ERRATA

Records of the Indian Museum, Vol. 59 (Parts 1 & 2), published 1963.

Paper by ROONWAL & BHANOTAR, pp. 1-17—

P. 9, line 21 : *for* "*a*", *read* "*b*".

P. 9, line 22 : *for* "*b*", *read* "*a*".

Paper by KAPUR, pp. 131-141—

P. 131, line 6 : *for* KAPUK, *read* KAPUR.

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CONTENTS

STUDIES IN INTRASPECIFIC VARIATION. IX*.

HIND-FEMORAL SPINES AS A PHASE CHARACTER IN THE DESERT LOCUST

By

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and

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(With 7 Tables and 3 Text-figures)

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* For earlier parts see : Roonwal *et al.* : *Rec. Indian Mus.*, **44**(4), pp. 369-374 (1946) ; **45**(2-3), pp. 149-165 (1949) ; 167-180 (1949) ; **47**(3-4), pp. 265-275 (1951) ; and *Indian J. Ent.*, **14**(2), pp. 95-152 (1952) ; **15**(1), pp. 6-10 (1955) ; **17**(2), pp. 155-158 (1955).

I—Introduction

That the hind-femur is susceptible to the "phase" type of differences in the Desert Locust, *Schistocerca gregaria* (Forskal) (Orthoptera, family Acrididae), is now well known. Hitherto, the principal phase difference known has been in the length-character only, the length of the hind-femur (F) being shorter in phase *gregaria* individuals than in the phase *solitaria* ones (*vide*, Roonwal, 1949, 1955 ; Roonwal & Nag, 1951 ; Misra, Nair & Roonwal, 1952), the range and mean values being as follows (E, length of elytron ; F, length of hind-femur) :—

	Mean F	*Mean E/F*
Ph. *gregaria*-♂(6-eye-striped)	24·32 mm.	2·17
Ph. *solitaria*-♂(6- and 7-eye-striped)	25·40-26·13 mm.	2·00
Ph. *gregaria*-♀(6-eye-striped)	26·44 mm.	2·25
Ph. *solitaria*-♀(6 and 7-eye-striped)	29·37-30·92 mm.	2·09-2·03

This difference is also reflected in the E/F ratio. Some phase variability is also weakly discernible in the number of hind-tibial spines where, according to Roonwal (1947), individuals of the phase *solitaria* show a greater degree of variability than those of the phase *gregaria*.

In *Locusta migratoria*, Mukerji & Chatterjee (1956), from a study of three specimens from southern India, brought forth some evidence to show that "the relative development of denticles on the upper (or dorsal) edge of hind-femur may prove to be an additional morphological phase character" (p. 164). The denticles are well developed in phase *solitaria* and absent in phase *gregaria*. We have studied the spines ("denticles" of Mukerji & Chatterjee) on the upper (dorsal) margin of the hind-femora in *Schistocerca gregaria* and also find that their development is markedly correlated with phase—they are, generally well developed in phase *solitaria* and weakly developed in phase *gregaria*. The following is a detailed account of these spines ; a preliminary account will be found in Roonwal & Bhanotar (1959).

Acknowledgment.—The statistical analyses of the various values were carried out by Shri D. B. Panji, Computor, in the Zoological Survey of India.

II—Material and Methods

Samples of typical *solitaria* phase individuals from western India were obtained from the collections of the Zoological Survey of India and from the collections made in the later part of the year 1955 from the same area by the Locust Warning Organisation of the Plant Protection Directorate of the Government of India. In almost all these cases the population density at the time of collection was well below 1,000 individuals per square mile. Typical phase *gregaria* individuals were obtained from the swarm which visited Sri Dungargarh (Bikaner Division, Rajsthan) on the 1st January 1955. In all, a total of 61 specimens were examined and measurements of about 214 individual spines were taken.

The spines were measured under a stereo-binocular and with an ocular micrometer. For interphase and other comparisons of the various values, Fisher's "*t*" test was employed in all cases.

III—HIND-FEMORAL SPINES IN THE DESERT LOCUST

(Text-figs. 1-3)

1. *General*

On the upper (dorsal) surface of the hind-femur, from the proximal to the distal end, numerous denticle-like spines are present. Each spine is accompanied by a long slender seta which arises from the distal base of the spine. The spines are of two types, *viz.*, (i) "well-developed" spines, and (ii) "weakly-developed" spines. Both the types are present in phase *solitaria* individuals, one or two "weak" spines roughly alternating with the "well-developed" ones. But in phase *gregaria* individuals only "weak" spines are present. The "well developed" spines (Text-fig. 3*a*) arise gradually from the surface of the femur, taper at the tip and then fall concavely on the surface of the femur. The "weak" spines (Text-fig. 3*b*) are triangular in appearance, and are often so poorly developed as to form merely a wavy line on the edge of the femur.

2. *Size of spines*

(Text-figs. 1-3 ; and Tables 1 and 2)

As mentioned above, two types of spines are distinguishable as regards size—the "well-developed" and the "weakly-developed". For quantitative data of size, only two measurements, "A" and "B", of height were taken, thus (Text-fig. 3) :

Height "A".—Maximum straight-line distance from the distal tip to the distal base of the spine.

Height "B".—Vertical distance from the distal tip of the spine to the surface of the femur.

(a) *"Well-developed" spines*

(Text-figs. 1-3 ; and Tables 1 and 2)

The "well-developed" spines are present only in the phase *solitaria* individuals and are absent in phase *gregaria*.

(i) *Height "A" (maximum height)*

"A" ranges from 0·037-0·092 mm. (mean 0·067±0·003) in phase *solitaria* males, and is significantly less than in *solitaria* females (range 0·037-0·111 mm. ; mean 0·072±0·003).

(ii) *Height "B" (vertical height)*

Height "B" ranges from 0·037-0·092 mm. (mean 0·053±0·002) in phase *solitaria* males, and is significantly less than in *solitaria* females (range 0·037-0·092 mm.; mean 0·059±0·002).

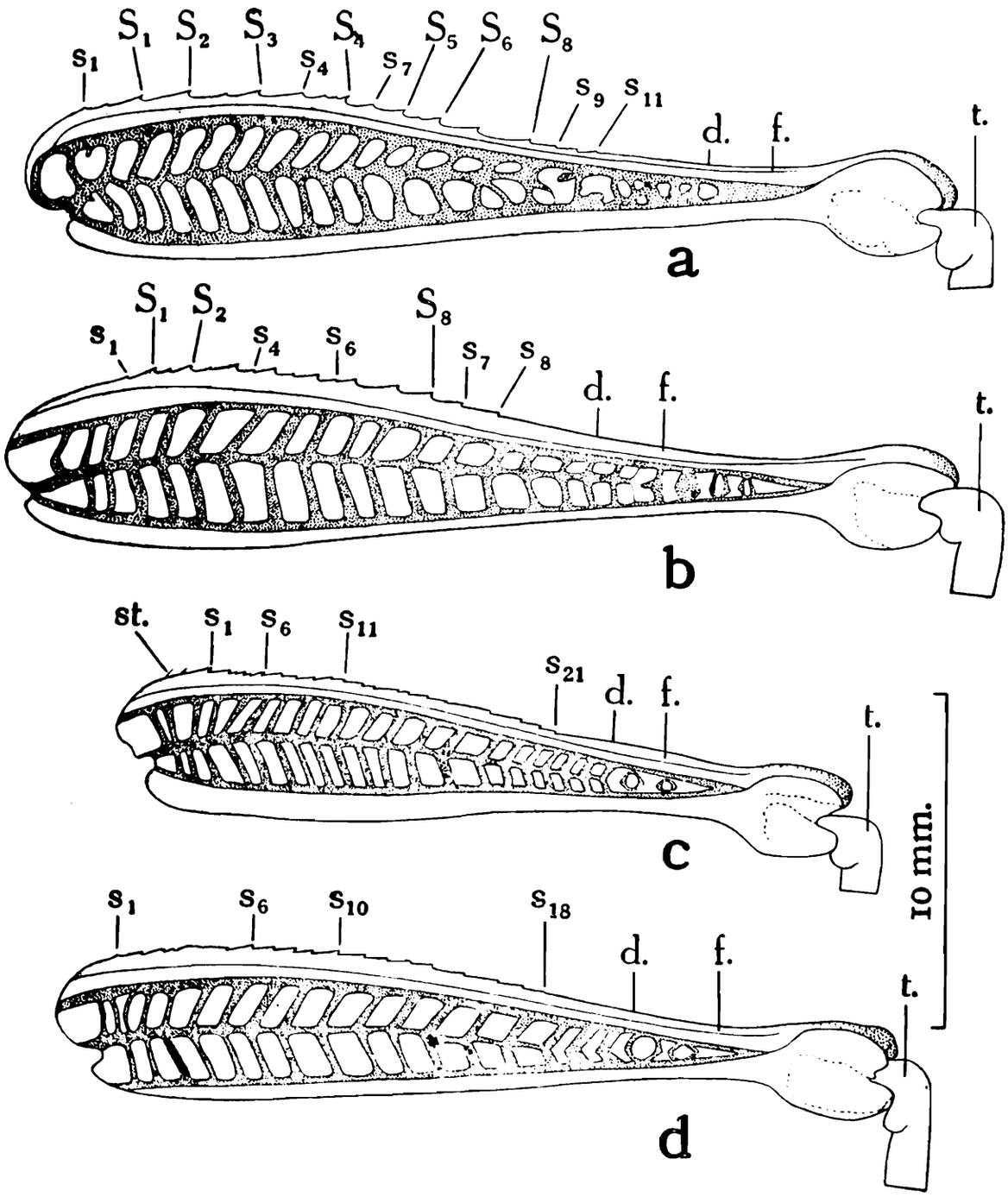
(b) *"Weakly-developed" spines*

(Text-figs. 1-3 ; and Tables 1 and 2)

The "weak" spines are present both in phase *solitaria* and phase *gregaria* individuals. The heights "A"and "B" vary as follows :

(i) *Height "A" (maximum height).*

Phase solitaria.—Height "A" ranges from 0·009-0·037 mm. (mean 0·018±0·0009) in *solitaria* males, and is significantly less than in *solitaria* females (range 0·009-0·037 ; mean 0·026±0·002).

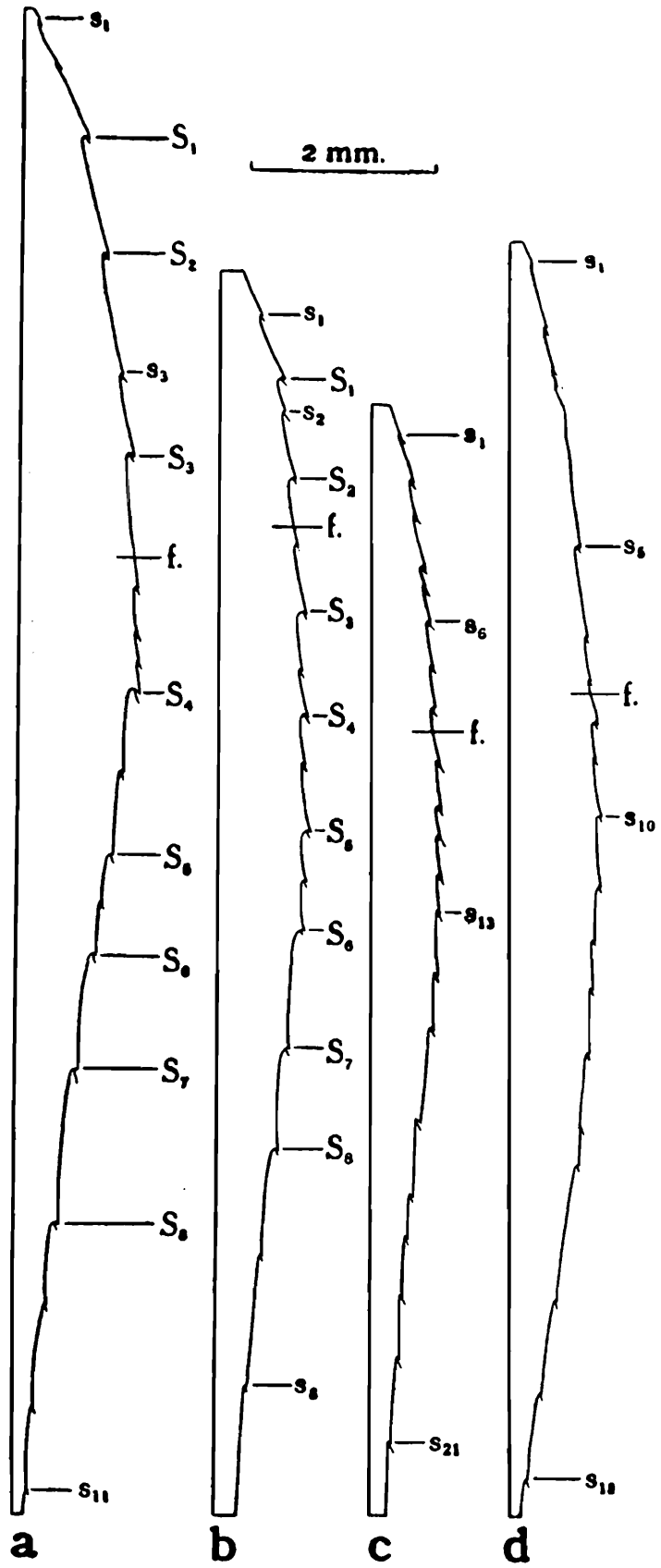


TEXT-FIG. 1.—*Schistocerca gregaria* (Forsk.). Left hind-femora, in side view (outer side), to show the femoral spines on the dorsal ridge.(*Z.S.I.*, collection with the Director, Zoological Survey of India; *P.P.A.*, collections with the Plant Protection Adviser to Government of India, New Delhi.)

(*a*). Phase *solitaria*, male. Z. S. I. Reg. No. 1189/H5. Ambagh *reks* (Mekran, Baluchistan, W. Pakistan), *don.* Y. Ramachandra Rao, 4.×.1936. (*b*). Phase *solitaria*, female. Z.S.I. Reg. No. 1173/H5. Guruchela, Baluchistan (West Pakistan), *don.* Y. Ramachandra Rao, 15.xi.1937). (*c*). Phase *gregaria*, male. P.P.A. No. 7. Dungargarh. (Churu District, Rajasthan, India), B. Nath *coll.*, 1. i. 1955., (*d*).Phase *gregaria* female. P. P. A. No. 16. Dungargarh (Churu District, Rajasthan, India), B. Nath *coll.*, 1. i. 1955.

d., dorsal ridge of femur; *f.*, hind-femur; S_1 —$S_{8.}$, first to eighth "well-developed spines; s_1 —s_{21}, first to twenty-first "weakly-developed" spines; *st.*, seta; *t.*, tibia.

Phase gregaria.—Height "A" ranges from 0·009-0·055 mm. (mean 0·021±0·001) in *gregaria* males, and is significantly less (at the 5%



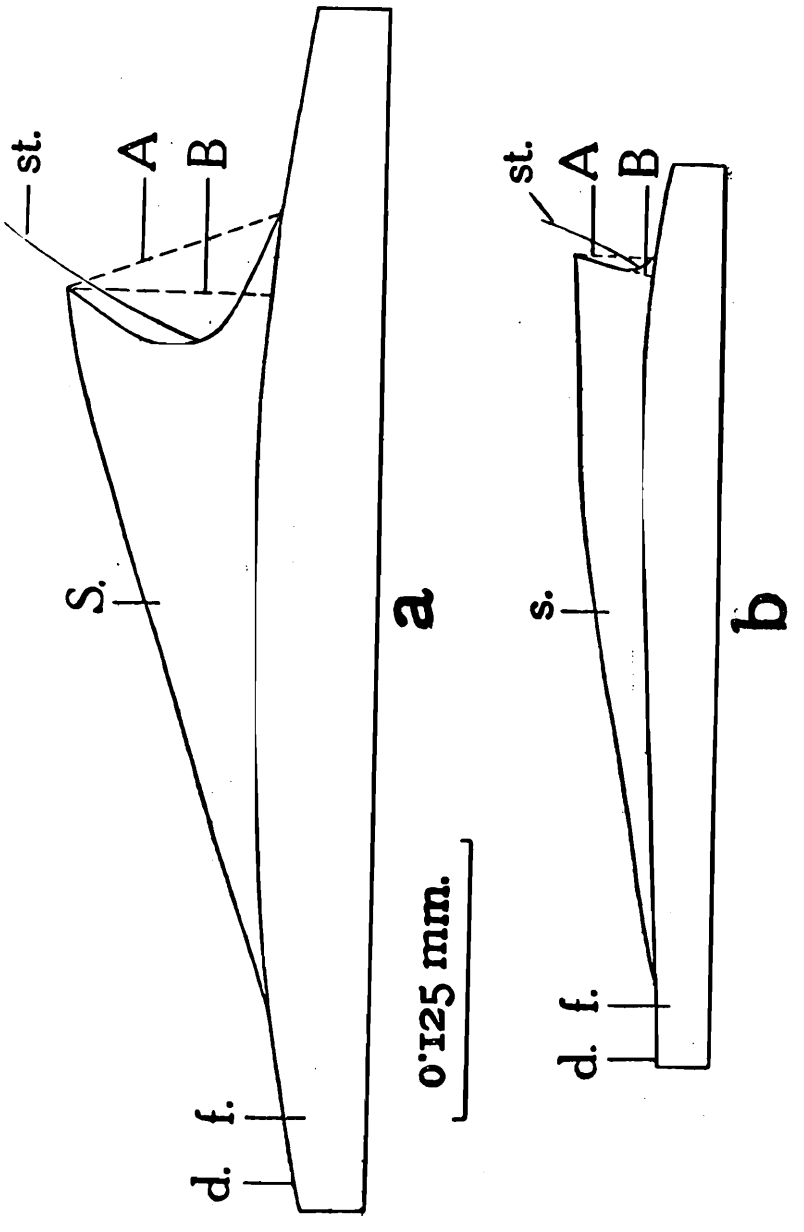
TEXT-FIG. 2.—*Schistocerca gregaria* (Forsk.). Dorsal edge of the left hind-femur, to show the femoral spines greatly enlarged. Same data as in Text-fig. 1.

(*a*) Phase *solitaria*, male. Z. S. I. Reg. No. 1189/45. Ambagh *reks* Mekran, Baluchistan, W. Pakistan). 4.x.1936, *don.* Y. Ramachandra Rao. (*b*). Phase *solitaria*, female. Z. S. I. Reg. No. 1173/H5 (*c*). Phase *gregaria*, male. P. P. A. No. 7. (*d*). Phase *gregaria*, female. P P. A. No. 16.

d., dorsal ridge of femur; *f.*, hind-femur ; S_1 —S_8, first to eighth "well-developed" spines; s_1 —s_{21}, first to twenty-first "weakly-developed" spines.

level but not at the 1% level) than in *gregaria* females (range 0·009-0·055 mm. ; mean 0·025±0·001).

Inter-phase and inter-sex comparisons (Table 2).—Heights "A" of the weak spines, while being significantly different between the two sexes within the same phase, is not significantly different in the *solitaria* and *gregaria* phase within the same sex. A detailed comparisons will be found in Table 2.



TEXT-FIG. 3.—*Schistocerca gregaria* (Forsk.). Hind-femoral spine enlarged, to show the methods of measurements of their "height".

(*a*). A large, well-developed spine, from a phase *solitaria* male specimen. (*b*). A weakly-developed spine, from a phase *gregaria* male specimen.

A., maximum straight-line height of femoral spine from the tip to the distal base of spine; B., vertical height of the femoral spine from the tip to the surface of femur; *d*., dorsal ridge of hind-femur; *f*., hind-femur; *S*., "well-developed" spine; *s*., "weakly-developed" spine; st., seta.

(ii) *Height "B" (vertical height)*

Phase solitaria.—Height "B" ranges from 0·009-0·037 mm. (mean 0·017±0·0004) in *solitaria* males, and is significantly less than in *solitaria* females (range 0·009-0·037 mm. ; mean 0·024±0·002).

Phase gregaria.—Height "B" ranges from 0·009-0·037 mm. (mean 0·021±0·001) in *gregaria* males, and is not significantly different from *gregaria* females (range 0·009-0·055 mm. ; mean 0·024±0·001).

Inter-phase and inter-sex comparison (Table 2).—Height "B" of the "weak" spines in the *solitaria* phase is significantly less in males than in females, but in the *gregaria* phase there is no significant difference between the sexes. Within the same sex, the height "B" is significantly less in *solitaria* males (mean 0·017±0·0004) than in *gregaria* males (mean 0·021±0·001), but within the female sex there is no significant phase difference. A detailed comparison will be found in Table 2.

3. *Number of spines*

(Text-figs. 1 and 2 ; and Tables 3 and 7)

In the *solitaria* phase, as stated above, both "well-developed" and "weak" spines are present, whereas in the *gregaria* phase only "weak" spines are present. The number of spines varies as follows :—

Phase solitaria males.—Well-developed spines 7-9 (mean 8) ; weak spines 6-11 (mean 8) ; total 14-19 (mean 16).

Phase solitaria females.—Well developed spines 7-9 (mean 8) ; weak spines 6-11 (mean 8) ; total 15-19 (mean 16).

Phase gregaria males.—Well-developed spines absent ; weak spines 18-22 (mean 20).

Phase gregaria females.—Well-developed spines absent ; weak spines 17-21 (mean 18).

Inter-sex comparison (Table 7).—In the *solitaria* phase there is no significant difference in the number of spines between males and females. But in the *gregaria* phase the number in males (mean 20·06±0·295) is significantly higher than in females (mean 18·4±0·370).

Inter-phase comparison (Table 7).—Within the same sex, whether male or female, the total number of spines is significantly less in the *solitaria* phase than in the *gregaria.*

4. *Relationship between the length of spine-bearing area and the total length of hind-femur*

(Text-fig. 1 ; and Tables 4 and 5)

To determine the relationship between the length of the spine-bearing area and the total length of the hind-femur, 35 *solitaria* and 26 *gregaria* phase individuals were measured.

The length of the spine-bearing area "*b*" measures about 10·0-15·6mm., and forms about 0·380-0·54 part of the total length "*a*" of the hind-femur.

In phase *solitaria* individuals the mean ratio *b/a* is 0·428±0·006 in males and is significantly less than in females (0·469±0·007). In phase *gregaria* individuals, however, the reverse situation occurs—the ratio in males (mean 0·486±0·007) being significantly higher than in females (mean 0·453±0·013). Within the same sex, the ratio in males is significantly less in the *solitaria* (mean 0·428±0·006) than in the *gregaria* phase (mean 0·486±0·007), but in females there is no phase difference.

5. *Sexual dimorphism*

(TABLE 6)

That the degree of sexual dimorphism in the length of the hind-femur varies with phase is already known (Murat, 1939 ; Roonwal, 1949 ; Roonwal & Nag, 1951 ; and Roonwal & Misra, 1952). In the size and number of the hind-femoral spines also a certain degree of sexual dimorphism, expressed as Sexual Dimorphism Percentage (S. D. P.), $\left[\left(\frac{♀♀}{♂♂}-1\right)\times 100\right]$, is discernible, as discussed below.

(*i*) *Size of spines*

The spines are 7·5-44·4% larger in females than in males ; thus :

Well-developed spines : The S. D. P. for the Heights "A" and "B" is 7·5 % and 11·3% respectively in phase *solitaria.*

Weakly-developed spines : The S. D. P. for Height "A" is 44·4% in phase *solitaria* and 19% in phase *gregaria.* For Height "B", the S. D. P. is 41·2% in phase *solitaria* and 14·3% in phase *gregaria.*

(*ii*) *Number of spines*

In regard to the number of spines, sexual dimorphism is discernible only in respect of the weakly developed spines in the *gregaria* phase where the value of the S. D. P. is 10%, *i.e.*, there are fewer spines in females than in males.

(*iii*) *Ratio b/a* (*length of spine-bearing area to the total length of hind-femur*)

The value of the S. D. P. in phase *solitaria* is 9·6%, and in phase *gregaria* 3·7%.

IV—SUMMARY

1. The series of spines present on the upper (dorsal) edge of the hind-femur of the Desert Locust, *Schistocerca gregaria* (Forskal), were studied and found to show differences correlated with the "phase" (*e.g.*, *solitaria* or *gregaria*) of the specimens.

2. Two types of femoral spines are distinguishable as regards size *viz.*, (i) the large or "well-developed" spines (Height "A" or maximum straight-line height from tip to base, 0·037-0·111 mm.) ; and (ii) "weakly-developed" spines (Height "A' , 0·009-0·055 mm.).

3. In the *solitaria* phase both types of spines (the well-developed and the weakly-developed) are present in almost equal numbers. In the *gregaria* phase, on the other hand, only the weak spines are present.

4. Two measurements, "A" and "B", of the spine were taken as regards height. Height "A" (maximum height) is the maximum straight-line distance from the distal tip to the distal base of the spine. Height "B" is the vertical distance from the tip of the spine to the surface of the femur.

5. The inter-phase and inter-sex differences in the height of spines was studied.

6. In the *solitaria* phase there are about 7-9 (mean 8) well-developed spines and 6-11 (mean 8) weak spines, or a total of about 14-19 (mean 16·31) spines. No sexual difference is discernible in this respect. In the *gregaria* phase, where only weak spines are present, their number in males is about 18-22 (mean 20·06) which is significantly higher than in females (17-21, mean 18·4).

7. The length of the spine-bearing area "*a*" was studied in relation to the total length, "*b*" of the hind-femur. In phase *solitaria* males the ratio *b*/*a* is $0{\cdot}428 \pm 0{\cdot}006$ and this figure is significantly less than in females ($0{\cdot}469 \pm 0{\cdot}007$). In the *gregaria* phase, however, the ratio in males ($0{\cdot}486 \pm 0{\cdot}007$) is significantly higher than in females ($0{\cdot}453 \pm 0{\cdot}013$). Within the same sex, the ratio is significantly higher in male *gregaria* ($0{\cdot}486 \pm 0{\cdot}007$) than in male *solitaria* ($0{\cdot}428 \pm 0{\cdot}006$) ; but in the female sex, the phases do not differ significantly.

8. Sexual Dimorphism in respect of the femoral spines was studied.

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TABLE 1.—*Size-range (height) (in mm.) and the Means (with S. E.) of hind-femoral spines in* Schistocerca gregaria *for phases* solitaria *and* gregaria.

A—Maximum straight-line height (in mm.) of spine from tip to distal base of spine.

B—Vertical height (in mm.) of spine from tip to surface of femur.

Sl. No.	Sex	No. of eye-stripes	No. of individuals examined	Total No. of spines examined	Size of hind-femoral spines (mm.)							
					Range (mm.)				Mean (with S.E.)			
					Well-developed spines		Weakly-developed spines		Well-developed spines		Weakly-developed spines	
					Maximum height A	Vertical height B	Maximum height A	Vertical height B	Maximum height A	Vertical height B	Maximum height A	Vertical height B
					1. Phase solitaria							
1	♂	6—7	3	51	0·037—0·092	0·037—0·092	0·009—0·037	0·009—0·037	0·067±0·003	0·053±0·002	0·018±0·0009	0·017±0·0004
2	♀	6	3	49	[0·037—0·111	0·037—0·092	0·009—0·037	0.009—0·037	0.072±0·003	0·059±0·002	[0·026±0·002	0·024±0·002
3	Both sexes	6—7	6	100	[0·037—0·111]	0·037—0·092]	[0·009—0·037	0.009—0·037	0·070±0·003	0·056±0·002	0·022±0.001	0·020±0·001
					2. Phase gregaria							
4	♂	6	3	61	..	..	0·009—0·055	0·009—0·037	..	..	0·021±0·001	0·021±0·001
5	♂	6	3	53	..	..	0·009—0·055]	0·009—0·055	..	..	0·025±0·001	0.024±0·001
6	Both sexes	6	3	114	..	..	0·009—0·055	0·009—0·055	..	..	0·023±0·001	0·022±0·001

TABLE 2.—*Comparison of size-range (height, in mm.) and variability of heights ("A" and "B") of hind femoral spines in* Schistocerca gregaria.

Abbreviations :

A—Maximum height of spine (from tip to distal base).

B—Vertical height of spine (from tip to surface of femur).

S—Significant.

NS—Not significant.

C. V.—Coefficient of Variation.

S. D.—Standard Deviation.

S. E.—Standard Error.

Ph. *greg.*—Phase *gregaria.*

Ph. *sol.*—Phase *solitaria.*

Sl. No. of Pairs	Nature of population, with sex and number of eye-stripes (6 or 7)	Character of spines	No. of spines	Size-range of height (mm.)	Category of (Height)	Mean ± S. E. (mm.)	S. D. ± S. E.	C.V.	Significance of difference of the Mean. At 5% level of probability	Significance of difference of the Mean. At 1% level of probability
1	Ph. *sol.* ♂ ♂ (6-7)	Weak	26	0·009—0·037	A	0·018±0·0009	0·004±0·0006	25·40	S	S
	Ph. *sol.* ♀ ♀ (6)	,,	23	0·009—0·037	A	0·026±0·002	0·010±0·001	40·77		
2	Ph. *sol.* ♂ ♂ (6-7)	,,	26	0·009—0·037	A	0·018±0·0009	0·004±0·0006	25·40	NS	NS
	Ph. *greg.* ♂ ♂ (6)	,,	61	0·009—0·055	A	0·021±0·001	0·011±0·0009	52·38		
3	Ph. *sol.* ♀ ♀ (6)	,,	23	0·009—0·037	A	0·026±0·002	0·010±0·001	40·77	NS	NS
	Ph. *greg.* ♀ ♀ (6)	,,	53	0·009—0·055	A	0·025±0·001	0·010±0·0009	39·83		

4	Ph. *sol.* (both sexes) (6-7)	..	Weak	49	0·009—0·037	A	0·022±0·001	0·007±0·0008	33·08	NS	NS
	Ph. *greg.* (both sexes) (6)	..	,,	114	0·009—0·055	A	0·023±0·001	0·010±0·0009	46·10		
5	Ph. *greg.* ♂ ♂ (6)	..	.. ,,	61	0·009—0·055	A	0·021±0·001	0·011±0·0009	52·38	S	NS
	Ph. *greg.* ♀ ♀ (6)	..	.. ,,	53	0·009—0·055	A	0·025±0·001	0·010±0·0009	39·83		
6	Ph. *sol.* ♂ ♂ (6-7)	..	.. ,,	26	0·009—0·037	B	0·017±0·0004	0·002±0·0003	14·16	S	S
	Ph. *sol.* ♀ ♀ (6)	..	.. ,,	23	0·009—0·037	B	0·024±0·002	0·010±0·001	42·60		
7	Ph. *sol.* ♂ ♂ (6-7)	..	.. ,,	26	0·009—0·037	B	0·017±0·0004	0·002±0·0003	14·16	S	S
	Ph. *greg.* ♂ ♂ (6)	..	.. ,,	61	0·009—0·037	B	0·021±0·001	0·010±0·0009	49·02		
8	Ph. *sol.* ♀ ♀ (6)	..	.. ,,	23	0·009—0·037	B	0·024±0·002	0·010±0·001	42·60	NS	NS
	Ph. *greg.* ♀ ♀ (6)	..	.. ,,	53	0·009—0·055	B	0·024±0·001	0·009±0·0009	40·39		
9	Ph. *sol.* (both sexes) (6-7)	..	,,	49	0·009—0·037	B	0·020±0·001	0·006±0·0006	28·38	NS	NS
	Ph. *greg.* (both sexes) (6)	..	,,	114	0·009—0·055	B	0·022±0·001	0·009±0·0009	44·70		
10	Ph. *greg.* ♂ ♂ (6)	..	.. ,,	61	0·009—0·037	B	0·021±0·001	0·010±0·0009	49·02	NS	NS
	Ph. *greg.* ♀ ♀ (6)	..	.. ,,	53	0·009—0·055	B	0·024±0·001	0·009±0·0009	40·39		

TABLE 3.—*Summary of the data on the number of hind-femoral spines in* Schistocerca gregaria *from specimens collected in Western India (Rajasthan, Punjab, Sind and Baluchistan).*

Phase and sex	No. of individuals examined	No. of eye-stripes	E/F ratios	No. of "well developed" spines		No. of "weakly developed" spines		Total No. of spines	
				Range	Mean	Range	Mean	Range	Mean
1. *solitaria* males	16	6—7	1·92—2·10	7—9	8	6—11	8	14—19	16
2. *solitaria* females	19	6—7 (8)	1·95—2·16	7—9	8	6—11	8	15—19	16
3. *gregaria* males	16	6	2·05—2·30	0	..	18—22	20	18—22	20
4. *gregaria* females	16	6	2·18—2·31	0	..	17—21	18	17—21	18

TABLE 4.—*Relationship between total length of hind-femur and the length of spine-bearing area of femur in* Schistocerca gregaria.

(*a*) Length of hind-femur (in mm.).

(*b*) Length of spine-bearing area of the femur (in mm.).

Serial No.	Sex	No. of eye-stripes	No. of individuals examined	Total No. of spines	MEASUREMENTS (mm.)					
					Size-range (mm.)			Mean (mm.)		
					Length of hind-femur (*a*)	Length of spine-bearing area of the femur (*b*)	Ratio *b*/*a*	Length of femur (*a*)	Length of spine-bearing area of the femur (*b*)	Ratio *b*/*a*
					1. Phase solitaria					
1	♂	6—7	16	16	25·0—28·2	10·6—12·0	0·380—0·476	26·3	11·2	0·428
2	♀	6—7	19	16	26·9—34·1	11·4—15·6	0·410—0·528	30·4	14·2	0·469
3	Both sexes	6—7	35	16	25·0—34·1	10·6—15·6	0·380—0·528	28·3	12·7	0·448
					2. Phase gregaria					
1	♂	6	16	20	21·8—25·2	10·1—12·1	0·427—0·540	23·2	11·2	0·486
2	♀	6	10	18	23·3—26·9	10·0—12·2	0·397—0·523	24·8	11·2	0·453
3	Both sexes	6	26	19	21·8—26·9	10·0—12·2	0·397—0·540	24·0	11·2	0·457

TABLE 5.—*Comparison of the mean ratio (b/a) between the total length of hind-femur and the length of the spine-bearing area of femur in* Schistocerca gregaria.

Abbreviations :

S Significant.

NS—Not significant.

S. D.—Standard Deviation.

S. E.—Standard Error.

Ph. *greg.*—Phase *gregaria.*

Ph. *sol.*—Phase *solitaria.*

Serial No. of pairs	Nature of population, with sex and number of eye-stripes (6 or 7)	Mean ratio ± S. E. (*b/a*)	S. D. ± S. E.	Significance of difference of the Mean ratio	
				At 5% level of probability	At 1% level of probability
1	Ph. *sol.* ♂ ♂ (6—7)	0·428±0·006	0·025±0·004	S	S
	Ph. *sol.* ♀ ♀ (6—7)	0·469±0·007	0·031±0·005		
2	Ph. *greg.* ♂ ♂ (6)	0·486±0·007	0·030±0·005	S	NS
	Ph. *greg.* ♀ ♀ (6)	0·453±0·013	0·043±0·009		
3	Ph. *sol.* ♂ ♂ (6—7)	0·428±0·006	0·025±0·004	S	S
	Ph. *greg.* ♂ ♂ (6)	0·486±0·007	0·030±0·005		
4	Ph. *sol.* ♀ ♀ (6—7)	0·469±0·007	0·031±0·005	NS	NS
	Ph. *greg.* ♀ ♀(6)	0·453±0·013	0·043±0·009		

TABLE 6.—*Sexual Dimorphism Percentage* $[(\frac{♀}{♂} - 1) \times 100]$ *in the hind-femoral spines in* Schistocerca gregaria.

Character and Phase	Sexual Dimorphism Percentage
1. Size of spines	
(A) WELL-DEVELOPED SPINES	
(i) Height "A"—Phase *solitaria*	7·5
(ii) Height "B"—Phase *solitaria*	11·3
(B) WEAKLY-DEVELOPED SPINES	
(i) Height "A" —Phase *solitaria*	44·4
(ii) ,, ,, —Phase *gregaria*	19·0
(iii) Height "B" —Phase *solitaria*	41·2
(iv) ,, ,, —Phase *gregaria*	14·
2. Number of spines	
WEAKLY-DEVELOPED SPINES	
Phase *gregaria*	—10
3. Ratio *b/a* (ratio of length of spine-bearing area to total length of hind-femur).	
Phase *solitaria*	9·6
Phase *gregaria*	—3·7

TABLE 7.—*Significance of inter-sex and inter-phase differences in the total number of hind-femoral spines in* Schistocerca gregaria.

Abbreviations :

NS.—Not significant.
S.—Significant.
S. D.—Standard Deviation.
S.E.—Standard Error.
Ph. *greg.*—Phase *gregaria.*
Ph. *sol.*—Phase *solitaria.*

Sl. No. of pairs	Nature of population, with sex and number of eye-stripes (6 or 7)	Total number of hind-femoral spines		Significance of difference in the Mean	
		Mean±S.E.	S. D.±S. E.	At 5 % level of probability	At 1 % level of probability
	Ph. *sol.* ♂ ♂ (6—7)	16·31±0·350	1·400±0·248	NS	NS
	Ph. *sol.* ♀ ♀ (6—7)	16·68±0·362	1·577±0·256		
2	Ph. *greg.* ♂ ♂ (6)	20·06±0·295	1·181±0·209	S	S
	Ph. *greg.* ♀ ♀ (6)	18·40±0·370	1·170±0·262		
3	Ph *sol.* ♂ ♂ (6—7)	16·31±0·350	1·400±0·248	S	S
	Ph. *greg.* ♂ ♂ (6)	20·06±0·295	1·181±0·209		
4	Ph. *sol.* ♀ ♀ (6—7)	16·68±0·362	1·577±0·256	S	S
	Ph. *greg.* ♀ ♀ (6)	18·40±0·370	1·170±0·262		

CLASSIFICATION AND SYNONYMY OF THE CRANE-FLIES DESCRIBED BY ENRICO BRUNETTI (DIPTERA: FAMILIES PTYCHOPTERIDAE, TRICHOCERIDAE AND TIPULIDAE)

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CONTENTS

I—INTRODUCTION

Between 1911 and 1924, the late Enrico Brunetti described as new approximately 240 species of crane-flies, the great majority from the area comprised within the limits of former British India and Burma. Due in part to circumstances beyond his control, as discussed in papers by Alexander (1942) and Edwards (1924)**, Brunetti's arrangement of many of his species to genera was questionable, with the result that subsequent taxonomic work on these flies from this faunal area proved difficult and uncertain. Edwards (1924) was able to examine certain of the Brunetti types that were brought to London by the describer while some others have been seen by the writer, having been loaned me for study through the kind and appreciated interest of the authorities of the Indian Museum. It is believed that the present distribution of these species, with an indication of synonymy as it appears certain at the present time, may prove helpful to later workers on the crane-flies of this particularly interesting region.

*Contribution No. 1234 from the Department of Entomology, University of Massachusetts, Amherst, Massachusetts, U.S.A.

**Dates in parenthesis refer in most instances to papers cited in the short Bibliography that follows this introductory statement.

Almost all of the species concerned are Indian and these are treated separately from the few further forms that were described from elsewhere in the Oriental and Australasian regions. In virtually all cases, the locality given represents the type station for the species in question.

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Brunetti, E. 1924. Diptera of the Siju cave, Garo Hills, Assam. I. Tipulidae, Tabanidae, Anthomyidae, Acalyptrate Muscidae and Phoridae.—*Rec. Indian Mus.*, Calcutta, **26**, pp. 99-106.

Edwards, Fred W. 1924. Notes on the types of Diptera Nematocera (Mycetophilidae and Tipulidae) described by Mr. E. Brunetti.—*Rec. Indian Mus.*, Calcutta, **26**, pp. 291-307.

II—The Indian species of crane-flies described by Brunetti

Ptychopteridae

**Ptychoptera annandalei* Brun., 1918 : 256 . . Burma : Southern Shan States.

P. distincta Brun., 1911 : 232 . . E. Himalayas : Darjiling.

**P. tibialis* Brun., 1911 : 233 (synonym *P. atritarsis* Brun., 1911 : 234) E. Himalays : Darjiling.

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*Indicates species of which type material is present in the collection of the Zoological Survey of India, Calcutta (*A .P. Kapur*).

TRICHOCERIDAE

**Paracladura elegans* Brun., 1911 : 288 . .	E. Himalayas : Darjiling.
**P. gracilis* Brun., 1911 : 287 (synonym *P. flava* Brun., 1912 : 512, as *Trichocera*) .	E. Himalayas : Darjiling.
**Trichocera montana* Brun., 1912 : 513 . .	W. Himalayas : Garwal District.
**T. punctipennis* Brun., 1912 : 511 . .	W. Himalayas : Simla.

TIPULIDAE

TIPULINAE

Ctenacroscelis carmichaeli (Brun., 1913 *b* : 257, as *Tipula*)	E. Himalayas : Darjiling.
**C. dives* (Brun., 1912 : 307, as *Tipula*)	E. Himalayas : Kurseong.
**C. flavoides* (Brun., 1918 : 267, as *Tipula*)	Assam : Garo Hills.
C. flavus (Brun., 1911 : 252, as *Tipula*) .	E. Himalayas : Sikkim.
**C. fulvolateralis* (Brun., 1911 : 249, as *Tipula*) (synonym *C. sikkimensis* Enderlein, 1912 : 1)	W. Himalayas : Kumaon.
C. fumipennis (Brun., 1911 : 250, as *Tipula*) (preoccupied—renamed *cerbereanus* Alexander, 1942 : 29)	E. Himalayas : Darjiling.
**C. majesticus* (Brun., 1911 : 248, as *Tipula*)	E. Himalayas : Darjiling.
**C. ochripes* (Brun., 1911 : 260, as *Tipula*)	Ceylon.
**C. ornatithorax* (Brun., 1911 : 258, as *Tipula*)	E. Himalayas : Darjiling.
**C. serricornis* (Brun., 1912 : 309, as *Tipula*) (preoccupied—renamed *cressida* Alexander, 1953)	W. Himalayas : Kumaon.
**Nephrotoma concolorithorax* (Brun., 1912 : 346, as *Pachyrhina*)	Assam : Khasi Hills.
**N. consimilis* (Brun., 1911 : 266, as *Pachyrhina*)	E. Himalayas : Darjiling.
**N. dorsopunctata* (Brun., 1911 : 265, as *Pachyrhina*)	Bihar : Purneah District.
N. fuscoflava (Brun., 1918 : 275, as *Pachyrhina*)	Pakistan : Punjab.
**N. gamma* (Brun., 1912 : 347, as *Pachyrhina*)	Assam-Bhutan Border.
**N. hypocrites* (Brun., 1918 : 276, as *Pachyrhina*) (synonym—*N. nigroapicalis* Brun., 1918 : 335, as *Eriocera*)	E. Himalayas : Darjiling.
N. parvinotata (Brun., 1918 : 276, as *Pachyrhina*)	Pakistan : Peshawar District.
**N. pleurinotata* (Brun., 1912 : 343, as *Pachyrhina*)	Ceylon.
**N. puncticornis* (Brun., 1912 : 343, as *Pachyrhina*)	E. Himalayas : Darjiling.
**N. serricornis* (Brun., 1912 : 341, as *Pachyrhina*) .	E. Himalayas : Darjiling.

**Pachyrhina demarcata* Brun., 1912 : 344 (preoccupied—renamed *Tipula* (*Schummelia*) *sessilis* Edwards)	E. Himalayas : Darjiling.
Ctenophora (*Tanyptera*) *indica* (Brun., 1918 : 257, as *Xiphura*)	E. Himalayas : Darjiling.
**C* (*Pselliophora*) *aurantia* (Brun., 1918 : 260, as *Pselliophora*)	Assam : Garo Hills.
**C.* (*P.*) *approximata* (Brun., 1918 : 259, as *Pselliophora*)	S. India : North Kanara District.
**C.* (*P.*) *divisa* (Brun., 1911 : 242, as *Pselliophora*)	"East Indies" ; E. Himalayas.
**C.* (*P.*) *flavofasciata* (Brun., 1918 : 259, as *Pselliophora*)	Assam : Garo Hills.
**C.* (*P.*) *immaculipennis* (Brun., 1911 : 243, as *Pselliophora*)	Assam : Sylhet.
C. (*P.*) *laeta trilineata* (Brun., 1911 : 240, as *Pselliophora*)	S. India : Nilgiri Hills.
C. (*P.*) *latifascipennis* (Brun., 1918 : 260, as *Pselliophora*)	S. India : Coorg.
Prionota (*Plocimas*) *serraticornis* (Brun., 1911 : 242, as *Pselliophora*) (synonym *P.* (*P.*) *elongata* Edwards, 1913 : 202, as *Pselliophora*)	Ceylon.
**Tipula* (*Brithura*) *gravelyi* Brun., 1918 : 264 (synonym of *T.* (*B.*) *crassa* Edwards, 1916)	E. Himalayas : Darjiling.
T. (*B.*) *imperfecta* Brun., 1913 : 260	E. Himalayas : Darjiling.
**T.* (*Bellardina*) *griseipennis* Brun., 1912 : 321	W. Himalayas : Garhwal District.
**T.* (*B.*) *splendens* Brun., 1912 : 314 (preoccupied-renamed *brunettiana* Alexander, 1920)	W. Himalayas : Garhwal District.
**T.* (*B.*) *tesselatipennis* Brun., 1912 : 317	W. Himalayas : Kumaon.
**T.* (*Nippotipula*) *pulcherrima* Brun., 1912 : 310	W. Himalayas : Kumaon.
**T.* (*Schummelia*) *continuata* Brun., 1912 : 328	E. Himalayas : Darjiling.
**T.* (*S.*) *demarcata* (Brun., 1912 : 344, as *Pachyrhina*) (preoccupied—renamed *sessilis* Edwards)	E. Himalayas : Darjiling.
**T.* (*S.*) *picticornis* (Brun., 1918 : 279, as *Nesopeza*)	Burma : Southern Shan States.
**T.* (*Formotipula*) *rufiventris* Brun., 1918 : 268 (preoccupied—renamed *rufoabdominalis* Alexander, 1927)	E. Himalayas : Darjiling.
T. (*Yamatotipula*) *fumifasciata* Brun., 1911 : 250 (synonym of *T.* (*Y.*) *nova* Walker, 1848)	Assam : Manipur State.
T. (*Acutipula*) *interrupta* Brun., 1911 : 256	E. Himalayas : Darjiling.

**T.* (*A.*) *munda* Brun., 1912 : 336 (synonym *T.* (*A.*) *vicaria* Walker, 1856, preoccupied)	W. Himalayas : Mussoorie.
**T.* (*A.*) *princeps* Brun., 1912 : 306 (synonym *T.* (*A.*) *fuscinervis* Brun., 1912 : 312)	E. Himalayas : Kurseong.
**T.* (*A.*) *quadrinotata* Brun., 1912 : 330 (synonym *T.* (*A.*) *fumicosta* Brun., 1918 : 266)	Assam : Manipur State.
T. (*A.*) *robusta* Brun., 1911 : 254 (synonyms *T.* (*A.*) *fumifascipennis Brun.*, 1918 : 266; *T.* (*A.*) *nigrotibialis* Brun., 1912 : 324)	E. Himalayas : Darjiling.
	W. Himalayas : Mussoorie.
**T.* (*A.*) *fumifascipennis* Brun., 1918 : 266	E. Himalayas : Darjiling.
**T.* (*Indotipula*) *cinctoterminalis* Brun., 1912 : 338	E. Himalayas : Kurseong.
**T.* (*I.*) *demarcata* Brun., 1911 : 259	Ceylon.
T. (*I.*) *divisa* Brun., 1911 : 261	E. Himalayas : Darjiling.
**T.* (*I.*) *elegantula* Brun., 1912 : 339	Assam.
**T.* (*I.*) *flavescens* Brun., 1912 : 334	Ceylon.
**T.* (*I.*) *flavithorax* Brun., 1918 : 268	S. India : Cochin State.
T. (*I.*) *gracilis* Brun., 1911 : 262	E. Himalayas : Darjiling.
**T.* (*I.*) *walkeri* Brun., 1911 : 246 (renaming of *T.* (*I.*) *fulvipennis* Walker, 1850, preoccupied ; synonym **T.* (*I.*) *tenuipes* Brun., 1912 : 333)	Nepal.
	Assam : Sylhet.
**T.* (*Tipulodina*) *contigua* Brun., 1918 : 265	Assam : Garo Hills.
**T.* (*T.*) *gracillima* Brun., 1912 : 302	Ceylon.
**T.* (*T.*) *patricia* Brun., 1912 : 313	E. Himalayas : Kurseong.
**T.* (*T.*) *simillima* Brun., 1918 : 265	S. W. India : North Kanara District.
**T.* (*Vestiplex*) *brevis* Brun., 1918 : 270	Assam : Khasi Hills.
(synonym of *T.* (*V.*) *reposita* Walker, 1848)	Nepal.
**T.* (*V.*) *himalayensis* Brun., 1911 : 252	E. Himalayas : Darjiling.
T. (*V.*) *nigroapicalis* Brun., 1911 : 257	E. Himalayas : Darjiling.
**T.* (*V.*) *quasimarmoratipennis* Brun., 1912 : 320	E. Himalayas : Darjiling.
**T.* (*V.*) *subtincta* Brun., 1912 : 326	E. Himalayas : Kurseong.
**T.* (*Oreomyza*) *striatipennis* Brun., 1912 : 325	E. Himalayas : Kurseong.
T. (*Lunatipula*) *fasciculata* Brun., 1918 : 269 preoccupied—renamed *subvernalis* Alexander, 1927)	E. Himalayas : Darjiling.
	E. Himalayas : Darjiling.
**T.* (*L.*) *marmoratipennis* Brun., 1912 : 319	E. Himalayas : Darjiling.
**T.* (Subgenus incertis) *brunnicosta* Brun., 1912 : 332	W. Himalayas : Simla.

T. (Subgenus incertis) *elegans* Brun., 1911 : 255 (preoccupied—renamed *perelegans* Alexander, 1921) — W. Himalayas : Mussoorie.

**T.* (Subgenus incertis) *filicornis* Brun., 1918 : 267 — E. Himalayas : Darjiling.

**Dolichopeza* (*Oropeza*) *albitarsis* (Brun., 1918 : 278, as *Nesopeza*) — E. Himalayas : Darjiling.

**D.* (*Sinoropeza*) *postica* Brun., 1912 : 564 — E. Himalayas : Darjiling.

**D.* (*Mitopeza*) *longicornis* (Brun., 1918 : 278, as *Nesopeza*) — Assam : Garo Hills.

**D.* (*Nesopeza*) *costalis* Brun., 1918 : 277 — S. India : Cochin State.

**D.* (*N.*) *infuscata* Brun., 1912 : 565 — S. India : Nilgiri Hills.

D. (*N.*) *obscura* Brun., 1912 : 355 (preoccupied—renamed *himalayae* Alexander, 1952) — E. Himalayas : Kurseong.

D. (*N.*) *orientalis* Brun., 1912 : 354 — E. Himalayas : Kurseong.

Nesopeza picticornis Brun., 1918 : 279 — see *Tipula* (*Schummelia*) *picticornis* Brun.

Cylindrotominae

**Stibadocera quadricellula* (Brun., 1911 : 268, as *Cylindrotoma*) — E. Himalayas : Kurseong.

**Stibadocerella pristina* Brun., 1918 : 283 (synonyms *Cylindrotoma latefurcata* Brun., 1918 : 280 ; lapsus *Stibadocerella bifurcata* Brun., 1920 : 212 ; lapsus) — Assam : Garo Hills.

Limoniinae

Lechriini

**Lechria bengalensis* Brun., 1911 : 301 — Calcutta ; Pusa.

**Trichoneura* (*Xipholimnobia*) *nepalensis* (Brun., 1918 : 317, as *Lechria*) — Nepal.

Limoniini

Limonia (*Limonia*) *biannulata* (Brun., 1912 : 430, as *Teucholabis*) — E. Himalayas : Kurseong.

**L.* (*L.*) *bicolor* (Brun., 1918 : 285, as *Dicranomyia*) — Assam : Khasi Hills.
(synonym *L.* (*L.*) *bipunctata* Brun., 1918 : 291, as *Limnobia*) — Assam : Garo Hills.

**L.* (*L.*) *centralis* (Brun., 1912 : 403, as *Limnobia*) — E. Himalayas : Kurseong.

L. (*L.*) *cinctiventris* (Brun., 1912 : 382, as *Dicranomyia*) — E. Himalayas : Kurseong.
(synonym—*L.* (*L.*) *vitripennis* Brun., 1912 : 405, as *Limnobia*) — E. Himalayas : Darjiling.

**L.* (*L.*) *confinis* (Brun., 1918 : 290, as *Limnobia*) (preoccupied—renamed *brunettiella* Alexander, 1929) — Assam : Garo Hills.

**L.* (*L.*) *festiva* (Brun., 1912 : 400, as *Limnobia*) — E. Himalayas : Kurseong.

**L.* (*L.*) *flavocincta* (Brun., 1918 : 289, as *Limnobia*)	W. India : Satara District.
**L.* (*L.*) *holoptica* (Brun., 1911 : 273, as *Atypophthalmus*)	Calcutta.
(synonym of *L.* (*L.*) *umbrata* de Meijere, 1911 ; synonym *L.* (*L.*) *quinque-notata* Brun., 1918 : 292, as *Limnobia*)	Assam : Garo Hills.
**L.* (*L.*) *longipennis* (Brun., 1918 : 292, as *Limnobia*) (preoccupied—renamed *garoensis* Alexander, 1921)	Assam : Garo Hills.
**L.* (*L.*) *marginata* (Brun., 1918 : 290, as *Limnobia*) (preoccupied—renamed *marginella* Alexander, 1929) . .	Assam : Garo Hills.
**L.* (*L.*) *nigra* (Brun., 1912 : 404, as *Limnobia*) (preoccupied— renamed *brunettii* Alexander, 1921). May prove to be identical with *bidentata* (Skuse, 1890)	S- India : Travancore.
**L.* (*L.*) *nigrescens* (Brun., 1918 : 293, as *Limnobia*) (preoccupied—renamed *nigricans* Alexander, 1929)	Assam : Garo Hills.
**L.* (*L.*) *niveipes* (Brun., 1912 : 404, as *Limnobia*)	E. Himalayas : Darjiling.
**L. Libnotes fuscinervis* (Brun., 1912 : 411, as *Libnotes*)	E. Himalayas : Darjiling.
**L.* (*L.*) *indica* (Brun., 1912 : 401, as *Limnobia*)	Calcutta.
**L.* (*L.*) *longinervis* (Brun., 1912 : 403, as *Limnobia*)	E. Himalayas : Kurseong.
**L.* (*L*) *notatinervis* (Brun., 1912 : 412, as *Libnotes*)	E. Himalayas : Kurseong.
**L.* (*L.*) *punctithorax* (Brun., 1918 : 293, as *Limnobia*)	SW. India : N. Kanara District.
**L.* (*L.*) *trimaculata* (Brun., 1912 : 402, as *Limnobia*)	E. Himalayas : Kurseong.
**L.* (*L.*) *tritincta* (Brun., 1918 : 291, as *Limnobia*)	Assam : Garo Hills.
**L.* (*Dicranomyia*) *absens* (Brun., 1912 : 372, as *Dicranomyia*)	E. Himalayas : Kurseong.
**L.* (*D.*) *approximata* (Brun., 1912 : 567, as *Dicranomyia*)	E. Himalayas : Darjiling.
**L.* (*D.*) *cinerascens* (Brun., 1912 : 381, as *Dicranomyia*) .	E. Himalayas : Darjiling.
**L.* (*D.*) *columbina* (Brun., 1912 : 567, as *Dicranomyia*)	Ceylon.
**L.* (*D.*) *delicata* (Brun., 1912 : 383, as *Dicranomyia*) .	E. Himalayas : Darjiling.
**L.* (*D.*) *fascipennis* (Brun., 1912 : 379, as *Dicranomyia*) .	E. Himalayas : Kurseong.
**L.* (*D.*) *flavobrunnea* (Brun., 1912 : 384, as *Dicranomyia*)	Calcutta.
**L.* (*D.*) *fortis* (Brun., 1912: 385, as *Dicranomyia*)	E. Himalayas : Darjiling.
**L.* (*D.*) *fraterna* (Brun., 1912 : 378, as *Dicranomyia*)	E. Himalayas : Darjiling.

**L.* (*D.*) *nigrithorax* (Brun., 1912 : 385, as *Dicranomyia*)	E. Himalayas : Darjiling.
**L.* (*D.*) *pulchripennis* (Brun., 1912 : 376, as *Dicranomyia*)	E. Himalayas Darjiling.
**L.* (*D.*) *puncticosta* (Brun., 1912 : 377, as *Dicranomyia*)	E. Himalayas : Kurseong.
(synonym *L.* (*L.*) *tinctinervis* Brun., 1912 : 401, as *Limnobia*) . . .	E. Himalayas: Darjiling.
**L.* (*D.*) *simplex* (Brun., 1912 :384, as *Dicranomyia*)	Calcutta : Assam.
**L.* (*D.*) *sordida* (Brun.,1912 : 382,as *Dicranomyia*)	E. Himalayas : Kurseong.
(synonym *L.* (*L.*) *innocens* Brun., 1912: 568, as *Dicranomyia*)	W. Himalayas : Almora, Kumaon.
**L.* (*D.*) *subfascipennis* (Brun., 1912 : 380, as *Dicranomyia*)	E. Himalayas : Kurseong.
**L.* (*Geranomyia*) *circipunctata* (Brun. 1912 : 390, as *Geranomyia*)	India : Lower Bengal.
**L.* (*G.*) *flavicosta* (Brun., 1912 : 389 as *Geranomyia*)	India : Ganges Delta.
**L.* (*G.*) *flaviventris* (Brun., 1918 : 288, as *Geranomyia*) .	E. Himalayas: Darjiling.
L. (*G.*) *genitalis* (Brun., 1911 : 275, as *Geranomyia*)	S. India: Tenmalai, Travancore.
(synonym of *L.* (*G.*) *fletcheri* Edwards, 1911)	
L. (*G.*) *nigronotata* (Brun., 1918 : 287, as *Geranomyia*) .	S. India : Malabar District.
**L.* (*G.*) *notatipennis* (Brun., 1913*a* : 152, as *Geranomyia*)	Assam Abor District.
**L.* (*G.*) *pulchripennis* (Brun., 1912 : 393, as *Geranomyia*) . .	E. Himalayas : Kurseong.
(preoccupied—renamed *pictorum* Alexander, 1929)	
L. (*G.*) *semifasciata* (Brun., 1911 : 276, as *Geranomyia*) .	E. Himalayas : Darjiling.
**L.* (*G.*) *semistriata* (Brun., 1911 : 277, as *Geranomyia*)	Bihar : Paresnath.
**L.* (*G.*) *tridens* (Brun., 1912 : 391, as *Geranomyia*)	India : Ganges Delta.
L. (*G.*) *vinaceobrunnea* (Brun., 1911 : 274, as *Geranomyia*) .	W. Himalayas : Simla.
**L.* (*Rhipidia*) *antennata* (Brun., 1911 : 272, as *Ceratostephanus*) . .	W. Himalayas : Simla.
**L.* (*R.*) *demarcata* (Brun., 1912 : 370, as *Dicranomyia*)	E. Himalayas : Kurseong.

**L.* (*R.*) *marmoripennis* (Brun., 1912 :369, as *Dicranomyia*)	E. Himalayas : Kurseong.
(synonym of *L.* (*R.*) *pulchra* de Meijere)	
**L.* (*R.*) *subtesselata* (Brun., 1912 : 565, as *Dicranomyia*) (synonym *L.* (*R.*) *zeylanica* S. W.)	Ceylon.
**L.* (*Alexandriaria*) *prominens* (Brun., 1918 : 285, as *Dicranomyia*) . . .	SW. India : Goa.
**L.* (*Pseudoglochina*) *bicinctipes* (Brun., 1912 : 566, as *Dicranomyia*) . .	Burma : Dawna Hills.
**L.* (*P.*) *pictipes* (Brun., 1918 : 286, as *Dicranomyia*)	SW. India : Goa.
Dicranomyia cinctiventris Brun., 1912 : 382	see *Limonia* (*Limonia*).
D. demarcata Brun., 1912 : 370	see *Limonia* (*Rhipidia*).
**D. festiva* Brun., 1912 : 400 .	see *Limonia* (*Limonia*).
D. marmoripennis Brun., 1912 : 369 . . .	see *Limonia* (*Rhipidia*).
**D. niveiapicalis* Brun., 1918 : 285 . .	see *Riedelomyia*.
D. ornatipes Brun., 1912 : 380	see *Gonomyia* (*Lipophleps*).
D. prominens Brun., 1918 : 285 . .	see *Limonia* (*Alexandriaria*).
**Limnobia triangularis* Brun., 1912 : 406 . .	see *Antocha* (*Antocha*).
L. trimaculata Brun., 1912 : 402 . .	see *Limonia* (*Libnotes*).
**Helius* (*Helius*) *ferruginosus* (Brun., 1912 : 418, as *Rhamphidia*) . .	Burma : Dawna Hills.
H. (*H.*) *fratellus* (Brun., 1918 : 296, as *Rhamphidia*)	S.W India : N. Kanara District.
**H.* (*H.*) *inconspicuus* (Brun., 1912 : 419,as *Rhamphidia*) . . .	E. Himalayas : Kurseong.
**H.* (*H.*) *unicolor* (Brun., 1912 : 419, as *Rhamphidia*)	E. Himalayas : Darjiling.
**H.* (*Eurhamphidia*) *abnormalis* (Brun., 1918 : 296, as *Rhamphidia*) . .	Assam : Khasi Hills.
**Antocha* (*Antocha*) *indica* Brun., 1912 : 426 . .	E. Himalayas : Kurseong.
**A.* (*A.*) *triangularis* (Brun., 1912 : 406, as *Limnobia*)	W. Himalayas : Simla.
**A.* (*A.*) *unilineata* Brun., 1912 : 427	W. Himalayas : Dehra Dun.
**Orimarga* (*Orimarga*) *peregrina* Brun., 1912 : 424	E. Himalayas : Darjiling.

PEDICIINI

**Pedicia* (*Tricyphona*) *elegans* (Brun., 1912 : 516, as *Amalopis*) . .	E. Himalayas : Kurseong.
P. (*T.*) *flavipennis* (Brun., 1918 : 327, as *Limnophila*) .	E. Himalayas : Darjiling.
**P.* (*T.*) *glabripennis* (Brun., 1912 : 515, as *Amalopis*)	E. Himalayas : Darjiling.

**Dicranota* (*Amalopina*) *elegantula* (Brun., 1912: 517, as *Amalopina*)	E. Himalayas: Darjiling.
D. (*Plectromyia*) *incompleta* (Brun., 1912 : 493, as *Gnophomyia*)	E. Himalayas: Kurseong.
**D.* (*Rhaphidolabina*) *spectralis* (Brun., 1918 : 321, as *Amalopis*)	E. Himalayas: Darjiling.
**D.* (*Rhaphidolabis*) *aperta* (Brun., 1912 : 492, as *Gnophomyia*)	E. Himalayas: Darjiling.
(preoccupied—renamed *brunettii* Edwards, 1916)	
**D.* (*R.*) *fascipennis* (Brun., 1911 : 289, as *Cladduroides*) . . .	E. Himalayas: Darjiling.
(synonyms *D.* (*R.*) *fascipennis* Brun., 1912: 519, as *Rhaphidolabis* ; *D.* (*R.*) *longipennis* (Brun., 1912: 489, as *Gnophomyia*)	
D. (*R.*) *sordida* (Brun., 1911 : 290, as *Cladduroides*) (synonym **D.* (*R.*) *indica* (Brun., 1912 : 519, as *Rhaphidolabis*) . . .	W. Himalayas: Simla.

