

1. The geographical distribution of *Trochus niloticus* is indicated.
2. The two common types of shell of *T. niloticus* which occur throughout the Andamans and Nicobars do not represent two distinct species as was supposed by some authors, but only plastic phases of *T. niloticus* or changes due to differences in the rate of growth at various ages.
3. *T. niloticus* occurs commonly on the reefs and boulders between tide-marks and at depths ranging from 2—7 fathoms on the weather side within $\frac{1}{2}$ to 1 mile from the shores of the islands of the Andaman and Nicobar groups. The younger shells up to 5 cms. in diameter are found at all times of the year amongst coral shingle and under coral slabs between tide-marks, but are rather scarce where the adult shells are found. There is no evidence at present to show that they are more abundant at depths greater than 7 fathoms from where they crawl up to the shallower parts on reaching maturity.
4. *T. niloticus* is not a gregarious species in the strict sense of the term. It is not massed in large numbers like the members of the families, the Neritidae and Littorinidae, which are well-represented on the rocks and boulders between tide-marks of the Andaman islands.
5. The species does not thrive under the artificial conditions of Laboratory aquaria. The behaviour of animals under these conditions is described. The animal is able to survive dessication for 48 hours.
6. Within the limits of the reefs surrounding the islands, *T. niloticus* wanders a great deal in search of food and shelter.

- 7 The feeding habits of *T niloticus* are described. It is shown that the species lives chiefly on bottom deposits and on fresh algal vegetation. The features of the radular teeth of animals of various ages are described.
8. No certain method of determining the sex of the shell without breaking it open or damaging it is known. The sexes are separate and are distinguished by the colour of the gonads, green in the adult female, white or cream in the adult male. The young male or female can only be distinguished by examining smears of the gonad under the microscope, or by microscopic examination of microtome sections. Hermaphroditism and sex-change have not been observed, and are considered improbable of occurrence.
9. The two sexes occur in about equal numbers in the adult age-groups with shell-diameter between 7.0 and 11.99 cms. This fact is supported by statistical evidence.
10. In the Andamans and Nicobars, sexual maturity is reached in the female when the shell has attained a diameter of 9.0 cms., and in the male when the shell has a diameter of 6.0—7.0 cms.
11. No evidence of a slack season for growth in shell or of a period of aestivation for *T niloticus* in the Andamans has been obtained.
12. The mature condition of the gonads and the readiness for spawning which has been observed in adults of *T niloticus* throughout the year, and the occurrence, during the twelve months of the year, of shells of all ages indicate that breeding is continuous with perhaps an intensive spell of breeding during or immediately after the warm seasons.
13. The opinions held in regard to the problems of the stimulus for spawning, and of the period and frequency of breeding in tropical marine animals are reviewed. The inadequacy of any one environmental factor alone to stimulate sexual activity is pointed out. It is suggested that a more detailed investigation of the physiology of tropical marine animals would provide satisfactory solutions to these problems.
14. The age of *T niloticus* in the Andamans is shown to exceed 10 years. Certain features in the shell suggestive of senility are described.
15. The incidence of mortality due to diseases or old age is indicated to be low. Animals associated with the shell or the soft parts of *T niloticus* and causing in some instances damage to the shell are described.

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TABLE I.

Table showing the percentage frequency of individuals with ova of three different dimensions.

Age or size-group (Diameter in cms.).	RITCHIE'S ARCHI- PELAGO.			CINQUE, SISTER, BRO- THER, PASSAGE AND LITTLE ANDAMAN ISLANDS.			INTERVIEW I. AND OTHER ISLANDS OF THE WEST COAST OF ANDA- MAN ISLANDS.			PORT BLAIR AND ENVIRONS.		
	PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA			PERCENTAGE FREQUENCY OF INDIVIDUALS WITH OVA		
	below 0.05 mm.	between 0.05 and 0.20 mm.	above 0.20 mm.	below 0.05 mm.	between 0.05 and 0.20 mm.	above 0.20 mm.	below 0.05 mm.	between 0.05 and 0.20 mm.	above 0.20 mm.	below 0.05 mm.	between 0.05 and 0.20 mm.	above 0.20 mm.
6—6.99	..	..	..	100.0		..	..	..	..	..	..	..
7—7.99	41	59	..	85.7	14.30		80	..	20.00	66.6	..	33.3
8—8.99	19	46	35	60.0	23.30	16.70	18	32.00	50.00	..	66.6	33.3
9—9.99	10	13	77	7.5	40.00	52.50	..	16.42	83.58	11.2	..	88.8
10—10.99	..	..	100	..	4.88	95.12	..	..	100.00	..	..	100.0
11—11.99		..	100	..	..	100.00		1.25	98.75	..		100.0
12—12.99	..		..	..		100.00	..	..	100.00	..	..	..
13—13.99	..	..	..	..	..	100.00	..	..	..	..	..	..
Total No. of shells examined	148			192			340			55		
No. of shells in each group	29	51	68	41	28	123	13	28	299	11	6	38

TABLE II.
No. of shells collected at Port Blair in each month of the year 1931-32.

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1.99	..	..	..		..		..	..	..	..	..	..		
2— 2.99	..		2	..	..		..	..	..	..		..	2	0.29
3— 3.99		..	..	..	1	..		..	2	..	..	..	3	0.44
4— 4.99			..	..	1	..	..	4	10	2	4	2	23	3.36
5— 5.99	..	..	3	2	18	5		3	7	2	3	4	47	6.86
6— 6.99	..		6	6	37	33	9	5	7	2	4	1	110	16.06
7— 7.99			6	7	29	39	16	4	4	8	6	2	121	17.66
8— 8.99			4	9	25	27	10	6	10	12	14	10	127	18.54
9— 9.99		..	4	8	19	15	5	6	7	4	9	12	89	12.99
10—10.99			2	11	17	8	4	6	3	4	19	6	80	11.68
11—11.99			..	3	6	10	1	4	5	1	23	2	55	8.03
12—12.99	..		..	2	2	..	3	5	2	..	11	..	25	3.65
13—13.99			..		..	..			..		3	..	3	0.44
Total No. for each month	..	..	27	48	155	137	48	43	57	35	96	39	685	100.00

TABLE II—*contd.**No. of shells collected at Port Blair in each month of the year 1932-33.*

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1.99			..			..	..	..	..	..	..	..	..	
2— 2.99			..	..		..	..	..	1	1	1	..	3	1.0
3— 3.99		..	..		2	2	1	5	1	..	..	1	12	4.7
4— 4.99			..	..	1	1	1	3	10	3	2		21	8.2
5— 5.99	1	1	..	5	8	1	..		2	3	8		29	11.4
6— 6.99	1	4	..	4	14	16	1	2	1	6	2	..	51	20.0
7— 7.99	1	3		6	19	19	2	2		2	1		55	21.6
8— 8.99	1	1	1	1	5	19	..		1	..	2	..	31	12.2
9— 9.99		1				6	3	1	2	1			14	5.5
10—10.99		3	2	3	..	5	..	..	1			..	14	5.5
11—11.99		3		5		5		1	2			..	16	6.3
12—12.99	..	1	1	1	..	6	..	..	..	..	..	..	9	3.5
13—13.99			..	..	..		..	..						..
Total No. for each month	4	17	4	25	49	80	8	14	21	16	16	1	255	99.9

