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ON SOME CILIATE PARASITES OF FROGS AND TOADS OF KARNATAK, BOMBAY PRESIDENCY*

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CONTENTS.

INTRODUCTION.

The occurrence of binucleate opalinids in Indian Anura has been a subject of great controversy in the past. Bezzenberger (1904), for the first time, described *Zelleriella macronucleata* (Bezz.) from an Asian toad, *Bufo melanostictus* Schneider, but his findings were later rendered doubtful by Metcalf (1923) who opened thirty-nine specimens of this toad to find no *Zelleriella* in them. Bhatia and Gulati (1927) who conducted extensive survey of the ciliate parasites of the Anura of the Punjab also reported a complete absence of both *Zelleriella* and *Protoopalina* in *Bufo melanostictus* as well as other Anurans they studied. The absence of these ciliates in Indian Anura was, thus, more or less accepted, until Nie (1935) again reported *Protoopalina caudata microhyla* Nie, from an Indian frog *Microhyla ornata* Dumeril and Bibron (*Ind. Mus.* Reg. No. 17287), a specimen of which collected at Harnai, Ratnagiri District, Bombay, was supplied to him by the Indian Museum, Calcutta (Metcalf, 1940 ; p. 472). This discovery of Nie evidently raised the question asked by Metcalf (p. 577) " Why are there no more Protoopainas in these Indian Ocean Lands ?", and, thus, led the writer to undertake this interesting piece of work.

The present investigation establishes, beyond doubt, the existence of binucleate opalinids in the Anura of Karnatak, and includes the description of five new forms, *i.e.*, *Protoopalina indica*, *P. karnatakensis*, *P. dharwarensis*, *Zelleriella microhylae* and *Z. froilanoi*. Since the locality is situated in South India which forms the most ancient part of the Asian continent, the presence of *Zelleriella* and *Protoopalina* in this region, may modify the present conclusions in the field of Zoogeography.

During the course of this work, the following twelve species of other ciliates found parasitic in the gut of the hosts examined have also been recorded : *Nyctotherus macropharyngeus* Bezz., *N. magnus* Bezz., *N. magnus malabarica* De Mello., *N.cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk *et* Val., *Cepedea virgula* (Dobell) Metcalf., *C. philauti* sp. nov., and *C. dimidiata*

* Thesis submitted for the degree of M.Sc. of the University of Bombay.

naglavensis subsp. nov. Most of the host species have been examined for the first time in India, and in the cases of those already studied more ciliates have been added to the list of their parasites.

The smears made on cover-glasses were either fixed in Schaudinn's sublimate alcohol and stained with Mayer's haemalum or they were fixed in Bouin's fluid and stained with Iron-haematoxylin. Some smears stained with Borax-carmine were also found to be very useful.

All drawings are made with the aid of camera lucida.

The writer is deeply indebted to Col. I. F. De Mello (Nova Goa) and Prof. P. W Gideon (Dharwar) for their valuable help and guidance during this work. Thanks are also due to Dr. B. R. Seshachar (Bangalore) and Dr. L. S. Ramaswami (Mysore University) in their personal kindness in identifying the frogs.

Notes on Hosts.

1. *Bufo melanostictus* Schneider.—The toad is very common in Dharwar and on account of its sluggishness, is easy to collect. Out of twenty-one specimens each measuring about 80 mm. from snout to vent, only seven were found infected.

Habitat: Gardens. Collected during December, 1944.

Ciliates recorded for the first time : Nyctotherus macropharyngeus Bezz.

*2. *Micrixalus opisthorhodus* Boulenger.—On account of its rarity, only five specimens each measuring about 63 mm. from snout to vent could be examined. All the five were well infected with parasites.

Habitat: Tank near Dharwar. Collected during October, 1944.

Ciliates found : Nyctotherus macropharyngeus Bezz., *N magnus* Bezz., *Balantidium helenae* Bezz., *B. duodeni* Stein., B. *gracile* Bezz., *Opalina ranarum* Purk. *et* Val.

*3. *M. saxicola* Boulenger.—This is also a very rare frog. Only two specimens each measuring 40 mm. from snout to vent were obtained and examined. Both were found to be well infected with parasites.

Habitat: Tank near Dharwar. Collected during October, 1944.

Ciliates found : Nyctotherus macropharyngeus Bezz., *N. magnus* Bezz., *N magnus malabarica* De Mello., *N cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk *et* Val., and *O. coracoidea* Bezz.

*4. *Microhyla ornata* Dumeril and Bibron.—This frog occurs in large numbers round about Dharwar. The young ones were generally found in day time in paddy fields during rains; but the adults due to their nocturnal and burrowing habits are rarely found during the day and usually leave their abode after sunset when large number of them may be met with. The best time to collect the young ones is during September and November. As many as 25 tadpoles and 10 froglings collected at Naglavi, a forest area about twelve miles from Dharwar, showed heavy infections of both *Zelleriella* and *Protoopalina.*

Habitat : Paddy fields. Collected during October, 1944 and August 1945.

* The host species preceded by an asterisk(*) have been examined for their ciliate parasites for the first time in India.

Ciliates found : Nyctotherus cordiformis Stein., *Protoopalina indica* n. sp. *P. karnatakensis* n. sp. , *P. dharwarensis* n. sp. and *Zelleriella microhylae* n. sp.

*5. *Philautus* sp.—As stated by McCann (1932), it is one of the most elusive frogs and is rare and difficult to locate. As only young ones were obtained the species could not be ascertained. Some specimens were infected with *Zelleriella*. Fifteen juvenile frogs each about 16 mm. long and five tadpoles each measuring about 48 mm. long were examined. All the five tadpoles and ten out of the fifteen froglings were found with parasites.

Habitat : Paddy fields at Naglavi. Collected during September, 1944 and August, 1945.

Ciliates found : Nyctotherus orcdiformis Stein., *Cepedea virgula* (Dobell)., *Zelleriella froilanoi* n.sp., and *Cepedea philauti* n.sp.

6. *Rana cyanophlyctis* Schneider.—The frog is most common in Dharwar. Out of thirteen specimens (each measuring about 43 mm. long from snout to vent) ten were found infected.

Habitat : Ponds. Collected during April, 1944.

Ciliates recorded for the first time : Nyctotherus magnus Bezz., *N magnus malabarica* De Mello., *Balantidium gracile* Bezz., *Cepedea dimidiata naglavensis* n. sp.

*7. *R. leptodactyla* Boulenger.—The species is somewhat rare. Two specimens each measuring 50 mm. from snout to vent, were studied.

Habitat : Ponds. Collected during October, 1944.

Ciliates found : Nyctotherus macropharyngeus Bezz., *N. cordiformis* Stein., *Balantidium helenae* Bezz., and *B. duodeni* Stein.

8. *R. limnocharis* Wiegman.—Five specimens of this common frog, each measuring about 50 mm. long, were examined. All of them were found to be parasitized.

Habitat : Ponds. Collected during April, 1944.

Ciliates recorded for the first time : Nyctotherus magnus malabarica De Mello., *N. cordiformis* Stein., *Balantidium duodeni* Stein, *B. gracile* Bezz., *Opalina ranarum* Purk *et* Val and *O. coracoidea* Bezz.

*9. *R. temporalis* Boulenger.—Only two specimens of this rare frog each 55 mm. long were examined.

Habitat : Ponds. Collected during October, 1944.

Ciliates found : Nyctotherus macropharyngeus Bezz., *N. magnus malabarica* De Mello., *N cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk *et* Val., and *O. coracoidea* Bezz.

SYSTEMATICS.

Nyctotherus macropharyngeus Bezz.

This ciliate is very common in the frogs of Dharwar. Besides being present in the old hosts (*Rana limnocharis* Wieg. and *Rana cyanophlyctis* Schn.), the parasite was met with in a number of new hosts : *Micrixalus saxicola* Boul., *Micrixalus opisthorhodus* Boul., *Rana temporalis* Boul., *Rana leptodactyla* Boul., and *Bufo melanostictus* Schn. In *M. saxicola*, the form was slightly more ellipsoidal than oval, about two times as long as broad ; the cytoplasm appeared very much alveolated ; the contractile

vacuole situated at the posterior end was single; the macronucleus usually surrounded by a halo varied in its shape; the micronucleus, however, could not be detected. In other hosts, typical forms were found.

Measurements (in microns) of N. macropharyngeus *Bezz.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
Micrixalus saxicola—					
Host I	91	200—350 × 110—180	275 × 135	2·03 : 1	55 × 31
Host II	62	172—335 × 105—190	253 × 147	1·75 : 1	50 × 26
Micrixalus opisthorhodus	32	200—305 × 110—160	252 × 135	1·80 : 1	48 × 28
Rana leptodactyla ..	25	220—290 × 115—150	255 × 132	1·93 : 1	43 × 25
Rana temporalis ..	67	205—305 × 105—150	255 × 127	2·00 : 1	46 × 27
*Bufo melanostictus** ..	11	200—255 × 120—150	227 × 135	1·66 : 1	55 × 30

*Parasites scanty in number.

Nyctotherus cordiformis Stein.

With the exception of *Rana temporalis* and *R. leptodactyla*, the parasite, though scanty in number, was found in all the hosts examined. In *Bufo melanostictus*, the ciliate reached a maximum body size of 138×88 microns, and appeared somewhat beanshaped. Those observed by Bhatia and Gulati (1927), in the same species of the host, were smaller. The cytopharynx in many individuals was not as much developed and curved as in the typical form described by Stein (1867). In *M. saxicola* and *M. opisthorhodus*, individuals having a somewhat longer cytopharynx were met with. De Mello (1932) observed a similar elongation of the cytopharynx in the forms studied by him from *Rana malabarica*. The macronucleus also showed variations in the shape and size from host to host.

Measurements (in microns) of Nyctotherus cordiformis *Stein.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
Micrixalus saxicola ..	17	70—110 × 50—70	90 × 60	1·50 : 1	44 × 9
„ *opisthorhodus*	10	70—100 × 40—60	85 × 50	1·70 : 1	45 × 15
Rana cyanophyctis ..	18	90—130 × 50—80	103 × 60	1·71 : 1	55 × 15
Rana limnocharis—					
Host I	20	110—150 × 80—105	130 × 92	1·41 : 1	50 × 15
Host II	12	75—120 × 45—75	97 × 60	1·61 : 1	50 × 15
Mirrohyla ornata ..	8	85—125 × 65—85	105 × 75	1·40 : 1	50 × 25
Philautus sp. ..	5	115—140 × 60—80	127 × 70	1·81 : 1	55 × 30
Bufo melanostictus ..	14	110—155 × 65—90	132 × 77	1·71 : 1	55 × 30

Nyctotherus magnus Bezz.

This giant *Nyctotherus* was met with only in four hosts, namely, *Rana limnocharis*, *R. temporalis*, *Micrixalus saxicola* and *Rana cyanophlyctis* of which the first three are new hosts for this ciliate. In all these infections the individuals were rather few in number. Their exceptionally large body measurements helped to distinguish them from other species such as *N. macropharyngeus* Bezz., *N. cordiformis* Stein., which were always found associated with it. The form though small in size as compared to Bezzenberger's approached the typical in character. However, the cytoplasm in some individuals exhibited a much alveolated condition, and showed large food-vacuoles in which were found ingested specimens of *Balantidium helenae*. A similar instance was noted by Carini (1939) in *Nyctotherus vorax* Carini., in the body of which he found few specimens of *N. cordiformis* being ingested and digested there as food. Whether such food-habits are normal or the smaller ciliates fall as prey by chance during the process of feeding cannot definitely be stated here.

Measurements (in microns) for Nyctotherus magnus *Bezz.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : bredth) average.	Average nucleus.
		Range.	Average.		
Rana cyanophlyctis ..	5	550—610 × 335—380	580 × 357	1·34 : 1	180 × 50
Rana limnocharis ..	1	485 × 340		1·42 : 1	180 × 45
Rana temporalis ..	4	340—518 × 230—340	429 × 285	1·50 : 1	186 × 60
*Micrixalus saxicola** ..	1	620 × 450		1·37 : 1	200 × 60

* Showed cannibalistic character.

Nyctotherus magnus malabarica De Mello.

Typical forms were observed in *Rana limnocharis*, *Rana temporalis*, *R. leptodactyla* and *Micrixalus saxicola*, all of which have been opened for this parasite for the first time. Individuals from *Rana leptodactyla* and *R. temporalis* showed considerable variations in the curvature of their cytopharynx. The inner end was not so bent as shown by De Mello (1932). The furrow running from the tip of the cytopharynx to the anal opening was very prominent. The finely granulated cytoplasm appeared somewhat thin and less alveolated. The micronucleus could not be traced throughout. In *Micrixalus saxicola*, the forms though small in size, were typical in character.

Measurements (in microns) for Nyctotherus magnus malabarica *De Mello.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
Micrixalus opisthorhodus	6	120—150 × 90—110	135 × 100	2·00 : 1	55 × 20
Rana temporalis ..	10	135—190 × 90—130	162 × 110	1·56 : 1	50 × 25
Rana leptodactyla—					
Host I	21	140—200 × 95—145	170 × 120	1·41 : 1	55 × 30
Host II	25	200—280 × 110—170	240 × 140	1·91 : 1	55 × 30
Rana limnocharis ..	17	105—170 × 75—110	137 × 92	1·48 : 1	60 × 30

Balantidium helenae Bezz.

Though *Microhyla ornata*, *Philautus sp.*, and *Bufo melanostictus* were entirely devoid of this ciliate, it was abundantly present in other host species. In *Micrixalus saxicola*, the form varied from elongately oval to broadly oval. The position of the macronucleus varied in many individuals. Out of 75 specimens 32 had their nucleus in about the middle of the body, while in the remaining 43, it was found to lie in the posterior half of the body. The cytoplasm contained some irregular bodies which were stained like the nucleus. The anal opening situated at the posterior pole was clearly visible. The boring apparatus as reported by Ray, (1932) and Chakravorti (1933) was not detected. In *M. opisthorhodus*, *Rana temporalis*, *R. leptodactyla*, *R. limnocharis*, and *R. cyanophlyctis* typical forms were found.

The broadly oval forms have been described under a new species *B. ovale* (Dobell 1910, p. 74). After studying these forms in the Lahore frogs, Bhatia and Gulati (1927, p. 107) came to the conclusion that they were identical in structure with *B. helenae* and differed only in size; and should, therefore, be treated as one and the same species. Similar forms having been met with in the hosts of Dharwar, the writer is of the opinion that Bhatia and Gulati are probably correct.

Measurements (in microns) for Balantidium helenae *Bezz.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length: breadth) average.	Average nucleus.
		Range.	Average.		
Micrixalus saxicola ..	75	80-140 × 40-150	110 × 95	1·10 : 1	30 × 12
M. opisthorhodus ..	10	45-60 × 28-32	52 × 30	1·73 : 1	20 × 10
Rana temporalis ..	22	55-115 × 30-50	85 × 40	2·12 : 1	30 × 10
R. leptodactyla ..	34	50-105 × 30-65	77 × 47	1·50 : 1	25 × 10
R. limnocharis ..	20	40-90 × 30-45	65 × 37	1·71 : 1	30 × 9
R. cyanophlyctis ..	49	50-85 × 25-50	67 × 37	1·81 : 1	30 × 10

Balantidium gracile Bezz.

With the exception of *Microhyla ornata*, *Bufo melanostictus* and *Philautus sp.* the parasite occurred in all the hosts examined at Dharwar. It was usually located in the intestine. Bezzenberger (1904) found the macronucleus lying mostly at the hinder end and seldom in the middle. In Dharwar forms it was usually in the middle.

Measurements (in microns) for Balantidium gracile *Bezz.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
*Micrixalus saxicola** ..	27	145-210 × 25-30	177 × 27	6·55 : 1	20 × 10
M. opisthorhodus ..	46	95-185 × 20-35	140 × 27	5·18 : 1	20 × 9
Rana temporalis† ..	4	130-155 × 20-35	142 × 25	5·60 : 1	20 × 11
Rana leptodactyla ..	44	170-285 × 20-35	227 × 27	8·40 : 1	36 × 10
Rana limnocharis ..	65	90-195 × 30-40	142 × 35	4·05 : 1	20 × 10
Rana cyanophlyctis ..	24	120-260 × 20-25	190 × 22	8·60 : 1	30 × 10

* Pure culture in small intestine.
† Parasites scanty in number.

Balantidium duodeni Stein.

The ciliate occurred in the new hosts, *Rana temporalis*, *R. leptodactyla*, *Micrixalus saxicola*, and *M. opisthorhodus* as well as in the old hosts *R. limnocharis* and *R. cyanophlyctis*. Typical specimens were met with in all the hosts.

Comparing the characters of *B. rotundum* Bezz. with *B. duodeni* Stein, it is found that the former differs from the latter in having a straight dorsal surface (which, perhaps, is due to the much rounded sides) that gives the parasite an appearance of an egg. In other characters like the nucleus, the triangular area in the cytoplasm and the peristome they are quite identical. In the specimens studied at Dharwar, it was noted that both oval and egg-shaped forms were present. Those that were small in size appeared egg-shaped, while the larger forms appeared longer and oval. *B. rotundum*, therefore, may well be compared to these smaller forms of *B. duodeni*. And since *B. rotundum* is not structurally very different from *B. duodeni*, I am inclined to think that both these duodenal forms are identical.

Measurements (in microns) for Balantidium doudeni *Stein.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length: breadth) average.	Average nucleus.
		Range.	Average.		
*Micrixalus saxicola** ..	19	25-43 × 14-30	34 × 22	1·54 : 1	10 × 7
M. opisthorhodus ..	53	30-55 × 20-30	42 × 25	1·68 : 1	11 × 8
Rana temporalis ..	23	30-48 × 20-24	39 × 22	1·77 : 1	10 × 8
R. limnocharis† ..	7	40-50 × 20-30	45 × 25	1·80 : 1	9·5 × 9
R. cyanophlyctis ..	16	35-45 × 25-30	40 × 27	1·58 : 1	10 × 8

* Abundant in duodenum.
† Parasites scanty in number.

Opalina ranarum Purk and Val.

The parasite occurred both in the new hosts (*Rana temporalis*, *Micrixalus saxicola* and *M. opisthorhodus*) and in the old ones (*Rana limnocharis* and *Bufo melanostictus*). In all these infections the parasites were abundant and were usually lodged at the anterior end of the rectum. In the same infection, both oval and truncated forms were noticed. Metcalf (1923) has considered these forms as two separate subspecies. Since all these forms are common in all the infections studied at Dharwar, it seems that they are only the variations, of one and the same species. The parasite resembled the typical form in all other characters.

Measurements (in microns) for Opalina ranarum *Purk & Val.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus (diameter).
		Range.	Average.		
*Micrixalus saxicola** ..	21	170-210 × 75-200	190 × 137	1·84 : 1	3—4
M. opisthorhodus ..	61	225-410 × 110-185	317 × 147	2·13 : 1	3—4
Rana temporalis ..	44	170-280 × 70-175	225 × 122	1·84 : 1	3—4
R. limnocharis ..	21	130-190 × 70-90	160 × 80	2·00 : 1	3·5—4
Bufo melanosticutus ..	31	110-180 × 55-100	147 × 77	1·90 : 1	3—4

* Truncated forms.

Opalina coracoideo Bezz.

In Dharwar, the species occurred in three hosts, *Rana limnocharis*, *R. temporalis* and *Micrexalus saxicola*. Of these the latter two are recorded here as new hosts for this parasite. The ciliate showed a number of shapes especially in the length of the beak which varied from individual to individual. In some, the beak was considerably reduced while in others it was exaggerated into a well developed tail. Bhatia and Gulati (1927) have described these forms with elongated beaks under a new species, *Opalina coracoidea lahorensis*. Metcalf (1940) while studying three infections of *O. coracoidea* from *R. cyanophlyctis* of Bogawan talava, Ceylon, found the beak to be either long or short or absent. These differences in the length of the beak were also present in the infections studied at Dharwar.

Measurements (in microns) for Opalina coracoidea *Bezz.*

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length: breadth) average.	Average nucleus (diameter).
		Range.	Average.		
Micrixalus saxicola					
Host I*	20	190-270 × 100-250	230 × 175	1·31 : 1	4—5
Host II† ..	27	150-240 × 90-155	195 × 122	1·51 : 1	4
Rana temporalis‡ ..	31	125-325 × 70-200	225 × 135	1·65 : 1	4
R. limnocharis§ ..	12	130-210 × 75-120	170 × 97	1·74 :1	3—4

* Length of beak (average) 30-40.
† Length of beak (average) 30-40.
‡ Length of beak (average) 30-42.
§Length of beak (average) 30-40

Cepedea virgula (Dobell) Metcalf.

The ciliate was met with in *Philautus sp.* which was heavily infected. The horizontally placed endospherules were well stained with iron-haematoxylin.

Measurements in microns.—35 parasites.

Body (length × breadth) : range, 80-125×35-50 ; average, 102×42 ; length : breadth (average), 2·33 : 1 ; average nucleus (diameter), 5.

Cepedea philauti, sp. nov.

The body, clothed with short cilia, is cylindrical and somewhat fusiform with the posterior middle of the body having the greatest width. The anterior and the posterior ends are broadly rounded. The coarsely alveolated cytoplasm is not differentiated into ectosarc and endosarc and appears somewhat compact near the anterior pole. The features that are characteristic in this new species are the numerous large and oval nuclei spread irregularly in the cytoplasm. Incomplete transverse constrictions similar to those seen in *C. formosae* Met. were observed in some individuals.

Host.—*Philautus sp.*

Measurements in microns.—19 individuals.

Body (length × breadth) : range, 255-360 × 50-80 ; average, 307 × 65 ; Average nucleus (diameter), 4-5. Dividing nucleus (oval), 10×7. Cilia line interval, anterior region 1, posterior region, 2. Diameter of endospherule, 3-4.

Key to the species of Cepedea.

1	(3)	Anterior end with a spine-like projection ..	2
2		Body triangular in cross-section. Posterior end bluntly rounded. Length, 82 μ ..	*C. punjabensis* Bh. & G.
3	(1)	Anterior end without a spine-like projection ..	4
4	(15)	Body greatly elongated	5
5	(10)	Body with transverse constrictions	6
6	(9)	With one or two incomplete constrictions ..	7
7	(8)	Spindle-shaped body with elliptical nuclei.Length, 170 μ	*C. formosae* Met.
8	(7)	Fusiform body with spherical nuclei. Length, 307 μ	*C. philauti* sp. n.
9	(6)	With many complete constrictions. Length, 365 μ	*C. segmentata.* Met.
10	(5)	Body without any constrictions	11
11	(12)	Nuclei ellipsoidal. Length, 680-1000 μ ..	*C. longa* Bezz.
12	(11)	Nuclei spherical	13
13	(14)	Cilia short. Length, 848	*C. dolicosoma* Met.
14	(13)	Cilia long. Length, 500 μ	*C. ophis* Met.
15	(4)	Body not greatly elongated .. .	16
16	(25)	Body cylindrical ..	17
17	(24)	Sides of the body curved, anterior end rounded and posterior tapering to a point	18
18	(19)	With a naked spine at the posterior pole small round nuclei (diameter) 3·8 μ, Length, 124 μ ..	*C. spinifera* Met.
19	(18)	Without a naked spine at the posterior pole ..	20
20	(23)	Nuclei spherical	21
21	(22)	Endospherules round and irregularly placed Length, 180 μ	*C. dimidiata* Stein.
22	(21)	Endospherules elongated and transversely placed Length, 98 μ	*C. virgula* (Dobell)

23 (20) Nuclei dumbell-shaped. Length, 131 μ	*C. celebensis* Met.
24 (17) Sides of the body straight. Anterior end presenting a vacuolated appearance. osterior end rounded, sometimes pointed. Length, 125—440 μ ..	*C. thiagi* De Mello.
25 (16) Body lanceolate. Anterior end broad and rounded. Posterior, slender and tapering to a point. Nuclei only 4 or 5, Length, 82 μ ..	*C. lanceolata* Met.
26 (25) Body obovate. Length, 315 μ	*C. obovoidea* Met.
27 (26) Body globose	28
28 (29) Nuclei elliptical. Cilia dense and long. Length, 170 μ . ..	*C. globosa* Met.
29 (28) Nuclei spherical. Cilia sparse and short. Length, 87 μ ..	*C. bandivii* Met.
30 (27) Body sub-cylindrical ..	31
31 (32) Both ends rounded or anterior end less pointed than the posterior. Length, 35—250 μ	*C. subcylindrica* De Mello.
32 (31) Both ends pointed. Length, 64—89 μ	*C. sialkoti* Bh. & G.

Cepedea dimidiata naglavensis subsp. nov.

Description and discussion.—

Cepedea dimidiata has a number sub species. They are generally described as slender, more slender, stocky and Zelleriella forms. De Mello (1944) found more slender forms in the present host (*R. cyanophlyctis*) from Nova Goa, and named them as *C. dimidiata cottoniana*. The forms found in *R. cyanophlyctis* from Dharwar differ from *cottoniana* in having a much attenuated posterior end, and also in having a greater number of nuclei. The present sub-species is named as *Cepedea dimidiata var. naglavensis* after the locality from where the host was collected.

Host.—*Rana cyanophlyctis*

Measurements in microns.—28 parasites.

Body (length × breadth) : range, 180-255 × 15-30 ; average 207 × 22, length : breadth (average), 9·40 : 1. Average nucleus (diameter) : 3-4.

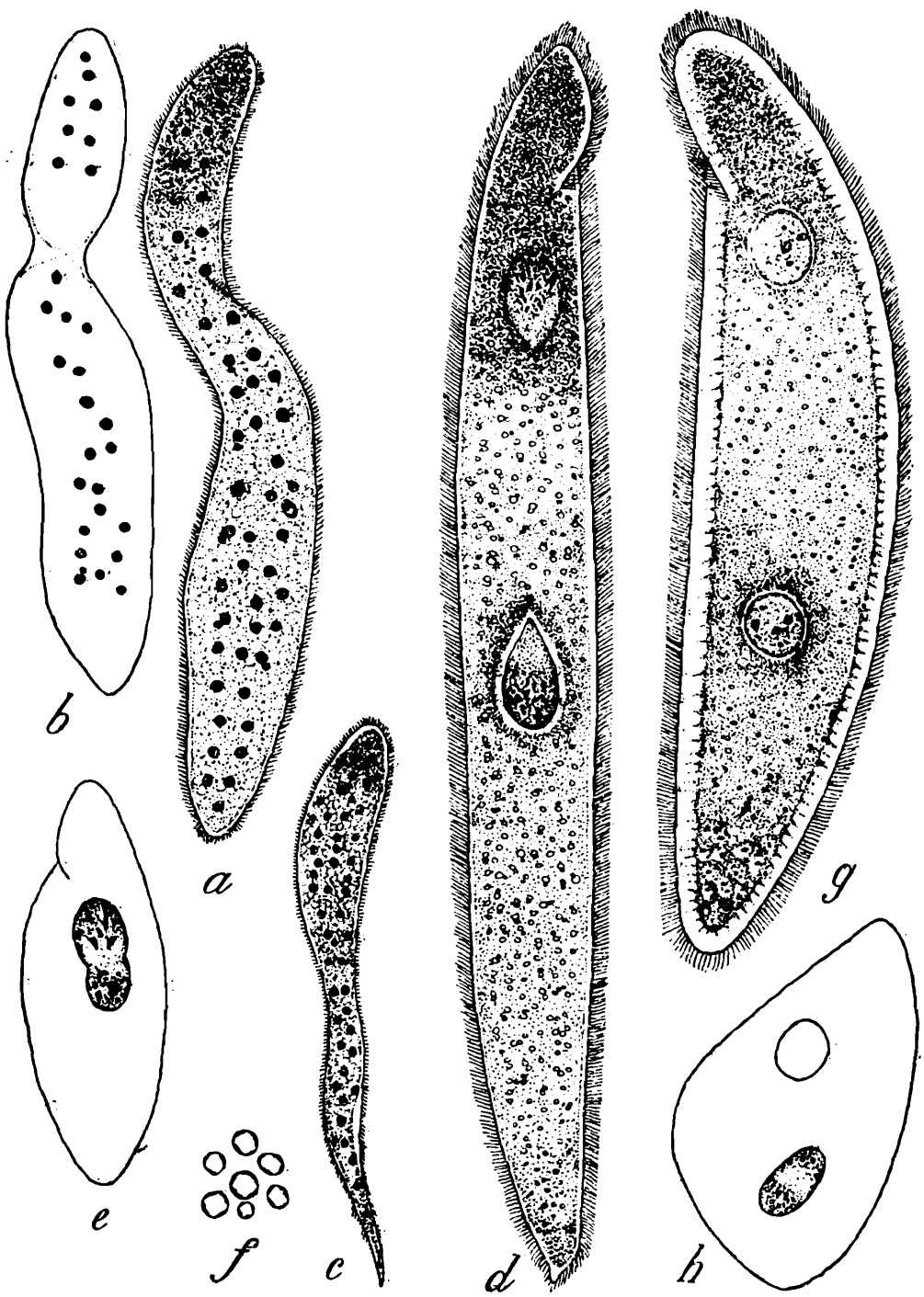
Key to subspecies of C. dimidiata

1 (2) Anterior end broadly rounded with a narrow posterior end	3
3 (4) Posterior pole rounded. Body (length × breadth), 138×45 μ, nucleus diameter 4 μ ..	*C. d. paraguensis* Met.
4 (3) Posterior end slender and rounded. Cilia longer. Body (L×B), 180 × 45 μ Nucleus diameter 4 μ	*C. d. orientalis* Met.
2 (1) Body lanceolate. Anterior end slender and posterior end attenuated to a pointed end	5
5 (6) Posterior tip pointed. Body (L×B), 120—140×25 μ Nucleus large 4-5 μ ..	*C. d. cottoniana* De Mello.
6 (5) Posterior end much attenuated ending in a sharp point. Nuclei small and spherical, 3—4, μ, in diameter, Body (L×B). 207×22 μ	*C. d. naglavensis*, subsp. nov.

Protoopalina indica, sp. nov.

Description.—The body is cylindrical, broadest near the anterior end and gradually tapering towards the posterior. The anterior pole is bent to one side while the posterior narrowing into a rounded point appears somewhat mamillionated. The cytoplasm is not well diffentiated into cortical and medullary zones. Numerous large oval endospherules (stained well with iron-haematoxylin) were seen in the medullary zone. Towards the anterior pole these endo-spherules aggregate, so

that, a more compact and denser region is formed. It is somewhere in this compact region that the anterior nucleus is usually located while the posterior nucleus is almost always in the middle of the body. The two pear-shaped nuclei are so placed that they lie with their pointed ends facing one another. The so called nuclear thread (consisting of attenuated nuclear membrane) connecting the two nuclei was not



TEXT-FIG. 1. *a* and *b*.—*Cepedea philauti*, sp.nov. *a*. Normal individual showing general structure : × 215; *b*. Dividing individual : × 215 : *c*. *Cepedea dimidata naglavensis*, sub sp. nov. : × 430. *d-e*.-*Protoopalina indica* sp. nov. *d*. Normal individual showing, general structure : × 430 ; *e*. Daughter individual from a recent division ; *f*. Endospherules under oil-immersion objective ; *g* & *h*.—*Protoopalina karnatakensis*, sp. nov. *g*. Full grown slender individual showing general structure : ×430 ; *h*.—A stocky (Zelleriella) form in division : × 430.

visible. The chromatin element of the nucleus in the normal individual is broken up into numerous bits (the nucleoli) the exact number of which could not be determined. In some the number was more than

twenty. The cilia were long and thick. Individuals undergoing division (both transverse and longitudinal), were present. The daughter cells come from transverse division were all uninucleated.

Host.—Microhyla ornata

Measurements in microns.—61 individuals.

Body (length × breadth) : range, 135-415 × 40-75 ; average (L×B) 275 × 57 ; length : breadth (average) 4·82 : 1 ; nucleus (length × breadth) : range, 27-33 × 14-17. Endospherule (length × breadth) : range, 2·5-3·5×1·5-2. Cilia line interval, anterior region, 1·8 ; middle region 2·10 ; posterior region, 3·00. Width of ectosarc, 3·00.

Comparison.—On account of its slender pointed posterior end, as well as the body measurements and the shape of the nucleus, *P. indica* is classed under the sub-generic group II (Metcalf 1940, p. 571-576).

The following table shows the specific differences of the group.

Key to subgeneric group II.