HEXATOMINI

**Paradelphomyia* (*Oxyrhiza*) *flavescens* (Brun., 1911: 284, as *Cladura*) .	E. Himalayas: Darjiling.
(synonym—*P.* (*O.*) *furcata* (Brun., 1912: 491, as *Gnophomyia*)	
**Epiphragma* (*Epiphragma*) *kempi* Brun., 1913*a* : 155	NE. Indian Frontier.
**E.* (*E.*) *ornatipennis* (Brun., 1918 : 328, as *Limnophila*) .	E. Himalayas: Darjiling.
**E.* (*E.*) *vicina* Brun., 1918 : 331	E. Himalayas: Darjiling.
**Taiwanomyia cavernicola* (Brun., 1924 : 100, as *Troglophila*) . . .	Assam: Siju Cave, Garo Hills.
Pseudolimnophila (*Pseudolimnophila*) *fusca* (Brun., 1918 : 326, as *Limnophila*) .	E. Himalayas: Darjiling.
**P.* (*P.*) *glabra* (Brun., 1918 : 325, as *Limnophila*). May belong in *Pilaria* Sintenis . .	SW. India: N. Kanara District.
**P.* (*P.*) *multipunctata* (Brun., 1912 : 569 : as *Limnophila*)	S. India: Nilgiri Hills.
P. (*P.*) *pallidicoxa* (Brun., 1912: 523, as *Limnophila*)	E. Himalayas: Darjiling.
**Eupilaria annulipes* (Brun., 1918: 324, as *Limnophila*)	SW. India: N. Kanara District.
**E. inconsequens* (Brun., 1918: 326, as *Limnophila*)	SW. India: N. Kanara District.
Limnophila (*Elaeophila*) *fascipennis* (Brun., 1912 : 526, as *Ephelia*)	E. Himalayas: Darjiling.
L. (*E.*) *ornata* (Brun., 1912: 527, as *Ephelia*)	W. Himalayas: Kumaon.

**L.* (*Dicranophragma*) *interrupta* (Brun., 1918 : 319, as *Cladura*)	E. Himalayas : Darjiling.
L. (*D.*) *multipunctipennis* (Brun., 1918 : 329, as *Dicranophragma*)	E. Himalayas : Darjiling.
**L.* (*D.*) *pulchripennis* (Brun., 1912 : 524, as *Dicranophragma*) (preoccupied—renamed *venustipennis* Alexander, 1921)	E. Himalayas : Kurseong.
**L.* (Subgenus incertis) *honesta* Brun., 1912 : 570	W. Himalayas : Kumaon.
**Limnophila annulipes* Brun., 1918 : 324	see *Eupilaria*.
**L. claripennis* Brun., 1913*a* : 153	see *Crypteria*.
L. flavipennis Brun., 1918 : 327	see *Pedicia* (*Tricyphona*).
**L. fusca* Brun., 1918 : 326	see *Pseudolimnophila*.
**L. glabra* Brun., 1918 : 325	see *Pseudolimnophila*.
**L. incompleta* Brun., 1918 : 326	see *Gonomyia* (*Protogonomyia*).
**L. inconsequens* Brun., 1918 : 326	see *Eupilaria*.
**L. multipunctata* Brun., 1912 : 569	see *Pseudolimnophila*.
**L. ornatipennis* Brun., 1918 : 328	see *Epiphragma*.
L. pallidicoxa Brun., 1912 : 523	see *Pseudolimnophila*.
**L. parvicellula* Brun., 1918 : 325	see *Gonomyia* (*Gonomyia*).
**L. quartaria* Brun., 1913*a* : 154	see *Gnophomyia*.
**L. simplex* Brun., 1912 : 523	see *Neolimnophila*.
**Hexatoma* (*Eriocera*) *aterrima* (Brun., 1912 : 540, as *Eriocera*)	S. India : Travancore.
**H.* (*E.*) *aurantia* (Brun., 1918 : 335, as *Eriocera*)	E. Himalayas : Darjiling.
H. (*E.*) *badia* (Brun., 1911 : 310, as *Eriocera*)	Ceylon.
**H.* (*E.*) *caliginosa* (Brun., 1918 : 339, as *Eriocera*)	S. India : N. Kanara District.
H. (*E.*) *cincta* (Brun., 1918 : 333, as *Eriocera*) (synonym **H.* (*E.*) *cingulata* Brun., 1912 : 570, preoccupied)	E. Himalayas : Darjiling District.
**H.* (*E.*) *decorata* (Brun., 1918 : 337, as *Eriocera*)	E. Himalayas : Darjiling.
**H.* (*E.*) *elongatissima* (Brun., 1912 : 542, as *Eriocera*)	S. India : Travancore.
H. (*E.*) *fenestrata* (Brun., 1911 : 312, as *Eriocera*)	Central Tonkin (type) ; Assam : Khasi Hills.
**H.* (*E.*) *flavipes* (Brun., 1912 : 544, as *Eriocera*)	E. Himalayas : Kurseong.
**H.* (*E.*) *gravelyi* (Brun., 1918 : 337, as *Eriocera*)	E. Himalayas : Darjiling.

**H.* (*E.*) *greenii* (Brun., 1911 : 313, as *Eriocera*)	Ceylon.
**H.* (*E.*) *kempi* (Brun., 1918 : 339, as *Eriocera*)	SW. India : N. Kanara District.
**H.* (*E.*) *nigerrima* (Brun., 1912 : 571, as *Eriocera*)	E. Himalayas : Darjiling, Ghumti.
**H.* (*E.*) *plumbicincta* (Brun., 1911 : 311, as *Eriocera*)	Assam : Manipur.
**H.* (*E.*) *pulchrithorax* (Brun, 1918 : 336, as *Eriocera*)	S. India : Cochin State.
H. (*E.*) *rufibasis* (Brun., 1911 : 310, as *Eriocera*)	Lower Burma : Tenasserim.
**H.* (*E.*) *rufithorax* (Brun., 1912 : 534, as *Eriocera*) (Synonym of *H.* (*E.*) *ctenophoroides* Edwards, 1911)	Ceylon.
**H.* (*E.*) *rufiventris* (Brun., 1918 : 336, as *Eriocera*)	S. India : Coorg ; Cochin State.
H. (*E.*) *semilimpida* (Brun., 1911 : 311, as *Eriocera*) (synonym **H.* (*E.*) *maculiventris* Brun., 1918 : 340, as *Eriocera*)	Assam : Khasi Hills. Assam : Garo Hills.
**H.* (*E.*) *tenuis* (Brun., 1912 : 539, as *Eriocera*)	S. India : Nilgiri Hills.
**H.* (*E.*) *testacea* (Brun., 1912 : 548, as *Eriocera*). May be identical with *tenuis*	S. India : Nilgiri Hills.
**H.* (*E.*) *triangularis* (Brun., 1912 : 572, as *Eriocera*)	S. India : Nilgiri Hills.
**H.* (*E.*) *tripunctipennis* (Brun., 1918 : 338, as *Eriocera*)	SW. India : N. Kanara District.
**Eriocera nigroapicalis* Brun., 1918 : 335	see *Nephrotoma*.
**Atarba* (*Atarbodes*) *flava* Brun., 1912 : 435	E. Himalayas : Darjiling.
**Elephantomyia* (*Elephantomyodes*) *aurantia* (Brun., 1918 : 289, as *Aporosa*)	Assam : Garo Hills.

ERIOPTERINI

**Franckomyia gracilis* (Brun., 1913*a* : 156, as *Dicranophragma*) (preoccupied—renamed *recessiva* Alexander, 1927)	NE. Indian Frontier.
**Crypteria claripennis* (Brun., 1913*a* : 153, as *Limnophila*)	NE. Indian Frontier.
Neolimnophila genitalis (Brun., 1912 : 490, as *Gnophomyia*) (synonym—*N. simplex* Brun., 1912 : 523)	W. Himalayas : Kumaon, Bhowali.
**Dasymallomyia signata* Brun., 1911 : 304	E. Himalayas : Kurseong.
**Gnophomyia quartaria* (Brun., 1913*a* : 154, as *Limnophila*)	NE. Indian Frontier.
G. strenua Brun., 1912 : 492	E. Himalayas : Kurseong.
**Gnophomyia aperta* Brun., 1912 : 492	see *Dicranota* (*Rhaphidolabis*)

G. furcata Brun., 1912 : 491 .	see *Paradelphomyia*.
G. genitalis Brun., 1912 : 490 .	see *Neolimnophilla*.
G. incompleta Brun., 1912 : 493	see *Dicranota* (*Plectromyia*).
G. longipennis Brun., 1912 : 489 .	see *Dicranota* (*Rhaphidolabis*).
G. nigra Brun., 1912 : 494 .	see *Gonomyia* (*Protogonomyia*).
Gonomyia (*Protogonomyia*) *nigripes* (Brun., 1912 : 458, as *Mesocyphona*)	E. Himalayas : Darjiling.
(synonyms *G.* (*P.*) *gracilis* (Brun., 1918 : 310, as *Mesocyphona*)	E. Himalayas : Assam-Bhutan Frontier.
**G.* (*P.*) *incompleta* (Brun., 1918 : 326, as *Limnophila*)	E. Himalayas : Darjiling.
**G.* (*P.*) *nigra* (Brun., 1912 : 494, as *Gnophomyia*)	W. Himalayas : Kumaon.
**G.* (*Idiocera*) *proxima* Brun., 1912 : 474	Bengal.
**G.* (*Gonomyia*) *affinis* Brun., 1912 : 472 .	E. Himalayas : Kurseong.
**G.* (*G.*) *aperta* Brun., 1912 : 473	Bihar : Purneah District.
**G.* (*G.*) *parvicellula* (Brun., 1918 : 325, as *Limnophila*)	SW. India : N. Kanara District.
**G.* (*Lipophleps*) *incompleta* Brun., 1912 : 471	Calcutta.
**G.* (*L.*) *flavomarginata* Brun., 1912 : 472	E. Himalayas : Kurseong.
G. (*L.*) *ornatipes* (Brun., 1912 : 380, as *Dicranomyia*)	S. India : Travancore.
**Gonomyia antica* Brun., 1912 : 568	see *Cheilotrichia* (*Empeda*).
**Teucholabis* (*Teucholabis*) *angusticapitis* Brun., 1918 : 305	Assam : Garo Hills.
**T.* (*T.*) *assamensis* Brun., 1918 : 306	Assam : Khasi Hills.
**T.* (*T.*) *fenestrata insignis* Brun., 1912 : 430	S. India : Travancore.
**T.* (*T.*) *ornata* Brun., 1918 : 305	Ceylon.
**Teucholabis biannulata* Brun., 1912 : 430	see *Limonia* (*Limonia*).
**Gymnastes* (*Gymnastes*) *violacea* Brun., 1911 : 282 (synonym of *G.* (*G.*) *cyanea* Edwards, 1911 : 61)	Ceylon.
**G.* (*Paragymnastes*) *bistriatipennis* Brun., 1918 : 307	SW. India : N. Kanara District.
G. (*P.*) *pennipes* Brun., 1918 : 308	Assam : Garo Hills.
**Trentepohlia* (*Plesiomongoma*) *venosa* (Brun., 1918 : 314, as *Plesiomongoma*)	Assam : Khasi Hills.
**T.* (*Mongoma*) *flava* (Brun., 1918 : 314, as *Mongoma*)	Assam : Garo Hills.
**T.* (*M.*) *kempi* (Brun., 1918 : 313, as *Mongoma*)	Assam : Garo Hills.

T. (M.) pallidiventris (Brun., 1912 : 481, as *Mongoma*) (may be identical with *T. (M.) tenera* O.S., 1882 : 89) — S. India : Travancore.

T (M.) splendida (Brun., 1918 : 313, as *Mongoma*) — Assam : Garo Hills.

T. (Anchimongoma) simplex (Brun., 1918 : 316, as *Anchimongoma*) — S. India : N. Kanara District.

T. (Trentepohlia) albogeniculata (Brun., 1912 : 569, as *Mongomioides*) . . — Burma : Dawna Hills.

T (T.) marmorata (Brun., 1912 : 483, as *Mongomioides*) . . . — Calcutta.

T (T.) nigroapicalis (Brun., 1912 : 483, as *Mongomioides*) . — Lucknow.

T. (T.) ornatipennis Brun., 1918 : 315 . — SW. India : N. Kanara District.

Riedelomyia niveiapicalis (Brun., 1918 : 285, as *Dicranomyia*) — SW. India : N. Kanara District.

Ormosia (Ormosia) geniculata (Brun., 1912 : 441, as *Rhypholophus*) — E. Himalayas : Kurseong.

O. (O.) pulchra (Brun., 1912 : 442, as *Rhypholophus*) — W. Himalayas : Phagu, Simla District.

Cryptolabis (Baeoura) distans (Brun., 1912 : 451, as *Erioptera*) — E. Himalayas : Kurseong.

Cheilotrichia (Empeda) brevior (Brun., 1912 : 452, as *Erioptera*) . . . — E. Himalayas : Darjiling.

(synonyms *C. (E.) antica* (Brun., 1912 : 568, as *Gonomyia*) . . — E. Himalayas : Ghumti.

C. (E.) inconspicua (Brun., 1912 : 475, as *Empeda*) . . — E. Himalayas : Darjiling.

Erioptera (Meterioptera) flava Brun., 1912 : 455 (preoccupied—renamed *bengalensis* Alexander, 1921) — Bengal : Calcutta.

E. (M.) halterata Brun., 1912 : 457 . . — E. Himalayas : Darjiling.

E. (M.) subtincta Brun., 1912 : 455 . . . — E. Himalayas : Darjiling.

E. (Erloptera) ferruginea Brun., 1912 : 450 . . — S. India : Travancore State.

E. (E.) grandior Brun., 1912 : 456 . . . — W. Himalayas : Simla.

E. (E.) incerta Brun., 1912 : 452 . . . . — E. Himalayas : Darjiling.

E. (E.) orientalis Brun., 1912 : 453 (synonym *E. (E.) dictenidia* Alexander, 1921) . . — E. Himalayas : Darjiling.

E. (Teleneura) parallela Brun., 1912 : 453 . — E. Himalayas : Kurseong.

E. (T.) punctipennis Brun., 1912 : 449 . . (preoccupied—renamed *annnandaleana* Alexander, 1953) — E. Himalayas : Kurseong.

**Erioptera genitalis* Brun., 1912 : 456	see *Molophilus.*
**Molophilus* (*Molophilus*) *assamensis* Brun., 1912 : 445	Assam : Sylhet.
**M.* (*M.*) *genitalis* (Brun., 1912 : 456, as *Erioptera*)	W. Himalayas : Kumaon, Bhowali.
**M.* (*M.*) *inconspicuus* Brun., 1912 : 444	W. Himalayas : Simla.
**Styringomyia flava* Brun., 1911 : 301	S. India : Travancore State.
**S. obscura* Brun., 1911 : 300	Nepal : Thamaspur.
**Toxorhina* (*Ceratocheilus*) *brevifrons* (Brun., 1918 : 300, as *Conifrons*)	Assam : Garo Hills.
T. (*Toxorhina*) *incerta* Brun., 1912 : 422	E. Himalayas : Kurseong.

III—THE EXTRA-LIMITAL TIPULIDAE DESCRIBED BY BRUNETTI

TIPULINAE

Ctenacroscelis borneensis (Brun., 1918 : 263, as *Tipula*) (renaming of *Tipula pallida* Walker, 1865, preoccupied)	Borneo.
Ctenophora (*Pselliophora*) *bifascipennis* (Brun., 1911 : 241, as *Pselliophora*)	E. China : Shanghai.
(synonyms)—	
C. (*P.*) *sackeni* Edwards, 1916 : 257	as *Pselliophora.*
C. (*P.*) *horikawae* Matsumura, 1916 : 449	as *Psellicphora.*
C. (*P.*) *compta* Enderlein, 1921 : 220	as *Pselliophora*).
C. (*Pselliophora*) *terminalis* (Brun., 1911 : 244, as *Pselliophora*)	Indochina : Tonkin.
Tipula (*Formotipula*) *sciariformis* Brun., 1911 : 259	Indochina : Tonkin.
T. (*Tipulodina*) *schummeli* Brun., 1911 : 247 (synonym of *T.* (*T.*) *fumifinis* Walker, 1861 : 145, synonym—*T.* (*T.*) *longicornis* Doleschall, 1858 : 79, preoccupied)	Amboina.
T. (Subgenus incertis) *cinerea* Brun., 1911 : 252 (preoccupied—renamed *lombokensis* Alexander, 1942)	Lombok.
T. (Subgenus incertis) *pluto* Brun., 1911 : 251	Indochina : Tonkin.

LIMONIINAE

**Orimarga* (*Orimarga*) *borneensis* Brun., 1911 : 280	Borneo : Sarawak.
Gynoplistia (*Gynoplistia*) *octofasciata* Brun., 1911 : 307	South Celebes.
**Toxorhina* (*Ceratocheilus*) *latifrons* (Brun., 1918 : 299, *Conithorax*)	Malay States : Selangor-Pahang Border.

IV—Synopsis

The accompanying report discusses the Tipuloidean flies that were described by the late Enrico Brunetti between 1911 and 1924, a total of approximately 240 valid species, with numerous additional names that are considered to be synonyms of other species. This synonymy and the erroneous assignment to genera of many of his species has made it difficult to proceed with studies on the Indian crane-fly fauna. The late Dr. Fred W. Edwards was able to settle much of the synonymy through a study of the personal collection made by Brunetti and now preserved in the British Museum of Natural History. The great bulk of Brunetti's types are preserved in the collections of the Zoological Survey of India at Calcutta and several doubtful species were made available to the present writer for appraisal. As a result of these examinations of critical materials it is believed that the synonymy of the Brunetti species is more firmly established.

The apparently valid species described by Brunetti are distributed in the following groups :

Ptychopteridae	3
Trichoceridae	4
Tipulidae : Tipulinae	71
Cylindrotominae	2
Limoniinae—	
Limoniini	59
Lechriini	2
Pediciini	9
Hexatomini	41
Eriopterini	51
Total	242

Dr. A. P. Kapur has indicated the various types that are preserved in the collection of the Zoological Survey of India.

A NEW SPECIES OF ACANTHOCEPHALA *NEOECHINORHYNCHUS ROONWALI* FROM AFGHANISTAN, AND NOTES ON *POMPHORHYNCHUS KASHMIRENSIS* KAW

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(With 1 Text-figure)

CONTENTS

I—INTRODUCTION

The present paper deals with a new species of *Neoechinorhynchus* Hamann, being the first species of the genus to be recorded from Afghanistan ; it is based on the material collected from Kabul by Mr. Ali Akhtar from the fish *Orienus* sp., and sent to the Zoological Survey of India, Calcutta, for identification. The paper also contains notes on some variations indicated by *Pomphorhynchus kashmirensis* Kaw, another Acanthocephalan parasite from the same host *Orienus* sp., but from a different locality.

Acknowledgments.—We are thankful to Mr. Ali Akhtar for donating the specimens to the Zoological Survey of India and to Dr. B. L. Kaw, Professor of Zoology, S. P. College, Srinagar, for supplying us data of the material of *Pomphorhynchus kashmirensis* examined by him in 1948.

II—Systematic Account

1. **Neoechinorhynchus roonwali** * Datta & Soota, sp. nov.

(Text-fig. 1*a*—*c*)

Material.—6 males, all from the host-fish (*vide infra*), from Kabul.

Diagnosis.—Sub-cuticular body nuclei 11—12 (dorsals 9—10 and ventrals 2) ; lemnisci equal or subequal, extending either upto the fore-margin of the anterior testis or attaining the anterior margin of the posterior testis ; nuclei of lemnisci 4—6 (3 : 3, 4 : 0, 4 : 2).

Description.—Male : Total body length of mounted specimens 3—8 mm. (holotype 8 mm.), width in middle 0·6—1·0 mm. (holotype 1 mm.). Proboscis length 0·09—0·12 mm. (holotype 0·12 mm.), with three circles of six hooks each. Hooks in the first row largest, being 0·044—0·052 mm. long (holotype 0·044 mm.) and diminishing in size posteriorly ; in the second row 0·040—0·044 mm. (holotype 0·044 mm.), in the third row 0·036 mm. (holotype 0·036 mm.). Proboscis sheath nearly 0·375—0·48 mm. long (holotype 0·48 mm.). Lemnisci overlapping, 2—3·8 mm. long (holotype 3·6—3·8 mm.). Testes slightly unequal, anterior larger nearly 0·5—1·0 mm. × 0·3—0·6 mm. (holotype 1·0 × 0·6 mm.), posterior smaller nearly 0·4—0·9 mm. × 0·3—0·6 mm. (holotype 0·9×0·6 mm.) ; in one paratype only one big testis 1·65× 0·6 mm. discernible. Cement gland nearly 0·2—0·65 mm. long (holotype 0·6 mm.). Cement gland reservoir nearly 0·09—0·2 mm. long (holotype 0·2 mm.). Seminal vesicle and bursa nearly 0·8—1·35 mm. long (holotype 1·35 mm.).

Female :Not available.

Type-specimens.—Holotype : A♂, deposited with Zoological Survey of India, Calcutta. Registered No. W 3990/1, mounted on a slide. *Paratypes :* Five ♂♂, with retracted proboscis, each mountedon a separate slide, Regd. Nos. W 3991/1 to W 3995/1.

Type-locality.—Kabul (Afghanistan).

Type-host.—From the intestine of the fish, *Orienus* sp. (Pisces : Order Cypriniformes. Family Cyprinidae). Host-fish identified by the donor, Shri Ali Akhtar.

Remarks.—We have placed the new species under the genus *Neoechinorhynchus* instead of under *Eosentis* van Cleave as in our opinion the character (number of body nuclei) by which the latter genus is differentiated from the former does not seem to be of generic significance in the light of recent researches (*vide* Lynch, 1936). When a revision of these genera is done, it is likely that *Eosentis* would become untenable. This is the only species of the genus *Neoechinorhynchus* so far recorded from Afghanistan.

2. **Pomphorhynchus kashmirensis** Kaw, 1941

1941. *Pomphorhynchus kashmirensis* Kaw, *Proc. Indian Acad. Sci.*, Bangalore, 13, pp. 369—374.

1948. *Pomphorhynchus kashmirensis* Kaw, *Proc. 34th Indian Sci. Congr. Assoc.* (Delhi, 1948), Pt. 3, *Abstracts*, Calcutta, p. 173.

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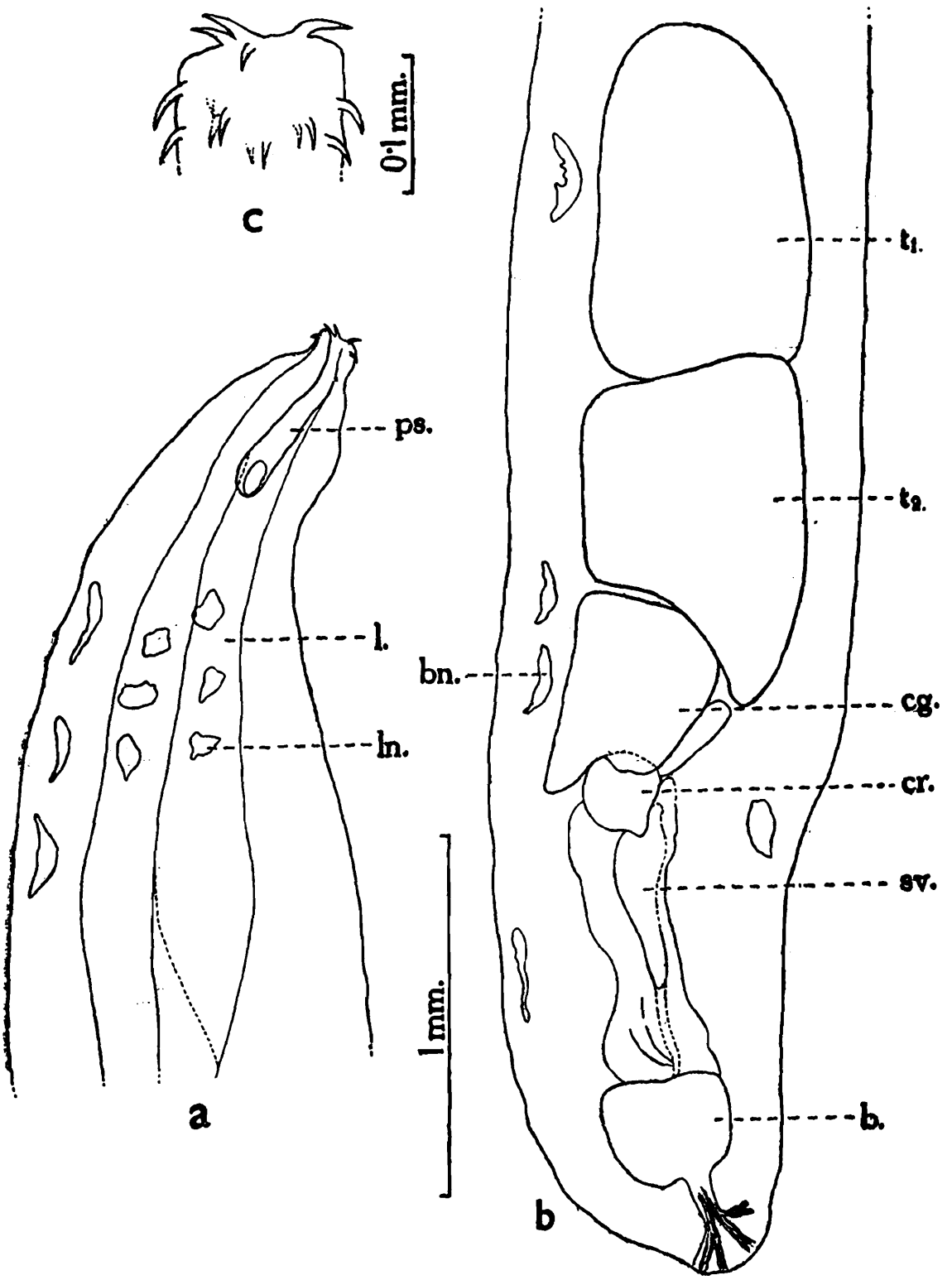
* The new species is named after our chief, Dr. M. L. Roonwal. in appreciation of his interest in the work.

Material.—5 ♂♂ and 6 ♀♀, in a poor state of preservation.

Kaw (1941) first recorded this species from the fish *Nemachilus kashmirensis* from Kashmir, and later (1948) from two schizothoracine



TEXT-FIG. 1.—*Neoechinorhynchus roonwali* Datta & Soota, sp. nov.

Holotype ♂ : (*a*). Anterior end. (*b*). Posterior end. (*c*). Proboscis enlarged.

b., bursa ; *bn.*, body nucleus ; *cg.*, cement gland ; *cr.*, cement gland reservoir ; *l.*, lemniscus ; *bn.*, lemniscus nucleus ; *ps.*, proboscis sheath ; *sv.*, seminal vesicle ; t_1., anterior testis ; t_2., posterior testis.

fishes (*Schizothorax esocinus* and *S. niger*) also from Kashmir and gave the observed variations. The present specimens are from another

schizothoracine fish *Orienus* sp. There are some variations in regard to size, etc., which are worth recording and are given below.—

	Kaw, 1941	Kaw, 1948	Specimens under report
Body—			
Length	♂10·3—11·6 mm.	6·3—11·6 mm.	7·9—19·8 mm.
	♀12·7 mm.	6·45—12·7 mm.	7·9—18·4 mm.
Proboscis—			
Length	0·55—0·62 mm.	0·4—0·9 mm.	0·8—1·1 mm.
Proboscis hooks—			
Length	0·022—0·041 mm.	0·024—0·045 mm.	0·02—0·07 mm.
Proboscis receptacle—			
Length ..	2·2—2·8 mm.	1·5—2·8 mm.	0·96—3·71 mm.
Neck including bulla—			
Length .. .	1·55—2·35 mm.	1·2—2·55 mm.	1·5—4·65 mm.
Bulla—			
Length	0·65—1·3 mm.		0·66—1·95 mm.
Anterior testis—			
Length	1·4 mm.	0·45—1·4 mm.	0·45—2·1 mm.
Posterior testis—			
Length	1·3 mm.	0·5—1·3 mm.	0·45—2·1 mm.
Cement gland—			
Length ..	0·65—0·95 mm.	0·65—0·95 mm.	0·645—0·82 mm.

Regd. Nos. W3972/1 to W3976/1, mounted on slides, deposited in the collections of the Zoological Survey of India, Calcutta.

III—Summary

A new species of the Acanthocephalan parasite *Neoechinorhynchus roonwali* (family Neoechinorhynchidae) is described, and the variations observed in *Pomphorhynchus kashmirensis* Kaw from the fish *Orienus* sp., the same host as of *Neoechinorhynchus roonwali* but from a different locality, have been recorded.

IV—REFERENCES

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ON A COLLECTION OF FISH FROM LAKE CHILKA, ORISSA

By

M. A. S. MENON

Zoological Survey of India, Calcutta

(With 1 Text-figure)

CONTENTS

I—INTRODUCTION

The first detailed systematic account of the fish fauna of the Chilka Lake is to be found in the papers of Chaudhuri (1916 ; 1917 ; 1923) and Hora (1923). They recorded 118 species from the Lake.

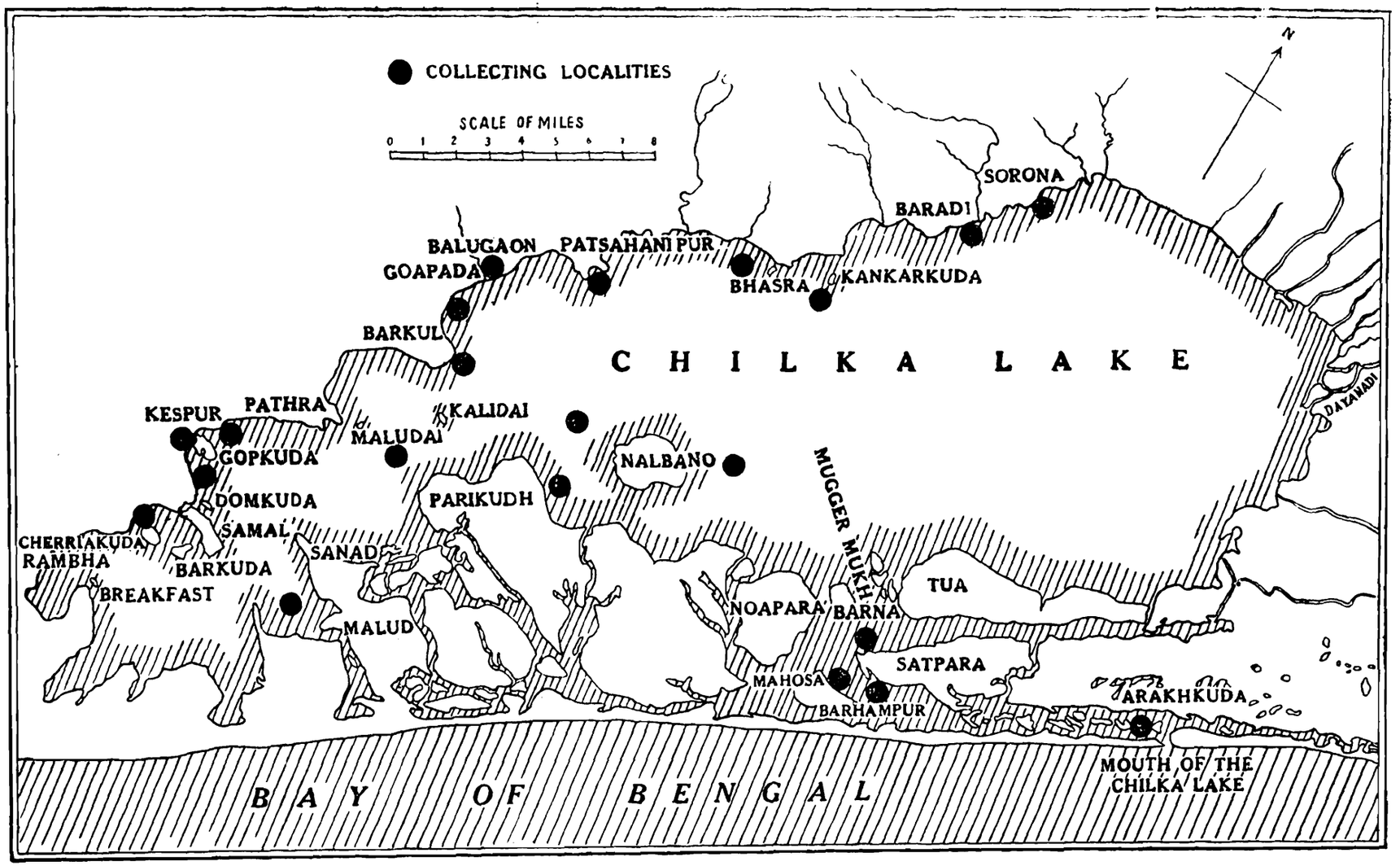
The present paper is based on a collection of fishes made during the period 20th January to 10th February 1954 by a Zoological Survey of India party, including the author, under the leadership of Dr. K. S. Misra, Assistant Superintendent. The survey covered 21 collecting localities spread along the shorewaters and midwaters of the main area and the outer channel of the Lake (Text-fig. 1). The number of specimens collected from each locality is mentioned within brackets.

I am grateful to Dr. M. L. Roonwal, Director, and Dr. K. S. Misra, Assistant Superintendent, for going through the manuscript of this paper.

II—SYSTEMATIC ACCOUNT

1. **Carcharhinus limbatus** (M. & H.)

Outer channel near the mouth of L. Chilka (1). Total length 1050 mm. First record from the Lake.



TEXT-FIG.1.—Map of Chilka Lake (Orissa), showing collecting localities.

2. **Elops saurus** L.

(i) Outer channel near the mouth of L. Chilka (1). (ii) Off the shores of Kespur, about 12 miles S. W. of Balugaon (1). Total length 264, 277 mm.

3. **Megalops cyprinoides** (Brouss.)

Off Bhasra Id., about 2 miles S. of Nairi and 10 miles E. of Balugaon (1). Total length 265 mm.

4. **Sardinella melanura** (C.)

(i) Outer channel near the mouth of L. Chilka (4). (ii) About half a mile N. W. of Parikudh (1). Total length 90—140 mm. First record from the Lake.

5. **Hilsa ilisha** (Ham.)

(i) Off Bhasra Id., about 2 miles S. of Nairi and 10 miles E. of Balugaon (1). (ii) About 2 miles E. of Nalbano (1). Total length 245—310 mm.

6. **Kowala coval** (C.)

(i) About 3 miles S. of Kalidai Id. (4). (ii) About 2 miles off Nalbano Id. (4). Total length 64—71 mm.

7. **Nematalosa nasus** (Bl.)

(i) About half a mile N. W. Parikudh (2). (ii) Off Baradi, nearly 12 miles E. of Balugaon (2). (iii) Off Sorona, about 16 miles E. of Balugaon (1). (iv) About 3 miles S. of Kalidai Id. (1). (v) Off Ke pur, about 12 miles S. W. of Balugaon (1). (vi) About 2 miles E. of Nal^{s}bano Id. (3). Total length 98-149 mm.

8. **Anodontostoma chacunda** (Ham.)

(i) About half a mile N. W. Parikudh (1). (ii) About 2 miles E. of Nalbano Id. (1). (iii) S. of Cherriyakuda Id., near Jagannathpatana about $4\frac{1}{2}$ miles N. of Rambha (1). Total length 83-155 mm.

9. **Thrissocles kammalensis** (Blkr.)

Off Baradi, nearly 12 miles E. of Balugaon (1). Total length 103 mm. New record from the Lake.

10. **Thrissocles malabaricus** (Bl.)

(i) Off Bhasra Id., about 2 miles S. of Nairi (3). (ii) About 3 miles S. of Kalidai Id. (2). (iii) S. of Cherriyakuda Id., near Jagannathpatana about $4\frac{1}{2}$ miles E. of Rambha (1). Total length 119-209 mm.

11. **Thrissocles rambhae** (Chaudhuri)

About 2 miles E. of Nalbano Id. (4). Total length 155—175 mm.

12. **Thrissocles valenciennesi**(Blkr.)

Off Baradi, about 13 miles E. of Balugaon (2). Total length 120-148 mm.

13. **Anchoviella indica** (v. Hasselt)

(i) About half a mile N. W. of Parikudh (3). (ii) About 3 miles S. of Kalidai Id. (1). Total length 76—112 mm.

14. **Anchoviella tri** (Blkr.)

Off Bhasra Id., about 12 miles S. of Nairi (1). Total length 70 mm.

15. **Puntius sophore** (Ham.)

(i) Inshore waters off Baradi, about 12 miles E. of Balugaon (3) (ii) Inshore waters off Sorona, about 16 miles E. of Balugaon (2). (iii Mouth of a partially dried up nullah opening into the Lake near Goapara about 20 miles S. W. of Balugaon (3). Total length 37—64 mm.

16. **Puntius ticto** (Ham.)

Inshore waters at Barkul Pt. (1). Total length 24 mm.

17. **Puntius vittatus** (Day)

(i) Rocky pools in shorewaters at Gheokala, Patsahnipur (2). (ii) Inshore waters along the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (1). (iii) Inshore waters off Kespur, nearly 12 miles S. W. of Balugaon (5). (iv) Inshore waters N. of Gopkuda Id., below the Rly. line, nearly 8 miles N. E. of Rambha (1). (v) Inshore-waters S. of Gopkuda Id., below the Rly. line, nearly 7 miles N. E. of Rambha (2). Total length 20-25 mm.

18. **Brachydanio rerio** (Ham.)

Inshore waters off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (2). Total length 17, 21 mm. New record from the Lake.

19. **Rasbora daniconius** (Ham.)

Inshore waters off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (1). Total length 31 mm. First record from the Lake.

20. **Oxygaster bacaila** (Ham.)

(i) Inshore waters off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripura P. O. (2). (ii) Mouth of a partially dried up nullah opening into the Lake near Goapara, about 2 miles S. W. of Balugaon (2). Total length 78-100 mm. New record from the Lake.

21. **Lepidocephalichthys guntea** (Ham.)

Mouth of a partially dried up nullah opening into the Lake near Goapara, about 2 miles S. W. of Balugaon (2). Total length 50, 51 mm. First record from the Lake.

22. **Tachysurus arius** (Ham.)

Off the shores of Mosa and Burhampur, nearly 3 miles S. W. of Satpara Dak Bungalow (1). Total length 382 mm.

23. **Osteogeneiosus militaris** (L.)

About 10 miles N. W. of Parikudh (4). Total length 271—381 mm.

24. **Plotosus canius** (Ham.)

Off Sorona nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (2). Total length 75, 90 mm.

25. **Mystus gulio** (Ham.)

About 3 miles S. of Kalidai Id. (1). Total length 133 mm.

26. **Mystus vittatus** (Bl.)

(i) Off Baradi, nearly 12 miles E. of Balugaon (3). (ii) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (3). (iii) Off Bhasra, about 2 miles S. of Nairi and 10 miles E. of Balugaon (1). (iv) Off the creeks of Gheokala, Patsahnipur (1). (v) Off the shores of Mahosa and Barhampur Ids., nearly 3 miles S. W. of Satpara Dak Bungalow (3). (vi) Off the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (1). (vii) Off Kespur, nearly 12 miles S. W. of Balugaon (1). Total length 68—146 mm.

27. **Clarias batrachus** (L.)

Inshore puddles at Baradi, nearly 12 miles E. of Balugaon (1). Total length 167 mm.

28. **Tylosurus strongylura** (v. Hasselt)

(i) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (1). (ii) Off Kespur, nearly 12 miles S. W. of Balugaon (1). (iii) About 2 miles E. of Nalbano Id. (1). Total length 234—392 mm.

29. **Hemirhamphus gaimardi** (V.)

(i) Off Baradi, nearly 12 miles E. of Balugaon (3). (ii) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (1). (iii) Off Bhasra, nearly 2 miles S. of Nairi and 10 miles E. of Balugaon (1). (iv) About 3 miles S. of Kalidai Id. (2). (v) N. of Gopkuda Id., below the Rly line, nearly 8 miles N. E. of Rambha (1). (vi) About 2 miles E. of Nalbano Id. (2). (vii) S. of Cherriyakuda Id., near Jagannathpatana, 4½ miles N. of Rambha (2). Total length 80—186 mm.

30. **Ichthyocampus carce** (Ham.)

(i) Off Bhasra Id., nearly 2 miles S. of Nairi and 10½ miles E. of Balugaon (1). (ii) Shorewaters about 2½ miles S. W. of Balugaon and 1½ miles E. of Burkul Bungalow (1). Total length 97, 108 mm.

31. **Oryzias melanostigmus** (Mc Clell.)

(i) Mouth of a partially dried up nullah opening into the Lake and near Goapara nearly 2½ miles S. W. of Balugaon (1). (ii) Rocky pools at Barkul Pt. (1). (iii) N. of Gopkuda Id., below the Rly. line, about 7 miles N. E. of Rambha (26). Total length 16—28 mm.

32. **Aplocheilus panchax** (Ham.)

(i) Mouth of a partially dried up nullah opening into the Lake near Goapara, about 2½ miles S. W. of Balugaon. (ii) S. of Gopkuda Id., below the Rly. line, nearly 7 miles N. E. of Rambha (2). Total length 21—41 mm.

33. **Sphyraena raghava** (Chaudhuri)

Off Bhasra Id., about 2 miles S. of Nairi and 10½ miles E. of Balugaon (1). Total length 249 mm.

34. **Mugil cephalus** (L.)

About 2 miles E. of Nalbano Id. (1). Total length 245 mm.

35. **Mugil speigleri** (Blkr.)

(i) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (3). (ii) Off the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (1). (iii) About 2 miles S. of Kalidai Id. (2). (iv) About 2 miles E. of Nalbano Id. (4). (v) S. of Cherriyakuda Id., near Jagannathpatana, about 4½ miles N. E. of Rambha (4). Total length 128—197 mm.

36. **Mugil subviridis** (V.)

(i) Off Kankarpara Id., nearly 11 miles E. of Balugaon (1). (ii) Off Bhasra Id., nearly 2 miles S. of Nairi and 10½ miles E. of Balugaon (1). (iii) Off the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (1). Total length 75—232 mm.

37. **Chelon oligolepis** (Blkr.)

(i) Off the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (2). (ii) About 2 miles E. of Nalbano Id. (2). Total length 46—78 mm.

38. **Chelon macrolepis** (Smith)

About 2 miles E. of Nalbano Id. (2). Total length 158, 169 mm.

39. **Eleutheronema tetradactylus** (Shaw)

(i) About half a mile N. W. of Parikudh (3). (ii) Off Baradi, nearly 13 miles E. of Balugaon (1). (iii) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (3). (iv) About 3 miles S. of Kalidai Id. (1). (v) About 2 miles E. of Nalbano Id. (2). (vi) S. of Cherriyakuda Id., near Jagannathpatana, about 4½ miles N. E. of Rambha (1). Total length 162—277 mm.

40. **Channa punctatus** (Bl.)

(i) Shorewaters off Baradi, nearly 12 miles E. of Balugaon (1). (ii) Shorewaters off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (1). (iii) Mouth of a partially dried up nullah opening into the Lake near Goapara, about 2½ miles S. W. of Balugaon (1). Total length 48—149 mm.

41. **Lates calcarifer** (Bl.)

About 2 miles E. of Nalbano Id. (1). Total length 203 mm.

42. **Ambassis commersonii** (C.)

Rocky pools at Gheokala, Patsahnipur (3). Total length 41—71 mm.

43. **Ambassis ranga** (Ham.)

Shorewaters off Baradi, nearly 12 miles E. of Balugaon (1). Total length 29 mm.

44. **Therapon jarbua** (Forsk.)

Off Kespur, nearly 12 miles S. W. of Balugaon (1). Total length 145 mm.

45. **Therapon puta** (C.)

(i) Outer channel near the mouth of the Lake (2). (li) About 8 miles B. of Nalbano Id. (1). (iii) S. of Cherriyakunda Id. near Jagannathpatna, abont 4½ miles N. E. of Rambha (1). Total length 92—135mm.

46. **Sillago sihama** (Forsk.)

(i) About 5 miles off Gheokala, Patsahnipur (1). (ii) Off the southern and western shores of Satpara Id., in the vicinity of the Dak Bungalow (1), (iii) Off Kospur about 12 miles S. W. Balugaon (1). Total length 97—191 mm.

47. **Carnax carangus** (Bl.)

Off Bhasra Id., nearly 2½ miles S. of Nairi and 10½ miles E. of Balugaon (2). Total length 185, 189 mm.

48. **Caranx praeustus** (Bennett)

Outer channel near the mouth of the Lake (1). Total length 128 mm.

49. **Atule mate** (C.)

About half a mile N. W. of Parikudh (3). Total length 126—133 mm. New record from the Lake.

50. **Datnioides quadrifasciatus** (Sevastianof)

Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W. of Jaripara P. O. (4). Total length 28—175 mm.

51. **Leiognathus daura** (C.)

(i) About half a mile N. W. of Parikudh (2). (ii) Off Bastara, nearly 2 miles S. of Nairi (1). Total length 40—94 mm.

52. **Leiognathus dussumieri** (V.V.)

Off Baradi, nearly 12 miles E. of Balugaon (2). Total length 69. 84 mm. New record from the Lake.

53. **Leiognathus equulus** (Forsk.)

(j) Off Bhasra Id., nearly 2 miles S. of Nairi (3). (ii) Off the southern and western shores of Satpara Id., in the vicinity of Dak Bungalow (2) (iii) About 2 miles E. of Nalbano Id. (3). (iv) N. of Gopkuda Id., below the Rly. line about 8 miles N. E. Rambha (1). Total length 57—124 mm.

54. **Leiognathus insidiator** (Bl.)

About half a mile N. W. of Parikudh (4). Total length 38—55 mm. First record from the Lake.

55. **Gerres filamentosus** (C.)

Off Kespur, nearly 12 miles S. W of Balugaon (1). Total length 78 mm.

56. **Gerres setifer** (Ham.)

(i) Off Bhasra Id., nearly 2½ miles S. of Nairi (2). (ii) Off the shores of Mosa and Burhampur Ids., nearly 3 miles S. W. of Satpara Dak Bungalow (1). (iii) About 3 miles S. of Kalidai Id. (3). Total length 88—156 mm.

57. **Gerres poeti** (C.)

N. of Gopkuda Id., below the Rly. line, nearly 8 miles E. of Rambha (1) Total length 122 mm.

58. **Pomadasys hasta** (Bl.)

(i) Off Baradi, nearly 12 miles E. of Balugaon and 3 miles W of Jaripara P. O. (2). (ii) Off Sorona, nearly 16 miles E. of Balugaon (1). (iii) Off Bhasra, nearly 2 miles S. of Nairi (1). (iv) Off the shores of Mosa and Burhampur Ids., nearly 3 miles S. W of Satpara Dak Bungalow (1). Total length 94—140 mm.

59. **Sciaena dussumieri** (V.)

(i) About 3 miles S. of Kalidai Id. (3). (ii) Off Kespur, nearly 12 miles S. W of Balugaon (2). Total length 101—130 mm.

60. **Sciaena macropterus** (Blkr.)

(i) About half a mile N. W of Parikudh (3). (ii) Off Baradi, nearly 12 miles E. of Balugaon (3). (iii) About 2½ miles N. E. of Nalbano Id. (3). (iv) S. of Cherriyakuda Id., near Jagannathpatana, about 4½ miles N. E. of Rambha (2). Total length 98—158 mm.

61. **Crenidens crenidens** (Forsk.)

(i) Off the shores of Mosa and Burhampur Ids., nearly 3 miles S. W of Satpara Dak Bungalow (1). (ii) Off Kespur, nearly 12 miles S. W of Balugaon (1). Total length 153—239 mm. New record from the Lake.

62. **Etroplus suratensis** (Bl.)

(i) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W of Jaripara P. O. (1). (ii) Off Kespur, nearly 12 miles S. W. of Balugaon (2) Total length 106—173 mm. First record from the Lake.

63. **Petroscirtes bhattacharyae** (Chaudhuri)

Rocky pools at Gheokala, Patsahnipur (2). Total length 25, 27 mm.

64. **Anabas testudineus** (Bl.)

Shallow pools in the Lake bed near Baradi, about 12 miles E. of Balugaon (2). Total length 101, 109 mm. New record from the Lake.

65. **Glossogobius biocellatus** (V.)

Southern and western shores of Satpara Id., in the vicinity of Dak Bungalow (2). Total length 30, 33 mm.

66. **Glossogobius giuris** (Ham.)

Mouth of a partially dried up nullah opening into the Lake near Goapara about 2½ miles S. W of Balugaon (10). Total length 15—30 mm.

67. **Brachygobius nunus** (Ham.)

(i) N. of Gopkuda Id., below the Rly. line, nearly 8 miles N. E. of Rambha (2). (ii) S. of Gopkuda Id., below the Rly. line, nearly 7 miles N. E. Rambha (15). Total length 10—18 mm.

68. **Acentrogobius globiceps** (Hora)

(i) Shorewaters off Kespur, nearly 12 miles S. W of Balugaon (6). (ii) N. of Gopkuda Id., below the Rly. line, about 8 miles N. E. of Rambha (14). (iii) S. of Gopkuda Id., below the Rly. line, about 7 miles N. E. of Rambha (10). Total length 15—37 mm.

69. **Platycephalus indicus** (L.)

About 2 miles E. of Nalbano (1). Total length 280 mm.

70. **Cynoglossus brevis** (Gthr.)

(i) About 5 miles S. E. of Gheokala, Patsahnipur (1). (ii) S. of Cherriyakuda Id., near Jagannathpatana, about 4½ miles N. E. of Rambha (6). Total length 117—155 mm.

71. **Chelanodon patoca** (Ham.)

Off Bhasra Id., nearly 2 miles S. of Nairi (2). Total length 30, 40 mm.

72. **Triacanthus brevirostris** (Schlegel)

(i) About half a mile N. W. of Parikudh (2). (ii) Off Baradi, nearly 14 miles E. of Balugaon (3). (iii) Off Sorona, nearly 16 miles E. of Balugaon and 3 miles W of Jaripara P. O. (1). (iv) Off Bhasra Id., nearly 2 miles S. of Nairi (1). (v) Off the shores of Mosa and urhampur Ids., nearly 3 miles S. W. of Satpara Dak Bungalow (1). (vi)Bff Kespur,

nearly 12 miles S. W. of Balugaon (1). (vii) N. of Gopkuda Id., below the Rly. line, nearly 8 miles N. E. of Rambha (1). Total length 28—130 mm.

Of the 72 species given above, *Carcharhinus limbatus*, *Sardinella melanura*, *Thrissocles kammalensis*, *Thrissocles valenciennesi*, *Brachydanio rerio*, *Rasbora daniconius*, *Oxygaster bacaila*, *Lepidocephalichthys guntea*, *Clarias batrachus*, *Atule mate*, *Leiognathus dussumieri*, *Leiognathus insidiator*, *Gerres poeti*, *Sciaena dussumieri*, *Crenidens crenidens*, *Etroplus suratensis* and *Anabas testudineus* are new records from the Chilka Lake. Of these new records, *Sardinella melanura* and *Atule mate* are marine species and were collected from the outer channel. The freshwater species *Brachydanio rerio*, *Rasbora daniconius*, *Oxygaster bacaila* and *Lepidocephalichthys guntea* were obtained from shallow shore waters in the vicinity of small nullahs opening into the the Lake. The rest of the newly recorded species as well as others mentioned above were taken from all over the main area of the Lake.

The total number of species so far known from the Chilka Lake is thus raised to 134, comprising of 87 genera, 51 families and 15 orders as given below :—

III—(a) LIST[1] OF FISHES SO FAR KNOWN FROM LAKE CHILKA

Class ELASMOBRANCHII
Subclass *SELACHII*
Order LAMNIFORMES
Suborder *SCYLIORHINOIDEI*
Family CARCHARHINIDAE

1. *Physodon mulleri* (M. H.)
2. *Carcharhinus gangeticus* (M.H.)
3. *Carcharhinus limbatus* (M.H.)
4. *Carcharhinus melanopterus* (Q.G.)

Order RAJIFORMES
Family PRISTIDAE

5. *Pristis pectinatus* Latham

Family TRYGONIDAE

6. *Dasyatis* (*Himantura*) *uarnak* (Forsk.)
7. *Dasyatis* (*Amphotistius*) *imbricata* (Schn.)
8. *Dasyatis* (*Pastinachus*) *sephen* (Forsk.)

Family MYLIOBATIDAE

9. *Aetobatus narinari* (Euphrasen)
10. *Aetomylus nichofi* (Schn.)

Class TELEOSTOMI
Subclass *ACTINOPTERYGII*
Order CLUPEIFORMES
Suborder *CLUPEOIDEI*
Family ELOPIDAE

11. *Elops saurus* (L.)

[1] Classification after L. S. Berg (1940).

Family MEGALOPIDAE

12. *Megalops cyprinoides* (Broussnet)

Family CLUPEIDAE

13. *Sardinella melanura* (C.)
14. *Hilsa ilisha* (Ham.)
15. *Kowala coval* (C.)
16. *Nematalosa nasus* (Bl.)
17. *Anodontostoma chacunda* (Ham.)
18. *Thrissocles annandalei* (Chaudhuri)
19. *Thrissocle kammalensis* (Blkr.)
20. *Thrissocles kempi* (Chaudhuri)
21. *Thrissocles malabaricus* (Bl.)
22. *Thrissocles mystax* (Schn.)
23. *Thrissocles purava* (Ham.)
24. *Thrissocles rambhae* (Chaudhuri)
25. *Thrissocles valenciennesi* (Blkr.)
26. *Anchoviella commersonii* (Lac.)
27. *Anchoviella indica* (v. Hasselt)
28. *Anchoviella tri* (Blkr.)

Suborder *CHANOIDEI*

Family CHANIDAE

29. *Chanos chanos* (Forsk.)

Order CYPRINIFORMES

Suborder *CYPRINOIDEI*

Family CYPRINIDAE

30. *Puntius sophore* (Ham.)
31. *Puntius ticto* (Ham.)
32. *Puntius vittatus* Day
33. *Brachydanio rerio* (Ham.)
34. *Rasbora daniconius* (Ham.)
35. *Oxygaster bacaila* (Ham.)
36. *Cirrhina latius* (Ham.)

Family COBITIDAE

37. *Lepidocephalichthys guntea* (Ham.)

Suborder *SILUROIDEI*

Family ARIIDAE

38. *Tachysurus arius* (Ham.)
39. *Tachysurus caelatus* (V.)
40. *Tachysurus falcarius* (Richardson)
41. *Tachysurus satparanus* (Chaudhuri)
42. *Osteogeneiosus militaris* (L.)

Family PLOTOSIDAE

43. *Plotosus canius* Ham.

Family SILURIDAE
44. *Wallago attu* (Bl. Schn.)
45. *Ompok bimaculatus* (Bl.)

Family BAGRIDAE
46. *Mystus cavasius* (Ham.)
47. *Mystus gulio* (Ham.)
48. *Mystus vittatus* (Bl.)

Family SCHILBEIDAE
49. *Pangasius pangasius* (Ham.)

Family CLARIIDAE
50. *Clarias batrachus* (L.)

Order ANGUILLIFORMES
Suborder *ANGUILLOIDEI*
Family MURAENESOCIDAE
51. *Muraenesox cinereus* (Forsk.)

Family MURAENIDAE
52. *Thyrsoidea macrurus* (Blkr.)

Family OPHICHTHYIDAE
53. *Ophichthys chilkensis* (Chaudhuri)
54. *Pisodonophis boro* (Ham.)

Order BELONIFORMES
Suborder *SCOMBERESOCOIDEI*
Family BELONIDAE
55. *Tylosurus strongylura* (v. Hasselt)

Suborder *EXOCOETOIDEI*
Family HEMIRHAMPHIDAE
56. *Hemirhamphus gaimardi* (V.)

Order SYNGNATHIFORMES
Suborder *SYNGNATHOIDEI*
Family SYNGNATHIDAE
57. *Ichthyocampus carce* (Ham.)
58. *Hippocampus brachyrhynchus* (Duncker)

Order CYPRINODONTIFORMES
Suborder *CYPRINODONTOIDEI*
Family CYPRINODONTIDAE
59. *Oryzias melastigmus* (Mc Clell.)
60. *Aplocheilus panchax* (Ham.)

Order MUGILIFORMES
Suborder *SPHYRAENOIDEI*
Family SPHYRAENIDAE
61. *Sphyraena raghava* (Chaudhuri)

Suborder *MUGILOIDEI*

Family MUGILIDAE

62. *Mugil caeruleomaculatus* (Lac.)
63. *Mugil cephalus* (L.)
64. *Mugil cunnesius* V.
65. *Mugil jerdoni* (Day)
66. *Mugil speigleri* (Blkr.)
67. *Mugil subviridis* V.
68. *Mugil tade* (Forsk.)
69. *Chelon macrolepis* (Smith)
70. *Chelon oligolepis* (Blkr.)

Order POLYNEMIFORMES

Family POLYNEMIDAE

71. *Eleutheronema tetradactylus* (Shaw)

Order OPHIOCEPHALIFORMES

Family OPHIOCELPHALIDAE

72. *Channa punctatus* (Bl.)

Order PERCIFORMES

Suborder *PERCOIDEI*

Family CENTROPOMIDAE

73. *Lates calcarifer* (Bl.)
74. *Ambassis commersoni* C.
75. *Ambassis gymnocephalus* (Lac.)
76. *Ambassis ranga* (Ham.)

Family THERAPONIDAE

77. *Therapon jarbua* (Forsk.)
78. *Therapon puta* C.

Family SILAGINIDAE

79. *Sillago sihama* (Forsk.)

Family CARANGIDAE

80. *Caranx carangus* (Bl.)
81. *Caranx praeustus* (Bennett)
82. *Atule mate* (C.)

Family LUTIANIDAE

83. *Lutianus johii* (Bl.)

Family LOBOTIDAE

84. *Datnioides quadrifasciatus* (Sevastianof)

Family LEIOGNATHIDAE

85. *Leiognathus blochii* (V.)
86. *Leiognathus daura* (C.)
87. *Leiognathus dussumieri* (V.)
88. *Leiognathus equulus* (Forsk.)
89. *Leiognathus insidiator* (Bl.)
90. *Gazza minuta* (Bl.)
91. *Gerres filamentosus* (C.)

92. *Gerres oyena* (Forsk.)
93. *Gerres poeti* (C.)
94. *Gerres setifer* (Ham.)

Family POMADASYSIDAE
95. *Pomadasys hasta* (Bl.)

Family SCIAENIDAE
96. *Sciaena dussumieri* (V.)
97. *Sciaena macropterus* (Blkr.)
98. *Sciaena russellii* (C.V.)
99. *Pseudosciaena coiber* (Ham.)

Family PSETTIDAE
100. *Monodactylus argenteus* (L.)

Family GIRELLIDAE
101. *Crenidens crenidens* (Forsk.)

Family CICHILIDAE
102. *Etroplus suratensis* (Bl.)

Suborder *BLENNIOIDEI*
Family BLENNIDAE
103. *Petroscirtes bhattacharyae* (Chaudhuri)

Suborder *ANABNTOIDEI*
Family ANABANTIDAE
104. *Anabas testudineus* (Bl.)

Suborder *GOBIODEI*
Family ELEOTRIDAE
105. *Eleotris fusca* (Bl. Schn.)
106. *Btuis butis* (Ham.)

Family GOBIIDAE
107. *Acentrogobius cyanomos* (Blkr.)
108. *Acentrogobius globiceps* (Hora)
109. *Bathygobius fuscus* (Ruppell)
110. *Brachygobius nunus* (Ham.)
111. *Glossogobius biocellatus* (V.)
112. *Glossogobius giuris* (Ham.)
113. *Glossogobius mas* (Hora)
114. *Gobiopterus chuno* (Ham.)
115. *Oligolepis acutipennis* (V.)
116. *Oligolepis cylindriceps* (Hora)
117. *Oxyurichthys tentacularis* (V.)
118. *Paragobiopsis ostreicola* (Chaudhuri)
119. *Parapocryptes rictuosus* (V.)
120. *Pseudapocryptes lanceolatus* (Bl. Schn.)
121. *Stigmatogobius javanicus* (Blkr.)
122. *Stigmatogobius minima* (Hora)
123. *Taenioides chilkensis* (Hora)

Family PERIOPHTHALMIDAE

124. *Periophthalmus koelreuteri* (Pallas)

Suborder *COTTOIDEI*

Family PLATYCEPHALIDAE

125. *Platycephalus indicus* (L.)

Order PLEURONECTIFORMES

Suborder *PLEURONECTOIDEI*

Family BOTHIDAE

126. *Pseudorhombus arsius* (Ham.)

Family SOLEIDAE

127. *Synaptura orientalis* (Bl. Schn.

Family CYNOGLOSSIDAE

128. *Cynoglossus brevis* Gthr.

Order MASTACEMBELIFORMES

Family MASTACEMBELIDAE

129. *Mastacembelus armatus* (Lac.)

Order TETRODONTIFORMES

Suborder *BALISTOIDEI*

Family TRIACANTHIDAE

130. *Triacanthus brevirostris* (Schlegel)

Suborder *TETRODONTOIDEI*

Family TETRODONTIDAE

131. *Torquigener oblongus* (Bl. Schn.)

132. *Chelanodon patoca* (Ham.)

133. *Chelanodon fluviatilis* (Ham.)

134. *Arothron reticularis* (Bl. Schn.)

III—(*b*) TABLE [1] OF IDENTIFICATION OF THE FISHES OF THE CHILKA LAKE

1(3). Gill slits covered by gill cover : skeleton bony : body without placoid scales.

2(97). Gill slits naked, without gill cover : skeleton cartilaginous : body with placoid scales.

3(5). Body symmetrical : eyes on either side of head.

4(93). Body asymmetrical : both eyes on same side of head.

5. Body with bony rings : gill openings reduced to small, dorsal apertures Fam. SYNGNATHIDAE, (*a*)-(*b*).

(*a*) Caudal fin present : tail not prehensile · *Ichthyocampus carce* (Ham.)

(*b*) Caudal fin absent : tail prehensile .. *Hippocampus brachyrhynchus* Duncker.

[1] This artificial key is applicable mainly to the species dealt with in the Table.

6(7). Body without bony rings : gill openings not reduced to small, dorsal apertures.

7(9). Both jaws much produced and bill-like, or only lower jaw produced.

8(11). Both jaws normal, neither produced nor bill-like.

9. Both jaws produced and bill-like : mouth large .... Fam. BELONIDAE ....*Tylosurus strongylura* (v. Hasselt) (=*Belone strongylura*).

10. Only lower jaw produced and bill-like : mouth small .... Fam. HEMIRHAMPHIDAE .... *Hemirhamphus gaimardi* V. (=*Hemirhamphus limbatus*).

11(13). Pelvics united and disc-like, or closely apposed together:

12(17). Pelvics neither united, disc-like nor closely apposed together.

13(15). Pelvics united and disc-like.

14. Pelvics separate and closely apposed together ... Fam. ELEOTRIDAE, (*a*)-(*b*).

(*a*). Snout blunt : lateral line scales 60-65 : lateral transverse scales 16-19 : predorsal scales 50 . . . *Eleotris fusca* (Bl. Schn.) (=*Eleotris cavifrons*).

(*b*). Snout pointed : lateral line scales 30 : lateral transverse scales 9-10 : predorsal scales 20 . . . . *Butis butis* (Ham.)

15. Eyes very prominent, placed close together : eye lids well developed .... Fam. PERIOPHTHALMIDAE ... *Periophthalmus koelreuteri* (Pallas).

16. Eyes neither very prominent nor placed close together : eyelids not well developed .... Fam. GOBIIDAE, (*a*)-(*q*).

(*a*). Body eel-like : single dorsal fin ... *Taenioides chilkensis* (Hora).

Body not eel-like : two dorsal fins separate or connected at their base .. .. (*b*).

(*b*). Teeth in lower jaw in several rows .. (*c*).

Teeth in lower jaw in single row .. (*p*).

(*c*). Caudal fin long, pointed or lanceolate, longer than head .. .. .. (*d*).

Caudal fin short, obtuse or rounded, shorter than head .. .. (*g*).

(*d*). Teeth in upper jaw in single row .. *Oxyurichthys tentacularis* (V.).

Teeth in upper jaw in several rows (*e*).