TABLE II—*contd.**No. of shells collected at Port Blair in each month of the year 1933-34.*

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1·99	..	..	..	..	..		..	..	..	..	..	..	..	..
2— 2·99	..	..	5	1	3	6	1	..	..	1	..	..	17	7·26
3— 3·99	2	5	8	4	3	2	1	1	3	4	1		34	14·53
4— 4·99	4	10	4		1		1	..	..	10	..	1	31	13·25
5— 5·99	1	7		5	6	2	2	..		2	..	2	27	11·54
6— 6·99	..	4	..	7	6	4	3	1	..	4		1	30	12·82
7— 7·99	..	1	..	7	1	2	5	5	..	6	..	3	30	12·82
8— 8·99	..	..	..	..	3	1	5	10	..	5		3	27	11·54
9— 9·99	..	3	..	..	1	1	5	2	..	2	..	3	17	7·26
10—10·99	..	..	..	2	..	..	2	..	1	2	..	4	11	4·70
11—11·99	..	..	1	4	..	..	..	..	1	..	..	..	6	2·56
12—12·99	..	..	1	1	..		..	..	2	..	..	..	4	1·71
13—13·99	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total No. for each month	7	30	19	31	24	18	25	19	7	36	1	17	234	99·99

TABLE II—concl'd.

No. of shells collected at Port Blair in each month of the year, 1934-35.

Age-group (Maximum diameter of shell in centimetres).	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	Total No. of shells for the year.	Percentage.
1— 1.99					2		1			..		..	3	0.62
2— 2.99 .		1	4	8	5	10	9	5	6	4	9	..	61	12.55
3— 3.99	8		4	4	17	16	23	5	24	11	34	11	157	32.30
4— 4.99 .	11	4	14	3	7	5	9	1	7	4	4	4	73	15.02
5— 5.99 . .	5	5	5	4	7	6		2	2		2	3	41	8.44
6— 6.99 . . .	..	5	6	4	7	1	3	2		2	1	1	32	6.58
7— 7.99 .		..	5	4	3	2	2		4	6			26	5.35
8— 8.99 .	..	6	5	3	1			5	3	5	1		29	5.97
9— 9.99 .	1	8	2	9	1	1	1	11	2	2	..	1	39	8.03
10—10.99 .	..	1	1	1	1		2	7	1		1		15	3.09
11—11.99	1	1	..	..	..	1		3	1			..	7	1.44
12—12.99 .			..		..					1			1	0.20
13—13.99			..		..		..			2			2	0.41
Total No. for each month .	26	31	46	40	51	42	50	41	50	37	52	20	486	100.00

TABLE III.

Table showing the percentage frequency of shells of the various age-groups collected in the four years, 1931-35 at Port Blair.

Age-groups.	1—1.99.	2—2.99.	3—3.99.	4—4.99.	5—5.99.	6—6.99.	7—7.99.	8—8.99.	9—9.99.	10—10.99.	11—11.99.	12—12.99.	13—13.99.
1931-32	..	0.29	0.44	3.36	6.86	16.06	17.66	18.54	12.99	11.68	8.03	3.65	0.44
1932-33	..	1.00	4.70	8.20	11.40	20.00	21.60	12.20	5.50	5.50	6.30	3.50	..
1933-34 .	..	7.26	14.53	13.25	11.54	12.82	12.82	11.54	7.26	4.70	2.56	1.71	..
1934-35 . .	0.62	12.55	32.30	15.02	8.44	6.58	5.35	5.97	8.03	3.09	1.44	0.20	0.41

TABLE IV.

Table showing the occurrence of shells of *T. niloticus* at Port Blair of various age-groups in the twelve months of the year.

Months.	Age-groups.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
May	—	×	×	×	×	×	×	×	×	—	×	—	—
June	—	×	×	×	×	×	×	×	×	×	×	×	—
July	—	×	×	×	×	×	×	×	×	×	×	×	—
August	—	×	×	×	×	×	×	×	×	×	×	×	—
September	×	×	×	×	×	×	×	×	×	×	×	×	—
October	—	×	×	×	×	×	×	×	×	×	×	×	—
November	×	×	×	×	×	×	×	×	×	×	×	×	—
December	—	×	×	×	×	×	×	×	×	×	×	×	—
January	—	×	×	×	×	×	×	×	×	×	×	×	—
February	—	×	×	×	×	×	×	×	×	×	×	×	—
March	—	×	×	×	×	×	×	×	×	×	×	×	—
April	—	×	×	×	×	×	×	×	×	×	×	—	—

× = indicates occurrence.