1	(2) Posterior pole tapering to a sharp point and sometimes with a posterior process	3
3	(6) Posterior end broad and abruptly ending in a point	4
4	(5) Posterior end not curved. Nucleoli 6 in number Nucleus (L × B) 40 × 26 μ. Body (L × B) 200 × 95 μ	*P. caudata* (Stein).
5	(4) Posterior end curved. Tail large and blunt. Nucleoli 8 in number. Nucleus (L × B) 30 × 14 μ. Body (L × B) 90 × 74 μ ..	*P. macrocaudata.* Met.
6	(3) Posterior end elongated and gradually tapering to a narrow point	7
7	(10) Posterior pole rounded or sometimes pointed ..	8
8	(9) Nucleoli 8 in number. Nucleus pear-shaped (L × B) 32 × 10 μ. Body (L × B) 330 × 68 μ ..	*P. intestinalis.* (Stein).
9	(8) Number of nucleoli undetermined. Oval nucleus, (L × B) 23 × 13 μ Body (L × B) 288 × 63 μ ..	*P. orientalis* Met.
10	(7) Posterior pole mamillionated. Nucleoli 20 in number. Nucleus pear-shaped, (L × B) 27 × 14 μ. Body (L × B) 275 × 57 μ	*P. indica* sp. nov.
2	(1) Posterior pole tapering to a broadly rounded point	11
11	(12) Nuclei close together in centre. Nucleus oval (L × B) 18 × 10 μ. Body (L × B) 230 × 46 μ. Nucleoli number not mentioned	*P. yunnanensis* Met.
12	(11) Nuclei far apart	13
13	(14) With definite number of nucleoli.—	
	(*a*) Nucleoli 6 in number. Body (L × B) 170 × 24 μ. Nucleus (L × B) 14 × 9 μ	*P. stejnegeri* Met.
	(*b*) Nucleoli 8 in number. Slender Body (L × B) 97 × 18 μ. Nucleus ellipsoidal (L × B), 10 × 6 μ ..	*P. pelobatides* Met.
	(*c*) Nucleoli 4 in number. Body (L × B) 240 × 68 μ. Nucleus (L × B) 25 × 8·9 μ	*P. dorsalis* (Raff).
	(*d*) Nucleoli 3 in number. Nucleus (L × B) 6 × 2 μ, (anaphase). Body (L × B) 63 × 11 μ	*P. caccosterni* Fantham.
14	(13) With an undetermined number of nucleoli ..	15
15	(16) Nucleus ellipsoidal (L × B) 10 × 6 μ. Body (L × B) 160 × 32 μ ..	*P. peronii* Met.
16	(15) Nucleus rounded ..	17
17	(18) Nucleus smaller (diameter) 10 μ. Body (L × B) 572 × 70 μ ..	*P. hylarum* (Raff).
18	(17) Nucleus large (diameter) 19 μ. Body (L × B) 313 × 70	*P. luzonensis* Met.

Protoopalina karnatakensis, sp. nov.

Description.—The body is somewhat cylindrical with its anterior end elongated and bent to one side. One side of the body is slightly curved while the other is nearly straight. The posterior and the anterior poles are broadly rounded.

Two forms, namely, (i) slender and long, and (ii) stocky and broad were recognised. The cytoplasm is very well differentiated into the cortical and the medullary zones. The medulla is dense and contains endospherules which are small and sparse. The two nuclei almost spherical in shape, are placed quite apart along the vertical axis of the body. The posterior nucleus is situated somewhat away from the middle of the body, while the anterior nucleus is located more or less near the compact anterior region as in *P. indica.* The nuclear strand could not be traced at all. The chromatin of the nucleus consists of 4-6 nucleoli. The cilia are long and fine, but are shorter as compared to those of *P. indica.*

Host.—Microhyla ornata.

Measurements in microns.—16 individuals. (slender and elongated) : length × breadth (average), 167 × 47. 14 Zelleriella forms measured : length × breadth (average), 85 × 35. Diameter of the nucleus, 13·5. Endospherules (diameter) 1-2. Cilia line interval, 1·5-3·2.

Width of ectosarc 5·5.

Comparison.—Because of its flattened body form and dumbell-shaped nuclei, *P. karnatakensis* belongs to the sub-generic group V of Metcalf.

The species of this group are arranged in key below :—

1 (8)	Nuclei spindle-shaped or elliptical ..	2
2 (5)	Body elliptical	3
3 (4)	Nuclei connected by a thread, elliptical (L × B) 13 × 3 μ. Body (L× B) 106 × 26 μ ..	*P. mossambicensis* Met.
4 (3)	Nuclei not connected by a thread, Long nucleus (L × B) 17 × 6 μ. Body (L×B) 76 × 30 μ ..	*P. longinucleata* Met.
5 (2)	Body broadened anteriorly and sharply pointed behind	6
6 (7)	Nucleoli 8 in number. Body (L × B) 196 × 30 μ. Nucleus (L × B), 30 × 13 μ	*P. regularis* Met.
7 (6)	Nuclei 6 in number. Body (L × B) 119 × 30 μ. Nucleus (L × B) 22 × 8 μ	*P. rhinodermatos* Met.
8 (1)	Nuclei ovoidal or dumbell-shaped	9
9 (12)	Posterior pole with a narrow posterior process ..	10
10 (11)	Nuclei 4 in number. Body (L × B) 90 × 40 μ. Nucleus (L ×B) 27 × 6·2 μ	*P. xamachana* Met.
11 (10)	Nucleoli 6-10 in number. Body (L × B) 102 ×42 μ. Dumbell-shaped nucleus, (L × B) 17 × 12 μ	*P. bufonis* Met.
12 (9)	Posterior pole broadly rounded. Nucleoli 4-6 in number. Slender forms (L × B) 167 × 47 μ. Zelleriella forms (L × B) 85 × 35 μ. Nucleus ovoidal 13·5 × 13 μ	*P. karnatakensis*, sp. nov.

Protoopalina dharwarensis, sp. nov.

Description.—The body as compared to the previous species (*P. indica* and *P. karnatakensis*) is much elongated and more slender. The anterior and the posterior poles are broadly rounded and look alike. The granular cytoplasm is not well differentiated into ectosare and endosarc as in *P. indica* and *P. karnatakensis*. The spherules in the endosarc are fine and appear somewhat elliptical in form. Often, some minute chromatinlike bodies appear to group together towards the posterior end of the body. A group of vacuoles (constituting the excretory system) are also seen at this region. The two round nuclei are placed in the anterior half of the body. In some individuals, a halo is often present round the nuclei. The chromatin consists of small and irregular bits. Approximately 6 nucleoli were observed in one of the dividing nuclei. The nuclear thread was absent.

Host.—Microhyla ornata.

Measurements in microns.—15 individuals. Body (L×B) : average, 207×25 ; L : B 8·02 : 1. Nucleus (i) 11·5×9, (ii) 13·5×11, (iii) 12·5×9·5.

Diameter of endo-spherule, anterior region 1·5 ; posterior region 2·2. Cilia line interval, anterior region 1·5-2 ; posterior region, 3·3. Width of ectosarc 2.

Because of the bodyform, the species is referred to the subgeneric group IV, the key to the species of wich is given below.

Key to the species of Group IV

1 (4)	Nuclei pear-shaped	2
2 (3)	Nucleoli apparently 6 in number. Body filiform (L × B) 300 × 35 μ. Nuclei connected by a thread, Nucleus (L × B) 25 × 6 μ ..	*P. filiformis* Met.
3 (2)	Nucleoli 10 in number. Body flattened (L × B) 238 × 22·8 μ. Nuclei (L × B) 22·8 × 9·5 μ	*P. limnocharis*, Nie.
4 (1)	Nuclear shape otherwise	5
5 (6)	Nuclei elliptical. Body very much attenuated. " Nucleoli in the form of 16 small chromatin masses." Body (L × B) 530 × 36 μ. Nucleus (L × B) 24 × 9 μ ..	*P. tenuis* (Raff).
6 (5)	Nuclei oval or round. Body elongated and slender. Nucleoli apparently 6 in number. Nucleus reticulate (L × B) 11·5 × 9 μ. Body (L × B) 207 × 25 μ	*P. dharwarensis*, sp. nov.

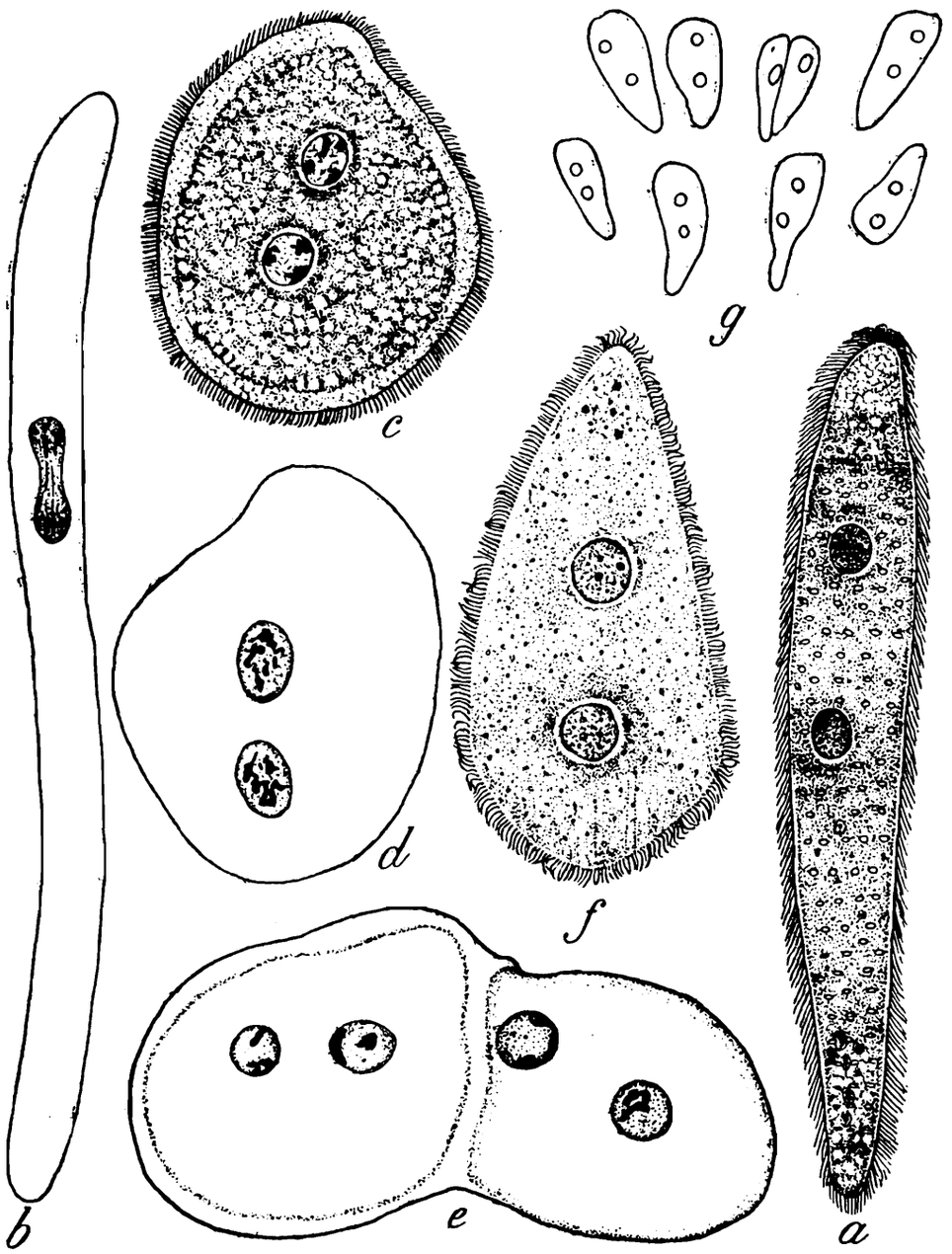
Zelleriella microhylae, sp. nov.

Description.—The body is round and flat. The posterior projection as reported by Nie (1935) in *Z. orientalis* is not present. The coarsely alveolated cytoplasm is differentiated into a thin ectosarc and a dense endosarc. The small, oval and well stained endospherules give the endosarc a dense appearance. The two nuclei almost spherical are obliquely placed over one another in the cytoplasm. In the normal state, the nucleoli (4-6 in number) appear as large irregular bits of chromatin hanging from the surface of the nucleus. The cilia are short, fine and uniformly distributed all over the body. Various stages of mitotic divisions of the nucleus were observed

Host.—Microhyla ornata.

Measurements in microns.—34 individuals.

Body (length × breadth) : range 70-110 ×60-80 ; average (L × B) × 70, Length : Breadth (average) 1·28 : 1 ; Dividing individual (L ×B),



TEXT-FIG. 2. *a* and *b.—Protoopalina dharwarensis* sp. nov. *a.* Normal individual showing general structure : × 430 ; *b.* Daughter cell from a longitudinal division showing dumbell-shaped nucleus : × 430. *c-d.—Zelleriella microhylae,* sp. nov. *c.* Normal individual showing general structure : × 430 ; *d.* Nuclei in prophase : × 430 ; *e.* Dividing individuals with nuclei in telophase : × 430. *f.* & *g.—Zelleriella froilanoi,* sp. nov. *f.* Normal individual showing general structure : × 430 ; *g.* Dividing individuals under low power : × 100.

150 × 90. Diameter of the resting nucleus, 10-13. Cilia line interval : anterior region, 3 ; posterior region, 4. Length of the cilia, 8. Width f ectosarc, 4-4·5.

Zelleriella froilanoi, sp. nov.

Description.—The body is thin, flat and bluntly rounded at the posterior end. The anterior pole is broad and round. The posterior one is tapering to a rounded point. The small and stocky forms have somewhat a wedge-shaped body. Unlike *Z. microhylae,* the cytoplasm is not well differentiated into the usual zones. The protoplasm is very finely granulated and is evenly distributed. Cytoplasmic inclusions in the form of very fine granules which stain like chromatin were seen in some individuals. The oval endospherules are small and sparsely distributed in the cytoplasm. Some small and large vacuoles are often seen to group together at the posterior pole of the body. The two spherical nuclei are placed one over the other in the vertical axis of the body. The chromatin is found to be in the form of minute granules and not in large bits as seen in *Z. microhylae.* In the dividing nucleus the nucleoli were approximately 8 in number but usually varied from 6-8.

Host.—Philautus sp.

Measurements in microns.—71 individuals.

Body (length × breadth) : range 80-150 × 25-55 ; average (L × B), 115 × 40 : Length : Breadth (average) 2·87 : 1 ; diameter of the nucleus 10-12. Distance between the two nuclei 15-30. Length of the cilia, 12. Cilia line interval, 3.

Key to the species of Zelleriella.

1 (13)	Body without a posterior curved process ..	2
2 (7)	Body with a posterior end narrowly elongated and pointed.—	
	(*a*) Body, trumpet-shaped, posterior end elongated. Body (L × B), 180—220 × 75—100 μ. Nucleus spherical, 20-22 μ diameter ..	*Z. cornucopia* Carini.
	(*b*) Body cone-shaped. Posterior pole rounded. Nucleus spherical 15-17 μ in diameter ; distance between two nuclei 20-25 μ. Body (L × B), 100 × 30 μ ..	*Z. falcata* Carini.
	(*c*) Body comma-shaped. Posterior pole pulled to a point. Body 70-90 μ in length. Diameter of the spherical nuclei, 8-10 μ ; distance between two nuclei, 10 μ	*Z. corniola* Carini.
	(*d*) Body wedge-shaped	3
3 (4)	Nuclei ellipsoidal or pear-shaped (number of nucleoli not mentioned) ; Body (L × B) 207 × 130 μ. Nucleus (L × B) 32 × 22 μ ..	*Z. magna* Met.
4 (3)	Nuclei spherical	5
5 (6)	Body very thin and broadly wedge-shaped ; L × B, 115 × 40 μ. Nucleus diameter 10-12 μ. Nucleoli 6-8 in number. Distance between two nuclei, 15-30 μ	*Z. froilanoi,* sp. nov.
6 (5)	Body narrowly wedge-shaped. Body (L × B), 93 × 50 μ. Nucleoli 4 in number. Nucleus diameter 10 μ ..	*Z. intermedia* Met.
7 (2)	Body with a posterior end broadly rounded.—	
	(*a*) Body irregularly rounded, thin and leaf-like. L × B, 300 × 200 μ. Nucleoli 8 in number. Spherical nucleus 25 μ ..	*Z. foliacea* Carini.

	(*b*) Body triangular with a truncated posterior end. Spherical nuclei 10-12 μ. Body (L × B), 80-150 × 45-65 μ	*Z. truncata* Carini.
	(*c*) Body oval and greatly flattened ..	8
8	(12) Nuclei rounded—	
	(*a*) Nuclei large, 20 μ in diameter ..	*Z. binucleata* (Raff.
9	(8) Nuclei smaller	10
10	(11) Nucleus 12 μ. in diameter. Nucleoli 3-4 number ..	*Z. macronucleata* Bezz.
11	(10) Nucleus 10-13 μ in diameter. Body thick (L × B), 70-110 × 60-80 μ. Nucleoli 4-6 in number ..	*Z. microhylae*, sp. nov.
12	(8) Nuclei ovoidal (L × B) 15 × 10 Nucleoli 4 in number. Body (L × B) 130 × 82 μ	*Z. brasiliensis* (Pinto).
13	(1) Body with a posterior curved process ..	14
14	(15) Posterior tail long and distinct, Nuclei (L × B) 23 × 13·9 μ. Body (L × B) 100 × 60 μ ..	*Z. antanesi* Pessoa.
15	(14) Posterior tail otherwise ..	16
16	(17) Posterior end terminates to a minute sharp point. Nucleoli 8 (?) in number. Body leaflike, (L × B) 87·5-120 × 45-70 μ. Nucleus 12·5 μ in diameter ..	*Z. orientalis* Nie.
17	(16) Body broad anteriorly. Nucleoli 3 in number. Nucleus 10 μ in diameter. Body (L × B) 105 × 80 μ	*Z. bufonix* Met.

SUMMARY.

1. The ciliate parasites of about one hundred and twenty-five specimens of frogs and toads of Karnatak, Bombay Presidency, comprising nine different species have been studied particularly with a view to ascertain the presence of binucleated opalinids in them.

2. Five new species of *Zelleriella* and *Protoopalina* have been described, thus establishing, beyond doubt, the presence of binucleated opalinids in these anurans.

3. Ciliate parasites of six of the host species have been recorded for the first time in India ; and some more ciliates have been added to the list of parasites of the hosts already examined. Besides one new species and one new sub-species of the genus *Cepedea*, ten old species of ciliates found parasitic in the gut of these anura have also been recorded.

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ON THE BIONOMICS, DEVELOPMENT AND GROWTH OF A CAUVERY CARP, *LABEO KONTIUS* JERDON*

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CONTENTS.

INTRODUCTION.

Our knowledge of the life-history of Indian food fishes is still very meagre, though valuable contributions have been made by Willey (1910), Raj (1916), Khan (1926, 1943), Job (1938, 1941), Jones (1937), Kulkarni (1943), Bhimachar (1944) and others. Mookerjee and co-workers (1944, 1945, 1946, 1949) have recorded extensive observations on the life-history of the major Indian carps. The position of our knowledge on the breeding and development of Indian freshwater and brackish-water fishes has been reviewed by Jones (1946) in two recent contributions. While complete and connected accounts of the life-history of the major carps of India are still wanting, the contributions of Khan (*loc. cit.*), Mookerjee (1944, 1945) and Nazir Ahamed (1944), among others, give valuable information about the development of these fishes.

The genus *Labeo* includes several of the major carps of Indian waters. The common species of the genus in the river Cauvery in south India are *Labeo kontius*, *L. fimbriatus*, *Labeo* sp. ('Parel'), *L. calbasu* and *L. bata*, mentioned in the order of their abundance. No complete and connected account of the breeding habits and development of any of the above species, excepting *L. calbasu* (Mookerjee, 1946) is yet available. That an intimate knowledge of the life-history of all the major food fishes is essential for any rational development and exploitation of the natural fisheries and their enrichment by cultural operations, is too well known to need any emphasis here.

While working under the Madras Rural Piscicultural Scheme of the Indian Council of Agricultural Research we had opportunities to study the biology of a common Cauvery Carp, *L. kontius*, the breeding habits and development of which were also elucidated by observations during the 1946 and 1948 spawn collection seasons. The information thus gathered is presented in this communication.

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Paper read before the 35th Indian Science Congress, Patna, 1948.

Economic Aspects.

L. kontius is indigenous to the Cauvery system. Locally called "*Karimuli*" at Mettur and "*Kalchel*" at Tanjore, *L. kontius* yields a valuable fishery ranging from 5 per cent. to 50 per cent. of the catches in the various fishing centres along the stretches of the river. It is fairly abundant in localities like Mettur, Bhavani and Tanjore and specimens are available at all seasons of the year, particularly during October to December. In the Tanjore area '*Kalchel*' forms an important item of the tank fisheries, in most cases the fry and fingerlings getting naturally stocked during rainy months when the tanks get connected with the irrigation canals leading from the river. Next to the White Carp, *Cirrhina cirrhosa*, *L. kontius* is generally the dominant species in the large congregations of fish in the supply channels of the Mettur Dam, and also below the Hoggainakkal Falls. Of the several thousands of fish that are annually trapped in the rock pools along the Ellis surplus course of the Mettur Dam, *L. kontius* constitutes about 25 to 40 per cent.

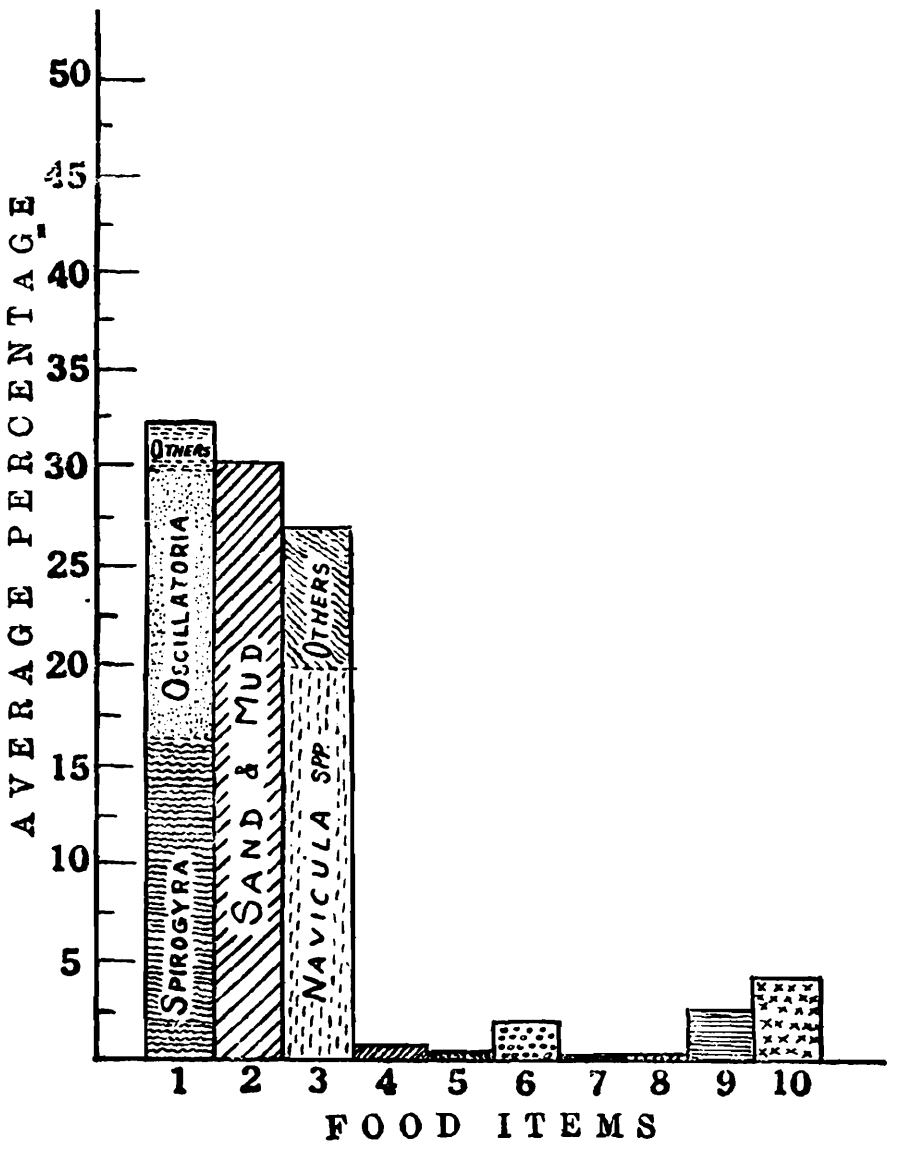
Characteristic Features and Bionomics.

The characteristic dorsal profile distinguishes *L. kontius* from the allied species in the river Cauvery. The snout is very conspicuous and thick; mouth appears to be somewhat sub-terminal and the lower lip is finely fringed at the margin. In the upper reaches of the river Bhavani, in places like Pungar and Satyamangalum *L. kontius* is known as "*Panni-vayi Kendai*", meaning 'Pig-mouthed Carp' It is interesting that the local fishermen have observed the rather remote resemblance of the projecting snout and somewhat sub-terminal mouth of this carp to the facial features of the pig.

The fingerlings of this carp are of a deep slaty colour, particularly towards the dorsal aspect. Fully grown specimens are a little lighter in colour and have the scales along either side spotted with red in the centre. The body is more cylindrical than in *L. fimbriatus*, from which it is easily distinguished by the short dorsal fin, conspicuous snout and the characteristic dorsal profile. It is a very active, hardy fish and in the supply channels of the Mettur Dam specimens could very often be seen jumping up in the air in their attempt to negotiate the cascade-like steps and move upstream. In the natural habitat they are found to withstand wide ranges in the conditions of existence. Fingerlings and adult specimens abound in the black, malodorous water, surcharged with sulphuretted hydrogen, issuing forth from the sluices of the Mettur Dam and also from the tail race of the Mettur Power House during periods of summer stagnation in the reservoir. They were observed to be actively feeding on algal growth and diatoms in the area and were none the worse for the presence of the poisonous gas. While the species thrives well when stocked in ponds, transport of fingerlings has been found to be comparatively difficult. During conditioning and in transit, generally heavy mortality results. While excessive activity of the fingerlings in the limited space of the conditioning box or the tin carrier is bound to result in mechanical injury to several and might lead to their death, systematic study of this aspect is urgently called for.

FOOD AND FEEDING HABITS.

Detailed analyses of the stomach contents of 42 specimens, ranging from 4·4 inches to 19·5 inches in total length, collected from localities like Hoggainakkal, Mettur, Bhavani, Tanjore and the Chetput Fish Farm, were made and the data are represented in Figure I. Like most other species of the genus, *L. kontius* is a predominantly vegetable feeder; the animal part of the food being only about 5 per cent. on the average.



TEXT-FIG. 1.—Food of the Cauvery Carp, *Labeo kontius* (Jerdon). Percentage composition of the important items encountered in the guts of 42 specimens.

1. Filamentous algae and aquatic macrophytes; 2. Sand and mud; 3. Desmids and Diatoms; 4. Dinophyceae; 5. Unicellular green algae; 6. Copepods; 7. Rotifers; 8. Earthworms; 9. Insects; 10. Organic debris.

The following 25 items were encountered in the gut contents :—

Cosmarium, Staurastrum, Navicula, Synedra, Pleurosigma, Pinnularia, Amphora, Gomphonema, Fragillaria, Scenedesmus, Ankistrodesmus; Selenastrum; Euglena, Peridinium, Microcystis, Merismopedia, Oscillatoria, Spirogyra, Leaf bits, insect parts, copepods, rotifers, earthworm remains, organic debris, sand and mud.

Filamentous algae and leaves of aquatic plants together constituted about 32·3 per cent. of the feed. *Spirogyra* was present in 70 per cent. of the specimens examined and ranged from 10 to 80 per cent. of the gut contents; constituting just over half the average total quantity of filamentous algae consumed. *Oscillatoria* was less frequently met with (in 50 per cent. of the specimens examined) and ranged from 3 to 70 per cent. of the feed in the different specimens. Diatoms accounted for over 27 per cent. of the average total feed and of these about 20 per cent. was formed of *Navicula* spp. only. Diatoms were almost invariably met with in the stomach contents and ranged from 10 to 60 per cent. of the latter. Sand and mud particles were encountered in 80 per cent. of the specimens examined and constituted about 30·5 per cent. of the average total feed; while, in individual specimens it ranged from 10 to 80 per cent. Insect parts, earthworm remains, copepods and rotifers which constituted the animal part of the diet, accounted only for 5 per cent. of the average total feed and in 50 per cent. of the specimens examined the stomach contents were of purely vegetable nature.

It is interesting to observe that the majority of the planktonic algae listed above were found in the guts of specimens from lentic water—from the Chetput farm ponds. Sand or mud and organic debris formed only very minor items of the stomach contents in these specimens, in sharp contrast to specimens from riverine habitats.

Post-larval specimens and early fingerlings kept in laboratory aquaria were observed to feed voraciously on zooplankton consisting of rotifers, cladocerans and copepods. Whenever available they were found to gorge the guts with phytoplankton organisms like *Microcystis* also.

Bottom feeding and browsing on stones and other objects in the marginal shallows are clearly indicated from the nature of the stomach contents. While several of the diatoms encountered are planktonic in nature, it is also observed that all of these as very commonly found among growths of filamentous algae. When filamentous algae are consumed in quantities, the epiphytic and embedded diatoms will also be taken in along with them. Several naviculid diatoms are found, as frustules and also in the fresh condition, in the surface layers of the bottom mud, and these are likely to enter the stomach when the fish feeds on insects and worms from these habitats. The presence of quantities of diatoms in the gut in this instance, is therefore not considered as indicating plankton feeding habit to any appreciable extent. The fact that unicellular green algae, including euglenoid flagellates which are truly planktonic, were rarely met with in the stomach contents lends support for the above suggestion.

The observation that planktonic algae were appreciable and that the quantity of sand and mud was limited in the gut contents of specimens from fresh water ponds, would seem to indicate that with the change from the lotic to the lentic environment there has been a slight change in the feeding habits also, probably as an adaptation to the food available in the habitat. This point, however, needs confirmation after systematic investigation, as it is bound to be of practical significance in fish culture.

The proportion of body length (Total length) to the length of gut in *L. kontius* is about 1 : 11. In the closely related *L. fimbriatus*, however, the gut is much longer, the proportion being approximately 1 : 22. The length of gut in *L. calbasu* is more or less the same as in *L. kontius*. The length of gut of an animal is known to depend on the nature of the food it consumes, the length increasing with increasing proportions of vegetable matter in the diet. In *L. kontius* 95 per cent. of the average feed is found to be of vegetable nature and still the entire gut is only about half the length of that in *L. fimbriatus*. It might be of interest to correlate the length of gut and nature of food in the different species of the genus *Labeo*.*

SEXUAL MATURITY AND BREEDING.

Specimens collected from the river Cauvery, below the Mettur Dam, in April, had the gonads in the third stage. Some males were already in milt, oozing on slight pressure. Early in July, the majority of specimens, 12 to 14 inches long, were sexually ripe. While oozing males were very common, females in that stage were not then available. In the Hoggainakkal area also the species was in roe early in July. Lower down at Bhavani, ripe specimens were available in the 4th week of June ; while, in Tanjore, at the Grand Anicut several specimens had the gonads in the 4th stage, early in June. Breeding thus coincides with the monsoon months, June—July. The smallest mature specimen obtained measured 10·6 inches in total length and was a male with the testes in the 4th stage. It is known that in certain carps like *Barbus hexagonolepis* the males mature when they are still of a relatively much smaller size as compared with the size of the mature females (Hora, 1944, Hora and Nair, 1943). In *L. kontius*, however, there does not appear to be any such marked disparity in size between the two sexes.

The fish was breeding in the Cauvery during July—August, 1946 and developing eggs, with advanced embryos inside, were collected in fair numbers at Hoggainakkal. In the river Bhavani the fish spawned during June 1948 and large number of eggs in all stages of development were collected at Satyamangalom and Pungar. The hydrological conditions during collection of spawn were as follows :—

Place.	Date.	Time. Hrs.	Temp. (°C).	Turbidity (Cms.)	pH.	Diss. 02· (cc/L).	Percentage of Saturation.
River Cauvery at Hoggainakkal	27-7-46	9·30	23·6 to 23·5	7·5 to 9·0	7·5 to 7·8	5·225 to 6·094	84·5 to 98·4
River Bhavani at Satyamangalom.	24-6-48	6·20 to 22·00	22·3 to 24·2	5·0	7·5	5·030 to 4·891	77·5 to 82·2
River Bhavani at Pungar	26-6-48	2·30	22·7	6·0	6·6	5·310	84·65
River Moyar at Pungar	25-6-48	22·40	23·2	6·0	6·6	5·030	80·9

* Dr. Hora informs us (in a personal communication, dated 16th January, 1951), "I think food containing more cellulose matter will require a longer intestine for assimilation. This may explain the difference observed between the relative length of the intestines of *L. fimbriatus* and *L. kontius*."