(*e*). Head scaly above and behind eyes .. *Acentrogobius cyanomos* (Blkr.) (=*Ctenogobius dentifer*).

Head naked above and behind eyes (*f*).

(*f*). Lateral line scales 27-30 : lateral transverse scales 7-8 .. .. .. *Oligolepis acutipennis* (V.) (=*Centrogobius acutipennis*).

Lateral line scales 25 : lateral transverse scales 5	*Oligolepis cylindriceps* (Hora).
(*g*). Maxillary prolonged beyond postorbit	*Paragobiopsis ostriecola* (Chaudhuri) (=*Gobius ostriecola*).
Maxillary not prolonged beyond post-orbit	(*h*).
(*h*). Upper pectoral rays free and silk-like	*Bathygobius fuscus* (Ruppell).
Upper pectoral rays neither free nor silk-like	(*i*).
(*i*) Gill openings wide, extending beyond pectoral base	(*j*).
Gill openings narrow, not extending beyond pectoral base	(*l*).
(*j*). Lateral line scales 24-26	*Glossogobius mas* (Hora.)
Lateral line scales 28-36	(*k*).
(*k*). Lateral transverse scales 7-8 : first dorsal with two ocelli	*Glossogobius biocellatus* (V.).
Lateral transverse scales 9-14 : first dorsal with one or no ocellus	*Glossogobius giuris* (Ham.).
(*l*). Foremost scale in median line behind eye enlarged	(*m*).
Foremost scale in median line behind eye not enlarged	(*o*).
(*m*). A median longitudinal groove on nape	*Brachygobius nunus* (Ham.) (=*Ctenogobius alcocki*).
No median longitudinal groove on nape	(*n*).
(*n*). Head 4·25 times in standard length : a dark stripe from eye to maxillary	*Stigmatogobius javanicus* (Blkr.) (=*Ctenogobius chilkensis*).
Head 3·7 times in standard length : no dark stripe from eye to maxillary	*Stigmatogobius minima* (Hora) (=*Ctenogobius minima*).
(*o*). Predorsal scales 14	*Acentrogobius cyanomos* (Blkr.).
Predorsal scales 7-8	*Acentrogobius globiceps* (Hora).
(*p*). Second dorsal fin long, 24-32 rays ..	(*q*).
Second dorsal fin short, 8-9 rays ..	*Gobiopterus chuno* (Ham.) (=*Micrapocryptes fragilis*).
(*q*). Scales minute, about 200 in lateral line : second dorsal with 31-32 rays	*Pseudapocryptes lanceolatus* (Bl. Schn.) (=*Apocryptes lanceolatus*).
Scales moderate, about 80 in lateral line : second dorsal with 24-27 rays	*Parapocryptes rictuosus* (V.) (=*Apocryptes rictuosus*).

17(19). Body very elongate, cylindrical and eel-like.

18(25). Body neither very elongate, cylindrical nor eel-like.

19. With 32-39 stumpy, dorsal spines Fam. MASTACEMBELIDAE *Mastacembelus armatus* (Lac.).

20(21). Without any stumpy, dorsal spines.

21. Snout elongate : upper jaw notched towards snout end . . Fam. MURAENESOCIDAE *Muraenesox cinereus* (Forsk.).

22(23). Snout moderate : upper jaw without a notch towards snout end.

23. Dorsal and anal fins united with caudal : pectorals absent .. Fam. MURAENIDAE *Tyrsoidea macrurus* (Blkr.)(=*Rhabdura macrurus*).

24. Dorsal and anal fins not united with caudal : pectorals present Fam. OPHICHTHYIDAE, (*a*)-(*b*).

(*a*). Length of head 3½ to 4 times in length from snout end to vent — *Pisodonophis boro* (Ham.) (=*Ophichthys hijala and O. (boro)*.

(*b*). Length of head 5½ times in length from snout end to vent — *Ophichthys chilkensis* (Chaudhuri).

25(27). Body scaleless or naked : pectoral fins with a strong, pungent spine.

26(37). Body scaly or not naked : pectoral fins without a strong pungent spine.

27. Two rayed dorsal fins : the long, second dorsal (procurrent caudodorsal) united with caudal and anal fins : caudal pointed .. . Fam. PLOTOSIDAE *Plotosus canius* (Ham.).

28(29). Single rayed dorsal fin (no procurrent caudodorsal) : caudal forked.

29(31). Anal fin long (45-93 rays) : dorsal without a pungent spine.

30(33). Anal fin short (9-34 rays) : dorsal with a pungent spine.

31. Dorsal fin long (62-76 rays) : 8 barbels ... Fam. CLARIIDAE,. *Clarias batrachus* (L.).

32. Dorsal fin short (4-5 rays) : 4 barbels Fam. SILURIDAE, (*a*)-(*b*)

(*a*). Cleft of mouth deep, extending beyond hind border of eye — *Wallago attu* (Bl. Schn.).

(*b*). Cleft of mouth narrow, not extending beyond hind border of eye — *Ompok bimaculatus* (Bl.) (=*Callichrous bimaculatus*).

33. Posterior nostrils with a valve : 2 or 6 barbels ...Fam ARIIDAE, (*a*)-(*b*).

(*a*). 2 semi-osseous barbels .. — *Osteogeneiosus militaris* (L.)

6 non-osseous barbels — (*b*).

(*b*). Teeth on palate villiform : dorsal spine as long as head — *Tachysurus caelatus* (V.) (=*Arius caelatus*).

Teeth on palate granular : dorsal spine shorter than head — (*c*).

(*c*). Band of teeth in upper jaw narrow, divided in the middle — *Tachysurus satparanus* (Chaudhuri) (=*Arius satparanus*).

Band of teeth in upper jaw broad, not divided in the middle — (*d*).

(*d*). Occipital process keeled: pectoral spine longer than dorsal spine — *Tachysurus falcarius* (Richardson) (=*Arius falcarius*).

Occipital process not keeled: pectoral spine as long as dorsal spine — *Tachysurus arius* (Ham.) (=*Arius arius*).

34(35). Posterior nostrils without a valve : 4 or 8 barbels.

35. Anal fin long (31-34 rays) : 4 barbels Fam. SCHILBEIDAE *Pangasius pangasius* (Ham).

36. Anal fin short (9-15 rays) : 8 barbels. Fam. BAGRIDAE, (*a*)-(*b*).

(*a*). Occipital process reaching basal bone of dorsal — (*b*).

Occipital process not reaching basal bone of dorsal — *Mystus gulio* (Ham.) (=*Macrones gulio*).

(*b*). Adipose dorsal long, commencing just behind rayed dorsal fin — *Mystus cavasius* (Ham.) (=*Macrones cavasius*).

Adipose dorsal short, commencing at a distance from rayed dorsal — *Mystus vittatus* (Bl.).

37. Pectoral fin with (4) free, elongated rays at its base .. Fam. POLYNEMIDAE *Eleutheronema tetradactylus* (Shaw).

38(39). Pectoral fin without any free, elongated rays at its base.

39. Two detached pre-anal spines .. Fam. CARANGIDAE, (*a*)-(*b*).

(*a*). Last dorsal and anal ray a little detached or finlet-like — *Atule mate* (C.).

Last dorsal and anal ray neither detached nor finlet-like — (*b*).

(*b*). Keeled scutes along lateral line, 33-37 : pectorals longer than head — *Caranx carangus* (Bl.).

Keeled scutes along lateral line, 25-30 : pectorals equal to or a little shorter than head .. — *Caranx praeustus* (Bennett).

40(41). No detached pre-anal spines.

41. With 2 strong pelvic spines .... Fam. TRIACANTHIDAE . *Triacanthus brevirostris* Schlegel.

42(43). Without any strong pelvic spines.

43(45). Pelvic fins present.

44. Pelvic fins absent Fam. TETRODONTIDAE, (*a*)-(*f*).

(*a*). Two nostrils on each side : lower lateral line with a distinct fold or keel	*Torquigener oblongus* (Bl. Schn.) (=*Tetrodon oblongus*).
A single nostril on each side or nasal sac open, appearing as two tentacles : lower lateral line absent or when present without fold or keel	(*b*).
(*b*). A single lateral line	*Arothron reticularis* (Bl. Schn.) (=*Tetrodon reticularis*).
Two lateral lines	(*c*).
(*c*). Dorsal fin with 14-16 rays : spines on body two-rooted, widely separated	*Chelanodon fluviatilis* (Ham.) (=*Tetrodon fluviatilis*).
Dorsal fin with 10-11 rays : spines on body four-rooted, widely separated	*Chelanodon patoca* (Ham.) (=*Tetrodon patoca*).

45. Gill opening reduced to a small foramen above the root of pectoral fins : dorsal origin anterior to gill opening Fam. BLENNIDAE *Petroscirtes bhattacharyae* Chaudhuri.

46(47). Gill opening not reduced to a small foramen above the root of pectoral fins : dorsal origin behind gill opening.

47(49). Single dorsal fin, with no distinct spinous and soft parts.

48(65). Two dorsal fins, or when single with distinct spinous and soft parts.

49. An erectile, bifid spine near eye : inner pectoral ray modified as spine. .Fam. COBITIDAE.....*Lepidocephalichthys guntea* (Ham.).

50(51). No erectile, bifid spine near eye : inner pectoral ray not modified as spine.

51. Dorsal fin in the posterior half of body : dorsal origin far behind anal origin. .Fam. CYPRINODONTIDAE, (*a*)-(*b*).

(*a*). Opening of mouth small, terminal : pectorals placed higher ..	*Oryzias melastigmus* (Mc Clell.) (=*Aplocheilus melastigmus*).
(*b*). Opening of mouth moderate, lateral : pectorals placed lower	*Aplocheilus panchax* (Ham.).

52(53). Dorsal fin not in the posterior half of body : dorsal origin not far behind anal origin.

53. Dorsal fin long (29-32 rays) : dorsal origin just above pectoral base : body sub-cylindrical Fam. OPHIOCEPHALIDAE, *Channa punctatus* (Bl.).

54(55). Dorsal fin short (9-24 rays) : dorsal origin far behind pectoral base : body not sub-cylindrical.

5(57). Abdomen keeled and serrated : lateral line absent.

56(59). Abdomen neither keeled nor serrated : lateral line present.

57. Upper jaw prominent, projecting over lower jaw : maxillaries much elongated.. Fam. ENGRAULIDAE, (*a*)-(*j*).

(*a*). Spiny abdominal scutes restricted between pectorals and pelvics : anal fin short — (*b*).

Spiny abdominal scutes not restricted between pectorals and pelvics : anal long — (*d*).

(*b*). Maxillary longer, reaching gill opening — (*c*).

Maxillary shorter, not reaching gill-opening — *Anchoviella indica* (v. Hass.) (=*Stolephorus indica*).

(*c*). Abdominal scutes between pectorals and pelvics 7 — *Anchoviella commersonii* (Lac). (=*Stolephorus commersonii*).

Abdominal scutes between pectorals and pelvics 4-5 — *Anchoviella tri* (Blkr.) (=*Stolephorus tri*).

(*d*). Maxillary extending beyond gill opening — (*e*).

Maxillary not extending beyond gill-opening — (*h*).

(*e*). Maxilliary reaching pectoral base — (*f*).

Maxilliary reaching beyond pectoral base — *Thrissocles valenciennesi* (Blkr.).

(*f*). Lower gill rakers 13 : anal fin more than 3 times in standard length — *Thrissocles mystax* (Schn.).

Lower gill rakers 11 : anal fin 2⅔ times in standard length — (*g*).

(*g*). Height of body 4¼ to 4½ times in total length — *Thrissocles purava* (Ham.) (=*Engraulis purava*).

Height of body 2⅔ times in total length — *Thrissocles annandalei* (Chaudhuri) (=*Engraulis annandalei*).

(*h*). Lower gill rakers 10-17 : abdominal scutes 22-23 — (*i*).

Lower gill rakers 27 : abdominal scutes 23-27 — (*j*).

(*i*). Lower gill rakers 10 : abdominal scutes 23 — *Thrissocles kempi* (Chaudhuri) (=*Engraulis kempi*).

Lower gill rakers 17 : abdominal scutes 22 — *Thrissocles rambhae* (Chaudhuri) (=*Engraulis rambhae*).

(*j*). Snout equal to eye : abdominal scutes 23 — *Thrissocles kammalensis* (Blkr.).

Snout ¾ of eye : abdominal scutes 27 — *Thrissocles malabaricus* (Bl)..

58. Upper jaw neither prominent nor projecting over lower jaw : maxillaries not much elongated. Fam. CLUPEIDAE, (*a*)-(*b*).

(*a*). Last dorsal ray prolonged into a filament	*Nematalosa nasus* (Bl.) (= *Dorosoma nasus*).
(*b*). Last dorsal ray not prolonged into a filament	(*b*).
(*b*). Upper jaw with a distinct median notch	*Hilsa ilisha* (Ham.).
Upper jaw without a distinct median notch	(*f*).
(*c*). Last 2 anal rays enlarged	*Sardinella melanura* (*C*).
Last 2 anal rays not enlarged ..	(*d*).
(*d*). Dorsal origin before pelvic origin : body deeper : lateral transverse scales 12-15	*Anodontostoma chacunda* (Ham.) (= *Dorosoma chacunda*).
Dorsal origin behind pelvic origin : body shallower : lateral transverse scales 9-11	*Kowala coval* (C.) (= *Clupeoides lile*).

59(61). An elongate, bony, gular plate between the rami and towards the end of lower jaw.

60(63). No bony, gular plate between the rami and towards the end of lower jaw.

61. Last dorsal ray produced to a filament : dorsal fin (16-21 rays shorter than anal fin (23-28 rays) : lateral line scales 37-42. . Fam. MEGALOPIDAE. *Megalops cyprinoides* (Brouss.).

62. Last dorsal ray not produced to a filament : dorsal (21-24 rays longer than anal (15-17 rays): lateral line scales 94-100 Fam. ELOPIDAE *Elops saurus* (L.).

63. Anal fin far behind dorsal fin : mouth small, terminal : gill membranes totally united below : accessory branchial organ present. Fam. CHANIDAE *Chanos chanos* (Forsk.).

64. Anal fin not far behind dorsal fin : mouth moderate, lateral : gill membranes not totally united below: no accessory branchial organ. Fam. CYPRINIDAE, (*a*)-(*f*).

(*a*). Abdominal edge cutting : lateral line scales 80-93	*Oxygaster bacaila* (Ham.).
Abdominal edge not cutting : lateral line scales 20-40	(*b*).
(*b*). Dorsal fin with an osseous ray : lateral line scales 20-26	(*c*).
Dorsal fin without an osseous ray: lateral line scales 26-40	(*e*).

(*c*). Lateral line complete : lateral line scales 23-26 : a dark spot near hind extremity of lateral line — *Puntius sophore* (Ham.) (=*Barbus sophore*).

Lateral line incomplete : lateral line scales 20-26 : 2 or 4 black spots on body — (*d*).

(*d*). 4 black spots on body : 3 rows of scales between lateral line and pelvic base : lateral line scales 20-22 : osseous ray weak, smooth — *Puntius vittatus* Day (=*Barbus vittatus*).

2 black spots on body : 4 or 5 rows of scales between lateral line and pelvic base : lateral line scales 23-26 : osseous ray strong, serrated — *Puntius ticto* (Ham.) (=*Barbus ticto*).

(*e*). Cleft of mouth oblique, directed upwards : dorsal origin behind pelvic origin — (*f*).

Cleft of mouth neither oblique nor directed upwards : dorsal origin a little ahead of pelvic origin — *Cirrhina latius* (Ham).

(*f*). Anal fin short, with 7 rays : no barbels ... — *Rasbora dniconius* (Ham).

Anal fin long with 15-16 rays : 4 barbels .. — *Brachydanio rerio* (Ham).

65(67). Two widely separated dorsal fins : dorsal spines 4.

66(69). Single dorsal fin or when two, closely placed or connected at their base : dorsal spines 7-19.

67. Snout long, pointed : cleft of mouth deep : teeth in jaws large, cutting : dorsal spines weak — Fam. SPHYRAENIDAE — *Sphyraena raghava* Chaudhuri.

68. Snout short, blunt : cleft of mouth narrow : teeth in jaws neither large nor cutting : dorsal spines strong. — Fam. MUGILIDAE, (*a*)-(*b*).

(*a*) With well developed adipose eye lids — (*b*).

With no or poorly developed adipose eye lids — (*h*).

(*b*) Lateral line scales 38-44 — (*c*).

Lateral line scales 30-35 — (*e*).

(*c*) Height of body $4\frac{1}{2}$ to $4\frac{2}{3}$ times in total length : lateral line scales 38 — *Mugil caeruleomaculata* Lac.

Height of body $4\frac{1}{5}$ to $5\frac{2}{3}$ times in total length : lateral line scales 40-44 — (*d*).

(*d*) Lateral transverse scales 14 : height of body $5\frac{1}{3}$ to $5\frac{2}{3}$ times in total length : soft anal rays 8 — *Mugil cephalus* L.

Lateral transverse scales 11-12 : height of body $4\frac{1}{5}$ to 5 times in total length : soft anal rays 9 — *Mugil speigleri* Blkr.

(*e*). Height of body 4½ to 4¾ times in total length	(*f*).	
Height of body 5 to 5½ times in total length	(*g*).	
(*f*). Lateral line scales 30 : length of caudal 6⅓ times in total length	*Mugil subviridis* V. V.	
Lateral line scales 35 : length of caudal 5½ times in total length	*Mugil cunnesius* V.V.	
(*g*). Length of caudal 5 times in total length : eye diameter 3½ times in length of head : lateral line scales 31-32 ..	*Mugil jerdoni* Day.	
Length of caudal 6 times in total length : eye diameter 4 times in length of head : lateral line scales 34-35 ..	*Mugil tade* Forsk.	(=*Mugil gymnocephalus*).
(*h*). Lateral line scales 26-28 : length of caudal 4⅔ and height of body 3⅔ times in total length ..	*Chelon oligolepis* (Blkr.).	
Lateral line scales 31-34 : length of caudal 5 to 5⅓ and height of body 4½ to 5 times in total length	*Chelon macrolepis* (Smith)	(=*Liza borneensis and L. troschelii*).

69 (71). Single dorsal fin, with spinous and soft parts continuous.

70 (87). Two dorsal fins, with spinous and soft parts separate or connected at their base.

71. Anterior rays of dorsal and anal fins elongated and more or less falciform : pelvics rudimentary : body profile abruptly elevated behind head... .Fam. PSETTIDAE. .*Monodactylus argenteus* (L.).

(72)(73). Anterior rays of dorsal and anal fins neither elongated nor falciform : pelvics well developed : body profile not abruptly elevated behind head.

73(75). Dorsal spines 17-19.

74(77). Dorsal spines 7-13.

75. Anal spines 8-10. ..Fam. ANABANTIDAE.. .*Anabas testudineus* (Bl.).

76. Anal spines 14-15. .Fam. CICHLIDAE. .*Etroplus suratensis* (Bl.)

77. A median longitudinal groove behind chin. Fam. POMADASYIDAB .. .*Pomadasys hasta* (Bl.).

78(79). No median longitudinal groove behind chin.

79. Broad cutting teeth in fornt of jaws .. . Fam. GIRELLIDAE .... *Crenidens crenidens* (Forsk.).

80(81). No broad cutting teeth in front of jaws.

81. Mouth very protractile : body very much compressed. ..Fam. LEIOGNATHIDAE, (*a*)-(*i*).

(*a*). Bony ridges and a nuchal spine on top of head : gill-membranes attached to isthmus	(*e*).
No bony ridges and nuchal spine on top of head : gill membranes not attached to isthmus	(*b*).
(*b*). Second dorsal spine prolonged into a filament	*Gerres filamentosus* C. (=*Gerres punctatus*).
Second dorsal spine not prolonged into a filament	(*c*).
(*c*). Dorsal and ventral profiles equally convex	(*d*).
Dorsal profile more convex than ventral profile ..	*Gerres oyena* (Forsk.).
(*d*). Highest dorsal spine as long as head excluding snout	*Gerres poeti* C.
Highest dorsal spine less than head excluding snout.	*Gerres setifer* (Ham.).
(*e*). Teeth in jaws minute : no symphisial canines ..	(*f*).
Teeth in jaws large : with symphisial canines ..	*Gazza minuta* (Bl.).
(*f*). Mouth when fully protracted forms an upwardly directed tube ..	*Leiognathus insidiator* (Bl.).
Mouth when fully protracted forms a downwardly directed tube .	(*g*).
(*g*). Height of body 2¼ to 2½ in total length : lateral line extending to caudal base	(*h*).
Height of body 2¼ to 3⅜ in total length : lateral line not extending to caudal base	(*i*).
(*h*). Lower jaw strongly concave : supra-orbital edge serrated	*Leiognathus equulus* (Forsk.).
Lower jaw not strongly concave : supra-orbital edge smooth	*Leiognathus dussumieri* (V.V.).
(*i*). Chest naked : supra-orbital edge smooth ..	*Leiognathus daura* (C.C.).
Chest scaly : supra-orbital edge serrated .	*Leiognathus blochii* (V.V.).

82(83). Mouth not very protractile : body not very much compressed.

83. Hind border of preopercle notched, Fam .... LUTIANIDAE .... *Lutianus johnii* (B.).

84(85). Hind border of preopercle not notched.

85. Head pointed : dorsal fin not notched : caudal not forked. .Fam. LOBOTIDAE.. .*Datnioides quadrifasciatus* Sevastianof (=*Coius quadrifasciatus*).

86. Head not pointed : dorsal fin notched : caudal forked. .Fam. THERAPONIDAE, (*a*)-(*b*).

(*a*). Lateral line scales 90-100 : nostrils distant : 4 straight bands on body *Therapon puta* C.

(*b*). Lateral line scales 80-90 : nostrils close together : 3 convex bands on body *Therapon jarbua* (Forsk.).

87(89). Dorsal fins connected at their base.

88(91). Dorsal fins separate.

89. Two weak anal spines : muciferous system on head well developed .Fam. SCIAENIDAE, (*a*)-(*c*).

(*a*). Mouth inferior : upper jaw overhanging lower jaw : a barbel at mandibular symphysis (*b*).

Mouth terminal : upper jaw not overhanging lower jaw : no barbel at mandibular symphysis *Pseudosciaena coiber* (Ham.).

(*b*). Maxillary reaching below to middle of eye : barbel half as long as eye : lateral transverse scales 5-6/15-17 (*c*).

Maxillary reaching beyond middle of eye : barbel nearly as long as eye : lateral transverse scales 6/15 *Sciaena russellii* (C. C.) (=*Umbrina indica*).

(*c*). Lateral line scales 48 : lateral transverse scales 5-6/15 *Sciaena macroptera* (Blkr.).

Lateral line scales 52 : lateral transverse scales 6/17 *Sciaena dussumieri* (V. V.).

90. Three strong anal spines : muciferous system on head not well developed. .Fam. CENTROPOMIDAE, (*a*)-(*c*).

(*a*). Maxillary reaching hind border of eye : opercle spinate : caudal rounded *Lates calcarifer* (Bl.).

Maxillary not reaching hind border of eye : opercle not spinate : caudal forked (*b*).

(*b*). Height of body $2\frac{1}{3}$ to $2\frac{1}{2}$ times in total length : pelvics nearly reaching anal .. *Ambassis ranga* (Ham.).

Height of body $3\frac{1}{4}$ to $3\frac{1}{2}$ times in total length : pelvics not reaching anal (*c*).

(*c*). Lateral line continuous : lateral transverse scales 4/9 *Ambassis commersonii* C. (=*Chanda ambassis*).

Lateral line interrupted : lateral transverse scales 3/8 *Ambassis gymnocephalus* (Lac.) (=*Priops gymnocephalus*).

91. Head depressed, flat and armed with spines .. Fam. PLATYCEPHALIDAE. .*Platycephalus indicus* (L.) (=*Platycephalus insidiator*).

92. Head neither depressed, flat nor armed with spines. .Fam. SILLAGINIDAE. .*Sillago sihama* (Forsk).

93. Preopercular margin free, not hidden by skin and scales of head : lower jaw more prominent than upper jaw. .Fam. BOTHIDAE. *Pseudorhombus arsius* (Ham.).

94(95). Preopercular margin not free, hidden by skin and scales of head : lower jaw not more prominent than upper jaw.

95. Vertical fins confluent : eyes on left side. .Fam. CYNOGLOSSIDAE. *Cynoglossus brevis* Gthr.

96. Vertical fins not confluent : eyes on right side. .Fam. SOLEIDAE .*Synaptura orientalis* (Bl. Schn.).

97(99). Gill openings ventral : head and trunk depressed or broadly disc-like.

98. Gill openings lateral : head and trunk neither depressed nor disc-like. .Fam. CARCHARHINIDAE, (*a*)-(*c*).

(*a*). Teeth with smooth edges, those at sides with swollen bases : snout elongate	*Physodon mulleri* M. H.
Teeth with serrated edges, none with swollen bases : snout not elongate	(*b*).
(*b*). Second dorsal fin larger than anal fin : snout obtuse : preoral length 2/3 of mouth width	*Carcharhinus gangeticus* (M.H.) (=*Carcharias gangeticus*).
Second dorsal fin not larger than anal fin : snout pointed : preoral length equal to or 2/3 of mouth width	(*c*).
(*c*) Second dorsal fin smaller than anal fin : preoral length equal to mouth width : fins not tipped black	*Carcharhinus limbatus* (M.H.).
Second dorsal fin and anal fin subequal : preoral length 2/3 of mouth width : fins tipped black	*Carcharhinus melanopterus* (Q.G.) (=*Carcharias melanopterus*).

99. Head and trunk depressed : snout much produced and saw-like. .Fam. PRISTIDAE. .*Pristis pectinatus* Latham.

100(101). Head and trunk broadly disc-like : snout neither produced nor saw-like.

101. Head distinct from disc and with a distinct snout : Fam. MYLIOBATIDAE, (*a*)-(*b*).

(*a*). Snout pointed : a strong caudal spine : teeth in single row	*Aetobatus narinari* (Euphrasen). (=*Aetobatus flagellum* and *A. guttata*).
(*b*). Snout blunt : no caudal spine : teeth in many rows .. .	*Aetomylus nichofi* Schn.

102. Head not distinct from disc and without a distinct snout. .. Fam. TRYGONIDAE, (*a*)-(*d*).

(*a*). Cutaneous fold on tail	(*b*).	
No cutaneous fold on tail		*Dasyatis* (*Himantura*) *uarnak* (Forsk.) (=*Trygon pareh* and *T. uarnak*).
(*b*). Tail with a ventral cutaneous fold		*Dasyatis* (*Pastinachus*) *sephen* (Forsk).)=*Hypolophus sephen*).
Tail with a dorsal cutaneous fold ..		*Dasyatis* (*Amphotistius*) *imbricata* (Schn.) (=*Trygon imbricata*).

IV—SUMMARY

1. The paper deals with a recent collection of fish from the Chilka Lake, Orissa. The collecting localities are marked in the map (Text-fig. 1).

2. Of the 72 species represented in the collection under report, 17 are new records from the Lake.

3. The total number of fishes so far recorded from the Lake is thus raised to 134 species, comprising 87 genera, 51 families and 15 orders. A table of identification of these species is given at the end of the paper.

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A NEW SPECIES OF THE GENUS *JAURAVIA* MOTS. FROM INDIA (COLEOPTERA: COCCINELLIDAE)

By

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(With 1 Text-figure)

The genus *Jauravia* Motschulsky (1858) is distributed mostly in Ceylon and southern India but a few of its species also occur in the north as far as Assam and Burma. In 1946, I had published[1] a taxonomic revision of the genus and had dealt with eleven species, of which three were described as new. The species hitherto known from Assam and Burma are *J. quadrinotata* Kapur and *J. dorsalis* Weise, respectively. More recently Dr. G. M. Das, Entomologist, Tea Experimental Station, Tocklai, Assam, sent us for identification some Coccinellidae material which contained two species of *Jauravia*, that were reported to be feeding on "aphids, scale insects and mites" at Tocklai. While one of the species is *J. quadrinotata*, the other is apparently a new species and is being described below. I am indebted to Dr. Das for giving me the opportunity of studying the material and to Dr. M. L. Roonwal, Director of this Survey, for providing facilities for work.

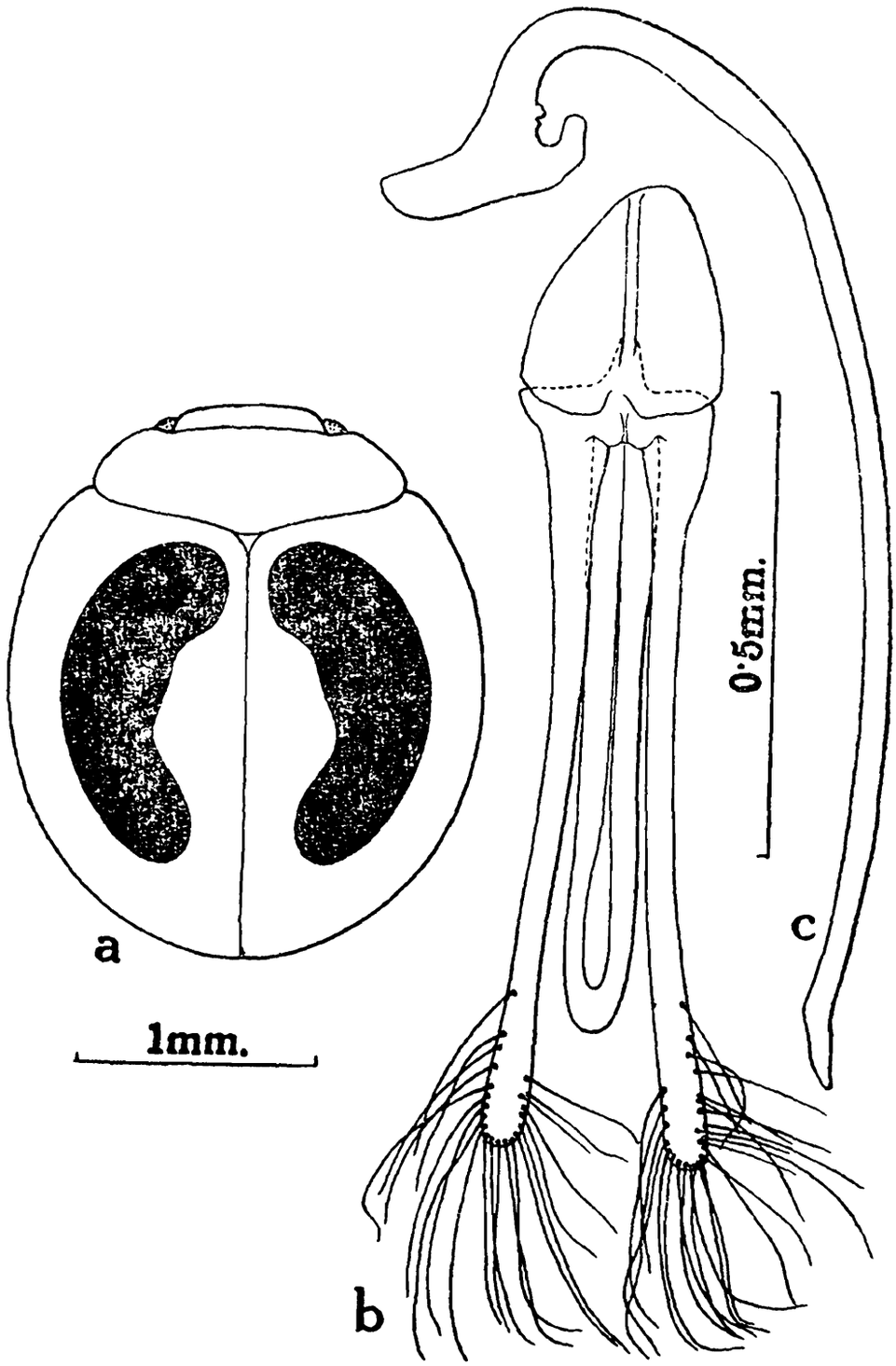
Jauravia assamensis, sp. nov.

♂. Body subrounded, strongly convex, upper surface testaceous to pale testaceous except the dark-brown apices of mandibles, the greyish to black eyes and an elongate, rather kidney-shaped, black marking on each elytron. The elytral marking as wide as one-third the maximum width of the elytron, commencing from a short distance away from the basal and sutural margins and extending as far as two-thirds the length of elytron, rounded at either end ; the outer margin of the marking widely rounded and running parallel to the external margin of the elytron and the inner margin (facing the suture) widely emarginate in the middle (Text-fig. 1*a*). Underside pale testaceous except for the dark testaceous to piceous mesosternum, the almost black metasternum, and the piceous median part of the first abdominal sternite.

Head with fine, rather sparse punctures, and greyish, rather short and sparse pubescence. Pronotum moderately emarginate anteriorly, subrounded laterally, punctation and pubescence similar to that on the head. Scutellum, as usual, very small, triangular and with one or two punctures and hairs. Elytron narrowly expanded at the external border,

[1]Kapur A. P. A revision of the genus *Jauravia* Mots. (Coleoptera, Coccinellidae).— *Ann. Mag. nat. Hist.* (11) **13**, pp. 73-93, 30 figs. (1946).

punctation slightly coarser, deeper and closer than that on the pronotum ; the interspaces smooth and shining ; pubescence finer than that on the pronotum but slightly longer and closer. Prosternal carinae straight, slightly diverging anteriorly and reaching the anterior margin ; punctures rather fine and sparse on the prosternum and coarse, shallow and very



TEXT-FIG. 1.—*Jauravia assamensis*, sp. nov.

(*a*). Outline of the beetle showing the elytral pattern. (*b*) Male genitalia except sipho. (*c*). Sipho.

sparse on the meso-and metasternum and the first abdominal sternite; the interspaces smooth and shining. Rest of the underside with fine, usually dense punctures and with short and thin pubescence. The male genitalia with the basal plate (Text-fig. 1*b*) subtriangular in outline

when viewed from the front ; median lobe of the aedeagus elongate, narrow, uniform in width from the base to nearly as far as the apex which is slightly narrowed and rounded ; parameres distinctly longer than the aedeagus, slightly expanded and rounded at the apex, with about 20 long hairs near the apex ; sipho (Text-fig. 1*c*) narrow, siphonal capsule moderately expanded, with the outer division longer than the inner one which is provided with a moderately wide hook.

Length 2·13 mm.; width 2·0 mm.

♀. Slightly larger than the male, but otherwise similar in external characters.

Length 2·25-2·32 mm.; width 2·10-2·13 mm.

Holotype.—A male. INDIA : Assam : Tocklai, 21.xi.1956, feeding on aphids. (*G. M. Das*) ; deposited in the Zoological Survey of India scale insects and mites (Regd. No. 10990/H4).

Allotype and *Paratype.*—Each a female, with the same data as the holotype, also deposited in the Zoological Survey of India (Regd. No. 10991/H4 and 10992/H4, respectively).

Remarks.—The species is closely related to *J. quadrinotata* Kapur in general appearance, but is easily distinguished from it by the following characters : (i) It is slightly smaller in size than *J. quadrinotata.* (ii) Pattern of the black elytral markings in the two species is quite distinct ; in the latter there are two rounded spots on each elytron, while in *J. assamensis* there is a well defined, elongate, kidney-shaped elytral marking which does not show any tendency to break up into spots. (iii) Punctation on the elytra is coarser and sparser in *J. quadrinotata* than is the case in *J. assamensis.* (iv) Likewise, the pubescence is also denser and a little longer in the latter than in the former. (v) Of the male genitalia, the penis is narrower in *J. assamensis* than in *J. quadrinotata ;* the shape of the siphonal capsule is also different in the two species, the inner arm of the capsule being more widely open in the latter species than in *J. assamensis.*

In the key to the species of the genus published earlier (Kapur, *loc. cit.*, pp. 77-78), *J. assamensis* would come next to *J. quadrinotata* from which it may be easily separated by the differences in the elytral markings.

A HISTOLOGICAL STUDY OF THE OVULAR ATRESIA IN THE CATFISH, *MYSTUS SEENGHALA* (SYKES)

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(With 2 Plates)

CONTENTS

I—INTRODUCTION

Brambell (1956) observed that "the follicular atresia is common and may be regarded as a process in the ovaries of vertebrates at all ages" The resorption of eggs appears to be a common occurrence in the growing ovaries of vertebrates (Hisaw & Albert, 1947). Earlier reports on the degeneration of the ovarian ova of teleosts are of His (1873), Brock (1878), Emery (1880), Owsiannikov (1885), Barfurth (1886) (cited by Wallace, 1903) and Cunningham (1897). The works of Cunningham (1897) and Wallace (1903) give comprehensive reviews of the earlier studies on the subject. Turner (1933, 1938), Matthews (1938), Frazer (1940), Mendoza (1943), Bretschneider and de Wit (1947), D'Ancona (1950) and Stolk (1950, 1951) are some of the recent authors who have dealt with the subject. Many investigations on the ovarian ova of teleosts lack references to the atresia of oocytes, while some workers have made passing remarks on this phenomenon (James, 1946 ; Sathyanesan, 1959). The extensive studies of Bretschneider and de Wit (1947) reveal that in *Rhodeus amarus,* homologous structures function as endocrine organs. Basing on its function, the above authors termed this structure as "pre-ovulation corpus luteum" Dixit's (1956) observations on the atretic oocyte of *Mystus seenghala* are rather fragmentary.

In this paper an attempt is made to study in detail the histological changes occurring in the atretic oocyte of *Mystus seenghala* during its resorption.

Acknowledgments.—The author wishes to express his grateful thanks to Professor A. B. Misra for his continued guidance and valuable suggestions throughout the course of this study. He is also indebted to the Government of India for the award of their Scholarship which made this work possible.

II—Material and Methods

For this study specimens were collected from the river Ganges every month for one complete year. Fishes were killed by severing the head, and portions of the anterior, middle and posterior regions of the ovary were fixed in appropriate fixatives immediately. Bouin's picro-formol, Allan's modification of Bouin's picro-formol, Zenker-formol and Pereney's fluid were used as fixatives. Paraffin sections were cut at 4, 6 and 8μ thick and stained in Delafield's Haematoxylin, Heidenhain's iron Haematoxylin and Erlich's Haematoxylin ; Eosin and Orange-G were the counterstains employed.

III—Observations

The ovary of *M. seenghala* shows an all round enlargement during the pre-spawning phase. In the larger oocytes yolk deposition is in progress, and in many cases the deposition is even complete. In the spawning phase the ovary is turgid and completely distended. During these phases a number of oocytes abort and are in different stages of resorption. Degeneration of the immature oocytes is not so common as that of the matured and maturing ones. The terms " degenerating or atretic oocyte " (Matthews, 1938 ; Mendoza, 1943) and " pre-ovulation corpus luteum " (Bretschneider and de Wit, 1947) are used by workers to describe homologous structures.

The ripe oocyte of *M. seenghala* has a prominent vitelline membrane. The follicular layer which overlies it is made up of a single row of columnar cells. A thin vascular theca corresponding to the follicular membrane in the oocyte of *Pleuronectes* (Cunningham, 1890) covers the follicular layer (Pl. 1, Fig. 2*a*). The vitelline membrane and the follicular layer of *M. seenghala* correspond to the oolemma and the granulosa layer described in the oocyte of *Rhodeus amarus* (Bretschneider and de Wit, 1947) ; the thin theca may be homologous with the theca interna, while the basement membrane and the theca externa of *Rhodeus amarus* is not clearly differentiated in *M. seenghala.*

In *M. seenghala,* during its resorption, the atretic oocytes present different patterns. Though the end product of atresia is the same, the pattern of the process by which it is accomplished varies.

In the abortive oocytes initially the nucleus disappears and the follicular layer shows indications of hypertrophy. Liquefaction of the contents of oocyte is evident towards the periphery (Pl. 1, Fig. 1), even when the vitelline membrane persists and the follicle cells retain their definition (Pl. 1, Fig. 2). The vitelline membrane is deflected off from the follicular layer (Pl. 1, Fig. 2) and may be thrown into folds. During the next stage prominent cytoplasmic granules are seen in the follicle cells. On further hypertrophy, these cells lose their definition and the entire follicular layer becomes a syncytium (Pl. 1, Fig. 3). At a later stage vacuoles of varying size and shape appear in this syncytium (Pl. 1,

Fig. 4). Some of these vacuoles contain homogeneous globular bodies (Pl. 1, Fig. 5). Such bodies are recorded in the hypertrophing post-ovulatory follicle of *Fundulus heteroclitus* (Matthews, 1938) and in the hypertrophying follicle of the atretic oocyte of *Zoarces* (Wallace, 1903). The above authors considered these globular bodies to be of fatty or oily consistency, which dissolve during the preparation of the slides. As the process of resorption is in progress the cavity of the oocyte (oocoel) is narrowed down by the approximation of the hypertrophying follicular layer which is thrown into folds (Pl. 1, Fig. 6). Blood cells are always present among the infiltrating follicular element ; but they abound in the folds of the follicular layer (Pl. 1, Fig. 6). Probably they arise from the vascular membranous theca which covers the follicular layer. When the oocoel is almost obliterated the follicular layer becomes more compact and the vacuoles gradually dwindle (Pl. 1, Fig. 6*a*). In the subsequent stage the entire mass becomes more compact and presents a yellowish hue. When this structure becomes more condensed a close examination reveals that it is made up of irregular yellow granular mass and round or oval cells (Pl. 2, Fig. 3) having yellow pigments in them. In some case the non-cellular pigment mass abounds. Gradually the intracellular pigment disappears. These cells lose their regular form, become variously shaped, migrate along strands of connective tissue (Pl. 2, Fig. 2) and finally are lost among the stromal elements. The entire process appears to take about two to four months to accomplish. In the final stage of the histogenesis of the " pre-ovulation corpus luteum " in *Rhodeus amarus* Bretschneider and de Wit (1947) record necrosis and migration of the cells as two different ways to decrease the number of cells from this structure. In *M. seenghala* the yellow pigment mass may be the remnant of necrosis. And the migrating cells described, have close similarity to that reported in *Rhodeus amarus*.

In some oocytes after the disappearance of the nucleus the follicular cells hypertrophy and show distinct numerical increase. They lose their definition and the entire follicular layer becomes a syncytium. Vacuoles and globular bodies as reported in the preceding case are not evident (Pl. 1, Figs. 7 and 8). The granulation of the cytoplasm of the follicular syncytium and the liquefaction of the yolk contents of the oocyte are not extensive. In some cases, in the region of the theca, capillaries are prominently seen (Pl. 1, Fig. 7). The proliferation of follicular cells is not uniform all around. In the areas of active proliferation these cells form regular or irregular groups. Some of these groups of cells have a regular shape resembling the so-called " cell pearls " (Pl. 2, Fig. 4) described in the " pre-ovulation corpus luteum " of *Rhodeus amarus* (Bretschneider and de Wit, 1947) and *Lebistes reticulatus* (Stolk, 1951). Dixit (1956) observed that " the invasion of the follicular cells is more pronounced at the corners than at other points" The present writer does not recognise any region in the atretic oocyte which can be termed as corner with any justification. Also, the pronounced invasion of the follicular elements at certain points as noticed by Dixit (1956), is not a general feature, since in some cases it is seen that the follicular invasion is more or less uniformly spread over (Pl. 1, Fig. 8). Irrespective of the initial pattern of arrangement of these proliferating follicle cells, they steadily invade the ovular contents. This centripetal

migration of the follicular cells results in the resorption of the ovular contents, and its replacement by the moving mass of cells (Pl. 2, Fig. 1). This strongly recalls the structure of corpus luteum atreticum. Bullough (1951) defines the corpus luteum atreticum as a solid body similar to the normal corpus luteum, which is formed from the ovarian follicle when an egg is resorbed. The fate of this cellular mass is similar to that described earlier.

In some cases of atresia the follicular hypertrophy is less pronounced than that of the preceding two types. However, the follicular layer becomes a syncytium which is generally devoid of vacuoles (Pl. 2, Figs. 5 and 6). Granulation of their cytoplasm is moderate. Liquefaction of the ovular contents is generally not prominent. It is interesting to note that the vitelline membrane is retained almost entire even when the major part of the ovular contents is resorbed. The follicular components together with the vitelline membrane are thrown into several irregular digitate folds, leaving only a narrow strip of obliterating oocoel inside (Pl. 2, Fig. 6).

IV—Discussion

The follicular components of the teleostean oocyte is found to vary in size and appearance depending on the stage of maturity and the species of the fish. Generally the vitelline membrane is covered by the follicular layer, which is enveloped by the thecal elements (Cunningham, 1890, 1897 ; Wallace, 1903 ; Bailey, 1933 ; Hann, 1927 ; Matthews, 1938 ; Mendoza, 1943 ; James, 1946 ; Bretschneider and de Wit, 1947 ; Chaudhry, 1956 ; Sathyanesan, 1959). But in *Pomoxis* (Cooper, 1952) the only follicular covering is formed by a capsule-like layer of loose reticular fibres. The terms zona radiata (James, 1946 ; Chaudhry, 1956) granulosa layer (Bretschneider and de Wit, 1947) and connective tissue covering or follicular membrane (Cunningham, 1890, 1897) are used by authors to denote the vitelline membrane, follicular layer and the theca respectively.

Several workers have studied the structure and changes occurring in the teleostean post-ovulatory follicles. But studies on the structure, function and fate of the atretic oocytes of teleosts are few. Cunningham (1897), and others observed the process of resorption of dead eggs to be similar to that of the empty follicles. Wallace (1903) and Bretschneider and de Wit (1947) have reported that these two processes are different.

Opinions differ as to the part played by the different components of the follicle in the resorption of the atretic oocyte. Cunningham (1897) reported that the cells from the connective tissue covering of the follicle proliferate and invade the contents of the oocyte to effect resorption. According to Wallace (1903) the cells of the follicular layer are responsible for the resorption. During the first stage in the formation of the preovulation corpus luteum, Bretschneider and de Wit (1947) observed that the granules of the granulosa act as a disintegrating ferment to dissolve the oolemma. The absorption of the ovular contents by the granulosa cells takes place through resorption of liquefied ovular substances and phagocytosis of solid yolk elements. During the second stage they reported penetration of the thecal cells into the follicular space by breaking through the granulosa layer. Thus it appears that

in *Rhodeus amarus* the theca cells also have some part to play in the formation of this structure. In *Heterandria formosa* (Frazer, 1940) and *Neotoca bilineata* (Mendoza, 1943) the follicular layer takes part in the resorption of the atretic oocyte. Hoar (1955) observed that the function of the follicular derivatives is by no means clear.

The role of blood cells in the resorption process appears to vary. Ruge (cited by Wallace, 1903) records a simultaneous incursion of blood and follicular cells into the degenerating egg and he regards both kinds of elements as taking active part in the breaking down of the egg. Wallace (1903) noted in *Zoarces* the appearance of leucocytes at a late stage in the resorption process. He attributed them, the probable function of conveying the product of degeneration (the yellow non-adipose granules) into the lymph or blood channel. Mendoza (1943) believes that the slight lymphocyte infiltration usually occurring during the process may be instrumental in aiding the process of disintegration. Barfurth (1886, cited by Wallace, 1903) considers that the leuccoytes play only a subordinate part in the degeneration of the eggs in the trout. Bretschneider and de Wit infer that the hormone of the lutein-cells (transformed granulosa cells) is directly secreted into the blood vessels lying close to them.

In *M. seenghala* the cells of the follicular layer hypertrophy, proliferate and penetrate into the substance of the oocyte, The blood cell seen among the hypertrophying follicle may probably belong to the theca. These blood cells persist throughout the entire process of resorption. As in the case of goldfish (Hoar, 1955), marked vascularisation and hypertrophy of the theca is not seen in this species. However, in some cases prominent capillaries are present overlying the theca. The so-called " cell pearls " of the *Rhodeus amarus* is formed by the invading theca and granulosa cells having a part of the oolemma remnant inside. In *M. seenghala* the " cell pearl-like " bodies are formed by the excessive proliferation of follicular cells at certain areas. These bodies may be sometimes regular, but more often they are irregular in shape.

The process of resorption of atretic oocyte in *M. seenghala* exhibits wide variations. In the first type described elsewhere in this paper, the hypertrophy of the follicular layer is seen. Liquefaction of the ovular contents is profound. The follicular syncytium has granules, vacuoles and globular bodies. In the second type, numerical increase in the follicular cells is noted. The follicular syncytium is devoid of vacuoles and globules. Granulation is sparse and liquefaction is much less in comparison to the former. In the third type the hypertrophy of the follicular layer is less pronounced than that of the preceding cases. The liquefaction of the ovular contents is meagre. The vitelline membrane is almost intact even when the entire content is resorbed. Unlike the " pre-ovulation corpus luteum " of *Rhodeus amarus*, the considerable variations involved in the process of resorption in *M seenghala* render it difficult to arrange them into continuous series of interrelated stages.

Dixit (1956) reports that atresia in *M. seenghala* appears to take place in " two general ways " " In one case the cytoplasm loses its normal yolk-laden structure, vacuoles make their appearance and the whole mass appears to be somewhat a vacuolated mass of debris. In

the second type the follicle cells lose their normal cellular appearance, proliferate and invade the enclosed yolk-laden cytoplasm from the sides", resulting in their gradual disappearance. The study of the present writer on the same species reveals that, what the "two general ways" or types of atresia mentioned by Dixit (1956) may be two stages in a particular type of resorption.

Variations in the process of resorption of the atretic oocyte are suggested by several workers. Cunningham (1897) has recorded the presence of aborted eggs in a state of resorption in the spent and immature ovaries of teleosts. He observed that their appearance differs very much according to the stage at which their development has been arrested. Mendoza (1943) states that in *Neotoca bilineata* "the degeneration picture most definitely is not one of complete breakdown of all or most cells at once. In a few isolated cases an abnormally heavy lymphocyte infiltration may occur and in others follicle may precede the egg in degeneration" Further he adds that regardless of the method of atresia the end result is the removal of the degenerating mass of cells from the stroma of the ovary. Hoar (1955) writes that in goldfish he did not observe marked vascularisation and hypertrophy of the theca described in the second stage of corpora lutea formation in *Rhodeus amarus* (Bretschneider and de Wit, 1947). Wallace (1903) reports that he is unable to find some intermediate stages in the fatty degeneration of the atretic oocyte of *Zoarces*. Speaking of follicular atresia in general Brambell (1956) states that atresia exhibits much variation not only in different species but also in follicles of different size.

The findings of the above authors and the present writer suggest the absence of a regular sequence of stages in the resorption of the abortive oocytes. It is probable that, depending on the growth stage at which atresia sets in and the rate of proliferation and hypertrophy of the follicular cells, stages in the process of resorption may be added or inhibited or telescoped.

Bretschneider and de Wit (1947) found that the "pre-ovulation corpus luteum" secretes a hormone which is responsible for the development of the ovipositor in *Rhodeus amarus*. It would be interesting to investigate the endocrinological implications involved in the case of *Trigla hirundo* (Cunningham, 1897) and the trout (Barfurth, 1886; cited by Wallace, 1903) where the whole batch of ripe ova meant for spawning are resorbed *in situ*.

More recently in summing up the present position of this problem in fishes (Hoar, 1957) states, "several writers have noted the degeneration and atresia of developing eggs and have speculated as to the significance and cause of this atresia. Others have emphasised the hypertrophy of the follicular cells, the apparently healthy condition of the resulting structure and the possible endocrinological significance. There is not yet sufficient information to establish the physiology of the follicular layers and their derivatives" Bursting atresia occurring in the ovary of monotremes, birds and reptiles is considered to be a method by which heavily yolked eggs are climinated when atresia sets in (Garde 1930, Davis 1942, Dominic 1960, Bragdon 1952). Instances of comparable burst atretic follicles are reported in *Mystus seenghala* (Sathyanesan 1960). These findings support

the inference of Beach (1959) that the formation of "corpus luteum" like structure in the resorptive oocyte is apparently associated with the removal of the yolk rather than secretion of hormone. However it is probable that these may perform both the functions.

V—SUMMARY

1. The presence of atretic oocytes in the maturing and mature ovary of *M. seenghala* is not uncommon as reported by Dixit (1956).

2. The presence of variations in the process of resorption of the atretic oocytes is evident.

3. It may be difficult to arrange all the stages in the resorption process recorded in this species into a continuous series.

4. It is likely that these variations may depend on the growth stage of the oocyte at which atresia sets in and the varying activity of the follicular component during resorption.

5. Histological observations reveal that the follicular cells have a major role in removing the yolk. It is likely that this structure may also be responsible for the production of horomone.

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PLATE 1

Mystus seenghala (Sykes)

FIG. 1. Photograph of an atretic oocyte in the initial stage of resorption, showing liquefaction of the ovular contents towards the periphery. × 80

FIG. 2. Photograph of a portion of an atretic oocyte, showing the granulated follicle cells, liquefied ovular contents and deflected vitelline membrane. × 224

FIG. 2*a*. Photograph, showing the vitelline membrane and follicular components of a portion of two adjacent normal mature oocytes. The thin vascular theca overlying the follicular layer may be seen. × 352

FIG. 3. Photograph of a portion of an atretic oocyte, showing the hypertrophying granulated follicular syncytium and liquefied ovular contents. × 272

FIG. 4. Photograph of a portion of the atretic oocyte, showing the vacuolated hypertrophied follicular syncytium. X 272

FIG. 5. Photograph of a portion of the follicular syncytium, showing the vacuoles and globular bodies. × 480

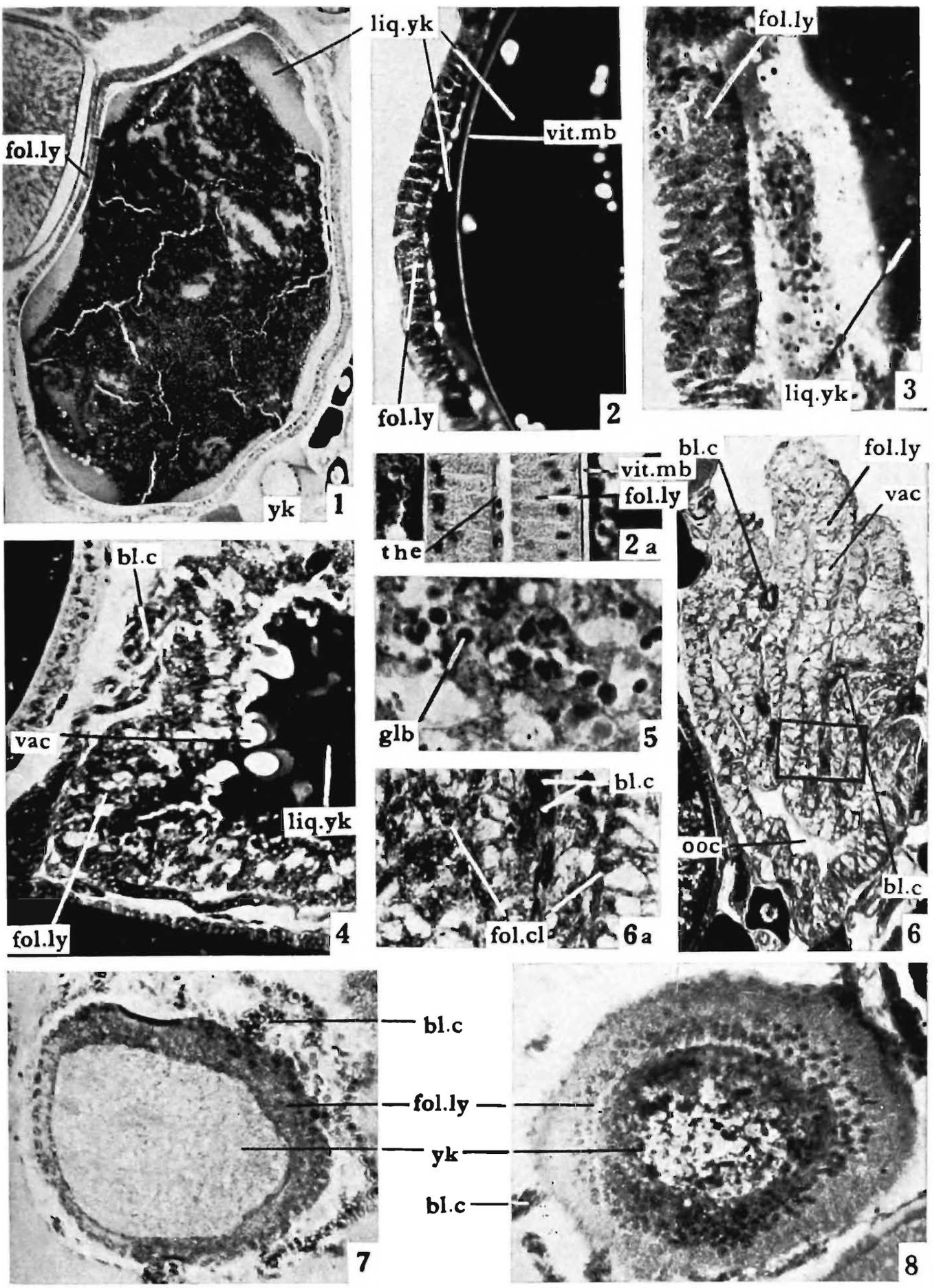
FIG. 6. Photograph of an atretic oocyte in which the ovular contents are completely resorbed. The folded follicular layer containing blood cells in between the folds and restricted oocoel may be noted. × 116

FIG. 6*a*. Photograph, showing a part of figure 6 enlarged (Note inset in figure 6). × 256

FIG. 7. Photograph, showing the hypertrophying follicular syncytium in an atretic oocyte. The marked vascularisation around the theca may be seen. × 208

FIG.8. Photograph, showing the invading follicular syncytium which is devoid of vacuoles. × 208

bl. c., blood cell ; *cl. prl.*, cell pearl-like body ; *cnt. ts.*, connective tissue ; *fol. ly.*, follicular layer ; *glb.*, globule ; *liq. yk.*, liquefied yolk ; *pig. cl.*, pigment cell ; *vac.*, vacuole ; *vit. mb.*, vitelline membrane ; *yk.*, yolk granule ; *the.*, theca.



Atretic oocyte : *Mystus seenghala* (Sykes).

PLATE 2

Mystus seenghala (Sykes)

FIG. 1. Photograph, showing further penetration of the nonvacuolated follicular syncytium into the ovular contents. × *ca.* 288

FIG. 2. Photograph, showing the cells of the atretic oocyte moving along strands of ovarian connective tissue. × *ca.* 304

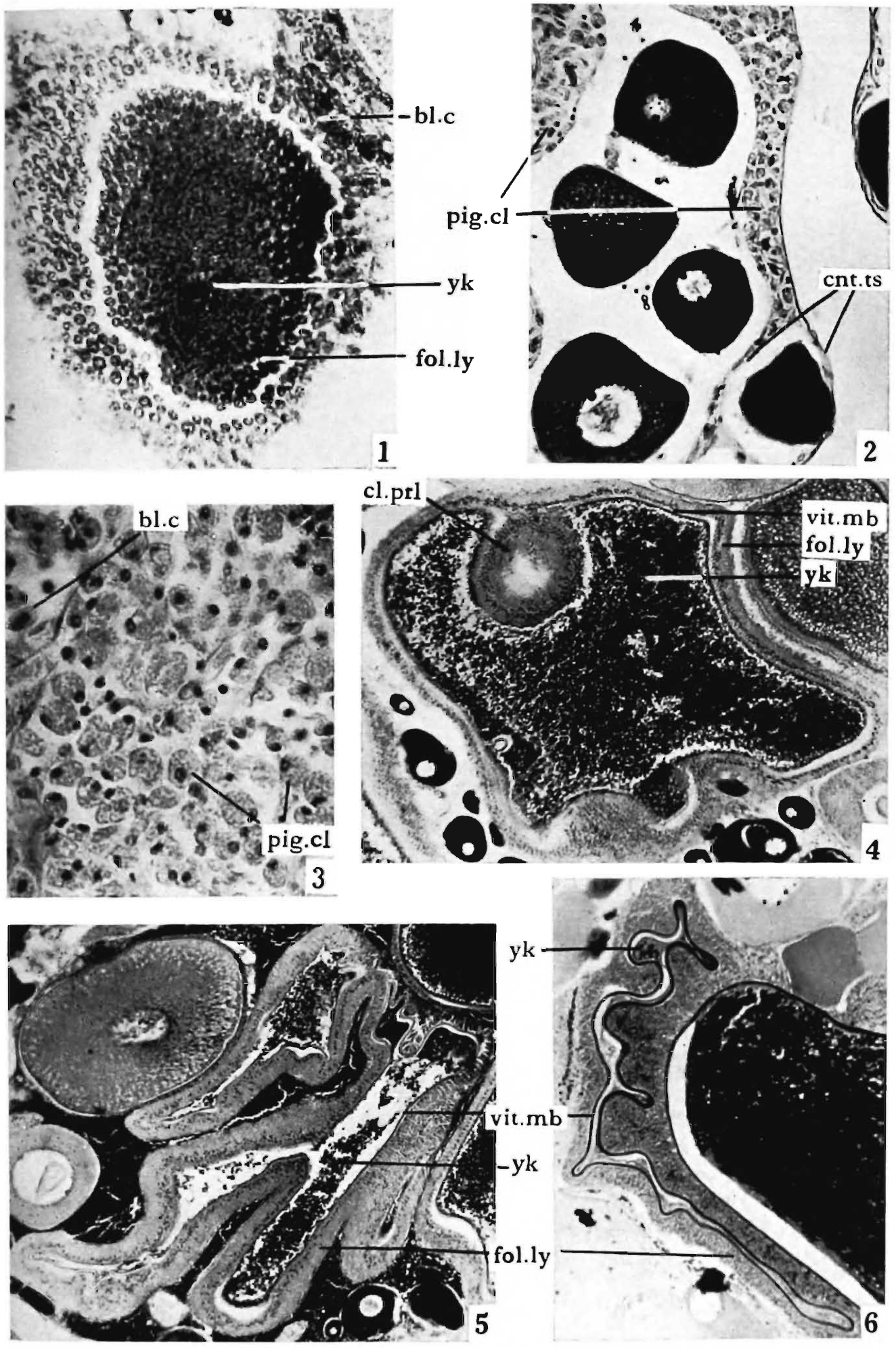
FIG. 3. Photograph, showing the yellow pigment cells. × *ca.* 432

FIG. 4. Photograph of an atretic oocyte, showing irregular proliferation of follicular cells resulting in the formation of " cell pearl-like " bodies. Towards the lower margin two irregular group of proliferated follicular cells can be made out. × *ca.* 80

FIG. 5. Photograph of an atretic oocyte, showing very little hypertrophy of the follicular layer and the presence of vitelline membrane. × *co.* 80

FIG. 6. Photograph, showing a similar atretic oocyte in which the ovular contents are resorbed. The vitelline membrane may be seen almost intact. × *ca.* 144

bl. c., blood cell ; *cl. prl.*, cell pearl-like body ; *cnt. ts.*, connective tissue ; *fol. ly.*, follicular layer ; *glb.*, globule ; *liq. yk.*, liquefied yolk ; *pig. cl.*, pigment cell ; *vac.*, vacuole *vit. mb.*, vitelline membrane ; *yk.*, yolk granule ; *the.*, theca.



Atretic oocyte : *Mystus seenghala* (Sykes).

MORPHOLOGY OF THE URINO-GENITAL SYSTEM IN SOME INDIAN TELEOSTEAN FISHES*

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(with 21 Text-figures)

CONTENTS

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I—Introduction

(a) *General*

The urino-genital organs of fishes in general and of certain species in particular have received the attention of zoologists from early times. Yet a comprehensive study of this system has seldom been attempted with the result that we have still to fall back upon the descriptions of this system as given for *Acipenser*, *Lepidosteus*, *Protopterus*, *Lepidosiren*, *Salmon* and *Clupea* for basic information and guidance. Standard treatises written by Balfour (1882), Parker and Haswell (1935), Sedgwick (1905), Goodrich (1930), and Kingsley (1926) do not give exhaustive information on the urino-gential system of the common fishes. The position has been well summed up by Pfeiffer (1933) who says that "All modern text-books follow either Balfour, Parker or Goodrich. The work of Goodrich shows that our knowledge of the urino-genital systems in these forms is very vague and incomplete".