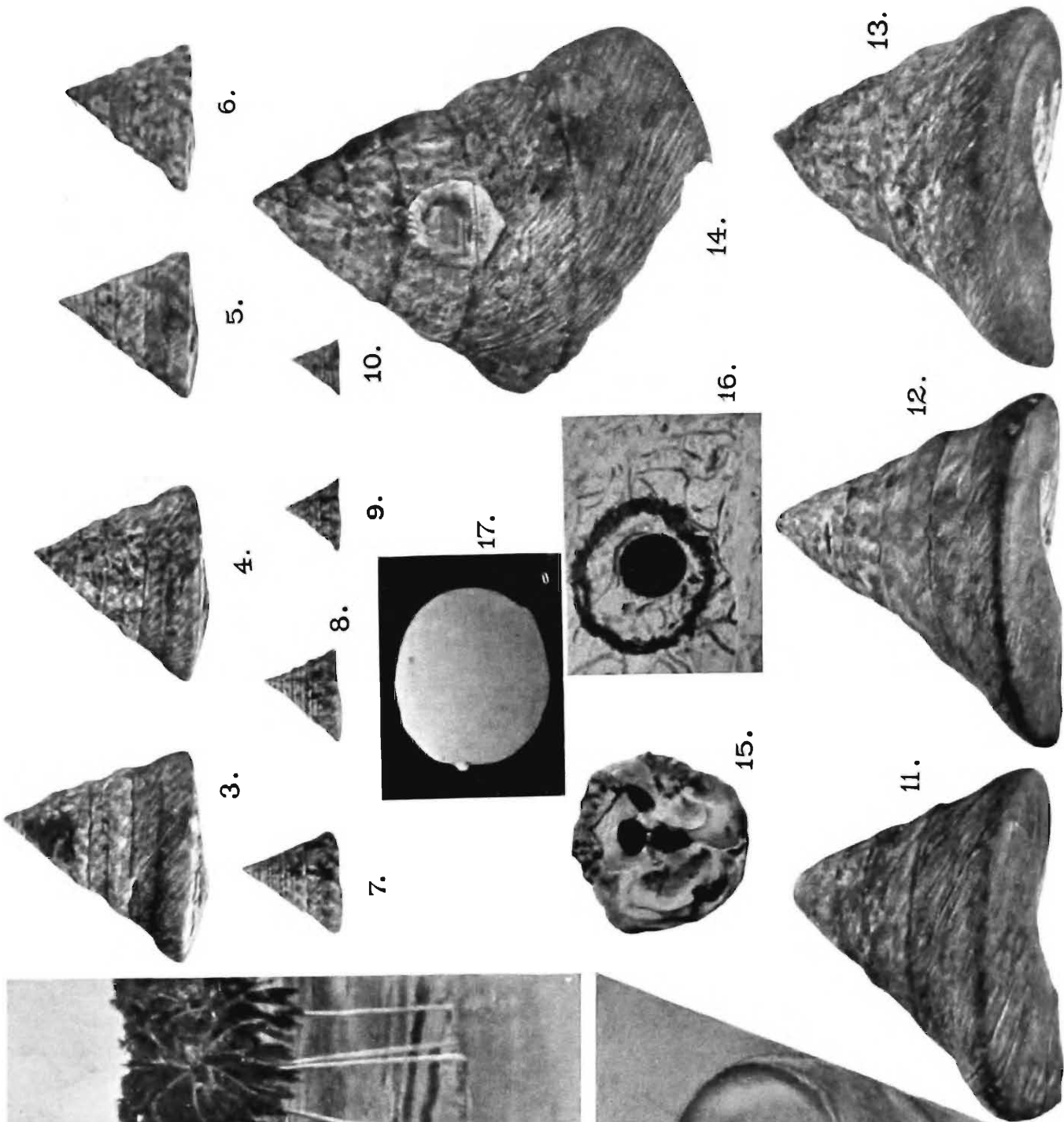
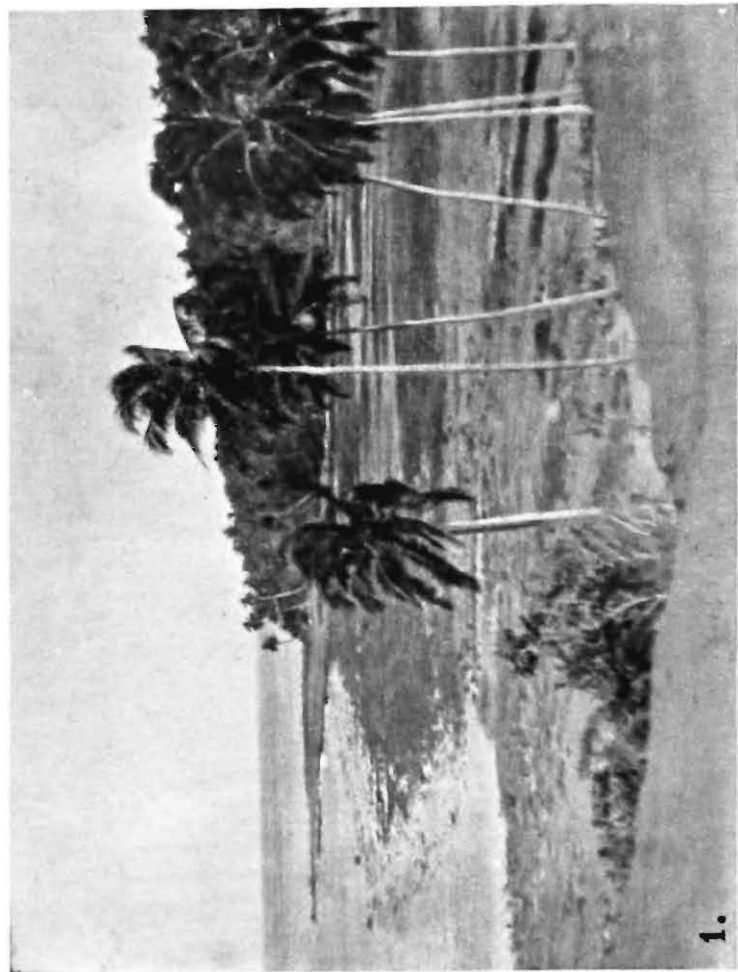
TABLE V

Daily average surface-water temperature of the inshore region on Ross I.
in degrees centigrade.

Months.	Forenoon.	Afternoon.	Difference in average.
1933—			
May	28·8	29·5	0·7
June . . .	28·1	28·1	0·0
July . . .	27·7	28·5	0·8
August . .	28·7	29·2	0·5
September	27·9	28·0	0·1
October .	28·5	30·4	1·9
November	28·4	29·3	0·9
December .	27·5	28·2	0·7
1934—			
January .	27·4	28·5	1·1

EXPLANATION OF PLATE I.

- FIG. 1.—Murdakhari Bay, Port Blair, Andamans, uncovered by the sea at spring tide. Sand and shingle made up of branches and slabs of Madreporarian coral constitute the region between tide-marks. Small shells of *Trochus niloticus* below 5 cms. in diameter are of common occurrence amongst the shingle.
- FIG. 2.—Live specimens of *T. niloticus* in glass aquaria in the Laboratory at Port Blair a few hours after capture. The animal is never fully expanded in aquaria, and shows only the operculum, parts of the foot and the epipodia ($\frac{1}{2}$ Nat. size).
- FIGS. 3—10.—Shells of *Trochus niloticus* of various age-groups, 5 cms. and below in diameter. The diameters in cms. of shells of the upper row from left to right are 5.00, 4.77, 3.48, and 3.43 respectively, and of shells of the lower row from left to right are 2.32, 2.15, 1.74, and 1.21 respectively ($\frac{1}{2}$ Nat. size).
- FIGS. 11—13.—Types of shell of *Trochus niloticus* of the 8 cms. category viewed from the side away from the aperture. 11. convex type, 12. flat type, 13. plano-convex type with a peripheral ridge (from N. Andaman, January 1935) ($\frac{1}{2}$ Nat. size).
- FIG. 14.—Shell of young *T. niloticus* 5 cms. in diameter bearing the scar left by the Lepetellid, *Saptadanta nasika* Prashad and Rao. (Nat. size).
- FIG. 15.—Top portion of the spire of *T. niloticus* (bored by a species of *Lithophaga*) as viewed from below, McPherson Strait, Andamans (18.i.34) (Nat. size).
- FIG. 16.—A portion of the basal part of the last whorl of a large shell of *T. niloticus* from the Nicobar Is. (Nov., 1933) showing the hole made by a species of *Lithophaga*. The winding grooves surrounding the hole are presumably the impressions of worm-tubes. ($\times 3$).
- FIG. 17.—Calcareous mass from the apex of the visceral coil of *T. niloticus* from Sister Is., Andamans (24.ii.33). ($\times 5$).



SEASONAL VARIATIONS IN THE DISTRIBUTION OF *SAGITTA* OF THE MADRAS COAST

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INTRODUCTION.

A preliminary account of the Plankton of the Madras coast was published five years ago (K. S. Menon, 1931) in which was recorded for the first time the occurrence of *Sagitta* along this coast. Menon observes that *S. bipunctata* occurs in the plankton collections fairly regularly and uniformly during all seasons. In a review of this paper published in 'Nature' (1932) the conclusion was drawn that this uniform distribution is probably due to the tropical condition of the sea. As I have discussed in a later part of this paper, wherever the distribution of *Sagitta* was studied it has been definitely shown that seasonal variations of most of the species is a marked feature of its occurrence, hence the statement of Menon about the uniformity of its distribution was naturally noted with some interest.