On all the above occasions the river was in spate and there were occasional showers of rain. The flow of water was at the rate of 4 to 7 ft. per second. At Hoggainakkal, the eggs when collected in the morning were fairly well advanced in development, with the embryos actively moving inside. As the day advanced no eggs were caught in the nets. On the other hand at Satyamangalom, eggs in different stages were being caught in appreciable numbers almost throughout the day and night, from 5-30 P.M. to 10 A.M., indicating that spawning was taking place continuously for hours together. Temperature of water ranged from 22·3°C to 24·2°C. The conditions were more or less the same at Pungar and Moyar except that pH. of the water was very low (6·6). The factors influencing spawning of carps in south Indian rivers have been discussed in detail elsewhere (Ganapati and Alikunhi, 1949).

DEVELOPMENT.

Since fertilized eggs were collected from the river in 1946 and 1948, the development could be studied and the details fully checked up. While some late embryonic stages were collected from Hoggainakkal in July, 1946, the account of the embryonic development that follows is mainly based on material collected from the river Bhavani at Satyamangalom in June 1948. The larval and post-larval development were followed in detail from material collected in 1946 and the stages were fully checked with the 1948 material.

Unfertilized Egg.—In the ripe female the ovary is of a dull bluish colour. The ova are fairly large, almost rounded in shape, with a diameter of 1·1 mm. to 1·25 mm. and when teased out have a faint pale bluish tinge. The vitelline membrane closely adheres to the egg surface. The eggs are not sticky in nature.

(*a*) *Embryonic Development.*

Fertilized Egg.—As in other Indian carps, fertilization of the egg is followed by a remarkable swelling of the vitelline membrane, creating the characteristic peri-vitelline space between the latter and the egg proper. In *L. kontius* the fertilized egg when fully swollen is 3 to 3½ times the size of the ripe ovarian egg and generally measures 3·7 mm. to 4·4 mm. in diameter.

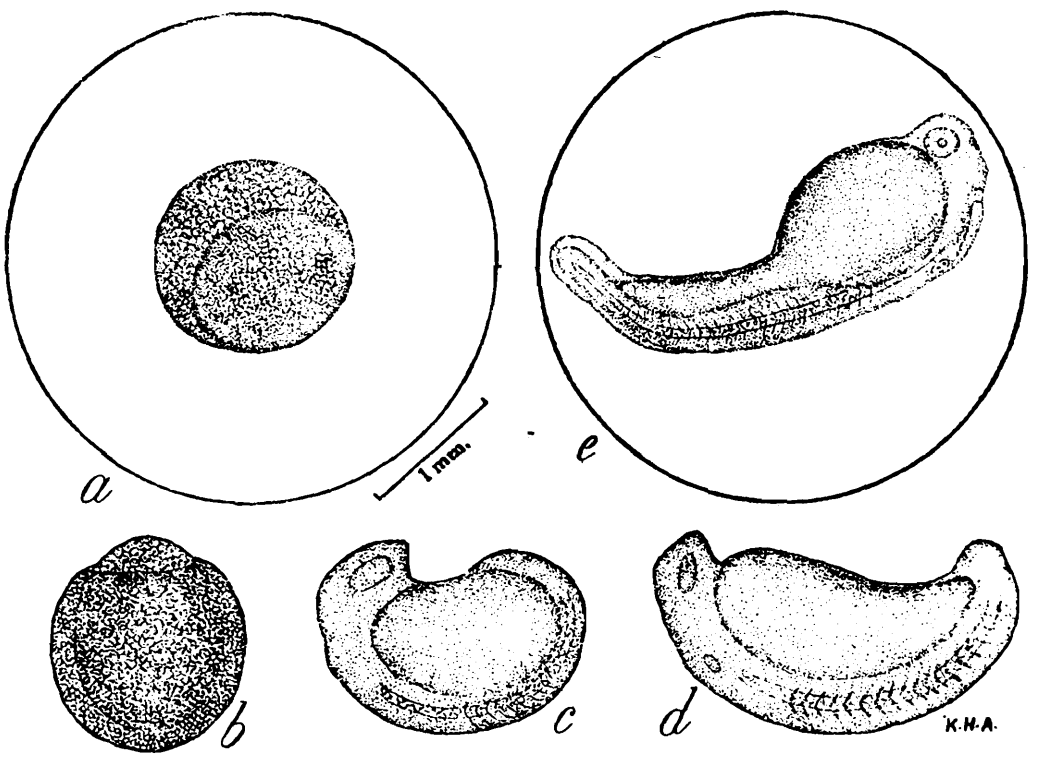
Stage i: *X hours old after fertilization.* (text-fig. 2*a*).—Collected in spawn-catching net from river Bhavani at Satyamangalom, on 24th June 1948, at 17-30 hours. Earliest stage in the collection; two eggs.

Demersal and drifting with the main current, in the river proper, the eggs are perfectly spherical and have the surface remarkably clean without any dirt or debris sticking to it. The diameter of the two eggs is 3·76 mm. and 4·48 mm. respectively. The peri-vitelline space is broad and the egg inside measures 1·28 mm. in diameter. Early cleavage is over and the blastoderm cells have begun spreading over the yolk mass. The yolk is coarsely granular and of a pale transparent blue tinge.

Stage ii : *X*+2½ *hours after fertilization.* (text-fig. 2*b*).—The invasion of yolk by the blastoderm cells is progressing and within an hour after collection, almost three-fourth of the yolk mass is enveloped by the latter. Within 2½ hours, only a small plug-like portion of the yolk remain uncovered. The egg is slightly elongating and measures 1·6 mm. along the long axis.

Stage iii : *X*+3½ *hours after fertilization.*—Formation of the embryo has started as a ridge-like thickening over the yolk mass. Head and tail ends are not yet distinct. 3-4 myotomes have been differentiated.

Stage iv : *X*+5½ *hours after fertilization.* (text-fig. 2*c*).—Several eggs in this stage were simultaneously collected from the river also.



TEXT-FIG. 2.—Developmental stages of *Labeo kontius* (Jerdon). *a*. Fertilized egg, earlist stage collected from river; *b*. Developing egg ; 2½ hours after collection ; *c*. Same 5½ hours after collection ; *d*. Same 11 hours after collection ; *e*. Same 14 hours after collection.

(All figures are of the same magnificatino ; vitelline membrane is not shown in *b*, *c* and *d*.)

The embryo is slightly elongated, with the head and tail ends quite distinct. Optic cup rudiments are visible. 9-11 myotomes have appeared. Yolk mass is oblong. The everage dimensions are as follows :—

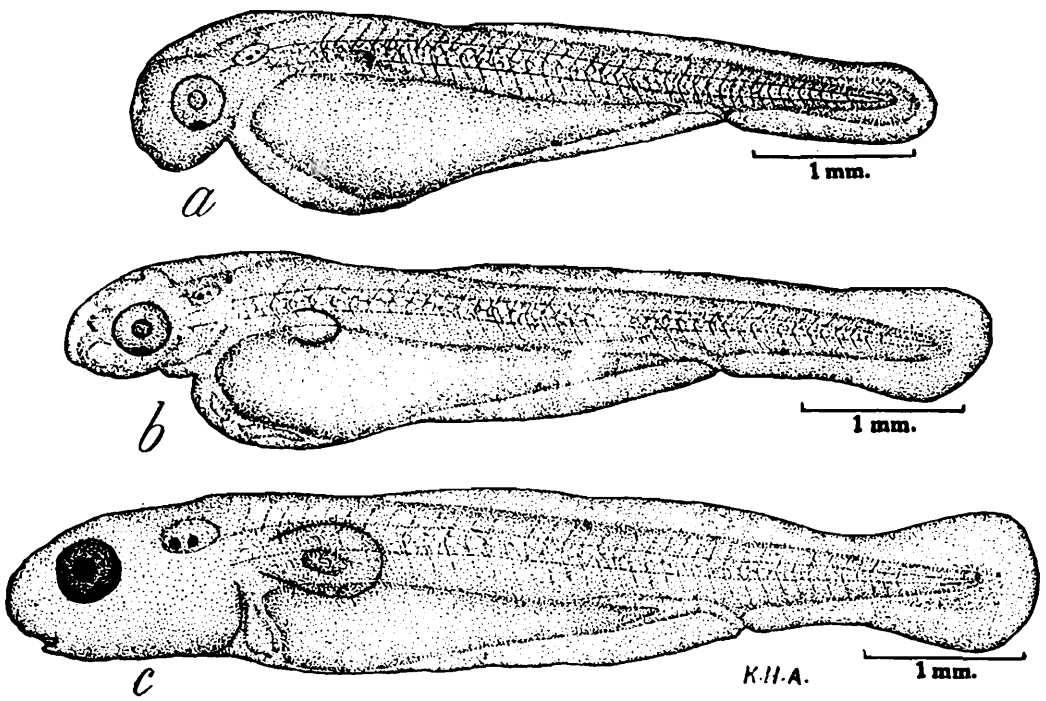
Total length of embryo	1·88 mm.
Max. height of embryo ..	1.16 mm.
Length of yolk mass	1·36 mm.
Height of yolk mass .. .	0·88 mm.

Stage v : *X*+11 *hours after fertilization.* (text-fig. 2*d*).—Embryo is roughly C—shaped ; yolk mass is elongating ; auditory cups are distinct ; head and tail ends are projecting from the yolk mass and 17—19 myotomes have appeared. The embryo is now 2·4 mm. in length.

Stage vi: *X+12½ hours after fertilization.*—The embryo has further elongated and has begun to execute occasional side to side movement of the tail which is well drawn out from the yolk mass. The latter is tapering posteriorly. The number of myotomes has increased to 22.

Stage vii: *X+14 hours after fertilization.* (text-fig. 2*e*).—The embryo now executes active movements within the egg membrane. Two minute concretions have appeared in each of the auditory vesicles which are still far removed from the eyes. Pericardial space has been differentiated between the head and the yolk mass. 26 myotomes have appeared. The tapering hind portion of the yolk mass is slender. The embryonic fin fold is distinct around the tail region. Head portion is still largely adherent to the yolk mass.

Stage viii: *X+15½ hours after fertilization.*—Embryo is now well differentiated and almost ready to hatch. 36 myotomes could be counted. Head is distinct from the yolk mass which is still very conspicuous. No pigment has yet appeared on the body. Heart has begun pulsating feebly. The embryo is making constant, vigorous movements within the egg membrane.



Text-fig. 3.—Developmental stages of *Labeo kontius* (Jerdon).

a. Hatchling, 5·04 mm. long, *b*. Larva, 18 hours after hatching, 5·84 mm. long *c*. Larva, 40 hours after hatching, 6·64 mm. long.

Period of Incubation.—The earliest stage in which the blastoderm cells had begun invasion of the yolk took about 16 hours to hatch in the laboratory. The temperature of water ranged from 22 to 23°C. If the early cleavage and the formation of the blastoderm are assumed to have been completed in about 4 hours after fertilization, the total period of incubation will be about 20 hours. A prolonged period of incubation was, however, noticed in the batch of eggs collected from the Cauvery, at Hoggainakkal, during July—August, 1946. The prevailing temperature of water then was also about 23°C. The eggs when collected were in a fairly advanced stage of differentiation and had the embryos moving

inside, and their age after fertilization was presumed to be about 8—10 hours. These, however, hatched in the laboratory, only 19 hours after collection, indicating a total period of 28—30 hours incubation.

(*b*) *Larval Development.*

The Hatchling. (text-fig. 3*a*).

Total length	5·04 mm.
Maximum height of body ..	1·36 mm.
Length of yolk sac.	2·72 mm.
Maximum height of yolk sac.	0·97 mm.
Height of body at anal level	0·56 mm.

Delicate and almost transparent, the hatchling has a conspicuous yolk mass which is still of a faint bluish tinge when seen against a white background. The head is distinct and projects out from the yolk mass. The eyes are transparent, but each has a small dark spot, ventro-medially. Pectoral rudiments are just indicated as smooth prominences on either side at the level of the thickest portion of yolk sac. The auditory vesicles have migrated closer to the eyes. Of the two concretions in each of the auditory vesicles the anterior one is bigger than the posterior. Mouth is absent. 36 myotomes could be counted. No chromatophores have appeared on the body.

Larva (*Pro-Larva*), *18 hours after Hatching.* (text fig. 3*b*).

Total length	5·84 mm.
Maximum height of body	1·12 mm.
Length of yolk sac.	2·72 mm.
Maximum height of yolk sac.	0·72 mm.
Height of body at anal level	0·68 mm.

Head is conspicuous; mouth and gills are indicated; the eyes are getting pigmented; pectoral rudiments are flat and foliaceous and the yolk is being steadily absorbed. The young larva confines to the bottom of the dish where it often lies quiet, but swims vigorously when disturbed.

Larva (*Pro-Larva*), *24 to 27 hours after Hatching.*

Total length	6·56 mm.
Maximum height of body	1·12 mm.
Length of yolk sac.	2·68 mm.
Maximum height of yolk sac.	0·56 mm.
Height of body at anal level	0·75 mm.

Mouth opening is better indicated and is more forward in position than in the previous stage. The eyes appear dark against a white background. The pectorals are functional. Blood appears reddish. Rudiment of the air bladder is indicated and a few chromatophores are present near the same.

Larva (Pro-Larva), 40 hours after Hatching. (text-fig. 3c).

Total length	6·64 mm.
Maximum height of body	1·24 mm.
Length of yolk sac.	2·44 mm.
Maximum height of yolk sac.	0·64 mm.
Height of body at anal level	0·88 mm.

Eyes have become fully pigmented and dark. Air bladder appears like a small oval bubble. Both the concretions in the auditory vesicle are of equal size. Mouth is well formed and is sub-terminal. The lower jaw is capable of being moved occasionally. Snout is blunt and from the dorsal aspect appears more or less truncated. Pectoral fin is fully functional. The yolk has been considerably absorbed. Chromatophores have appeared all over the body, particularly over the dorsum of head, continued as a mid-dorsal line to the tail, and also along the dorsal aspect of the yolk sac, continued backwards as a median ventral row.

Larva (Pro-Larva), 48 hours after Hatching.—Very similar to the previous stage ; yolk is further reduced ; eyes have become prominent ; air bladder is almost double the size of that in the 40 hours stage ; more chromatophores have appeared on the body. The fry do not lie quiet at the bottom ; but now move about almost constantly, by rapid, active darting movement, characteristic of carp fry.

Larva (Pro-Larva), 84 to 88 hours after Hatching.—

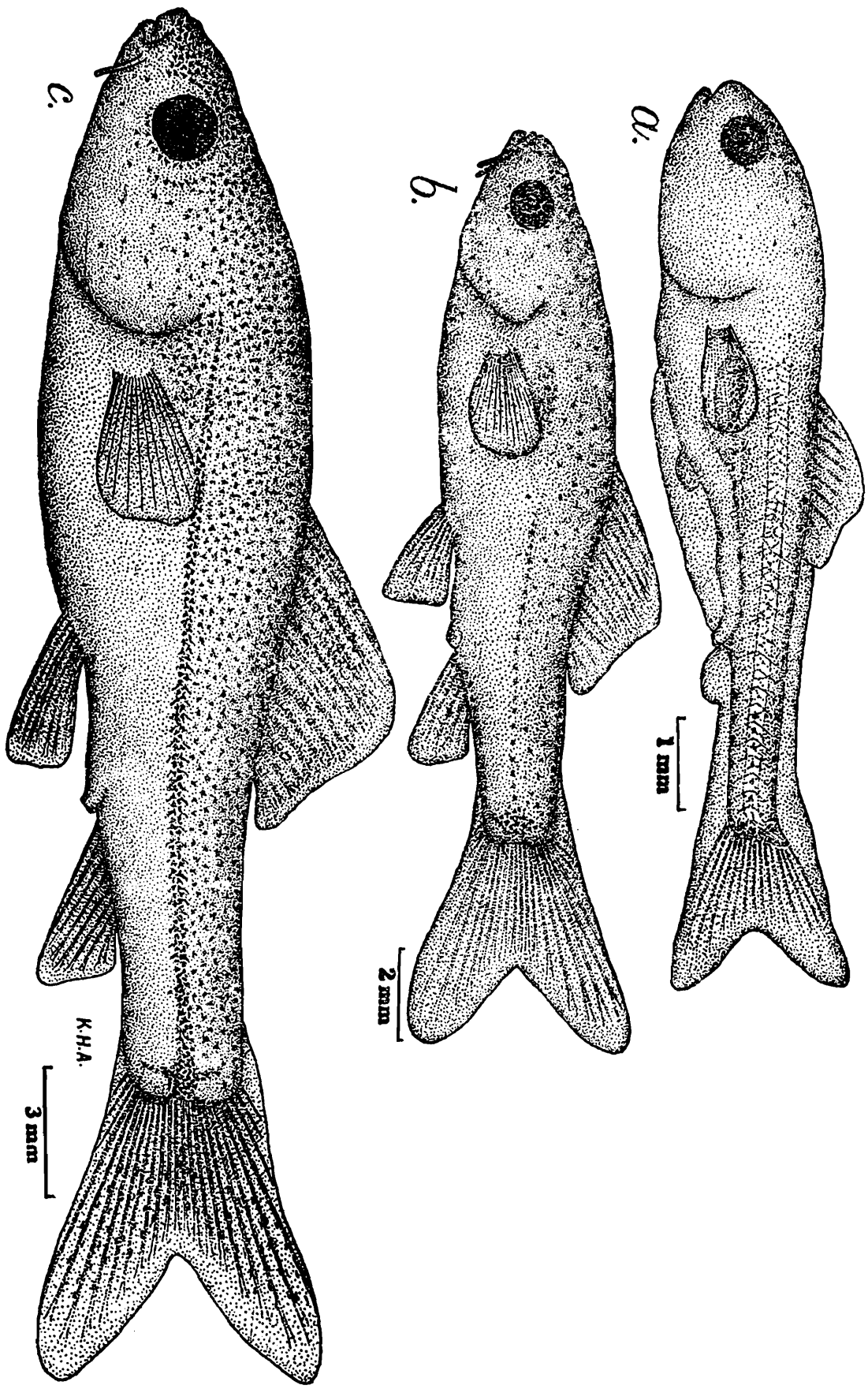
Total length	6·72 mm.
Maximum height of body	1·20 mm.
Length of yolk sac.	1·60 mm.
Height of body at anal level	0·88 mm.

Only a small remnant of the yolk remains to be absorbed. Air bladder, oblong in shape, has become large and conspicuous. Mouth is large, almost terminal and transverse. Chromatophores are numerous and distributed all over the body. An inconspicuous group of chromatophores has appeared on the tail, beneath the tip of the notochord.

Larva (Post-Larva), 5 days after Hatching.

Total length	7·62 mm.
Maximum height of body	1·37 mm.

The embryonic fin fold is continuous ; the dorsal fin rudiment is, however, indicated. Yolk has been fully absorbed and the larva has begun feeding. Tip of the notochord is turned upwards. Rudiments of caudal fin rays are indicated. More chromatophores have appeared particularly on the dorsum of head, on the caudal fin and on either side of the body along the lateral line.



TEXT-FIG. 4—Developmental stages of *Labeo kontius* (Jerdon).

a. Post-Larva, 7 days after hatching, 9·4 mm. long ; *b*. Young fish, 14 days after hatching, 20·0 mm. long ; *c*. Young fish, one month after hatching, 32·0 mm. long.

Larva (Post-Larva), 7 days after Hatching. (text-fig. 4*a*).

Total length	9·4 mm.
Maximum height of body	1·87 mm.

Differentiation of structures has progressed rapidly after the fry began to feed on plankton organisms. While the embryonic fin fold is still continuous, the dorsal fin is clearly indicated and has 7—8 rays. A notch in the dorsal fold indicates the hind margin of the dorsal fin, which is now continued as a narrow strip to the tail. The caudal fin is forked and has 14 rays. Anal fin is also indicated but no rays have appeared and it is continuous with the caudal. Rudiments of the ventral fins are indicated as thickened patches, opposite the dorsal, ventrally. The pre-anal fin fold is broad. More chromatophores have appeared around the tip of caudal peduncle and at the base of the caudal fin, but they have not yet concentrated into any distinct spots.

Larva (Post-Larva), 10 days after Hatching.

Total length	12·00 mm.
Maximum height of body	2·12 mm.

The dorsal fin is fully differentiated and has 3/13 rays. It is completely separate from the caudal fin which now has 17 rays. Fin rays have appeared in the anal fin which is still continuous with the caudal, by a narrow strip of the embryonic fin fold. The ventral rudiment is flat and still undifferentiated. Pre-anal fold is present. Chromatophores are numerous and are large and patch-like on the dorsum of head. At the caudal peduncle they have concentrated into an inconspicuous vertically disposed spot which has its dorsal and ventral edges darker than the middle portion. The row of chromatophores along the lateral line is distinct.

Young Fish, 14 days after Hatching. (text-fig. 4*b*).

Total length	20·00 mm.
Height of body	3·8 mm.

All the fins have been differentiated and have the same number of rays as in the adult. The pre-anal fin fold has disappeared. The mouth has become terminal, with rather thin, though weakly fimbriated lips. A pair of maxillary barbels have appeared. The air bladder is constricted. The caudal spot is rather diffused and is almost the same as in the previous stage. The row of chromatophores along the lateral line is more distinct and appears almost like a band when the specimens are fixed in formalin.

Young Fish, One Month after Hatching. (text-fig. 4*c*).—32 to 36 mm. in total length, the young fish is a miniature adult, except in pigmentation and in the proportions of the snout. A row of scales just above the

lateral line is provided with dark pigment, giving the appearance of a conspicuous dark lateral band extending from the operculum right up to the caudal peduncle where it is confluent with the caudal spot. The caudal spot—a central blotch with streak—like extensions dorsally and ventrally—is rather inconspicuous and finally disappears, along with the lateral band in larger specimens. Pigment is scarse below the lateral line, except near the operculum ; while, all over the body above the lateral line chromatophores are uniformly distributed. By about the 40th day when it attains a length of about 41 to 43 mm., the snout also attains the characteristic shape as in the adult.

DEVELOPMENT COMPARED WITH RELATED SPECIES.

The ovarian and laid eggs being of a bluish tinge, resemble those of *L. calbasu* and *L. gonius*, but are slightly smaller than in the latter species. In *L. fimbriatus* the eggs, though of almost the same bluish tinge, are slightly smaller than those of *L. kontius*. The period of incubation is also longer than in its north Indian congeners. The hatchling is longer than in the allied species and is in more or less the same stage as in *L. fimbriatus*. In the presence of the ventro-median dark spot in the eye, the hatchlings appear to be slightly more advanced than those of *L. calbasu*, *L. gonius* and *L. rohita*.

After absorption of yolk the rate of differentiation of structures depends largely on the availability of food in the environment. Given ample food in the form of live plankton, it is found that the hatchling metamorphoses into a young fish, with all the fins fully differentiated, by the 14th day. The first indication of the dorsal fin rudiment was visible on the 5th day after hatching ; while, in *L. calbasu*, *L. gonius* and *L. rohita* Mookerjee (1945) found similar stage only on the 7th-8th day. If the influence of food is not taken into account, it will be seen that in *L. kontius* the differentiation of structures in the fry takes place at a quicker rate than in the former species.

The conspicuous lateral band in the young fish is characteristic, but the caudal spot is not prominent. In the allied species, *L. fimbriatus*, while the young one has a distinct spot at the caudal peduncle, the lateral pigment band is absent. In the above features *L. kontius* differs from *L. calbasu* and *L. rohita* also.

GROWTH.

(*a*) *In Aquaria and Cisterns.*

The young ones are quite hardy and could be easily transported, even in glass jars, without frequent renewal of water. They could also be fed with crumps of bread, boiled potato, maize, etc. By regular feeding with live plankton collected from ponds it was relatively easy to rear the hatchlings to later stages in aquaria and cement cisterns. The data on early growth gathered by rearing hatchlings from eggs collected at Hoggainakal in July, 1946 are furnished in Table I.

TABLE I.—Data on early growth of *L. kontius* in cement cisterns.

No. of specimens : 35. Size of cistern : 6′ × 3′ × 2·5′.

Date	Age after hatching (Days)	Total length (mm.)			Period elapsed (days)	Growth in length (mm.)			Remarks.
		Max.	Min.	Aver.		Max.	Min.	Aver.	
23-7-46	Hatchling.	..	..	5·04	..		..		
30-7-46	7	9·55	9·25	9·4	7	..	..	4·36	
3-8-46	11	13·5	11·5	12·8	4	3·95	2·25	3·4	
19-8-46	27	27·0	24·0	26·0	16	14·5	13·5	13·2	
26-8-46	34	35·0	31·0	33·6	7	8·0	7·0	7·6	
2-9-46	40	42·0	40·0	41·3	6	9·0	7·0	7·7	
16-9-46	54	52·0	49·0	51·0	14	10·0	9·0	9·7	
27-9-46	65	56·0	54·0	55·0	11	5·0	4·0	4·0	
2-11-46	100	71·0	63·0	66·8	35	15·0	9·0	11·8	Only 9 measured,
21-11-46	119	84·0	66·0	72·7	19	13·0	3·0	5·9	—11—
12-12-46	140	98·0	72·0	80·1	21	14·0	6·0	7·4	—9—
17-1-47	175	106·5	78·0	87·5	35	8·5	6·0	7·4	—6—
1-2-47	190	114·0	81·0	91·6	15	7·5	3·0	4·1	—10—

*Due to incessant rains the nursery got flooded and the majority of fingerlings jumped out and escaped into the adjoining pond during the night.

After 1-2-47 only one specimen survived in the cistern. This was kept under observation for the next 3 months. The growth was very poor and on 23-5-47 it measured only 129 mm. in total length. After the first two months, growth in the cistern has been poor and this is probably accounted for by changes in feeding habits.

(*b*) *In Natural Pond.*

Five of the specimens that escaped into the nursery pond on 12-12-46 were netted out on 9-5-47, when they were 287 days old, and measured 356·6 mm., 344·4 mm., 341·4 mm., 310·9 mm., and 307·8 mm., respectively in total length. All the specimens looked quite healthy and were in excellent condition. They had been in the pond for 147 days during which period the maximum growth in lenght was 258·6 mm. (minimum : 235·8 mm. and average : 152·1 mm.). For the corresponding period growth in the cistern was only 31·0 mm. The limited space, water content and food in the cistern, no doubt, account for the poor growth.

In the natural habitat specimens over 12 inches in length have been found to be sexually mature. In the fresh water pond a maximum length of 11·7″ was attained in the course of 287 days, of which the first 140 days were spent in the cistern. Larger size would, undoubtedly have been attained if the young fish were released into the pond earlier. From the above observations it is apparent that *L. kontius* attains maturity size late in the first year of its life. It is, however, possible that growth in the natural fluviatile environment might not be as quick as that in the pond where food is generally plentiful.

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SUMMARY.

1. *Labeo kontius*, a major carp, indigenous to the Cauvery to river system, in South India, yields a valuable fishery, accounting for 5 to 50 per cent. of the catches in the different fishing centres along the river.

2. Attaining a maximum length of 20 to 24″, it becomes sexually mature when it is about 12 to 14″ long. It breeds during the monsoon months, June to August.

3. It has been found to breed almost at all hours of the day and night, in waters with pH. ranging from 6·6 to 7·1 and temperature from 22·3 to 24·2 C.

4. Laid eggs in large numbers were collected from Cauvery at Hoggaidakkal and the Bhavani at Satyamangalom, and the embryonic, larval and post-larval development were studied and described in detail.

5. The food and feeding habits of the fry, fingerlings and adults have been described.

6. Data on the early growth of the specimens is cement cisterns are furnished. In the natural pond growth is quick and the maturity size is attained late in the first year of life.

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ON A COLLECTION OF REPTILIA AND BATRACHIA FROM THE KANGRA AND KULU VALLEYS, WESTERN HIMALAYAS.

By M. N. Acharji, M.Sc., *Assistant Zoologist, and* Miss M. B. Kripalani, M.Sc., *Zoological Assistant, Zoological Survey of India, Indian Museum, Calcutta.*

Introduction.

The report on the herpetological researches of the Eastern Himalayas (Sikkim and Nepal) and Assam were first published by Blyth[1] as early as 1851. Subsequently Günther[2] in 1861 and Wall[3] in 1907 and 1911, published few papers on the fauna of that area and casually dealt with some reptilian collection of the Western Himalayas. So far, no systematic and comprehensive studies have been carried out regarding the reptilian fauna of the Western Himalayas.

The present report has been drawn up on a collection made under the joint auspices of the East Punjab University and Zoological Survey of India parties during the months of May and June 1950. The value of the collection has been increased because of the accurate field notes regarding the localities, trigonometrical heights etc., at which each specimen was collected. These field notes have been available to us for writing out this report.

The collection[4] consists of 81 specimens referable to 11 species as follows :—

Saurians :	Gekkonidae 1 .	
	Agamidae 3 ..	Scincidae 1.
Ophidians :	Viperidae 1 ..	
Amphibians :	Ranidae 4 .	Microhylidae 1.

It has been mentioned in the Gazetteer[5], that wild life is fairly plentiful in the Kangra district. Snakes of non-poisonous varieties are abundantly met with and only poisonous species that has been recorded is *Agkistrodon himalayanus* (Günther). " Lizards, frogs and toads are universal "

Most of the specimens have been sexed by dissection, except for some male lizards whose sexes could be determind by the femoral pores. Juvenile specimens have been left unsexed and marked " juv. "

Acknowledgments.

We record here our thanks to Dr. J. L. Bhaduri of the Calcutta University, Zoology Department, for checking some of the identifications of Amphibians. To Dr. S. L. Hora, Director, we are grateful for

[1] Blyth, E., *Journ. Asiat. Soc. Bengal*, XX, p. 523 (1851).

[2] Günther, A., *Proc. Zool. Soc. London*, pp. 1-8 (1861).

[3] Wall, F., *Rec. Ind. Mus.* I, pp. 149-158 (1907) ; *Journ. Bombay Nat. Hist. Soc.* XXI, pp. 201-202 (1911).

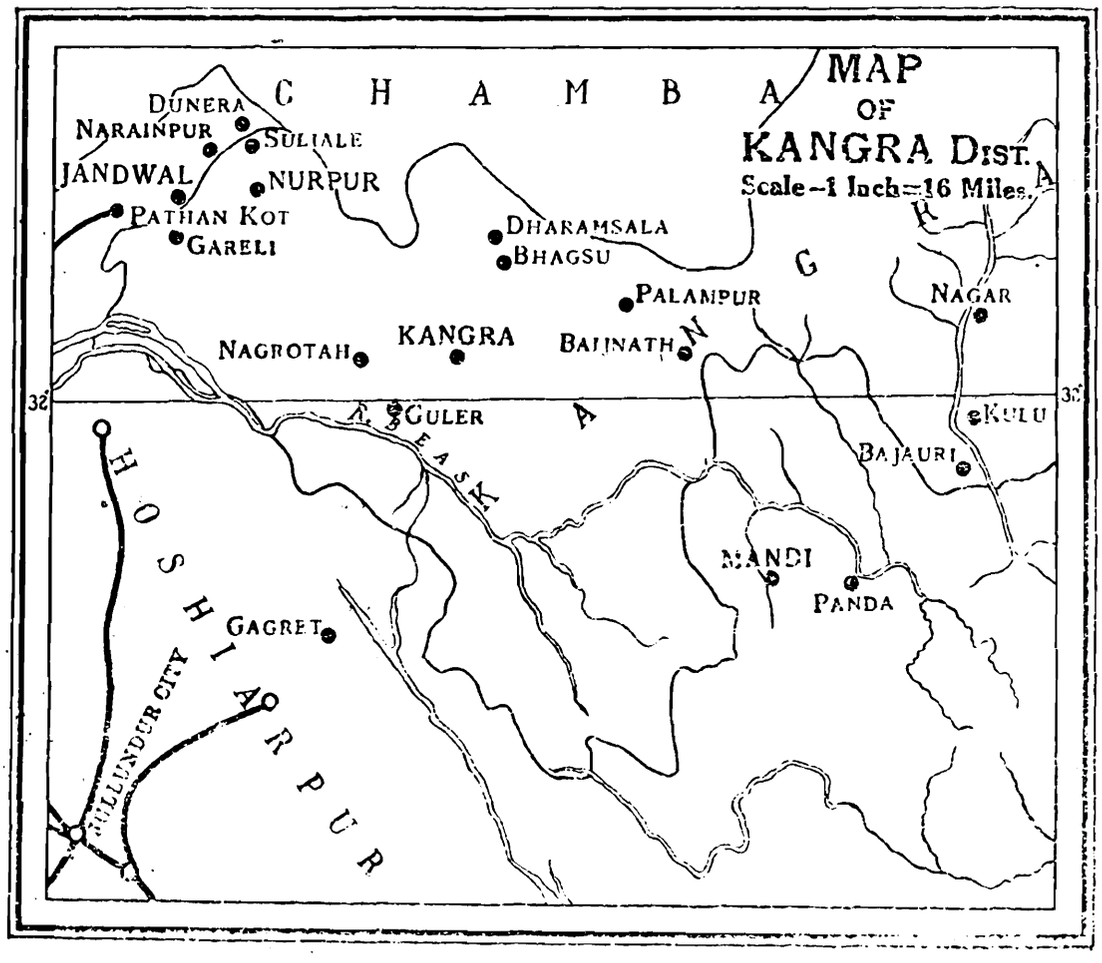
[4] Some tadpoles in various stages of development were also collected along with other. They have been excluded from this report.