The above mentioned works deal more with some of the rarer forms like *Lepidosteus, Acipenser* or *Polypterus* than with the common species of fishes. A knowledge of the structure and disposition of the urino-genital system in the above mentioned genera of fishes is undoubtedly helpful, but being restricted in their zoo-geographical distribution and obtainable with difficulty remain only of theoretical importance. Being confined in distribution to South America, South Africa, and Australia, these fishes are not ordinarily available to the students of zoology for dissection or detailed study. Much of the work on the urino-genital system of fishes is based on *Salmo*, an European form, not available in tropical Asia. These sources of information are, therefore, of little help in the study of the urino-genital system of the common Indian species. The need of an accurate description of the urino-genital system of the common Indian fishes has been felt in the Indian zoological laboratories for more than a quarter of a century.

Bridge (1932) states "Quot homines tot sententiae" regarding the morphology of the teleostean gonads. This statement holds good even to-day. Therefore, an attempt has been made by the present author to study the urino-genital organs of some of the common Indian teleostean fishes so as to further the bounds of knowledge in this field and to make reliable information available to teachers and students alike.

(b) *Historical Résumé*

As already mentioned, the literature bearing on this subject is scanty. The early workers had mostly concerned themselves with the development of the urino-genital organs. The earliest work in this field can be attributed to Rathake (1805) and Scott (1805) who traced the development of the renal organs in the *Ammocoetes* larva. Müller (1884) and Hyrtl (1855) described, perhaps for the first time, the anatomy of the excretory organs and the gono-ducts of the female of *Lepidosteus*. Hyrtl declared that the products from the testes passed through a duct (vas deferens) homologous to the oviduct of the female and entered the wolffian duct. Later, Balfour and Parker (1882) re-investigated this and proved that these ducts within the mesorchium were vasa efferentia and that the seminal fluid passed through the kidneys and the urinary

ducts to the exterior. Since then no substantial advance has been made in this direction.

It may be pointed out that the above work dealt with *Lepidosteus* only, and, as such, the description cannot hold good for the common teleostean fishes without some modification. The premier attempt to study the morphology of the teleostean urino-genital system was probably made by Sedgwick (1905) whose general account of the urino-genital organs of the Teleostei, however, was based on the work of Balfour and Parker (1882). Goodrich (1931) attempted to bring together, under one jacket, the existing knowledge of the urino-genital systems of the Dipnoi and the Teleostomi, and by schematising the diagrams attempted to bring out the points of resemblance and of difference between the various genera. Subsequent treatises or text-books on fishes have freely drawn upon the works of Balfour and Parker (1882) or Goodrich (1931). Bridge (1932) attempted to give a comparative account of the development and disposition of the urino-genital system in Cyclostomes, Elasmobranchs and other Teleostei in a generalised manner, so as to emphasize the basic points of difference and of resemblance between them in the well-known Cambridge Natural History volume on fishes.

Later workers, like Pfeiffer (1933) and Owen (1938), have worked only on *Lepidosteus* and *Cyclothone* respectively. Subsequent workers, during the last ten years or more, have been paying increasing attention to the development, breeding habits, stomach contents, sexual dimorphism and environmental ecology than to the anatomy of the common species of fishes.

(c) *Acknowledgment*

The author is grateful to Dr. A. B. Misra, Professor of Zoology, under whose guidance this work was done, for constant help, valuable guidance and constructive criticisms throughout the course of this work, without which it would not have been successfully completed.

II—MATERIAL AND METHODS

Great difficulty was experienced in obtaining fresh material for purposes of dissection and study throughout the year. Large-sized fishes like *Catla catla* (Hamilton), *Mastacembelus armatus* (Lacep.). *Labeo rohita* (Hamilton), *Ophiocephalus marulius* (Hamilton) could be had only at the fishing centres far away from the University campus. Except *Hilsa ilisha* (Hamilton) which could be had from the river Ganges, the remaining fishes were obtained from ponds or tanks situated several miles away from the University. The fishes available in the local market were found to be unsuitable for the purpose of this study as they were often in a semi-decomposed condition having been trapped at night or in the small hours of the morning and then dumped into the market. Freshly caught fishes were quickly brought to the laboratory or dissected

on the spot, sketched and preserved in 5 per cent formalin. Data bearing on the size of the gonads and the gonoducts were collected and recorded throughout the year.

Name	Famil
1. *Hilsa ilisha* (Hamilton)	Clupeidae.
2. *Catla catla* (Hamilton)	Cyprinidae.
3. *Rasbora rasbora* (Hamilton)	Cyprinidae.
4. *Cirrhina mrigala* (Hamilton)	Cyprinidae.
5. *Labeo rohita* (Hamilton)	Cyprinidae.
6. *Wallago attu* (Bloch and Schneider)	Siluridae.
7. *Mystus aor* (Hamilton)	Bagridae.
8. *Eutropiichthys vacha* (Hamilton)	Schilbeidae.
9. *Heteropneustes fossilis* (Bloch)	Saccobranchidae.
10. *Clarias batrachus* (Linn.)	Clariidae.
11. *Ophiocephalus gachua* (Hamilton)	Ophiocephalidae.
12. *Ophiocephalus marulius* (Hamilton)	Ophiocephalidae.
13. *Ophiocephalus punctatus* (Bloch)	Ophiocephalidae.
14. *Notopterus notopterus* (Pallas)	Notopteridae.
15. *Notopterus chitala* (Hamilton)	Notopteridae.
16. *Mastacembelus armatus* (Lacepede)	Mastacembelidae.

III—Description of the Urino-genital System

1. **Hilsa ilisha** (Hamilton)

(Text-fig. 1 *a*, *b*)

The kidneys, which are, in fact, double, look single on account of fusion along their inner margins. They are deep red in colour and extend from the cardiac region to the posterior end of the body cavity. Their outer margins are uneven, the anterior end being turned up. The upturned portion of the kidney lies anterior to the pericardium and corresponds to the head-kidney of other species.

The ureters arise from the last quarter of the length of the kidneys. In some cases, one of them is absent. When both are present, they unite posteriorly into a single wide ureter not assuming the form of a urinary bladder as in many other Teleosts. It narrows down posteriorly as it approaches the cloaca to open behind the genital pore (Text-fig. 1*a*,*b*, and 18*a*)

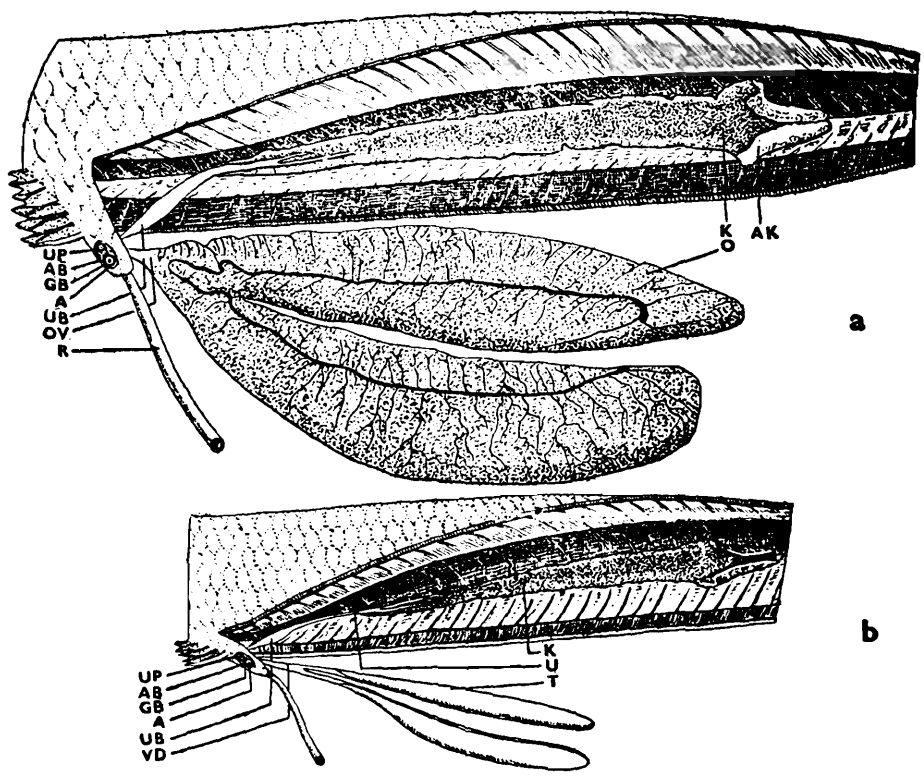
The gonads, which are paired, lie on the sides of the air bladder and do not become so much reduced in size in the "off-season" as in other species. The mesovariun and the mesorchium are highly pigmented during the "off-season", being black in immature specimens, red on approaching maturity and light pink in the ripe males or females. When the greater part of the colouration disappears from the mesovarium or mesorchium, it still persists in the oviduct or the vas deferens.

The ovaries are saccular and smooth-walled structures in immature pecimens which are found from September to January. Mature specimens are available from March to August when the ovaries are bright yellow in colour with an abundance of blood vessels distributed over the surface (Text-fig. 1*a*).

Before the end of August, the eggs are discharged and the ovaries become very much depleted of their contents and lose their yellow colour.

The testes are elongated, tubular, opaque structures creamy white in colour in the mature specimens. Mature males are available from March to August. (Text-fig. 1*b*).

The two vasa deferentia emerge from the anterior tip of the testes, run along their inner borders, and, on leaving them, career for a short distance to unite into a thick duct which opens into the cloaca behind the anus.



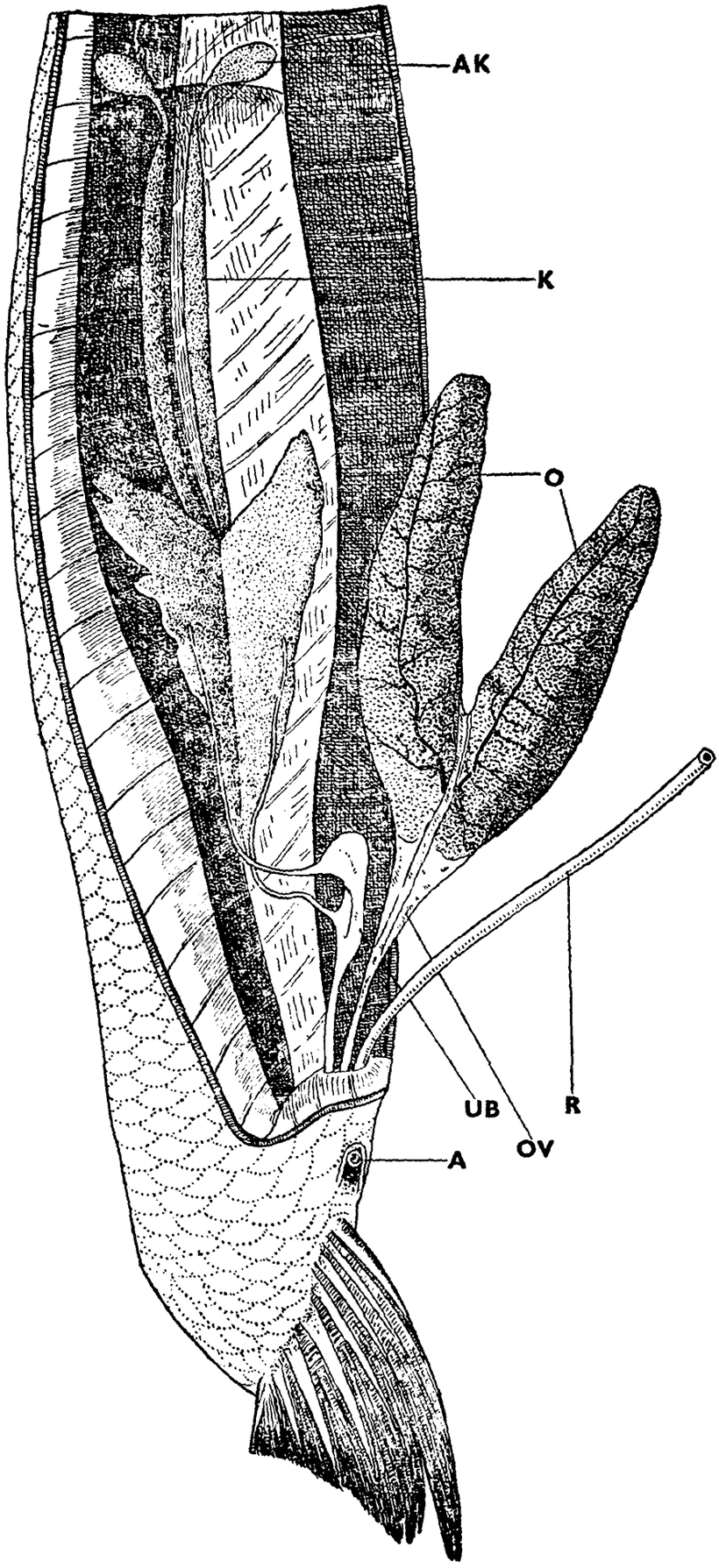
TEXT-FIG. 1.—*Hilsa ilisha* (Hamilton). (*a*). Female. (*b*). Male×½ Natural size).

The cloaca is similar in structure in the two sexes of *Hilsa ilisha* (Text-fig. 18*a*). It is not very deep but oval in outline and placed far behind the pectoral fins. The anus opens into its anterior sector, while the single median genital pore and the urinary orifice are placed one behind the other in succession and occupy the other sector of the cloaca. At the inner sides of the cloaca lie the abdominal pores (Text-fig. 1*a*,*b*).

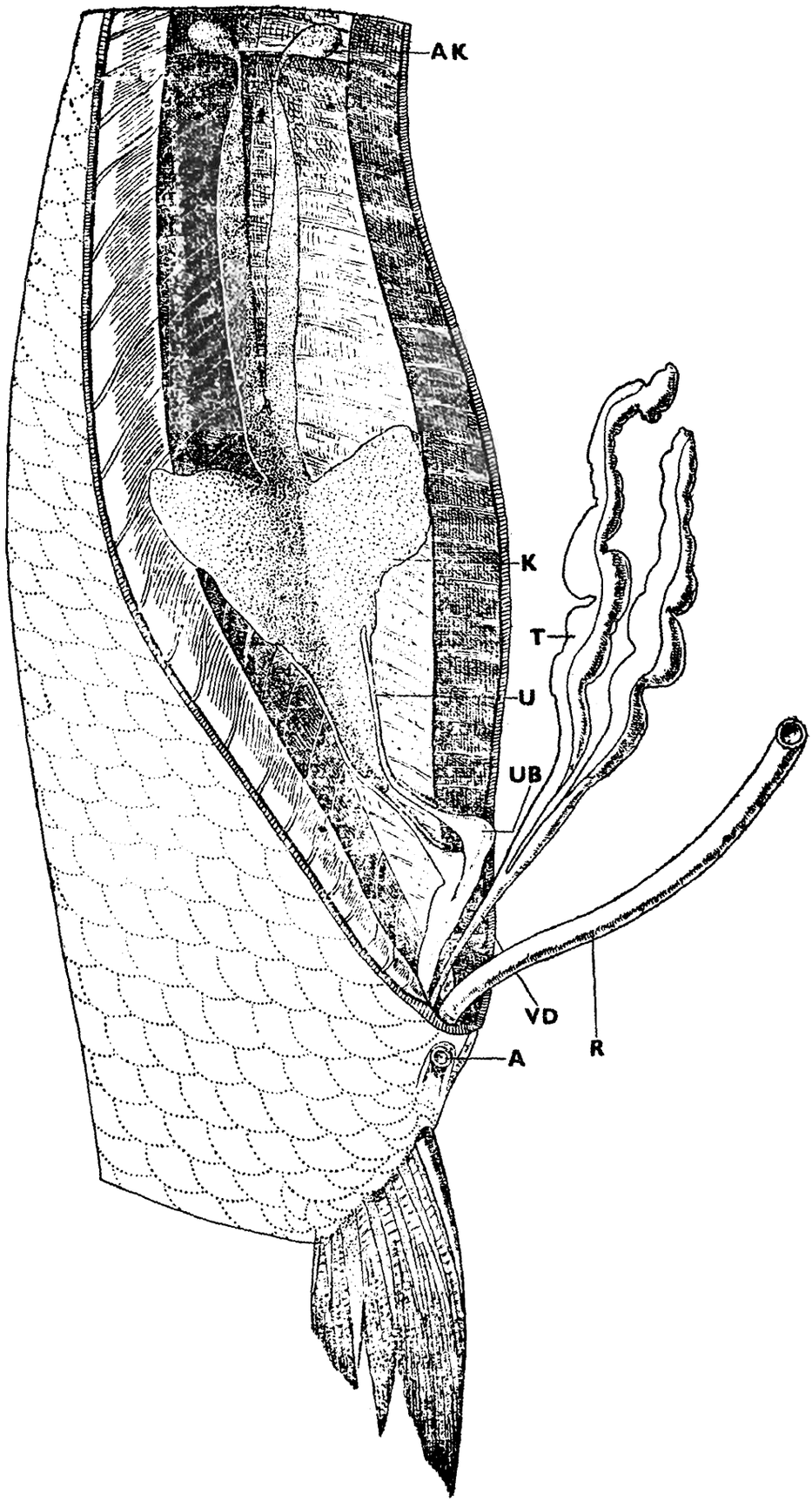
2. **Catla catla** (Hamilton)

(Text-figs 2 and 3)

The abdominal kidneys are tubular in outline in the anterior half of their length and are free from fusion or adhesion. The head-kidneys are attached to the anteriar ends of the kidneys by means of a narrow



TEXT-FIG. 2.—*Catla catla* (Hamilton). Female. (×5/6 Natural size).



TEXT-FIG. 3.—*Catla catla* (Hamilton). Male. (× 3/4 Natural size).

'neck and lie in front of the pericardium. At the middle of their length, they fan out into two lobes. From the point where the fanning occurs, the two kidneys are fused along their inner border. At the posterior extremity, the kidneys taper off. The fused portion of the kidneys is thick and massive thereby producing a difference in the level of the two halves (Text-figs. 2 and 3).

The point of origin of the ureters varies greatly in different individuals, but they are distinctly paired. Each of them dilates into a thin walled urinary bladder. The two urinary bladders unite and narrow off posteriorly to form a common duct which opens into the cloaca (Text-fig. 18*b*).

The sexes are separate but indistinguishable in the immature condition even on dissection, because the male and the female gonads are almost thread-like and thin. During the breeding season, it is easy to distinguish them because the ovaries become sac-like but the testes are like thick cords (Text-figs. 2 and 3).

During the non-breeding season, which extends from October to March, the ovaries are filamentary in form measuring about 5.8 cms. in length with a negligible width, even in specimens measuring $1\frac{1}{2}$ to 2 ft. in length. By the end of February or the beginning of March, enlargement of the gonads commences attaining full size by the end of March. At this time, the ovaries become massive organs in the body-cavity and measure about 40.2 cms. in length and 15.6 cms. in width. Fully mature ovaries are greyish in colour, and thin-walled smooth sacs abundantly covered with blood vessels. From their posterior ends, the oviducts arise as thin-walled tubes opening into the cloaca (Text-fig. 2).

The testes are also inconspicuous and thread-like, in form (measuring about 1.3 cms. in length with a negligible width) in the "off-season". By about the middle of March, they become enlarged and grow in thickness as well as in length. Further elongation occurs in the third week of April as a result of which it attains a length of 15.2 cms. and a width of 4.9 cms.

The cloaca, which is very deep and oval in outline is placed far behind the pelvic fins. The anus which is on a level with the ectal surface of the body occupies a great deal of it somewhat obscuring the genital and the urinary orifices placed behind it. The single median genital pore is placed immediately below the anus. The urinary pore is placed just behind the genital orifice (Text-fig. 18*b*).

3. **Rasbora rasbora** (Hamilton)

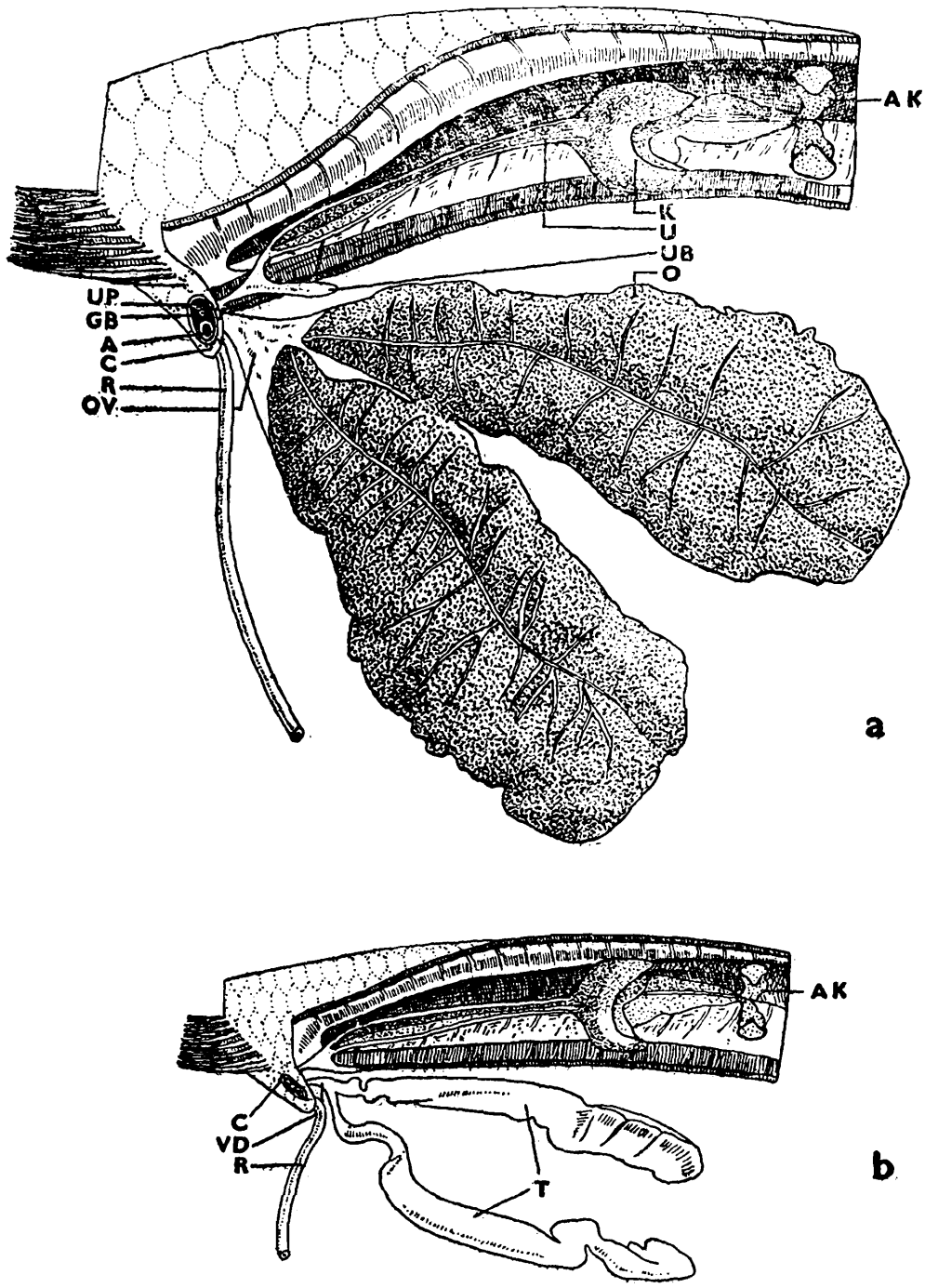
(Text-fig. 4*a*, *b*)

The kidneys resemble closely those of *Cirrhina mrigala* (Hamilton). Lateral expansions of part of the kidney, and difference between the levels of the anterior and the posterior halves of the kidney are the characters common to *Rasbora rasbora* and *Cirrhina mrigala*. The head-kidney is present and lies close to the pericardium. It is bilobed and the lobes are placed transversely.

The ureters, which are distinct and paired, arise from the hind end of the expanded portion of the kidney, run parallel for part of their course

and then unite into a common ureter which soon gives off the urinary bladder as a diverticulum (Text-fig. 4*a*,*b*).

Sexes are separate and the gonads paired in this species, but in the "off-season" the gonads are detectable with difficulty because they thin out considerably.



TEXT-FIG. 4.—*Rasbora rasbora* (Hamilton). (*a.*) Female. (*b.*) Male. (× 1/2 Natural size).

The "unripe" ovaries are hardly noticeable and remain so between November and February. The breeding season extends from March to August, or even up to October. The ovaries begin to enlarge in February and become marked off from their ducts. The enlargement proceeds rapidly thereafter, and by the end of April fully mature ovaries measuring

about 14.2 cms. in length and 6.6 cms. in breadth are present. When fully ripe, they are irregular in outline, dull yellow in colour and richly vascularised (Text-fig. 4*a*).

The mesovarium is continued behind as the oviducts which are confluent and transparent near the ovaries but narrow down posteriorly to open by means of a single median aperture into the cloaca (Text-fig. 4*a*).

The testes are also paired but not easily discernible during the non-breeding season which lasts from October to February. Towards the end of February, enlargement of them begins and they tend to become prominent. By March the testes and their ducts become distintcly defined and begin to enlarge rapidly thereafter, attaining 14.9 cms. in length and 1.9 cms. in width. The two testes are separate for the greater part of their length, giving off posteriorly the vasa deferentia which unite to form the common ejaculatory duct. The latter is a very short, thick-walled and straight tube running close to the ureter and opening into the cloaca (Text-fig. 4*b*).

The cloaca, which is a longitudinal slit, is not very deep as in the case of *Catla catla*, the anal opening being more prominent than tthe other openings. Below and behind the anus and at the middle of he cloaca lies the single median genital pore after which comes the single urinary pore.

4. **Cirrhina mrigala** (Hamilton)

(Text-fig. 5*a*, *b*)

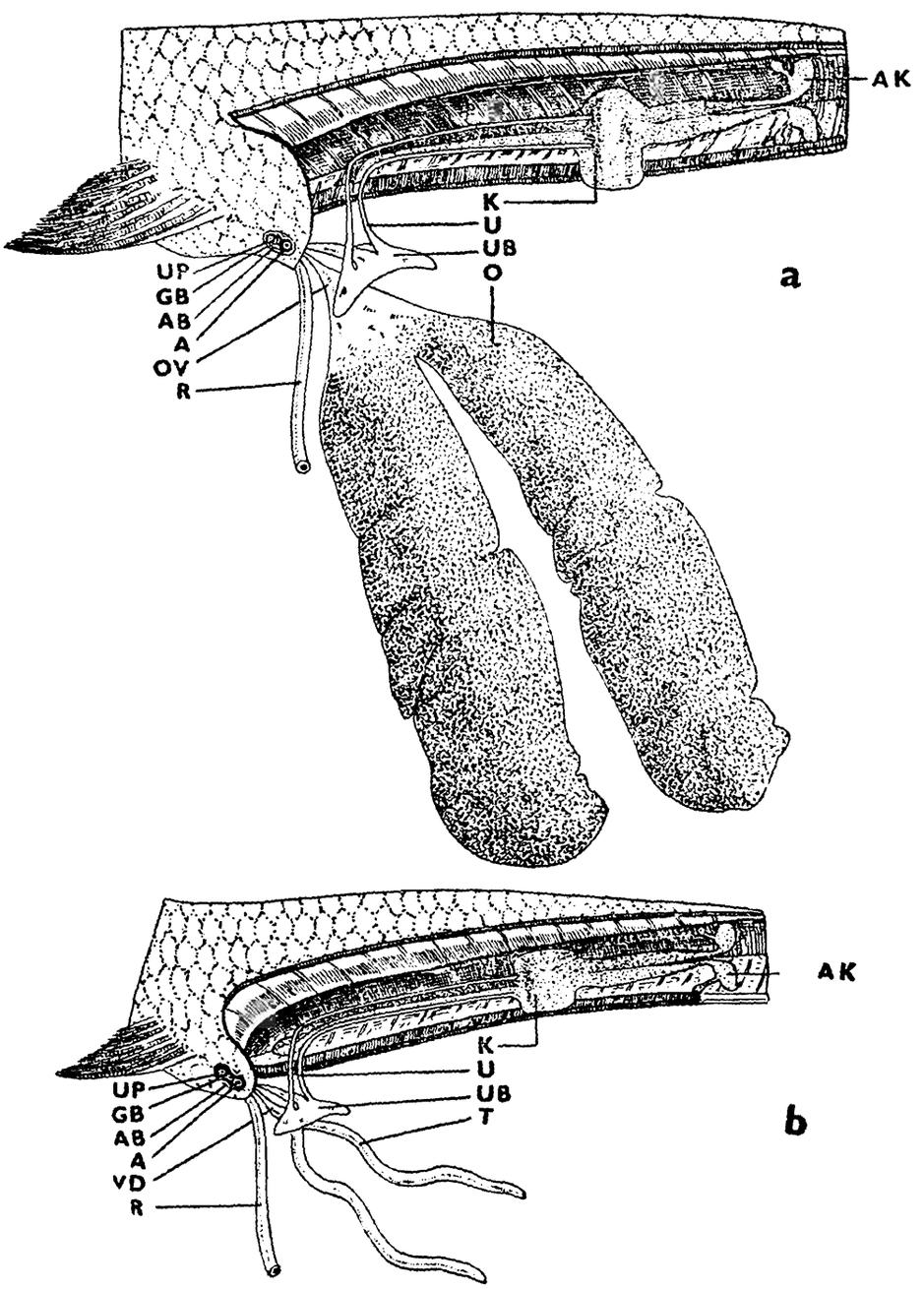
The kidneys, which are partly free and partly fused, have a somewhat peculiar shape on account of the thickening and enlargement of the middle portion in the transverse axis. The anterior end is double which shows that the two kidneys have become fused from the middle of their length. Behind this thickening, the kidneys narrow off and become defined again, being separated by a blood-vessel in the mid-line. To the free ends of the kidneys are attached the head-kidneys which, however, lie in front of the pericardium.

The ureters arise from behind the expanded portion and run somewhat parallel to where they expand into the urinary bladders. The latter are thin-walled sacs which unite posteriorly to form a duct that opens into the cloaca (Text-fig. 5*a*, *b*).

Between the months of September and March, which is the non-breeding season, the ovaries become filamentous, and, unless their position in the mature specimen is known, it is rather difficult to locate and identify them. They have a length of about 5.6 cms. and practically no width in the "off-season" By the third week of April, they begin to enlarge. Becuase of the limited space available in the body-cavity, the hypertrophied ovaries require considerable space for their lodgement, and, for want of it, become folded here and there. The ovaries are demarcated from the oviducts by their colour, opacity, uneven surface and the prominences due to the ova inside them. The thin, short and transparent oviduct opens into the cloaca by means of a single median pore (Text-fig. 5*a*).

A fully grown ovary measures 11.6 cms. in length and 4.2 cms. in breadth. Regression sets in after July, and, by the end of August, the ovaries become depleted of their contents and shrink in size.

The paired testes become reduced during the non-breeding season into short, thread-like structures measuring about 5.5 cms. in length.



TEXT-FIG. 5.—*Cirrhina mrigala* (Hamilton). (*a*). Female. (*b*). Male. × 1/2 Natural size).

Towards the end of April, they become convoluted by reason of having grown in length to 8.8 cms. and in width to 2.3 cms.

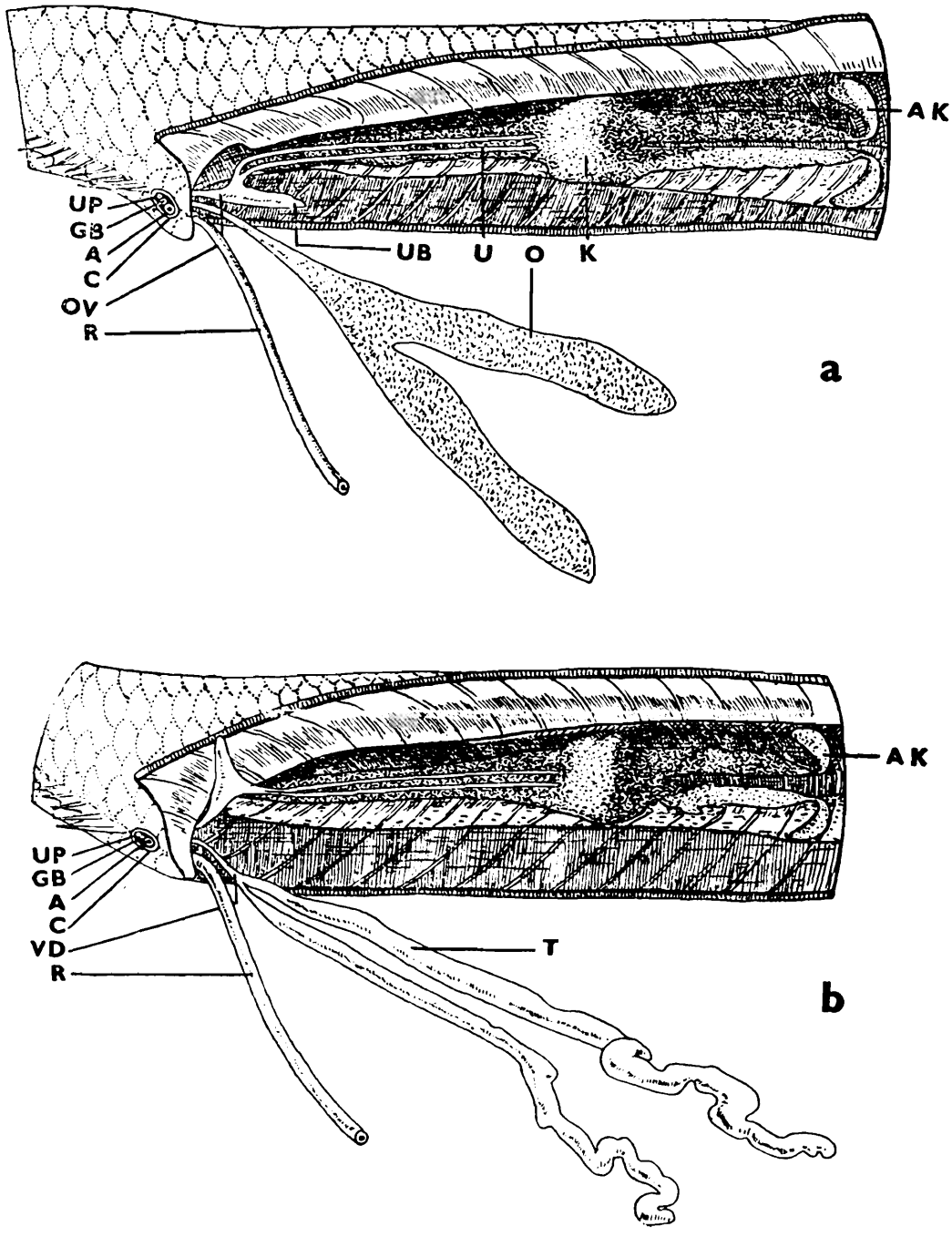
The testes lead into the vasa deferentia which unite to form the ejaculatory duct opening by a single median orifice into the cloaca (Text-fig. 5*b*).

The cloaca is oval in outline and not very deep. The anus, and the genital and the urinary pores open into it in the usual order. Abdominal pores are present on the lateral walls of the cloaca (Text-fig. 5*b*).

5. **Labeo rohita** (Hamilton)

(Text.Fig. 6*a*, *b*)

The head-kidneys of *L. rohita* resemble those of *R. rasbora* and *Cirrhina mrigala* in respect of disposition. The kidneys are separate and



TEXT-FIG. 6.—*Labeo Rohita* (Hamilton). (*a*). Female. (*b*). Male. × 1/2 Natural size).

free in the anterior one-third of their length, but fused in the latter two-thirds of their course. About the middle of their length, they are thickened and flattened out transversely (Text-fig. 6*a* ,*b*).

The ureters are distinct and arise just behind the thickening referred to above. They run almost parallel below the kidneys for a short dis-

tance, then converge behind them to form the urinary bladder which empties itself into the cloaca by means of a short duct.

In immature specimens, the testes and the ovaries are indistinguishable because both of them are filamentary in appearance, but, on attaining maturity, the gonads become properly differentiated in shape, size, and colour (Text-fig. 6*a*, *b*).

The ovaries commence to enlarge late in January and grow very rapidly becoming mature by the middle of February. In the ripe condition they measure about 16.3 cms. in length and 3.8 cms. in width, are yellow in colour and vascularised on the surface.

The two ovaries unite posteriorly and pass off into a thin walled duct which opens by a single median aperture into the cloaca.

Young testes are thread-like in form and begin to enlarge and thicken in February and fully ripe males are available in April. A fully grown testes measures 15.5 cms. in length and 1.2 cms. in breadth.

Posteriorly the two testes give off vasa deferentia, which unite to open by a single pore into the cloaca (Text-fig. 18*c*).

The cloaca is oval in outline and deep. The anus opens into its anterior section,while the posterior portions occupied by the genital and the urinary pores (Text-fig. 18*c*).

6. **Wallago attu** (Bloch & Schneider)

(Text-fig. 7*a*, *b*)

The abdominal kidney, which is broadly triangular and thick, is dark-red in colour. Its apex is bilobed, while the main body is compact and fused. Unlike other cases where the kidneys lie below the air-bladder, in this species they are placed behind it, the air-bladder being lodged in the fork of the kidney. The head-kidney lies in front of the pericardium and is practically severed off from the kidney proper, excepting for a blood vessel that links the two. The blood vessel of the left side is however separate, being very thin and embedded in lymphoidal tissue. In some cases, the lymphoidal tissue is so developed as to obliterate the blood vessel. The blood vessel of the right side, however, is prominent and extends between the head-kidney and the kidney. Remnants of the penal tissue are found adhering to this blood vessel.

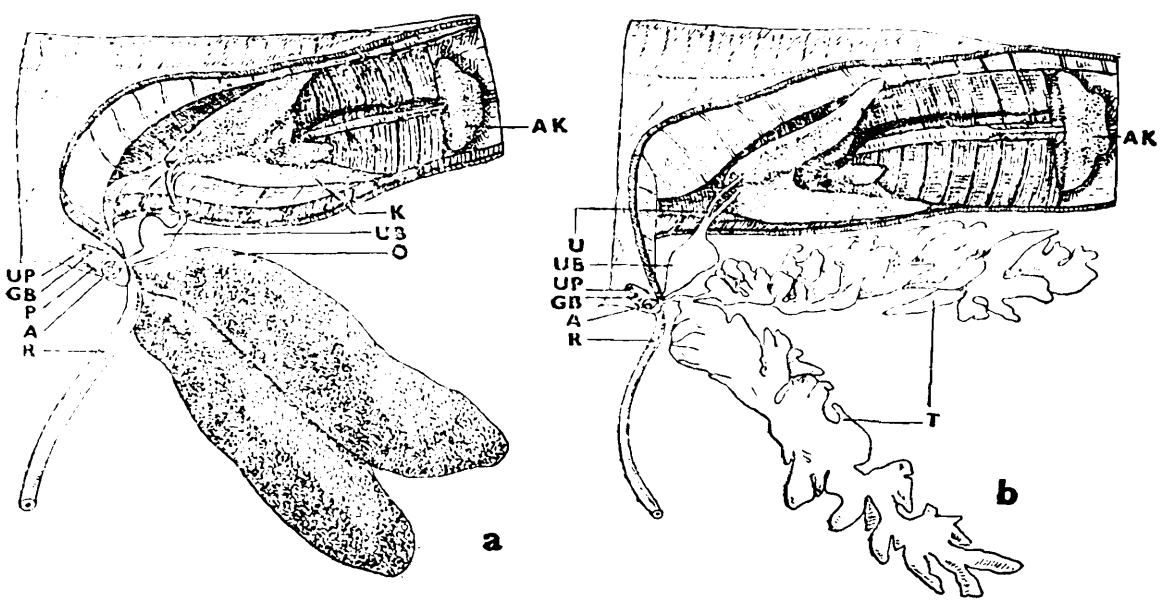
The head-kidney is massive in form and triangular in shape. Because of the thick short and compact nature of the kindeys the ureters are also shorter in length and arise from the fused posterior portion. After traversing a short distance, they unite and dilate to form the urinary bladder. The bladder tapers off posteriorly into a narrow duct (Text-figs. 7*a*, *b*; 19*a*) which opens on a very prominent urino-gential papilla.

The gonads are paired organs which adhere closely together and are separable with difficulty. The ovaries are sac-like structures having a pimpled surface, but the testes are lobulated and feathery in external form. Moreover, the immature ovaries are moss-green in colour, while

the testes look creamy white. When the gonads recress in the non-breeding season, they still retain their distinctive external appearance and can easily be made out.

The ovaries are paired, sac-like organs which are adherent for the greater part of their course, except for a short length anteriorly. In the early stages, they are dirty green in colour becoming light yellow in the regressive phase and vascularised in the breeding season. An immature ovary in January or February measures 3.6 cms. in length and 11.8 cms. in length and 3.5 cms. in width in July.

Posteriorly, the united ovaries form a single short oviduct which opens on the papilla by means of a separate opening in front of urinary orifice (Text-figs. 7*a*; 19*a*).



TEXT-FIG. 7.—*Wallago attu* (Bloch & Schneider). (*a*). Female. (*b*). Male. (*a* and *b* × 2/5 Natural size).

The testes do not suffer much change in length during the non-breeding season, but their finger-shaped out-growths decresae in size. A fully mature testes measures about 6.2 cms. in length and 2.3 cms. in width.

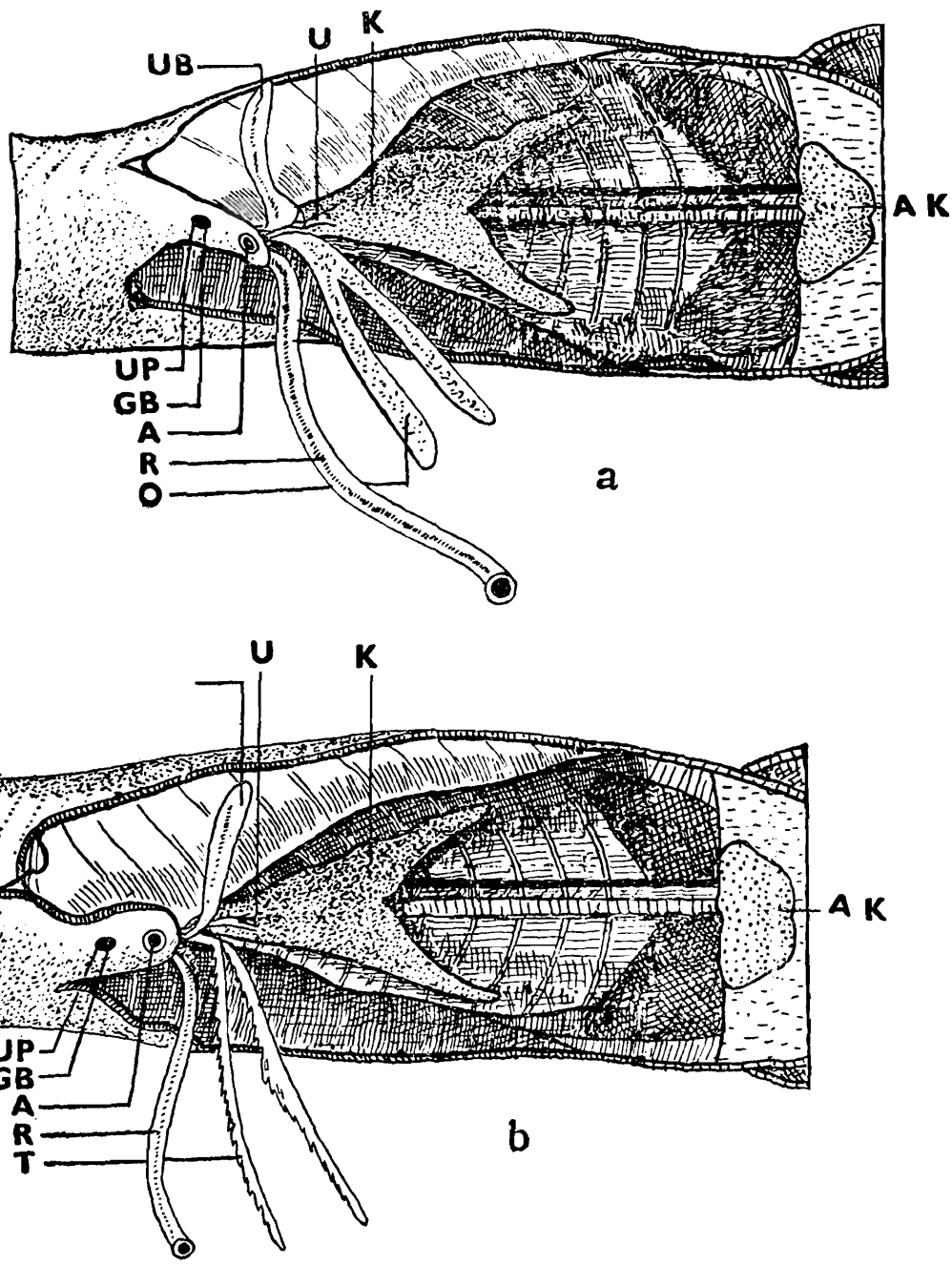
Posteriorly the two testes give off vasa deferentia which unite to open on the urino-genital papilla by means of a single pore placed in front of the urinary aperture (Text-figs. 7*b*; 19*a*).

There is no cloaca in this species and abdominal pores are wanting. The anus is aflush with the ectal surface. Behind the anus lies a very prominent urino-genital papilla which is similar in both sexes, being fleshy and blunt. On its summit are found the urinary and the genital apertures placed separately, the genital one being in front of the urinary. In mature specimens, it becomes reddish in colour, and in the males the urinary opening has a small protruberance on the papilla (Text-fig. 7*a*, *b*). The presence of such a big papilla in the male suggests that it acts as an intromittant organ, and in the female as an ovipositor.

7. **Mystus aor** (Hamilton)

(Text-fig. 8*a*, *b*)

The head-kidneys and the rest of the kidneys are connected in the same way as in *wallago attu*, that is, by means of a blood vessel. The kidney which is light red in colour looks single but its double nature is testified by the two anterior cornua-like prolongations of it. Between the cornual arms of the kidney lies the air-bladder. The ureters at their



TEXT-FIG. 8.—*Mystus aor* (Hamilton). (*a*). Female. (*b*). Male. × 2/3 Natural size).

origin are embedded in the mass of the kidney and the free portion is, therefore, short and single. Soon after emerging from the kidneys, it dilates into the urinary bladder, which is comparatively long, tubular and less muscular than that in *Wallago attu*. Posteriorly, the bladder opens in the immature specimens into a urino-genital sinus, and in the mature ones on a papilla (Text-figs 8*a*, *b*; and 21*a*).

The gonads are tubular sac-like structures which are united posteriorly for a short distance. Although they regress considerably and become thread-like during the non-breeding season, the gonads are still distinguishable from each other, the testes by their frilled ventral edge and the ovaries by their smooth outline.

The ovaries lie under the kidneys, but during the breeding season, they extend even below the air-bladder. During the non-breeding season, they look like elongated sacs measuring about 4.1 cms. in length and 0.2 cms. in breadth. The ovaries begin to enlarge from March onwards and grow somewhat slowly till July when they are full of eggs. The ovary does not become bright yellow in colour as in the case of *Wallago attu*, but remains creamy white and opaque. A fully enlarged right ovary in the breeding season measures about 12.8 cms. in length and 2.3 cms. in breadth. Towards the end of September, the ovaries become depleted of their contents and by December they are highly reduced.

A very peculiar change occurs during the breeding season. The urino-genital sinus which was aflush with the ectal surface now forms a protruberance in the form of a highly muscular papilla (Text-fig. 21*a*) on which the urinary and the genital pores are separately placed.

The testes are filamentous with one of their edges frilled. In the non-breeding season they become thin like a piece of sewing cord. This gives us an important means of distinguishing the males from the females during the non-breeding season. The enlargement of the testes begins by the end of April or at the beginning of May and proceeds rapidly thereafter. By July they become fully enlarged. The testes in the "off-season"measute about 5.2 cm. in length (and the right one about 3.6 cms.) but have a negligible breadth, whereas the fully hypertrophied ones measure 11.6 cms. in length and 2.1 cms. in breadth.

The vas deferens is short and thin, and opens by means of a single poe in front of the urinary aperture (Text-fig. 8*b*).

There is no cloaca and the abdominal pores are also wanting. The anus, which is aflush with the general surface, is placed in front of the urino-genital openings In the non-breeding season, there is a urino-genital sinus lying aflush with the general surface of the body, but, during the breeding season, the sinus becomes transformed into a finger-shaped vascularised papilla (Text-figs. 8*a*, *b* ; and 21 *a*).

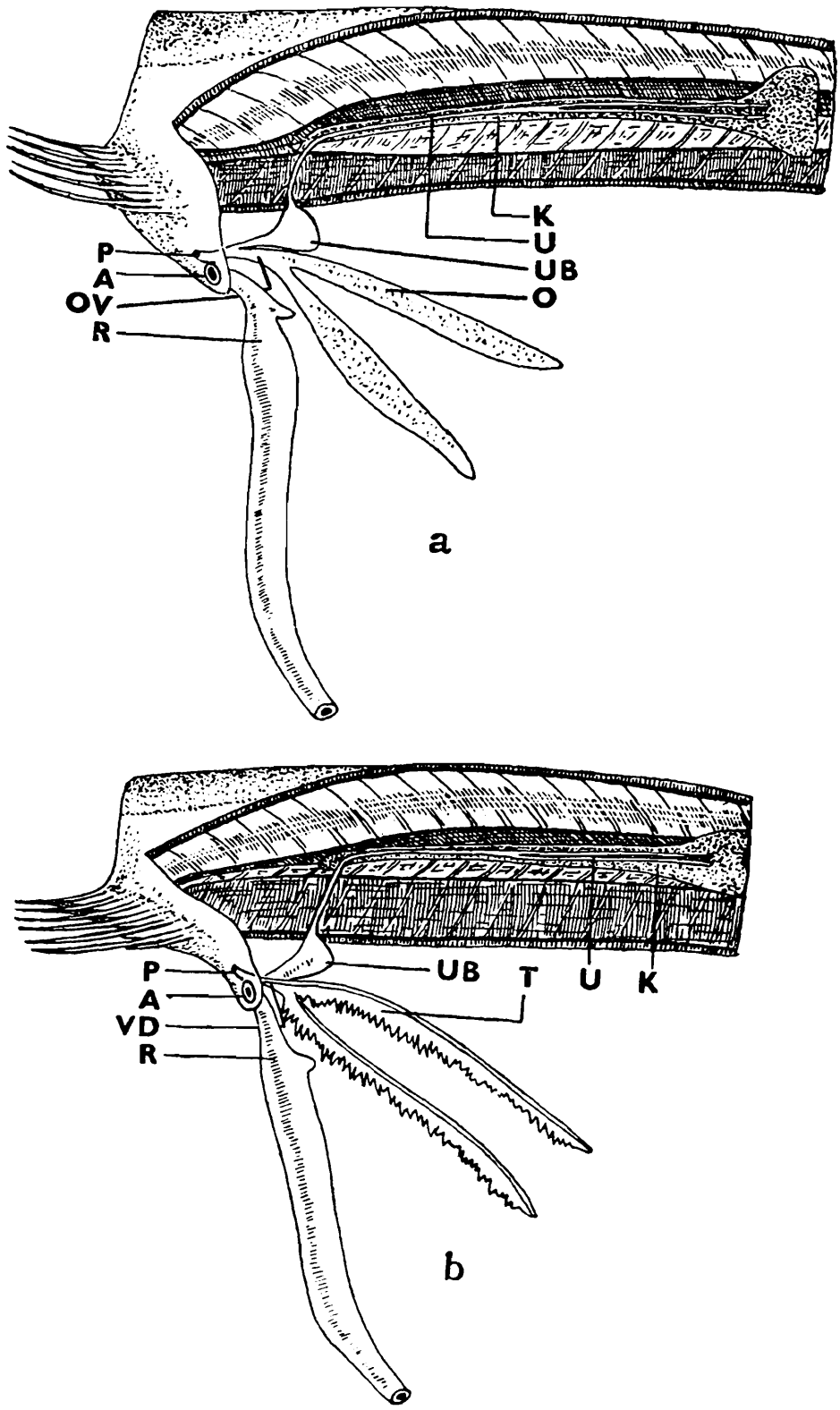
8. **Eutropiichthys vacha** (Ham.-Buch.)

(Text-fig. 9 *a*, *b*)

The head kidney is absent in this species and the abdominal kidney is saddle-shaped in front, but posteriorly a sudden narrowing takes place finishing off to a point at the posterior end.

The ureters, which are paired, emerge from the mid-posterior part of the broad saddle-shaped area and run caudal parallel to each other. Half the way down their course, they unite into a single duct, which

after leaving the kidney dilates into a single urinary bladder. The latter narrows off posteriorly to open on a papilla in confluence with the genital duct (Text-figs. 9*a*, *b* ; and 19 *b*).



TEXT-FIG. 9.—*Eutropiichthys vacha* (Hamilton). (*a*). Female. (*b*). Male. (× 1/3 Natural size).

The sexes are separate and are easily distinguishable because the testes have frilled edges and are cordlike, while the ovaries are saccular and smooth in outline (Text-fig. 9*a*, *b*).

The young ovaries are white in colour, smooth in outline and placed below the air-bladder. A fully grown ovary is 20·2 cms. long and 6·8 cms. broad. In August, when the ova are shed, the ovaries become flabby. The two ovaries remain free for the greater part of their length fusing behind only to form the single oviduct which unites with the ureter to open on the summit of a papilla (Text-figs. 9 *a* ; and 19 *b*).

The testes are filamentous in form and have a frilled edge. The two testes are flattened laterally and are white in colour in the " off-season. " When they begin to grow in May they first acquire pink dots and then turn completely pink in colour. The testes mature rapidly and though they start doing so only in May, they become ripe in July measuring 15·8 cms. in length and 3·8 cms. in width.

The two lobes unite posteriorly to form the single vas deferens which opens on the summit of a papilla (Text-figs. 9*b* ; and 19 *b*).

There is no cloaca and abdominal pores are absent. The anus, which lies separately in front of the papilla, is at the level of the surface. The single urino-genital papilla is placed immediately behind the anus. It is short, and on its summit lies the single urino-genital pore (Text-fig. 19 *b*).

9. **Heteropneustes fossilis** (Bloch)

(Text- fig. 10 *a*, *b*)

The head-kidneys are placed laterally and, being in the form of triangular lobes, are attached to the antero-lateral sides of the kidney proper. The abdominal kidneys are separate for the greater part of their length anteriorly and are united for a short distance, only posteriorly. The two kidneys are in close apposition to each other, being separated by a dorsal aorta running between them.

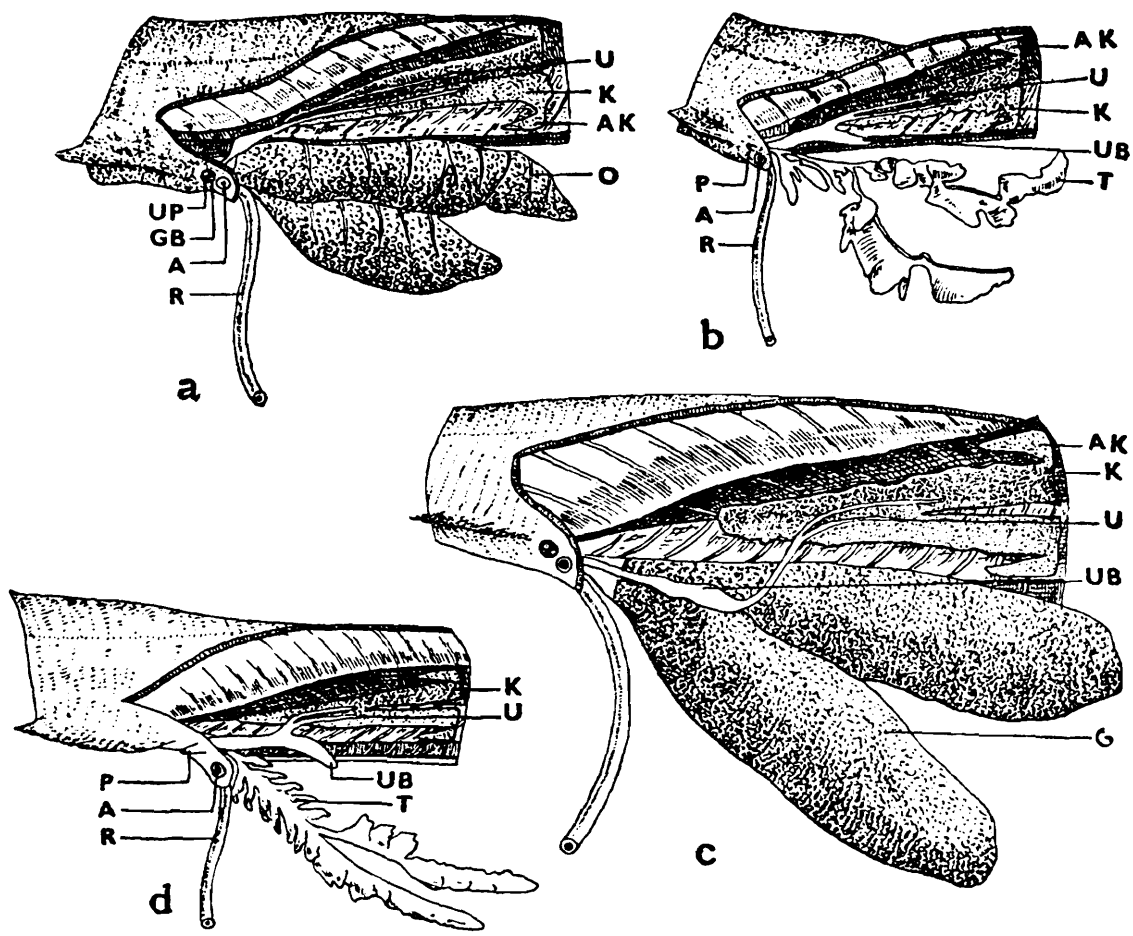
The paired ureters arise at about the same level, a little in front of the middle of the length of the kidneys and converge posteriorly to unite to form a short ureter which dilates into a thin walled urinary bladder The latter narrows down to a duct opening in the case of the male on the summit of a papilla along with the genital duct (Text-figs. 10 *b* and 19 *c*). The two ducts open very close to each other. In the case of the female, the ureter opens separately from the genital opening (Text-fig. 21 *b*). A comparison of Text-figs. 19 *c* and 21 *b* will make the point clear.

The sexes are separate and externally distinguishable by the presence of a urino-genital papilla in the male, and its absence in the female.

Immature and young ovaries are dull red in colour and saccular in shape. Between November and February (" the off-season ") the walls are wrinkled and the ovaries become flattened like a ribbon. In February, their enlargement commences and as they grow in size the red colour first changes into a greenish tint and finally into the dirty green colour persists during the breeding season from March to August. At this time, the ovaries measure about 5·5 cms. in length and 2·4 cms. in breadth. Towards the end of August, the eggs are discharged when the ovaries become flabby and begin to shrink in size.

The testes, which are paired, thin, white and thread-like structures, have a frilled edge during the non-breeding season, and lie close to the kidneys. The non-breeding season lasts from September to January. Towards the end of February, enlargement of the testes begins, frilling becomes more marked and the testes turn bright yellow in colour (Text-fig. 10 *b*).

The testes give off, posteriorly the vasa deferentia which open on the summit of a papilla along with the ureter in the male (Text-fig. 19 *c*).



TEXT-FIG. 10.—(*a* and *b*). *Heteropneustes fossilis* (Bloch). (*a*). Female. (*b*). Male. (× 1/2 Natural size).
(*c* and *d*). *Clarias batrachus* (Linn.). (*c*). Female. (*d*). Male. (× 1/2 Natura size).

In the immature condition, the vas deferens presents the normal appearance. But, in the middle of March two pairs of papillae-like outgrowths appear on them. As the testes grow in size, these diverticula also enlarge and become prominent. These are quite distinct from the testes and represent glandular appendages (Text-fig. 10 *b*).

There is no cloaca and the abdominal pores are also absent. The anus, which is placed a little behind the pelvic fins, lies in front of the urino-genital papilla. In the female, the papilla is wanting and the urinary and the genital pores separate and not confluent (Text-fig. 21 *b*).

10. **Clarias batrachus** (Linn.)

(Text-fig. 10 *c*, *d*).

In this species the head-kidneys are antero-laterally placed with respect to the kidneys proper and are small triangular structures. The

kidneys are dark red in colour, separate anteriorly, but fused posteriorly. The two kidneys are somewhat flattened at the anterior end.

The two ureters arise at about the level where the fusion of the two kidneys occurs, then proceed caudad converging to unite and, lastly, dilate into the urinary bladder. The bladder ends in a thin-walled urinary duct which proceeds posteriorwards to open on the summit of a papilla in the case of the male, and into a sinus in the case of the female (Text-figs. 10 *c*, *d* ; 20 *a* and 21 *c*).

The ovaries are paired, flattened, sac-like structures lying close to the kidneys and dull red in colour during the non-breeding season which extends from November to January. A few cases of hermaphroditism have also been noticed. Breeding season extends from February to October. Normally the two lobes of the ovaries are of equal size and are held together by a thin mesovarium. When fully ripe, they are dirty green in colour and measure about 7·9 cms. in length and 4·2 cms. in width.

The oviducts are clearly marked off from the ovaries and converge to open into an urino-genital sinus (Text-figs. 10 *c* and 21 *c*).

The testes resemble those of *Heteropneustes fossilis*, but the indentations are not so deep (Text-fig. 10 *d*). In the regressive condition, they are almost thread-like with serrated edges. By the end of March, the enlargement of the testes begins when their vascularisation becomes intensified. They measure 7·7 cms. in length and 2·5 cms. in breadth in April.

Posteriorly, the two lobes of the testes give rise to a vas deferens which courses along with the urinary duct to open on the urino-genital papilla (Text-fig. 20 *a*).

The anus is aflush with the surface of the body and opens in front of the papilla or the urino-genital sinus in the case of the female. Abdominal pores are absent.

11. **Ophiocephalus gachua** (Hamilton)

(Text-fig. 11 *a*, *b*, *c*).

The forked anterior end of the kidneys tapers off anteriorly and is connected with the head-kidneys. The kidneys, which are separate anteriorly, join each other at about the middle of their length to the posterior. The abdominal kidneys extend into the body cavity behind the cloaca (Text-figs. 11 *a*, *c* ; and 18 *d*).

The ureters, which are paired, arise from the posterior-middle region of the kidneys and proceed caudad. The two ureters take a turn to the left, become applied to the latero-ventral face of the air-bladder and finally dilate into the thin-walled urinary bladder which ordinarily lies between the two gonads in both the sexes (Text-fig. 11 *b*, *c*).