Since the Plankton of the Madras coast had never been studied before Menon's work was of the nature of a pioneer attempt and as such was accompanied with all those unavoidable obstacles which necessarily beset works of that type. He identified *Sagitta* of the Madras coast as *S. bipunctata* and recognised only one species. It may now safely be affirmed that this species is not found in Indian waters. From the west coast of India Doncaster (1902) collected thirteen species of *Sagitta* including a number of new forms and from the Bombay coast Lele (1936) obtained three species including one which was recorded for the first time. The only reference to *Sagitta* in the Bay of Bengal is found in the reports of the "Siboga" Expedition (Fowler, 1906). Though that Expedition did not investigate the Bay of Bengal two of the distribution charts of the Reports of the Expedition make note of the occurrence of *S. enflata* and *S. subtilis*. From Menon's collections, which were carefully preserved in the Zoological Laboratory of the Madras University, the author identified five species (John, 1933) and two more species, *S. planktonis* and *S. hispida* have since been identified and included in this paper, but so far no specimen of *S. bipunctata* has been observed either in the Bay of Bengal or in the West coast. It was probably this mistake in identification which was responsible for the misconception that *Sagitta* occur fairly constantly during all the seasons: some species or other always occurs during most of the months, though not always showing the same degree of abundance.

A few years after the publication of Menon's paper the Madras University kindly awarded me a fellowship, which enabled me to carry on some investigations in the University Laboratory. During this time I made a thorough examination of the entire material collected by Menon and through the kindness of the Director of the laboratory was

able to collect some new material as well, but before long I had to leave Madras. The publication of my results was withheld with the hope that I may be able to carry out some more analysis with fresh material. However, since time and circumstances never permitted me to realize this object, I am now venturing to publish these results, which though fairly complete and conclusive are not entirely based on material collected under my personal supervision. The fact that I have used the very material which formed the basis of Menon's work has the added advantage of eliminating the possibility of all exceptions regarding dates and time of catch.

From the captures of Burfield and Harvey of the "Sealark" Expedition (1926) Aida for Japan (1897) Michael for Philippines (1919), Fowler for "Siboga" (1906), Doncaster for the Maldive and Laccadive Islands (1902) and Lele for Bombay (1936) it is evident that the Indo-Pacific region is very rich in Chaetognatha. So far some thirty valid species of *Sagitta* are recognised, out of these no less than twenty one are found in these collections. The great uniformity of *Sagitta* fauna over this vast region is also clearly brought out when these collections are compared. Eight species are found in common in five of the collections, extending from Japan to the Western Indian Ocean and no fewer than thirteen species are found from Philippines to the coast of Africa. Out of these *S. enflata*, *S. tricuspidata*, *S. serratodentata*, *S. hispida* and *S. regularis* have been recorded from the Arabian sea. The Maldive and Laccadive collections have also brought to light a number of new forms, e.g., *S. septata*, *S. polydon*, *S. pulchra*, *S. gardineri*, *S. ferox* and *S. robusta*, to this must be added *S. bombayensis*, sp. nov. and *S. bedoti*, recorded from Bombay. Taking all these into consideration it will be seen that the Arabian Sea has yielded fifteen species of *Sagitta*, out of which seven species are common in the rest of the Indian Ocean. From the Bay of Bengal only eight species have been so far recorded, of these four are found in the Arabian Sea and six species, i.e., *S. hispida*, *S. enflata*, *S. subtilis*, *S. neglecta*, *S. tenuis* and *S. planktonis* are common to the rest of the Indian Ocean. Two of the new species of the Maldive and Laccadive regions have been obtained from Madras also, but *S. tenuis*, *S. neglecta*, *S. planktonis* and *S. subtilis* have not so far been observed in the Arabian Sea.

The plankton collections described in this paper were made under conditions quite different from those employed at other Marine Biological Laboratories. On days when a collection was to be made a local fisherman was engaged. Early in the morning before sunrise he sets out into the sea in the common fishing craft called 'catamaran', which is made by yoking together three to five cylindrical logs of light wood into a shape remotely resembling a flat boat. The crudeness of its construction hardly enables it to gather a speed of more than three miles an hour even when under full sail. Collections were made with a simple tow net made of No. 6 standard silk bolting cloth (74 meshes to the inch). The fisherman was always given strict instructions to use more or less the same locality for towing and to drag the tow net always a definite number of times. By these instructions it was hoped to confine the collections to one definite area and to keep the duration of the drag constant as far as possible under such conditions.

Owing to the simple nature of the methods employed it may be argued that no definite and positive conclusions could be drawn from the analysis of such collections, but in spite of its simplicity, the collections have been fairly regular and systematic and give an accurate idea of the distribution of the plankton fauna during all the months of the year. Further as the collections extended over a period of four years they give great scope for comparison and confirmation of results.

Tables 1—4 represent an analytical study of the distribution of *Sagitta* from 1929-1932. It was probably in 1929 that the Madras University first decided to study the Plankton fauna of the Madras coast. During this year collections were not quite regular. I was not able to find any material of collections made in March, April, May and August. Even during the other months the collections were not rich in *Sagitta*. The collections for 1930 were the most regular and systematic and these yielded a complete set of results for the present study. In 1931 captures were made during January, March, April, May, June, July, August and September, and out of the collections of 1932 I was able to study only part of the materials collected during March, April, May, June and July.

In the present work I take the collections of 1930 as typical and those of 1929, 1931 and 1932 are included only for comparison. The 1930 collections of Madras has one great advantage over any other collections made elsewhere in that they yield a complete record of the distribution of *Sagitta* during all the months of the year.

As I have already pointed out seven species of *Sagitta* have so far been recorded from the Madras coast. In certain cases some specimens have been regarded as 'doubtful' These do not represent unidentified species but are mostly specimens of one or other of the definite species which are partly damaged or mutilated.

During January *S. inflata* was most numerous though their number was not comparatively high. *S. gardineri*, *S. tenuis* and *S. neglecta* were also found; of these *S. neglecta* was only represented by a very few specimens. *S. planktonis*, *S. robusta* and *S. hispida* were not present during this month. In February *S. inflata* and *S. gardineri* became much scarcer, while *S. tenuis* becomes the most dominant species and *S. neglecta* still continues to be represented only by a few specimens. As in January *S. robusta*, *S. planktonis* and *S. hispida* are totally absent.

In March though *S. inflata* is still represented by a few specimens *S. gardineri* is totally absent and while *S. tenuis* maintains its predominance *S. neglecta* is scarcer than during the preceding month, being represented only by three specimens for the whole month. During this month *S. robusta* first begins to make its appearance and is represented by three specimens, while *S. planktonis* and *S. hispida* still continue to be conspicuous by their total absence.