[5] *District Gazetteers, Kangra district*, XXX A, p. 12 (1917), with Maps and photographs (Published from Lahore).

going over the manuscript and suggesting improvements and for writing a short note on the ecological conditions prevailing in the Kangra valley at the time when the collections were made.

Physiography of the Kangra District.[1]

From the physiographic point of view the entire area may be divided broadly into three divisions, the plains, the mountains and a transitional zone between them, the foot hills. The Kangra district lies in the lower reaches of the Himalayas in the Punjab, bounded on the north-west by the district of Gurudaspur ; on the north by the Chamba state ; on the south-west by the district of Hoshiarpur ; on the south-east by Kulu and the districts of Mandi and Bilaspur (Text-fig. 1).



Text-fig. 1. Map of Kangra district.

The principal river of the district is Beas, which drains the water of the entire surrounding mountains.

There is a great variation of rainfall throughout the district as well as in the surrounding areas. Lower Dharamsala and Palampur have the annual rainfall up to 114 and 110 inches respectively, whereas at Dehra Gopipur and Hamirpur have 58 and 55 inches. Kangra has an average rainfall of 78 inches annually. The average annual temperature of Kangra town is 67·6°F

[1] Adapted from *Punjab District Gazetteers*, VI (part A). pp. 1-11 (1924-25).

List of specimens with localities.

Date of collection	No. of specimens	Localities	Name of species		
			Saurians	Ophidians	Amphibians
28.V.1950 ..	5	Swan Nadi, 1½ miles beyond Gagret, *alt. ca.* 2,000 ft., Hoshiarpur district.	X	X	Family Ranidae *Rana limnocharis* Weigm.
28.V.1950 ..	5	From the main stream of R. Beas at Dehra Gopipur, Kangra district.	X	X	Family Ranidae *Rana tigrina* Daud.
6.VI.1950 ..	8+2=10	Neugal Nadi, about 1½ miles from Palampur, Kangra district.	Family Agamidae : *Agama tuberculata* Gray.	X	Family Ranidae *Rana cyanophyctis* Schneid.
7.VI.1950 ..	2	Punhkhad, 1½ miles from Baijnath, *alt.* 3,330 ft., Kangra district.	X	X	Family Ranidae *Rana cyanophlyctis* Schneid.
7.VI.1950 ..	8	Binwa Khad at Baijnath, *alt. ca.* 3,300, ft. Kangra district.	Family Agamidae : *Calotes versicolor* (Daud.)	X	X
9.VI.1950 ..	9	Mandi Dak Bungalow premises ..	Family Gekkonidae : *Hemidactylus brooki Gray.*	X	X
10.11.VI.1950 ..	10+2=12	From the main stream of River Beas at Kulu.	Family Agamidae : *Agama tuberculata* Gray *Agama agrorensis* (Stol.)	X	Family Ranidae *Rana xyanophlyxria* Schneid.
12.VI.1950 ..	6	Trout Farm at Katrain near Nagpur, 4,800 ft., Kulu.	Family Agamidae : *Agama tuberculata* Gray. Family Scincidae : *Leiolopisma himalayanum* Gunth.	X	X
15.VI.1950	18	Road from Nagpur to Manali, *alt.* 6,200 ft.	Family Agamidae : *Agama tuberculata* Gray *Agama agrorensis* Stol. Family Scincidae : *Leiolopisma himalayanum* (Gunth.)	X	X
15.VI.1950 ..	1+2	Naggar Nala on the road from Naggar to Manali.	X	Family Viperidae *Agkistrodon himalayanus* Gunth.	Family Ranidae *Rana himalayanus* Boulgr.
16.VI.1950 ..	2	A cold spring at Vashist-Nag ..	X	X	Family Ranidae *Rana cyanophlyctis* Schneid.
23.VI.1950 ..	1	Stream near P.W.D. Dak Bungalow at Jogindranagar.	Family Gekkonidae : *Hemidactylus brooki* Gray.	X	X

Ecological Conditions during May and June 1950.

The collections were made during the hot and dry months of the year when most of the smaller streams had dried up or had just a trickle of water with shallow pools here and there. On account of the melting of the snow, there was, however, considerable volume of cold water in the Beas river and its main tributaries. The House Gecko, *Hemidactylus brooki*, was common in the Dak Bungalow at Mandi, while two species of *Agama tuberculata* and *Agma agrorensis*, were plentiful on rocks by the road side and in the beds of the streams visited by the party. Common frogs of the genus *Rana* were to be found in pools with filamentous algae, but *Rana himalayanus* was found clinging to rocks over which the water was flowing. In such situations, its green colour harmonised with the back ground and it was difficult to notice it.

Systematic Discussion.

SAURIANS.

Family Gekkonidae.

Hemidactylus brooki Gray.

1845. *Hemidactylus brookii* Gray, *Cat. Liz. Brit. Mus.*, p. 153 (type locality: Borneo ; London).

1935. *Hemidactylus brooki*, Smith, *Faun. Brit. India*, Rept. and Amph. II, p. 89.

9 specimens (4♂♂, 5 ♀♀), collected from Dak Bungalow premises, Mandi, 23.VI.1950.

1♂, from a stream near P.W.D. Dak Bungalow at Jogindranagar, 23.VI.1950.

Upper labials 8-10 ; lower labials 7-9 ; preano femoral pores 10-13 on each side of the male specimens.

Snout to vent of 5♂♂ 48-55 mm.
,, 5 ♀♀ 42-58 mm.

This species has got a very wide distribution. It has already been recorded from the Kulu Valley, Western Himalayas, *alt.* 6,000 ft.

Family Agamidae.

Calotes versicolor (Daudin).

1802. *Agama versicolor* Daudin, *Hist. Nat. Rept.*, III, p. 395, pl. XLIV (type locality : India ; Paris).

1935. *Calotes versicolor*, Smith, *Faun. Brit. India* (Rept. and Amph.) II, p. 189.

1♂, from Binwa Khad at Baijnath, Kangra district, *alt.* 3,300 ft., 7.VI.1950.

It has been recorded from Darjeeling district, Nepal valley, *ca.* 4,500—6,500 ft. (I.M. Register No. 18413) in the Eastern Himalayas and from the Kumaon hills, Western Himalayas at an elevation of 6,000 ft.

Agama tuberculata Gray.

1827. *Agama tuberculata* Gray, *Zool. Journ.* III, p. 218 ; *Illus. Indian Zool.* II, pl. Ixxii (1830-35) ; (type locality : Bengal).

1949. *Agama tuberculata*, Constable, *Bull. Mus. Comp. Zool.* CIII (No. 2), p. 94.

37 specimens as follows :—

8 specimens (5♂♂, 1♀, 2 juv.) from Neugal Naddi about 1½ miles from Palampur, Kangra district, 6. VI. 1950 (Coll. Nos. : 9-16).

7 specimens (4♂♂, 2♀♀, 1 juv.) from Binwa Khad at Baijnath, *alt.* 3,300 ft.7. VI. 1950 (Coll. Nos. : 2-8).

4 specimens (3♂♂, 1♀) from main stream of River Beas and its tributaries at Kulu, 10-11. VI. 1950 (Coll. Nos. : 19, 28, 29).

5 specimens (2♂♂, 2♀♀, 1 Juv.) at Trout farm at Katrain near Naggar, *alt. ca.* 4,800 ft. 12. VI. 1950. (Coll. Nos. : 48-52).

13 specimens (9♂♂, 3♀♀, 1 Juv.) on road from Naggar to Manali, *ca.* 6,200 ft. 15. VI. 1950 (Coll. Nos. : 28, 31-33, 35, 36, 42-47).

From 5 different localities 37 examples (23♂♂, 9♀♀, 5 juv.) were collected. They measure as follows :—

Snout to vent of 23 ♂♂ : 90—150 mm.
,, 9 ♀♀ : 80—120 mm.
,, 5 juv. : less than 75 mm.

The longest measurement : 120 mm., while Smith[1] recorded measurement of adult as 140 mm.

Out of 9 females, 8 were egg bound (except Coll. No. : 3). 5 had semi-matured eggs (Coll. Nos. : 2, 16, 27, 31 and 36), size varying between 12×9 mm. to 8×6 mm.

2 specimens (Coll. Nos. : 46, 49) were full with 10 and 6 matured eggs, size varying between 22×11 mm. to 20×12 mm. and were ready for expulsion.

From the statistical data presented above, it will be seen that there were 62·2 per cent males, 24·3 per cent females and 13·5 per cent juveniles. There is a great preponderance of males in proportion to females.

Dodsworth[2] has mentioned that the breeding period of this species commences from the month of May and continues to the early part of August. Our observations also support his views. During the breeding season, the males become very agile and pugnacious and are often seen fighting with each other, as a result of which some time they loose their tails. Specimens with stumpy or regenerated tails are often met with.

During the cold weather, they hibernate but some of them are occasionally seen basking in the sun. In the summer months they are found in abundance.

Agama agrorensis (Stoliczka).

1872. *Stellio agrorensis* Stoliczka, *Proc. Asiat. Soc. Bengal*, p. 128 (type locality : Sussel Pass, Hazara district, N. W. Punjab, India ; Calcutta).

1949. *Agama agrorensis*, Constable, *Bull. Mus. Com. Zool.* CIII (No. 2), p. 95.

6 specimens (2♂♂, 3♀♀, 1 juv.) from the main stream of the river Beas and its tributaries at Kulu, 10-11-VI. 1950 (Coll. Nos. : 18-20, 22-24).

3 specimens (2♂♂, 1♀) on road from Naggar to Manali, *ca.* 6, 200 ft. 15. VI. 1950 (Coll. Nos. : 39-41).

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[1] Smith, M. A., *Faun. Brit. India*, Rept. and Amph. II, p. 215 (1935).
[2] Dodsworth, P. T. L., *Journ. Bombay Nat. Hist. Soc.* XXII, p. 40 (1913).

Agama dayana (=*Stellio dayanus* Stol.) was described from Hardwar, U. P. in 1871. Subsequently it was merged with *A. tuberculata* (*loc. cit.*, p. 214), as there are no distinguishing characters to rank it as a separate species. According to Smith's conception "Both *dayana* and *agrorensis* have no doubt been derived from a more widely distributed *tuberculata*, and both have progressed along the same lines. *A. agrorensis* appears to be confined to a small area of a country in the extreme north-west of the Punjab and the adjacent hills in Kashmir"

With the collection under report, it has been observed that both *tuberculata* and *agrorensis* were collected almost in the same locality, *alt.* 3,300—6,200 ft. They were found to live under the same ecological conditions with the same type of food habits. The gut contents of both the species showed that mostly insects were eaten. No vegetable matter could be traced. They were heavily infected with nematode worms[1] *Thelandros baylisi* Chatterji.

The chief distinguishing characters on which the two forms have been separated are as follows :

	A. tuberculata	*A. agrorensis*
1.	Median dorsal scales sub-equal, roundish-hexagonal, imbricate, keeled, 10-15 rows across the middle of the back. Scales about as large as ventrals.	Median dorsal scale distinctly larger than some time twice as large as ventrals, more strongly keeled than *tuberculata*.
		8-12 longitudinal rows across the middle back, may be divided by vertebral series of small scales.
2.	Preanal patch of callose scales (6 or 7 rows) and elongated abdominal patch in males.	Abdominal patch usually absent, preanal patch of callose scales present in males.
3.	Scales on the flanks with a few scattered enlarged keeled scales.	Flanks with numerous enlarged strongly keeled scales. A large oblong patch on the middle of the flanks always present.
4.	Maximum length from snout to vent 140 mm.	Maximum length from snout to vent 110 mm.

In the Indian Museum collection there are 4 specimens (2♂♂, 2 juv.) of *agrorensis*, out of which one ♂ (I. M. Register No. 4206) is the type. On examining this specimen, it was observed that the abdominal callose scales on the flanks are absent. Vertebral series of small scales are present between the rows of the median dorsal enlarged scales (Text-figure 2b). Nine specimens identified as *agrorensis* from the Kangra valley show these character to a marked degree, except three longitudinal stripes on the back which are present only in juvenile specimens.

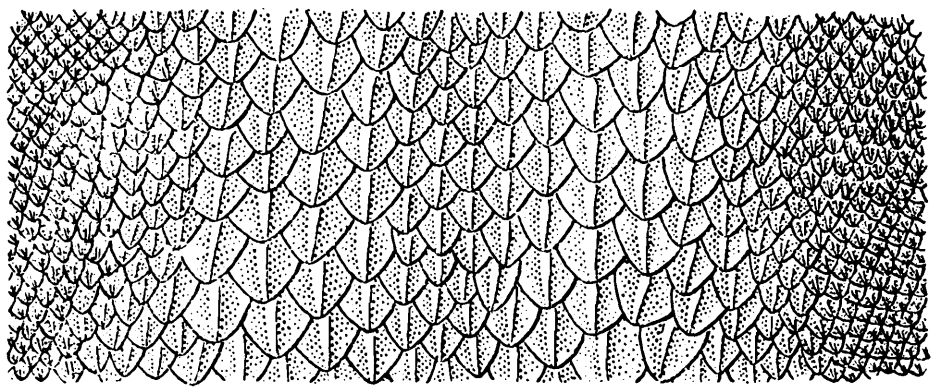
Out of 8 adults (♂ and ♀), 7 measure more than 110 mm. from snout to vent and in one specimen it is 132 mm. Total length of a ♀, as recorded by Constable (*loc. cit.*, p. 95), is 226 (74+152) mm.

[1] We are thankful to Dr. B. S. Chauhan and Mr. T. D. Soota for identifying these worms.

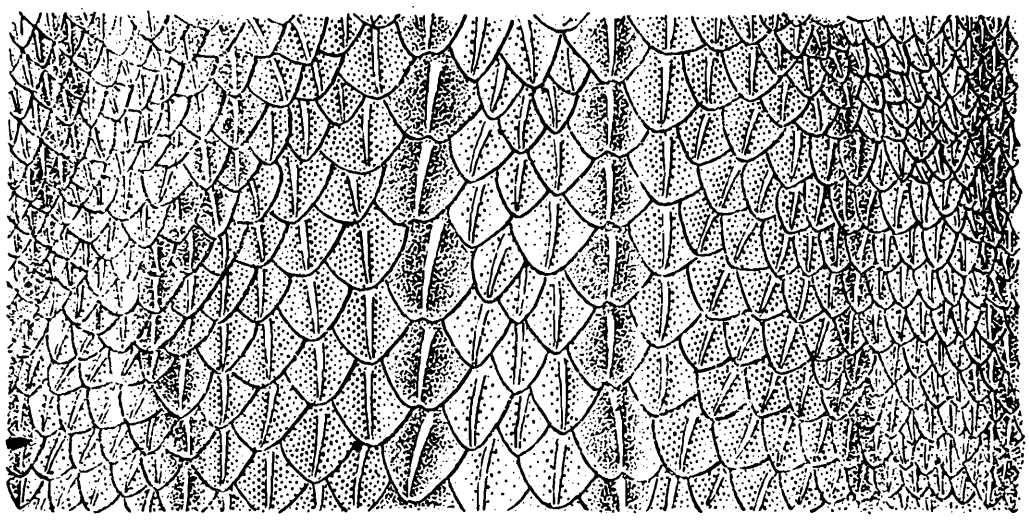
3 ♀♀, specimens measuring from :—

Snout to Vent : 125 mm., had 5 eggs, size 12×9 mm.
„ 120 mm., 8 „ „ 13×9 mm.
„ 100 mm., 6 „ „ 9×8 mm.

Hitherto *agrorensis* was known only from Agror valley, alt. 6,000 ft., N. W. Punjab. In the present case it has been recorded from the western Himalayas (Kangra and Kulu valleys) along with the species *tuberculata.*



a



b

TEXT-FIG. 2.—Dorsal scale pattern of *Agama agrorensis* (Stol.) *a.* From Kangra valley : × 6 ; *b.* Type specimen (Register No. 4206) : × 9.

Family SCINCIDAE.

Leiolopisma himalayanum (Günth).

1864. *Eumeces himalayanus* Günther, *Rept. Brit. India,* p. 86, pl. X, fig. H (type locality : W. Himalayas : London).

1935. *Leiolopisma himalayanum,* Smith, *Faun. Brit. India,* Rept. and Amph. II, p. 229.

3 specimens (unsexed) from the road from Naggar *ca.* 6,2000 ft., 15. VI. 1950.

1 specimen from Trout farm at Katarin *alt. ca.* 4, 4,800 ft. 12 VI. 1950.

Scales round the mid-body 26-30; lamellae under fourth toe 14-18 limbs rather short.

In the western Himalayas, it has been recorded between 4,000 ft. and 7,000 ft. Alcock collected one example (I. M. Register No. 13854) from Borzil Pass, Kosh, Pamir at an elevation of 12,000 ft.

OPHIDIANS.

Family VIPERIDAE.

Sub-family *CROTALINAE.*

Agkistrodon himalayanus (Günther).

1864. *Halys himalayanus* Günther, *Rept. Brit. India*, p. 393, pl. XXIV, fig. A (type locality : Garhwal, Western Himalayas ; London).

1949. *Agkistrodon himalayanus*, Constable, *Bull. Mus. Comp. Zool.* CIII (No. 2), p. 157.

1 specimen (unsexed) from Naggar Nala at Naggar on the road from Naggar to Manali *ca.* 6,200 ft., Kulu district, 15. VI. 1950.

Scales in the mid-body 15; ventral 159; sub-caudals 48 in pairs; upper labials 7, not touching the loreal pit.

Total length : 510 mm., tail 76 mm.

Bluish brown above with indistinct black spots. Upper lips dirty brown; ventral part light bluish with no spots.

It is essentially a montanic form and has been recorded (I. M. Register No. 12875) below the glacial line at Dharamsala *alt.* 16,000 ft.

AMPHIBIANS.

Family RANIDAE.

Rana cyanophlyctis Schneider.

1799. *Rana cyanophlyctis* Schneider, *Hist. Amph.* I, p. 137.

1920. *Rana cyanophlyctis*, Boulenger, *Rec. Ind. Mus.* XX, p. 12.

2♂♂, from Neugal Naddi, about 1½ miles from Palampur, 6. VI. 1950.

2 adult (1♂, 1♀ egg bound) collected from the cold spring[1] at " Vashist Nag ", 16. VI. 1950.

2 juv. (unsexed) from Punh Khad, 1½ miles from Baijnath *ca.* 3, 300 ft., 7. VI. 1950.

2 adult ♀♀, from the main stream of the River Beas and its tributaries at Kulu, 10-11. VI. 1950.

The total length (snout to vent) of 6 adults (3♂♂, 3♀♀) varies between 30 to 35 mm.

In the Himalayas, it has been recorded (*loc. cit.*, p. 15) from an altitude of 6,000 ft., while in Southern India Annandale and Sewell collected one specimen (I. M. Register No. 18993) from a " Small stream near Kotagiri, Nilgiris", *alt.* 5,700 ft.

[1] In the Kangra district there are many hot and cold springs. They contain good quantity of minerals and some of them are beneficial to health and said to cure goitra. For detailed description and water analysis *see Punjab District Gazetteers*, VII, (Part A), p. 328 (1924-25).

Rana tigrina Daudin.

1803. *Rana tigrina* Daudin, *Rain. Gren. Crap.* p. 64, pl. XX.

1920. *Rana tigrina*, Boulenger, *Rec. Ind. Mus.* XX, p. 17 (*forma typica*).

4 adults (2♂♂, 2♀♀) from Dehra Gopipur *alt. ca.* 3,350 ft., 29. VI. 1950. Field notes " From wells on the way to Jwalamukhi from Dehra Gopipur ".

The total length of 4 specimens varies between 69 to 93 mm.

Boulenger (*loc. cit.*, p. 20) has separated *Rana tigrina* (forma typica) into two distinct varieties *e.g. crassa* Jerdon and *pantherina* Firtz. The separation is mainly based on the presence or absence of the glandular folds found on the dorsal aspect of the specimens. The number of longitudinal glandular fold of the specimens under report are as follows :—

2♀♀, specimens with 12 and 8 folds.

2♂♂, ,, 8 and 6 ,,

The number of glandular folds of the specimens under report tallies with that of *Rana tigrina* (forma typica).

The variety *crassa* Jerdon is distributed from the United Provinces to Ceylon through Madras and Malabar, while *pantherina* Firtz., is found in Burma, Siam, French Indo-China. The typical form of the species is very widely distributed. In the Eastern Himalayas it has been recorded from the Darjeeling district *alt. ca.* 7,000 ft.

Rana limnocharies Weigm.

1835. *Rana limnocharies* Weigm., *N. Acta Ac. Leop-Carol.* XVII, p. 255.

1920. *Rana limnocharies*, Boulenger, *Rec. Ind. Mus.* XX, p. 28.

5 juv. (unsexed) from Swan Naddi, 1½ miles beyond Garget alt. 2,000 ft., Hoshiarpur district, 28. VI. 1950. Field notes : " A large number of frogs were present among wet pebbles by the side of the stream".

1 juv. (unsexed) from " A stream near P. W. D. Dak Bungalow at Jogindranagar ", 23. VI. 1950.

In the Eastern Himalayas (Sikkim), it was collected from an alt. 7,000 ft. It has also been recorded from the plains as well as from the high hills in the Western Himalayas.

Rana himalayana Boulenger.

1888. *Rana himalayana* Boulenger, *Ann. Mag. Nat. Hist.* (6) II, p. 50 (type locality : Darjeeling district, Eastern Himalayas, *alt.* not mentioned).

1920. *Rana himalayana*, Boulenger, *Rec. Ind. Mus.* XX, p. 219.

2 adult ♂♂, from Naggar Nala at Naggar on the road from Naggar to Manali *alt. ca.* 6,200 ft., Kulu sub-division of the Kangra district, 15. VI. 1950.

In both the specimens the hind limbs are long and the toes with larger discs, but smaller than those of the fingers and instead of being completely webbed, they are webbed from little below the tip. Fingers rather slender and less stouter than the specimens found in the Eastern Himalayas.

In 1888, Boulenger (*loc. cit.*, p. 50) designated 4 specimens (2♂♂, 2♀♀) collected from Darjeeling, Eastern Himalayas as the types. It will be evident from the measurement chart that the Kangra valley specimens are slightly smaller in size than the types, with the exception of snout (1 mm.); eye (0·5 mm.) and the first finger (1 mm.), and with the rest of the measurements they almost tally with the types.

Measurements in millimeters.

	Type specimens[1] E. Himalayas			Kangra valley Coll. W. Himalayas			
	♀	♀	Average	♀	♀	Average	Deviation
From snout to vent ..	83	80	81·5	79	77	78	3·5
Head	27	27	27	27	25	26	1
Width of the head ..	28	29	28·5	28	27	27·5	1
Snout	9	9	9	10	10	10	1
Eye ..	9	9	9	9	10	9·5	0·5
Inter orbital width ..	7	6	6·5	6	6	6	0·5
Tympanum	3	3	3	3	3	3	..
Fore limb ..	67	65	66	64	65	64·3	1·5
First finger ..	11	11	11	12	12	12	1
Second finger	15	15	15	14	14	14	1
Third finger ..	23	22	22·5	23	22	22·5	..
Fourth finger ..	17	17	17	16	14	15	2
Hind limb	150	162	156	151	145	148	8
Tibia	50	52	51	44	42	43	8
Third toe	26	28	27	26	26	26	1
Fourth toe	39	42	40·5	35	37	36	3·5
Fifth toe	30	31	30·5	27	31	29	1·5

It has been recorded from the Eastern Himalayas, Lebong alt. 6,000 ft., Darjeeling district. In the Indian Museum collection there was a specimen[2] (I. M. Register No. 13587), collected from Simla, Western Himalayas by A. Newnham in 1891. The specimen is not traceable now.

Family Microhylidae.

Microhyla ornata (Dum. and Bibr.).

1841. *Engystoma ornatum* Dum. and Bibr., *Erpet. Gen.* VIII, p. 745 (type locality : Malabar coast).

1934. *Microhyla ornata*, Parker, *Mongr. Microhylidae*, p. 139 (British Museam publication).

1♂ specimen from the main stream of the River Beas at Dehra Gopipur *alt. ca.* 3,350 ft. 29. VI, 1950.

Traces of the rudiment of webs present in the toes. There is a distinct old across the chest.

Length from snout to vent 24 mm.

In the Eastern Himalayas it has been recorded from Sukhna, Darjeeling district. Boulenger[3] has mentioned about a specimen collected from Kashmir.

[1] We have not been able to examine the type specimens as they are not available in the Indian Museum collection. For the sake of preparing a comparative chart, the measurements of the ♀ type specimens have been drawn from Boulenger's paper in the *Rec. Ind. Mus.* XX. p. 220 (1920).

[2] Sclater, W. L., *List of Snakes in the Indian Museum*, p. 11, (1892).

[3] Boulenger, G. A ,*Faun. Brit. India*, Rept. and Batr. p. 492 (1890).

ON SOME DEEP-SEA MOLLUSCS FROM THE INDIAN OCEAN, WITH DESCRIPTIONS OF THREE NEW SPECIES (BIVALVIA).

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[Plate IV.]

Introduction.

In the unnamed spirit collections of the Zoological Survey of India I happened to come across one bottle containing some bivalves of the families Nuculidae, Lyonsiidae, Poromyidae and Cuspidariidae and bearing the locality-label ' Indian Ocean ' The specimens were medium-sized, mostly thin-shelled, and found to represent the genera *Nucula, Lyonsia, Cetoconcha* and *Cuspidaria*. Some of them, on a closer study, proved to be new to science, since the peculiarities as observed in their shell-characters did not seem to agree with any of the known forms of these genera described so far. They are designated here as *Nucula prestoni, Lyonsia annandalei* and *Cetoconcha indica*. Besides these, there was one specimen of the genus *Cuspidaria* representing the well-known species *C. macrorhynchus* Smith (1895) and also one of *Cetoconcha* representing the rare species *C. eximia* (Prashad, 1932) hitherto known only from the Flores Sea, north of Sumbawa. Although the exact locality and depths at which these specimens were collected are not known, they may be classed with the deep-water molluscs in view of the form, texture, sculpture, colouration and affinities.

My cordial thanks are due to Dr. S. L. Hora, Director, Zoological Survey of India, for his useful suggestions and criticism. The figures used in this paper are all sketched by Sri A. K. Mondal, artist of this department, to whom my thanks are also due.

Family Nuculidae.

Genus **Nucula** Lamarck, 1759.

Subgenus **Acila** H. & A. Adams, 1858.

Nucula prestoni, sp. nov.

(Plate IV, figs. 1-3).

There are two very good specimens in the collection which I assign to this new species. They possess thick shells unlike any other in the collection and appear on a cursory view to be somewhat identical with *Nucula (A.) granulata* Smith (1906)[1] from the west of Burma in the

[1] Smith, E. A. *Ann. & Mag. Nat. Hist.* (7) XVIII, pp. 251, 252 (1906); *Illustr. Zool. R. I. M. S.* ' *Investigator* ', *Moll.* Part VI, pl. xxiii, figs. 1, 1a (1909). See also Prashad's paper in *Archiv f. Naturges. N. F. II, pp.* 134, 135 (1933) and Winckworth's paper in *Proc. Malac. Soc. London,* XXIV(1), p. 25 (1940).

Bay of Bengal, in 448 fathoms. But a careful examination reveals certain very interesting features in their shell-characters which may amply justify their separate specific rank. So, I consider it a great pleasure to associate with this new species, *Nucula prestoni*, the name of the late Mr. H. B. Preston who contributed so much towards our knowledge of the Molluscan fauna of India.

The remarkable features which may easily distinguish this interesting species from its nearest ally *N. granulata* are :—

(i) The radiating ridges (see figs. 1, 2) on the surface of the shell are quite simple and lack entirely in granules or pustules so characteristic of *granulata*, but appearing more stronger, oblique, regular and distant, though less in number (16). They, no doubt, divaricate anteriorly like those of the latter, but their upward limbs are stronger, oblique and less in number, though showing slight granulations here and there. Moreover, they show slight knob-like dilatations at the end (see fig. 3) on both the sides. But what is more remarkable is that some of them even appear bifid or trifid at the end—a feature recalling that found in the teeth of the well-known cowry, *Staphylaea consobrina consobrina* (Garrett).

(ii) The umbonal caps are quite plain, but bear no radiating ridges at all.

(iii) The postero-ventral end of the shell is not so produced and, consequently, the angle formed there appearing somewhat blunt or less pronounced.

But its resemblance to *granulata* is also quite close, *i.e.*, its shell is ovate, subtrigonal, tumid and olivaceous green like that of the latter. Moreover, the difference in size of the shells between these two species also appears quite negligible. Because the holotype of *granulata* is known to measure 15 mm. in length, 11 mm. in height and 7 mm. in diameter, while that of *prestoni* measures 13 mm. in length, 11 mm. in height and 7 mm. in diameter. The paratype of the latter measures $12\frac{1}{2}$ mm. $\times 10\frac{1}{4}$ mm. $\times 7$ mm.

Type-locality.—Indian Ocean.

Holotype.—Reg. No. M 16107/2 Zool. Surv. Ind.

Paratype.—Reg. No. M 16108/2 Zool. Surv. Ind.

Remarks.—The new species *Nucula* (*A.*) *prestoni* differs from its ally *N. granulata* Smith not only in the essential characters of its shell, but also in its distribution. It is important to note here that the discovery of this new form marks the third occurrence of the subgenus *Acila* in the Indian waters, the 1st and 2nd being represented by *N. fultoni* Smith (1892) from the Bay of Bengal, off the mouth of the River Hooghly (in deep water) and *N. granulata* from the west of Burma respectively as pointed out by Prashad in his paper on the revision of the Indian Nuculidae (1933, p. 35).

Family LYONSIIDAE.

Genus **Lyonsia** Turton, 1822.

Subgenus **Lyonsia** S. S.

Section ALLOGRAMMA Dall, 1903.

Lyonsia annandalei, sp. nov.

(Plate IV, figs. 4, 5.)

There is only one very handsome and interesting specimen in the collection which I designate as *Lyonsia annandalei* after the late Dr. N. Annandale, Founder-Director of the Zoological Survey of India, who made notable contributions to Indian Zoology. The species is described as follows :—

Shell medium, very thin and fragile, whitish, translucent, inequilateral, oblong—slightly more than *Lyonsia formosa* Jeffreys[1] off Gomera, Canaries (620 fathoms), off Carysfort in the Gulf of Mexico (349 fathoms) and Bay of Biscay (552-600 fathoms), somewhat quadrate, subcompressed, marked by very low, regular, rounded, poorly defined concentric folds throughout somewhat-like those in *L. oahuensis* Dall-Bartsch-Rehder[2] from the south coast of Oahu in Hawaii ; posterior side subtruncate as in *oahuensis* looking somewhat-like the unedged blade of a blunt chisel and bearing regular, close-set series of minute nodular spines (more prominent than in *formosa*) arranged longitudinally on diagonal flexuous ribs appearing more in number (10 to 11) and prominent than in the latter (only 6 to 8)—the innermost one of which is the largest and strongest of all and forms a distinct carina as in *formosa*, but slightly more produced below and, as such, the angle formed there appearing more pronounced, dorsal margin of this side slightly more incurved than in the latter ; anterior side obliquely rounded with slight elevation at the end and concavity at the dorsal margin, but, unlike *formosa*, lacking entirely in radiating ridges ; in the middle of the shell are five (instead of only one as in *formosa*) very strong and conspicuous, keel-like, slightly oblique radiating ridges which originate from the umbones and bear similar nodular spines as on the posterior side (though the nodules appear less stronger and bear less sharp spines)—the ridges being placed quite apart from one another with the interstices between them gradually becoming more narrow from behind forwards ; umbones almost median and slightly elevated with the beaks slightly inclined towards the anterior side ; ventral margin rendered greatly wavy by the external sculpture.