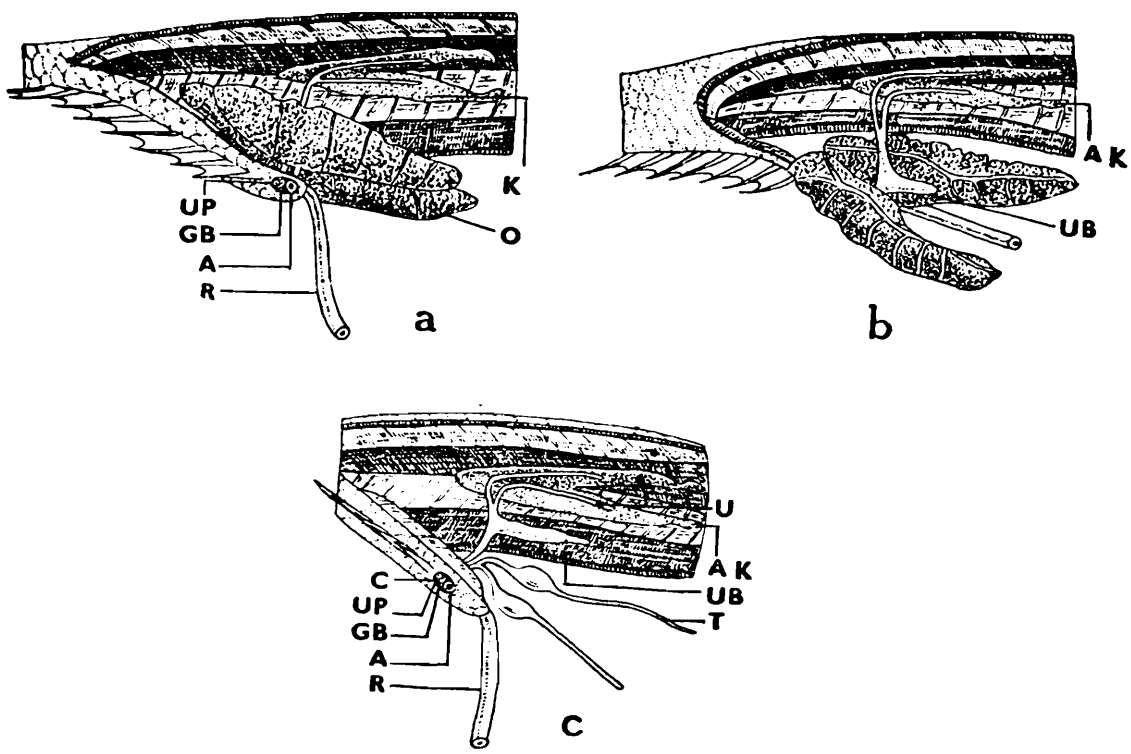
The bladder narrows off posteriorly into a thin duct which opens by a single pore at the posterior end of the cloaca (Text-figs. 11 *a*, *b* ; and 18 *d*).

In the female, the ovaries begin to enlarge about the middle of March, the growth manifesting itself in the posterior half first. The superficial

blood vessels show themselves more prominently at this time (Text-fig. 11*a*). Mature ovaries are bright yellow in colour, highly vascularised on the surface and measure about 5·9 cms. in length and 1·4 cms. in breadth. In this condition they are available from March to October. In fact, ripe females can be had throughout the year but are more abundant during the breeding season.

The testes are smaller in size than the ovaries and grow to 3·1 cms. in length and 1·2 cms. in breadth. During the non-breeding season, the testes are inconspicuous on account of reduction in size. Mature testes are of a pinkish hue and mature males are available from April to July but are not common during the remaining part of the year (Text-fig. 11 *c*).

Abdominal pores are absent, but a shallow cloaca is present into which the anus opens anteriorly. In the middle of it lies the single genital



TEXT-FIG. 11.—*Ophiocephalus gachua* (Hamilton). (*a* and *b*). Female. (*c*). Male. (× 1/2 Natural size).

pore which is small like a pin-hole during the non-breeding season but becomes prominent during the breeding season. The urinary orifice lies behind it (Text-fig. 18 *d*).

12. **Ophiocephalus marulius** (Hamilton)

(Text-fig. 13 *a, b*)

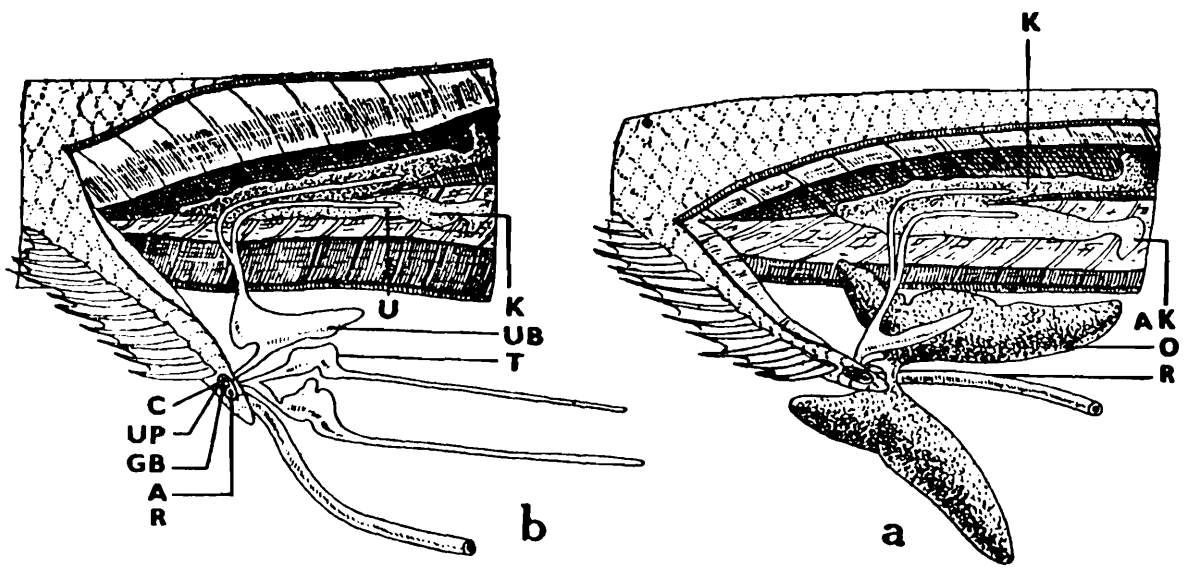
The head-kidneys are triangular or pyramidal in shape and are attached to the anterior ends of the kidneys by means of a short 'neck' Although the urino-genital organs of *O. marulius* resemble those of *O. gachua* and *O. punctatus* still there obtains difference in details.

The kidneys are separate anteriorly and somewhat elongated. Their outer edges are irregularly indented or wavy. The inner edges are, however, smooth. Posteriorly, the kidneys extend beyond the cloacal

region. The ureters arise somewhat suddenly from the hind portion as a thick-walled tube, which, piercing through the air-bladder, emerges on the ventral side to expand into a large-sized bladder. This narrows off posteriorly to open into the cloaca behind the genital duct (Text-fig. 13 *a, b*).

Sexes are distinct, but during the non-bereeding season the ovaries and the testes are scarcely distinguishable with the naked eye. During the breeding season, a ripe ovary measures about 5·9 cms. in length and 1·3 cms. in breadth. The right ovary is slightly longer than the left (Text-fig. 13 *a*).

The testes are very small when compared to the size of the fish. They never grow to more than 3·1 cms. in length and 2 cms. in width. During the non-breeding season they are not discernible because of their reduction in size, but assume a reddish hue during the breeding season.



TEXT-FIG. 12.—*Ophiocephalus punctatus* Bloch. (*a*). Female. (*b*). Male. (× 1/2 Natural size).

The anterior half of the cloaca is occupied by the anus which is partitioned off from the posterior half by a muscular sheet or partition. In the posterior half of it lies the single, median genital pore bordered by a thick rim which becomes vascularised during the breeding season. Behind it lies the single urinary pore. On the sides of the cloaca lie a pair of abdominal pores (Text-fig. 13 *a, b*).

13. **Ophiocephalus punctatus** Bloch

(Text-fig. 12 *a, b*)

The urino-genital organs of this fish differ little from that of *O. gachua.* Ripe ovary measures about 8·5 cms. in length and 2·1 cms. in breadth.

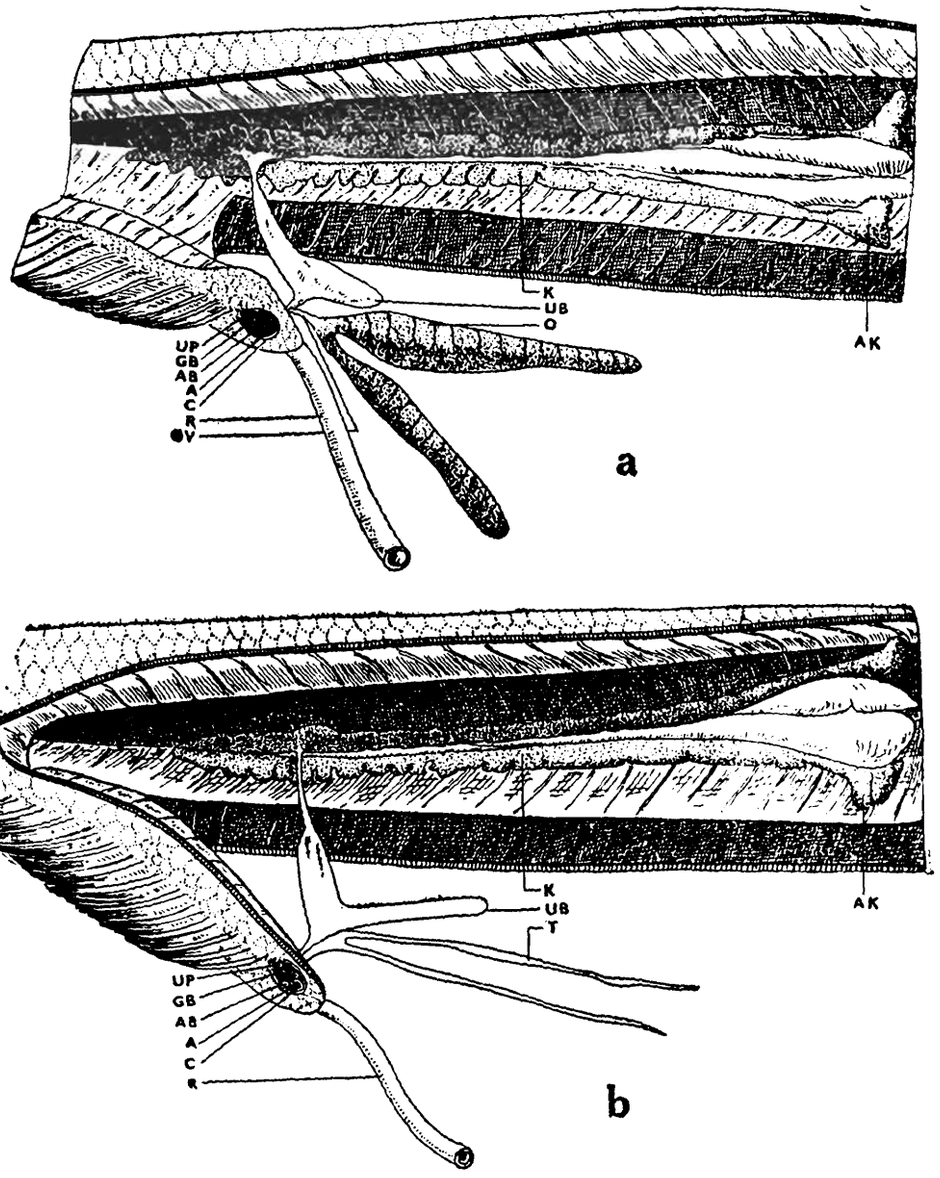
Testes measures 3·2 cms. in length and 1·4 cms. in breadth during the breeding season which extends from May to August. They become so reduced in size during the rest of the year as to be hardly distinguishable.

The structure of the cloaca is the same as that in *O. gachua.*

14. **Notopterus notopterus** (Pallas)

(Text-fig. 14 *a*, *b*)

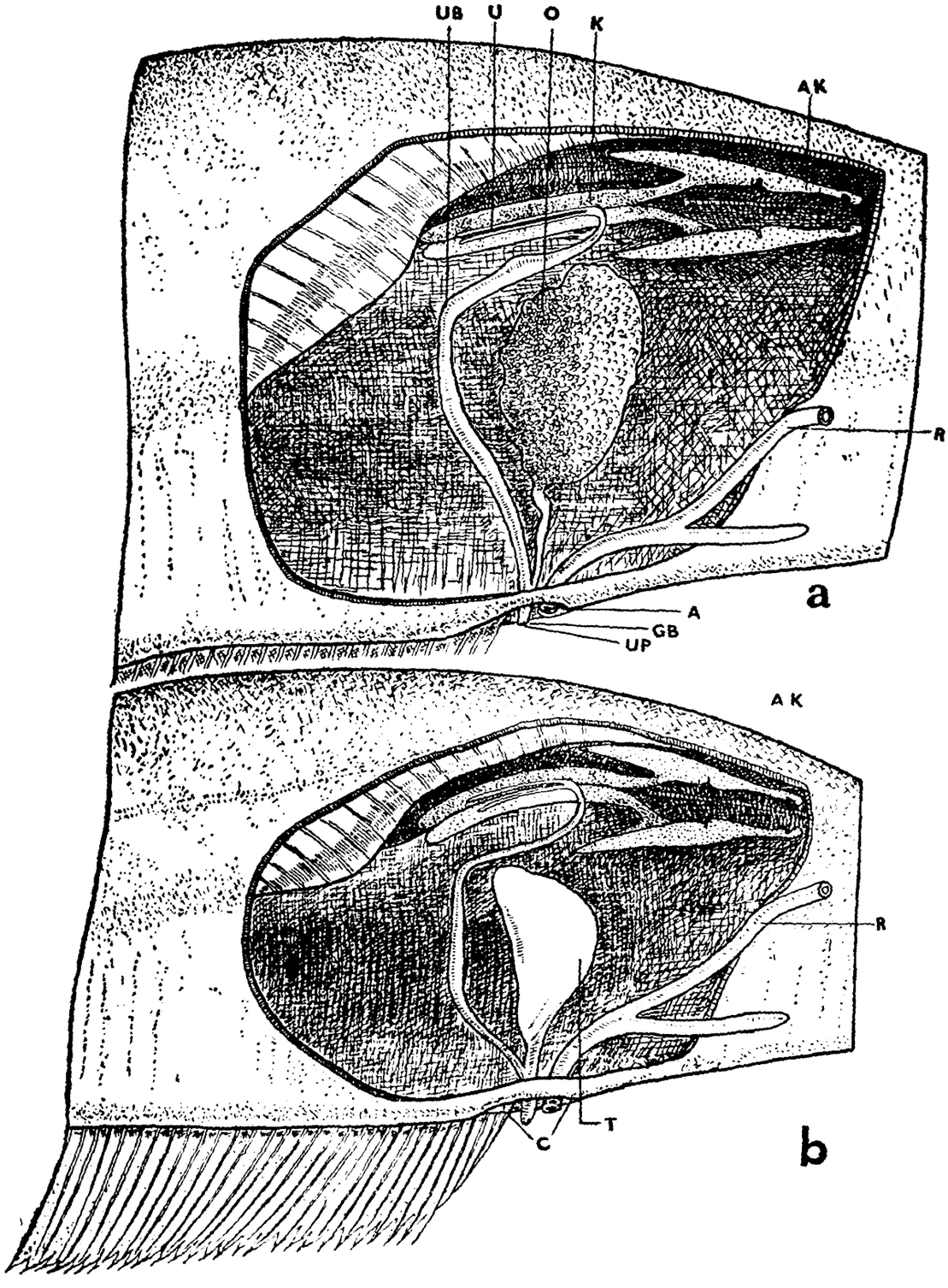
Due to the pronounced lateral compression of the body and the great reduction of the body-cavity, several peculiarities are noticeable in this fish. In both the sexes the *gonad is unpaired and usually present on the right side only.* The gonads are of the " open " type facing the body-wall (on the right side) and are covered by a loose mesovarium or mesorchium on the left side only which may be slightly projecting on the right side also (Text-fig. 14 *a*, *b*).



TEXT-FIG. 13.—*Ophiocephalus marulius* Hamilton. (*a*). Female. (*b*). Male. (× 5/6 Natural size).

The head-kidneys are prominent and very nearly equal to the kidney proper in size. The head-kidneys are more or less spindle-shaped and smooth-contoured, except for two small notches on their inner sides. They are connected with the main kidneys behind the middle of their length. The kidneys and the head-kidneys are separated by the

pericarddium. The kidneys are very small in size as compared to the body-size of the fish. Roughly they are bean-shaped, smooth-edged, pointed at both ends, and dark-red in colour, their inner faces being closely apposed.

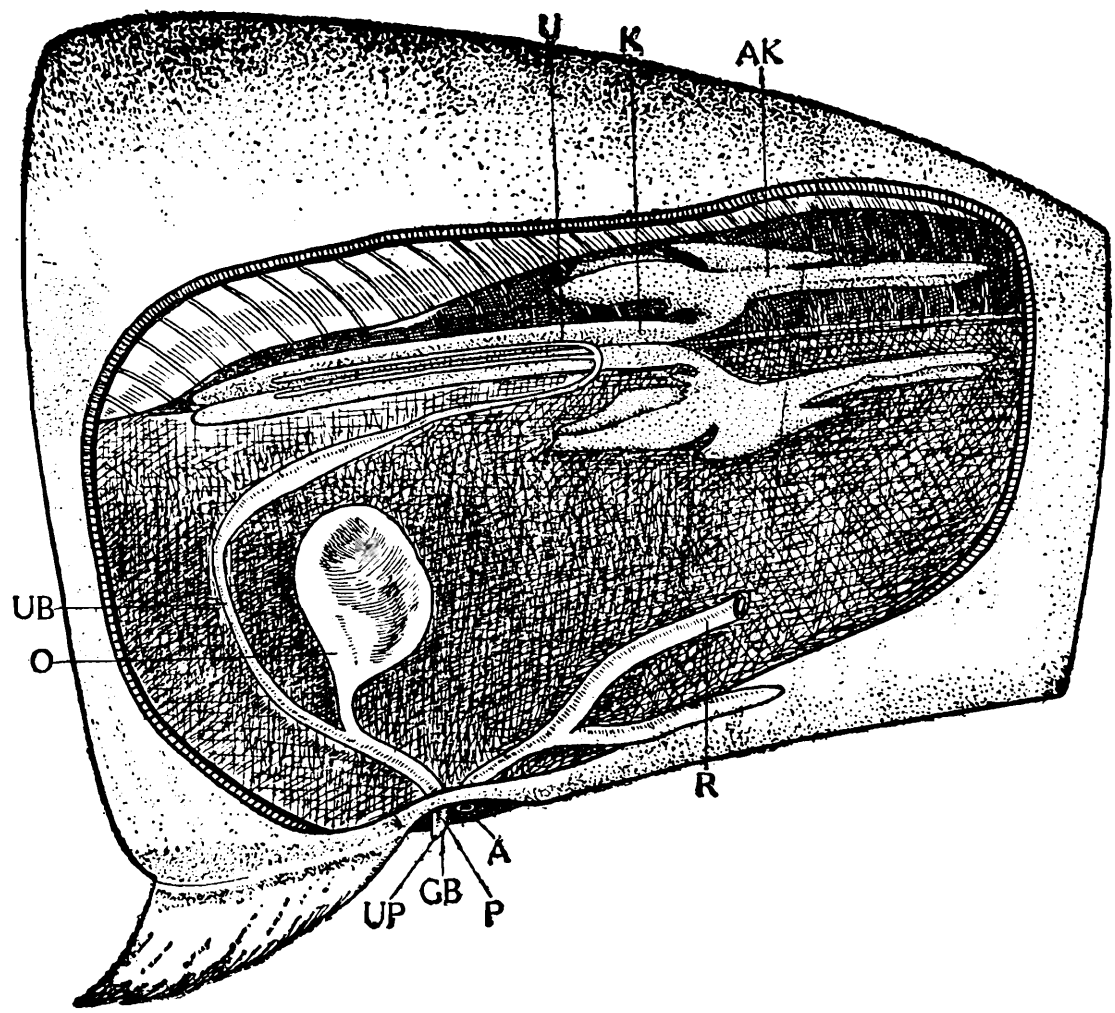


TEXT-FIG. 14.—*Notopterus notopterus* (Pallas). (*a*). Female. (*b*). Male. (× 1/4 Natural size).

The two ureters arise from the inner edges of the kidneys and run cephalad. This is quite the reverse of what occurs in other teleosts, a feature that has seldom been reported by previous workers. On leaving the kidneys, the single ureter formed by their union pierces

through the air-bladder to reach the ventral side of the body-cavity. Such a course of the ureter is uncommon in fishes and baffled the author for a long time as on emerging from the kidneys it was soon lost to view. By cutting through the air-bladder and following the course of the ureter it was found that it passed through the air-bladder. Soon after emerging from the air-bladder, it dilates into a glistening tubular structure which bends and then turns caudad to reach the cloaca and to open on a prominent papilla placed in it (Text-fig. 14 *a*, *b*).

A fully mature ovary is almost globular in outline (Text-fig. 14 *a*), measuring 2·4 cms. in length and 3·4 cms. in breadth. As has been already mentioned, the right ovary alone is present on the right side of the stomach adhering to the body-wall. The left face of the ovary is covered



TEXT-FIG. 15.—*Notopterus chitala* (Hamilton). Female. (×5/6 Natural size).

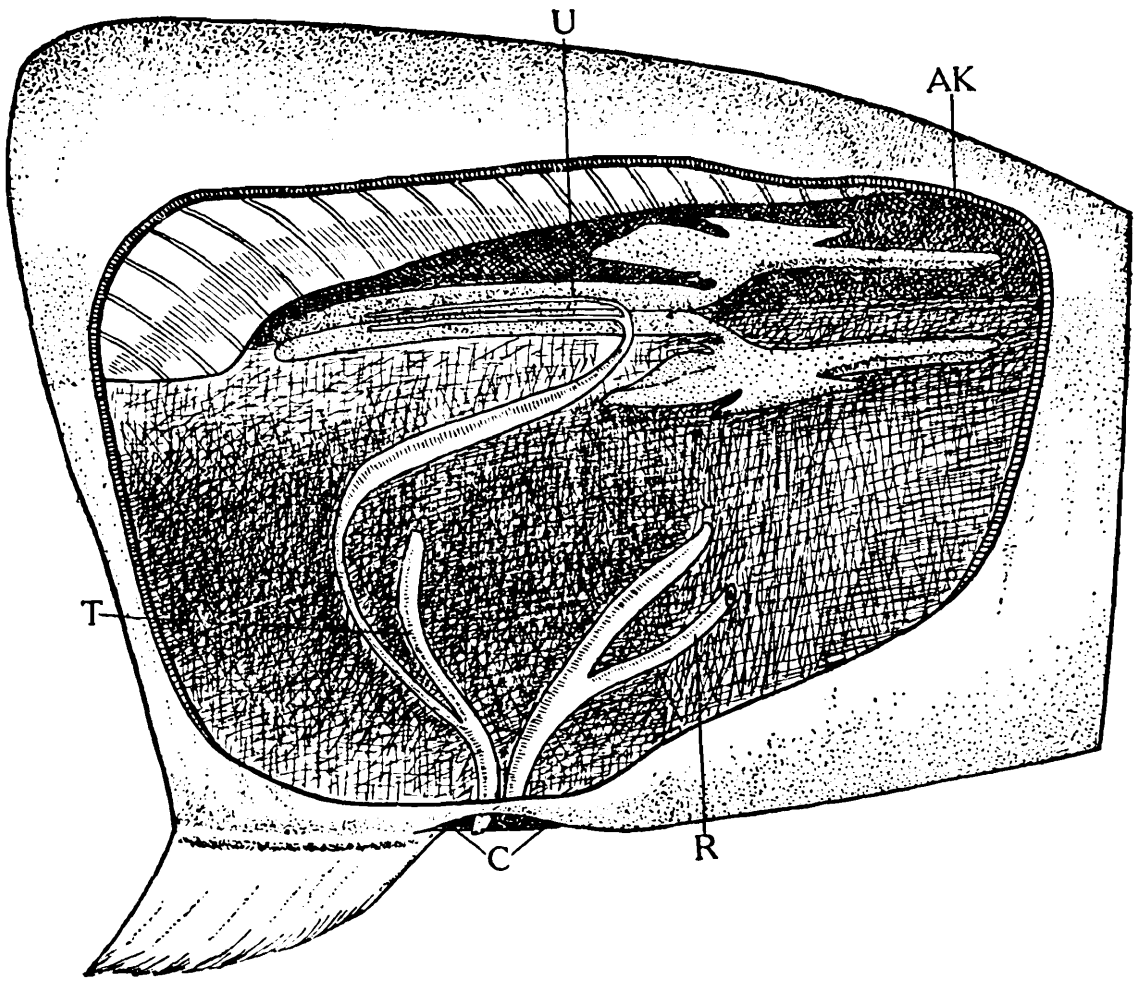
by the mesovarium which is a transparently loose and thin covering. On the ' open ' side (right side) the young ovary bears, in the breeding season, ridges or folds like those of the human cerebral hemispheres (Text-fig. 14 *a*). The ovary, at this time, is bright yellow in colour. The breeding season extends from April to August.

A duct in the form of an open groove proceeds for part of its course from the ovary, becomes tubular and muscular, and opens on the urino-genital papilla in the cloaca (Text-fig. 14 *a*). This duct measures about 2·2 cms. in length. In August, the mature specimens become scarce and by December the ovary and the duct become reduced in size

and shrivelled up. They begin to enlarge again in March for the next reproductive cycle.

The testis of the male, which is also single, occurs like the ovary on the right side and resembles it in external form and disposition except that the ridges are small and not very much convoluted (Text-fig. 14 *b*). It never grows bigger than 2·3 cms. in length. Fully mature males are available from July to August. The immature testis is white in colour, while the mature and ripe one is pinkish in hue.

The cloaca is a deep cavity placed betwen the reduced pectoral and ventral fins. It is an oval concavity in which the anus lies anteriorly and the genital and the urinary pores open on a papilla. The abdominal pores are absent (Text-figs. 14 *a, b* ; and 18 *e*).



TEXT-FIG. 16.—*Notopterus chitala* (Hamilton). Male. (× 5/6 Natural size).

15. **Notopterus chitala** (Hamilton)

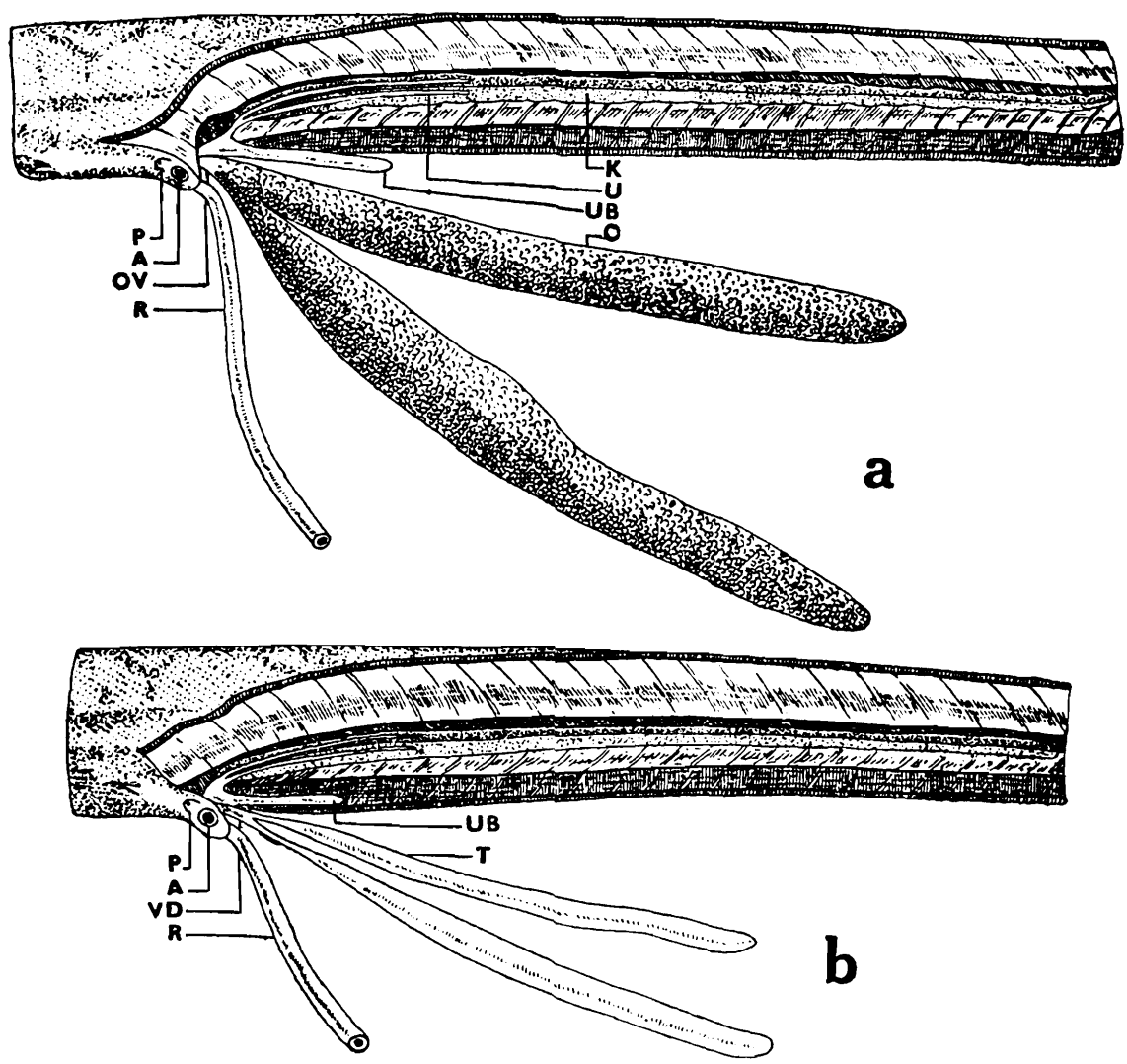
(Text-figs. 15 and 16)

N. chitala resembles *N. notopterus* in all essential respects so far as the urino-genital system is concerned. But the head-kidneys are proportionately larger than those of the *N. notopterus*. Further, the head-kidneys are not smooth in contour but are lobed.

The ovaries begin to enlarge in May and continue to do so till July when they become fully ripe. The ovarian ridges and convolutions are not so much pronounced in this species as in the case of *N. notopterus*.

A fully ripe ovary is pinkish in colour and measures 3·8 cms. in length and 3·2 cms. in breadth (Text-fig. 15).

In immature specimens the testis is ribbon-like in form and smooth on the surface (Text-fig. 16). The enlargement begins in May, and the species becomes fully ripe by July. At this time it measures 2·5 cms. in length and 1·6 cms. in breadth. The interior of the cloaca resembles that of *Notopterus notopterus.*



TEXT-FIG. 17.—*Mastacembelus armatus* (Lacépède). (*a*). Female. (*b*). Male. (x 1/2) Natural size).

16. **Mastacembelus armatus** (Lacépède)

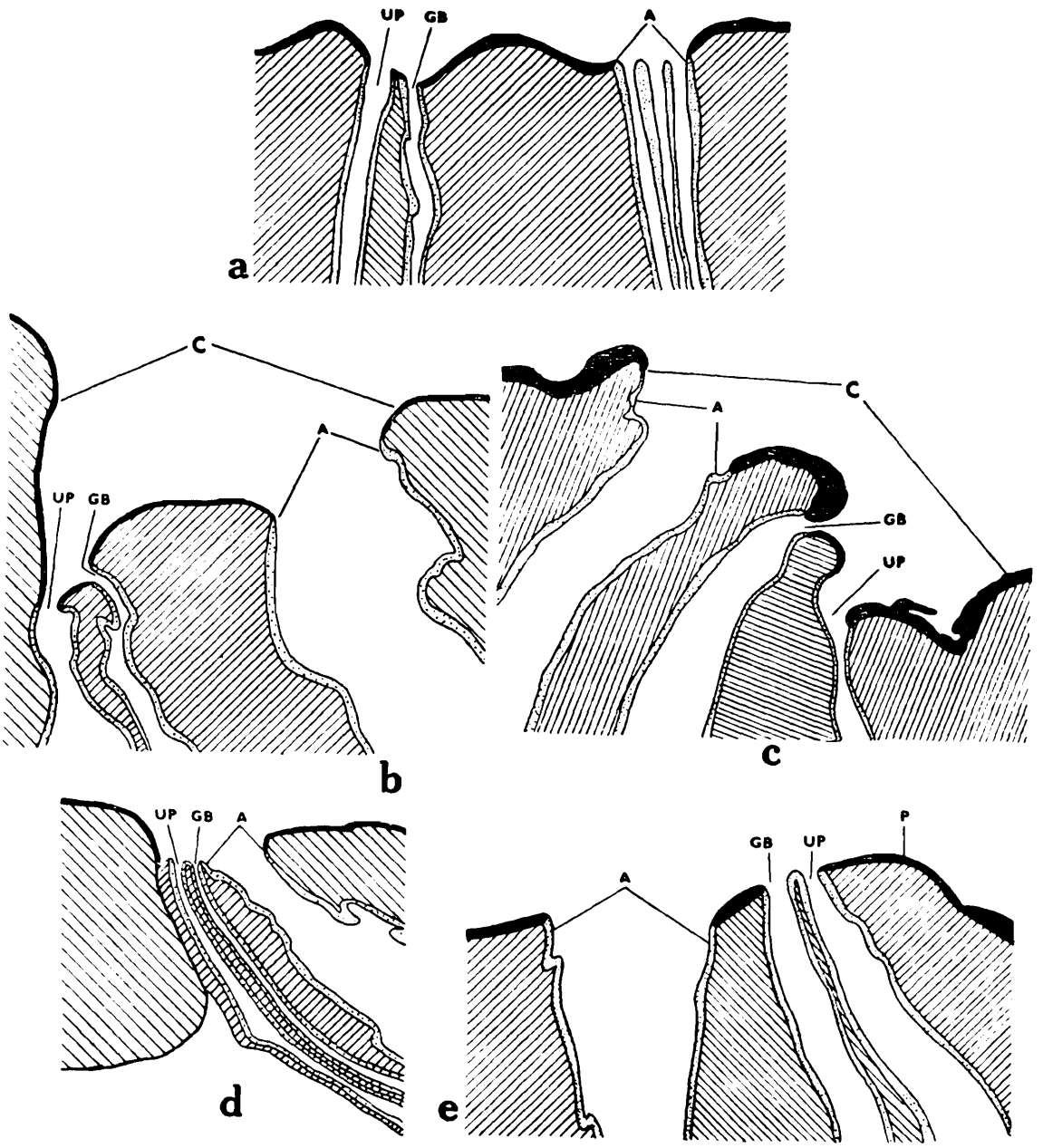
(Text-fig. 17 *a*, and *b*)

In this species, there is no head-kidney. The two kidneys remain separate throughout their length except in the hindmost part where they unite (Text-fig. 17 *a*, *b*.)

The paired ureters arise separately from the two lobes in the last quarter of their length, run caudad for a short distance and then join to form the ureter. The ureter gives off a long finger-shaped bladder which lies in between the gonads. The ureter joins the gonoduct just before opening at the summit of the papilla (Text-fig. 20 *b*).

The gonads are elongated and tubular structures. Immature male and female gonads resemble each other in external appearance.

In a mature female, the ovaries, which are bright yellow in colour and granulated on the surface, occupy a large part of the body-cavity, displacing other organs. At this time, they measure 18 to 20 cms. in length and 3 to 4·5 cms. in breadth. Ripe females are available from March to September. By the middle of September, the ovaries shrink in size, maximum reduction being reached in December. The mesovarium covering the immature ovries is somewhat thick.



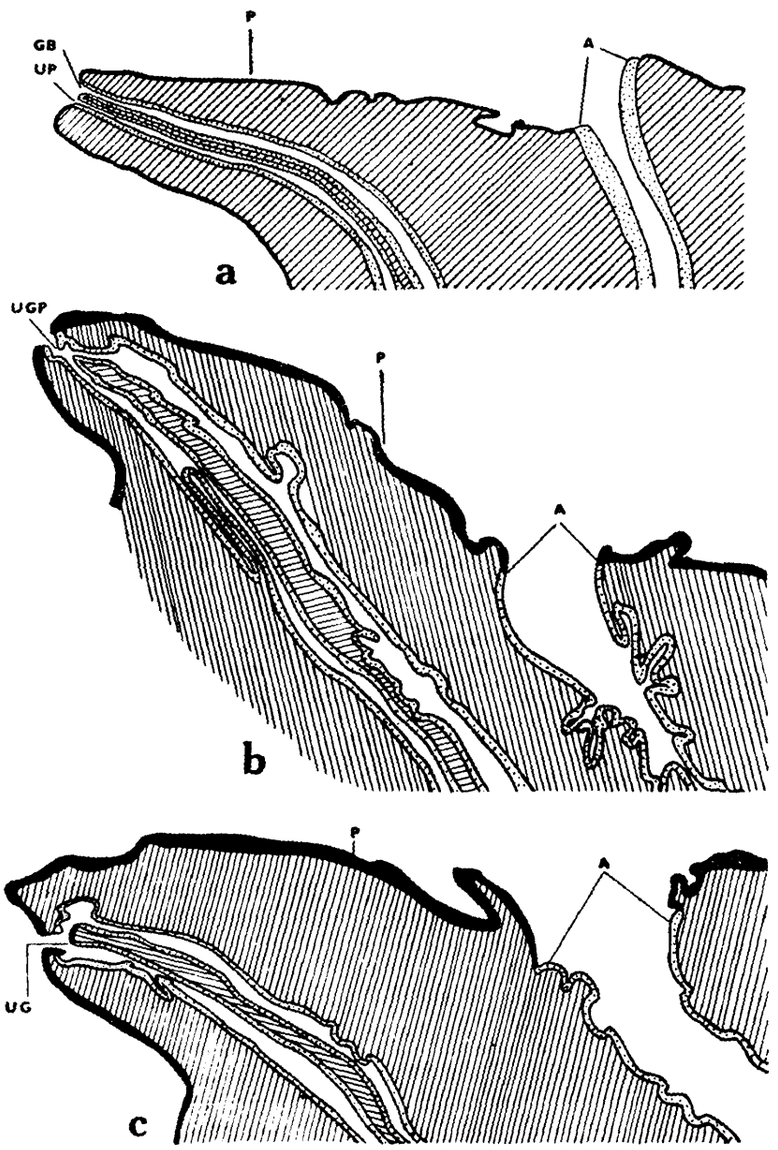
TEXT-FIG. 18.—Longitudinal sections through the cloaca of : (*a*). *Hilsa ilisha* (Hamilton). (*b*). *Catla catla* (Hamilton). (*c*). *Labeo rohita* (Hamilton). (*d*). *Ophiocephalus gachua* (Hamilton). (*e*). *Notopterus notopterus* (Pallas). (× 26·6).

The two ovaries narrow down caudally, and pass into the oviducts which unite and join with the urinary duct to open on the summit of a papilla (Text-figs.17 *a* and 20 *b*).

The paired testes are elongated, tubular, smooth-walled structures, pale white in colour in the immature stage, becoming pink as they grow.

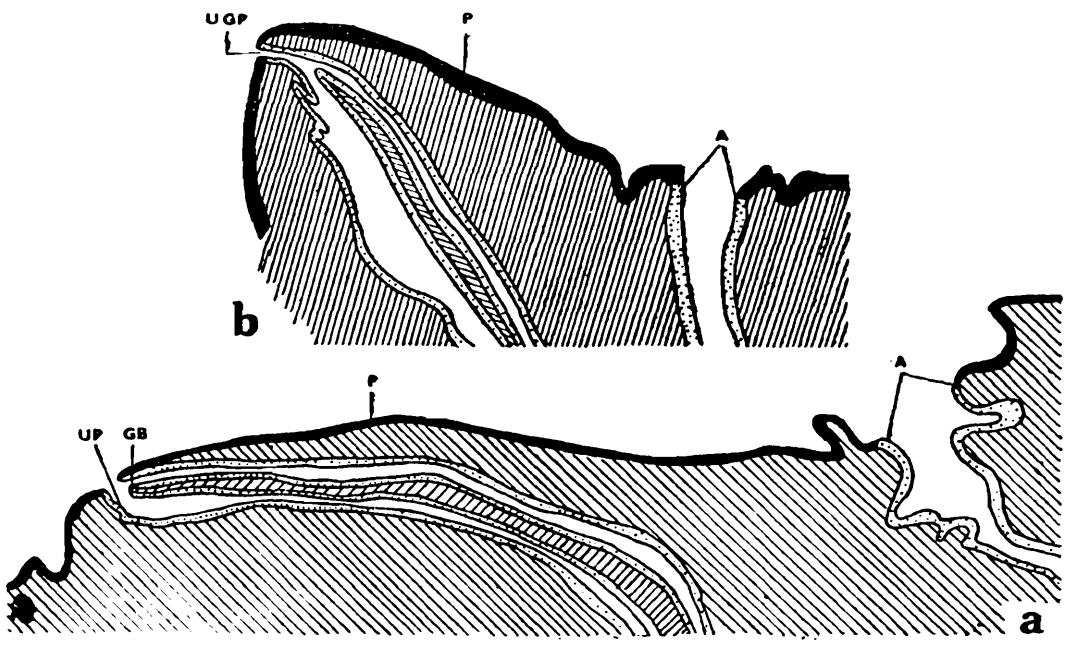
A fully mature testis measures from 18 to 20 cms. in length and 1 to 1·5 cms. in breadth.

At the posterior end, the testes give off the vasa deferentia which are distinguishable by their lighter colour. The two vasa deferentia join and then unite with the urinary duct to open on a papilla (Text-fig. 20 *b*).

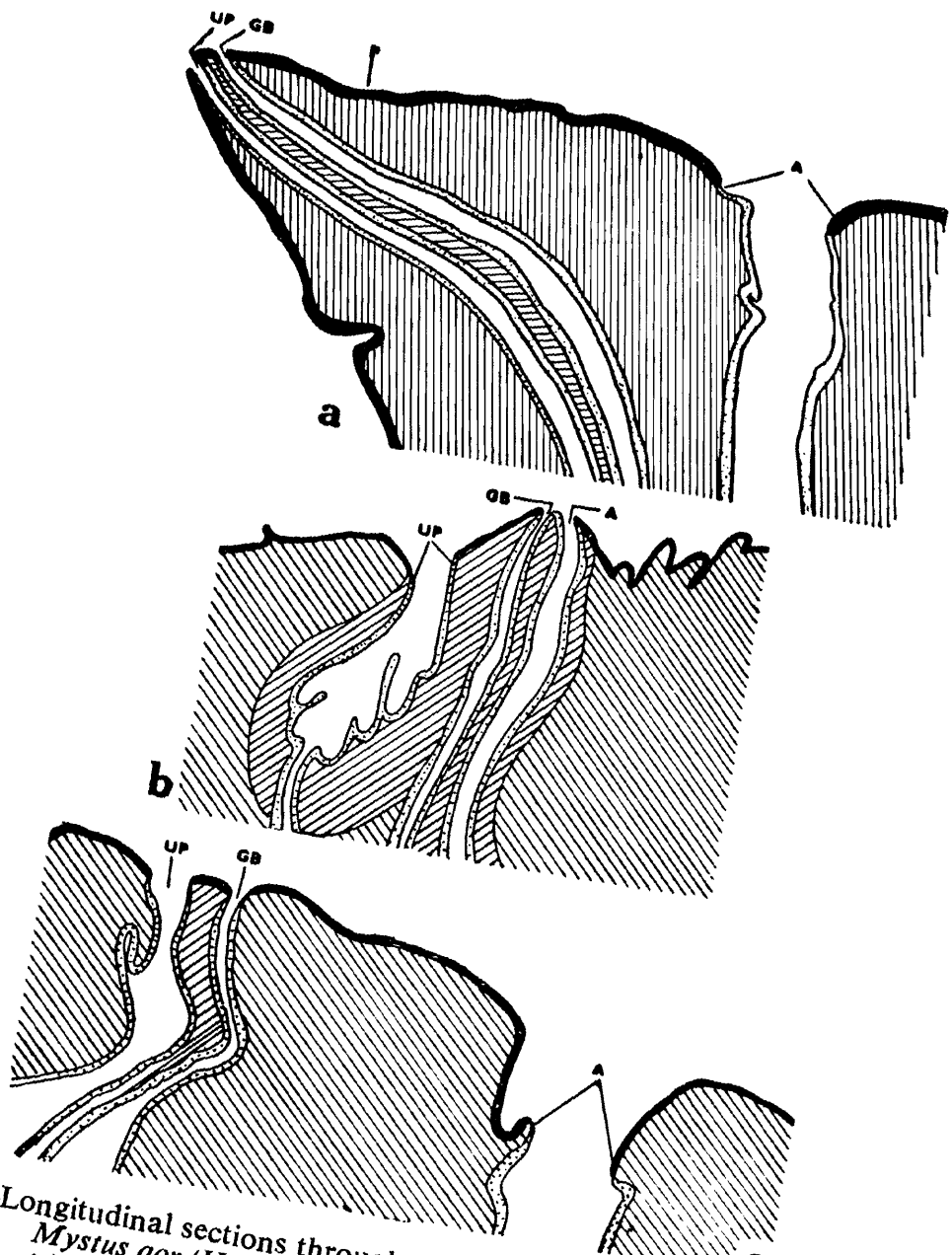


TEXT-FIG. 19.—Longitudinal sections through the anus and papilla of : (*a*). *Wallago attu* (Bloch and Schneider). (*b*). *Eutropiichthys vacha* (Hamilton). (*c*). *Heteropneustes fossilis* (Bloch). (× 26·6).

Immediately behind the anus lies the single urino-genital papilla, inconspicuous in the non-breeding season, but very prominent in the breeding season. The papilla is short and bears a wide and round pore at its tip (Text-fig. 17 *a*, *b*).



TEXT-FIG. 20—Longitudinal sections through the anus and papilla of : (*a*). *Clarias batrachus* (Linn.). Male. (*b*). *Mastacembelus armatus* Lacépède. (× 26·6).



TEXT-FIG. 21.—Longitudinal sections through the anus and urino-genital sinus of : (*a*). *Mystus aor* (Hamilton). (*b*). *Heteropneustes fossilis* (Bloch). Female. (*c*). *Clarias batrachus* (Linn.). Female. (× 26·6).

IV—General Remarks

Dissections and observations on several species of common fresh-water fishes have revealed many interesting facts and have cleared up ambiguities and misconceptions concrening the urino-genital oragns in teleostean fishes as the following remarks will show.

Kidney.—Balfour and Parker (1882), Goodrich (1930) and Bridge (1932) recorded that the kidneys in fishes are *separate* and double, but Kingsley (1926) mentioned that *fusion* also occurred in them. Embryologically the kidneys have a paired origin in the teleosts but they need not necessarily remain so in the adult stage. In all the fishes examined by the present author, the kidneys are not separate and double throughout their entire length, except in the Notopteridae and the Mastacembelidae. In *Hilsa ilisha* (Hamilton) the kidney is topographically single but for a short bifurcation at its anteriormost end. In the Cyprinoids like *Labeo rohita* (Hamilton), *Catla catla* (Hamilton), *Cirrhina mrigala* (Hamilton) and *Rasbora rasbora* (Hamilton), the kidneys have peculiar shape. They are bifid anteriorly, becoming fused for a short length, separate again and then become reunited posteriorly ; while in the Siluridae (composite family of Day) *Clarias batrachus* (Linn.) (Clariidae), *Eutropiichthys va ha* (Hamilton) (Schilbeidae), *Mystus aor* (Hamilton) (Bagridae), *Wallago attu* (Bloch & Schneider) (Siluridae), and *Heteropneustes fossilis* (Bloch) (Saccobranchidae) the composite kidney is bilobed anteriorly but fused into one posteriorly. Similar condition occurs in the Ophiocephalidae, but in the Notopteridae and Mastacembelidae the kidneys are bilobed and separated for the greater part of their length.

Sedgwick (1905) referred to the occurrence of head-kidneys in all the Teleosts and my findings concur with his generalisation. The *Cyclothone* kidney according to Owen (1938) consists only of a pair of tubules, but in all the forms examined by the present author the kidneys are massive structures. The shape and contour, however, vary considerably in different species of fishes.

Ureters.—Sedgwick, Goodrich and Bridge report ureters as being invariably paired, united posteriorly and arising from the hind end of the kidneys, dilating to form a single " urinary bladder " Sedgwick mentions that " There are two longitudinal urinary ducts which unite posteriorly to form the single ureter. This structure, which frequently has a bladder-like dilatation, passes ventral-wards on one side of the air-bladder to open externally behind the anus, or into the rectum " Pfeiffer (1933) described the bladder as opening into the rectum and thought that " the above (this) condition would seem to resemble that found in most Teleosts " Variations in the number and position of the ureters and of the urinary bladder were found by the present author in the species of fishes dealt with here. Variations were sometimes found even among individuals belonging to the same species. For instance, in *Hilsa ilisha*, the ureters may be paired or single. When paired, the two may arise at the same level in some cases, while in others the left one may arise in advance of the right, or *vice versa*. Similarly, in *Labeo rohita, Cirrhina mrigala* and *Catla catla* the point of the origin of the ureters varies considerably from individual to individual. In *Wallago*

attu and *Mystus aor*, the paired ureters arise and leave the kidney abruptly, while in *Ophiocephalus marulius* a single ureter arises and leaves the kidney suddenly.

The condition in which the ureters run latero-ventrad on one side of the air-bladder, as indicated by Sedgwick, was found only in the case of *Ophiocephalus gachua* and *O. punctatus* by the present author. In the Notopteridae, the ureters pierce through the air-bladder and emerge on its ventral side to pursue their usual course to the cloaca. The first part of the course of the ureters is directed anteriorward, then they pierce through the air-bladder and emerge out of it ventrally. This is a novel course for the ureters to follow. Such a condition has not yet been reported in any other case. In *Ophiocephalus marulius* also the disposition of the ureters is through the air-bladder.

Urinary bladder.—The presence of a posterior dilatation of the ureters (or the 'urinary bladder') has been mentioned by Sedgwick, Goodrich, Bridge, Parker and Haswell, Pfeiffer and Owen. Goodrich, however, prefers to call it cloacal bladder. But the occurrence of two bladders has not been mentioned by any previous author. In *Cirrhinn mrigala, Labeo rohita* and *Catla catla*, the two ureters dilate separately into two bladders. This is very conspicuous in *Cirrhina mrigala* than in the other two species, The bladder in all the cases mentioned above narrows down caudally and opens independently or in confluence with the genital duct to the exterior *but does not open into the rectum* as stipulated by Sedgwick. The genital ducts also do not open into the bladder as mentioned by Pfeiffer in the case of *Lepidosteus.*

Ovary.—The author's observations on the ovaries agree mostly with the descriptions given by the previous investigators. In the majority of cases, the ovaries are paired, tubular or saccular and smooth-contoured. In the Cyprinidae, the ovaries are flat and slightly constricted in the middle. Mention of the unpaired condtion of the ovary in the Notopteridae was made by Francis Day (1889) and Goodrich (1930).

Oviducts.—According to Bridge in the Notopteridae and Salmonidae, the oviducts lose their continuity with the ovaries and degenerate to a great extent. He further holds the view that in some Salmonidae, the oviducts end anteriorly in wide funnel-like coelomic apertures, but do not embrace the ovaries. Such gymnovarian condition has not been found in the sepcies of fishes reported here. The oviducts are continuous with the ovaries being confluent with them posteriorly and opening externally by a single orifice. But in the Notopteridae it was found that a rut-like passage is formed by the partial folding of the mesovarium which serves as a conduit for the escape of ova to the exterior. On account of the degeneration of the oviduct reported by Bridge, this improvisation by nature is noteworthy.

Testes.—The description given by Sedgwick and Goodrich of the disposition of the male genital organs and their ducts has been found to be substantially correct.

Vasa deferentia.—There are two vasa deferentia in each case, excepting in the Notopteridae, which unite posteriorly and :

(*a*) open separately into the cloaca, e.g., *Hilsa ilisha* (Text-fig. 1 *a*, *b*) *Catla catla* (Text-figs. 2, 3) ; *Rasbora rasbora* (Text-fig. 4 *a*, *b*) ; *Cirrhina mrigala* (Text-fig. 5 *a*, *b*) ; *Ophiocephalus gachua* (Text-fig. 11 *a*, *b*, *c*) ; *O. punctatus* (Text-fig. 12 *a*, *b*) and *O. marulius* (Text-fig. 13 *a*, *b*) ;

(*b*) join the common ureter and open by means of a pore on the papilla, e.g., *Eutropiichthys vacha* (Text-fig. 9 *a*, *b*) ; *Heteropneustes fossilis* (Text-fig. 10 *a*, *b*) ; *Clarias batrachus* (Text-fig. 10 *c*, *d*) and *Mastacembelus armatus* (Text-fig. 17 *a*, *b*) ;

(*c*) do not join the common ureter but open separately on the papilla, e.g., *Wallago attu* (Text-fig. 7 *a*, *b*) ; *Notopterus notopterus* (Text-fig. 14 *a*, *b*) and *Notopterus chitala* (Text-figs. 15 and 16).

Cloaca.—In the Clupeidae, Cyprinidae and Notopteridae, the cloaca is very deep, but it is very shallow in the Ophiocephalidae. In the Siluridae (Day) and Mastacembelidae the cloaca is absent.

Abdominal pores.—Abdominal pores occur in *Hilsa ilisha*, some of the Cyprinidae like *Labeo rohita* and *Catla catla*, and in *Ophiocephalus marulius*. They are not found in gymnovarian forms like *Notopterus notopterus* and *N. Chitala*.

Sexual dimorphism.—Though a few cases of sexual dimorphism have been reported occasionally, this character is not so well-established in the fishes as in the case of the higher verterbrates. Davidson (1935) describes a very peculiar secondary sexual character in the male of pink Salmon, *Oncorhynchus gorbuscha*. As the breeding season approaches. the snout elongates, and a hump is developed on the dorsal side which starts from behind the head and tapers off caudally, the deepest portion being behind the dorsal fin. In the same year, Parker and Brower (1935) discovered the appearance of a melanophoric mark on the dorsal fin of the male of *Fundulus heteroclitus* which the authors label as the " nuptial secondary sex-character " because of its appearance in the breeding season.

Vladykov (1935) finds certain differences in the number and disposition of the fin-rays between the males and the females of some Chinese Cobitid fishes, which, according to him, are of some taxonomic importance.

According to Fraser-Brunner (1940), in the family Ostraciontidae sexual dimorphism is of common occurrence, but not of a very striking nature. It consists in colour differences, depth of the body and the form of the snout in the two sexes.

Among the sixteen species of fishes examined throughout the year by the present author, secondary sexual dimorphism was noticed only in *Heteropneustes fossilis* and *Clarias batrachus*. A urino-genital papilla occurs in the males of *Heteropneustes fossilis* and *Clarias batrachus* and the cloaca is absent, the anal opening being distinct and separate. In the case of the corresponding females, a urino-genital sinus exists. Day (1889) in his monumental work on Indian fishes does not record this important sexual difference.

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VI—Key to the Lettering used in the Diagrams

A., anus.
AK., head-kidney.
AB., abdominal pore.
ABL., air-bladder.
C., cloaca.
GB., genital pore.
GL., gland.
K., kidney.
O. ovary
OV., oviduct.
P., papilla.
R., rectum.
T., testis.
U., ureters.
UB., urinary bladder.
UGP., urino-genital pore.
UP., urinary pore.
VD., vas deferens.

THE URINARY BLADDER OF SOME INDIAN TELEOSTEAN FISHES*

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(With 4 Plates)

CONTENTS

*Part of the thesis submitted to the Banaras Hindu University for the award of the Ph. D. degree in 1954.

I—Introduction

(*a*) *General*

From early times zoologists have paid considerable attention to the study of the urino-genital organs of fishes. However, inspite of the valuable contributions made by Muller (1875), Balfour and Parker (1882), Wheeler (1899), Woods (1902), Price (1904), Conell (1917), Kingsley (1926), Pfeiffer (1933), Owen (1938) and Parker and Haswell (1940), there still remain gaps in our knowledge. In a previous paper (Kamalaveni, 1962) the urino-genital organs of a number of freshwater fishes have been described by the author. During the course of that study several new features were noticed, and in this paper the urinary bladder of the fishes in question is dealt with.

(*b*) *Historical Résumé*

A survey of the literature on the urino-genital organs of fishes shows that one of the earliest workers on the subject was Rathke (1827), who described, probably for the first time, the development of the renal organs in the Ammocoetes larva. Later other workers like Muller (1875), Schneider (1879) and Bujor (1891) studied them and added to our knowledge on the subject. Detailed account of the development of the pronephros and mesonephros was given by Wheeler (1899) and of the pronephros alone by Hatta (1900). The early development of the mesonephros was described by Price (1904) in *Bdellostoma.*

The following excerpt from Goodrich (1931) indicates the present position :

"The origin, growth and prolongation of the pronephric duct has remained a controversial problem and even now it remains so. But many have carried out researches on the problem, prominent among them being Beard (1887) and Ruckert (1888). The controversy has been set at rest to some extent by some of the later writers like Field (1891) and others, who have come to the conclusion that the ducts are purely mesodermal in origin. Work on the Teleostean pronephric duct has been carried out by Sween and Brachet (1901) *but many points still remain to be clarified*"

Sedgwick (1905), Goodrich (1931) and Parker and Haswell (1940) mention the occurrence of a median, posterior dilatation of the mesonephric duct. Sedgwick (1905) opines that this dilatation opens into the rectum in some teleosteans, while Goodrich (1931) holds that this contributes towards the formation of the urino-genital sinus. Parker and Haswell (1940) suggest that this dilatation is analogous to the allantoic bladder of the higher vertebrates. Owen (1938) casually refers to the structure of the urinary bladder in the genus *Cyclothone.*

Apart from these citations, little is known about the urinary bladder of the teleostean fishes.

(*c*) *Acknowledgment*

The author is deeply indebted to Professor A. B. Misra, Professor of Zoology, for his constant encouragement, valuable criticisms and guidance throughout the course of this work.

II—MATERIAL AND METHODS

The material required for this work was obtained from the river Ganges at Banaras, or from the tanks and ponds in the adjoining areas. Freshly caught fishes were decerebrated and then dissected on the river bank. Usually the fixative was injected into the bladder through the urinary pore by means of a pipette, then it was quickly removed and dropped into Bouin's fluid. Sections were cut 7 to 10μ thick, and stained in Delafield's Haematoxylin, Iron Haematoxylin or Mayer's Haemalum, and counter-stained with Eosin. The following fishes were employed in this study.

1. *Ophiocephalus gachua* Ham.	Ophiocephalidae
2. *Ophiocephalus punctatus* Bloch	Ophiocephalidae
3. *Ophiocephalus marulius* Ham.	Ophiocephalidae
4. *Hilsa ilisha* (Ham.)	Clupeidae
5. *Heteropneustes fossilis* (Bloch)	Saccobranchidae
6. *Clarias batrachus* (Linn.)	Claridae
7. *Wallago attu* (Bloch & Schneider)	Siluridae
8. *Mystus aor* (Ham.)	Bagridae
9. *Eutropiichthys vacha* (Ham.-Buch.)	Schilbeidae
10. *Notopterus notopterus* (Pallas)	Notopteridae
11. *Notopterus chitala* (Ham.)	Notopteridae
12. *Mastacembelus armatus* (Lacép.)	Mastacembelidae
13. *Catla catla* (Ham.)	Cyprinidae
14. *Labeo rohita* (Ham.)	,,
15. *Cirrhina mrigala* (Ham.)	,,
16. *Rasbora rasbora* (Ham.)	,,

III—THE URINARY BLADDER AND ITS STRUCTURE

The fundamental plan of the structure appears at a glance to be similar in almost all fishes studied by the author except in the case of the *Notopteridae*. But, inspite of the similarity, there are differences that are noteworthy. It is therefore essential that a short description of the structure of the urinary bladder of each fish be given. Since the general structure of the urinary bladder has not been described by any worker, an account of it is being given here before emphasising the differences.

The epithelium.—The lumen of the urinary bladder is an undivided chamber in all fishes excepting in *Catla catla* (Ham.) in which it is divided into two (Plate 5, Fig. 13 *a*). The lumen is lined by stratified epithelium (endothelium) disposed in several layers of cells, ranging from four to six. Some of these cells appear to be secretory in function as shown by the occurrence of goblet-cells in them and the discharge of secretory matter from them. These secretory cells occur in a continuous row in some cases (Plate 5, Figs. 10-12), while in others they occur in isolated groups scattered irregularly (Plate 4, Fig. 9*b*) or even singly distributed here and there (Plate 4, Fig. 5). In most of the fishes, they are very prominent and appear in the sections like vesicles filled with some kind of secretion ready to burst into the lumen (Plate 3, Fig. 4*b*; Plate 4, Fig. 9*b*). In some fishes apical portions of the cells become detached or " pinched off " from the parent cell. Groups of erythrocytes occur among

the cells of the stratified epithelium or under the epithelium which shows that the epithelium is traversed by capillaries. The capillaries lie at different levels in the epithelium, especially in the Ophiocephalidae, where they are so superficial as to even burst forth into the lumen of the bladder (Plate 3, Figs. 1, 3). Generally the capillaries do not enter the epithelial layer but stay below it. Here we have ample evidence to the contrary.

The cells composing the stratified epithelia in various fishes are of different shapes and sizes. In some, they are longer than broad bearing a prominent nucleus ; in others, they are nearly pentagonal or hexagonal in shape with a small nucleus, and in still others the cells are elongated without the nuclei prominently defined.

The Submucosa.—The epithelium is followed by the submucosa in which connective tissue and strands of plain muscle fibres exist. It bears a superficial resemblance to the submucosa of the intestines of vertebrates.

The Muscular layers.—The connective tissue is followed by a layer of plain muscle fibres, the thickness of which varies according to the size and age of the fish. In some cases, they occur as broad, uninterrupted bands, while in others they occur in groups or bundles interspersed with connective tissue. The muscular layer is divisible into an inner layer of circular muscle fibres and an outer layer of longitudinal muscle fibres. Both these layers are highly vascularised.

IV—Description of the Urinary Bladder

1. **Ophiocephalus gachua** Ham.

(Plate 3, Fig. 1*a*, *b*)

In this fish, the epithelium is very prominently developed and greatly vascularised. It is several layers thick, seven to eight of them being easily discernible. The cells are hexagonal or polygonal in outline.

Closely associated with the epithelium and often aggregated on one side is a lymphoidal mass traversed by capillaries which extend even into the epithelium.

2. **Ophiocephalus punctatus** Bloch

(Plate 3, Fig. 2*a*, *b*).

3. **Ophiocephalus marulius** Ham.

(Plate 3, Fig. 3*a*, *b*)

In these two species, the epithelium is several layers thick as in the foregoing case and is thrown into folds. The cells in *Ophiocephalus punctatus* as well as in *Ophiocephalus marulius* are somewhat long and irregularly arranged. The cells in the lower strata are grouped into bundles, while those towards the lumen are arranged in rows. Here also the epithelium is vascular and the blood vessels reach even the free border where some of them burst into the lumen (Plate 3, Fig. 1*b*.)

The epithelium is surrounded by a thin layer of connective tissue which in turn is covered by loose muscular strands with sparsely scattered nuclei. This kind of disposition of the muscular layers is peculiar to the Ophiocephalidae. Another distinguishing mark of the urinary bladder of these fishes is the absence of the secretory vesicles as described in the species to follow.

4. **Hilsa ilisha** (Ham.)

(Plate 3, Fig. 4*a*, *b*)

The epithelium is generally three to four cells thick and bears prominent nuclei. The epithelium is thrown up into folds and the cells lying at the summit of the folds show considerable secretory activity. The secretory matter is discharged into the lumen of the urinary bladder along with some erythrocytes discharged by the disrupted capillaries.

The submucosa is seen only at certain points because the thick development of the muscular layers has practically obliterated it.

The nuclei of the muscles lie enmeshed within the strands of muscles.

5. **Heteropneustes fossilis** (Bloch)

(Plate 4, Fig. 5*a*, *b*)

The epithelium is thrown into folds at some points. The epithelial cells are disposed in three to five layers and form the inner lining of the bladder. The cells are small and possess round nuclei. The secretory cells are not so numerous as in the case of *Hilsa ilisha*, but are scattered at irregular intervals at different levels. When actually secreting they become vesicular in appearance. Blood capillaries lie scattered amongst the epithelial cells and extend even up to the free margin of the border.

The submucosa is traversed by strands of muscles (Plate 4, Fig. 5*a*).

The circular muscle fibres are grouped into bundles (Plate 4, Fig. 5*b*) between which connective tissue exists. The nuclei though fewer in number and scattered are nevertheless detectable.

6. **Clarias batrachus** (Linn.)

(Plate 4, Fig. 6*a*, *b*)

The epithelial cells lining the bladder are pentagonal or hexagonal in shape and possess prominent nuclei. The secretory vesicles are scattered irregularly. The epithelium is three or four cells deep at some places, and eight cells deep at other points. It is not so much vascularised as in the case of *Ophiocephalus*, but a few erythrocytes lie here and there.