April shows the same scarcity for *S. inflata* as in the preceding month but *S. gardineri* begins to reappear. *S. tenuis* which had been showing a progressive tendency towards increase in numbers, reaches its maximum intensity and is represented by a quantity which is not surpassed by any other species during any other month. *S. neglecta*

and *S. robusta* are still very scarce. In June *S. enflata* becomes comparatively more numerous and *S. gardineri* also increases in number, while *S. tenuis* shows a sudden fall. The most dominant species during this month is *S. neglecta*, which seems to have increased suddenly. *S. robusta* is also fairly well represented and *S. planktonis* begins to appear for the first time in the year.

S. tenuis is totally absent in July and from now onwards till the end of the year it is not found in the tow net water at all. During this month *S. enflata* is more numerous than *S. gardineri*. However the most conspicuous species of the month is *S. neglecta*. *S. robusta* also reaches its maximum, while *S. planktonis* is fairly well represented. *S. hispida*, which was totally absent from January to June, appears suddenly in the beginning of July and catches made during this month show its maximum for the whole year. *S. planktonis* also reaches its maximum. *S. enflata*, which has been steadily increasing in numbers from the middle of February, now reaches a state of abundance. After the 9th July though three collections were made there were no traces of even stray specimens of *Sagitta*. However they reappear again on the 10th August. The collection of this date gives the maximum for *S. enflata* and *S. gardineri*. *S. hispida* and *S. planktonis* are also fairly well represented, but three species *S. tenuis*, *S. neglecta* and *S. robusta* are totally absent and continued to be so till the end of the year.

The quantity of *Sagitta* in the plankton dwindles considerably by the beginning of September. In the collection of 12th September though *S. enflata* and *S. gardineri* are dominant *S. planktonis* and *S. hispida* are only represented by stray specimens. During this month a second collection was made on the 19th, but *Sagitta* was totally absent, and in October though six collections were made not a single specimen of *Sagitta* could be found in them. It may therefore be concluded that from the middle of September till the beginning of November *Sagitta* are not found in the surface plankton fauna of the Madras coast. In November though they reappear they are only represented by stray specimens and this continues on till the end of December.

Comparing the above analysis for 1930 with those of 1929, 1931 and 1932 we find a great deal of uniformity in the distribution of the various species during the different seasons, for example in 1929 the collections of February, July and August show very close similarity. During January and February *S. robusta*, *S. planktonis* and *S. hispida* are totally absent. In July *S. enflata* is numerous as in 1930 and in the same month *S. planktonis* and *S. hispida* reach their maximum. From June *S. tenuis* is totally absent and though ten collections were made from the 26th September to 28th October not a single specimen of *Sagitta* was observed, thus supporting the condition of October 1930.

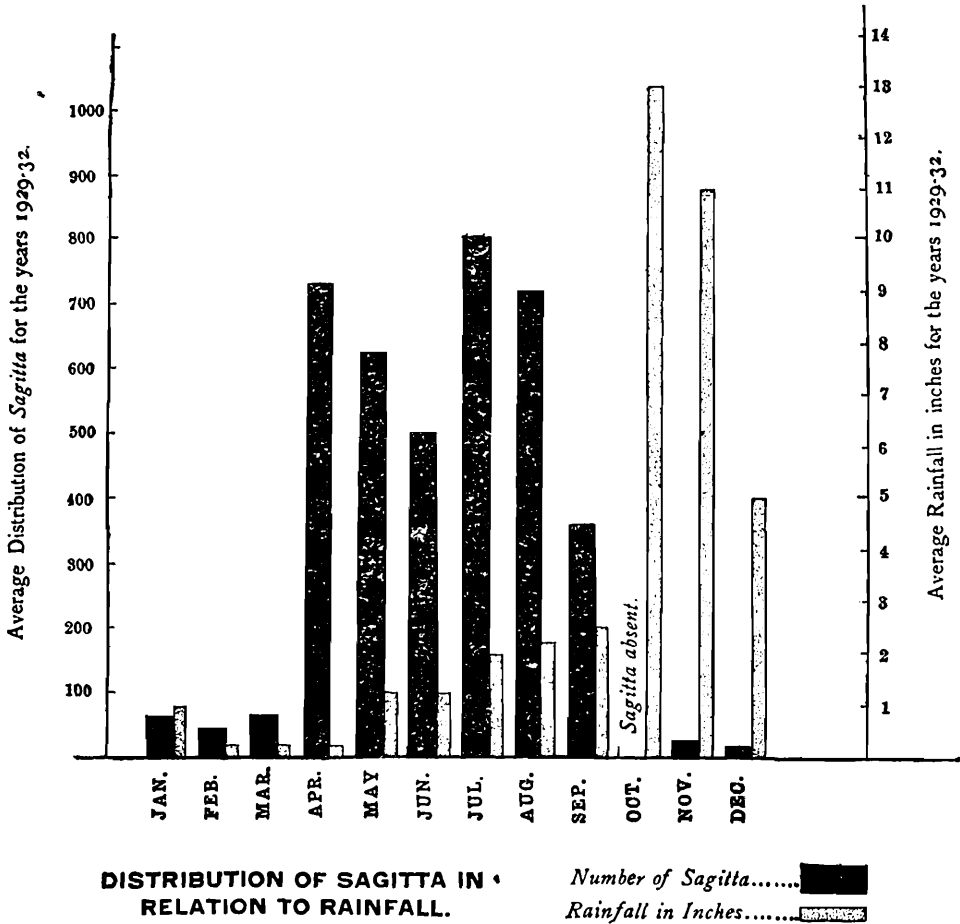
The April collections of 1931 are very similar to those of 1930. *S. tenuis* reaches its maximum but unlike 1930 *S. enflata* is totally absent. This does not, however, alter the general conclusions regarding the distribution of *S. enflata* since in April 1930 only a few stray specimens of that species were recorded, i.e., one to eight specimens in each catch. *S. neglecta* and *S. planktonis* reach their maxima on 3rd June, while in 1930 *S. planktonis* shows its greatest intensity only on the 9th August.

Out of the 1932 collections I was not able to examine the entire lot. So I selected those collections which showed the largest number of *Sagitta* and only analysed them. Out of the March collections only one was examined. Comparing this with the one made on 14th March 1930, it was found that in both cases *S. tenuis* is the most predominant species, though the latter was much richer in numbers. In both cases a few specimens *S. enflata* and *S. neglecta* were also obtained. The April collections of 1932 compare very well with similar collections of 1930. In both cases *S. tenuis* reaches its maximum, while *S. enflata*, *S. gardineri*, *S. neglecta*, *S. robusta* and *S. planktonis* only show evidence of their occurrence by the presence of a few stray specimens only.

The collections of May 1932 are rich in *S. enflata*, *S. gardineri*, *S. tenuis* and *S. robusta*, while *S. planktonis* is represented by only a few specimens. With regard to most of the species mentioned above the numbers are much higher than those of 1930. However, in both cases it is evident that during this month *S. neglecta* reaches its maximum. This month is also interesting because it is during this time of the year that the maximum number of species is found.

In July *S. enflata* and *S. planktonis* reach their maximum and the collection of 25th July 1932, was the richest for all the four years for *S. enflata* and *S. hispida*.