The presence of strong radiating ridges on the surface of the shell of this new species amply justifies its position, like that of *formosa*, into the section *Allogramma* Dall[3] of the subgenus *Lyonsia*. The shell measures 13·1 mm. in length, 8·6 mm. in height and 5 mm. in diameter.

[1] Jeffreys, J. G. *Proc. Zool. Soc. London*, p. 930, pl. lxx, fig. 1 (1881). See also Smith's paper in *Zool. Chall. Exped.* XIII, Pt. XXXV, p. 72, pl. vi, figs. 3-3b (1885).

[2] Dall, W. H., Bartsch, P. and Rehder, H. A. *Bernice P. Bishop Mus. Bull.* No. 153, pp. 215, 216, pl. lvi, figs. 9-12 (1938).

[3] Dall, W. H. *Trans. Wagner Free Inst. Sci.* III, pt. 6, p. 1514 (03).

Type-locality.—Indian Ocean.

Holotype.—Reg. No. M 16109/2 Zool. Surv. Ind.

Remarks.—*Lyonsia* (*A.*) *annandalei*, no doubt, appears closely allied to Jeffreys's *formosa* and Dall-Bartsch-Rehder's *oahuensis*, but differs markedly from both in certain very essential features already discussed above. Preston's *L. samalinsulae*[1] off Samal Id., Chilka Lake, Orissa, also differs greatly from this new species both in regard to shape and sculpture of its shell. Jeffreys while describing his species *formosa* made an interesting remark : " A most lovely shell, and one of the prizes of the deep-sea dredger." The shell of the new species is also very pretty.

Family Poromyidae.

Genus **Cetoconcha** Dall, 1886[2].

Cetoconcha was introduced by Dall as a section of the genus *Poromya* Forbes (1844). But it so appears in the explanation of his pl. viii, fig. 10 concerning the new species *margarita* that he has given a clear indication, probably unconsciously, as to the use of *Cetoconcha* as a distinct genus. Woodring (1925)[3], Smith (1895)[4] and Prashad (1932)[5] seem to have upheld the former view, while Thiele (1935)[6] and Winckworth (*loc. cit.*, p. 28, 1940) the latter view, to which I also fully subscribe. Fulton (1924)[7], Thiele and Dall-Bartsch-Rehder (*loc. cit.*, p. 223) have rightly followed Dall in adopting the family name Poromyidae instead of Poromyacidae as used by Woodring, Prashad, and Smith-Gordon (1948)[8].

Woodring in dealing with the genus *Poromya* remarked : " There are only a few Tertiary and living species of *Poromya*. The living species, some of which are deep-water dwellers, have a restricted distribution around the borders of the Atlantic and Pacific." Prashad's account of *Poromya* in the Siboga Expedition volume also appears to support more or less the same view. But the discovery of such deep-water forms, namely, *Cetoconcha tornata* (Jeffreys) by Smith (*loc. cit.*, p. 11, 1895) on the east of Ceylon (in 1997 fathoms) which was hitherto known only from the great depths of the Atlantic and *C. indica*—the new species described below, in the Indian waters leaves no doubt about the fact that the range of the genus has certainly crossed the borders of the Atlantic and Pacific and extended into the far south-east Asia.

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[1] Preston, H. B. *Rec. Ind. Mus.* X, pp. 305, 310, text-figs. 16, 16a (1914); *ibid.* XI, p. 309 (1915).

[2] Dall, W. H. *Bull. Mus. Comp. Zool. Harvard Coll. Camb. Mass.* XII, pp. 195, 280 (1886).

[3] Woodring, W. P. *Miocene Moll. from Bowden, Jamaica, Pelecypoda*, 1, p. 88 (1925).

[4] Smith, E. A. *Ann. & Mag. Nat. Hist.* (6) XVI, p. 11 (1895).

[5] Prashad, B. *Siboga-Exped. Monogr. Pelecypoda*, LIIIc, p. 326 (1932).

[6] Thiele, J. *Handb. der Syst. Weichtierk.* II, p. 946 (1935).

[7] Fulton, H. G. *Shells of Rec. Moll.*, p. 32 (1924).

[8] Smith, A. G. and Gordon, M. *Proc. Calif. Acad. Sci.* (4) XXVI(8), p. 172 (1948).

Cetoconcha indica, sp. nov.

(Plate IV, figs. 6, 7.)

Two specimens represent the genus *Cetoconcha* in the collection, They exhibit some novelty as regards shape, size and other important characters of their shells. So, I propose to describe them as a new species under the name of *C. indica*. The following is a description of the species :—

Shell medium, subglobose, somewhat inflated, inequivalve, somewhat longer than high, bluntly rostrate posteriorly, compressed and vertically striated in the rostral area, pale straw coloured as in *P.* (*C.*) *eximia* Prashad (*loc. cit.*, p. 327, pl. vii, figs. 31, 32), granulations on the surface ill-defined, less in number but confined only to the margin of the shell, concentric striations on the surface somewhat regular ; umbones central but not so much inflated and prominent as in *eximia*, beaks rather inclined towards the anterior side ; posterior side distinctly truncated and beak-like—the beak appearing shorter and slightly more upwardly placed than in the latter, with a distinct angulation (about 135°) at its dorsal margin just below the umbonal area and great contraction at its ventral margin resulting in a greater convexity below in the postero-median ventral margin ; anterior side somewhat obliquely rounded as in *Cetoconcha* (=*Pecchiolia*) *tornata* (Jeffreys)[1] with the dorsal margin only slightly incurved and the ventral margin slightly contracted. The shells measure 12·6 mm. in length, 11·8 mm. in height and 7·5 mm. in diameter (holotype) and 11¼ mm. × 11 mm. × 7¼ mm. (paratype) respectively.

Type-locality.—Indian Ocean.

Holotype.—Reg. No. M 16110/2 Zool. Surv. Ind.

Paratype.—Reg. No. M 16111/2 Zool. Surv. Ind.

Remarks.—The new species *Cetoconcha indica* shows some resemblance to *C. eximia* (Prashad) and *C. tornata* (Jeffreys) i certain important features of its shell, but the difference is also quite remarkable.

Cetoconcha eximia (Prashad, 1932).

1932. *Poromya* (*Cetoconcha*) *eximia*, Prashad, *Siboga Exped. Monogr. Pelecypoda*, LIIIc, p. 327, pl. vii, figs. 31, 32.

This very rare species is represented in the collection by a single specimen which in form, colouration and sculpture appears to correspond to Prashad's description and figures. But its occurrence in the Indian waters is rather remarkable and extends its range more westwards.

Family CUSPIDARIIDAE.

Genus **Cuspidaria** Nardo, 1840.

Subgenus **Cuspidaria** S. S.

Cuspidaria macrorhynchus Smith, 1895.

Type-locality.—Off West Coast of India in the Arabian Sea, 363 fathoms.

1895. *Cuspidaria macrorhynchus*, Smith, *Ann. & Mag. Nat. Hist* (6) XVI, p. 12, pl. ii, figs. 5, 5a.

[1]Jeffreys, J. G. *Ann. Mag. Nat. Hist.* (4) XVIII, p. 494 (1876). The species is figured by Smith in *Zool. Chall. Exped.* XIII, pl. xxv, nos. 9-9b (= *Verticordia*), 1885.)

1897. *Cuspidaria macrorhynchus*, Smith, *Illustr. Zool. R. I. M. S.* '*Investigator*', *Moll.*, pl. iii, figs. 5, 5a.

1931. *Cuspidaria macrorhynchus*, Thiele and Jaeckel, *Wiss. Ergebn. deuts Tiefsee—Exped.* XXI, p. 225.

1932. *Cuspidaria* (*Cuspidaria*) *macrorhynchus*, Prashad, *Siboga Exped. Monogr. Pelecypoda*, LIIIc, p. 328, pl. ix, fig. 17.

1937. *Cuspidaria macrorynchus*, Viader, *Maur. Inst. Bull.* 1(2), p. 69.

1940. *Cuspidaria macrorhynchus*, Winckworth, *Proc. Malac. Soc. London*, XXIV(1), p. 28.

Smith's name *macrorhynchus* for the species, though unanimously adopted by all workers, appears to have been wrongly spelled by Viader as '*macrorynchus*' Smith has clearly pointed out the close affinity of this form with his species, *C. Woollastoni* (after T. V Wollaston), from the Atlantic (*loc. cit.* p. 40, pl. x, 1885, figs. 6-6b, a little west of the Azores, 1,000 fathoms) in the general appearance of its shell and also its marked difference from the latter in the character of the rostrum. Prashad has also fully corroborated his statement.

The single specimen of *C. macrorhynchus* in the collection appears to agree with Smith's description and figures. Moreover, the small size of its shell measuring 22½ mm. in length, 9 mm. in height and 7½ mm. in diameter (with the rostrum 9¾ mm. in length) agrees somewhat closely with the holotype of *macrorhynchus* measuring 22 mm. × 9 mm. × 8 mm.

Distribution.—*Cuspidaria* (*C.*) *macrorhynchus* Smith was originally recorded from the Arabian Sea, but subsequently known from Mauritius, Sulu Sea and Timor Sea.

ON TWO NEW GASTROMYZONID FISHES FROM BORNEO.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., C.M.Z.S., F.A.S., F.N.I., Director,* and K. C. JAYARAM, *B.Sc., Assistant, Zoological Survey of India, Calcutta.*

The specimens under report formed part of a collection of fishes and other animals made by Mr. J. A. Griswold Jr. in the mountain streams of British North Borneo. The material is now preserved in the Museum of Comparative Zoology at Harvard, Cambridge Mass., U.S.A. The circumstances under which these Gastromyzonid fishes were found in this collection have been described by Hora,[1] with brief comments on the forms already known to science. On the basis of this material, the systematic positions of *Protomyzon* Hora and *Glaniopsis* Boulenger have been elucidated by Hora and Jayaram[2] in two short articles. Two specimens were found in the lot which appeared to represent new species, one belonging to *Protomyzon* and one representing a new genus allied to *Gastromyzon* Günther. These species are of great interest for the study of the phylogeny of the Gastromyzonidae and, therefore, they are described here inspite of the fact that each is represented by a single specimen.

We wish to record here our sincerest thanks to Dr. Henry B. Bigelow and Dr. W. C. Schroeder for making the entire collection of Gastromyzonid fishes available to us in Calcutta for detailed study.

Progastromyzon, gen. nov.

The new genus comprises small, flattened fishes, in which the snout is broad and rounded and is provided on the dorsal surface with short tubercles. The mouth is broad and transverse, and is bordered by fleshy lips. The posterior lip is fimbriated. The anterior lip is covered by a rostral hood which is notched in four places to accommodate the four short rostral barbels. There are two short maxillary barbels also, one at each corner of the mouth. The gill-openings are restricted to the dorsal surface, just extending to the bases of the pectoral fins. The paired fins are well-developed and horizontal. The pectorals possess 22 rays each, of which only one is unbranched. The pelvics have 10 rays each, of which only one is unbranched; they are converging but not united to form a disc as in *Gastromyzon* and *Neogastromyzon*. Some of the anterior rays in both the fins are provided with adhesive pads. The body is covered with small scales which are much reduced on the ventral surface and are absent altogether between the bases of the pectoral fins. Behind the bases of the pectoral fins, there are narrow lateral extension of the body which are so characteristic of *Gastromyzon* and *Neogastromyzon*.

The new genus, as constituted above, represents a stage in the evolution of *Gastromyzon*; their close similarity is evident from the form and

[1]Hora, S. L. *Rec. Ind. Mus.* XLVIII, p. 50 (1950).
[2]Hora, S. L. & Jayaram, K. C., *Rec. Ind. Mus.* XLVIII, pp. 61-68; 85-88 (1950).

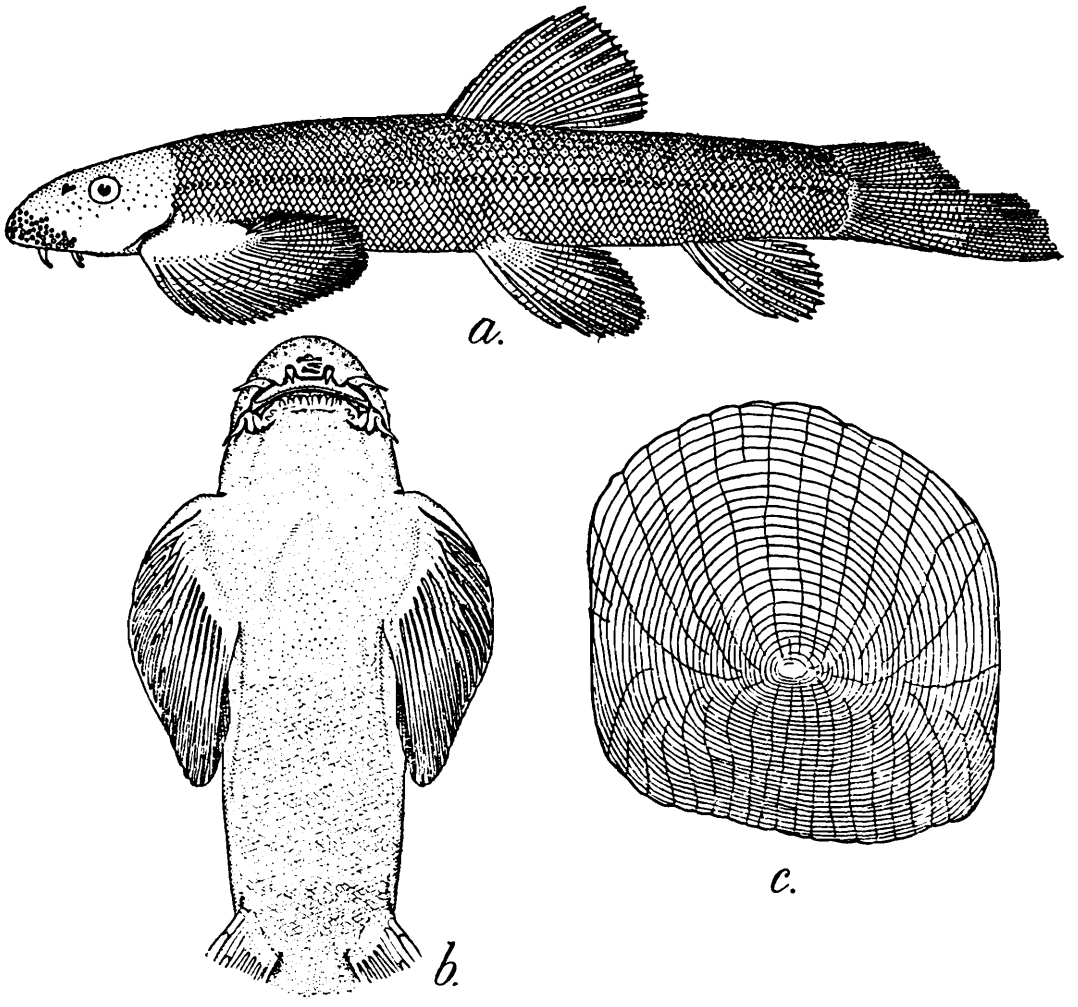
structure of the mouth parts. The differences lie in the disposition of the pelvic fins and the relative development of the lateral skin flaps.

Genotype.—Progastromyzon griswoldi, gen. *et.* sp. nov.

Progastromyzon griswoldi, gen. *et.* sp. nov.

D.3/8; A.2/5; P. 1/21; V. 1/9; C.18 (damaged).

For a description of the general features of the species, reference may be made to the description of the genus given above.



TEXT-FIG. 1.—*Progastromyzon griswoldi*, gen. *et* sp. nov.

a. Lateral view: × 1½; *b*. Ventral surface of head and body: × 2; *c*. Scale from below the dorsal fin: × 45.

The length of the head is contained 4·5 times and the depth of the body 6 times in the standard length. The height of the head is equal to the length of the snout. The eyes are dorso-lateral in position and are equal to one-third the length of the snout. The interorbital distance is equal to 2·5 times the diameter of the eye. The nostrils are situated close to the eyes and are fairly conspicuous.

The origin of the dorsal fin is slightly in advance of that of the pelvics and is nearer to the base of the caudal fin than to the tip of the snout. The pectorals are provided with muscular bases, which are devoid of scales; they are separated from the pelvics by a distance nearly equal to half of their length. The pelvics are almost as long as the head and do not extend as far as the anal fin which just misses the caudal fin. The caudal peduncle is almost as long as high.

The lateral line is complete. There are 79 scales along it, 9 above it to the base of the dorsal fin and 9 below it to the insertion of the pelvic fin. A scale from below the base of the dorsal fin and above the lateral line is slightly longer than broad with a horizontal basal portion and a rounded apical portion. The nucleus is small and well-defined ; it is considerably nearer the base than the apex. There are 36 circuli and 38 radii, of which only 17 reach the centre. In general structure, the scale is similar to that of *Gastromyzon borneensis*[1] though the latter is more elongated with the apex more conical.

The colour in spirit is olivaceous brown above and yellowish below. The upper surface of the head is greyish and the fins light grey.

Locality.—Kina Balu Mountain, British North Borneo.

We have great pleasure in naming this species after Mr. J. A. Griswold Jr., whose collection has enabled us to elucidate several points in the taxonomy and systematics of the Gastromyzonid fishes of Borneo.

Holotype.—No. CMZ 34806, Museum of Comparative Zoology, Harvard College, Harvard, Cambridge Mass., U.S.A.

Protomyzon borneensis, sp. nov.

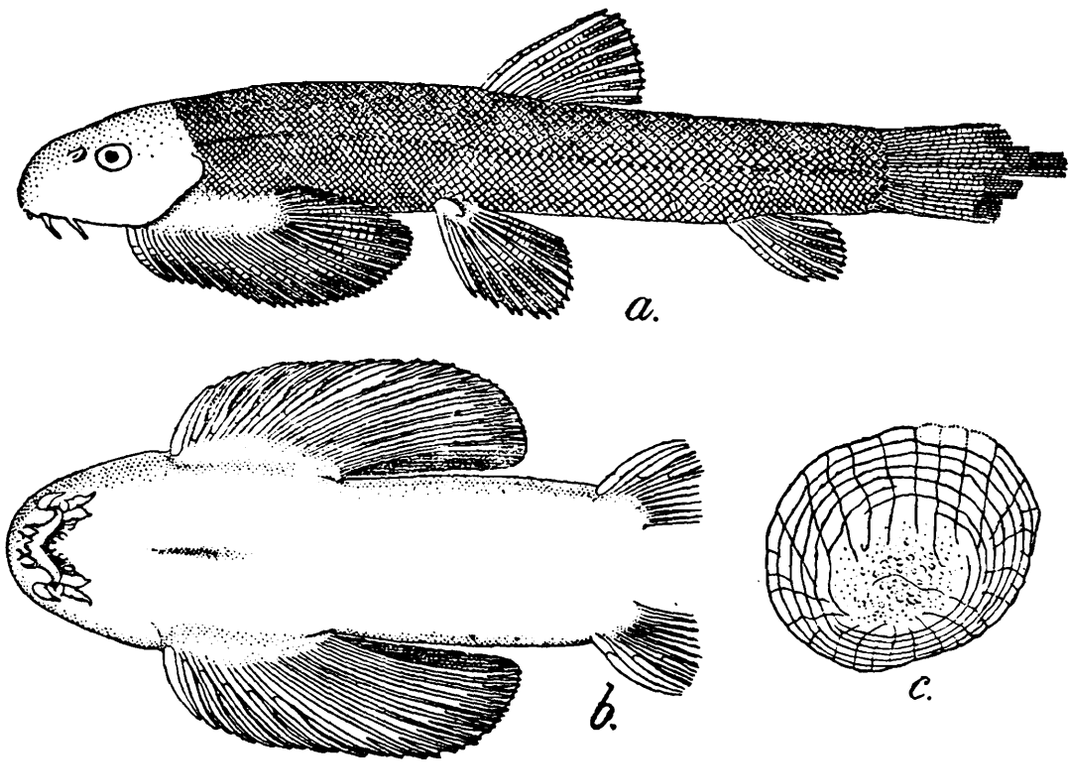
D. 1/6 ; A. 2/4 ; P. 1/22 ; V. 1/8 ; C. 18 (damaged).

Protomyzon borneensis is a small, loach-like Gastromyzonid fish in which the dorsal profile is only slightly arched and the ventral profile is horizontal throughout. The head and the anterior part of the body are greatly depressed and flattened. The length of the head is contained 4·5 times and the depth of the body 8 times in the standard length. The head is not as high as the length of the snout. The snout is smooth and broadly pointed. The eyes are small and dorso-lateral in position ; the diameter of the eye is contained 2 times in the length of the snout and 1·5 times in the interorbital width. The nostrils are prominent and are situated just before the eyes. The mouth is small and lunate ; it is situated on the ventral surface considerably behind the tip of the snout. The lips are fleshy and continuous ; the upper lip overhangs the mouth and is papillated. The rostral fold does not cover the anterior lip and is produced into finger-like processes. There are two pairs of short, stumpy rostral barbels and a pair of maxillary barbels at each corner of the mouth. The gill-openings are restricted to the dorsal surface and extend as far as the bases of the pectoral fins.

The origin of the dorsal fin is slightly behind that of the pelvics and is nearer the base of the caudal than the tip of the snout. The pectorals are well-developed, are longer than the head and are provided with strong muscular bases ; they are horizontal with several anterior rays acting as organs of adhesion. They are separated from the pelvics by a considerable distance. The pelvics have converging bases but are not united to form a disc-like structure. Only one ray of the paired fins is simple. The pelvics extend beyond the anal opening but are separated from the anal fin by a great distance. The anal fin misses the base of the caudal. The caudal peduncle is slightly longer than deep.

[1]Law, N. C. *Rec. Ind. Mus.*, XLVIII, p. 81, pl. iv, fig. 10(1950).

The scales are small and closely set. There are about 77 scales along the lateral line and 11 rows above and 14 rows below it. The ventral surface in front of the anal opening and the fleshy bases of the pectoral fins are devoid of scales. The structure of a scale from below the dorsal fin and above the lateral line is very different from that described by Law[1] for *Protomyzon whiteheadi*. The scale is small and more or less rounded, but the nuclear area is disorganised and there are only 6-7 circuli. There are 30 radii of which only 15 reach the disorganised central mass. Law has regarded this disorganization of the scales as a character of specialization. On this criterion, *Protomyzon borneensis* would appear to be more specialized than its only other congener *P. whiteheadi*. This state of affairs is parallelled by the scale structures of *Balitora brucei brucei* (disorganized scale) and *B. b. burmanicus* (less specialized with well-defined scale structures). It may here be noted that the scale of *Parhomaloptera* of Borneo (*vide* Law, *loc. cit.*, p. 79, pl. iv, fig. 12) shows great affinity to the disorganised scale of *P. borneensis*. In the structure of the mouth and its associated parts, the two forms show great resemblance and it is likely, therefore, that *Parhomaloptera* and *Protomyzon* are derived from the same ancestral stock.



TEXT-FIG. 2.—*Protomyzon borneensis*, sp. nov.

a. Lateral view: ×2 ; *b*. Ventral surface of head and body. ×2½ ; *c*. Scale from below the dorsal fin: ×62.

The colour in spirit is olivaceous grey above with the head portion somewhat darker. The ventral surface is pale olivaceous. The fins are greyish.

Locality.—Kina Balu Mountain, British North Borneo.

Holotype.—No. CMZ 34801, Museum of Comparative Zoology, Harvard College, Harvard, Cambridge Mass., U.S.A.

[1]Law, N. C. *Rec. Ind. Mus.* XLVIII, p. 80, pl. iv, fig. 6 (1950).

Relationships.—The new species can be readily distinguished from *P. whiteheadi* by the possession of two barbels at each corner of the mouth (*versus* one), by the absence of scales on the ventral surface in front of the anal fin (*versus* scales extending upto a short distance behind the bases of the pectorals) and by the structure of the scales (compact and well-defined in *P. whiteheadi versus* disorganised in *P. borneensis*). All these features and better developed paired fins indicate that the new species is more specialized than its only other known congener *P. whiteheadi.*

INDIAN SPECIES OF THE GENUS *APUS* (CRUSTACEA BRANCHIOPODA) WITH DESCRIPTION OF TWO NEW SPECIES.

By KRISHNA KANT TIWARI, *M.Sc., Zoologist, Zoological Survey of India, Calcutta.*

INTRODUCTION.

Sometime ago Mr. P. I. Chacko, Assistant Director of Fisheries, Madras State, sent one specimen of *Apus*, collected during April 1949, from the Nagasunni Temple Tank, Tirunelveli District (Madras State), for identification to the Zoological Survey of India. This specimen appears to be closely allied to *Apus sudanicus* Brauer, and may perhaps be identical with it. The discovery of the genus *Apus* in South India is interesting and a note, recording this occurrence, has been published by Mr. Chacko elsewhere.[1] Another lot of sixteen specimens of *Apus* collected by Mr. K. S. Pradhan at Mavli in Rajputana in October 1948, proved to belong to a new species and it is described below as *Apus mavliensis*, sp. nov. Recently Dr. S. L. Hora, Director, Zoological Survey of India, handed over to me two tubes containing reddish and greenish specimens of *Apus* collected at Panchgani. These specimens are identical with those described as *Apus asiaticus* by Gurney from this locality, earlier on two occasions. A detailed study of these specimens, along with other material of *Apus* from Panchgani preserved in the Zoological Survey, has convinced me that the Panchagani examples do not seem to be conspecific with *Apus asiaticus* Gurney (=*Apus granarius* Sars, *nec* Lucas) from Central Asia. I, therefore, propose a new specific name *Apus orientalis*, sp. nov., for the Panchagani examples.

The relative value of the characters, on which species of *Apus* are based, is very doubtful in many cases, since these characters depend to a great extent on the state of preservation of the specimens. Barnard (*vide infra.* pp. 229-234), while assessing the diagnostic value of various characters in the genus *Apus*, suggested that the most reliable characters for specific diagnosis are the shape of carapace, shape of nuchal organ and the number of apodal segments. To these I may add the total number of movable somites, as this character is independent of the state of contraction or expansion of the animal.

The species of *Apus* dealt with in this paper, can be distinguished as follows :—

1. Nuchal organ triangular—
   i. Number of movable somites 41-42 .. .. .. *A. asiaticus* Gurney.
   ii. Number of movable somites 36-39—
      a. Apodal segments 11-13 in females, 12-14 in males. .. .. .. *A. orientalis*, sp. nov.
      b. Apodal segments 8-10 in females .. .. *A. mavliensis*, sp. nov.
2. Nuchal organ oval—
   i. Apodal segments 6-8 in males, 5-8 in females *A. cancriformis* Sch.
   ii. Apodal segments 10 in male .. .. *Apus* sp. prox. *sudanicus* Brauer.

[1]Chacko, P. I., *Journ. Bombay Nat. Hist. Soc.* XLIX, p. 571 (1950).

Systematic Account.

Apus asiaticus Gurney.

1901. *Apus granarius*, Sars, *Ann. Mus. Petersb.*, VI, pp. 131-142, pl. i, figs. 1-7 & pl. ii, figs. 1-12. (*nec. Apus granarius*, Lucas, *Bull. Entom. Paris*, 1864.)

1921. *Apus asiaticus*, Gurney, *Jour. Bombay Nat. Hist. Soc.* XXVII, pp. 836-838.

Gurney proposed a new name, *Apus asiaticus*, for the specimens from the Chinghan Mountains in Central Asia, referred by Sars to *A. granarius* Lucas, and included a collection of *Apus* from Baghdad under the former species. In 1924 and 1925 (*vide infra*) he extended the range of this species to India, by referring to it some examples collected at Panchagani, near Poona (Bombay State).

I have carefully examined a large number of specimens collected at Panchagani on different occasions, and I am of the opinion that these specimens are not identical with the Central Asian forms. I, therefore propose a new name, *A. orientalis*, sp. nov., for the Indian examples.

The Central Asian examples, belonging to *A. asiaticus* Gurney (*s.s.*), differ from the Indian examples in the following features :—

(i) The angles of the nuchal organ are rounded.

(ii) Total number of movable somites are 41-42.

(iii) The abdomen is relatively much longer than carapace and 32-33 abdominal somites are exposed in dorsal view.

(iv) The fifth endite of the first thoracic legs is much shorter than the carapace.

(v) The posterior sinus of carapace is broader and shallower than in *A. orientalis*.

The examples from Baghdad are probably more related to Central Asian forms, referable to *A. asiaticus*.

Apus orientalis, sp. nov.

1924. *Apus asiaticus*, Gurney (pp.), *Ann. Mag. Nat. Hist.* (9) XIV, pp. 566-568.

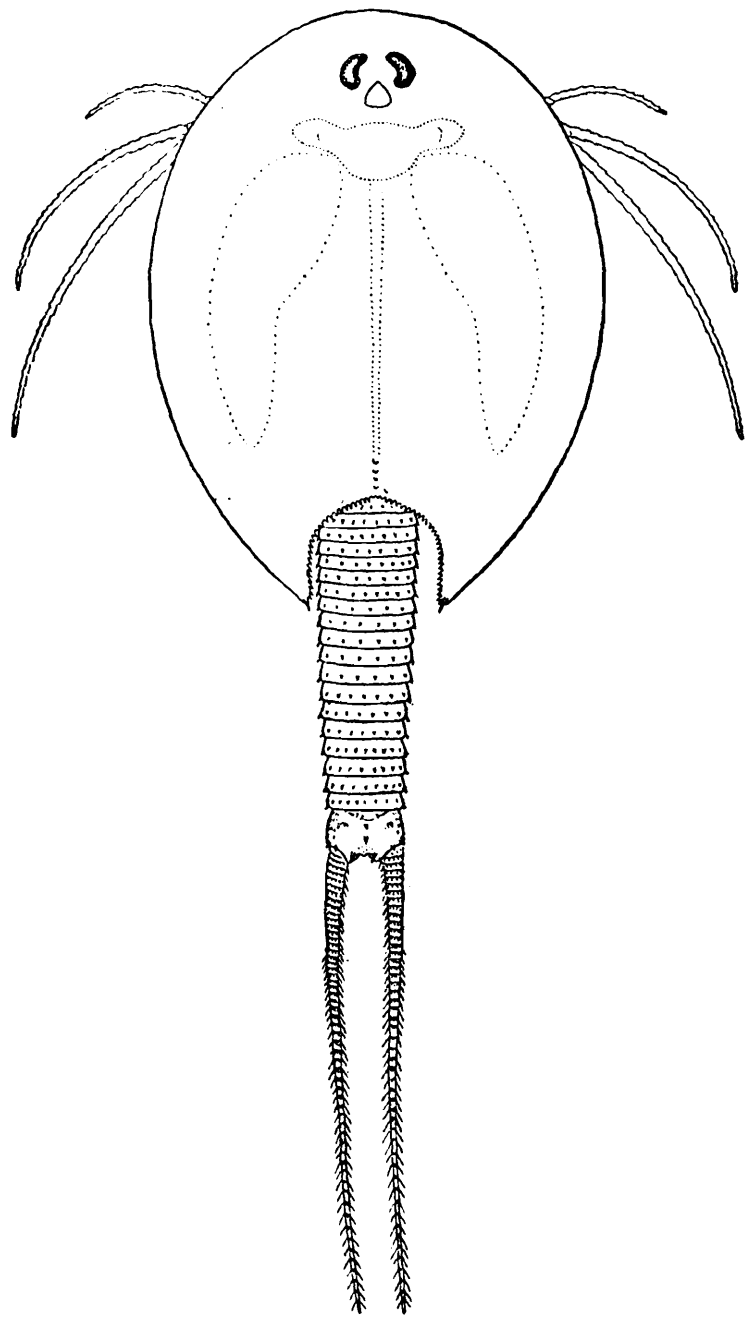
1925. *Apus asiaticus*, Gurney, *Rec. Ind. Mus.* XXVII, p. 440.

This species includes Indian examples from Panchagani, earlier identified by Gurney as *A. asiaticus*.

This species is characterised by the following features :—

Carapace is orbicular and broadly rounded in front (text-fig. 1). The nuchal organ is rounded, with apex somewhat pointed. Posterior sinus is slightly notched in the middle and its outer angles are somewhat produced. It bears 42 to 56 spines on its free edge. The fifth endite of first pair of thoracic legs usually reaches the posterior end of carapace in males.

The exposed part of abdomen in most of the well preserved specimens is longer than carapace in large examples but distinctly sub-equal to, or shorter than the latter in smaller individuals. The caudal furca, when unbroken, are about as long or somewhat longer than the exposed part of abdomen.



TEXT-FIG. 1.—*Apus orientalis*, sp. nov., ♀, dorsal view : ×3.