The connective tissue below the epithelium follows the course of the epithelium and consequently villi-like projections occur in it. The muscles exist in groups and in bands. Blood capillaries are interspersed between the circular and the longitudinal muscle fibres.

7. **Wallago attu** (Bloch & Schneider)

(Plate 4, Fig. 7*a*, *b*)

The epithelium is six or seven cells thick. The cells are small in size, hexagonal in shape and bear small nuclei. It is slightly uneven in disposition except for elevations at some points. The secretory vesicles are quite numerous and lie irregularly distributed among the epithelial cells. These vesicles burst forth into the lumen (Plate 4, Fig. 7*b*) and discharge their contents. The epithelium is vascularised in this species also, but the capillaries are not so numerous as in *Ophiocephalus*. The submucosa is moderately wide and traversed by muscular strands distributed irregularly in it. This is followed by a circular layer of muscle fibres, next to which are the longitudinal fibres. The former is easily recognized by the manner of its disposition, while the latter is disposed in groups or bundles.

8. **Mystus aor** (Ham.)

(Plate 4, Fig. 8*a*, *b*)

The structure of the wall of the urinary bladder very closely resembles that of *Wallago attu* except for some minor differences. The epithelium is thrown into less prominent folds. It is not vascularised and is only 3-4 cell-deep, excepting where it is elevated. The secretory vesicles are quite numerous and are scattered without any apparent order close to the edge of the epithelium. Some of them are seen bursting into the lumen and discharging their contents.

9. **Eutropiichthys vacha** (Ham. & Buch)

(Plate 4, Fig. 9*a*, *b*)

The structure of the urinary bladder does not differ much from that found in either *Wallago attu* or *Mystus aor*, but the epithelium is slightly thicker and more vascularised. The secretory vesicles are irregularly distributed as in the other two species. The connective tissue and the muscles are not uniformly thick all round.

10. **Notopterus notopterus** (Pallas)

(Plate 5, Fig. 10*a*, *b*)

11. **Notopterus chitala** (Ham.)

(Plate 5, Fig. 11*a*, *b*)

The epithelium is broad and several layers in thickness, and the first two layers of cells are actively concerned in secretion as can be inferred from the presence of vacuoles and secretory granules in them. These cells burst and discharge their contents into the lumen, become spent out and the lower layers of cells take up their place and elaborate secretions (Plate 5, Fig. 10*b* and 11*b*). The epithelium is folded into villi-shaped projections such as are usually found in the intestine.

The submucosa is broad, vascularised possessing something like muscularis mucosa.

The muscles investing the submucosa are distinctly recognisable as consisting of an inner layer of circular and an outer layer of longitudinal muscle fibres.

12. **Mastacembelus armatus** (Lacép.)

(Plate 5, Fig. 12*a*, *b*)

The epithelium is comparatively narrow, being only two or three layers thick. The marginal epithelial cells are studded with secretory vesicles and form a conspicuous feature of the epithelium of *M. armatus.* Blood vessels are distributed under the epithelium abundantly. The cells in the secretory phase stain deeply and therefore stand out prominently to view.

The submucosa is moderately broad and vascularised. " Muscularis mucosa " is absent, but small bundles of muscles lie in the submucosa.

The investing layer of muscle fibres consist of an inner circular and an outer longitudinal layer, the former being somewhat discontinuous.

13. **Catla catla** (Ham.)

(Plate 5, Fig. 13*a*, *b*)

The cavity of the urinary bladder is double. Both are lined by an epithelium that is four or five cells thick. The cells are small in size, hexagonal in shape and bear small nuclei. The secretory vesicles are fewer in number, scattered at intervals and not disposed in groups. The capillaries penetrate up to the surface of the epithelial layer.

The connective tissue lying below is dense vascularised and strewn with strands of muscle fibres.

The investing layer of muscle fibres is thin, fibrous and loosely compact.

14. **Labeo rohita** (Ham.)

(Plate 6, Fig. 14*a*, *b*)

The lumen is single and lined by epithelium four or five cells deep. The cells are small but their nuclei are prominent (Plate 6, Fig. 14*b*). At certain places the epithelium is folded and not vascularised. The secretory vesicles occur in the marginal epithelium at varying levels.

There is a distinct strand of " muscularis mucosa " in the submucosa under the epithelium. The connective tissue is traversed by thin strands of muscle fibres and blood vessels.

The muscles lying below the submucosa are often in the form of small bundles, but they are not arranged as regularly as in some of the species decribed before. The longitudinal layer is inconspicuously thin.

15. **Cirrhtna mrigala** (Ham.)

(Plate 6, Fig. 15)

The epithelial folds are more prominently disposed than in *Labeo rohita*. In other respects, the structure of the urinary bladder of *Cirrhina mrigala* resembles that of *Labeo rohita*. The secretory vesicles are however less numerous.

The circular layer of muscle fibres is thick, but the longitudinal layer is less prominent to view.

16. **Rasbora rasbora** (Ham.)

(Plate 6, Fig. 16*a*, *b*)

The structure of the urinary bladder of this species is almost similar to that of *Cirrhina mrigala* but the secretory vesicles are not prominent as in other cases but some secretory material is found adhering to the free edge of the epithelium.

The submucosa is moderately broad with a distinct muscularis mucosa in it. The layer of circular muscle fibres is thick. The longitudinal muscle fibres are fairly well represented.

V—Discussion and Conclusion

(*a*) A short survey of the previous work

Conflicting views have been expressed in the past in regard to the homology, analogy, embryology and morphology of the urinary bladder of fishes in generai. Sedgwick (1905) casually mentions the bladder opening either into the rectum or on the summit of a papilla without referring to its structure in detail. Some excerpts from Goodrich (1931) will indicate the position obtaining to-day : " The morphology of the Teleostean ducts is very difficult to interpret, and the homology of the parts by no means yet established. " " The exact relation of the testicular canals and marginal canal to the mesonephric tubules and peritoneal funnels has not yet been satisfactorily described in various groups of Pisces "

Goodrich opines that " from the combined, terminal ends of the ureters arises another diverticulum (urinary bladder) which becomes a receptacle for urine "

Parker and Haswell (1940) mention the occurrence in many fishes of a dilatation of the mesonephric duct *serving as a receptacle for urine*, thus becoming analogous to the allantoic bladder of the higher vertebrates.

Kingsley (1926) writes that " in most of the fishes, *the bladder arises by a fusion of the hinder ends of the wolffian ducts plus a part derived from the hinder end of the digestive tract* (*cloaca*), the wolffian ducts emptying into it and the whole opening to the exterior, usually dorsal and posterior to the anus. In the Dipnoi there is a diverticulum from the dorsal wall of the cloaca, anterior to the openings of the Wolffian ducts. This is usually called the urinary bladder but it may be homologous with the rectal gland of the Elasmobranchs "

According to Pfeiffer (1933), in the male of *Lepidosteus*, the vasa efferentia enter the kidney and join the malpighian bodies, then through the urinary tubules, they open into the Wolffian duct. From the Wolffian duct, the sperms pass into the " bladder " which opens on a small papilla posterior to the anus. He further describes that along the dorsal " horns" of the bladder are small " pockets" where the urinary ducts enter. The Wolffian duct begins in a group of urinary tubules at the anterior end of the kidney, traverses the entire length on the outer, ventral border and posteriorly it joins with its mate to form an unpaired dilatation. This dilatation, he says, has been termed the ' Urinary bladder ' by Balfour and Parker (1882), a wrong terminology to be used for a structure which is embryologically derived from the Wolffian duct.

In the female of *Lepidosteus*, Pfeiffer finds the eggs passing directly into the oviduct which opens into the bladder on the summit of a papilla. *He asserts that this is the condition found in most teleosts.*

Owen (1938) describes the *Cyclothone* kidney as consisting of two parallel tubules, each starting from a Bowman's capsule, running backwards and posteriorly uniting together into a bladder which opens behind the anus. In the males, the testes possess no separate ducts and so Owen (1938) infers that *the semen is discharged through the bladder.* To describe the structure of the tubule and the bladder in his own words " Some portions have a droplet-like appearance as if to be pinched off into the lumen which suggests that these cells are engaged in some sort of apocrine secretion. The bladder is lined with a low cuboidal epithelium in which the curved tops of the cells give a characteristic biscuit-like appearance. A very thin coat of smooth muscles completes the structure "

(*b*) *Discussion*

A critical survey of the views expressed by the previous workers, together with the actual findings in several fishes belonging to different families results in the following conclusions :

If the " Urinary bladder " is a mere dilatation of the mesonephric duct, as expressed by Goodrich, Parker and Balfour, then the actual structure of it, as seen in the cases described above, does not justify such a belief because of the presence of the stratified epithelium with the secretory cells, submucosa and muscular layers in it. The actual findings are more in conformity with Kingsley's point of view that the " urinary bladder " is partly formed from the posterior end of the rectum, or as he himself puts it, " the cloaca " It would be more appropriate to regard it as having been derived from the terminal end of the rectum, because, the cloaca is not universally present in all the teleosts as assumed by Kingsley and shown here. The studies by the present author on the urino-genital organs of several species of freshwater teleostean fishes tend to disprove the assumption of Kingsley. Moreover, cloaca represents a part of the external world into which the urinary, genital and anal openings lie. Judging from his own statement, it becomes doubtful whether the dilatation of the bladder is formed partly from the Wolffian duct (or the mesonephric duct) and partly from the cloaca. Kingsley has expressed the view that in teleosteans, the pronephric (archinephric) duct does not split into the Wolffian and the Mullerian ducts. If so,

then Goodrich's view that it is a dilatation of the mesonephric duct becomes more plausible. But to call it an " urinary bladder " looks like a terminological inexactitude as Pfeiffer has pointed it out, for, embryologically this structure is not the same as that found in higher vertebrates. In the Amniotes, the allantois forms the bladder and the ureters are not direct descendents of the pronephric ducts. In Amphibia, the bladder is an inpushing from the ventral wall of the cloaca, and there is a striking resemblance between the structure of this organ as found in the Amphibia and that in the Teleostean fishes described here. But in the former, the ureters do not directly open into the bladder, while in the latter there is a direct connection between the two. Moreover, in some species like *Hilsa ilisha*, the bladder is a continuation of the ureters. The important point to bear in mind is that all Teleostean fishes do not possess a cloaca. Therefore, it can be safely asserted that this structure that is found in all the Teleosteans may be an inpushing for aught we know from the terminal, ventral portion of the rectum, which acquires connexion with the ureters. This conclusion will be in harmony with what Sedgwick wrote that in some fishes, the ureters open into the rectum. The strong point in support of the urinary bladder being an outgrowth from the wall of the rectum lies in the fact that there is a strong resemblance between the histological appearance of the rectum and the urinary bladder. Histologically the structure of the *ureter* or the *cloaca* is not in concord with the histological picture of the urinary bladder. Therefore, the urinary bladder cannot be regarded as having been derived from the ureter or the cloacal wall. The presence of secretory granules and goblet cells strongly suggest that far from being merely a " receptacle for urine " as stated by Parker and Haswell, it may be concerned in some kind of secretory and absorptive activities also. The presence of a stratified epithelium with abundant secretory cells in the urinary bladders of the species investigated shows that this structure is not merely a receptacle for holding urine. Moreover, sections show the haze of the secretions in the lumen, (*e.g.*, *Notopterus notopterus* and *N. chitala*) (Plate 5, Figs. 10 *a* and *b* ; 11 *a* and *b*), and in some cases, even proof of holocrine secretion exists as testified by the discharge of cells, nuclei and erythrocytes into the lumen (*e.g.*, *Hilsa ilisha* and *Mystus aor*) (Plate 3, Fig. 4*b*; Plate 4, Fig. 7*b*). The signs of secretory activity as well as the high degree of vascularization of the epithelium lead us to infer that the bladder is more than a mere reservoir for the storage of urine, but concerned in secretory and absorptive activities also.

In the migration of fishes from the sea to the fresh-waters or vice-versa, it is the urino-genital organs, especially the renal organs, that have suffered change because they are osmo-regulatory in function. Thus, the kidney has been subjected to a lot of strain. In order to minimize this, the bladder may have taken on itself part of the osmo-regulatory function. The fact that its epithelium is highly vascularised and the cells are engaged in apocrine and holocrine secretory activities is a pointer in this direction. It may serve as a receptacle for urine but it may also be eliminating certain salts and absorbing water from the urine. It may not be out of place to mention here that a rounded mass of highly vascular tissue is found in close association with the inner epithelium of the urinary bladder in *Ophiocephalus gachua* (Plate 3, Fig. 1*a*).

The evolution of this osmo-regulatory mechanism may have taken place in more than one step. In the first place, it was necessary to increase the blood supply to the urinary bladder. Unless this happened, the mechanism of elimination of salts and the absorption of water from the urine could not have been perfected. So the Ophiocephalidae represent the first step in this direction. In them, the epithelium is several layers thick, traversed by numerous capillaries that reach almost the free edge and even islands of blood cells are formed (Plate 3, Figs. 1*a*, *b*, and 2*b*). The next step in the evolution of this mechanism is represented by *Hilsa ilisha* (Plate 3, Fig. 4*a*, *b*) where several of the cells of the epithelium are engaged in apocrine secretion or both holocrine and apocrine secretion (Plate 4, Fig. 9*b*) as seen in *Eutropiichthys vacha*. Recent work in cytohistology have shown that secretory and absorptive cells belonging to a common epithelium may exist side by side but may be demarcated from one another by physiological functions. Hence, it may notbe wrong to infer that some of the cells of the epithelium are serving for absorbing water from the urine stored in the urinary bladder.

VI—SUMMARY

1. The structure of the urinary bladder as found in sixteen species of fresh-water fishes is given.

2. The histology of the urinary bladder of these fishes has been described for the first time.

3. Comparisons have been made between the structure of the urinary bladder as found in the sixteen species and the difference brought out.

4. It has been shown that the histology of the urinary bladder resembles that of the rectum.

5. Facts have been brought to light disproving that it had been derived from the cloaca or the urinary ducts.

6. Lastly, it has been suggested that this structure may be performing osmo-regulatory functions, besides being a receptacle for urine.

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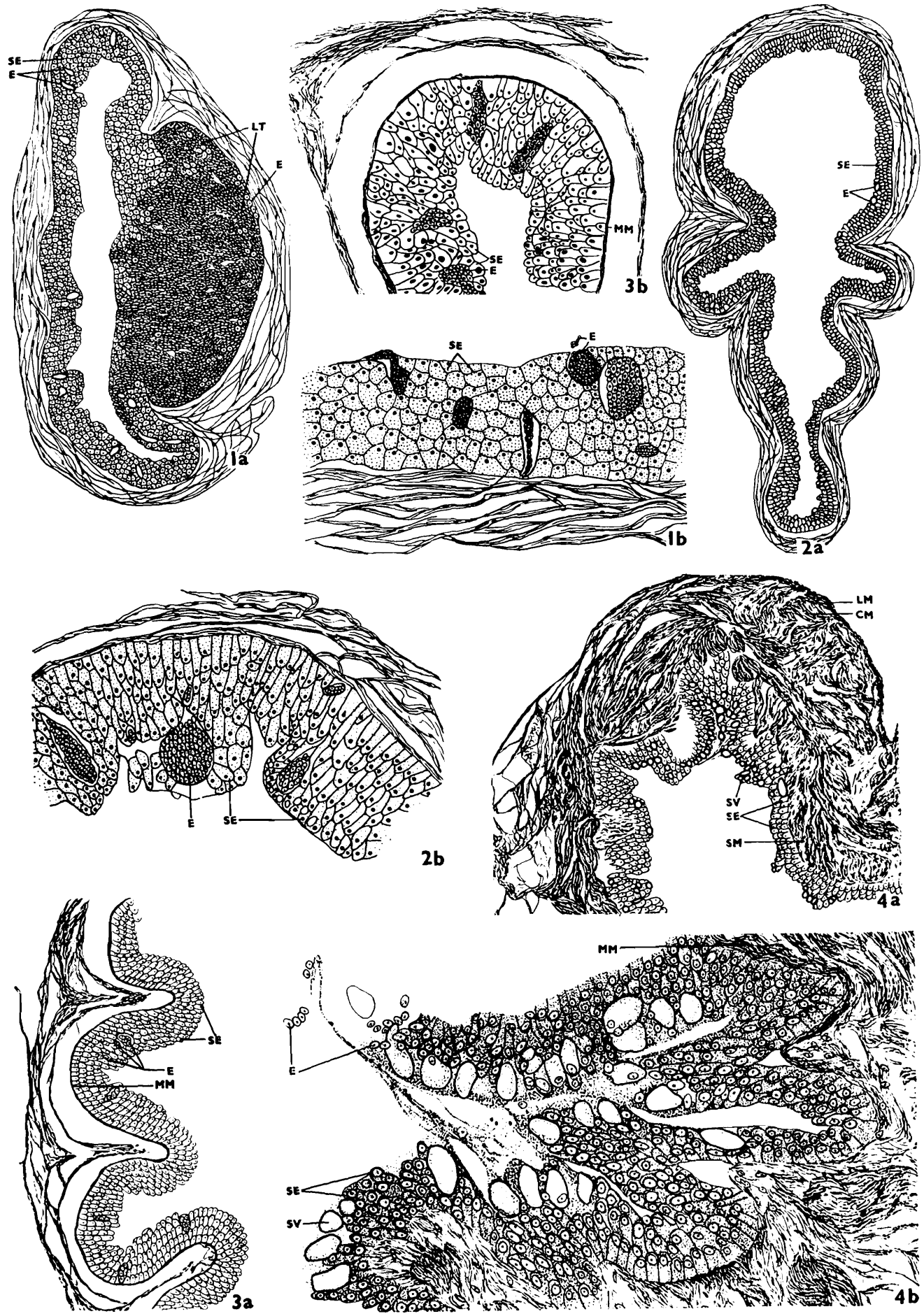
PLATE 3

Transverse sections of the urinary bladder of the following teleostean fishes :—

FIG. 1*a*. *Ophiocephalus gachua* . . . . ×40.
FIG. 1*b*. *Ophiocephalus gachua* . . ×196·6.
FIG. 2*a*. *Ohpiocephalus punctatus* . . . ×40.
FIG. 2*b*. *Ophiocephalus punctatus* . . . ×196·6.
FIG. 3*a*. *Ophiocephalus marulius* . . . ×40.
FIG. 3*b*. *Ophiocephalus marulius* . . . . ×196·6.
FIG. 4*a*. *Hilsa ilisha* . . . . . ×40.
FIG. 4*b*. *Hilsa ilisha* . . . . ×196·6.

Abbreviations

CM., circular layer of muscle fibres
E., erythrocytes
LM., longitudinal layer of muscle fibres
LT., lymphoidal mass
MM., muscularis mucosa
SE., stratified epithelium
SM., submucosa
SV., secretory vesicles



Transverse sections of the urinary bladder of teleostean fishes.

PLATE 4

Transverse sections of the urinary bladder of the following teleostean fishes :—

FIG. 5*a*. *Heteropneustes fossilis* . . . . ×40.
FIG. 5*b*. *Heteropneustes fossilis* . . . . ×196·6.
FIG. 6*a*. *Clarias batrachus* . . . . ×40.
FIG. 6*b*. *Clarias batrachus* . . . . . ×196·6.
FIG. 7*a*. *Wallago attu* . . . . ×40.
FIG. 7*b*. *Wallago attu* . . . . . ×196·6.
FIG. 8*a*. *Mystus aor* . . . . . ×40.
FIG. *8b*. *Mystus aor* . . . . . ×196·6
FIG. 9*a*. *Eutropiichthys vacha* . . . ×40.
FIG. 9*b*. *Eutropiichthys vacha* . . . . . ×196·6.

Abbreviations

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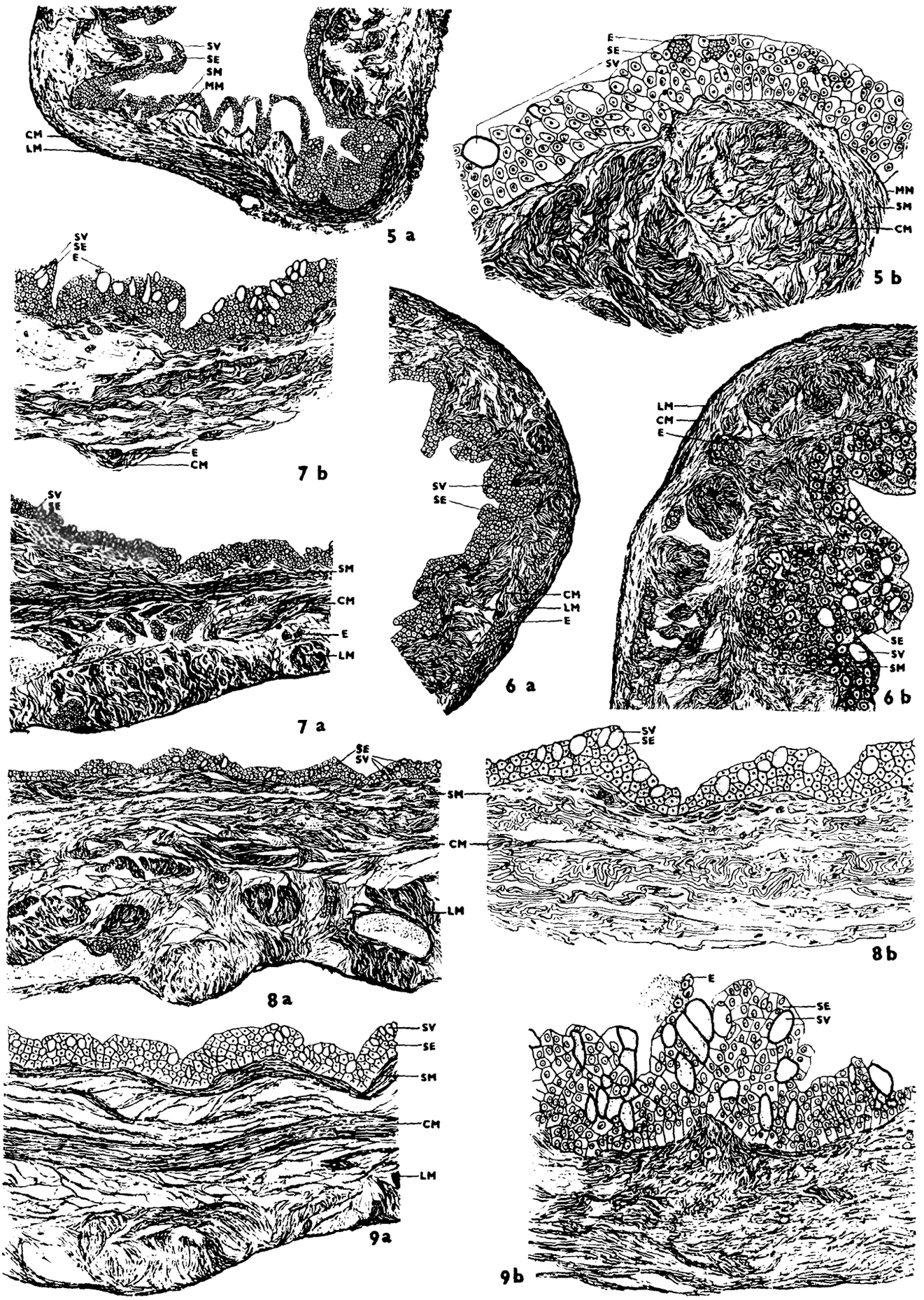

Transverse sections of the urinary bladder of teleostean fishes.

PLATE 5

Transverse sections of the urinary bladder of the following teleostean fishes :—

FIG. 10*a*. *Notopterus notopterus* . . . × 40.
FIG. 10*b*. *Notopterus notopterus* . . × 196·6.
FIG. 11*a*. *Notopterus chitala* . × 40.
FIG. 11*b*. *Notopterus chitala* . . . × 196·6.
FIG. 12*a*. *Mastacembelus armatus* . × 40.
FIG. 12*b*. *Mastacembelus armatus* . . × 196·6.
FIG. 13*a*. *Catla catla* . × 40.
FIG. 13*b*. *Catla catla* . × 196·6.

Abbreviations

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E., erythrocytes
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SE., stratified epithelium
SM., submucosa
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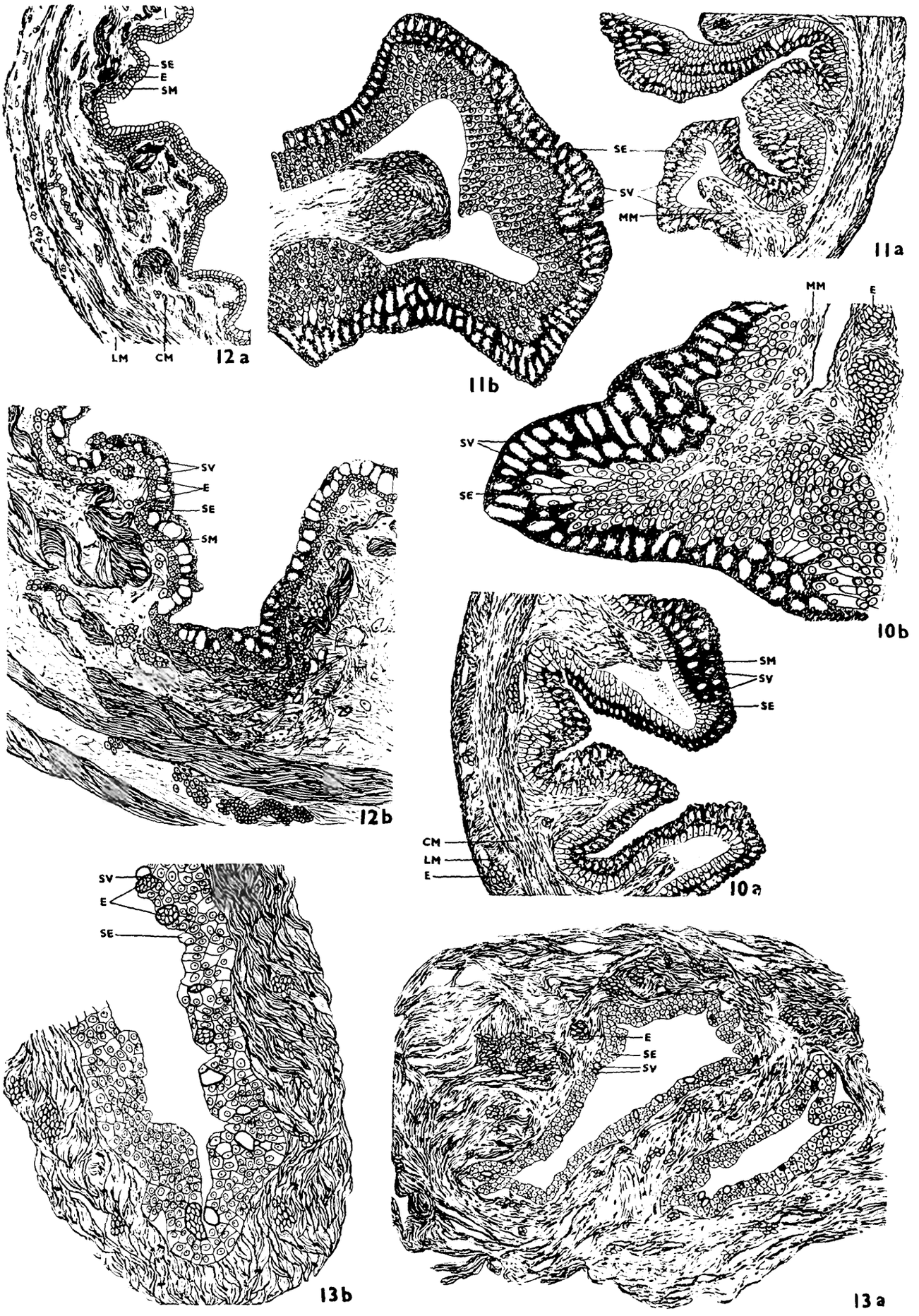


Transverse sections of the urinary bladder of teleostean fishes.

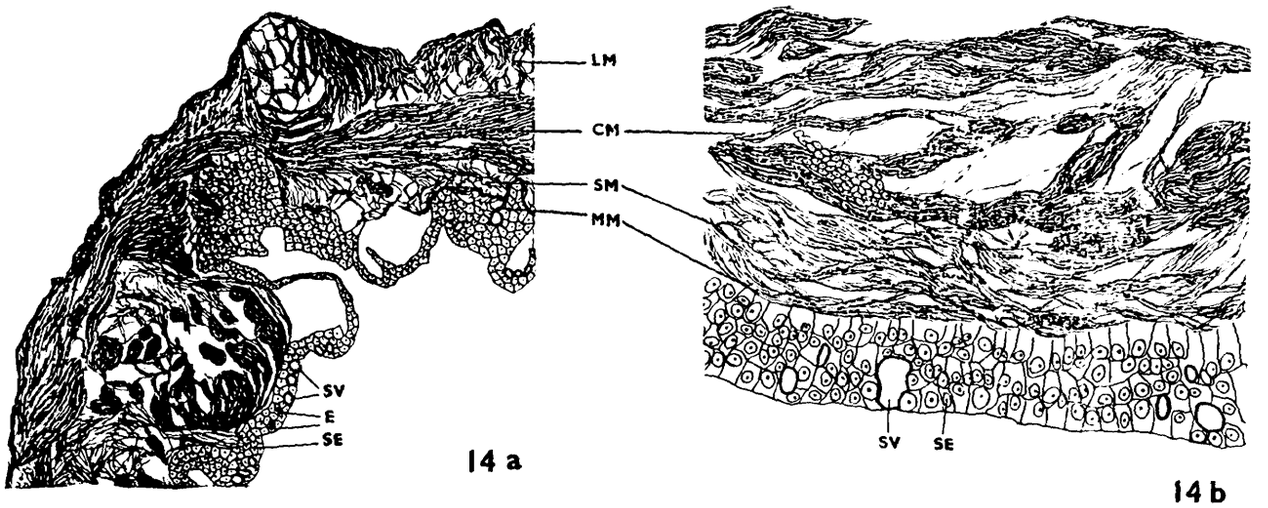
PLATE 6

Transverse sections of the urinary bladder of the following teleostean fishes :—

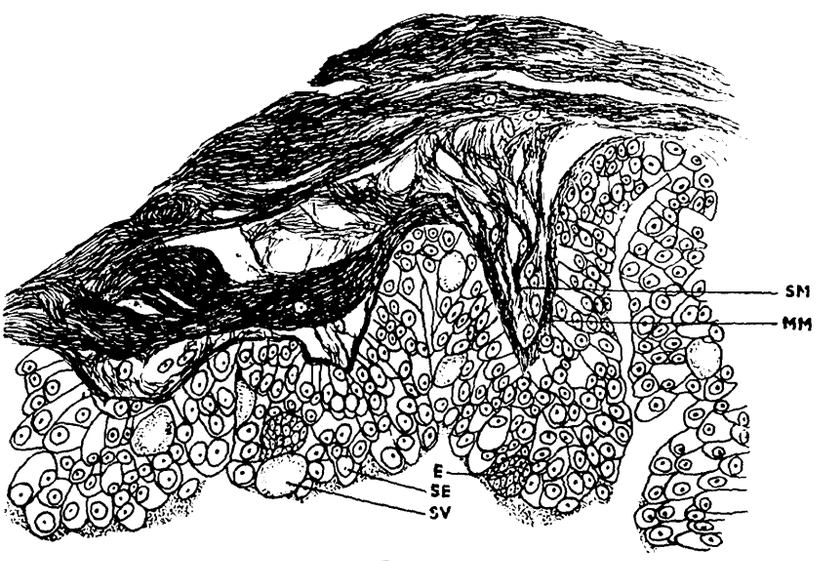
FIG. 14*a*. *Labeo rohita* . . . × 40.
FIG. 14*b*. *Labeo rohita* . . . . . × 196·6.
FIG. 15. *Cirrhina mrigala* . . . . . × 196.6.
FIG. 16*a*. *Rasbora rasbora* . . . . . × 40.
FIG. 16*b*. *Rasbora rasbora* . . . . . × 196·6.

Abbreviations

CM., circular layer of muscle fibres
E., erythrocytes
LM., longitudinal layer of muscle fibres
LT., lymphoidal mass
MM., muscularis mucosa
SE., stratified epithelium
SM., submucosa
SV., secretory vesicles



14 a 14 b



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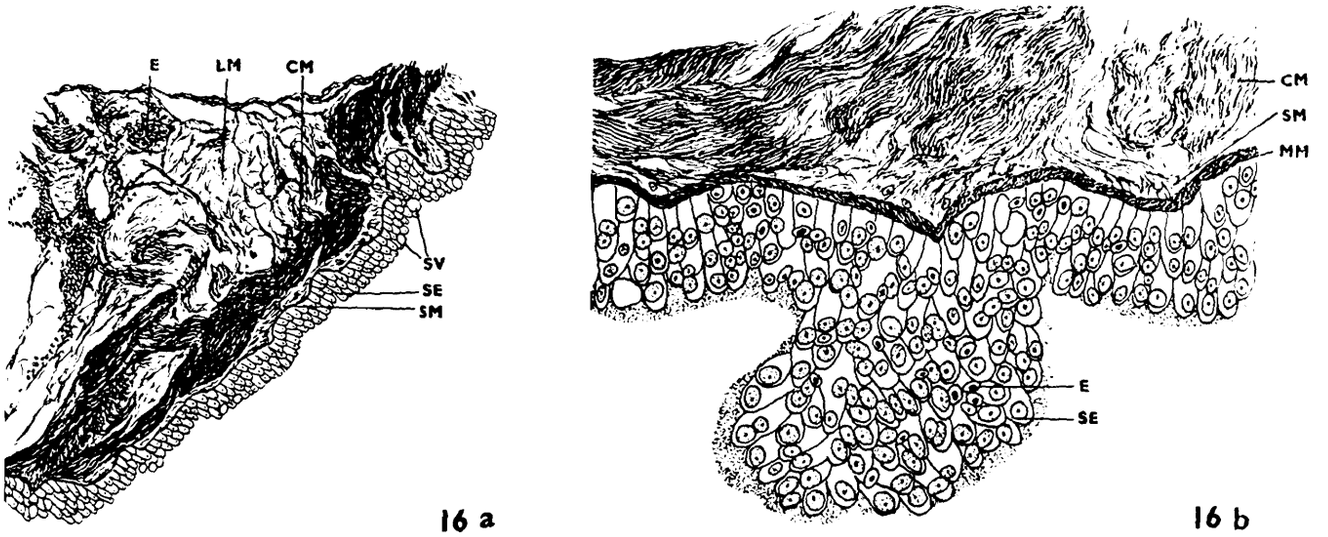


16 a 16 b

Transverse sections of the urinary bladder of teleostean fishes.

SOME NEW OR A LITTLE KNOWN SPECIES OF COCCINELLIDAE (INSECTA : COLEOPTERA)

PART 1—FOUR NEW SPECIES OF EPILACHNINAE FROM INDIA AND BURMA

By

A. P. KAPUR

Zoological Survey of India, Calcutta

(With 4 Text-figures)

While identifying the unnamed and rearranging the named collections of the subfamily Epilachninae (Coccinellidae, Coleoptera) in the Zoological Survey of India, I came across some interesting material belonging to four new species which are described in the following pages. Of these, two species come exclusively from India, namely, *Epilachna ornata* from Anaimalai Hills (southern India), and *Afissa cherrapunjiensis* from Khasi Hills (Assam). *Afissa sureilica* comes from Darjeeling district (West Bengal) ; its variety *marginotata* occurs in Ruby Mines (northern Burma) and was found in the unnamed collections on loan with me from the British Museum (N. H.), London. The fourth species, namely, *Afissa gokteika*, is known only from Gokteik, northern Burma.

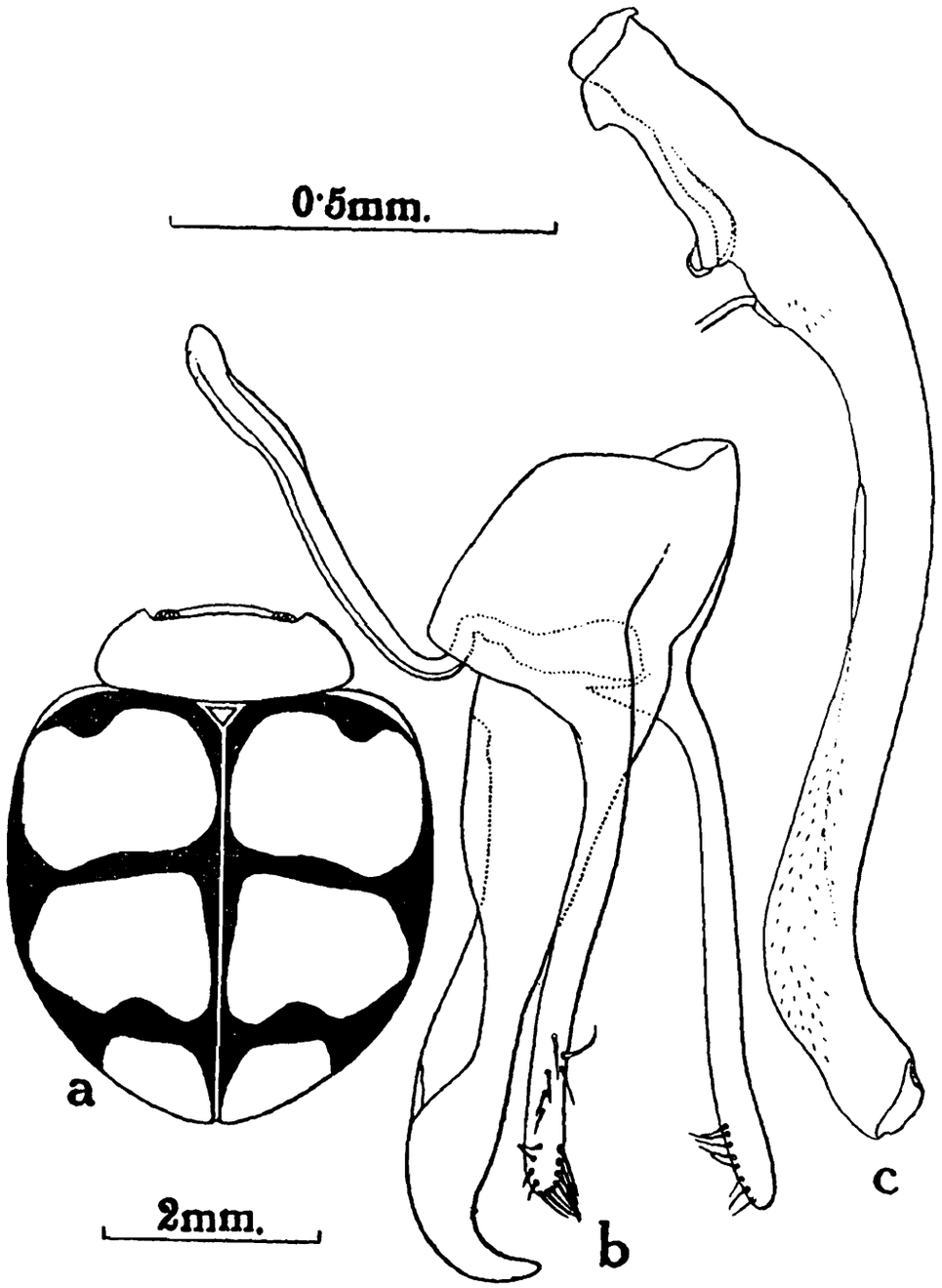
I am grateful to Dr. M. L. Roonwal, Director of this Survey for kindly providing facilities for this work.

Epilachna ornata, sp. nov.

(Text-fig. 1)

Body shortly oval (Text-fig. 1*a*) and moderately convex ; pubescence yellowish grey except in the black areas of the elytra, metasternum, etc. Head testaceous except the black eyes and the dark brown apices of mandibles. Pronotum testaceous in the middle, light testaceous laterally, especially near the anterior angles ; without spots or markings. Scutellum testaceous. Elytra also testaceous except for the narrow, black areas as shown in text-fig. 1*a*. Greater part of the basal margin, the suture, and the basal three-fourths of the lateral margin are bordered black; a narrow black fascia runs across the middle of body and reaches the lateral black borders on the elytra ; another, though slightly bent and irregularly wide, fascia runs across at three-fourths of the length of elytra. Thus, each elytron is ornamented with one large, basal cell, one large sub-median cell, and one small apical but incomplete cell. Under-side testaceous, excepting most of the basal parts of the metasternum and the first two abdominal sternites.

Head with the eyes finely faceted, punctation fine and rather sparse, pubescence very fine and moderately long ; antennae nearly as long as the width of head and with the terminal three segments formed into a subserrate club ; labrum wide, about three times as wide as long, covering the mandibles except the apices. Pronotum a little over twice as wide as long, subrounded and narrowly margined laterally, rather deeply emarginate in the front ; finely and fairly closely punctured ; pubescence fine, fairly close, moderately long and semierect. Scutelium



TEXT-FIG.—1. *Epilachna ornata*, sp. nov.

(*a*). Outline and colour-pattern of the beetle. (*b*). Male genitalia except the siphо. (*c*). Sipho. (2 mm. scale for fig. *a* ; 0.5 mm. scale for figs. *b* and *c*).

small, triangular, nearly as wide at base as at the sides, with about eight fine punctures and hair. Elytra widely rounded at the shoulder angles, with rather well-defined shoulder-boil, narrowly margined laterally except towards the apex which is rounded ; punctation of the mixed type, coarser punctures impressed, sparse, and interspersed all over

among the more closely placed, fine and shallower punctures ; pubescence moderately long, fairly close and sub-erect. Underside with fine and close punctation and subdepressed, generally short, and fairly close pubescence except on the thoracic sternites where the punctures are relatively coarse and sparse. Elytral epipleurae slightly but uniformly depressed, without foveae ; legs (when in repose) not extending beyond the elytra, claws bifid, the outer division being a little longer than the inner, basal tooth subtriangular and short ; abdominal lines subrounded, complete, subterminal, reaching as far as the apical four-fifths of the length of the abdominal sternite ; the second to fifth sternite subequal, the sixth sternite subrounded, notched at the apex in the male. Male genitalia (Text-fig. 1*b*, *c*), asymmetrical ; sipho tubular, slightly twisted, sigmoid, with an ill-defined and narrow siphonal capsule ; basal piece distinctly wider than long, median-lobe destinctly asymmetrical, twisted in the middle, narrowed towards the apex which is bent towards the parameres ; the latter rather narrow throughout, slightly curved proximally and provided with a few small setae near the apices.

Length 5.00 mm. ; width 4.00 mm.

Holotype.—A male from INDIA, Anaimalai Hills, Cinchona, 3,500 ft. iv. 1957 (*P.S. Nathan* coll.) ; in the Zoological Survey of India, Calcutta (Regd. No. 1159/H4).

Remarks.—This species is very attractive in the colour pattern of the elytra and remiuds one of several other species which occur in the hills and other places in southern India, and which have similar coloration though different in exact design of the markings and other details of the structure. It may be distinguished from *Epilachna delessertii* (Guerin) by its smaller size (*E. delessertii* is 7.8-8.3 mm. long and about 6.1 mm. wide), relatively coarser punctures and sparse and long pubescence. The male genitalia in the two are very distinct and the median lobe of aedeagus in *E. delessertii* is symmetrical. *E. ornata* bears superficial resemblance to *Afissa andrewesi* (Gorham), *Afissa endomycina* (Gorham), and *Afissa loculosa* (Sicard) in as much as all these species have black fasciae and stripes on the elytra instead of the usual black spots, etc., so common in other species of the genus. However, *E. ornata* has a distinctive elytral pattern and could also be easily distinguished from the above-mentioned three species of *Afissa* on account of the presence of the tooth at the base of bifid claws. Incidently it may be mentioned that hitherto *Afissa loculosa* has been placed in the gunus *Epilachna* but an examination of a fairly long series shows that it does not belong to that genus (*sen. str.* as revised by Dieke[1]) but to the genus *Afissa* Dieke.

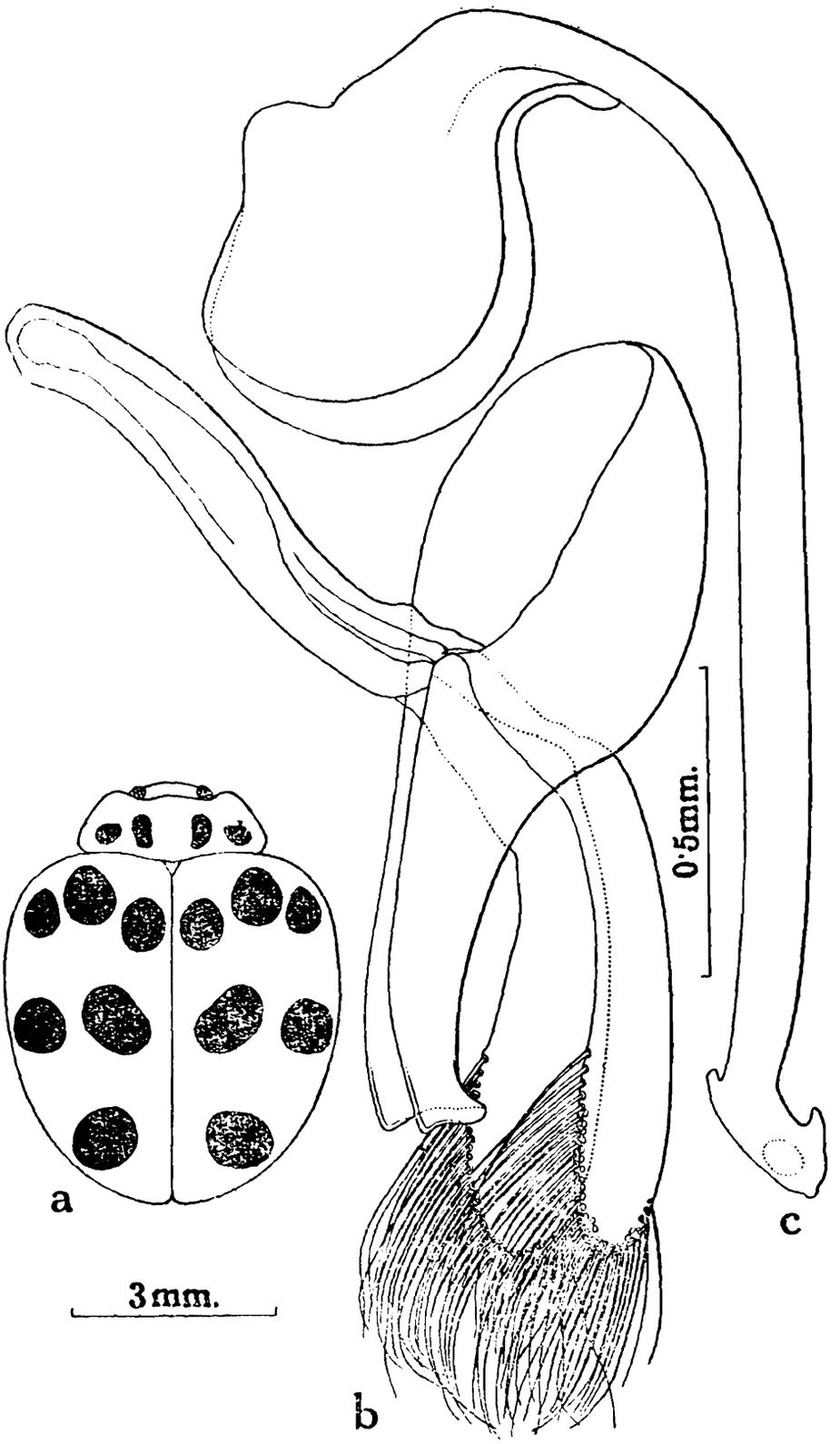
Afissa cherrapunjiensis, sp. nov.

(Text-fig. 2)

Body shortly oval (Text-fig. 1*a*) ; moderately convex, most so in the middle ; pubescence greyish except on the black elytral spots where it is black. Head reddish testaceous except the dark brown apices of mandibles and the black eyes. Pronotum reddish testaceous with four black to dark fuscous spots arranged in a transverse row, the median pair oblong, situated at equal distance from the longitudinal median line

[1]Dieke, G.H. *Smithson. misc. Coll.*, Washington, **106** (15), p. 22 (1947).

and the lateral pair which is subrounded. Scutellum reddish testaceous. Elytra also reddish testaceous except for six spots on each elytron arranged as 3, 2, 1 ; the outermost of the basal three spots roundish, situated



TEXT-FIG. 2.—*Afirsa cherrapunjiensis*, sp. nov.

(*a*). Outline and colour-pattern of the beetle. (*b*). Male genitalia except the sipho. (*c*). Sipho. (3 mm. scale for fig. *a* ; 0.5 mm. scale for figs. *b* and *c*).

below and external to the shoulder-boil and narrowly separated from the external margin ; the central spot larger, subovate, situated lateral to the shoulder-boil and closer to, though not touching, the basal margin ; the

inner spotroundish like the outer one, situated closer to the suture and more distant from basal margin than either of the other two spots. The next two spots on the elytron lie in a row on the median transverse line ; the inner of these spot subquadrangular, situated a little away from the suture, and directed obliquely towards the shoulder-angle of the elytron, the outer spot a little smaller, rather transverse-oval, close to, but not quite touching the external margin. The subapical or the sixth spot largest, sub-rounded, situated at equal distance from the sutural and external margin. Underside dark-brown, excepting the metathorax and the first two abdominal sternites which are fuscous medially.

Head finely and closely punctate on the front, the punctures becoming slightly coarser near the vertex; pubescence short and fairly close ; eyes finely faceted ; antennae long, extending a little beyond the apex of prosternum, the club subserrate on the inner side ; mouth-parts with the labrum relatively short, transverse, about three times as wide as long. Pronotum transverse, widely emarginate in front, distinctly narrower anteriorly, anterior and posterior angles rounded, lateral margins almost straight ; punctation similar to that on the vertex of the head, close and uniform ; pubescence moderately long and fairly close. Scutellum equilaterally triangular, with fine, fairly close punctation and pubescence. Elytra widely rounded at the anterior angle, shoulder-boil moderately defined, external margin forming a shallow channel except in the apical one-fourth of its length ; punctation of the mixed type, coarser punctures fairly impressed, sparse and interspersed among the more closely finer and impressed punctures ; pubescence moderately long and subdepressed. Underside with fine, to moderately coarse and sparse punctures and thin, rather short and depressed pubescence ; elytral epipleurae shallowly foveolate, the foveae not separately defined for the femora ; legs (when in repose) not extending beyond the elytral epipleurae ; inner division of the bifid claws slightly shorter than the outer which is otherwise similar ; abdominal lines widely curved, terminal and incomplete ; the second to sixth abdominal sternites subequal, the last being truncate apically. Male genitalia (Text-fig. 2*b*,*c*) relatively short, the sipho gradually bent proximally, narrow and straight in the middle and obliquely bent near the apex as shown in the figure, the siphonal capsule roundish ; basal-piece cup-shaped, median-lobe like an incomplete tube, open ventrally for the most part, about 0·75mm. long and 0·25 mm. wide at the base, the apex truncate to slightly emarginate, slightly bent towards parameres ; the latter subspatulate, gently bent at one-third their length, distinctly longer than the median lobe and provided with many long setae at the apical one-third, especially along the margin ; trabes also well developed, somewhat sigmoid. Length 5·5 mm., width 4.6 mm.

Holotype.—A male from INDIA : Assam, Cherrapunji, 4,400 ft., 2-8.x.1914, (*S.W Kemp* Coll.) ; in the Zoological Survey of India, Calcutta (Regd. No. 11600/H4).

Remarks.—This species is easily distinguished from all other species of the genus *Afissa* by its unique colour-pattern of the pronotum and elytra, namely, the four black spots in a transverse row on the pronotum and the elytral spots arranged as 3, 2, 1. Its nearest ally may be *Afissa intermixta* Dieke[2] described from Dibrugarh, Assam, which has three spots on the pronotum (one central and one each close to the lateral

[2]Dieke, G.H., *loc. cit.*, p. 156.

margin) and seven dark spots on each elytron, *i.e.*, it has an additional apical spot ; the arrangement and relative size of the spots is, however, different from those in *A. cherrapunjiensis* ; moreover, *A. intermixta* is a smaller species, being 4·8 mm. in length. From the shape of the male genitalia *A. cherrapunjiensis* would appear to belong to the *complicata* group of the species of *Afissa*, and not to the *fallax* group to which *intermixta* belongs. In respect of colour-pattern and details of structure of the male genitalia *cherrapunjiensis* is distinct from all other known species of the *complicata* group.

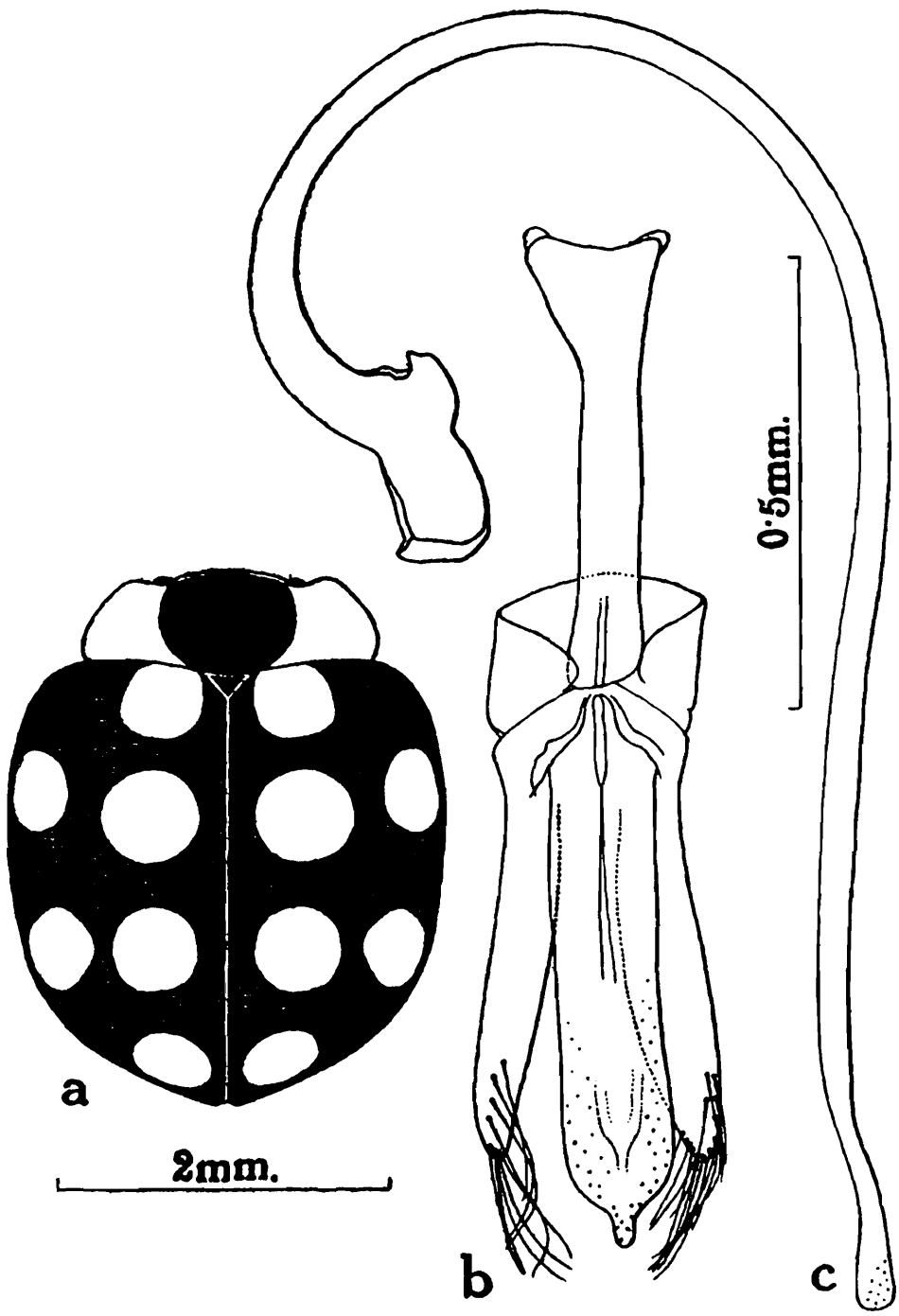
Afissa sureilica, sp. nov.

(Text-fig. 3)

Body shortly oval (Text-fig. 3*a*), rather strongly convex, pubescence uniformly dirty-grey. Head in the male mostly reddish testaceous excepting the greyish black eyes, dark-brown club of antennae, and apices of mandibles ; vertex also piceous in the female. Pronotum reddish testaceous laterally, black, fading into dark-brown, in the median one-third. Scutellum black. Elytra black excepting six testaceous or reddish testaceous, roundish spots on each elytron, arranged as 1, 2, 2, 1 (Text-fig. 3*a*). Spot No. 1 situated at the base, close to scutellum but not touching the latter, extending to about one-sixth the length of elytron and much beyond the apex of scutellum ; spot No. 2 (near suture) and No. 3 (near external margin) situated slighly anterior to the transverse medium line ; spot No. 2 roundish, lies close to, but not touching, the suture ; spot No. 3 roundish to rather transverse-oval, a little variable in size and outline, not touching the external margins in the type ; spot No. 4 (near suture) and No. 5 (near external margin) situated a little posterior to the transverse median line of the elytron, spot No. 4. subrounded, not touching the suture ; spot No. 5 similar and not touching the lateral margin in the type ; spot No. 6 roundish, subapical not touching the sutural, nor, the apical margins in the type. Underside reddish testaceous excepting the meso-and metasternum, and the basal two or three abdominal sternites which are black to piceous ; the femora sometime fumeus.

Head with the punctation fine, impressed and fairly close ; the pubescence fine, moderately short and close ; eyes finely faceted ; antennae nearly as long as the width of head, club subserrate with the apical segment obliquely truncate ; labrum a little over twice as broad as long, a little emarginate in front and not covering the apices of mandibles, the latter with a pair of unequal apical teeth. Pronotum nearly twice as broad as long, slightly narrowed anteriorly, widely emarginate in front, anterior and posterior angles rounded, lateral margins slightly so ; punctation and pubescence similar to that of the head. Scutellum small, like an equilateral triangle in outline, with very fine punctation and pubescence. Elytra strongly convex, without any well-defined shoulder-boil ; external margin marked with a narrowly chanelled border except near the apex ; apical angle rounded ; punctation of the mixed type, finer punctures moderately close but less impressed, coarser punctures fewer, shallow, irregular in outline, interspersed

between the finer punctures ; pubescence short, subdepressed and moderately close. Underside with the prosternum finely and sparsely punctate, meso- and metasternum with moderately coarse punctures except in the middle of the latter where these are coarse and much impressed ; pubescence on the thoracic sternites very fine and sparse, legs (in repose)



TEXT-FIG. 3.—*Afissa sureilica*, sp. nov.

(*a*). Outline and colour-pattern of the beetle. (*b*). Male genitalia except the sipho. (*c*). Sipho. (2 mm. scale for fig. *a* ; 0.5 mm. scale for figs. *b* and *c*).

not extending beyond the epipleurae, the inner two divisions of the bifid claws subequal in length, the inner division slightly stouter ; elytral epipleurae shallowly depressed, without any foveae ; abdominal sternites with coarse, fairly close, and impressed punctures on the first sternite and finer and close punctures on the remaining sternites which

are subequal ; abdominal lines semicircular rather imcomplete and subterminal, reaching as far as four-fifths of the length of the first sternite ; the terminal, or the sixth sternite rounded apically in both sexes. Male genitalia (Text-fig. 3*b*, *c*) with the basal-piece wider than long, trabes very much elongate, sigmoid in outline when seen in profile , median-lobe of aedeagus about five times as long as broad, narrowed and rounded distally and produced forward a little into a narrow apex ; parameres a little shorter than the median lobe, with long hair near the apices ; sipho (Text-fig. 3*c*) long, widely curved in the proximal half, almost straight distally, siphonal capsule subrectangular, apex of sipho slightly rounded and clubbed. Female with the genital plates elongate but not quite so narrow distally, a little over twice as long as wide.

Length 3·3 mm. ; width 2·6 mm.

Holotype.—A male from INDIA : Sureil, (*ca.* 5,000 ft.), (near, " Mangpu " [Mongphu], Darjeeling district, northern West Bengal, iv-v. 1917 (*S. W Kemp* coll.), in the Zoological Survey of India (Regd. No. 11603/H4).

Allotype.—A female with the same data as the holotype, also in the Zoological Survey of India (Regd. No. 11604/H4).

Paratype.—One with the same data as the holotype ; in the Zoological Survey of India (Regd. No. 11605/H4).

Remarks.—The general colour pattern and arrangement of elytral spots of *A. sureilica* are like those in *Afissa lugubris* Dieke known from Kiautschau, China. The latter species is, however, larger, measuring, 6·0 mm. in length and has an indistinct lighter margin all round the pronotum ; the reddish-brown elytral spots (1, 2, 2, 1) are relatively smaller and indistinct in outline. Dieke[3] compares *Afissa pembertoni* (Crotch) (originally described from Bhutan but further example seen by me from Cherrapunji, *ca.* 4,000 ft., Khasi Hills, Assam) with *A. lugubris*. *A. pembertoni* is also a larger species, being about 6·0 mm. long, and has reddish-brown elytral marking but its apical elytral spots are united and occupy the suture ; in outline of the body, *pembertoni* is distinctly narrowed posteriorly unlike *A. sureilica* in which the sides are rather subparallel ; the pronotum in *A. pembertoni* is black except for a small reddish patch near each anterior angle. *A. sureilica* is, therefore, easily separable from *A. lugubris* and *A. pembertoni*. It can also be easily distinguished from *Afissa marginicollis* (Hope) which is a larger species (6·7-7·5 mm. long and 4·5-5·2 mm. wide) and which has seven testaceous spots on each elytron instead of the six as in *A. sureilica*. The two species also differ in the character of punctation (more impressed in *A. marginicollis*) and structure of male genitalia.

Afissa sureilica var. **marginotata,** var. nov.

This variety differs in the elytral pattern from the typical form described above. In all the five examples from Ruby Mines, Burma, the external three testaceous spots (No. 3, 5 and 6) are so enlarged as to reach the external margin of the elytron unlike the case in all the three examples from Sureil, district Darjeeling, India. In all other respects the material from the two countries looks alike. It is quite possible that

[3]Dieke, G.H., *loc. cit.*, p. 157.

when more material becomes available from several parts of north-eastern India and northern Burma intermediate examples may be found but for the present, it seems desirable to regard the Burmese examples as belonging to a distinct variety.

Material. Five examples from BURMA : Ruby Mines (*Doherty* coll.) ; three in the British Museum (N.H.), London, and two (one dissected and partly on slide) in the Zoological Survey of India, Calcutta.