Table No. 5 and the accompanying graph show the variations in the intensity of Distribution during the different months. This table



represents the aggregate average for each month taking the collections of all the four years into consideration. Thus for instance in January

1929 two collections were made in the same month. In 1930 though five collections are on record only three of them showed the occurrence of *Sagitta* and in 1931 only one collection has been recorded. In calculating the aggregate average all the dates in January for all the years are taken together excluding those dates, on which there were no traces of *Sagitta*.

From table 5 it will be seen that in October *Sagitta* are totally absent from the surface plankton. In 1929 this absence was first noticed towards the beginning of the last week of September, in 1930 from the 19th and in 1931 few specimens were found even on the 30th.

Before attempting to explain the causes for these conspicuous differences in the intensity of periodic distribution of *Sagitta* in the Indian waters it is necessary to consider certain general principles. It has been stated by Johnstone (1908) that the nature of plankton distribution will depend on the hydrographic and meteorological conditions or in other words on variations in wind, rain, light, barometric pressure, heat, etc. Along the coast these factors change rapidly and are governed by seasonal changes of the locality. It may also be said that the intensity of any type of plankton will depend also on the intensity of other planktonic organisms which constitute the food of the former and these in turn will depend for their abundance either on the physical conditions of the sea or on their life cycles. This is very well illustrated by the work of Herdman, Scott and Dakin (1910) on an intensive study of the Marine plankton around the south end of the Isle of Man. They have observed that certain planktonic organisms show a remarkable regularity in their time of appearance. For example the nauplii of *Balanus* began to appear on February 22nd in 1907, February 13th in 1908, and February 6th in 1909. This is one of the cases where the regular periodic occurrence depends on the sequence of events in life cycle, which constitutes the dominant factor in determining the composition of the plankton at a given place and time. The occurrence of fish eggs and larvae and the crab zoea is also due to such sequence in life cycles which fall at definite times.

In the case of *Sagitta* it has been definitely established that they do not have any particular breeding seasons. During all the months of the year and at all times the mature specimens carry ripe eggs. In the case of *Spadella cephaloptera* it has been shown that the eggs are shed at intervals of eight to ten days (John, 1933). In *Sagitta* the condition may be more or less the same, considering that the two are very closely allied, so that it may be safely asserted that increase during certain seasons does not depend on the breeding habits of the animal.

During my stay at Plymouth I reared considerable numbers of *Sagitta* and *Spadella* in the Laboratory of the Marine Biological Association and both types were found to thrive on Harpacticids; these and similar small Crustaceans, which form the food of these animals are invariably found in the plankton during all the months, in the tropical waters. Therefore the postulate that the abundance of *Sagitta* during certain seasons may depend on the abundance of certain other planktonic organisms, which constitute their food, may be dismissed with equal certainty.

The only other factor therefore which remains is change in hydrographic conditions. Concerning this Kofoid (1903) says 'Somewhat regular alternations of growth and rest, of fission and spore formation or parthenogenesis and sexual reproduction are fundamentally the basis of cyclic movements in plankton production. The amplitude and to some extent the location and duration of the pulses are plainly affected by various factors of the environment—light, temperature, vegetation, tributary waters, various hydrographic factors, food supply and possibly also by chemical conditions, not directly concerned with nutrition but available data fail completely to afford any satisfactory environmental factor or groups of factors which stand in correlation with the cyclic movements in production.' However, when considering the cyclic movements of *Sagitta* we find that the periods of seasonal rains along the Madras coast seems to coincide with the periods of scarcity or absence of *Sagitta* in the surface plankton. During the greater part of the year the River Coovum, which reaches the coast close to the Northern side of the University is separated from the sea by a narrow bar of drift sand, but during the rainy season this bar is broken up and the rain water which accumulates in the river forces its way into the sea loaded with mud and dirt of the city. The direction of the coastal currents and the wind cause this muddy water to spread along the coast as a broad patch of reddish brown, clearly distinguishable from the sea water beyond. During this season tow netting is not usually conducted but during certain years when it was desired to obtain a complete record for all the months the fisherman was instructed to drag the net beyond this patch of muddy water. Even then *Sagitta* was not obtained. During the rainy season owing to the admixture of rain water there is bound to be a reduction in the percentage of salinity in the surface layers of the sea.

In 1931 I conducted some experiments with living specimens of *Sagitta* at Plymouth, to investigate their reactions to change of salinity and it was observed that even the slightest change makes them dormant. If the salinity is only altered in superficial layer they sink lower down. The hydrogen-ion concentration of the body fluids of marine animals bears a close relation to the hydrogen-ion concentration of the sea water. Since in the majority of species of *Sagitta* the body wall is thin and flabby any change in the hydrogen-ion concentration of the surface sea water will be felt by the animal which will consequently sink to the lower depths. It seems therefore very probable that the cause of the total absence or scarcity of *Sagitta* during the rainy months is the change of salinity brought about by the admixture of rain water in the superficial layer of the sea.

This conclusion seems to be very well supported by independent observations of Lele (1936) in the Bombay harbour. Of the three species described by him *S. gardineri* is the only one, in which the body wall is thin and flabby and from the table of surface distribution which he has given it will be seen that during March, April and May *S. gardineri* is totally absent from the Bombay coast. In June it is very scarce but from that time onwards there is a steady increase till September. In October the number again falls but rapidly rises again till it reaches

its maximum in December. It will be seen from his table that *S. gardineri* shows two maxima, one in September and the other in December. Alternating with these two periods of maxima are the rainy seasons of Bombay during which times they either become scarce or totally absent. The two other species recorded from Bombay also show seasonal variations in their intensity. For example *S. bedoti* shows three maxima during January, April and August. *S. bombayensis* shows four maxima during the year. It will be noticed that in the case of *S. bedoti* also the season of minimum distribution coincides with the rainy months as in the case of *S. gardineri*.

Species of Chaetognatha in which the body wall is tough and rigid such as *Spadella cephaloptera* are capable of withstanding considerable changes in salinity. *Spadella cephaloptera* is unaffected even when the salinity is reduced to 80 per cent of the normal (John, 1933). I have examined specimens of *S. bedoti* and I have also seen a few specimens of *S. bombayensis*, which Dr. Lele kindly showed me in 1934. In both these cases the body wall is rigid and though not very thick is capable of maintaining the shape of the body unlike *S. gardineri* or *S. enflata*. This characteristic probably enables these two species to withstand certain degree of chemical changes in the sea brought about by the addition of rain water and this probably explains why they do not become totally absent during the rainy seasons.

The south-west monsoon commences on the west coast of India somewhere about the middle of May and its vigour continues on till the end of June. During October Bombay again gets a fair share of rain from northerly winds.

On the East coast the south-west monsoon reaches very late and it passes northwards with only a few light showers along the Madras coast. Madras experiences its heaviest rainfall during the north-east monsoon. This wind, which collects some moisture during its progress across the Bay of Bengal, strikes the Madras coast towards the end of September and gives a considerable amount of rainfall during October, with moderate showers during November and December. Madras therefore has only one rainy season extending from October to December.