The number of abdominal somites, exposed behind the posterior limit of carapace is variable to a great extent and depends on the size of the individual as well as the state of its preservation. Although the total number of movable somites of the animal or the number of apodal somites do not vary much with age, the length of abdomen does appear to increase

with growth in this species. There also does not appear to be any sexual dimorphism in the length of abdomen. In 31 individuals (18♂♂,13,♀♀) the following figures express the number of exposed dorsal somites :—

No. of exposed somites (including telson).	No. of specimens.
18	1
19	3
20	3
21	2
22	5
23	7
24	2
25	6
26	..
27	1
28	1
	31

The apodal somites are less variable in number and seem to be correlated with sex. In 45 specimens of both sexes the number of apodal somites (including the telson) is as under.—

No. of apodal somites.	No. of specimens. ♂♂	♀♀
11	—	1
12	5	13
13	21	1
14	4	—
	30	15

Thus, generally speaking, males have 13 and females have 12 apodal somites, although the ranges are 11-13 for females and 12-14 for males. The total number of movable somites varies from 37-39 (generally 38-39). The telson (text-fig. 3*b*) resembles that of *A. asiaticus*.

Gurney (1925) states that " females are deep green in colour while males are paler and tend towards a brownish tinge " To me, however, the coloration appears to be independent of sex. I have examined two freshly collected samples of this species from Panchagani. One of the samples was labelled as " greenish variety " while the other was " reddish variety " In both these samples males outnumbered the females, there being two females and eleven males in the " greenish " sample while only one female and ten males in the " reddish " one. These two

samples were almost similar, except that the reddish specimens had the exposed part of abdomen somewhat shorter and with lesser number of segments.

Distribution.—Panchagani, Satara District (Bombay).

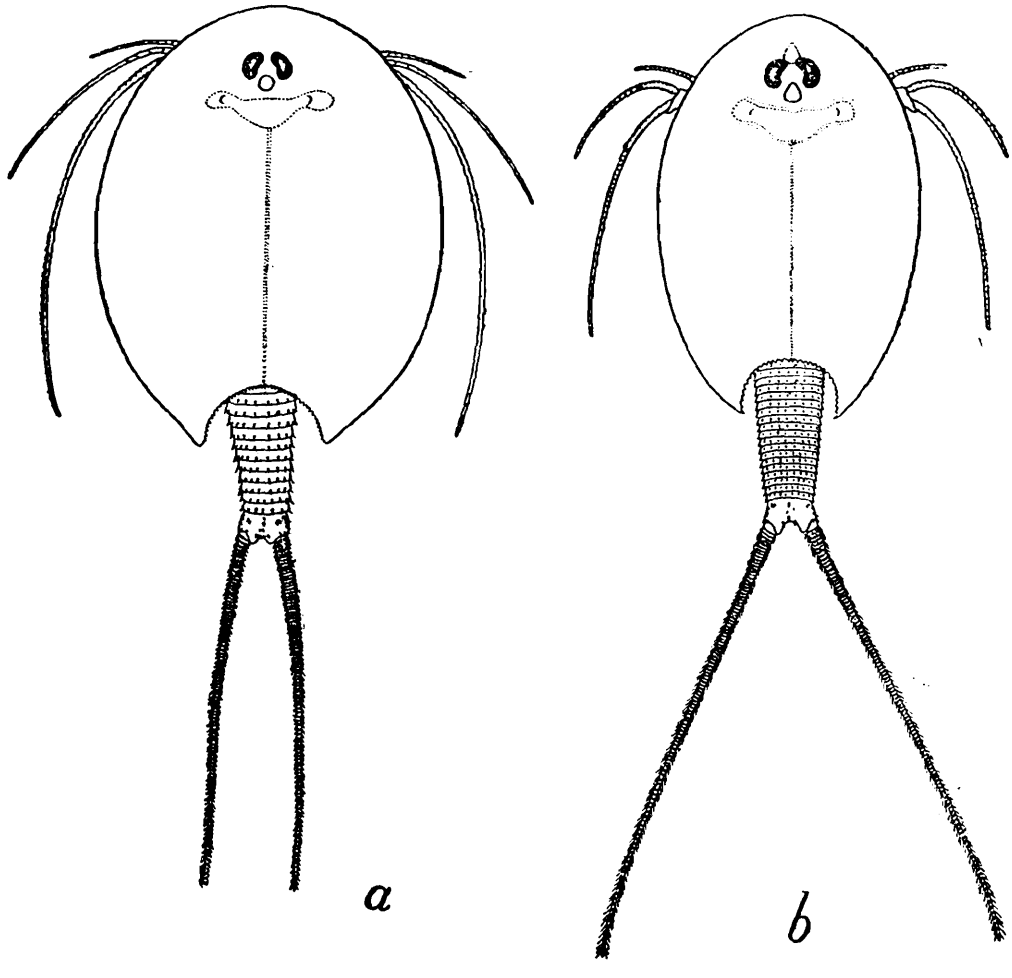
Apus mavliensis, sp. nov.

Diagnosis.—Carapace oval, somewhat longer than broad. Nuchal organ triangular. Apodal segments 8-10 in females. Fifth endite of first thoracic leg shorter than the median length of carapace. Caudal furca somewhat longer than or sub-equal to the body. Females 8·8 mm. to 15·8 mm. in body length (excluding caudal furca).

Holotype.—♀, Regd. No. C3066/1, Zoological Survey of India.

Paratypes.—16♀♀, Regd. No. C3067/1 Zoological Survey of India.

Locality.—Mavli (Jodhpur State), Rajasthan.

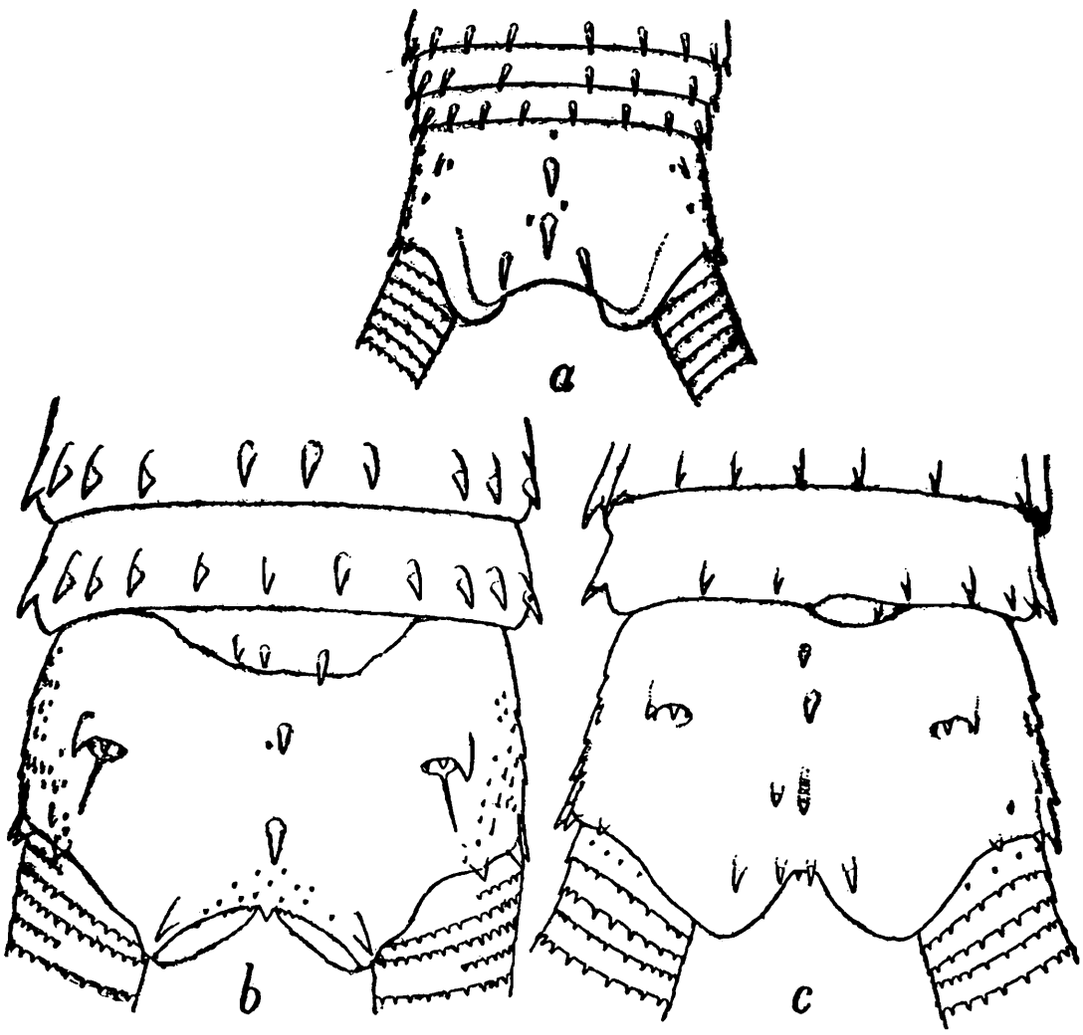


TEXT-FIG. 2.—*a. Apus* sp. prox *sudanicus*, ♂ dorsal view : ×3 ; *b. Apus mavliensis*, sp. nov., ♀ dorsal view : ×4½.

Description.—There are sixteen females of this new species present in the collection, varying in length from 8·8 mm. to 15·8 mm. The carapace is oval (text fig. 2*b*). The median carina is quite prominent, being about two-third as long as the total length of carapace. The nuchal organ is triangular in shape. The posterior sinus is rounded,

and bears from 36 to 44 small denticles. The posterior edge of carina is minutely serrate and the postero-dorsal surface of the carapace bears very fine spinules. The fifth endite of the first pair of thoracic appendages is shorter than the carapace. The fourth endite is about half as long as the fifth.

In the specimens before me the exposed part of the abdomen is shorter than the median length of carapace. The table on page 205 gives measurements of some female examples in this species. In the larger specimens the exposed part of abdomen is appreciably more than one-third of the total length of the body, but in shorter specimens it is only about one-third of the body length. The number of abdominal somites exposed behind the sinus varies from 20 to 24.* There are nine or ten, rarely eight, apodal somites. The number of post-genital somites varies from 25 to 27. Each abdominal ring bears a transverse row of six to nine dark, stout, backwardly directed dorsal spines, and somewhat more numerous and weaker ventral spines.



Text-fig. 3.—Dorsal surface of telson in *Apus*.

a. *Apus mavliensis*, sp. nov. : ×27 ; *b*. *Apus orientalis*, sp. nov. : ×27 ; *c*. *Apus* sp. prox *sudanicus* : ×27.

Telson (text-fig. 3*a*) is broader than the last abdominal ring, and conspicuously emarginate in the middle. The number of spines on its dorsal surface is variable. There is a median row of two or three moderately large spines, but in some cases there are shorter spinules between

* The number of somites includes the telson.

these. There are one or two spines on the posterior edge, on each side of the median row, which do not project beyond the telsonic edge. The lateral edges, above the insertion of the caudal appendages, bear some spines. The ventral surface is rough, and beset with minute spinules.

The caudal furca, when unbroken, are somewhat longer than the body, or sub-equal to it. In the basal region, each ring of the furca, bears one transverse scaly row on the margin, and another row of spines along the middle of the ring. Towards the distal region the scaly rows are replaced by circlets of bristles.

Eggs are spherical, measuring 0·44 mm. in diameter.

Affinities.—This species very closely resembles *Apus orientalis*, Tiwari from Panchagani (Bombay State, India). The following table gives the differences between *A. mavliensis*, sp. nov. and *A. orientalis*, Tiwari :—

A. mavliensis, sp. nov.	*A. orientalis*, Tiwari.
i. Carapace oval, being longer than broad.	i. Carapace proportionately broader than in *A. mavliensis*.
ii. Posterior sinus rounded with the angles not produced.	ii. Posterior sinus slightly notched in the middle. External angles somewhat produced.
iii. Exposed part of abdomen shorter than the median length of carina.	iii. Exposed part of abdomen longer than the median length of carina.
iv. No. of apodal segments generally 9-10.	iv. No. of apodal segments 11-13 in females, 12-14 in males.
v. Caudal furca sub-equal to body.	v. Caudal furca much shorter than body.

Apus orientalis attains a larger size than *A. mavliensis*. The pattern of telsonic armature does not differ much in the two species.

Apus cancriformis Sch.

1911. *Apus cancriformis*, Kemp, *Rec. Ind. Mus.* VI, pp. 353-357.
1925. *Apus cancriformis*, Gurney, *ibid.* XXVII, pp. 439-440.
1931. *Apus cancriformis*, Barnard, *Ann. S. Afr. Mus.*, XXIX, p. 241.
1934. *Apus cancriformis*, Bond, *Mem. Connecti. Acad. Sci.* X, p. 55. fig. 16.

The nuchal organ in this species is oval. Carapace is vaulted, and the median carina projects into the posterior sulcus, as a short spine. The abdomen is relatively very short. Number of apodal segments is five to seven according to most authors but in the examples seen by me the apodal segments were 6-7 in number. The total number of movable somites is 34-35; generally the examples with six apodal segments had 34 somites while those with seven had 35 movable somites. Caudal furca are longer than the body. Dorsal surface of the telson is beset with few stout spines, and its ventral surface is smooth.

This species has been recorded from Kashmir, Buland Shahar (Kemp; Major Walton[1]) Nuriwalla, Sargodha District, Punjab (Bond) and Gujrat (Mahabate[2]).

Apus sp. prox.. **sudanicus** Brauer.

1877. *Apus sudanicus*, Brauer, *Sitz. Ber. Ak. Wiss. Wien.* LXXV, p. 590.
1931. *Apus sudanicus*, Barnard, *Ann. S. Afr. Mus.* XXIX, pp. 240-241, text-fig. 25, c.

[1]Walton, H. J., *Rec. Ind. Mus.* VI, pp. 351-352 (1911).
[2]Mahabate, T. S., *Curr. Sci.* VIII, p. 471, (1939).

A single male specimen (text-fig. 2*a*) from Nagasunni Temple Tank, Tirunelveli District (Madras), appears to be closely related to *A. sudanicus* Brauer. It agrees with *A. cancriformis* in having an oval nuchal organ and a short tail, but, however, differs from it in the structure of telson, number of apodal segments and the number of exposed abdominal segments.

The following are the important measurements of this specimen :—

Length of body (excluding caudal furca)	17·4 mm.
Median length of carapace	12·8 mm.
Length of carina	8·0 mm.
Breadth of carapace	11·6 mm.
Breadth of posterior sinus (measured between external angles) ..	4·3 mm.
Depth of posterior sinus	2·0 mm.
Length of fifth endite of first thoracic appendage	14·2 mm.
Length of caudal furca ..	12·0 mm.
Total number of somites	36
No. of somites exposed beyond the carapace (telson included) ..	11
No. of apodal segments ..	10
Spines on posterior sinus	45
Dorsal spines on abdominal somites ..	7-9

Carapace in this specimen is oval, being slightly longer than its maximum breadth. The carina is about two-thirds as long as the carapace (in the middle). Posterior sinus is about one-third of the carapace breadth and about half as deep as broad, its edge carrying about 45 spines. The angles of sinus are not drawn out.

Fifth endite of first thoracic leg is slightly longer than carapace.

The abdomen is short being less than 1/3 of the total length of body. Total number of somites are 36, out of which only eleven (including telson) are exposed behind the carapace. Total number of apodal segments is 10. Each abdominal ring bears dorsally a transverse row of 7-9 spines.

Telson (text-fig. 3*c*) is emarginate in the middle. Dorsally it carries a median row of two spines, and the telsonic edge has a transverse row of four spines.

Caudal furca are about as long as the median length of carapace. The spines towards the base of furca are scaly. Each ring carries a proximal row of scaly spines and a distal row of acute spines. In the distal half the spines are replaced by bristles.

This specimen resembles *A. cancriformis* in the structure of its nuchal organ, and short ' tail ' It agrees with *A. mavliensis* in having 10 apdoal segments, as also in the dorsal spinulation of telson.

The nearest ally of this specimen is *Apus sudanicus* Brauer. I have not seen the original description, but Barnard's diagnosis of this species applies fairly closely to the Madras example, except that the number of apodal segments in this specimen is one less than that for the male of *A. sudanicus*.

Apus sudanicus is recorded from Khartoum, Ailar, North of Cairo and Cape Province, Namaqualand and Ovamboland in South Africa (sec. Barnard).

TABLE I.—*Measurements of females of* Apus mavliensis *sp. nov. from Rajputana.*

Specimen No.	1	2	3	4	5	6	7	8	9
Total length of body	15·8	15·0	14·6	12·4	12·1	11·3	10·9	9·9	8·8
Median length of carapace	8·7	8·7	8·9	8·3	7·9	7·0	7·3	6·5	5·3
Length of carina	..	..	5·7	5·2	5·4	4·6	4·8	3·8	3·8
Length of exposed part of abdomen	7·1	6·3	5·7	4·1	4·2	4·3	3·6	3·4	2·9
Length of fifth endite of first thoracic appendage.	6·7	6·3	6·8	6·5	5·9	5·7	..	4·5	4·2
Length of caudal appendage	14·5	..	12·8	10·3	11·4	..	..	11·4	9·9
No. of exposed abdominal somites	23	23	22	20	20	21	20	24	20
Number of legless segments	10	9	10	10	10	10	10	8	10
Number of post-genital abdominal somites	27	27	..	25	27	26	..	26	..
No. of spines on post-sulcus	37	36	40	38	..	42	..	38	38

NOTES ON THE INDIAN SPECIES OF THE GENUS *ARGULUS* MÜLLER (CRUSTACEA COPEPODA) PARASITIC ON FISHES.

By G. RAMAKRISHNA, *B.Sc. (Hons.), Zoological Assistant, Zoological Survey of India, Calcutta.*

INTRODUCTION.

This short note deals with a small collection of Argulids preserved in the Zoological Survey of India.

The only species of *Argulus* so far recorded from India was the one which was referred by Southwell and Hora (*Vide infra*), to the European *A. foliaceous* (Linn.). I have, however, examined Southwell's and Hora's collections and I am of the opinion that these specimens belong to *A. siamensis* Wilson. *Argulus foliaceous* is known to occur in European waters, while *A. siamensis* is recorded from Siam, and now its occurrence in India is reported for the first time.

[1]Khan has made a reference to some specimens of *Argulus* collected from *Cirrhina mrigala* Ham. in a tank at Lyallpur (Punjab). Unfortunately, the specific identity of these specimens has not been established.

Besides typical *A. siamensis*, this note also deals with the description of a new sub-species of the same, and two new species, *viz. A. giganteus* and *A. bengalensis*. In addition *A. indicus* Web. is also reported from Indian region for the first time.

I wish to acknowledge my thanks to Dr. B. S. Chauhan, Zoological Survey of India, for suggestions and general help, and to Shri K. K. Tiwari, Officer in charge, Crustacea section, for his keen interest and guidance.

SYSTEMATIC ACCOUNT.

Argulus siamensis Wilson, 1926.

1915. *Argulus foliaceous*, Southwell, *Rec. Ind. Mus.* XI, pp. 323-325, pl. xxviii, figs. 16-19.

1943. *Argulus foliaceous*, Hora, *Proc. Ind., Sci. Congr.*, XXX, III, pp. 66-67.

After careful examination of specimens named as *A. foliaceous* by Southwell and Hora, I find that they actually belong to *A. siamensis*, since they differ from *A. foliaceous* and agree with *A. siamensis* in the following characters.

The respiratory areas are placed side by side, parallel with the edge of the carapace. The anterior respiratory area, being club-shaped, is curved round the posterior one, and both of them are quite narrow. In *A. foliaceous*, which is excellently figured by Wagler[2], the anterior respiratory area is placed in front of the posterior one, and it is very minute in size compared with the large posterior area. The former is oval in shape and situated just by the side of the second maxilla, while the latter extends as far as the third pair of swimming legs.

[1] Khan, H., *Proc. Indian Acad. Sci.*, XIX B, V, pp. 171-175 (1944).
[2] *Wagler, E.*, Zool. AMZ., CX, pp. 7-10, pl. 3, figs. (*a-i*) (1935).

Carapace is ovate in all these specimens, and it is longer than wide. Males are slightly longer and narrower in size than females. The ribs of sucking cups are provided with 4 to 5 imbricate plates of which the basal one is the longest. The first antenna is comparatively stouter and shorter than the second. The lateral hook of the first antenna is quite long. The spine at the base of the second antenna is small and transparent. The post antennal spines are long and blunt. The basal plate of second maxilla is quite broad, and is provided with three teeth which are blunt and short. The first two pairs of swimming legs are provided with flagellum in both sexes. On the ventral surface of each of the third swimming leg of males there are three adhesive discs, while there is peg like structure on the anterior margin of the fourth leg. The boot-shaped lobe is present in the case of females, but they are totally absent in males. The toe of the lobe is drawn out into a long conical structure.

Due to long preservation the colour of these specimens are completely lost. But fresh specimens which are at my disposal are green in colour.

Wilson[1] described *A. siamensis* from the material that was placed at his disposal by Dr. H. M. Smith, who collected the same from a Cyprinid fish (*Cirrhina*) from Bangkok (Thailand). Meehan[2] redescribed this species in 1940. As far as I am aware this is the first record of this species from India.

The specimens at my disposal are from the following localities :—

Reg. No.	Locality.	Collector and date of collection.	Host.
C2975/1	Harischandrapur, Malda Dist., W. Bengal.	Civil Surgeon, Malda. 22-2-1922.	Not known.
C2967/1	Champahati, 15 miles south of Sealdah station, Calcutta, W. Bengal.	Mr. S. C. Baugh, Zool. Surv. of India. 11-12-1949.	*Ophicephalus punctatus* Bloch.
9054/10	Siripur, Bihar	Dr. T. Southwell (det. as *A. foliaceous*).	*Labeo rohita.*
9055/10	Mahananda river, Siliguri, Base of Himalayas.	Dr. N. Annandale 17-4-1911. (det. as *A. foliaceous.*)	Not known.
C2968/1	Dharangadhara State (Saurashtra).	Dr. S. L. Hora. (det. as *A. foliaceous*).	Murrel.

Argulus indicus Weber, 1892.

1892. *Argulus indicus*, Weber, *Zool. Ergeb.* II, p. 544, fig. 1.
1909. *Argulus indicus*, Van Kampen, *Zool. Anz.* XXXIV, p. 447, figs. 5 and 6.
1940. *Argulus indicus*, Meehan, *Proc. U. S. Nat. Mus.* XXCVIII, p. 483, fig. 25.
1944. *Argulus indicus*, Wilson, *Proc. U. S. Nat. Mus.* XCIV, pp. 552-553, pl. 22, figs. 34-39 and 48.

[1]Wilson, C. B., *Journ. Siam. Soc. Nat. Hist. Suppl.* VI, pp. 361-363, pl. xxii, figs. 1-7 (1926).

[2]Meeham, O. L., *Proc. U. S. Nat. Mus.* xxcviii, pp. 482-83, fig. 24 (1940).

Max Weber (*loc. cit.*) established this species to accommodate some female specimens from east coast of Java. The male was described by Wilson (*loc. cit.*) from Bangkok (Thailand.)

In the material at my disposal, I am hardly able to notice any difference between males and females, with regard to posterior lobe on the proximal segment of the fourth basipod, and also the posterior respiratory area as mentioned by Wilson.

Except for one, all other specimens are dark green in colour with characteristic dot like markings on the dorsal surface of the carapace.

Out of six specimens whose measurements are given below, only two are adult males.

Measurements in millimeters.

	1	2	3	4	5	6
Sex.	♀	♀	♀	♀	♂	♂
Total length	7·3	7·7	6·7	6·2	6·5	6·9
Maximum breadth	6·7	6·8	6·0	5·0	5·7	5·9
Length of carapace	6·4	6·3	5·5	4·9	5·3	5·8
Cephalic region—Length	3·3	3·2	3·0	3·1	3·0	3·1
,, —Breadth ..	3·3	3·0	3·1	3·0	3·0	3·0
Abdomen—Length	1·0	1·4	1·2	1·2	1·2	1·1
,, —Breadth	2·2	2·2	2·0	1·9	2·1	2·0

It is obvious from the above table of measurements that the length and greatest breadth of the cephalic region is almost equal in all the specimens. The extent of cephalic area is nearly 50 per cent. of the carapace in adult females and less than 50 per cent. in case of young females and adult males.

The specimens were collected by Mr. S. C. Baugh, formerly Research Scholar of the Zoological Survey of India, from the skin of *Ophicephalus punctatus* Bloch, a freshwater food fish, at Champahati, a village about 15 miles south of Sealdah Station, W Bengal, bearing the Register No. C. 2969/1.

The occurrence of this species, hitherto reported from Java (Max Weber), and Bangkok, Thailand (Wilson) only, in India is of great interest, especially with reference to its zoogeographical distribution, as it affords another example of the so called Malayan element in the Indian fauna.

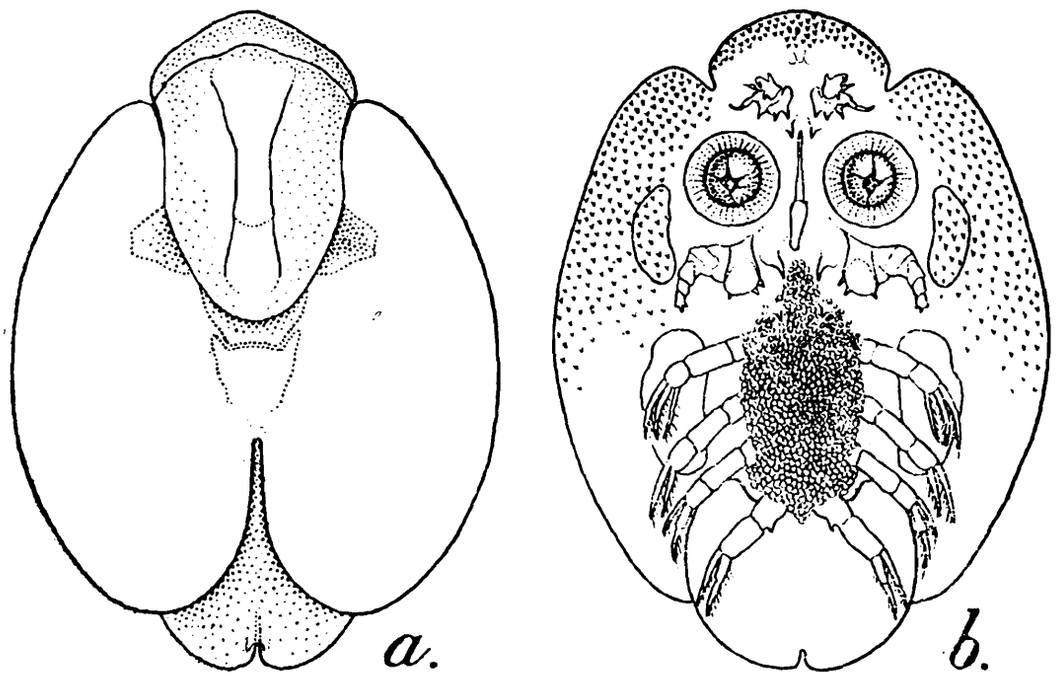
Argulus giganteus sp. nov.

Diagnosis.—A large species. Anterior respiratory area in front of the posterior one, and subequal to it. Ribs of the sucking cups with 25—26 imbricate plates. Eyes absent. First pair of swimming legs with a strong flagellum ; rest of the legs without flagella. Boot shaped lobe on the last pair of swimming legs very small.

Holotype.—Female. Register No. C. 2972/1, Zoological Survey of India.

Type,=Locality and Host.—Not known.

Description.—Carapace (text-fig. 1 *a.*) is ovate, being some what longer than broad. The lateral lobes of carapace are rounded and the latter overlaps two-thirds of the abdomen. The elliptical cephalic area is well separated from the rest of the carapace. The two dorsal ridges are simple and do not extend beyond the transeverse groove, which runs parallel to the anterior edge of the cephalic area, and they deviate at either ends.



TEXT-FIG. 1.—*Argulus giganteus*, sp. nov.

a. Dorsal view of the female holotype : × 3⅕. *b.* Ventral view of the same : × 3⅕.

I can not make out any trace of the paired and median eyes in the specimen at my disposal.

On each sides of the cephalic area towards the anterior end are two lobe like markings.

The anterior respiratory area is situated in front of the posterior one, and is subequal to it (text-fig. 1 *b.*). The former is oval in outline and is situated between the suckers and the second maxillipedes. The elongate, oval, posterior respiratory area extends from the first to the third pair of swimming legs.

The first antenna (text-fig. 2 *a*, *1*) is provided with strong armature. Lateral hook is moderately long, and the anterior spines are provided with a minute hook at the end. The two basal spines of the first antennae are strong and curved. Antennal flagellum consists of a long stout basal segment, bearing a short filament at the tip.

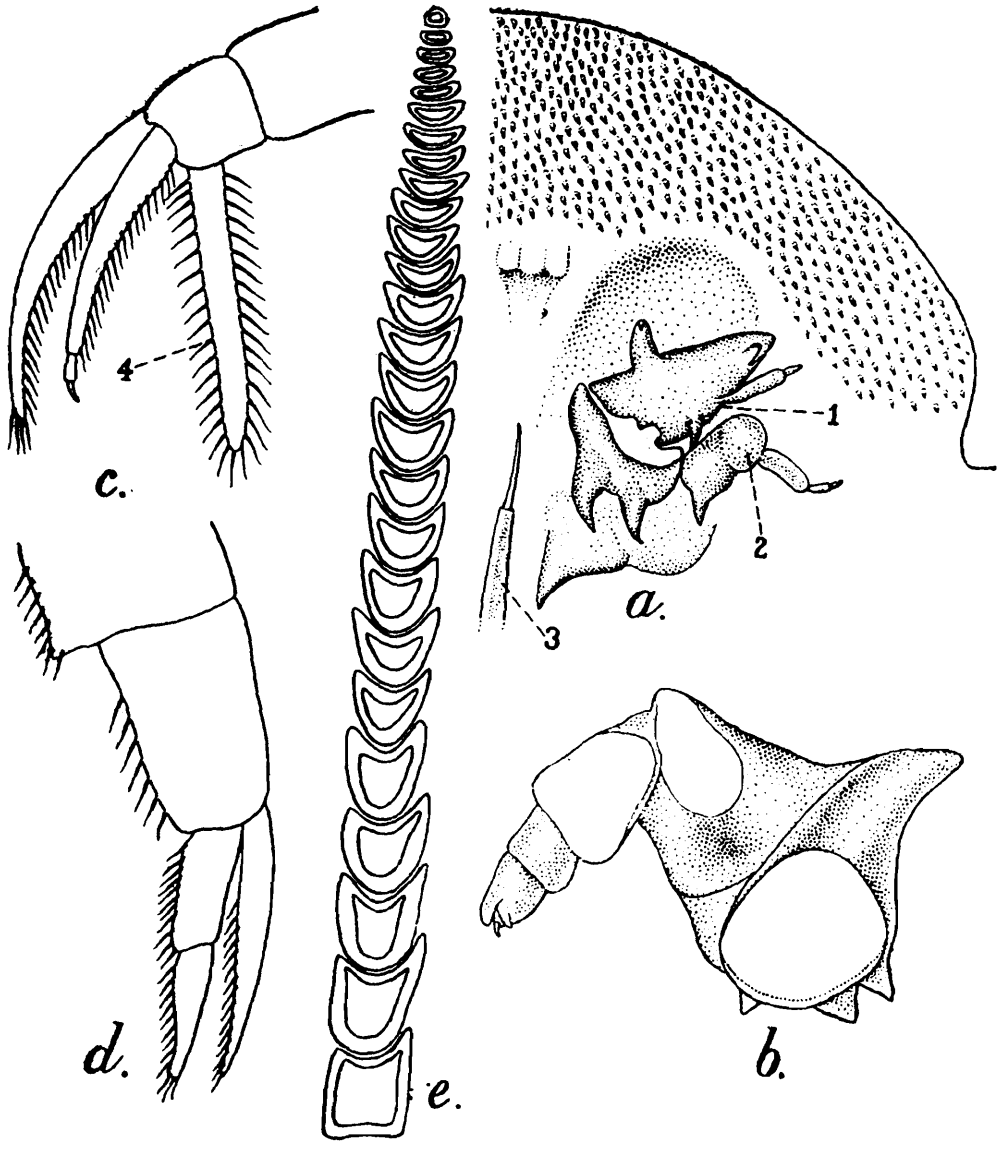
The spines at the base of the second antenna are small and straight and semi-transparent (text-fig. 2 *a*, *2.*). The flagellum consists of four joints the two basal segments being stouter than the two distal ones. The latter are at right angles to the former. Post antennal spines are large and broadly pointed.