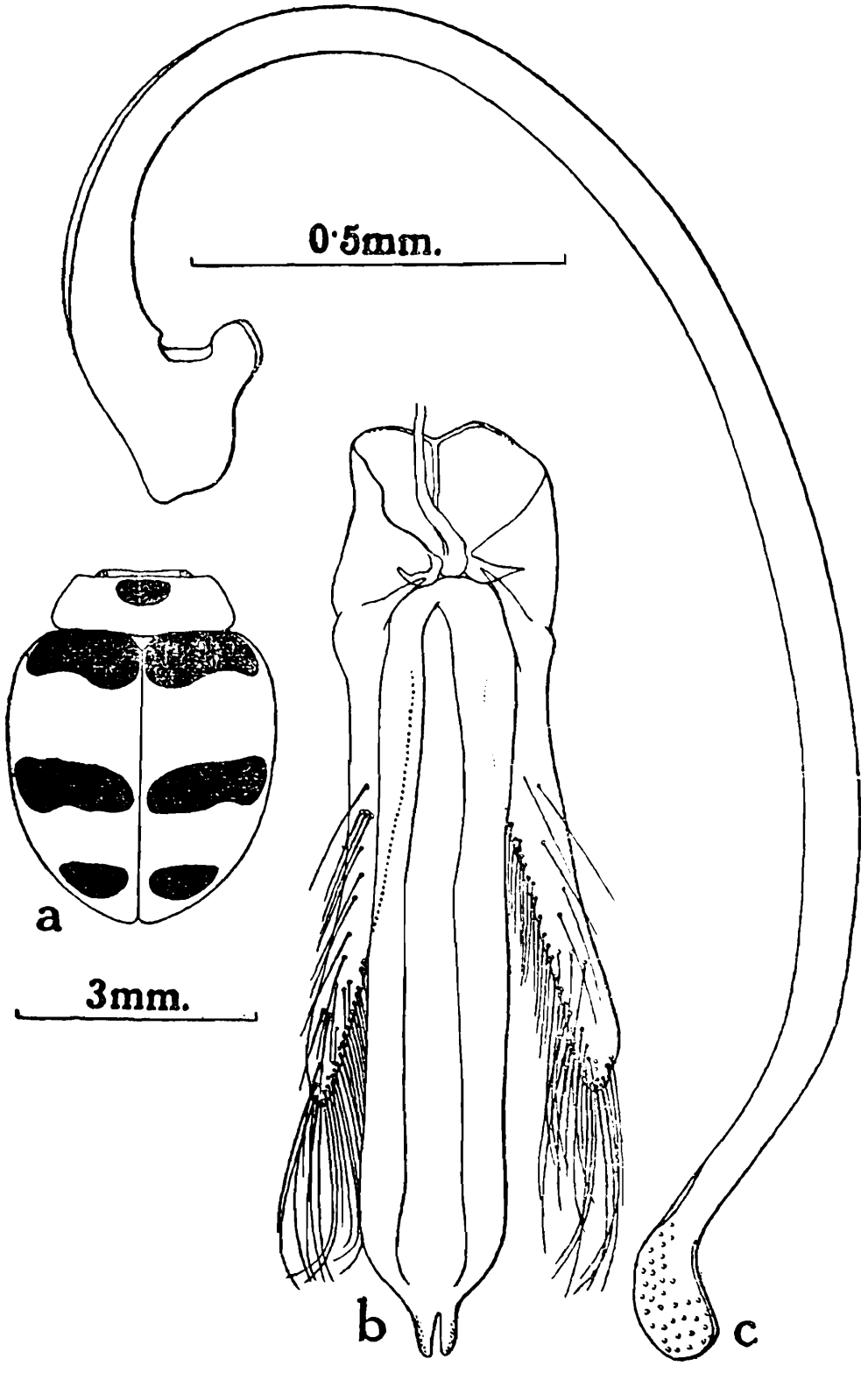
Afissa gokteika, sp. nov.

(Text-fig. 4)

Body oval, (Text-fig. 4*a*) and moderately convex ; pubescence yellowish grey except on the black areas where it is piceous. Head testaceous except for the black eyes, dark-brown apices of the mandibles and the two or three ill-defined black markings on the frons in the male ; in the female examples the frons uniformly testaceous, without such markings. Pronotum testaceous, with a transverse oval black spot near the middle of the anterior margin. Scutellum testaceous. Elytra testaceous, with three transverse bands or subfasciae ; the first or the basal band extends from the base to about one-fifth the length of the elytron, is slightly emarginate distally and runs transversely from about the sutural margin to cover the shoulder but not touching the lateral margin ; the second band situated along the middle of elytron, equal in width to the basal band but slightly narrowed near the suture ; the third or the subapical band transverse-oval, not reaching the sutural and lateral margins. Underside testaceous except the piceous metasternum, the median parts of first three abdominal sternites, and a narrow streak on each femora.

Head minutely and fairly closely punctate, punctures impressed ; pubescence fine, moderately long and close ; eyes finely faceted, antennae nearly as long as the width of the head, the terminal three segments forming a sub-serrate and obliquely truncate club ; labrum short, partly covering the distal half of the mandibles. Pronotum twice as wide as long, weakly emarginate in front, anterior and posterior angles rounded, the lateral margin slightly rounded ; punctation fine, impressed, and fairly close ; pubescence also fine, rather short, close and directed anterolaterally. Scutellum small, equilaterally triangular, with punctation and pubescence like that of pronotum. Elytra with clearly defined shoulder-boils, the shoulder angles rounded, external margin narrowly and rather shallowly channelled except near the apex where it is plain, the apical angles rounded ; punctation of the mixed type, the finer punctures like those on the pronotum though less impressed, the coarser punctures sparse, irregularly dispersed and moderately impressed ; pubescence fine, rather shorter and closer than that on the pronotum. Underside with the prosternum finely and fairly closely punctate and pubescent ; the meso- and metasternum with slightly coarser and sparser punctation ; legs with the outer division of the bifid claws slightly narrower and longer than the inner division ; elytral epipleurae shallowly depressed but without any foveae ; abdominal sternites unequal with mostly fine punctures and pubescence except in the middle where the

punctures are coarse ; abdominal lines subrounded, incomplete and subterminal ; the second, third and fourth abdominal sternites subequal the fifth sternite slightly longer and truncate distally in tke male, subrounded in the female ; the sixth sternite smaller and subrounded apically in both the sexes.



TEXT-FIG. 4.—*Afissa gokteika*, sp. nov.

(*a*). Outline and colour-pattern of the beetle. (*b*). Male genitalia except sipho. (*c*). Sipho. (3 mm. scale for fig. *a* ; 0.5 mm. for figs. *b* and *c*).

The male genitalia (Text-fig. 4*b*, *c*) with the basal-piece nearly quadrangular in outline, widely open proximally, median lobe or aedeagus tubular, nearly five times the length of the basal piece, nearly uniformly

wide throughout except near the apex which is distinctly bifid (*b*) ; parameres short, about two-thirds the length of median lobe, with long setae mainly in the distal half ; sipho widely curved with the siphonal capsule subtriangular and the apex slightly enlarged into a narrow bulb. Female genitalia typical of the genus *Afissa*, with the pair of genital plates subtriangular and elongate distally.

Length 4·0 mm. ; width 3·0 mm.

Holotype.—A male from Burma (Upper) : Gokteika, 1. iv. 1918 ("*A. G. R.*" coll.), in the Zoological Survey of India, Calcutta (Regd. No. 11601/H4).

Allotype.—A female from the same locality as the holotype, 31. iii. 1918. ("*Boy*" coll.), in the Zoological Survey of India (Regd. No. 11602/H4).

Remarks.—This species seems to fall in the *fallax* group of the genus *Afissa* Dieke, as defined by Dieke[4] and comes near *Afissa gedeensis* Dieke known from Mount Gede, Java. It can, however, be at once distinguished from the latter by the presence of pronotal black spot and other differences in the outline of the elytral fasciae. In *A. gedeensis* the distal margin of the basal fascia is straight but the median fascia always touches the sutural margin, owing to the incorporation of the sutural spot into the median fascia. The male genitalia differ considerably in the two species ; in *A. gedeensis* the parameres and sipho are relatively long and the median lobe is not bifid at the apex. The female genitalia of *A. gedeensis* remain undescribed and are not available to me for comparison.

SUMMARY

Four new species and one new variety of the subfamily Epilachninae (Coccinellidae, Coleoptera) mostly in the collection of the Zoological Survey of India are described. These are : *Epilachna ornata* from Anaimalai Hills, southern India ; *Afissa cherrapunjiensis* from Cherrapunji, Khasi Hills, Assam ; *Afissa sureilica* from Sureil, near Mongphu, Darjeeling district, northern West Bengal ; *A. sureilica* var. *marginotata*, from Ruby Mines, northern Burma ; and *Afissa gokteika* from Gokteik, northern Burma.

[4]Dieke, G. H., *loc. cit.*, p. 124.

NOTES ON SPIDER MITES IN THE COLLECTION OF THE ZOOLOGICAL SURVEY OF INDIA, CALCUTTA (ACARINA : TETRANYCHIDAE)[1]

By

SHÔZÔ EHARA

Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan

(With 14 Text-figures)

CONTENTS

I—INTRODUCTION

The material on which this note is based was recently sent to the writer for identification by Dr. A. P. Kapur, Officer-in-Charge of the Entomology Section of the Zoological Survey of India, Calcutta. On examination, the specimens were found to belong to the three species, *Petrobia latens* (Müller), *Eutetranychus banksi* (McGregor) and *Paratetranychus* sp. It seems to be worth while to publish this short note in order to furnish data for further detailed studies of Indian spider mites.

The writer wishes to express his cordial thanks to Dr. Kapur for giving the opportunity to study the present material. His thanks are also due to Prof. Tohru Uchida who kindly made valuable suggestions.

II—SYSTEMATIC ACCOUNT

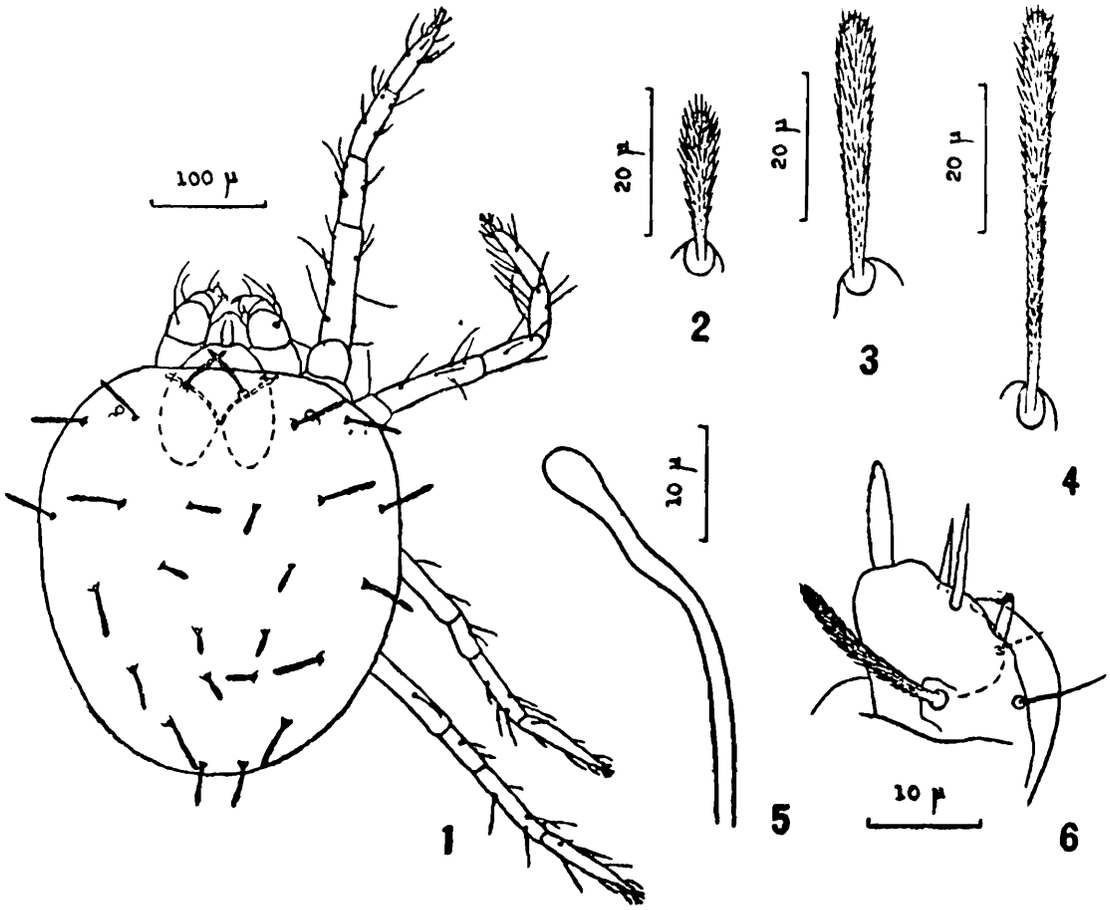
Petrobia latens (Müller)

1776. *Acarus latens* Müller, *Zool. Dan. Prodr.*, p. 287.
1804. *Trombidium lapidum* Hammer, in : Hermann *Mém. Apt.*, p. 49.
1877. *Petrobia lapidum*, Murray, *Econ. Ent. Apt.*, p. 118.
1915. *Petrobia latens*, Oudemans, *Arch. Naturgesch.*, Berlin, **81** (A, 5), p. 44.
1953. *Petrobia latens*, Baker & Pritchard, *Hilgardia*, Berkeley, **22**, p. 206, figs. 2—3.
1955. *Petrobia latens*, Pritchard & Baker, *Pacif. Coast Ent. Soc. Mem. Ser.*, San Francisco, **2**, p. 51, figs. 37—38.
1955. *Petrobia latens*, Evans & Browning, *Brit. Mus. (Nat. Hist.) Econ Ser.*, London, No. 17, p. 41, figs. 61—63.
1956. *Petrobia latens*, Ehara, *J. Fac. Sci. Hokkaido Univ.*, Sapporo, Ser. 6 Zool., **12** (3), p. 246, figs. 3—4.

[1]Contribution No. 440 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Specimens examined.—Many ♀♀, Gwalior (Madhya Pradesh), 15. ii. 1957 (on wheat), *O. S. Bindra* leg.

Remarks.—This mite is probably new to India. In Asia, so far as the writer is aware, it is known only from Japan (Ehara, 1956). Information on this well-known mite is summarized by several writers (Baker & Pritchard, 1953 ; Pritchard & Baker, 1955 ; Evans & Browning, 1955). This mite attracts attention as a wheat pest in U. S. A.



TEXT-FIGS.—1-6. *Eutetranychus banksi* (McGregor), female. (1). Dorsal view of body. (2), (3) and (4). Dorsal setae. (5). Peritreme. (6). Distal segment of palpus.

Eutetranychus banksi (McGregor)

(Text-figs. 1-10)

1914. *Tetranychus banksi* McGregor, *Ann. ent. Soc. Amer.*, Columbus, Ohio, 7 (4), p. 357, pl. 44.

1917. *Neotetranychus* (*Eutetranychus*) *banksi*, Banks, *Ent. News*, Philadelphia, 28 (5), p. 197.

1919. *Anychus banksi*, McGregor, *Proc. U.S. nat. Mus.*, Washington, 56(2303), p. 644.

1940. *Anychus ricini*, Rahman & Sapra, *Proc. Indian Acad. Sci.*, Bangalore, B, 11(5), p. 194, fig. 6.

1950. *Eutetranychus banksi*, McGregor, *Amer. Midl. Nat.*, Notre Dame, 44(2), p. 268.

1955. *Eutetranychus banksi*, Pritchard & Baker, *Pacif. Coast Ent. Soc. Mem. Ser.*, San Francisco, 2, p. 115, figs. 90-92.

Female: Body rotund, 360 μ long and 330 μ wide in widest part. Rostrum reaching the basal part of femur I. Distal segment of palpus longer than wide, with five setae including a stout, pectinate seta ; terminal sensillum slender, spindle-shaped, about five times as long as wide ; dorsal sensillum very small. Mandibular plate broadly oval (ratio of breadth to length, 8·4 : 10), slightly notched. Legs slender ; relative lengths of segments in leg I as follows : trochanter, 11 ; femur, 37 ; genu, 21 ; tibia, 23 ; tarsus, 22. Tarsi with a pair of strongly pectinate tactile setae distally. Tarsus I with twelve tactile and six sensory setae in total ; without duplex setae, but carrying on the dorsum a sensory seta that is probably homologous with a distal member of the duplex setae, and bearing lateroventrally a pair of associated setae resembling the second pair of duplex setae. Tibia I with nine tactile and one sensory setae. Tarsus II with five tactile setae proximal to duplex setae ; proximal member of the duplex setae slightly shorter than distal member ; tibia II with six tactile setae. Tarsus III with one sensory seta dorsoproximally, and without any sensory seta at the distal part ; tibia III with six tactile setae. Tarsus IV with one sensory seta dorsoproximally, and without any sensory seta at the distal part ; tibia IV with seven tactile setae. Empodia apparently lacking. Peritreme narrow, ending in an oval portion. Dorsal setae generally arising from tubercles, spatulate or blunt-ended, pubescent, and shorter than intervals to bases of setae next behind : laterally located setae on dorsum longer and less spatulate than mediodorsally situated setae in some specimens ; most of the dorsal setae short and spatulate in certain specimens ; other intergrade specimens present. Genital flap with transverse striae on anterior portion and with longitudinal striae on posterior portion. Area immediately anterior to genital flap with transverse striae.

Male : Not available to the writer.

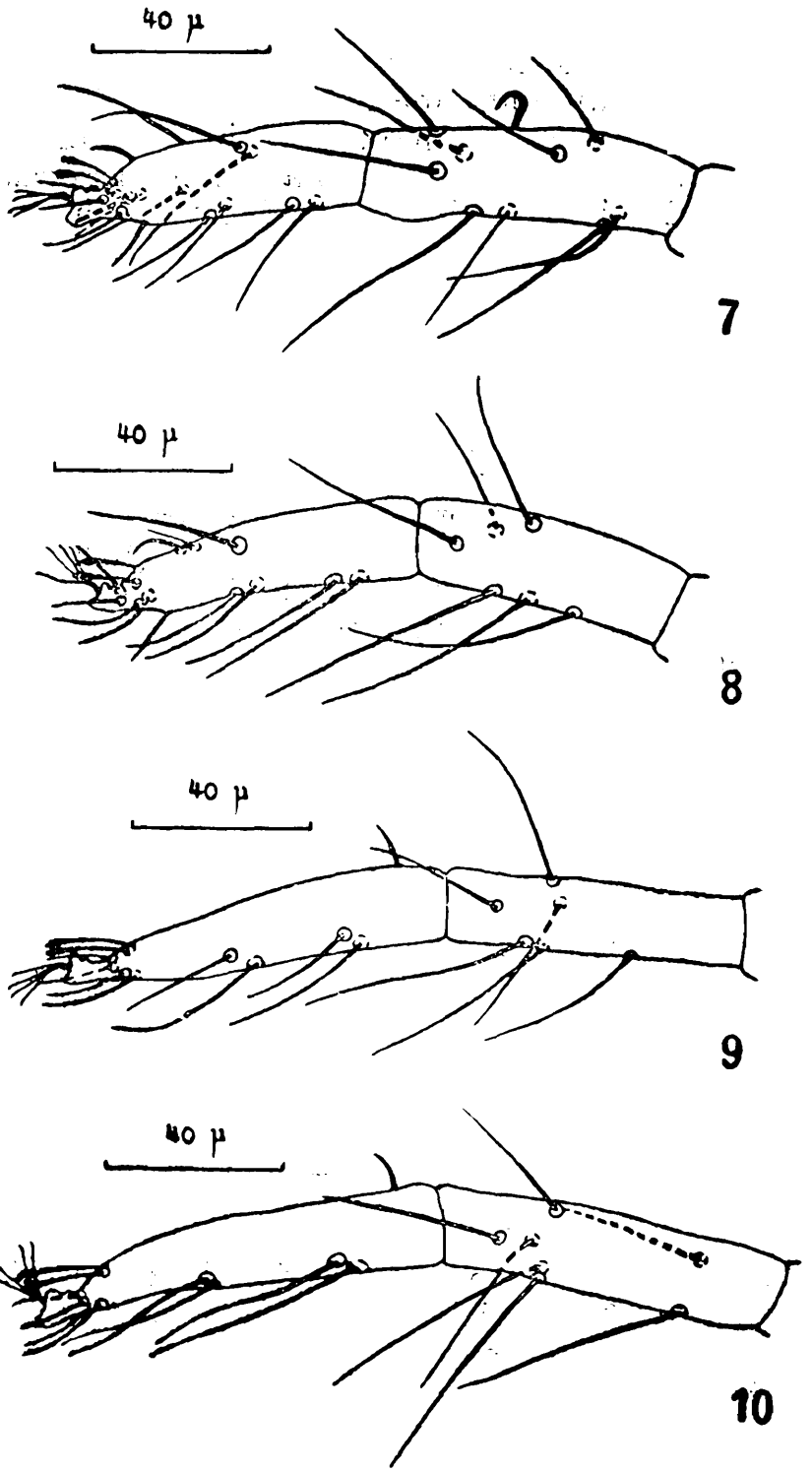
Nymph : Dorsal setae slender.

Specimens examined.—21♀♀ & 1 nymph, Eden Garden, Calcutta, 22. xii. 1956 (on oleander), *A. P. Kapur* leg.

Remarks.—Referring to the original description of *Anychus ricini* Rahman and Sapra, 1940, which is based on specimens from Lyallpur, Pritchard and Baker (1955) considered the species to be a synonym of *Eutetranychus banksi*. Their opinion is herein accepted. Indian material of *E. banksi* has been again treated in the present work.

E. banksi is known from India (*A. ricini*), Italy, the Near East, North and South America, and South Africa. It shows wide, local and individual variations in dorsal chaetotactic pattern. The drawings of *A. ricini* presented by Rahman and Sapra indicate that the type specimens carry long, laterally located dorsal setae. As is described above, a considerable range of variations in relative sizes of dorsal setae is found in the present specimens collected at the same time.

Based on American material, Pritchard and Baker present excellent drawings of the chaetotactic pattern of tarsi I and II and tibiae I and II. The Indian female specimens here examined are different from American ones in leg chaetotaxy. In the former, tarsus I is deficient in duplex setae, while in the latter tarsus I bears a pair of duplex setae on dorsum.



TEXT-FIGS.—7-10. *Eutetranychus banksi* (McGregor), female.
(7). Tarsus and tibia I. (8). Tarsus and tibia II. (9). Tarsus and tibia III. (10). Tarsus and tibia IV.

Furthermore, tarsus I of the former carries eighteen pairs of setae including one pair of strongly pectinate tactile setae, while tarsus I of the latter bears a less number of setae among which no strongly pectinate setae occur. No sensory seta is found at the proximal part of tibia III

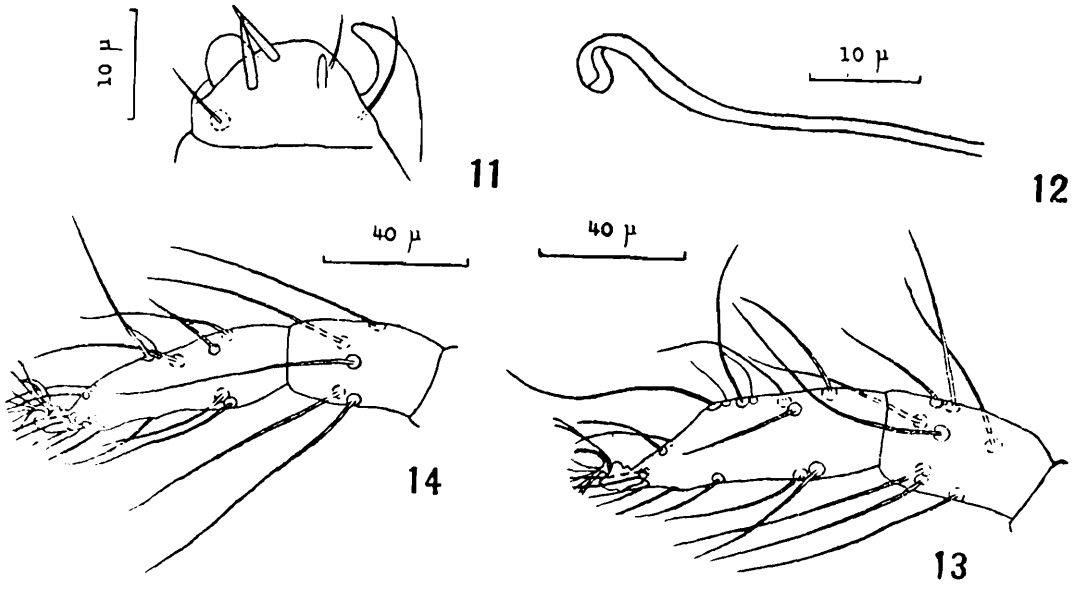
in the present specimens, although such seta is reported to occur in specimens from Israel.

Castor bean, almond, *Cassia fistula, Zigiphus jujuba,* and citrus are recorded as host-plants of *A. ricini* in India. The present material was collected on oleander. In regions other than India a number of other hosts have been recorded.

Paratetranychus sp.

(Text-figs. 11-14)

Female : Body from above oval, 430 μ long and 330 μ wide in widest part. Terminal sensillum of palpus about as broad as long ; dorsal sensillum spindle-shaped. Mandibular plate (ratio of breadth to length, 6·7 : 10) notched mediodistally. Tarsus I with four tactile and one sensory setae proximal to proximal set of duplex setae ; proximal duplex setae of tarsus I with proximal member more than one-third as long as



TEXT-FIGS.—11-14. *Paratetranychus* sp., female.
(11). Distal segment of palpus. (12). Peritreme. (13). Tarsus and tibia I. (14). Tarsus and tibia II.

distal member ; distal duplex setae of the tarsus with proximal member about one-fourth as long as distal member ; tibia I with seven tactile and one sensory setae. Tarsus II with three tactile and one sensory setae proximal to duplex setae, and with another tactile seta near the duplex setae ; tibiae II and III with five tactile setae respectively. Empodial claw of leg I with six pairs of proximoventral setae. Peritreme narrow, dilated at the distal end. Dorsal setae not set on tubercles, slender, tapering, pubescent, and longer than intervals between bases. Genital flap with transverse striae ; area immediately anterior to the flap with longitudinal striae.

Male : Not available.

Specimens examined.—5♀♀ & 1 nymph, Tholkabad, Singhbhum Dt., Chotanagpur, 9. ii. 1955 (sal leaves), *A. P. Kapur* leg.

Remarks.—This mite belongs to a species group of the genus ; the group is characterized by having seven tactile setae on tibia I and four tactile setae proximal to the duplex setae on tarsus I. Because of the unavailability of the male, however, the writer cannot state positively whether this mite belongs to the known Indian species, *Paratetranychus mangiferus* Rahman and Sapra or *P. punicae* Hirst, or to any other species. In India, *P. mangiferus* is known on mango, grape and *Eugenia jambolana*, and *P. punicae* is known on pomegranate and grape. Dr. Kapur stated in correspondence : " Mites as pests of sal have not been recorded before and when I collected these, I suspected that the record would be interesting."

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TAXONOMIC AND BIOLOGICAL OBSERVATIONS ON THE BATS OF THE RAJASTHAN DESERT

By

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(with 5 Tables and 1 Text-figure)

CONTENTS

I—INTRODUCTION

1. *General*

Bats and other mammals were collected from the Rajasthan desert in various seasons during 1953-56 and observations on them were made at Barmer, Gadra Road, Sheo, Jaisalmer, Phalodi, Bap, Bikaner, Ganganagar, Pilani and Jodhpur (Text-fig. 1). The observations include the biology of nine species of bats belonging to six families. Important variations in the colour and skull structure of a form of *Rhinopoma* have been given. Almost all the bats are reported for the first time from the Rajasthan desert. Field notes on their activities, sex-ratios, food,

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breeding and their associations, as well as the body and cranial measurements (which are in millimetres and according to Roonwal, 1950 and Cockrum, 1952) are given. The abbreviations used in the text are :—

HB., Head & body
T., Tail
E., Ear
HF., Hind Foot
FA., Fore arm
Tr., Tragus
op., occipitopremaxillar length
cb., Condylc basal length
on., Occipitonasal length
zw., Zygomatic width
io., Interorbital length
cw., Cranial width
ob., Occipital breadth
do., Depth of occiput
pm., Postmolar length
al., Auditory length
ltb., Length of tympanic bulla
btb., Breadth of tympanic bulla
ln., Length of nasals
wn., Combined width of nasals
pl., Palatal length
lut., Length of upper tooth row
llt., Length of lower tooth row
ml., Mandibular length

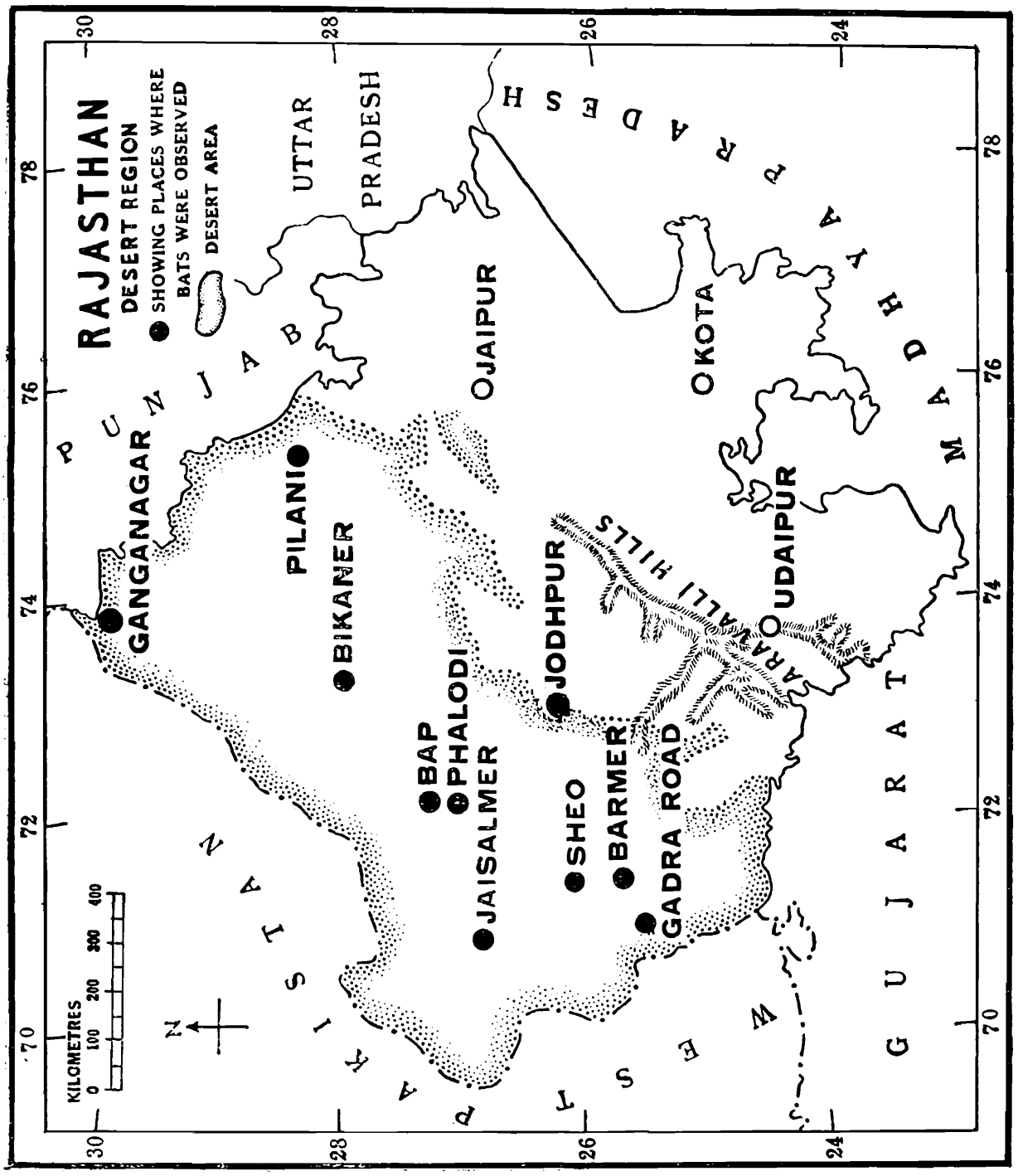
The body colours are described according to the colour schemes of Maerz and Paul (1950).

2. *Acknowledgment*

The writer is indebted to Professor Daya Krishna under whose supervision the work was carried out. Thanks are also due to Dr. M. L. Roonwal, Director, Zoological Survey of India, for his advice in revising the manuscript ; to Dr. W W A. Phillips and Mr. Humayun Abdulali for help ; and to UNESCO for financial assistance.

3. *Environment* (*Ecology of the desert region*)

Rajasthan desert lies between 25° and 30° N. lat. and 69·5° and 78°E. long. Covering about 60,000 sq. miles, and is partly arid and partly semi-arid. At certain places it is hilly , otherwise its surface is covered with sand consisting of well-rounded quartz grains, hornblende, felspar as well as foraminiferous shells (Wadia, 1939). According to rainfall, the desert of Rajasthan is divisible into two regions : an arid region in which the rainfall is ten inches or less per year and the mean diurnal temperature is 24° F. or more ; and a semi-arid region in which the rainfall is twenty inches and the annual diurnal temperature is 10° or less. Ninety per cent of the total rainfall is received in the monsoon season (July-September), the rainy days being only about 20 in number. The mean maximum temperature in May is usually 105-108° F. and mean minimum in December is 38°F. The annual humidity ranges from 19-76 per cent from April to August. The vegetation consists mainly of *Capparis aphylla*, *Gymnosporia montana*, and *Prosopis spicigera* and many species of *Zizyphus* and *Calligonum*. The herbaceous cover of the vegetation is represented profusely by *Tephrosia perpurea* in the rainy season. The winter vegetation is characterised by the dominant shrub-like *Capparis aphylla* and the perennial under-shrubs, *Leptadenia spartium* and *Calotropis procera*.


RAJASTHAN
DESERT REGION
SHOWING PLACES WHERE BATS WERE OBSERVED
DESERT AREA
PUNJAB
UTTAR PRADESH
MADHYA PRADESH
GUJARAT
PAKISTAN
WEST
GANGANAGAR
PILANI
BIKANER
BAP
PHALODI
JAISALMER
JODHPUR
SHEO
BARMER
GADRA ROAD
OJAIPUR
KOTA
UDAIPUR
ARAVALLI HILLS
KILOMETRES
0 100 200 300 400
N
30
28
26
24
78
76
74
72
70

4. *Localities where Bat-Colonies are Found*

Bats are usually found in dark, unattended buildings (ruins) and caves, natural as well as man-made. In the desert region natural caves are not many. They are found only at Jodhpur, Barmer and Jaisalmer regions where low hills occur. The various bat-localities from where the bats were collected are described below briefly :—

1. JODHPUR : MANDORE.—This place is a garden seven miles north of Jodhpur railway station. Low rocks cover one of its sides. To drain water from these rocks a hung *nullah* (water-course) has been constructed below the Mandore Palace. Its other end opens into the drainage by system of the main road. This *nullah* forms about 600 ft. long dark tunnel which is about 20 ft. broad and 18 ft. high. It is divided by arches into many chambers. It forms an excellent roosting place for bats— *Rhinopoma kinneari, Megaderma l. lyra* and *Taphozous p. perforatus.*

2. JODHPUR : BALSAMAND.—It is another garden near a large lake, about five miles north of Jodhpur and is on the way of Mandore. *Pteropus. g. giganteus* is found on *Ficus* trees in the garden. There is also a deserted Palace in which some *Rhinopoma. h. hardwickei* is found.

3. JODHPUR : FORT.—It is situated over a hillock about 1,000 ft. high to the north of Jodhpur City. Today, it is almost unattended. In the dark staircases of the palace were found a large number of *Rhinopoma h. hardwickei,* in two rooms *R. kinneari* and in one cell *Megaderma l. lyra.* In one of the wells in the Fort, males of *R. kinneari* were found.

4. JODHPUR : BHIMBHARAK.—It is about 7 miles west of Jodhpur. It is a hilly area about 1200-1500 ft. high. Bats live here in a natural cave which is extremely dark. It is inhabited by *Rhinopoma kinneari* and *R. h. hardwickei. Taphozous k. kachhensis* lives outside the cave in fissures add crevices of the rocks. Some bats *Rhinopoma sp.* are also found in the nearby ruins.

5-7. JODHPUR : (5) KAGA. (6) UDAIMANDIR. (7) JAIN TEMPLE. *R. kinneari, R. h. hardwickei* and *T p. perforatus* were also collected and observed in the above mentioned localities. *Pipistrellus mimus glaucillus* was observed clinging in small crevices in houses in the city as well as outside.

8. BARMER : CAVE.—It is a large natural cave about 150 ft. long, 10 ft. broad and 8 ft. high on the southern side of Barmer. It is situated on a hillock about 750 ft. high. The bottom of the cave is muddy and there exists a small pool of water in the blind distal end of the cave. Numerous examples of *R. kinneari* and some of *T p. perforatus* were found to roost in the cave.

9. BARMER : TEMPLE.—The other locality where bats were observed in Barmer was a temple which is situated in the city. In dark rooms of the ground floor and in dark staircases are found *R. h. hardwickei.*

10. JAISALMER : FORT.—There is a small building in the Fort premises, with high ceilings. *R. h. hardwickei* was observed in four rooms, while *R. kinneari* inhabited two rooms ; the latter were not as numerous as the former. In two other rooms sepcimens of *T p. perforatus* were found.

11. BIKANER : TUNNELS.—There are a large number of man-made tunnels in the earth, which are excavated for " Fuller's earth " The tunnels are sometimes as much as 50 ft. long, 10 ft. wide and 10 ft. deep, and water accumulates in their farther end which sometimes rises to 6 ft. The humidity is, therefore, considerably high in these tunnels. *Rhinopoma h. hardwickei* are found in the nearer apartments which have some light. *Rhinolophus l. lepidus* inhabit the dark distal portions.

II—SYSTEMATIC* ACCOUNT, BIOLOGY AND DISTRIBUTION

Suborder I. Megachiroptera

Family 1. PTEROPODIDAE (Fruit Bat)

Subfamily *PTEROPODINAE*

1. **Pteropus giganteus giganteus** Brünnich

(Indian Flying Fox)

1782. *Vespertilio gigantea* Brunnich, *Drynes Historie*, 1, p. 45. (India.)

7♂♂ and 3♀♀, Jodhpur.—March, May and August.

In the desert region the Flying Foxes were observed only at Balsamand, Jodhpur. They roost on *Ficus* trees in the garden where they continue to live throughout the year and also during heavy rains. During summer in the mornings and evenings, they climb the highest branches of the trees, while in the afternoon, when the sun is high and it is hot, they climb down to the lower branches in search of shade. In winter, however, the contrary happens : during the afternoon they are seen on the top of the trees. Throughout the day the bats confine themselves to the trees, but in the evening, when it is sufficiently dark, they leave the trees and fly over the adjoining Blasamand lake and skip over water, generally for drinking it. Their skipping over water was also observed at Mt. Abu in the Nakki Lake. Close observations were made from a boat and from the island in the lake, and it was found that they do open their mouth and gulp water. In May and June their feeding starts at about 7·15 P.M. and during winter at 6·15 P.M. At Jodhpur they have been observed to feed on guava, (*Pasidium guyava*), the Indian blackberry (*Syzygium cumini*), the mango (*Mangifera indica*) and *Ficus* berries. At Jaipur they were observed to feed on a *Ficus* tree which is situated near a cinema hall in the city. It is quite noisy there and bright due to the loud-speakers and the flood-lights, but the bats are not at all disturbed and about a score of them daily visit the tree when it is fruiting.

There breeding season lasts from April to May. Seven females were observed carrying one young each against their breast in May.

This bat has been collected only at Jodhpur. Blandord's (1888-91) statement that they are not well distributed in western India, is supported by this survey.

*Body and skull measurements are appended at the end of the text.

Suborder II. Microchiroptera

Family 1. RHINOPOMATIDAE (Rat-tailed Bats)

2. **Rhinopoma kinneari** Wroughton

(Rat-tailed Bat)

1912. *Rhinopoma kinneari* Wroughton, *J. Bombay nat. Hist. Soc.*, Bombay, 21, p. 767. (Bhuj, Kutch.)

23♂♂, Fort, Jodhpur.—October,

23♂♂, 30♀♀, Jodhpur.—All the year round,

36♂♂, Barmer.—June, November, January,

2♂♂, 1♀, Jaisalmer.—June.

This bat is the most common one in the desert region but is absent from the man-made caverns in loose earth at Bikaner. In every bat locality it is found in large numbers. Usually it inhabits those portions of a building or cave which are not completely dark. In the Mandore tunnel, specimens were found living in association of *Rhinopoma hardwickei, Taphozous p. perforatus* and *Megaderma l. lyra.* In the Barmer cave they were found with *Taphozous p. perforatus,* and at Jaisalmer with *Rhinopoma h. hardwickei.* Usually the various species reside in different apartments of the same cave or building. When disturbed they do intermingle but this lasts only for a short period after which they again segregate. When they are caught they make a loud noise—a long *cheen, cheen,* but normally, when not disturbed their vocal note is a single long *chue.* While flying they do not appear to make any noise.

The bats come out of their roosting places between 7-30 and 7-45 P.M. in summer and have been observed to return before dawn. They come out in small groups of 8-12, but afterwards fly singly. In the first two hours, some return to the roost and fly out again. Till about midnight all the bats are out. At about 2 A. M. the bats begin returning though some batches again fly out at intervals. The flight is quite fast, and steady. They fly sufficiently high, but after 11 p.m. they were observed near lamp-posts, catching insects. They usually fly away from trees and buildings, and do not take to the wing when it is raining heavily.

The breeding season is July-August, and the number of young born at a time is always one. Usually the females and the males live together, but in a well in the Fort at Jodhur only males were observed. It was visited in July, August and November and no female was found in this well—it was a male colony.

Wroughton (1912) described the colour of this bat as " brownish drab—warmer in colour than the drab grey of *hardwickei* " Most of the specimens collected and examined exhibit Wroughton's ' brownish drab ' (11, Pl. 6—sligtly lighter shade of hydrangea Red (K 1, Pl. 6—of Maerz & Paul, 1950) but several were ' drab grey ' (A 4, Pl. 47). This colour variation was noted in the Jodhpur and the Barmer material. Ou further examination it was found that the frontoparietal crest in the

skull of the drab-grey form was poorly developed or in some cases absent, as contrasted with the strongly-crested skull of the typical *kinneari*. The teeth of this form were also found to be smaller than in the typical race. The skulls also show slight swellings in the nasals, a characteristic feature of *Rhinopoma hardwickei*.

Khajuria (1953) reports large fat deposits at the posterior hairless part of the body among the bats collected at Agra and Cutch. The fat deposits particularly on the thighs, were also observed in the specimens collected from Jodhpur and Barmer, and were thinner in females, especially in winter.

The bat is evenly distributed in Rajasthan desert.

3. **Rhinopoma hardwickei hardwickei** Gray

(Lesser Rat-tailed Bat)

1831. *Rhinopoma hardwickei* Gray, *Zool. Miscl.*, p. 37.
(India.)

4 ♂♂, 1♀♀, Balsamand, Jodhpur.—April
12 ♂♂, 7♀♀, Kaga, Jodhpur.—May
9 ♂♂, 3♀♀, Mandore Jodhpur.—April
12 ♂♂, 7♀♀, Bikaner.—February
4 ♂♂, 2♀♀, Jaisalmer.—June

The bat inhabits the unattended dark portions of ruins at Jodhpur, Barmer and Jaisalmer and the man-made caverns at Bikaner. Like the *R. kinneari*, it also dwells in poorly lighted places in buildings and is found at the entrance of a bat-locality. At Jodhpur and Barmer its population was rather thin as compared with that at Jaisalmer and Bikaner. It was found living in association of *Rhinolophus l. lepidus* in man-made tunnels at Bikaner. In winter it is quite active except during the cold spell when it appears less active. At Jodhpur, during winter, all specimens appear to gather together in the Kaga ruins.

Usually males and females live together, but during September, 1954, seven males were collected from a cell at Balsamand, Jodhpur, and there were no females. At Bhimbharak, Jodhpur, all the females had one young each on their breasts early in July. About 12 females collected from Kaga, Jodhpur, (May 15) had an early embryo each, about seven days old. In the latter two localities, males were living together with females, where three more females gave birth in July.

The usual colour of the bat is burnt siena (Maerz & Paul, 1950, Pl. 5, F 12) on both sides. The naked pubic and femoral regions are chrome orange (Pl. 10, J 12). Certain specimen gave the general impression of sepia (Pl. 8, A10) on both the sides. The fur is sepia throughout.

*R. hardwickei** is uniformly distributed in the Rajasthan desert but is not so abundant as the *R. kinneari*.

*Tate (1947) has erroneously mentioned that *Rhinopoma* (*hardwickei*) has a noseleaf.

Family 2. EMBALLONURIDAE (Sheath-tailed Bats)

Genus **Taphozous** Geoffroy

Subgenus **Taphozous** Ceoffroy

4. **Taphozous perforatus perforatus** Geoffroy

(Tomb Bat)

1818. *Taphozous perforatus* Geoffroy, *Description de l'Egypte*, 2, p. 113. (Egypt.)

4 ♂♂, 3♀♀, Udaimandir, Jodhpur.—October.

17 ♂♂, 11♀♀, Mandore, Jodhpur.—March.

2 ♂♂, 3♀♀, Barmer.—September.

11 ♂♂, 7♀♀, Barmer.—June.

The bat lives in association with *R. kinneari*, both in caves and ruins, but the two species occupy separate sections of the same locality. Its number is much smaller than that of *R. kinneari*. In the Barmer cave not more than 30-40 specimens were found; they lived in the distal darkest portion of the cave where water accumulates in a pit sometimes to a depth of 4 ft. The bat was also observed at Mandore and Udaimandir, Jodhpur. It leaves the roosts slightly earlier than *R. kinneari*, but they return together. At Udaimandir, out of five garages occupied by bats, two are inhabited by *T p. perforatus*.

In nature, its enemy is the False Vampire which eats the head and drops away the body. About 20 examples of headless *Taphozous* were collected from the Mandore *nullah*. In captivity too, these bats were preferred by the vampires. When disturbed in the day, they fly out of their roosts and become prey of the kite (*Milvus migrans* Boddaert) and the crow (*Corvus splendens* Viellot).

The bat was collected from Barmer and Jodhpur only.

Subgenus **Liponycteris** Thomas

5. **Taphozous kachhensis kachhensis** Dobson

(Cutch Sheath-tailed Bat)

1872. *Taphozous kachhensis* Dobson, *J. Asiat. Soc. Bengal*, Calcutta, 41, p.221. (Cutch.)

13 ♂♂, 17♀♀, Jodhpur.—January, February.

2 ♂♂, 4♀♀, Jodhpur.—April.

This species lives in caves where it prefers crevices and fissures (as observed at Bhimbharak, Jodhpur) and is the most noisy of all other bats. When captured it utters a long *cheeee, cheeee, cheeee*. Usually when undisturbed its note is a *cheeak*. In the crevices at Bhimbharak it is a close associate of the swift, *Micropus affinis* Gray, with which it lives side by side. When they were disturbed and allowed to settle it was interesting to observe them returning almost together to enter the same crevice, only with one difference—the swifts entered their nests while the bats clung to the rocks. Some of the bats also usurped the nests of the swifts and were found occupying them. It was observed and collected from Jodhpur only.

Family 3. MAGADERMATIDAE

Genus **Magaderma** Geoffroy

Subgenus **Lyroderma** Peters

6. **Megaderma lyra lyra** Geoffroy

(Indian False Vampire)

1810. *Megaderma lyra* E. Geoffroy, *Ann. Mus. nat. Hist.*, Paris, 15, p. 190. (East coast of Madras, India.)

5 ♂♂ and 8♀♀, Jodhpur.—April, November.

The bat has been observed at Mandore and the Jodhpur Fort. In the Mandore *nullah* it occupied a small, dark interior apartment. At the Fort, it lived in a cell. It is found in large numbers, 500 were found in Mandore and about 200 in Fort. It becomes active in the *nullah* after 7 P. M., leaving the roost at about 7-30 P.M., in summer. It flies out in pairs and the flight is a steady one.

The bats fly very near to buildings and trees, probably, to capture food, and they are carnivorous rather than insectivorous. At Mandore they were observed scrunching other bats, *viz.*, *Rhinopoma kinneari*, *R. h. hardwickei* and *Taphozous p. perforatus*. In Ceylon, Phillips (1922) mentioned that they consumed a pipistrelle, *Pipistrellus mimus*, which was put in with them in a wooden box. The False Vampire holds its victim by its head which is eaten and the rest of the body is discarded. This was confirmed by me, as I collected many headless bats from the Mandore *nullah*. On other occasions they were observed to carry away the Wall Lizard (*Hemidactylus flaviviridis* Rüppel) from the shades of lighted electric bulb in the verandah of a house at Jodhpur. In another case a bat was observed eating a full grown sparrow and an orthopterous insect, *Schizodactylus monstrosus*. In captivity, when they were kept in wooden cages with other bats and animals, they consumed the following animals :—Birds : *Passer domesticus*, *Saxicola caprata*, Mammals : *Meriones hurrianae*, *Mus musculus*, *Rattus r. rufescens*, *Rhinopoma kinneari*, *Rhinopoma h. hardwickei* and *Taphozous p. perforatus*.

Aitken (1907), Gleadown (1907), Green (1907) and Primrose (1907) also had observed them eating birds—(sparrow, *Zosterops*, *Cinnyrus* and *Pranticola macrura*), while Mosse (1931) and McCann (1934) observed them eating lizard and pipistrelles. The stomach contents of ten specimens of bats were examined by me just after their feeding time. The contents showed the following :—Remains of insects, bones of Amphibia, fishes and bats, and the entire alimentary canal of a fish (Prakash, 1959).

Ten females had one foetus each on 4th April at Jodhpur. Several others were observed carrying one young each in May.

The bat was collected only from Jodhpur.

Family 4. RHINOLOPHIDAE (Horseshoe Bats)

7. **Rhinolophus lepidus lepidus** Blyth

(Little Indian Horseshoe Bat)

1844. *Rhinolophus lepidus* Blyth, *J. Asiat. Soc. Bengal*, Calcutta, 13, p 486. (Calcutta.)

6♂♂, 12♀♀, Bikaner.—November.

This bat was observed in small numbers at Bikaner in artificial caverns and at Pilani in a well. It selects a small pit in the ceiling of the caverns in which it fits so well that it is practically impossible to detect it. Their presence is revealed by a short, sweet *chuwik chuwik* which they utter. They hang like *M. l. lyra i.e.*, only with the help of the feet—other bats take the help of the forearm also. If any intruder in the cave disturbs them, they start flying inside the cavern but do not leave it like other bats. They prefer the darkest portions and become wary to slightest light. In mid-November they were found to be very agile.

The occurrence of the bat in Bikaner extends its range considerably to the West. It is interesting that the bat, an inhabitant of the humid area, is found in the desert also.

Family 5. VESPERTILIONIDAE (Pipistrelles and Yellow Bats)

Subfamily *VESPERTILIONINAE*

8. **Pipistrellus mimus glaucillus** Wroughton

(Indian Pigmy Pipistrelle)

1912. *Pipistrellus mimus glaucillus* Wroughton, *J. Bombay nat. Hist. Soc.*, Bombay, 21, p. 769.
(Multan, Punjab.)

2♂♂, 2♀♀, Jodhpur.—August.

Four small bats were observed flying near one of the houses in Jodhpur, and were recognized as pipistrelles by their characteristic flight, with frequent very quick turns and descents. A thorough search was made for these bats in all the bat localities of Jodhpur, but they were not found in any of them. One evening we sat to observe the 'emerging' place of the bats. At 7-10 P.M. (August 17) one bat was observed to emerge from the wall of the house where we were sitting. The bat took a circular flight and went back to its roost which was later on found to be a small crevice in the wall. At 7-12 P.M. two of them came out and started their circling movements. At 7-14 P.M. another pair emerged and joined the former pair. Next morning all the four were collected. It was observed that they do not hang head downwards as the majority of the bats do, but sit with the head up, grasping the walls with the claws. The pipistrelle is first among the bats to come out after dusk. It flies near trees and houses or over open ground in a small territory. It also enters the verandah or a room in search of insects, and ceases activity late at dawn. Pipistrelles are quite common in Jodhpur but their collection is difficult since only a few live in one crevice.

9. **Scotophilus heathi** Horsefield

(Greater Yellow Bat)

1831. *Nycticejus heathi* Horsefield, *Proc. Zool. Soc. Lond.*, London, 1831, p. 113. (Madras, India.)

1♀, Jodhpur.—August.

The single female had its young (about 10 days old) on her breast ; it was collected at flight under a lamp post with the help of a butterfly net at Jodhpur. The bat was not found in any of the bat-localities in the desert region.

Field Key for Identifications of Bats of the Rajasthan Desert.

(All measurements are in mm.)

(a) Size large (HB 240—350), roosting on trees. *Pteropus g. giganteus*

(a') Size small (HB 240 or less), found in other localities.

(b) Nose leaf and Tragus (or antitragus) both present.

(c) Size large (HB 75 or more), ears very large. *Megaderma l. lyra*

(c') Size small (HB 38 or more), ears moderate. *Rhinolophus l. lepidus*

(b') Tragus present, no nose-leaf.

(d) Tail entirely enclosed in inter-femoral membrane.

(e) Size large (HB 68), yellow colour. . *Scotophilus heathi*

(e') Size small (HB 34-37), mouse grey. . *Pipistrellus mimus glaucillus*

(d') A portion of the tail free.

(f) Tail emerging from the upper surface of the inter-femoral membrane.

(g) Size large (HB 86—94), lower abdomen pink and naked *Taphozous k. kachhensis*

(g') Size small (HB 69—80), lower abdomen covered with hairs . *Taphozous p. perforatus*

(f') Tail emerging from the end of the inter-femoral membrane.

(h) Size large (HB 70-86), tail shorter than head and body *Rhinopoma kinnear*

(h') Size small (HB 53-66), Tail longer than the head and body *Rhinopoma h. hardwickei*

III—DISCUSSION

1. *Relative numbers*

In the desert region Rat-tailed Bats of the genus *Rhinopoma* rae found in abundance. The number of *Rhinopoma kinneari* is more numerous in the Jodhpur Division, while *Rhinopoma h. hardwickei*

is more common in the Jaisalmer and Bikaner Divisions. The next in order of numbers are the two *Taphozous* species. While *Taphozous p. perforatus* is evenly distributed over the entire desert area, its number in any particular locality is not so large as that of *Rhinopoma kinneari*. *Taphozous k. kachhensis* is found only at Bhimbharak, Jodhpur, but in large numbers. For *Megaderma l. lyra* it was estimated that 500 specimens occur in the Mandore *nallah*, and 200 within the Fort, Jodhpur. In all the man-made caverns at Bikaner the number of *Rhinolophus l. lepidus* was not more than 100.

2. *Movements*

Among " local movements " are the journeys made by bats each night as they leave their roost to secure food. The time at which the bats leave their roost varies with the species as well as the season. The Pipistrelle and the Horseshoe Bat are the first to start their feeding rhythm. During summer they start their routine journey at about 7-15 P.M. and as the season progresses, they leave the roost earlier—in winter at about 6-25 P.M.; and on cloudy day even earlier, at 6-15 P.M. Next in order are the Flying Foxes which follow the Pipistrelles just after 10-15 minutes. The Rat-tailed and the Sheath-tailed Bats and the False Vampires start their flight at 7-30 — 7-45 P.M. in summer and at 6-35—6-45 P.M. in winter.

Local migrations are the movements from one retreat to another. The causes of migration can be several—disturbance by man, the climatic factors, etc. At Jodhpur, it has been observed that during winter the bats migrate to warmer localities and to those which are less exposed to the weather. At the Fort, Jodhpur, the False Vampires aggregate in the cell which has only one exit or entrance measuring 40 × 40 mm. ; all the vampires go in and come out through this small hole. Most of the *Rhinopoma kinneari* migrate to the Mandore *nullah*. The *Rhinopoma h. hardwickei* move to the Kaga ruins. *Taphozous p. perforatus* take shelter in the Mandore *nullah*.

Regarding the home range of these bats, something definite can be said only about the Pipistrelle which selects its small territory and never goes off the ' track ' *Megaderma l. lyra* moves near the trees and buildings, captures the prey and hangs in any verandah or over a branch of a tree and finishes the meals.

Further work is, however, needed to have a better idea of the summer and winter movements of the bats.

3. *Limiting factors*

The mortality is high during infancy of the bats since the babies fall down on the floor quite often and cannot fly. In nature, domestic cats and False Vampires have been observed to destroy bats. Ratcliffe (1932) observed in Australia that the crocodiles snap the flying foxes as they fly down to drink water. According to same author, other animals which feed on *Pteropus* are : *Varanus* spp.; the Carpet

Snake, *Python* spp.; the Wedge-tailed Eagle, *Uroeliis audax* ; and the Sea-eagle, *Haliactus leucogaster.* In the day when they are disturbed and fly out of their roost, kites and crows also prey upon them.

4. *Breeding and sex-ratio*

In the desert region the breeding season of the bats lasts from March to May. The majority of births occur by the end of April.

Sex-ratios (Table 1).—Out of seven species of bats collected from the Rajasthan desert, males in four species outnumber the females ; in the other three, females are more common. I found that bats of the genus *Rhinopoma* (*R. kinneari* 52·3 per cent ; *R. h. hardwickei* 61·9 per cent) show a clear preponderance of males, while Abdulali's (1949) results show the males of these species as only 32·6 per cent and 26·7 per cent respectively.

TABLE 1.—*Sex-ratios of bats of the Rajasthan Desert*

	Species	Males	Females	Total	%Males
1.	*Pteropus g. giganteus*	12	6	18	66·6
2.	*Rhinopoma kinneari*	157	143	300	52·3
3.	*Rhinopoma h. hardwickei*	13	8	21	61·9
4.	*Taphozous p. perforatus*	24	19	43	55·6
5.	*Taphozous k. kachhensis*	18	45	63	28·5
6.	*Megaderma l. lyra*	12	26	38	31·6
7.	*Rhinolophus l. lepidus*	6	12	18	33·3

IV—SUMMARY

1. Bats from the Rajasthan desert were collected during 1953-1956. This paper deals with taxonomy and biology of nine species of bats.

2. Certain variations in the colour and skull structure of *Rhinopoma kinneari* are pointed out.

3. The following bats are reported for the first time from the Rajasthan desert : *Pteropus g. giganteus, Rhinopoma kinneari, Taphozous p. perforatus, Taphozous k. kachhensis, Megaderma l. lyra, Rhinolophus l. lepidus* and *Scotophilus heathi.*

4. The activities, relative numbers, limiting factors, movements, food, breeding and sex-ratios, etc., of these bats are discussed.

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TABLE 2.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	*Pteropus g. giganteus*				*Rhinopoma kinneari*			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 2 ♂♂		Body : 2 ♀♀		Body : 55 ♂♂		Body : 29 ♀♀	
Hb	300·0—350·0	(325·0)	240·0—260·0	(250·0)	70·0—86·0	(78·3)	73·0—84·0	(78·5)
T	..	..	..	..	53·0—66·0	(59·5)	57·5—66·2	(61·8)
E	25·0—31·0	(28·0)	25·0—27·0	(26·0)	17·0—21·0	(19·0)	15·0—21·0	(18·0)
HF	34·0—44·0	(39·0)	40·0—44·0	(42·0)	13·5—16·0	(14·8)	13·0—16·5	(14·8)
FA	150·0—155·0	(152·5)	150·0		64·5—75·0	(69·5)	64·5—72·5	(68·2)
Tr	..	..	..	..	7·2—10·0	(8·6)	6·5—9·0	(7·8)
	Skull 3 ♂♂		Skull 3 ♀♀		Skull 8 ♂♂		Skull 4 ♀♀	
Op	68·0—74·0	(68·3)	64·0		21·0—22·5	(21·3)	20·5—21·0	(20·6)
cb	65·0—70·0	(67·5)	62·0		20·0—21·2	(20·3)	19·0—20·0	(19·2)
on	63·0—78·0	(70·5)	61·0		18·0—19·8	(18·4)	17·5—18·5	(17·8)
zw	37·5—41·0	(39·7)	34·0		12·5—13·5	(13·1)	12·0—13·0	(12·6)
io	10·5		10·5		3·0— 3·5	(3·2)	3·0—3·5	(3·1)
cw	17·2—24·8	(20·0)	14·5		8·5—10·0	(9·1)	9·0— 9·5	(9·1)
ob	17·0—18·0	(17·5)	15·0		8·0— 9·5	(8·3)	7·8— 9·0	(8·2)
md	13·5—14·0	(13·7)	13·8		6·8— 7·5	(7·1)	6·0— 6·5	(6·3)
pm	36·0—41·0	(39·5)	32·0		11·2—12·0	(11·8)	11·0—11·5	(11·1)
al	14·0		13·0		6·5— 7·5	(7·0)	7·0	
ltb	4·0— 6·0	(5·0)	7·0		5·0—5·5	(5·1)	5·0— 5·2	(5·1)
btb	3·0 —4·0	(3·5)	5·0		3·5— 4·0	(3·8)	3·2— 4·0	(3·6)
ln	23·0—36·0	(29·5)	20·0		6·0— 7·0	(6·2)	6·0— 8·0	(6·8)
wn	8·0— 8·5	(8·2)	6·5		5·0— 5·5	(5·3)	4·0— 6·0	(5·2)
pl	36·0—40·0	(38·0)	35·0		6·5— 7·0	(6·7)	7·0— 8·8	(7·8)
lut	30·0—31·2	(30·6)	30·0		8·0— 9·0	(8·3)	8·0	
llt	29·0—30·4	(29·7)	30·0		9·0— 9·2	(9·1)	8·8— 9·1	(8·9)
ml	52·0—57·0	(54·5)	50·0		15·0—16·0	(15·4)	14·0—15·0	(14·5)

TABLE 3.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	*Rhinopoma h. hardwickei*				*Taphozous p. perforatus*			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 3 ♂♂		Body : 2 ♀♀		Body : 3 ♂♂		Body : 2 ♀♀	
HB	53·0—66·0	(61·3)	63·0—65·0	(64·0)	69·0—86·0	(75·5)	80·0	
T	61·0—67·0	(65·0)	65·0—67·0	(66·0)	15·0—28·2	(19·6)	16·2—30·4	(23·0)
E	15·0		15·5—19·0	(17·2)	15·0—17·0	(16·0)	15·5—16·0	(15·7)
Hf	12·0—13·0	(12·6)	12·0		10·0—12·0	(11·0)	12·0	
FA	56·0—59·0	(58·1)	58·0—59·0	(58·5)	60·0—63·0	(61·5)	61·0—61·5	(61·2)
Tr	7·0— 8·0	(7·3)	7·5— 8·0	(7·7)	5·0—6·0	(5 5)	5·0	
	Skull : 3 ♂♂		*Skull* : 2 ♀♀		*Skull* : 2 ♂♂		*Skull* : 2 ♀♀	
op	18·0—19·0	(18·5)	18·5—19·2	(18·8)	20·4—21·0	(20·7)	19·2—20·0	(19·6)
cb	17·2—19·5	(18·4)	18·2—18·6	(18·4)	19·5—19·8	(19·6)	18·5—19·0	(18·7)
on	16·0—17·0	(16·4)	16·0—16·5	(16·2)	17·0—19·6	(18·3)	16·8—19·2	(18·0)

TABLE 3.—*Body and cranial measurements of bats from Rajasthan*—contd.