The distribution of *Sagitta* during the various months in relation to the average rainfall for each month is shown in the accompanying graph (*vide* text-fig. p. 87).

This graph shows that only in those months when the rainfall is very great the distribution of *Sagitta* is affected. For example at Madras though there are occasional showers in January, July, August and September these do not seem to have any effect on the intensity of distribution of *Sagitta* for it is only natural to infer that such showers cannot alter the salinity of the sea and further, the river Coovum does not empty itself into the sea during these months. But from October to December, when the rain fall is heavy and when there is a considerable rush of tributary waters the salinity is bound to change to such an extent as to make it unsuitable for these delicate organisms to survive in the surface waters.

Out of the three species recorded from Bombay I have only taken two of the well established species into consideration, since the third

is a new species, which appears to behave quite differently from other types. I shall not attempt to comment on this peculiarity till we know some more details regarding its habits and distribution.

Doncaster (1902) in his work on the Chaetognatha of the Maldive and Laccadive Islands does not go into statistical details regarding intensity of distribution. However, the following general idea may be gathered from a study of his paper :—

<i>S. tricuspidata</i>	Not found in April.
<i>S. serratodentata</i>	Common in winter and spring.
<i>S. hispida</i>	Scarce in winter but abundant in April.
<i>S. regularis</i>	Small numbers in winter.
<i>S. robusta</i>	Abundant in winter but scarce in April.
<i>S. gardineri</i>	Moderately abundant in winter.
<i>S. pulchra</i>	Moderate in winter and spring.
<i>S. polydon</i>	Fairly abundant in winter and spring.
<i>S. septata</i>	Moderately common in winter and spring.

From this it may be safely inferred that in the Maldive and Laccadive regions almost all the species reach their maxima during the colder months November to January, the only exception being *S. hispida* which seems to reach its maximum in Summer, just before the commencement of the rains. The rainy seasons in these regions are very much similar to those of Bombay, hence the distributions in these two places are more or less similar. In Bombay also *S. gardineri* reaches its highest maximum in December, while *S. bedoti* is scarce in winter but abundant in April, like *S. hispida* in the Maldive and Laccadive regions. It is therefore evident that on the Indian coast the seasonal fluctuations in the surface distribution of *Sagitta* is mainly governed by the seasons of local rainfall. As the rainy season varies from place to place the seasonal distribution of *Sagitta* is also bound to vary from place to place.

All the seven species recorded from Madras reach their maxima during the hot months April to August. For example *S. tenuis* reaches its maximum in April, *S. neglecta* in May, *S. robusta* in June, *S. enflata*, *S. planktonis* and *S. hispida* in July and *S. gardineri* in August. Of the seven species *S. enflata*, *S. gardineri* and *S. neglecta* occur during all the months of the year except October. The remaining four species *S. tenuis*, *S. robusta*, *S. planktonis* and *S. hispida* are only found during the summer months. We know very little about the vertical distribution of *Sagitta* in these waters and therefore it will be hazardous to venture upon any speculative suggestions before sufficient data are available. In the San Diego region of California where the periodic distribution of *Sagitta* has been recorded (Michael, 1911) the same condition is noticeable. For example *S. bipunctata* seems to be present during all the months, while *S. enflata*, *S. hexaptera*, *S. lyra*, *S. neglecta*, *S. planktonis* and *S. serratodentata* are found only during certain months. Michael makes no attempt to explain this phenomenon. Are they carried away by the surface current of the sea or do they sink to the lower depths during those months when they are not found in surface hauls. These questions can be answered only after a more intensive study of the vertical distribution of the various species during the different seasons of the year.

In conclusion I wish to express my deep sense of gratitude to the authorities of the Madras University and to Mr. R. Gopala Ayyar, Director of the University Zoological Department, for all the facilities they provided me for carrying on this work in their laboratory. My thanks are also due to Dr. Baini Prashad, Director of the Zoological Survey of India, for the loan of periodicals from the Zoological Survey Library.

SUMMARY AND CONCLUSIONS.

1. *Sagitta* does not show a uniform distribution throughout the year in the surface plankton. Out of the seven species recorded from Madras only two are found during most of the months: The other five appear only during the summer months.
2. Each species reaches its maximum only once in the year on the Madras coast and the periods of maxima are different for different species.
3. The distribution of *Sagitta* is at its minimum when the rain fall is very heavy, but it cannot be applied as a general rule that the distribution of *Sagitta* is inversely proportional to the rainfall, because slight occasional showers or irregular rains do not affect their intensity. From these observations the conclusion is drawn that *Sagitta* disappears from the surface plankton when the salinity of the sea water is appreciably altered by the admixture of rain and tributary waters.
4. The periods of maxima do not depend on the breeding habits or the abundance of any particular type of food of the animal.
5. The periods of maxima and scarcity vary from place to place always depending on the nature of the local rainfall. This is supported by recent work carried out at Bombay.

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TABLE No. 1.
Surface Distribution of Sagitta for the year 1929.

Date.	<i>S. enflata.</i>	<i>S. gardineri.</i>	<i>S. tenuis.</i>	<i>S. neglecta.</i>	<i>S. robusta.</i>	<i>S. planktonis.</i>	<i>S. hispida.</i>	Doubtful forms.
10th Jan. 1929 . .	12	29	..	3	..	..	..	..
27th Jan. 1929 . .	57	28	1	2	..	..	..	..
11th Feb. 1929 . .	2	4	11	2	..	..	..	..
19th Feb. 1929 . .	7	2	27	4	..	..	..	..
12th June 1929 . .	82	124	..	..	..	85	62	..
2nd July 1929 . .	176	85	..	..	..	187	149	..
12th Sept. 1929 . .	82	124	..	..	..	85	62	..
16th Sept. 1929 . .	143	217	..	8	..	98	31	..
26th Sept. 1929 . .	..	..	..	..	..	..	..	..
28th Sept. 1929 . .	..	..	..	..	..	..	..	..
4th Oct. 1929 . .	..	..	..	..	..	..	..	..
5th Oct. 1929 . .	..	..	..	..	..	..	..	..
13th Oct. 1929 . .	..	..	..	..	..	..	..	..
18th Oct. 1929 . .	..	..	..	..	..	..	..	..
30th Oct. 1929 . .	..	..	..	..	..	..	..	..
21st Oct. 1929 . .	..	..	..	..	..	..	..	..
25th Oct. 1929 . .	..	..	..	..	..	..	..	..
28th Oct. 1929 . .	..	..	..	..	..	..	..	..
6th Nov. 1929 . .	4	2	..	2	..	..	5	..
12th Nov. 1929 . .	..	..	..	..	..	..	7	2
18th Nov. 1929 . .	8	5	..	5	..	..	2	..
29th Nov. 1929 . .	..	..	..	..	..	..	..	..
30th Nov. 1929 . .	..	..	..	..	..	..	..	..
6th Dec. 1929 . .	3	7	..	3	..	..	..	..
8th Dec. 1929 . .	..	..	..	..	..	..	..	..
9th Dec. 1929 . .	5	8	..	1	..	..	..	..
13th Dec. 1929 . .	1	7	..	1	..	..	..	2
18th Dec. 1929 . .	..	..	..	..	..	..	..	..
20th Dec. 1929 . .	15	10	..	4	..	..	..	..