The ribs of sucking cups are provided with 25 to 26 imbricate plates (text-fig. 2 *e*) placed one above other. They gradually diminish in size towards the periphery.

Second maxilla (text-fig. 2 *b*) which is composed of six segments, has a broad basal plate. There are three teeth on the basal plate, the inner two widely separated from the third, and relatively longer and broadly pointed. The third spine is very small and blunt. Tips of second maxillae are provided with two curved accuminate spines. Out of two pairs of maxillary spines situated in the middle line of the body, the anterior pair are large and pointed.

Abdomen is broader than long. Posterior sinus is very short and notched. The lateral lobes of the abdomen are rounded.

The first pair of swimming legs (text-fig. 2 *c*) is provided with a well developed and strong flagellum, which is as long as the exopodite (text-fig. 2, *c 4*). The rest of the legs are devoid of flagella.



TEXT-FIG. 2.—*Argulus giganteus*, sp. nov.

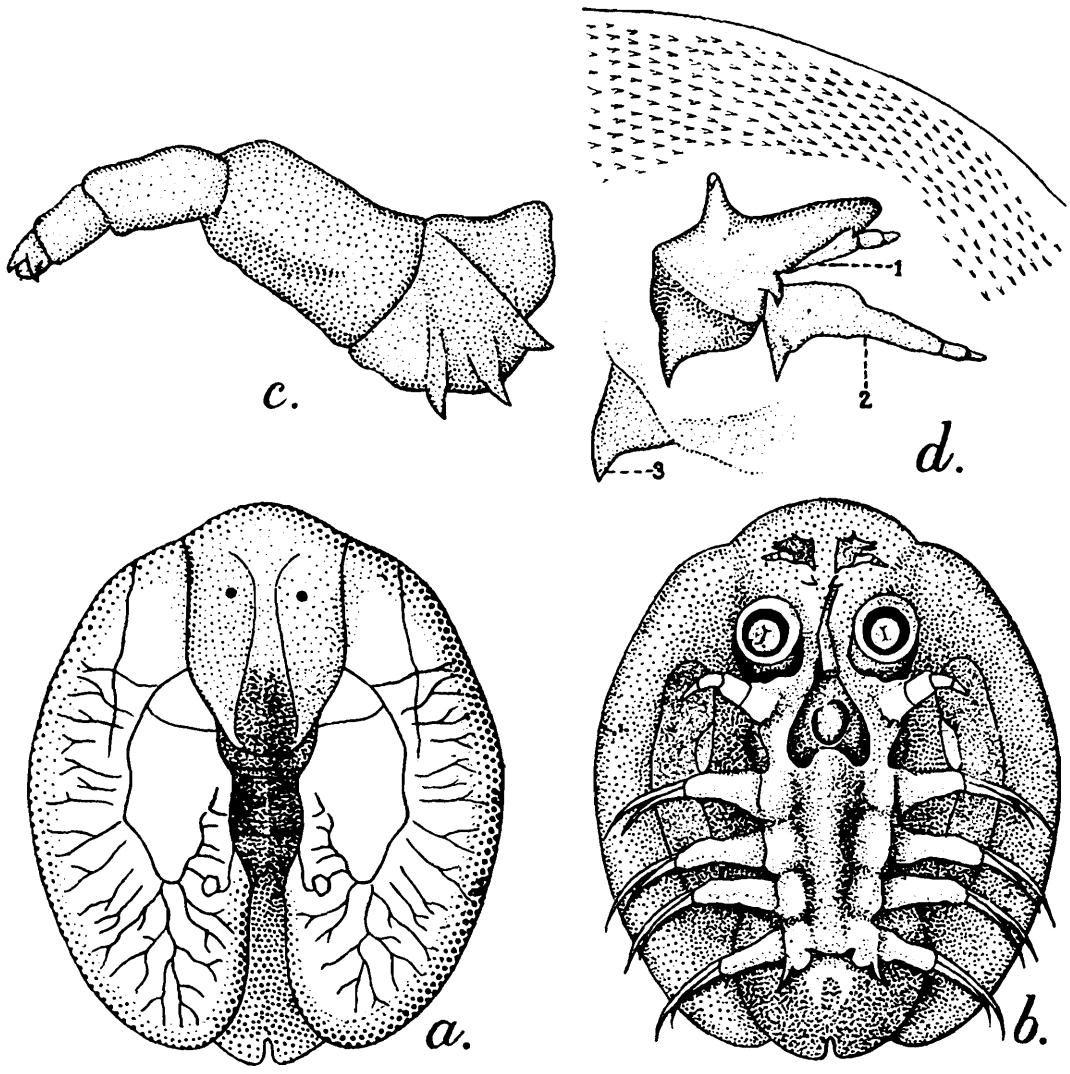
a. Ventral view of the left half of the cephalic region showing antennule and antenna × 16.; *b*. second, maxilla : × 16.; *c*. first swimming leg : × 16 ; *d*. fourth swimming leg : × 16.; *e*. ribs of the sucking cup : × 226⅔.

The boot-shaped lobe on the basal segment of the fourth pair of swimming legs is very short.

The holotype measures as follows :—

Total length of the body, 19·5 mm. *Greatest breadth*, 14·6 mm. *Carapace length*, 11·8 mm. *Abdomen length*, 4·6 mm., *breadth*, 7·00 mm. *Cephalic area—length*, 9·00 mm., *breadth*, 5·7 mm. *Diameter of suckers*, 2·8 mm.

Affinities.—In the arrangement of the respiratory areas *Argulus giganteus* sp. nov., resembles *A. scutiformis* Thiele 1900, *A. borealis* Wilson 1912, and *A. floridensis* Meehan 1940. It, however, differs from these in the absence of eyes, prescence of a large number of imbricate plates on the ribs of sucking cups, and in the shape and presence of a boot-shaped lobe on the last pair of swimming legs.



TEXT-FIG. 3.—*Argulus bengalensis*, sp. nov.

a. Dorsal view of the female holotype : × 7; *b.* ventral view of the same: × 7.; *c.* second maxilla × 33⅓.; ventral view of the left half of the cephalic region showing antennule and antenna : × 33⅓. (1. antennule ; 2 antenna ; 3 post antennal spine.)

Argulus bengalensis sp nov.

Diagnosis.—Anterior respiratory areas minute, situated in the central mesial notch of the posterior ones. Lateral sides of the carapace marked with a fine net work of capillaries. Ribs of sucking cups provided with 5 to 6 long imbricate plates, the basal plate being the longest.

With a transparent sac like structure on the third pair of swimming legs ; with a knob like peg on the fourth pair of swimming legs in males.

Holotype.—Female. Register No. C. 2970/1 ; *Androtype*—Male Register No. C. 2971/1 ;

Locality—Harischandrapur, Malda District, W. Bengal ; *Host*—Not known.

Description.—Carapace (text-fig. *3 a*) is ovate and is longer than broad. Posterior sinus is broad and deep. Lateral lobes of the carapace are very broad with rounded margins, overlapping abdomen almost completely in the female, but extending to only two thirds of the abdomen in males (text-fig. *4 a*). Lateral sides of the carapace are clearly marked with a net work of capillaries.

Cephalic region is distinct from the rest of the carapace and is elliptical. It projects slightly anteriorly. The extent of the cephalic area is slightly less than 50 per cent. of the total length of the body.

Lateral eyes are quite large and conspicuous, but they are not placed as farward as in *A. siamensis*. Median eye is not traceable. Dorsal ridges of the carapace are simple and they deviate at either ends.

Abdomen obovate and is wider than long, with a narrow anal sinus. The anal sinus is deeper in females.

The anterior respiratory areas (test-fig. *3 b*, *4 b*) are situated in the central mesial notch of the posterior ones, both being kidney shaped. Compared with the posterior the anterior one is minute.

Antennule or the first antenna (text-fig. *3d*, *1*) has a fairly long lateral hook, and a small anterior hook. Posterior spines are curved and acute. Basal spine is quite strong, long and pointed. Second antenna (text-fig. *3 d*, *2*) has a large and stout basal spine. Post antennal spines (text-fig. *3 d*, *3*) are large and broadly pointed. They are apposed to each other in the middle line.

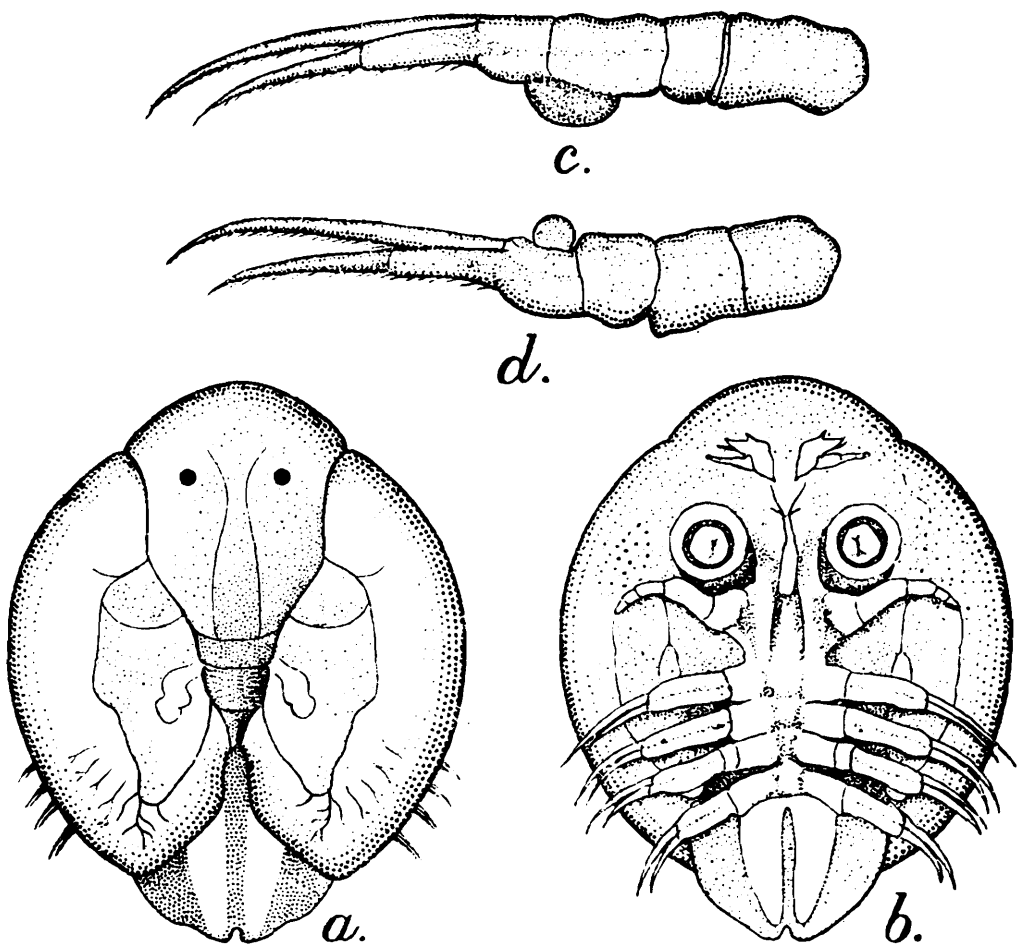
Sucking cups are situated just above the second maxillae, and they are wide apart. Each rib on the sucking cups is provided with 5 to 6 long imbricate plates of which the basal one is the longest.

Basal plate of second maxilla (text-fig. 3 *c*) is large and it bears three strong pointed spines. All of them are of the same size and they are placed side by side. Tips of maxilla are provided with two minute spines. A pair of maxillary spines are situated in between the second maxillae.

First two pairs of swimming legs are each provided with a flagellum. The basal segment of the fourth pair of swimming legs possesses a boot shaped-lobe in the female (text-fig. 3 *b*), but they are absent in the males (text-fig. 4 *b*.).

In the males the third pair of swimming legs (test-fig. 4 *c*) has a transparent sac like structure, situated on the posterior end of the legs. A knob like peg (text-fig. 4 *d*) is present at the anterior extremity of the fourth pair of swimming legs, towards the posterior end of the transparent sac of the third legs.

The testes in males (text-fig. 4 *b*) descends downwards as far as the anal sinus, and they are massive.



TEXT-FIG. 4.—*Argulus bengalensis*, sp. nov.

a. Dorsal view of the male androtype : ×12.; *b*. ventral view of the same ; ×12 *c*. third swimming leg : ×33⅓ ; *d*. fourth swimming leg : ×33⅓.

Measurements in millimeters.

	♂	♀
Total length of the body	4·4	7·6
Greatest breadth	3·3	6·3
Carapace length	2·9	5·0
Cephalic region—length	2·1	3·6
,, —breadth ..	1·8	2·4
Abdomen—length	1·3	1·8
,, —breadth ..	1·5	2·6
Diameter of the sucker	0·61	0·92

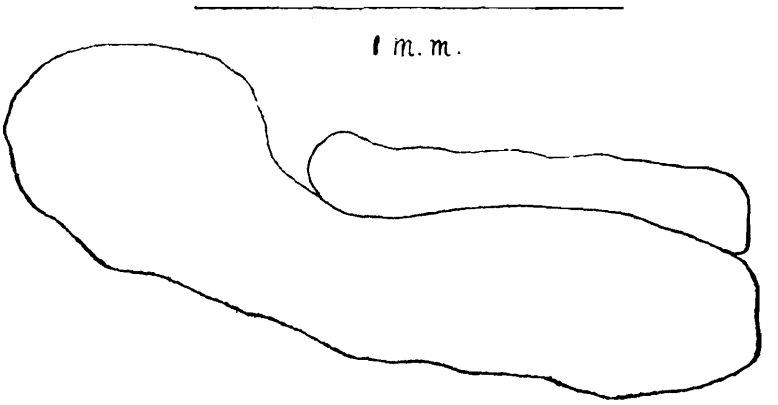
Affinities.—In the disposition of the anterior mesial respiratory area *Argulus bengalensis*, sp nov., resembles *A. catastomi*, but it differs from it with reference to the shape and extent of the respiratory areas, the extent of the cephalic area, shape and number of the sucking cups, and structure of the male accessory organs.

Argulus siamensis subsp. **peninsularis** nov.

This new subspecies differs from *Argulus siamensis* in the following features :—

Carapace overlaps abdomen to a very little extent. Cephalic area is nearly 50 per cent. of the total length of the body. Respiratory areas (text fig. 5) are kidney shaped with the anterior one curved round the posterior area. But the latter ends just by the side of the former and it is never prolonged backwards. It starts just at the bend of the anterior respiratory area, and is comparatively narrow. It is about two-thirds of the anterior in length.

Most of the specimens are adult females, and their total length varies from 4·25 mm. to 4·70 mm. One specimen from Rajahmundry is however 6·25 mm. in length.



TEXT-FIG. 5.—*Argulus siamensis* subsp. *peninsularis* nov. *a.* Respiratory area ×43⅓.

Holotype.—Register No. C. 2973/1, of the Zoological Survey of India, Calcutta ;

Locality.—Rajahmundry ; collector : Fishery Officer, Rajahmundry ; *Host ;* not known.

ON A NEW FORM OF FRESHWATER SNAIL FROM BANGKOK, THAILAND (MOLLUSCA, GASTROPODA: FAMILY LYMNAEIDAE)

By H. C. RAY, *M. Sc., D. Phil., Assistant Zoologist, Zoological Survey of India, Calcutta.*

(Plates V & VI.)

INTRODUCTION.

The present paper is based on the study of a collection of dry shells of molluscs received for determination in July, 1949, from Mr. Boon Indrambarya, Director-General of Fisheries, Department of Fisheries, Bangkok, Thailand. In forwarding the specimens, he noted that a kind of freshwater snail spawned in the aquarium at Bangkhen Fishpond Station and a study of its development from the egg stage was made, though the precise scientific name of the mollusc was not known. The specimens had, therefore, been sent to the Indian Museum for identification.

On a cursory view the collection was found to contain a fairly good series of specimens (numbering 51) of the well-known genus *Lymnaea* Lamarck. But a closer study revealed that they represent three different stages of development marked by certain very interesting features in their shell-characters which clearly indicate their close affinities with some forms of two very common Indian species *L. luteola* on the one hand and *L. acuminata* on the other. There was no difference regarding colouration and sculpture, save that a few shells were found covered with a black deposit more or less concealing the original pale yellow colour. One worn and decollate shell (see Pl. V, fig. 12) was also found partly orange-yellow in colour which may possibly be due to too much exposure. Of course, variation is not an unusual feature in the difficult genus *Lymnaea* where as Annandale and Rao (1925)[1] point out " Apart from differences due to age, we may, indeed, note three types :—(1) individual variability, (2) plasticity and (3) racial or local variation"

I am illustrating here with figures the remarkable variations as displayed by the shells in different stages of their growth (out of 51 shells, I have selected only 14 in order to show the nature and extent of variations in their shell-characters) and the close affinities shown by them with different forms of *Lymnaea luteola* and *L. acuminata*. That is, in the first stage (A) represented by the young shells (Pl. V, figs. 1—4) the spire appears distinctly narrow and elongate, sutures more impressed and bodywhorl (though oblong-ovate) more oblong than ovate—all these somewhat closely approaching the forms *patula* Troschel (Pl. VI, fig. 1—Rawalpindi, Punjab), *hians* Sowerby (fig. 2—Sangram Tank, Buldana, Berar) and *typica* Lamarck (fig. 3—South of Mandi, Punjab)

[1] Annandale, N. and Rao, H. S., *Rec. Ind. Mus.* XXVII, p. 137 (1925).

of the species *L. acuminata* available in our named collections. But there is one shell (Pl. I, fig. 5) in this lot which appears somewhat peculiar in being less thick in texture, more shining and provided with shorter spire and less oblong bodywhorl. In the second stage (B) represented by the intermediate shells (figs. 6—9) the spire gradually becomes short and less narrow, but slightly more broad and swollen, sutures less impressed and bodywhorl slightly more ventricose—all these approximating nearly to the forms *pinguis* Dohrn (Pl. VI, figs. 6, 7—Karachi; see also figs. 7, 10 in Pl. XX of *Conch. Ind.* (Hanley et Theobald), 1876—now considered as a synonym of the f. *australis* Annandale and Rao, pp. 159 (fig. 3), 184, 1925) and *succinea* Deshayes (fig. 8—Bollarum Tank, Secunderabad) of the species *L. luteola.* In this lot also there are two peculiar shells—one (Pl. V, fig. 10) having a more ovate bodywhorl and short but acuminate spire somewhat resembling the f. *chlamys* Benson (Pl. VI, fig. 4—4 miles from Gurdaspur, Punjab), while the other (Pl. V, fig. 11) in its narrow and elongate spire agreeing with those of the first stage, though the bodywhorl appears slightly more ventricose. In the third stage (C) represented by the large shells (figs. 12—14) the spire gradually becomes more short, broad and swollen (fig. 14) somewhat like *ovalis* Gray (Pl. VI, fig. 9—Assam), while the bodywhorl truly oblong-ovate like *acuminata.* This curious state of affairs really put me in great difficulty as to the exact identity of the specimens in question. In this connection I spared no pains to consult with care the admirable paper on Indian Lymnaeidae published by Annandale and Rao (1925) and also other relevant literature on the subject, but failed to come to any definite conclusion. So, the entire collection of Bangkok shells was sent to Dr. H. S. Rao, an authority on Indian Lymnaeidae and Chief Research Officer, Central Marine Fisheries Research Station, Mandapam, S. India, for opinion, and along with this some identified specimens representing different forms of the species *L. luteola* and *L. acuminata* were also sent from our named collections in order to help him in the way of comparison and study. The critical report he has so kindly given not only shows the depth of his knowledge and wide experience in the line extending over a quarter of a century, but also unravels many interesting points at issue as will be evident from the following :—

> " The Bangkok specimens certainly appear to represent the extreme variation of *L. luteola* towards *L. acuminata* and to provide a transition between the two species. I would therefore recommend the recognition of a new form designated as *L. luteola f. acuminata* [1] with close geographical affinities to the eastern type, f. *siamensis,* which will have the same status and significance as the other forms so far recognized. I appreciate the point you have raised about the likeness between these Bangkok shells and the Karachi ones. You will find the same tendency for variation even in the very small collection of 5 specimens from the Royal Lakes, Rangoon (Reg. No. 12042), in which two small shells are more near the Bangkok specimens in the shape and proportion of the spire in relation to the bodywhorl than the other three which have the typical outlines of an undoubted *L. luteola.* The best thing under the circumstances would be to publish good figures, as we did a quarter of a century ago, representing the whole gamut of variation with the species, *L. luteola,* and between it and *L. acuminata.* Of course, you will have to make a very careful selection of the more obviously ovate and long-spired forms to illustrate your point." *(15th April 1950.)*

[1] The name '*acuminata*' as suggested by Dr. H. S. Rao for this new form could not be used here, since it was found preoccupied among the Indian species of the genus *Lymnaea.*

As pointed out by Dr. Rao, the two small shells of the f. *siamensis* Sowerby (Pl. VI, figs. 10, 11) from the Royal Lakes, Rangoon, have been found after a careful examination to be more near the Bangkok shells than the other three (of which only one is shown here, see fig. 12) showing typical outline of an undoubted *L. luteola.* Now, I consider it a great pleasure to describe the shells in the series under investigation as a new form under the name of *L. luteola* f. *booni* in honour of Mr. Boon Indrambarya who sent the specimens. An attempt has also been made here to illustrate the extreme variation of this new form. In plate VI (figs. 1—12) I have tried to show as far as possible the affinity of this form with other existing forms of the species *L. acuminata* and *L. luteola* found in our named collections from various localities.

Lymnaea (Pseudosuccinea) luteola Lamarck, 1822 f. **booni**, nov.

(Plate. IV, figs. 1—14.)

Shell medium, solid, dextral, oblong-ovate, ventricose, pale yellow, polished and shining in most cases, surface covered with a black deposit only in a few cases (though not in all) which more or less conceals the original colour, ornamented with fine oblique longitudinal lines appearing more prominent but somewhat rough in the large shells ; spire much narrow and elongate in the young condition, but gradually becoming more short, broad and swollen in the adult, apex acuminate ; whorls $4\frac{1}{2}$ or 5, convex, regularly increasing in the upper part, but from the penultimate to bodywhorl appearing somewhat abrupt especially in the large shells, bodywhorl large, elongate (its length is about $2\frac{1}{2}$ times greater than that of the spire in the young shells, but $3\frac{1}{2}$ times or even more in the larger ones with rare exceptions), convex but not very broad, descends gradually downwards and becomes constricted at the base (excepting rarely) ; sutures more impressed and sinuous in the young than in the adult ; aperture large, somewhat oblong, less broad but more longer than in f. *australis* (=*pinguis*), white to pale yellow inside ; outer lip thin, long, curved at the upper part but compressed in the middle (Pl. V, figs. 7*a*, 9*a*, 14*a*) somewhat-like that of f. *australis* (see No. 3 in Text-fig. IV, p. 159, Annandale and Rao, 1925) and f. *chlamys* (Pl. VI, figs. 5, 5*a*) giving it a superficial angulated appearance at the upper part (Pl. V, figs. 6, 7, 9, 14 ; see also *ibid.* No. 6 in Text-fig. III. p.156) —this feature is not prominent in all cases, then descending downwards it makes a good curve before joining the inner lip or columella which is long, folded in the middle and slightly curved below.

Measurements.—The largest shell (fig. 14-*a*) in the series measures 21·5 mm. in length and 11 mm. in diameter with its aperture 16 mm. × 6 mm., while the smallest one (fig. I-*a*) measures 10·5 mm. in length and 5 mm. in diameter with its aperture 7 mm. × 3 mm.

Type-locality.—Aquarium at Bangkhen Fishpond Station, Bangkok, Thailand.

Type-series.—Reg. No. M $\frac{16087}{2}$ Zool. Surv. Ind.

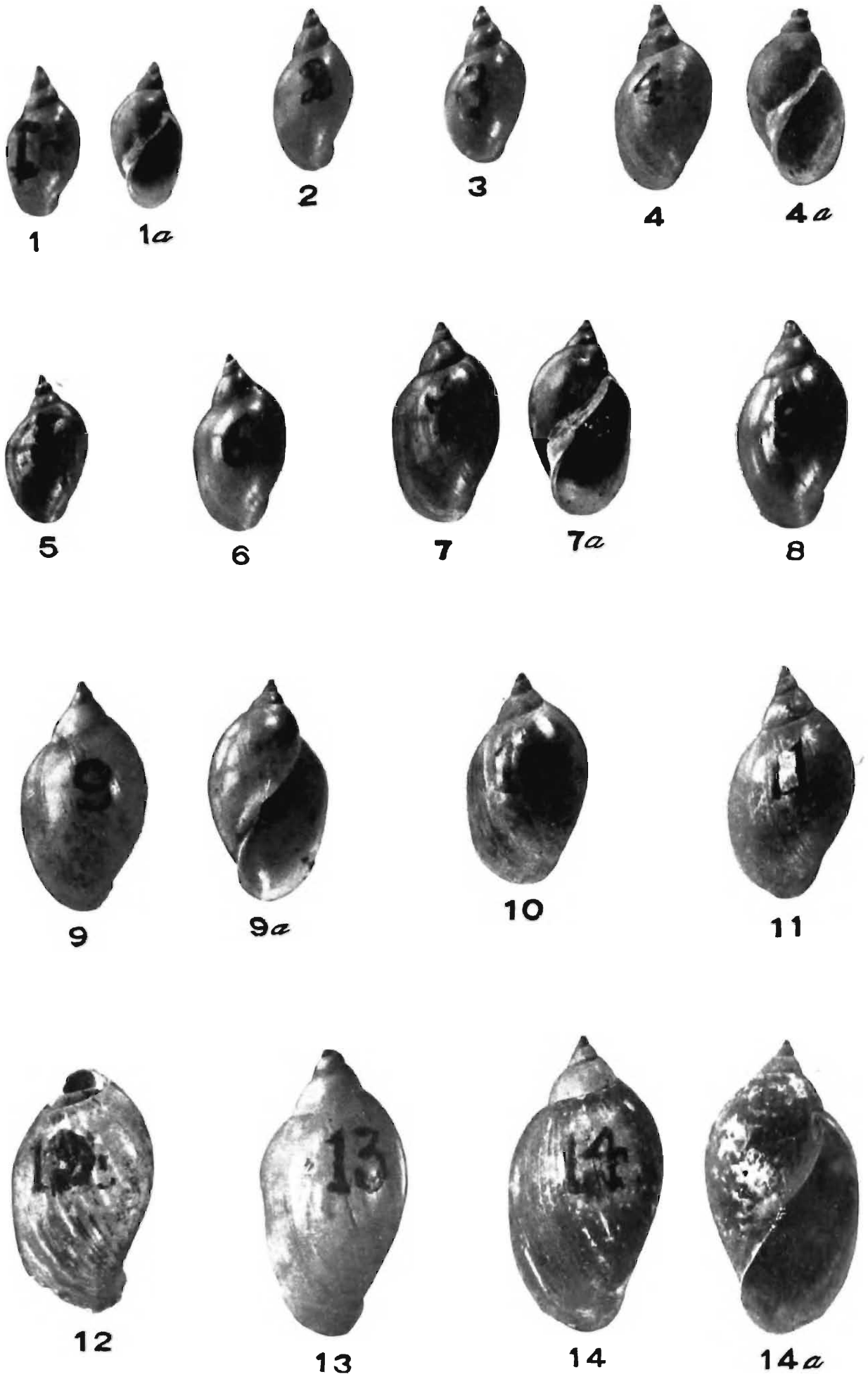
Remarks.—Lymnaea (*P.*) *luteola* f. *booni* appears quite unique in its shell-characters which certainly show, as stated by Dr. Rao, the

extreme variation of *L. luteola* towards *L. acuminata* and provide a transition between the two species. The important points indicating true affinities of this interesting form with other forms of the species *L. luteola* and *L. acuminata* have been clearly discussed with the help of figures of specimens selected from our named collections. Such a remarkable variation in shell-characters as displayed by this new form has not been met with in any other forms so far described.

I express my great indebtedness to Dr. H. S. Rao for the care and interest with which he has examined the specimens and also for his expert opinion. My gratefulness is also due to Dr. S. L. Hora, Director, Zoological Survey of India, for his valuable suggestions. Sri S. C. Mondal, artist of our department, has taken great trouble in taking photographs of the shells used in Plates V and VI, for which I offer him my best thanks.

EXPLANATION OF PLATE V

FIGS. 1-14.—Shells of *Lymnaea* (*Pseudosuccinea*) *luteola* f. *booni*, nov., from Bangkok, Thailand. ×2. Figs. I*a*, 7*a*. 9*b*, 14*b* show the ventral view of the same.



New Form of Snail From Bangkok

A. K. Mondal *del.*

EXPLANATION OF PLATE VI.

FIG. 1.—Shell of *L. acuminata* f. *patula* Troschel from Rawalpindi, Punjab. ×2.

FIG. 2.—Shell of *L. acuminata* f. *hians* Sowerby from Sangram Tank, Buldana, Berar. ×2.

FIG. 3.—Shell of *L. acuminata* f. *typica* Lamarck from South of Mandi, Punjab. ×2.

FIG. 4.—Shell of *L. acuminata* f. *chlamys* Benson from Gurdaspur, Punjab. ×2.

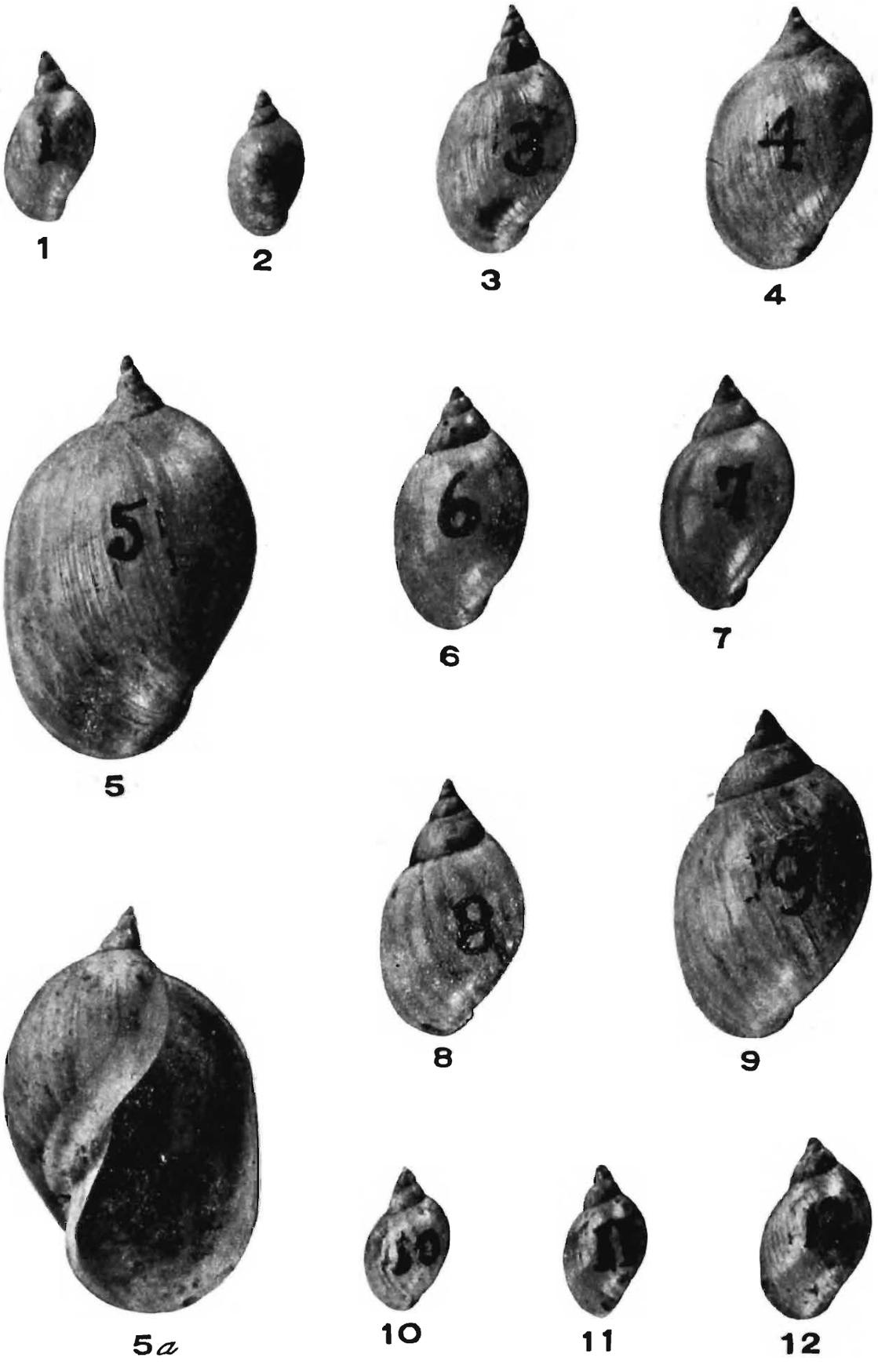
FIGS. 5, 5*a*.—Dorsal and ventral view of the same from Serampur. ×2.

FIGS. 6, 7.—Shells of *L. luteola* f. *pinguis* Dohrn (=*australis*) from Karachi. ×2.

FIG. 8.—Shell of *L. luteola* f. *succinea* Deshayes from Bollarum Tank, Secunderabad. ×2.

FIG. 9.—Shell of *L. luteola* f. *ovalis* Gray from Assam. × 2.

FIGS. 10, 11, 12.—Shells of *L. luteola* f. *siamensis* Sowerby from the Royal Lakes, Rangoon. ×2.



A. K. Mondal *del.*

TWO NEW SPECIES OF COPEPODS OF THE GENUS *PENICULUS* PARASITIC ON MADRAS FISHES.

By C. P. GUANAMUTHU, *M.A., D.Sc., F.Z.S., Director, Zoology Laboratory, University of Madras.*

INTRODUCTION.

Lernaeid copepods parasitic on Indian fishes are little known. Of the several genera *Peniculus* was first recorded from Asia by Yamaguti (1939) when he described *Peniculus ostraciontis*. The present author (1951c) added three more species, *P. trichiuri*, *P. theraponi* and *P. sciaena* found parasitic on Madras fishes. In the present paper full descriptions of two more new species, parasitic on the mackerel, *Scomber microlepidotus*, and the pomfret *Stromateus niger*, are given. A study of the structure of the proboscis, as well as the mandibles and maxillae contained within it, not made before in any other species of the genus, was possible in the present forms. In the light of the occurrence of these three pairs of mouth appendages, the enumeration of the cephalothoracic appendages followed by all the previous authors, had to be revised.

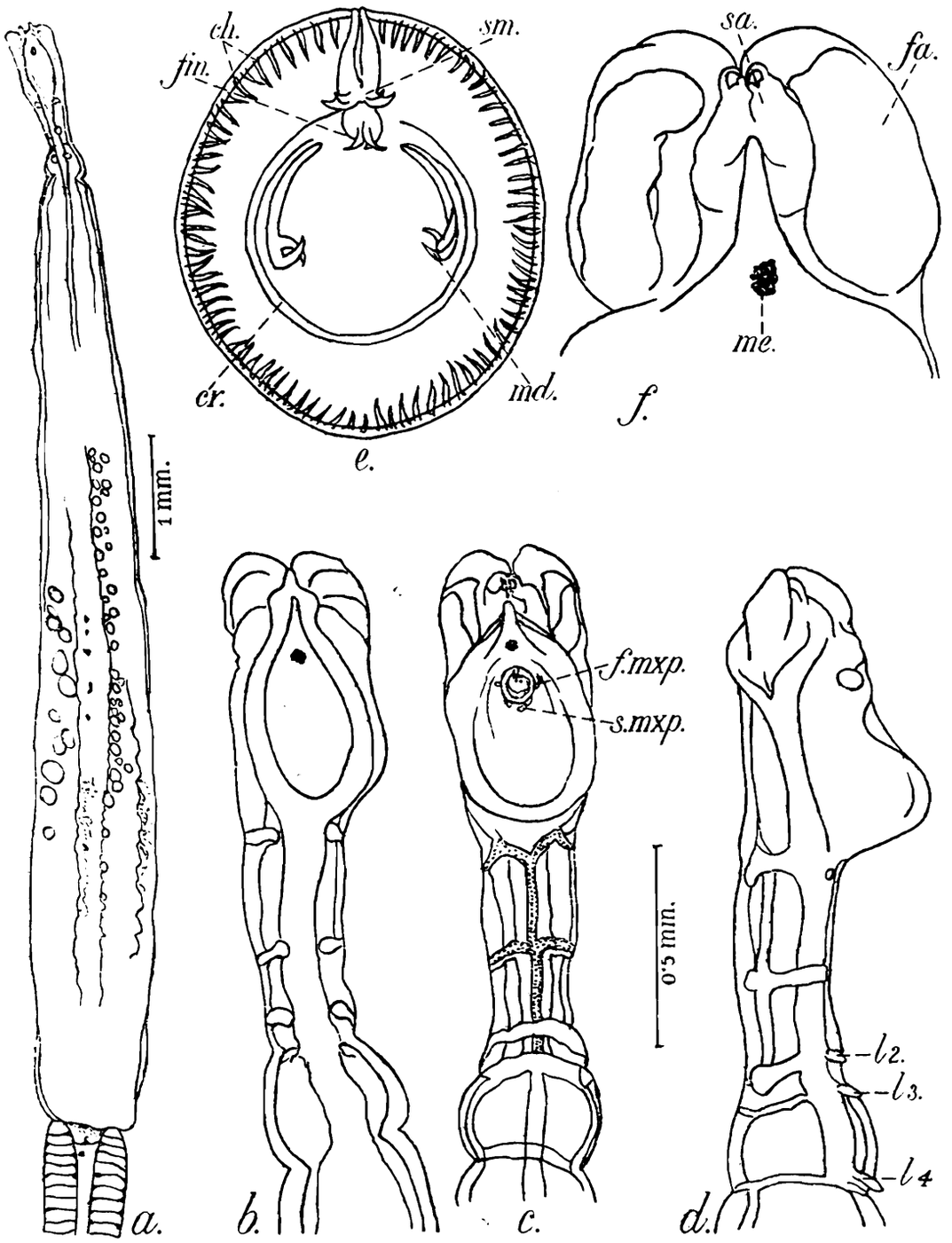
Peniculus stromatei, sp. nov.

Locality and type specimens.—Eight females were collected from three small sized *Stromateus niger* caught at Madras, in August 1950. The parasites were attached to the fin rays of the dorsal or caudal fins. All were mature adults, more or less of the same size and bore eggs. One of these on which this description is mostly based, will be lodged in the Indian Museum, Calcutta as the type specimen. The paratypes are in the author's collection.

Description.—The long cylindrical body (text-fig. 1*a*), exclusive of the egg strings measures 9·32 mm. The trunk is 8 mm. long and 1·06 mm. wide. The egg strings are longer than the body. In several specimens they were broken.

The cephalothorax is cylindrical with a large posterior heel-like prominence on the ventral side (text-fig. 1*d*). In front of the deep projection lies the small mouth cone. The forwardly directed antennae extend far beyond the frontal margin (text-fig. 1*f*, *sa & fa*). A median eye (text-fig. 1*f*, *me*) is noticeable anterior to the region of the mouth. The cephalothorax or head is followed by the four free thoracic segments which, being narrower by nearly half of its width, form the 'neck' of the parasite (text-fig. 1*b*, *c & d*). The fourth segment, however, becomes as broad as the head and is followed by a trunk which is nearly thrice its width. Of the four free thoracic segments the third is the shorter. If the cephalothorax is 20 units long, the four segments are 8, 5, 1 and 6 units in length. The chitinous bars supporting the neck and head form a pattern not very different from that of *P. theraponi*. The trunk which starts from a constriction behind the fourth thoracic segment, gradually widens to 1·06 mm. about three-fourth, of its length

This maximum thickness of the body is an eighth of the total length of the trunk. Posteriorly the trunk is marked by a ventral groove which ends between the genital apertures. Dorsal and posterior to these apertures, the very short abdominal region of the trunk bears two rounded prominences. These, under high magnification, show three stumps of anal setae. The egg strings are 0·24 mm. in diameter.



Text-fig. 1.—*Peniculus stromatei*, sp. nov.

a. Entire specimen with egg strings; *b*. Anterior region of body, dorsal view; *c*. Ventral and, *d*. lateral views of the same; *e*. Proboscis, oral view; *f*. Anterior extremity, ventral view.

Lettering: *ch*., chitinous hairs; *cr*., chitinous rnig; *fa*., First antenna; *fm*., first maxilla, *f. mxp*., first maxilliped; l_2. l_3 *and* l_4, second, third and fourth legs; *md*., mandible; *me*., median eye; *ea*., second antenna: *sm*., second maxilla; *s. xmap*., second maxilliped.

The antennae are directed forwards beyond the frontal margin. Medially they hold on to a fin ray of the host. The first antennae (text-fig. 1*f*, *fa*) are large, indistinctly three-jointed. The basal segment is prominent ventrally while the terminal two joints taper and are curved inwards. Between the two first antennae and ventral to them lie the second antennae (text-fig. 1*f*, *sa*). These are smaller and placed close to each other. The basal joint is larger, cylindrical, with the terminal claw folding down on a lobe of the inner margin of the base. The small mouth cone or proboscis is seen on the anterior side of the very large ventral prominence. When brushed clean, dehydrated and cleared, the structure of the proboscis and the appendages within, can be seen through the distal opening (text-fig. 1*e*). The mouth tube is supported by chitinous rings (text-fig. 1*e*, *cr.*) and has a fringe of long hairs on its distal rim (text-fig. 1*e*, *ch.*). As has been described by the author (1951*c*) in the species of *Lernaeenicus*, three pairs of appendages can be seen. These appendages, the mandibles and the maxillae appear to be attached at different levels within the tube and have their distal tips directed backwards. The mandibles lie deepest (text-fig. 1*e*, *md.*). Each consists of a long narrow base bearing two sharp, claw-like teeth turned inwards from the sides of the proboscis tube. The first maxilla (text-fig. 1*e*, *fm.*) consists of two slender hooks crossing each other, attached to a base in front. The second maxilla (text-fig. 1*e*, *sm.*) is most superficial. The long base attached to the anterior edge of the proboscis, is directed backwards to bear two powerful claws. This succession of the appendages with the second maxilla in front and the mandible behind, found in all the specimens examined, is a reversal of the usual arrangement and may be due to the rotation of the proboscis tube as a whole or a feature of the formation of the tubular mouth cone through a forward folding of the region behind the mandibles. On either side of the proboscis can be seen two pairs of appendages. The first maxillipedes (text-fig. 1*c*, *f. mxp.*) are short three-jointed tapering appendages attached to the sides of the proboscis. The second maxillipedes (text-fig. 1*c*, *s. mxp.*) are longer four-jointed appendages found on the posterior side of the proboscis. Of the four swimming legs, none were found complete. Stumps of the legs broken off legs persisted.

Remarks.—The present form differs from the three species listed by Wilson (1917) and the six species established since viz., *P. ostraciontis* Yamaguti (1939), *P. elegans* Leigh Sharpe, (1934) and *P. communis* Leigh Sharpe (1934) as well as the three species described by the author. This difference is seen in the trunk being eight times longer than wide, the width of the trunk being thrice as much as that of the fourth thoracic segment, and the trunk being over six times longer than the head and neck. It can be easily distinguished from *P. theraponi*, which it approximates in the breadth and length of trunk, by the narrower fourth thoracic segment and longer front part of body, thinner egg strings and the conspicuous cushion-like swelling on the ventral side of the cephalothorax. Hence the present form is described as a new species, ***Peniculus stromatei*** which can be defined as follows. " Trunk eight times longer than wide, fourth thoracic segment one-third as wide as trunk, proboscis

inconspicuous, the cephalothorax marked by prominent posterior ventral swelling, head and neck one sixth the length of the trunk and head three-fourths the length of the neck. Abdomen is a short stout swelling and the egg strings are thin."

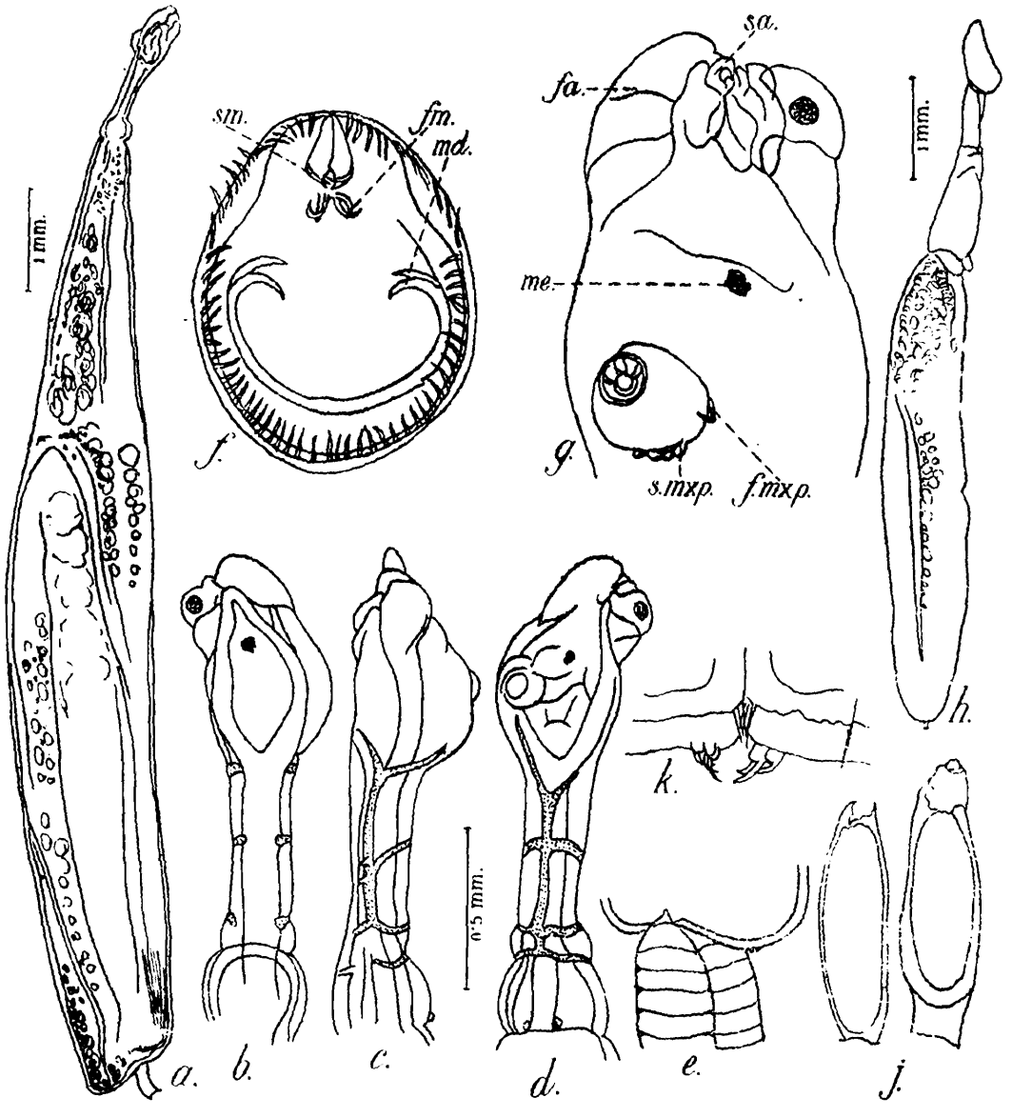
Peniculus scomberi, sp. nov.

Locality and type specimen.—Fifteen females were collected from two specimens of *Scomber microlepidotus* caught in August 1950. The parasites were attached to the fin rays of the median fins. Except two immature forms the rest bore long egg strings and were of nearly the same size. One measuring 11 mm. long served as type specimen and will be lodged in the Indian Museum, Calcutta. The paratypes are in the collection of the author.

Description.—The parasite (text-fig. 2*a*) was ivory white when fresh and is of the same colour in formalin. The cephalothorax is pyriform being broad behind and narrower in front. While the narrower anterior region, especially in the region of the antennae, appears excavated ventrally (text-fig. 2*d*) to hold the fin ray of the host, the hind part appears swollen and spherical, without the prominent heel-shaped protuberance found in the previous species. The region of the antennae was deeply buried in the skin of the host and the parasite was more difficult to remove. This firmer fixation, probably necessitated by the hosts being stronger swimmers, results in the axis of the cephalothorax being twisted. The antennae in front, and the conspicuous proboscis behind, appear displaced in opposite directions. A median dark eye-spot occurs about the middle of the dorsal side (text-fig. 2*g*, *me.*). The neck which follows the cephalothorax is about half its thickness. The first three free thoracic segments (text-fig. 2*b*, *c and d*) forming the neck are uniformly cylindrical and of more or less the same width while the fourth segment expands to twice their width, but constricts slightly before leading into the trunk behind. The neck is longer than the cephalothorax. If the head or cephalothorax were 54 units long the four segments of the neck are 20, 20, 8 and 21 units in length. The trunk, which is separated from the last or fourth segment of the neck by a slight constriction, widens to nearly four and a half times the breadth of that segment. In fact the 9·53 mm. long trunk is nearly six and half times its width which is 1·48 mm. Posteriorly the abdomen forms a (text-fig. 2*e*) slight prominence (more marked in the immature forms) and also shows three setae placed on either side of its hind tip. Egg strings are 0·33 mm. in diameter.

The first antenna (text-fig. 2*f and g* ; *fa.*) is large, slightly flattened dorso-ventrally, indistinctly three-joined. The end joint is pointed and curved inwards. Therefore its outer margin is convex. The second antennae (text-fig. 2*f and g* ; *sa.*) are shorter and more cylindrical. Its basal joint is large and lobed, while its distal segment is a stout hook, working against a lobe of the base. The proboscis (text-fig. 2*f*) is a conspicuous flask-shaped body with a small, nearly circular, distal opening at the posterior base. At the sides of the spherical prominence are the maxillipedes. Visible, through the opening are the mandibles

(Text-fig. 2*f*, *md.*). and maxillae (Text-fig. 2*f*, *fm. and sm.*). Though slightly differing in form from those of *P. stromatei*, these appendages resemble a great deal and are arranged in the same order. The first maxillipedes (Text-fig. 2*g*, *f. mxp.*) appear smaller, more slender, pointed and three-jointed while the second maxillipedes (Text-fig. 2*g*, *s. mxp.*) are larger and four-jointed. Of the four swimming legs, there were no traces in the adult. But in a young form, the protopods of the second, third and fourth legs were found as long, elliptical structures, bearing two distal claws and a tubercular vestige of the rest of the limb.



TEXT-FIG. 2.—*Peniculus scomberi*, sp. nov.

a. Entire specimen ; *b.*, *c. and d.* Dorsal, Lateral and Ventral view of anterior region of body ; *e.* Abdomen ; *f.* Proboscis, oral view ; *g.* Head, ventral view ; *h.* An immature specimen ; *j.* Vestiges of legs ; *k.* Anal setae.

Lettering as in Text-fig. 1.

Remarks.—Following Wilson's key for the genus, we find that because the trunk being six and a half times longer than broad, and the width of the fourth segment being four and half times the width of the trunk, this form can be marked as different from those established before and also from *P. stromatei* described in this paper. As the cephalothorax is

uniformly swollen, the head appears boader, while in *P. stromatei*, the heel-like prominence gives its head greater depth. In view of these differences, the present form is treated as belonging to a new species *Peniculus scomberi* which can be defined as follows :—The trunk is six and a half times longer than broad. It is five times broader than the fourth segment ; the cephalothrax is uniformly swollen behind, slightly twisted and asymmetrical. The proboscis is conspicuous.

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NOTES ON FISHES IN THE INDIAN MUSEUM.

XLVII.—On two new species of the genus *Nemachilus* from the Kangra Valley, Punjab.[1]

(Plate VII.)

By A. G. K. Menon, *M.A., I.C.I., Research Fellow, National Institute of Sciences, Delhi.*

During the course of my studies on the distribution of specialised hill-stream fishes along the Himalayas, the results of which have not yet been published, all the unnamed collections from the southern face of the Himalayas lying in the Zoological Survey of India were worked out. Among this material, a large number of well preserved specimens of two new species of *Nemachilus* collected by Dr. S. L. Hora, in the year 1926, from the Kangra Valley, Punjab, were found. I propose to describe them in this paper and designate the species as *Nemachilus horai* and *Nemachilus kangrae* respectively.

Nemachilus horai, sp. nov.

D. 12 (4/8) ; P. 11 (1/10) ; V 7 (1/6) ; A. 6 (1/5) ; C. 19.

The new loach, which I associate with the name of Dr. S. L. Hora, Director, Zoological Survey of India, is a large, strongly built species. The dorsal profile is gently arched but the ventral is almost straight or horizontal, except in gravid females where it is somewhat bulged out in the region of the stomach. The head is conical and the snout bluntly pointed. The length of the head is contained from 4·1 to 4·4 times in the standard length, its width 1·3 to 1·6 times and its height at the occiput 1·5 to 1·7 times in its length. The depth of the body varies considerably with the sex of the individuals ; in ripe females it is contained from 4 to 4·4 times whereas in the males it is 5·2 to 6 times in the standard length. The eyes are dorso-lateral in position and are not visible from the ventral surface. The diameter of the eye is contained from 4·2 to 4·6 times in the length of the head and 2 to 2·2 times in the length of the snout. The inter-orbital width is about one and a half times the diameter of the eye. The nostrils are situated considerably nearer to the eye than to the tip of the snout. There are three pairs of barbels ; all of them are longer than the diameter of the eye ; the inner rostrals are shorter than the other two pairs. The mouth is semicircular and horizontal ; it is bordered by fleshy lips which are continuous around the corners of the mouth. The lower lip is interrupted in the middle. The lateral line is complete and well marked throughout its length. The caudal peduncle is somewhat short and deep ; its least height is contained from 1 to 1·2 times in its length.

The commencement of the dorsal fin is in the middle between the tip of the snout and the base of the caudal fin ; the longest ray of the dorsal fin is shorter than the depth of the body in ripe females whereas

[1] Based on the work carried out in the laboratories of the Zoological Survey of India when I was a Research Scholar of the Government of India.

in the males it is as long as the depth of the body below it. The upper margin of the fin is almost straight or slightly emarginate. The pectoral fin is about the length of the head in the male but slightly shorter in the female ; it extends to almost three-fourths of the distance to the base of the ventral fins in the males whereas in the females it reaches only two-thirds the distance. The posterior margin of the fin is rounded in the females whereas in the case of the males a few anterior rays are somewhat elongated. The ventral fin is provided with a fleshy appendage ; it does not extend to the anal opening. The caudal fin is long and deeply emarginate with the lobes rounded.

The colouration is very characteristic of the species. The dorsal surface and the sides are dull-brown in colour. There are four dark broad bands encircling the body behind the dorsal fin ; they are much wider than the interspaces between them. The caudal fin is marked by a V-shaped band in its middle portion.

Type-specimens.—F 637/2, *Holotype*, ♂ ; F 638/2, *Paratype* 5♀ and 3♂ specimens, Zoological Survey of India, Calcutta.

Locality.—Bener khand, south of Kangra, Kangra District, Punjab.

Remarks.—The species can be readily distinguished from all the other known forms by its characteristic colouration and stumpy nature of the body.

Measurements in millimetres.

	♀ (Fig.)	♀	♀	♀	♀	♂ (Fig.)	♂	♂	♂
Total length ..	75·0	75·0	71·50	64·50	64·0	67·70	75·0	64·50	54·0
Standard length ..	62·50	63·5	59·5	53·0	53·0	55·0	62·50	53·0	43·0
Length of head ..	14·0	14·0	14·0	12·50	12·0	12·50	14·50	12·0	10·50
Height of head ..	9·50	9·50	9·0	8·0	7·50	7·50	9·0	7·50	6·0
Width of head ..	10·50	10·50	9·50	8·0	8·50	8·50	10·0	7·50	6·50
Diameter of eye ..	3·0	3·0	2·75	2·50	2·50	2·50	3·0	2·50	2·50
Length of snout ..	6·50	6·50	6·0	6·0	5·50	5·25	6·50	5·50	4·50
Interorbital distance ..	4·50	4·50	4·0	4·0	4·0	4·0	4·50	4·0	3·0
Depth of body ..	15·50	15·50	13·50	12·0	12·0	10·50	11·0	10·0	7·0
Length of caudal peduncle.	10·50	7·50	7·0	6·0	6·0	9·5	10·5	6·0	5·50
Height of caudal peduncle.	8·5	8·5	7·5	6·5	6·5	7·5	8·0	7·0	5·5
Height of dorsal fin ..	10·50	12·0	11·0	10·50	11·0	10·50	12·50	10·5	8·50
Length of pectoral fin	12·50	13·50	13·0	11·50	11·0	11·5	14·50	11·0	9·0
Length of anal fin ..	10·50	11·50	10·0	8·50	9·0	10·0	11·0	9·0	7·50
Length of the inner rostral barbel.	3·0	4·0	3·50	3·50	3·0	3·0	3·50	3·0	2·50
Length of the outer rostral barbel.	4·0	5·0	4·50	4·50	3·50	4·50	4·50	4·0	3·0
Length of the max. barbel.	4·0	4·0	3·50	3·50	3·50	3·50	4·0	4·0	3·0

Nemachilus kangrae, sp. nov.

D. 10 (3/7) ; P. 7 (1/6) ; V 7 (1/6) ; A. 6 (1/5) ; C. 18.

In this new loach, the body is very much elongated, the dorsal profile rising very little from the tip of the snout to the base of the dorsal fin beyond which it is almost straight. The ventral surface is flattened and almost horizontal. The head is conical and snout pointed. The length of the head is contained from 5 to 5·8 times, the maximum depth of the body 7·5 to 8 times, and the length of the caudal fin from 5·2 to 5·7 times in the standard length. The eyes are dorso-lateral in position and are not visible from the ventral surface, they are situated almost in the middle of the head. The diameter of the eye is contained from 4·5 to 5·2 times in the length of the head and 2·1 to 2·5 times in the length of the snout. The inter-orbital width is about one and a half times the diameter of the eye. The nostrils are situated nearer to the eye than to the tip of the snout. There are three pairs of barbels; the outer rostral and maxillary pairs are longer than the eye while the inner rostrals are almost as long as the eye. The mouth is semicircular and horizontal, it is bordered by fleshy lips which are continuous around the corners of the mouth. The lower lip is interrupted in the middle. The lateral line is complete and well marked throughout its length. The caudal peduncle is somewhat long and narrow, its height is contained from 1·6 to 1·8 times in its length.

The origin of the dorsal fin is nearer to the base of the caudal fin than to the tip of the snout; it is very much higher than the depth of the body. The upper margin of the fin is almost straight with the anterior upper corner somewhat rounded. The pelvic fins commence almost opposite to the origin of the dorsal and are situated nearer to the base of the caudal than to the tip of the snout. The pectoral fins are shorter than the length of the head ; they are without any elongated ray and extend only half way to the pelvic fins. The caudal fin is long and deeply emarginate ; its lower lobe is slightly longer than the upper.

The body, including the fin, is dirty yellow in colour with eight to eleven dark transverse bands which extend to slightly below the lateral line. There is a dark patch at the base of the caudal which is also provided by a zig-zag band across the centre of its margin.

Type-specimens.—F 639/2 *Holotype,* F 640/2 *Paratype,* Zoological Survey of India, Calcutta.

Locality.—Baijnath, Kangra District, Punjab.

Remarks.—*Nemachilus kangrae* can be easily distinguished from all the other known forms by its short rounded pectoral fins and the much elongated form of the body. The pectorals are shorter than the length of the head and extend only half way to the pelvic fins.

Measurements in millimetres.

Total length	62·0	59·5	58·5	53·5
Standard length	52·0	50·5	49·5	45·5
Length of head	10·50	10·0	10·0	9·0
Height of head	5·75	5·5	5·0	5·0
Width of head	6·50	6·50	6·0	6·0
Diameter of eye	2·0	2·0	2·0	2·0
Length of snout	5·0	4·75	4·5	4·25
Inter orbital distance	3·5	3·25	3·0	3·0
Depth of body	6·5	6·5	6·0	6·0
Length of caudal peduncle	8·0	7·5	7·5	7·0
Height of the caudal peduncle	5·0	5·0	4·5	4·0
Length of dorsal fin	8·0	8·0	7·50	7·0
Length of pectoral fin	8·0	8·0	7·50	7·0
Length of anal fin	6·0	7·0	7·0	6·50
Length of the inner rostral barbel	2·0	2·0	2·0	2·0
Length of the outer rostral barbel	3·0	2·25	2·25	2·25
Length of the max. barbel	2·50	2·0	2·25	2·25

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EXPLANATION OF PLATE VII.

Nemachilus horai, sp. nov.

FIG. 1.—Lateral view of the type specimen: X 2.

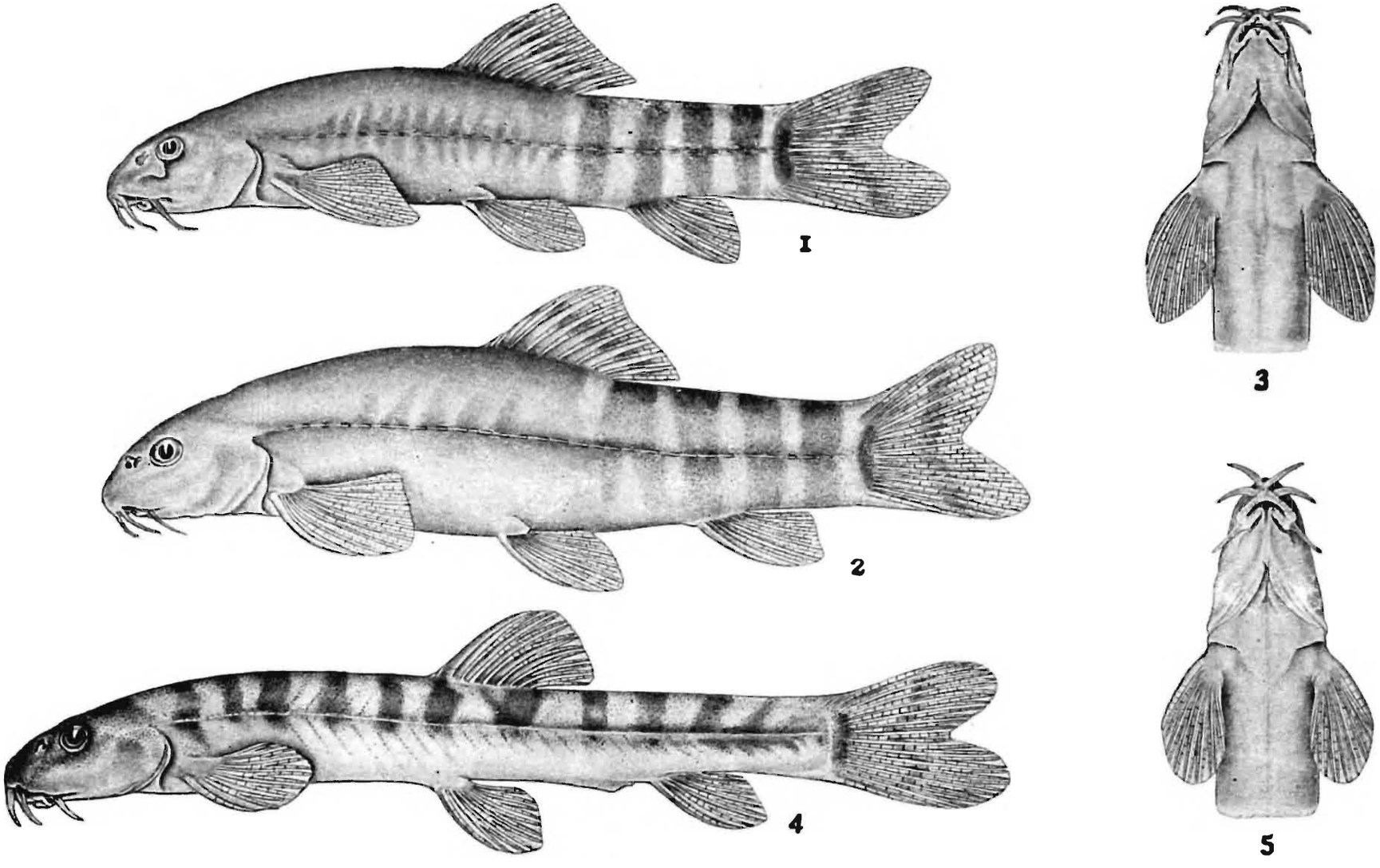
FIG. 2.—Lateral view of a female specimen: X 2.

FIG. 3.—Ventral surface of head and anterior part of body of the type specimen: X 2.

Nemachilus kangrae, sp. nov.

FIG. 4.—Lateral view of the type specimen: X 3.

FIG. 5.—Ventral surface of head and anterior part of body of the same X 3.



New Species of *Nemachilus* From The Kangra Valley

R. Bagchi *del.*