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TABLE NO. 2.

Surface Distribution of Sagitta for the year 1930.

Date.	<i>S. enflata.</i>	<i>S. gardineri.</i>	<i>S. tenuis.</i>	<i>S. neglecta.</i>	<i>S. robusta.</i>	<i>S. planktonis.</i>	<i>S. hispidula.</i>	Doubtful forms.
13th Jan. 1930.	55	37	33	9	..	..	..	..
20th Jan. 1930.	60	19	14	4	..	..	..	..
21st Jan. 1930.	3	1	14	3	..	..	..	..
23rd Jan. 1930.	..	..	..	..	..	..	..	..
30th Jan. 1930.	..	..	..	..	..	..	..	..
5th Feb. 1930.	..	..	..	..	..	..	..	..
7th Feb. 1930.	..	6	12	4	..	..	..	13
10th Feb. 1930.	..	2	27	3	..	..	..	..
15th Feb. 1930.	4	5	131	5	..	..	..	..
19th Feb. 1930.	6	3	14	..	..	..	..	..
26th Feb. 1930.	..	..	..	..	..	..	..	..
3rd Mar. 1930.	2	..	23	1	1	..	..	..
8th Mar. 1930.	3	..	126	1	..	..	..	..
14th Mar. 1930.	2	..	119	1	2	..	..	..
22nd Mar. 1930	1	..	8	..	..	..	..	5
29th Mar. 1930.	..	..	..	..	..	..	..	..
1st April 1930	..	..	..	..	..	..	..	..
2nd April 1930	1	..	30	1	1	..	..	..
16th April 1930	..	..	875	..	..	..	..	..
18th April 1930	5	..	1986	..	3	1	..	..
23rd April 1930	8	16	148	2	..	..	..	..
29th April 1930	..	..	..	..	..	..	..	..
1st May 1930.	..	..	..	..	..	..	..	..
5th May 1930.	..	..	..	..	..	..	..	..
15th May 1930.	161	62	124	187	40	5	..	..
29th May 1930.	42	29	5	..	..	..	..	..
4th June 1930.	7	3	..	2	1	3	..	..
12th June 1930.	129	51	..	344	72	38	..	..
14th June 1930.	114	7	..	103	55	49	..	..
16th June 1930.	..	..	..	..	..	..	..	..
9th July 1930.	347	143	..	..	..	154	231	..
21st July 1930.	..	..	..	..	..	..	..	..
23rd July 1930.	..	..	..	..	..	..	..	..
25th July 1930.	..	..	..	..	..	..	..	..
6th Aug. 1930.	..	..	..	..	..	..	..	..
10th Aug. 1930.	387	562	..	..	..	59	165	..
11th Aug. 1930.	316	418	..	..	..	67	114	..
15th Aug. 1930.	118	135	..	..	..	27	17	..
20th Aug. 1930.	..	..	..	..	..	..	..	..
12th Sept. 1930	184	237	..	..	..	..	..	..
19th Sept. 1930	..	..	..	..	..	..	..	..
4th Oct. 1930.	..	..	..	..	..	..	..	..
5th Oct. 1930.	..	..	..	..	..	..	..	..
13th Oct. 1930.	..	..	..	..	..	..	..	..
18th Oct. 1930.	..	..	..	..	..	..	..	..
20th Oct. 1930.	..	..	..	..	..	..	..	..
25th Oct. 1930.	..	..	..	..	..	..	..	..
4th Nov. 1930.	18	13	..	3	..	..	..	..
5th Nov. 1930.	35	28	..	..	..	..	..	..
13th Nov. 1930.	14	12	..	..	..	..	..	..
2nd Dec. 1930.	15	12	..	..	..	..	..	..
9th Dec. 1930.	12	14	..	..	..	..	..	..

TABLES No. 3 & 4.

Surface Distribution of Sagitta for the years 1931 & 1932.

Date.	<i>S. enflata.</i>	<i>S. gardineri.</i>	<i>S. tenuis.</i>	<i>S. neglecta.</i>	<i>S. robusta.</i>	<i>S. plank-</i> <i>tonis.</i>	<i>S. hispida.</i>	Doubtful forms.
21st Jan. 1931 .	4	7	2	4	..	..	..	5
5th Mar. 1931 .	12	..	87	3	7	..	..	..
26th Mar. 1931 .	..	..	21	..	..	..	..	..
3rd April 1931 .	..	17	1248	1	..	3	..	..
6th April 1931 .	..	4	457	3	..	2	..	..
8th April 1931 .	..	..	..	..	..	..	..	..
9th April 1931 .	..	15	168	1	..	..	..	1
10th April 1931 .	..	6	47	..	..	..	..	..
13th April 1931 .	..	..	..	..	..	..	..	..
15th April 1931 .	..	..	..	..	..	..	..	..
12th May 1931 .	83	21	14	293	26	2	..	17
21st May 1931 .	..	..	..	..	..	..	..	..
22nd May 1931 .	94	53	31	326	7	..	..	..
10th June 1931 .	14	38	..	91	4	3	13	..
12th June 1931 .	156	72	..	183	51	23	97	..
30th June 1931 .	169	287	..	376	69	485	180	..
1st July 1931 .	294	34	..	..	..	246	314	..
6th July 1931 .	173	183	..	21	13	..	..	..
7th Aug. 1931 .	263	477	..	4	1	89	63	..
9th Aug. 1931 .	114	211	..	1	..	1	4	..
13th Sept. 1931 .	..	..	..	..	..	..	..	..
30th Sept. 1931 .	24	4	..	..	..	..	..	..
16th Mar. 1932 .	1	..	56	1	1	..	..	..
18th April 1932 .	27	8	1642	22	1	..	6	..
27th April 1932 .	10	5	573	7	1	..	2	..
8th May 1932 .	48	52	186	252	12	2	..	..
17th May 1932 .	231	78	259	345	64	6	..	..
15th June 1932 .	147	96	..	176	19	47	..	..
25th July 1932 .	499	254	..	..		186	321	..

TABLE NO. 5.

Average monthly distribution of Sagitta for the years 1929-1932.

Name of Species.	January.	February.	March.	April.	May.	June.	July.	August.	Septem-ber.	October.	Novem-ber.	December.
<i>S. enflata</i> .	32	3	3	5	109	98	300	240	134	×	16	7
<i>S. gardineri</i>	20	4	×	7	48	71	140	361	146	×	12	10
<i>S. tenuis</i>	11	37	63	717	108	×	×	×	×	×	×	×
<i>S. neglecta</i>	4	3	1	4	234	181	4	1	2	×	2	2
<i>S. robusta</i>	×	×	2	1	25	34	2	1	×	×	×	×
<i>S. planktonis</i>	×	×	×	×	2	81	155	49	49	×	×	×
<i>S. hispida</i> .	×	×	×	1	×	36	203	73	25	×	×	×