Abbreviation	*Rhinopoma h. hardwickei*				*Taphozous p. perforatus*			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Skull : 3 ♂♂		*Skull* : 2 ♀♀		*Skull* : 2 ♂♂		*Skull* : 2 ♀♀	
zw	11·0		11·0		11·0—11·5	(11·2)	11·0—11·2	(11·1)
io	3·0		3·0		7·0		6·5— 6·8	(6·6)
cw	8·0— 9·0	(8·3)	8·0— 8·5	(8·2)	9·5—10·2	(9·8)	9·2—10·2	(9·7)
ob	6·5— 8·0	(7·1)	7·8		9·2—10·0	(9·6)	9·6— 9·8	(9·2)
md	6·5— 7·0	(6·8)	6·0— 6·2	(6·1)	6·5— 6·8	(6·6)	6·8— 7·0	(6·9)
pm	10·0—11·0	(10·6)	10·0—10·2	(10·1)	11·0		11·0	
al	4·5— 7·0	(6·0)	5·0— 5·8	(5·4)	5·0— 5·8	(5·4)	5·5— 6·5	(6·0)
ltb	3·0— 4·5	(4·0)	4·0— 4·5	(4·2)	4·5— 4·8	(4·6)	4·5	
btb	2·0		2·0		4·0		3·5— 3·8	(3·6)
fn	4·0— 5·0	(4·8)	5·0— 5·2	(5·1)	5·5		5·2— 5·5	(5·3)
wn	6·5— 7·0	(6·8)	6·5— 6·8	(6·6)	7·6— 7·8	(7·7)	7·5	
pl	8·0— 8·5	(8·1)	8·0		8·0—10·8	(9·4)	9·2—11·0	(10·1)
lut	7·0		7·0		9·0		9·0— 9·2	(9·1)
llt	8·0		8·0		8·0— 8·5	(8·2)	8·0	
ml	12·0—13·0	(12·6)	13·0		15·2		14·6—14·8	(14·7)

TABLE 4.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	*Taphozous k. kachhensis*				*Megaderma l. lyra*			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	Body : 2♂♂		Body : 1 ♀		Body : 4♂♂		Body : 2 ♀♀	
HB	94·0—95·0	(94·5)	86·0		72·5—81·0	(75·8)	83·0	
T	32·0		34·0					
E	20·0—21·0	(20·5)	18·0		26·0—32·0	(30·0)	28·0—37·0	(32·5)
HF	16·0—16·5	(16·2)	11·0		14·0—17·0	(15·2)	15·0—16·0	(15·5)
FA	71·5—74·0	(72·7)	74·0		63·0—64·0	(63·5)	66·0—70·0	(68·0)
Tr	5·5— 7·0	(6·2)	5·5		15·0—17·0	(16·0)	17·0—20·0	(18·5)
	Skull : 4♂♂		*Skull* : 2 ♀♀		*Skull* : 2♂♂		*Skull* : 1 ♀	
op	27·2—28·8	(28·0)	18·0—19·0	(28·5)	27·0—30·5	(28·7)	28·0	
cb	25·0—28·0	(26·1)	25·8—26·0	(25·9)	24·0—26·5	(25·2)	26·0	
on	23·0—28·0	(26·1)	24·0—25·0	(24·5)	22·0—22·8	(22·4)	22·0	
zw	12·2—15·0	(14·3)	14·0—16·5	(15·2)	16·0—16·5	(16·2)	16·5	
to	6·5— 9·0	(8·0)	8·0— 8·4	(8·2)	4·5— 5·0	(4·7)	5·0	

TABLE 4.—*Body and cranial measurements of bats from Rajasthan* —contd.

Abbreviation	*Taphozous k. kachhensis*				*Megaderma l. lyra*			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	
	Skull : 4 ♂♂		*Skull : 2 ♀♀*		*Skull : 2 ♂♂*		*Skull : 1 ♀*	
cw	10·2—11·0	(10·9)	11·2—12·0	(11·6)	12·0		13·0	
ob	9·0— 9·8	(9·3)	9·2—10·0	(9·6)	11·0—12·0	(11·5)	11·5	
md	7·0— 8·8	(8·1)	8·5— 9·5	(9·0)	6·8— 7·0	(6·9)	6·2	
pm	11·0—14·0	(13·0)	14·0		13·8—14·8	(14·3)	14·2	
al	5·5— 6·5	(5·9)	5·5— 6·0	(5·7)	5·8— 8·0	(6·9)	8·0	
tb	3·5— 4·5	(3·9)	3·8		3·2— 4·0	(3·6)	4·0	
btb	3·0— 3·8	(3·2)	3·0		2·0— 3·0	(2·5)	2·5	
in	8·5—10·0	(9·1)	9·8—10·0	(9·9)	6·5— 7·0	(6·7)	7·0	
wn	8·8—10·0	(9·6)	9·8—10·0	(9·9)	7·8— 8·0	(7·9)	8·0	
pl	12·0—14·0	(13·0)	13·0—16·0	(14·5)	10·0—10·8	(10·4)	11·0	
tnt	10·5—11·0	(10·8)	10·2—11·0	(10·6)	11·5—12·0	(11·7)	12·0	
llt	12·0—13·0	(12·3)	12·0—13·0	(12·5)	13·0—13·5	(13·2)	14·0	
ml	20·0—21·0	(20·3)	20·2—21·0	(20·6)	19·0—21·0	(20·0)	18·0	

TABLE 5.—*Body and cranial measurements of bats from Rajasthan.*

Abbreviation	*Rhinolophus l. lepidus*				*Pipistrellus mimus glaucillus*	
	Male		Female		Male	Female
	Range	Mean	Range	Mean		
	Body : 3 ♂♂		Body : 4 ♀♀		Body : 1 ♂	Body : 1 ♀
HB	43·0		38·0—40·0	(39·1)	37·1	34·0
T	19·0—23·0	(20·9)	18·0—21·0	(19·8)	24·5	23·5
E	13·0—15·0	(14·0)	12·0—14·0	(13·1)	9·0	8·5
FA	38·0—40·0	(39·0)	37·0—40·0	(39·0)	29·5	28·8
HF	7·0— 8·0	(7·6)	6·0— 7·0	(6·4)	5·0	5·0
Tr	—	—	—	—	4·0	4·0
	Skull : 2 ♂♂		*Skull* : 2 ♀♀		*Skull* : 1 ♂, damaged	
op	16·0—17·5	(16·7)	16·0		11·4	
cb	15·0—16·0	(15·3)	14·0—15·0	(14·5)	10·8	
on	11·5—11·8	(11·6)	11·5—11·8	(11·6)	10·2	
zw	9·0		8·0— 8·2	(8·1)	7·2	
io	2·5— 3·0	(2·7)	2·5— 2·8	(2·5)	3·4	

TABLE 5.—*Body and cranial measurements of bats from Rajasthan*—contd.

Abbreviation	*Rhinolophus l. lepidus*				*Pipistrellus mimus glaucillus*	
	Male		Female		Male	Female
	Range	Mean	Range	Mean		
	Skull : 2 ♂♂		*Skull* : 2 ♀♀		*Skull* : 1 ♂, damaged	
cw	6·5— 6·8	(6·6)	6·0— 6·8	(6·4)	6·2	
ob	5·8— 6·0	(5·9)	5·8— 6·2	(6·0)		
md	5·0		5·0— 5·5	(5·2)	4·2	
pm	9·0— 9·5	(9·2)	9·0— 9·5	(9·2)	6 4	
al	4·8— 5·0	(4·9)	4·5— 5·0	(4·7)		
ltb	5·0		5·0			
btb	4·0		4·0			
in	4·2— 4·5	(4·3)	4·2— 4·5	(4·3)		
cb	3·8— 4·0	(3·9)	3·5— 4·5	(4·3)		
pl	5·0		5·2		4.8	
lat	6·0·— 6·5	(6·2)	6·0— 6·5	(6·2)		
llt	6·5— 7·0	(6·7)	6·5— 7·0	(6·7)		
ml	9·5—10·0	(9·7)	10·0		7·8	

THF BEETLE FAUNA (INSECTA : COLEOPTERA) OF SOIL IN FOUR SMALL AREAS IN ALLAHABAD (U.P., INDIA)

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(With 1 Text-figure)

CONTENTS

I—INTRODUCTION

The insect fauna of soil has been studied in its different aspects by Cameron (1913, 1917), Dammermann (1937), Ghilarow (1937), Glasgow (1939), Jacot (1940), King (1939), King and Atkinson (1927), Trehan (1945), and a number of other authors, and much interesting information has thus been accumulated. The information available under Indian conditions, however, is extremely limited.

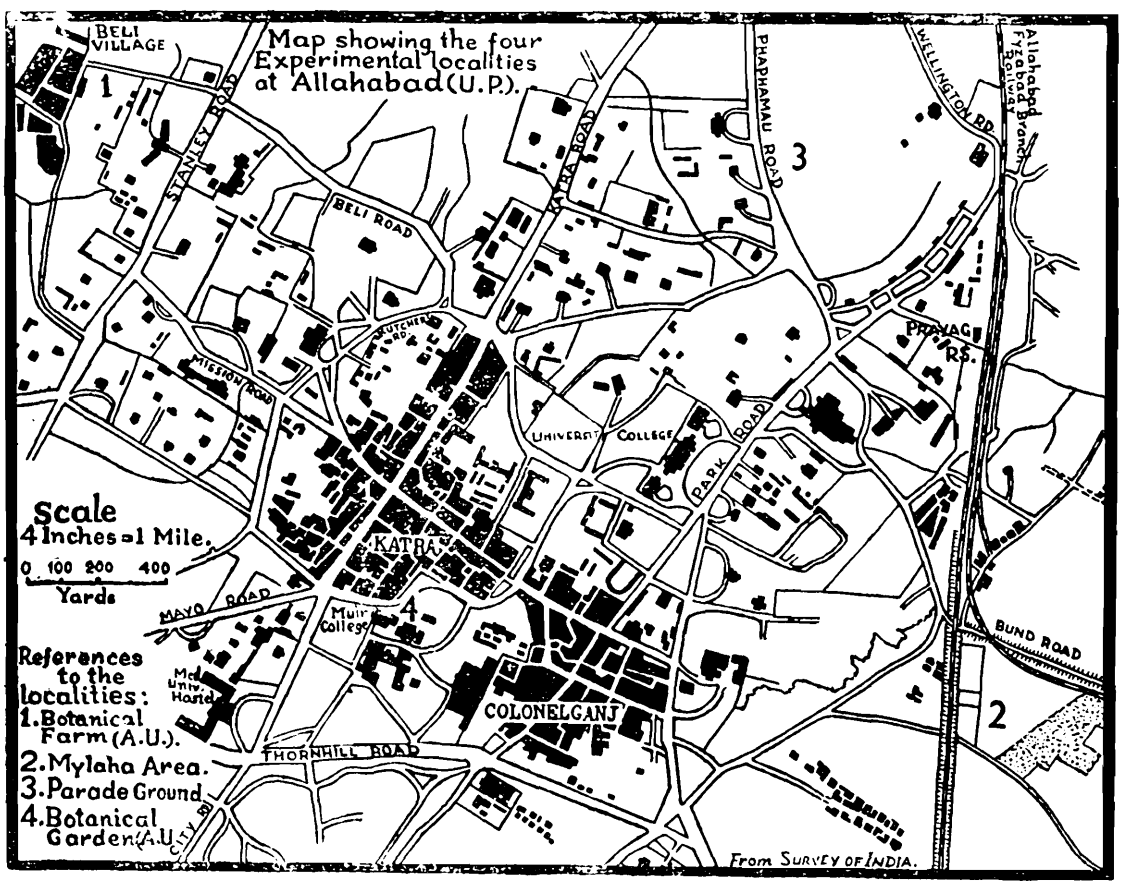
Some years ago (in 1949) I was able to carry out certain observations in four different localities (*vide infra*) in Allahabad (Uttar Pradesh). The observations were made during the *kharif* and part of the *rabi* seasons, *i.e.*, from the beginning of August to end of November, 1949. The localities selected were widely separated from one another and showed different physical conditions particularly in respect to its vegetation, manuring and nature and tillage of the soil. For a preliminary account of these studies, *vide* Kushwaha, 1959.

The observations were carried out while I was working in the Zoology Department of the University of Allahabad. I am thankful to Prof. H. R. Mehra for laboratory facilities and the late Shri S. C. Verma, Reader, for supervision. The identifications were carried out at the Forest Research Institute, Dehra Dun, and for assistance in this regard

I am indebted to the late Shri G. D. Bhasin, Assistant Systematic Entomologist, and to Shri Balwant Singh for valuable suggestions. My best thanks are due to Dr. M. L. Roonwal, Director, Zoological Survey of India, Calcutta, for critically going through the manuscript and making valuable suggestions for the improvement of the paper.

II—Material and Methods

Field observations and collections of the soil coleopteran fauna were carried out regularly in all the four localities selected for this study. Eesides these, many other coleopteran pests were observed damaging the aerial parts of the plants in these areas, but those have not been included here since they were not observed to exhibit the typical habits of the soil fauna particularly in the adult stage. For collections, the surface soil as well as the sub-surface soil mostly upto 22 cms. (*ca.* 9



TEXT FIG. 1.—Map showing the four experimental localities at Allahabad, U P.

inches) depth, which is ordinarily the cultivable soil profile for the agricultural crops in general, were searched extensively and during cultivation the plough was followed closely in search of the specimens. All the families, and under each family all the genera and species, have been arranged alphabetically ; the species which could not be identified have not been included. The whole collection was deposited in the Department of Zoology, University of Allahabad.

III—Description of the Four Experimental Localities

1. *Botanical Farm, University of Allahabad.*—The farm is located about a mile north-west of the Muir Central College on the left side of

the road leading to village Beli. The soil was sandy, manured with compost as well as ammonium sulphate and irrigated with well water during the *rabi* season. The major area was under *jowar* (*Sorghum valgare* Pers.) which followed wheat (*Triticum vulgare* Vill.); the adjoining crops included sugarcane (*Saccharum offlicinarum* L.), *arhar* (*Cajanus cajan* (Linn.) Millsp.; syn. *C. indicus* Spr.) and some solanaceous vegetables. The area was exposed to wind and sun.

2. *Mylaha Area, Tagore Town.*—The area lies about 2·5 kilometres south-east of the Muir Central College, and is about 65-75 metres south of the Bund Road and adjacent to an old graveyard in the north beyond the railway line running between Allahabad Junction and Prayag. All sorts of city refuge and animal carcasses are dumped in the area. The soil was more or less clayey in nature, with the upper profiles showing considerable deposit of humus. In the absence of drainage facilities, stagnant water got collected round about. The adjacent vegetation included castor (*Ricinus communis* L.), maize (*Zea mays* L.) and some solanaceous vegetables. The area was exposed to the sun, and the railway line running at a considerably high level formed wind-breaks.

3. *Parade Grounds, Chatham Lines.*—The area is about 2 kilometres north-east of the Muir Central College, and lies on the right side of the road leading to New Phaphamau. The land was lying fallow for several years and a portion of it was used for police parades. The soil is very poor in organic matter, and has a hard encrusted surface. It was cultivated with tomato (*Lycopersicum esculentum* Mill.) followed by *bajra* (*Pennisetum typhoides* Staph. & Habbard) for the first year. During cultivation the plough was followed closely for insect collections. No manure was used and there was no source of water at hand for irrigation. The area was exposed to sun, and the trees of *neem* (*Azadirachta indica* A. Juss.) and *shisham* (*Delbergia sissoo* Roxb.) bordering the adjacent road formed wind-breaks

4. *Botanical Garden, University of Allahabad.* The garden is situated in the Muir Central College behind the Zoology and Botany Departments, with the Muir Road bounding it in a semi-cricle and running north-east to south-west. The soil surface was covered considerably with organic matter. The area was partially shaded by trees of peach (*Prunus persica* Bth. & Hook. f.), *ashok* (*Saraca indica* L.), *simal* (*Salmalia malabarica* (DC.) Schott. **D** Fndl.; syn. *Bambax malabarica* DC.), *anjir* (*Ficus carica* L.), etc., on all the sides. Irrigation was by tap water.

IV—THE COLEOPTERAN FAUNA OF THE SOIL IN FOUR DIFFERENT LOCALITIES

(a) LIST OF SOIL COLEOPTERA FROM THE BOTANICAL FARM

Family 1. CARABIDAE (Ground beetles)

Omophron sp.: A single individual of *Omophron* sp. was collected, on 25th August 1949, from root region of *Jowar* (*Sorghum vulgare*) plant when the soil was not very moist, though these insects are semiaquatic in their habit.

Siagona fabricii Andrewes : A single specimen of *Siagona fabrici,* Andr. was found hidden on 25th August 1949 in soil crevices ; it was noticed to be a most active runner.

Family 2. CICINDELIDAE (Tiger beetles)

Cicindela erudita Wiedemann, *Cicindela sexpunctata* Linnaeus *Cicindela vigintiguttata* Herbst, and *Cicindela* sp. All the above species were collected between 4th August to 14th September 1949, but were most abundant in the 3rd and 4th weeks of August. They were mostly collected from surface on humid days and also by arranging light traps. All are predacious, swift runners with small but agile flights.

Family 3. MELOIDAE (Oil beetles, blister beetles)

Cyaneolytta sp. : Collected abundantly from 9th August to 3rd September 1949 on the surface, walking sluggishly and also observed on small plants of *jowar* (*Sorghum vulgare*), though no significant damage to the crop was observed. They are generally diurnal and herbivorous.

Family 4. SCARABAEIDAE (Dung-beetles, chafers, etc.)

Alissonotum sp. (Subfam. Dynastinae) : Collected from 6th September to 3rd October 1949, being abundantly observed in the 2nd week of September mostly about 5 cms. below soil amongst rootage of some wild creepers.

Apogonia hopei Ritsema (Subfam. Melolonthinae) : Collected from 28th August to 2nd October 1949, being observed more abundantly in the 1st and 2nd weeks of September, hardly 3 or 4 cms. below surface.

Apogonia sp. (Subfam. (Melolonthinae) : Observed in abundance in the 3rd and 4th weeks of September and mostly collected under clods of earth or other such shelters on the surface.

Bolbocerus inaequale Westwood (Subfam. Geotrupinae) : Commonly observed throughout August and September, but more abundantly collected from 15th September onwards for a week or so on surface ; is a general feeder on dung or on truffle.

Catharsius pithecius Fabricius (Subfam. Coprinae) : Collected from 6th August to 27th August 1949, being observed more abundantly in 3rd week of August and collected about 7—12 cms. below the ground surface. The area inhabited by these beetles was indicated at the surface by ample loose, porous, pulverised soil with numerous large and small holes

Chiron cylindrus Fabricius (syn. *Chiron digitatus* Cast.) (Subfam. Chironinae) : Collected from 2nd September to 14th November 1949, but abundantly observed in the 1st and 2nd weeks of September and mostly collected from surface ; the larvae as well as adults feed on dung.

Copris sp. (Subfam. Coprinae) : Collected from 2nd August to 4th October 1949, being abundantly observed in the last week of August and the 1st and 2nd weeks of September. Collected just below soil amongst *C. pithecius*- -(*vide supra*) under loose porous soil.

Holotrichia seticollis Moser (Subfam. Melolonthinae) : Collected from 28th August to 7th October 1949, being abundantly observed in the

1st and 2nd weeks of September, and mostly collected around the root region of *Jowar* plants, etc.; larvae are generally underground root feeders.

Onitis sp. (Subfam. Coprinae) : Collected from 29th July to 17th September 1949, about 9—12 cms. below soil surface. More abundantly observed in the beginning of August.

Onthophagus gazella Fabricius (Syn. *Onthophagus catta* Fabricius) (Subfam. Coprinae) : Commonly observed during August and September 1949, but occurring more abundantly in August ; collected about 10—12 cms. below soil. Search of their underground habitations revealed neither any dung nor any other visible organic matter which forms their usual food, though some species are known as carrion feeders and still others known as feeders on decomposed vegetable matter.

Onthophagus sp. Subfam. Coprinae) : Collected from 19th August to 25th September 1949, being more abundant in the 2nd and 3rd weeks of September. Observed mostly in upper profiles, hardly 4—6 cms. below ground.

Oxycetonia versicolor Fabricius (Subfam. Cetoniinae) : Only a few individuals were collected, from 7th August to 18th August 1949, under rubbish heaps of trash lying within the fields.

Serica sp. (Subfam. (Melolonthinae) : Collected from 3rd August to 14th September 1949, at about 7—9 cms. depth, in soil around the root region of the *jowar* plants, but also collected from the root region of *anar* (*Punica granatum* L.) plant on the Bund Road.

Family 5. STAPHYLINIDAE (Rove beetle)

Paederus sp. : Commonly observed during August and September but more abundant in the last three weeks of August. Mostly noticed running on ground under trash or in between over lapping leaf bases of crop-plants, particularly sugarcane. Have a characteristic, mobile abdomen moving up and down.

Family 6. TENEBRIONIDAE (Darkling ground beetles)

Adesmia orientalis Haag : Collected from 1st September to 8th October 1949, but observed only in meagre numbers ; hardly about 3 or 4 cm. below the loose soil. General scavengers ; light-seeking as well as light shunning species.

(b) LIST OF SOIL COLEOPTERA FROM THE MYLAHA AREA IN TAGORE TOWN

Family 1. CARABIDAE (Ground beetles)

Brachynus eucosmus Andrewes : Collected from 7th August to 21st September 1949, near surface under trash or similar shelters.

Brachynus sp.: Collected from 27th August to 8th September 1949 in meagre numbers, mostly from surface under clods and also under a big stone.

Callistomimus chalcocephalus Wiedemann : Only 4 specimens were collected, on 10th and 13th November 1949, from surface ; noticed running actively from shelter to shelter.

Chlaenius chlorodius Dejean : Collected from 3rd to 24th August 1949, in meagre numbers and invariably found under clods on surface.

Chlaenius duvauceli Dejean : About a dozen specimens collected from 14th August to 29th August 1949, under clods and also under a small plank of wood lying in the filed.

Chlaenius pretiosus Chaudoir : Collected from 7th August to 3rd September 1949, just below surface about 4—5 cms. below soil.

Melaenus piger Fabricius : A single individual was caught on 17th August under a clod of earth.

Siagona sp. : Only 3 specimens were collected on 21st August 1949, from cracks at the base of stem of *lissora* plant (*Cordia dichotoma* Forst f., syn. *Cordia myxa* Roxb. non Linn.; and *Cordia obliqua* Willd.), at about 10—12 cms. depth from the soil surface.

Family 2. CURCULIONIDAE (Weevils)

Lixus truncatulus Fabricius : A single individual was collected, on 21st August from exposed surface.

Tanymecus indicus Faust : Collected from the beginning of August to the end of November 1949, but very abundant in August and September, in field as well as in houses, and is commonly seen attracted towards light at night. In field it was found under fallen leaves and trash.

Family 3. HISTERIDAE (Hister beetles, Steel beetles)

Hister (*Pachylister*) *chinensis* Quensel, and *Hister* sp. : Some individuals of these were collected from the subsurface, at about 3—6 cms. depth, from 9th August to 12th September 1949. Generally found in concealment and are nocturnal.

Family 4. SCARABAEIDAE (Dung-beetles, chafers, etc.)

Chiron cylindrus Fabricius (syn. *Chiron digitatus* Cast.) (Subfam. Chironinae) : Collected from the beginning of September to the middle of November 1949, but more abundant during September. Collected invariably at the base of plants.

Hybosorus sp. (Subfam. Hybosorinae.) : Only the larvae and pupae were collected lying mostly side by side, at about 10—12 cms. depth, from 2 to 23rd November 1949. Both the immature stages were successfully reared to adults.

Family 5. TENEBRIONIDAE (Darkling ground beetles)

Adavius sp.: Commonly collected throughout November 1949, at the base of plants in cracks.

Cossyphus depressus Fabricius : Collected from 4th September to 25th October 1949, being observed abundantly in the narrow spaces at the base of plants in the 2nd and 3rd weeks of September.

Gonocephalum strangulatum Fairmaire, and *Gonocephalum* sp.: Both these were collected from 6th August to 16th September 1949, but were more abundant in the 3rd week of August. Found hidden in narrow, shallow cracks in the soil, particularly at the base of the plants.

Pachypterus infimus Fairmaire : Collected amongst *C. depressus* Fabr. (*vide supra*).

Sclerum reitteri Gebien (syn. *Scleron reitteri* Gebien) : Collected from 1st to 29th November 1949, just below surface or on surface.

(c) LIST OF SOIL COLEOPTERA FROM THE PARADE GROUNDS IN CHATHAM LINES

Family 1. CARABIDAE (GROUND beetles)

Amara sp. : Collected from furrows behind the plough, abundantly from 3rd to 17th November 1949.

Oxycentrus parallelus Chaudoir : Collected from furrows behind the plough, from 2nd to 13th August 1949.

Platymetopus flavilabris Fabricius : Collected from furrows behind the plough, abundantly from 3rd to 17th November 1949.

Scarites indus Olivier : Collected from 1st August to 12th October 1949, but observed more abundantly in August ; about 12—15 cms. below soil.

P. flavilabris Fabr. and *S. indus* Oliv. were observed to be the most common representatives of this family in this area. Also, the last three species recorded above in this family were observed to be very active runners.

Family 2. CURCULIONIDAE (Weevils)

Tanymecus indicus Faust : Collected from the beginning of August to the end of November 1949, mostly from surface, but more abundant in August and September.

Family 3. SCARABAEIDAE (Dung-beetles, chafers, etc.)

Chiron cylindrus Fabricius (syn. *Chiron digitatus* Cast.) (Subfam. Chironinae) : Collected from 2nd September to 14th November 1949, on surface and upto 8 cms. depth. More abundant in the 1st and 2nd weeks of September.

Onthophagus sp. (Subfam. Coprinae) : Mostly collected in this area from the middle of October to the middle of November 1949 ; just below surface.

Family 4. TENEBRIONIDAE (Darkling ground beetles)

Rhytinota sp. : Only one specimen was collected, about 9 cms. below soil, on 15th Septembe 1949.

(d) LIST OF SOIL COLEOPTERA FROM THE BOTANICAL GARDEN

Family 1. CARABIDAE (Ground beetles)

Calosoma maderae Fabricius var. *indicum* Hope: A single specimen was collected on 4th August 1949, about 13 cms. below soil under a flower pot growing fern where the soil was sufficiently moist.

Chlaenius malachinus Motschulsky : Collected from 15th August to 11th September 1949.

Chlaenius nitidicollis Dejean : Collected from 27th October to 30th November 1949.

Chlaenius rayotus Bates : Collected from 19th August to 4th October 1949, but abundant in the last week of August and the 1st week of September.

Chlaenius trinotatus Laferte, *Chlaenius xanthospilus* Wiedemann, and *Pheropsophus catoirei* Dejean : All these three species were collected amongst *C. rayotus* (*vide supra*) to which these species were observed to closely correspond in duration of occurrence as well as intensity.

Rhopalopalpus janthinus Redtenbacher (syn. *Rhopalistes janthinu* Redt.) : Except the species of *Calosama*, all the above Carabidae were collected from the surface of heaps of garden refuge including mainly the dry tree leaves dumped just behind the Entomology Laboratory under the shade of trees and a temporary shed. The heaps had sufficient moisture inside. *R. janthinus* Redt. was observed to be an active predator on small Blattids. *P. catoirei* Dej. is armed with a defensive apparatus for the discharge of a volatile, caustic fluid.

Family 2. SCARABAEIDAE (Dung-beetles, chafers, etc.)

Adoretus sp. (Subfam. Rutelinae) : Only three adults were collected from the root region of *gurhal* (*Hibiscus rosa sinensis* Linn.) plant on 9th September 1949. They are generally nocturnal defoliators in the beetle stage, mainly feeding at night ; and are injurious to rootlets of plants in the larval stage. Several common Indian species of this genus have been reported to feed upon roses (*Rosa* sp.), cannas (*Canna* sp.), vines (*Vitis vinifera* L.), mangoes (*Mangifera indica* L.) and other cultivated plants.

Chiron cylindrus Fabricius (syn. *Chiron digitatus* Cast.) (Subfam. Chironinae) : Collected from surface under refuge, mostly in the 1st and 2nd weeks of September (*vide supra*).

Gymnopleurus parvus Macleay (Subfam. Coprinae) : A few individuals were collected from 5th to 19th September 1949, invariably under refuge, though slightly buried at subsurface.

Hybosorus sp. (Subfam. Hybosorinae) : A few individuals were collected from 3rd to 20th September 1949, from surface under refuge.

Family 3. TENEBRIONIDAE (Darkling ground beetles)

Gonocephalum depressum Fabricius, and *Gonocephalum* sp. : Collected from 18th October to 21st November 1949, but observed more abundantly in the 1st and 2nd weeks of November. Commonly found under refuge on surface; and noticed slowly coming out to cleaned areas, particularly in the forenoons, from their hidden places. Many of them were coming to the cemented floor of the laboratory. *G. depressum* Fabr. was also noticed in great numbers under *anjir* (*Ficus carica* L.) tree among five cockchafer grubs which were cannibalistic in habit.

V—SUMMARY

1. The Coleopteran fauna of soil was studied at Allahabad from August to November, 1949, in four limited areas with variable physical conditions of vegetation, manuring and tillage of soil.

2. Altogether 68 species were collected, of which 57 could be indentified. They belong to 40 genera of 8 families, *viz.*, Carabidae, Cicindelidae, Curculionidae, Histeridae, Meloidae, Scarabaeidae, Staphylinidae, and Tenebrionidae. The Elaterids could not be satisfactorily identified. Family Scarabaeidae is represented by 8 subfamilies, *viz.*, Cetoniinae, Chironinae, Coprinae, Dynastinae, Geotrupinae, Hybosorinae, Melolonthinae and Rutelinae.

3. A total of 22 species, belonging to 18 genera of 6 families, are recorded from the Botanical Farm ; 20 species, belonging to 15 genera of 5 families, from the Mylaha Area ; 14 species, belonging to 9 genera of 3 families, from the Botanical Garden ; and 8 species, belonging to 8 genera of 4 families, from Parade Grounds.

4. Cicindelids and Carabids predominated in the Botanical Farm ; Carabids and Tenebrionids in the Mylaha ; and Carabids in the Botanical Garden and the Parade Grounds.

5. The families Carabidae, Scarabaeidae and Tenebrionidae were represented more or less in all the four areas. The Cicindelids and the Meloids were recorded only from the Botanical Farm, and the Histerids only from the Mylaha. Further, the Curculionids were absent from the Botanical Garden, whereas the Staphylinids were absent both from the Mylaha and the Botanical Garden.

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VII—APPENDIX

LIST OF THE COLEOPTERAN FAUNA COLLECTED AT ALLAHABAD

Family 1. CARABIDAE

Amara sp.
Brachynus eucosmus Andrewes
Brachynus sp.
Collistomimus chalcocephalus Wiedemann
Calosoma maderae Fabricius var. *indicus* Hope
Chlaenius chlorodius Dejean
Chlaenius duvauceli Dejean
Chlaenius malachinus Motschulsky
Chlaenius nitidicollis Dejean
Chlaenius pretiosus Chaudoir
Chlaenius rayotus Bates
Chlaenius trinotatus Laferte
Chlaenius xanthospilus Wiedemann
Melaenus piger Fabricius
Omophron sp.
Oxycentrus parallelus Chaudoir
Pheropsophus catoirei Dejean
Platymetopus flavilabris Fabricius
Rhopalopalpus janthinus Redtenbacher (syn. *Rhopalistes janthinus* Redt.)
Scarites indus Olivier
Siagona fabricii Andrewes
Siagona sp.

Family 2. CICINDELIDAE

Cicindela erudita Wiedemann
Cicindela sexpunctata Linnaeus
Cicindela vigintiguttata Herbst
Cicindela sp.

Family 3. CURCULIONIDAE

Lixus truncatulus Fabricius
Tanymecus indicus Faust

Family 4. HISTERIDAE

Hister (*Pachylister*) *chinensis* Quensel
Hister sp.

Family 5. MELOIDAE

Cyaneolytta sp.

Family 6. SCARABAEIDAE

Sub-family (i) *CETONIINAE*

Oxycetonia versicolor Fabricius

Sub-family (ii) *CHIRONINAE*

Chiron cylindrus Fabricius (syn. *C. digitatus* Cast.)

Sub-family (iii) *COPRINAE*

Catharsius pithecius Fabricius
Copris sp.
Gymnopleurus parvus Macleay
Onitis sp.
Onthophagus gazella Fabricius (syn. *O. catta* Fabr.)
Onthophagus sp.

Sub-family (iv) *DYNASTINAE*

Alissonotum sp.

Sub-family (v) *GEOTRUPINAE*

Bolbocerus inaequale Westwood

Sub-family (vi) *HYBOSORINAE*

Hybosorus sp.

Sub-family (vii) *MELOLONTHINAE*

Apogonia hopei Ritsema
Apogonia sp.
Holotrichia seticollis Moser
Serica sp.

Sub-family (viii) *RUTELINA*

Adoretus sp.

Family 7. STAPHYLINIDAE

Paederus sp.

Family 8. ENEERIONIDAE

Adavius sp.
Adesmia orientalis Haag
Cossyphus depressus Fabricius
Gonocephalum depressum Fabricius
Gonocephalum strangulatum Fairmaire
Gonocephalum sp.
Pachypterus infimus Fairmaire
Rhytinota sp.
*Sclerum reitteri Ge*bien (syn. *Scleron reitteri* Gebien)

THE MAYFLIES (EPHEMEROPTERA) FROM THE NORTH-WESTERN HIMALAYA*

By

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(With 1 Plate and 16 Text-figures)

CONTENTS

I—INTRODUCTION

The Mayflies (Ephemeroptera) of the north-western Himalayas are very inadequately known. Eaton (1883-1888), in a monograph on the order, recorded *Cloeon dipterum* Linnaeus from Europe to north-western India and *Epeorus psi* Eaton from Kulu in the Punjab. Ulmer (1935) reported *Cloeon inscriptum* Bengtsson, from the vicinity of Srinagar in Kashmir. Traver (1939) in her paper on the Himalayan Mayflies described five new species, namely *Caenis srinagari* Traver from Srinagar, *Cloeon kashmiri* Traver from Kashmir, *Baetiella ladakae* Traver, *Ameletus primitivus* Traver and *Ororotsia hutchinsoni* Traver from Ladak, thereby bringing the total number of species to eight. As a result of the present study eight more species are added to this number

The material was chiefly collected by one of us (A.P.K.) from the Kulu and the Lahaul-Spiti Valleys in the Punjab, India, in May and June, 1955, during the course of an insect survey of the area. It contained 130 examples of imagos and subimagos and some 500 nymphs belonging to various species. In addition, about 30 examples of imagos and subimagos of two species, very kindly lent by Dr. M. S. Mani, were also studied.

* For a general account of the insects collected in the same area see Kapur, A. P., 1958, *Proc. 10th intern. Congr. Ent.*, Vol. I, 1956 (1958), pp. 775—784 (1 map).

The eight new species described from the imago and subimago material belong to the genera *Ephemerella* Walsh, *Baetis* Leach and *Epeorus* Eaton. Hitherto *Ephemerella* was known from the nymphs only in the N. W Himalayas and Nepal. The nymphal material referred to above belongs to the genera *Paraleptophlebia* Lestage, *Ephemerella*, *Baetis*, *Ecdyonurus* Eaton, *Iron* Eaton, and *Ironopsis* Traver. Of these the first and the last are being recorded for the first time from India.

The main object of the insect survey referred to above was a study of the high altitude insects in these parts of the Himalayas and the collections under report came from the following localities with altitudes between 6,000 ft. and 13,000 ft. above sea-level. Brief notes on the general habitats of the material collected are given below.

Manali (*Ca.* 6,000 ft.=1,829 m.). In the Kulu Valley. Fast flowing to torrential Beas river, and moderately fast streams passing through pine forests, etc. ; 23rd May, 1955 and 23rd and 25th June, 1955.

Nymphs : *Paraleptophlebia* sp. 1, *Ephemerella* sp., *Baetis* sp., *Ecdyonurus* sp. and *Iron* sp.

Manali to Kothi (*Ca.* 6,500 ft.=1,981 m.). Moderately fast stream passing through forest and paddy fields ; 24th May, 1955.

Nymphs : *Ephemerella* sp.

Kothi (*Ca.* 8,000 ft.=2,438 m.). A moderately large stream of varying habitat on the right and back of the Rest House, passing through mixed but mainly *deodar* (*Cedrus deodara*) forest and with dense scrub growth near banks at lower elevations ; torrential at places, specially at higher altitudes but generally fast-flowing elsewhere ; 20th June, 1955.

Nymphs : *Paraleptophlebia* sp. 2, *Baetis simplex*, sp. n., *Baetis* sp., *Ecdyonurus* sp., *Iron* sp. and *Ironopsis* sp. 2.

Adults : *Baetis simplex*, sp. n.

Ralha base camp (*Ca.* 9,000 ft.=2,743 m.). Beas river, a few miles down its source ; torrential to fast flowing and generally with very cold and clear water except in the after-noon when the water gets slightly dirty owing to the melting of snow ; with little vegetation on the banks ; forest and meadows in the vicinity ; 26th May, 1956.

Nymphs : *Paraleptophlebia* sp. 2, *Baetis* sp., *Ecdyonurus* sp.

Adults : *Ephemerella indica*, sp. n., *Baetis chandra*, sp. n.

Two miles north-east of Ralha (*Ca.* 11,000 ft.=3,353 m.). Beas river, mostly torrential and fast flowing, as stated above ; 27th May, 1955.

Nymphs : *Baetis* sp., *Iron* sp.

Two miles south of Ralha (*Ca.* 10,000—11,000 ft.=3,048 m.—3,353 m.). At the edge of *deodar* forest and from very fast to moderately fast streams near or passing through the forest. Adults caught from shaded boulders and rocks ; 28th and 29th May, 1955.

Nymphs : *Baetis* sp., *Ecdyonurus* sp., *Iron* sp.

Adults : *Baetis bifurcatus*, sp. n., *Baetis festivus*, sp. n., and *Baetis punjabensis*, sp. n.

Near source of the Beas river (*Ca.* 11,000—12,000 ft.=3,353—3,658 m.). From the fast running Beas river, nearly 1 mile south of the Rohtang Pass ; 2nd June, 1955.

Nymphs : *Baetis* sp., *Iron* sp.

Ganddapu (*Ca.* 11,000 ft.=3,353 m.). In the Lahaul-Spiti Valley, from the river Chandra (10,500 ft.=3,200 m.) with enormous quantity of very fast-flowing water and with large boulders to smaller stones on its banks. Also from fast-running but smaller streams falling into the river ; 7th—9th June, 1955.

Nymphs : *Baetis chandra*, sp. n., *Baetis* sp., *Ecdyonurus* sp., *Iron sp.*, *Ironopsis* sp. 1.

Adults : *Baetis chandra*, sp. n.

Sissu (*Ca.* 10,500 ft.=3,200 m.). Lahaul Valley, torrential to fast-running streams near the Rest House ; with vegetation on the banks ; 10th June, 1955.

Nymphs : *Baetis* sp., *Iron* sp.

Adults : *Baetis himalayana*, sp. n., and *Epeorus lahaulensis*, sp. n.

Khoksar (*Ca.* 10,800 ft.=3,292 m.). Lahaul Valley ; torrential to fast-running streams falling into Chandra river ; little vegetation on the banks ; 11th June, 1955.

Nymphs : *Iron* sp.

Adults : *Baetis chandra*, sp. n.

Dorni Thach (*Ca.* 11,800—12,000 ft.=3,292—3,658 m.). Lahaul-Spiti Valley. Fast running streams falling into Chandra river ; 12th June, 1955.

Nymphs : *Baetis chandra*, sp. n.

Chhatoru (*Ca.* 11,000 ft.=3,353 m.). Lahaul-Spiti Valley. Fast running Chandra river with large to small boulders on the bank and little vegetation. Also torrential streams flowing into the river ; 15th and 16th June, 1955.

Nymphs : *Baetis chandra*, sp. n., *Ironopsis* sp. 1.

Adults : *Baetis chandra*, sp. n.

Purana Khoksar Nal (*Ca.* 13,000 ft.=3,962 m.). From fast flowing to torrential streams of small to moderate size. 17th June, 1955.

Nymphs : Baetis sp., *Iron* sp.

II—METHOD OF STUDY

The material, which was mostly preserved in alcohol, was at first carefully examined under a stereoscopic binocular and the body-form, size, colouration and other similar characters noted.

For the study of imagos, wings of one side were removed and mounted with a drop of alcohol on a slide and covered with a cover-glass which was fixed to the slide by strips of sticky paper. As the alcohol evaporated, the wing became dry and fit for study. The disadvantage of mounting wings in Canada balsam is that the weaker veins become

invisible. Permanent mounts in Canada balsam were, however, made of the male genitalia, legs of one side and of similar other structures when necessary. For permanent mounts in Canada balsam, usually dissected parts were treated with 10 per cent KOH (cold) for varying length of time, from a few hours to a day, depending on the size of the specimen, and after the usual process of neutralisation and dehydration, cleared in clove oil in which medium these were studied in greater detail. Finally, these were mounted in Canada balsam for study of minute structures and for making final sketches which were made with the help of camera lucida.

In the case of nymphs the gills and legs of one side and the mouth-parts were mounted in balsam on the slides.

III—Description of imagos and subimagos

Family Ephemerellidae

Genus **Ephemerella** Walsh

This holarctic genus was hitherto known from Nepal (Ueno, 1955) and India from nymphs only. In India Hora (1932) recorded nymphs of Ephemerellidae from the Krelnu Giri Nallah at Dalhousie, and Ravi River at Chamba. He did not assign these definitely to a genus, but stated that they looked like *Ephemerella*. We also consider from his description that he was dealing with *Ehpemerllea* only. Nymphs of the genus have been further recorded from Ladakh (Kashmir State) (Traver, 1939).

Ephemerella indica, sp. n. is being described from an adult caught at Ralha (*Ca.* 9,000 ft.=2,743 m.) in the Kulu Valley, Punjab. A few nymphs, apparently of another species, were also obtained from Manali (*Ca.* 6,000 ft.=1,829 m.) in the same valley.

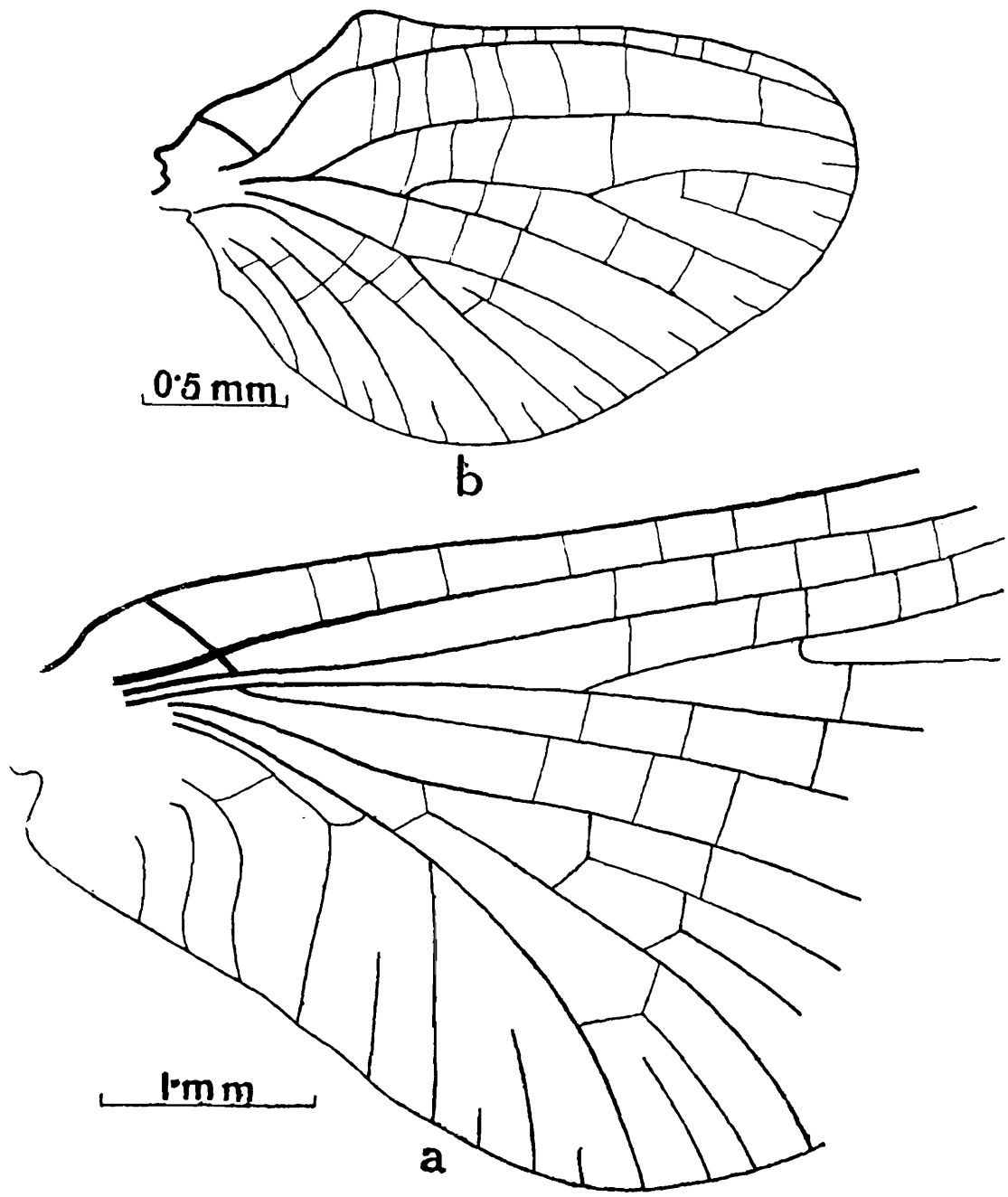
Ephemerella indica, sp. nov.

(Text-fig. 1)

Female imago Length of body 6 mm.; forewing 10 mm. Head mostly dull brown, eyes small and blackish, teeth whitish, antenna with the basal segment dark brown, the rest lighter. Thorax slightly darker than head, 3 white spots on the mesonotum, pleurae shaded with brown ganglionic area of mesosternum blackish. Coxae of legs light brown., Wings slightly opaque, the longitudinal veins brown, deepest on the costal margin of the forewings. In the forewing, stigmatic area opaque, whitish, the cross veins anastomosed ; 2 short intercalaries between median intercalary and posterior branch of M, also between the latter vein and Cu_1 (Text-fig. 1*a*). Hind wing (Text-fig. 1*b*) 2×1.2 mm., with Sc arched, ' Of ' of hind wing absent. Abdominal tergites brownish, much lighter in colour than thorax, anterior portions darker, giving the abdomen a ringed appearance ; sternites paler, ganglionic area on 7th sternite distinct, round and blackish. Terminal filaments (Tails) three

Holotype.—♀ imago, INDIA : Ralha (*Ca.* 9,000 ft.=2,743 m.), Kulu Valley, N. W Himalaya ; 26. v. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2456/H8).

Remarks.—As already stated, no adult of *Ephemerella* has been recorded from India before, although the nymphs of the genus have been collected from various localities in the Himalayas. In the adjoining area of Central Asia, the species of *Ephemerella submontana* Brodsky is



TEXT-FIG. 1.—*Ephemerella indica*, sp. nov.

(*a*). Basal part of forewing. (*b*). Hind wing.

known from Issyksee mountain and the Issyk river. *E. indica*, is easily distinguished from *submontana* by its smaller size, the presence of the whitish opaque stigmatic area and by the absence of the pattern (consisting of white spots) on the adbominal segments, which is characteristic of *submontana*.

Family BAETIDAE

Genus **Baetis** Leach

This large genus is widely distributed in the holarctic, neotropical and Indo-Australian regions. It is known from various localities in India, Ceylon and Nepal (Nymphs). In India a total of six species are recorded from Ladakh and Kashmir (both in Kashmir State), Darjeeling (N. Bengal), Hoshangabad (Madhya Pradesh) and Poona(Bombay State). Regarding the material from Ladakh and Kashmir Traver (1939) stated that it was inadequate in every case for specific determination. Gillies (1949) described six species from other localities mentioned above. Six more species are now being recorded from various habitats in the Kulu and Lahaul-Spiti Valleys in the Punjab.

The following key is given for determining the known Indian species of the genus.

Key to the Indian species of the genus Baetis *Leach*

1.	Hind wing with two longitudinal veins .	2
	Hind wing with three longitudinal veins, the third may be very weak .	5
2.	Costal spur of hind wing wanting .	3
	Costal spur of hind wing present .	4
3.	Body length 6—6.5 mm., abdominal tergites 2—6 yellow green, stigmatic veins 6—10, (♂+♀) (Poona)	*dipsicus* Gillies
	Body length 4—4.5 mm., abdominal tergites 2—6 white, stigmatic veins 4—7, (♂+♀) (Poona and Hoshangabad) .	*palmayrae* Gillies
4.	Body length 3.5-4 mm., abdominal tergites 2—6 white, stigmatic veins 5-6, (♂+♀) (Poona)	*fluitans* Gillies
	Body length 4.5—5 mm., abdominal tergites 2—6 lemon, stigmatic veins 6-7, (♂) (Darjeeling district, N. Bengal)	*solitarius* Gillies
5.	Second longitudinal vein of hind wing not forked	6
	Second longitudinal vein of hind wing forked	10
6.	Fore wing 11—11.5 mm., long, intercalaries between veins 1 and 2, 2 and 3 of hind wing present, (♂+♀) (Lahaul-Spiti and Kulu Valleys)	*chandra*, sp. nov.
	Fore wing 6—8.5 mm., long, intercalaries between veins 1 and 2, 2 and 3 of hind wing absent	7
7.	Fore wing with 3—6 stigmatic veins, dark mesosternal ring of thorax present, (♂) (Darjeeling district, N. Bengal)	*thurbonis* Gillies
	Fore wing with 7—9 stigmatic veins, dark mesosternal ring of thorax absent	8

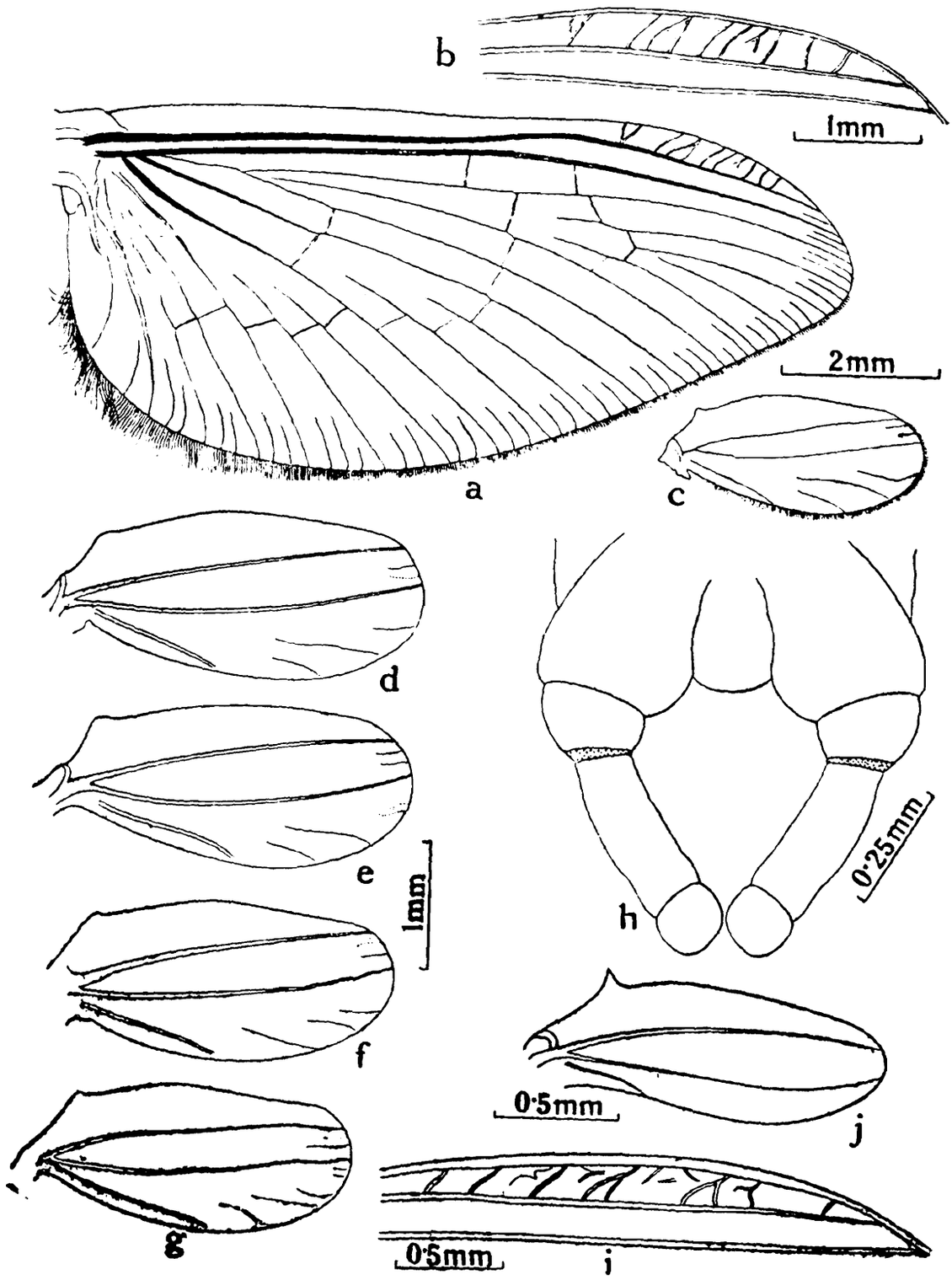
8.	Abdominal tergites red and yellow, bimaculate pigment in wings (♂+♀) (Darjeeling district N. Bengal)	*tigroides* Gillies
	Abdominal tergites and pigment in the wings not as above	9
9.	Costal spur of hind wing acute, abdominal tergites 2—6 light brown, veins 1 and 2 of hind wing convergent apically, (♂) (Kothi, Kulu Valley)	*simplex*, sp. nov.
	Costal spur of hind wing not acute, abdominal tergites 2—6 dull brown, veins 1 and 2 of hind wing not convergent apically, (♂) (Ralha, Kulu Valley)	*punjabensis*, sp. nov.
10.	Fore wing 8 mm., long, stigmatic area with 9 veins, area below this without cross veins, (♂+♀) (Sissu, Lahaul Valley)	*himalayana*, sp. nov.
	Fore wing 6-6.5 mm., long stigmatic area with 10—15 veins, area below this with cross veins	11
11.	Abdominal segments dull brown, stigmatic area with 10—12 cross veins, area below it with 7 cross veins, (♂) (Ralha, Kulu Valley)	*bifurcatus*, sp. nov.
	Abdominal segments golden brown, stigmatic area with 15 cross veins, area below it with 5 cross veins, (♂) (Ralha, Kulu Valley)	*festivus*, sp. nov.

Baetis chandra, sp. nov.

(Plate 7 ; and Text-fig. 2)

Male subimago.—Length of body 10 mm., fore wing 10·5 mm. Head brown ; turbinate eyes large and oval, stalk short, stalk and upper surface orange in alcoholic specimens ; lower portion black ; ocelli bluish-white, antennal segments brown, basal segment short and broad, second longer. Thorax generally chocolate-brown with white pattern (Plate I), pronotum chocolate-brown with white dots laterally, mesonotum with 3 white stripes, the central broader than the other two, all the three joining anteriorly ; pleurites with a few irregular, dark-brown patches, sternites pale brown except the meso and metasternum which are brownish laterally. Legs whitish, coxae dull brown, femur sometimes with dull brown patches at proximal end. Wings transluscent greyish with violet tinge, veins brown. Stigmatic area of fore wing (Text-fig. 2, *a*, *b*) with 8-9 simple, or very occasionally forked, slanting cross veins and without granulations, marginal intercalaries short, absent in the 1st interspace. Hind wing (Text-fig. 2, *c*, *g*) 3·5 × 1·4 mm., with 3 veins, 2nd not forked, third short, running close to the hind margin, tip of wing broadly rounded, two indistinct intercalaries between vein 1 and 2 usually present, 2-3 veins between vein 2 and 3 always present, costal projection not acute. Abdominal tergites 2-9 brown, slightly lighter medianly, with 4 whitish spots except on the 9th which is with only 2 spots, 10th tergite yellowish, sternites much lighter in colour, 4 rounded spots on sternites 2-8. Genostylas (Text-fig. 2, *h*) whitish, basal segment longer than broad, the second broader than long, but about one third the length of the first segment and without tubercle, third segment long, uniformly wide and abou

two and a half times longer than the second, fourth segment roundish. Terminal filaments two, whitish.



TEXT-FIG. 2.—*Baetis chandra*, sp. nov.

(*a*). Fore wing. (*b*). Stigmatic area of forewing. (*c*). Hind wing. (*d*) and (*e*). Hind wings of 2 males. (*f*) and (*g*). Hind wings of 2 females. (*h*). Genostyles of holotype : *Baetis simplex* (sp. nov.). (*i*). Stigmatic area of forewing. (*j*). Hind wing.

Female subimago.—Length of body 11 mm., forewing 11·5 mm., colour and pattern exactly like that of the male subimago.

Holotype.— ♂subimago, INDIA : Chhatoru, (*Ca.* 11,000 ft.=3,353 m.) Chandra River, Lahaul-Spiti Valley, N. W. Himalaya, 16. vi. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2457/H8).

Allotype.—♀subimago, INDIA : With the same data as the holotype. In the Zoological Survey of India.

Paratypes.—Several ♂ and ♀ subimagos from the N. W. Himalaya as follows : 26 ♂ subimagos, 62 female subimagos with the same data as the holotype ; 10 ♀ imagos, Khoksar, (*Ca.* 10,800—11,000 ft.=3,048—3,353 m.) Lahual Valley, 11. vi. 1955 (*A. P. Kapur*) ; 1 ♂ subimago, Ralha, (*Ca*, 9,000 ft.=2,743 m.) 26. V 1955 (*V K. Gupta*) ; 1 ♂, 1 ♀ subimago, Ganddapu, (12,000 ft.=3,658 m.) 7. vi. 1955 (*V K. Gupta* and *H. N. Baijal*) ; 9 ♂, 19 ♀ subimagos, (Chhatoru, *Ca.* 12,000 ft.=3,658 m.) 16. VI. 1955 (*H. N. Baijal*). All in the Zoological Survey of India.

Nymphs.—Many nymphs of this species have been collected from Ganddapu, Dorni Thach and Chhatoru, Spiti Valley, N. W. Himalayas, and are described in the next part dealing with nymphs.

Remarks.—The species is characterised by the presence of 3 veins in the hind wing, vein 2 being simple, presence of intercalaries between veins 2 and 3, and by the large size of the fore wing. From *Baetis transiliensis* Brodsky, from Central Asia, it is distinguished by the 9 cross veins in the stigmatic area and character of forceps. *B. transiliensis* has 5 cross veins in the stigmatic area and a distinct tubercle situated on the median side of the first segment of genostyles ; such a tubercle is wanting in *B. chandra.*

Ecological notes.—The species was found more commonly in the Chandra River, at various places in the Lahaul-Spiti Valley. At Chhatoru (*Ca.* 11,000 ft.=3,353 m.) where the bulk of the material reported above was collected, enormous quantity of water, mainly from rivulets fed by melting snow, ran at great speed. The nymphs of *B. chandra* were found literally in hundreds beneath stones and boulders at the bank. When a stone was lifted out of water the nymphs would at first wriggle backward and then laterally and would drop down in the water invariably to swim back to the undersurface of stones inspite of the great flow of the river. The subimagos of the species were collected from over the stones at the bank of the river.

At Khoksar (*Ca.* 10,800—11,000 ft.=3,292—3,353 m.) the species was collected from a torrential to fast flowing stream which fell into Chandra about hundred yards away. The subimagos and nymphs were found together.

Messrs Gupta & Baijal have collected the subimagos from Ralha in the Kulu Valley and it appears that the species is fairly widely distributed in these parts of the Himalaya.

Baetis simplex, sp. nov.

(Text-fig. 2)

Female imago.—Length of body 7 mm., fore wing 8·5 mm. Head brown ; oculli black with mauvish tinge ; ocelli bluish white ; antennal segments brown, basal segment short and broad, second longer. Thorax

generally brown without any conspicuous markings, pleurites slightly shaded with brown, sternites light brown. Legs light brown, coxae darker. Wings hyaline, veins light brown. On fore wing stigmatic area (Text-fig. 2, *i*) with about 8 veins, simple or forked, with slight tendency to anastomose, aslant and with a few granulations ; the subcostal area, immediately below stigmatic area, without any cross veins ; first cross veins between Sc—R_1, R_1—R_2, R_2 and the space behind it forming a more or less a straight line ; marginal intercalaries short none in the 1st and only one in the 2nd space. Hind Wing (Text-fig. 2, j) 1·1 × 0·2 mm., with 3 veins ; second not forked, third short, running close to the hind margin, and ending at about basal one third of that margin ; tip of margin rounded, no intercalaries ; costal projection present and acute. Abdominal tergites 2-8 brown, the 9th lighter, rather pale white, the 10th darker. Sternites very much lighter in colour. Terminal filaments two.

Holotype.— ♀ imago, INDIA Kothi (*Ca.* 8,000 ft.=2,438 m.) Kulu Valley, N. W Himalayas ; 20. vi. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2471/H8).

Paratypes.—6 ♀ imagos with the same data as the holotype. All in the Zoological Survey of India.

Nymphs.—Four nymphs of the species have been collected from the same locality as the adults and are described in the next part of the paper.

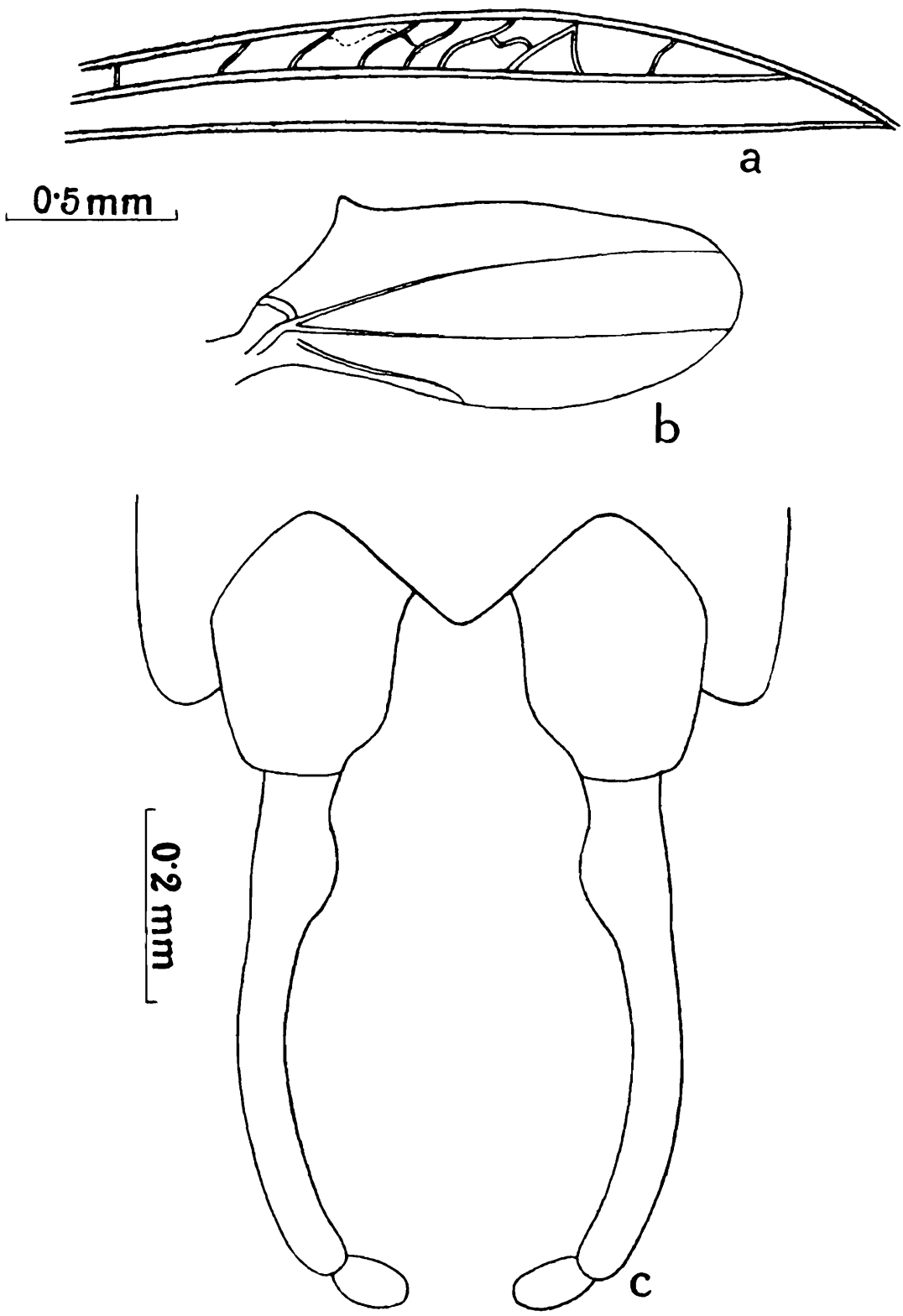
Remarks.—The species is characterised by its hind wing being long and narrow, second vein being simple and not bifurcated, absence of intercalaries and by the presence af acute spur of the hind wing. Its smaller size, acute spur and absence of intercalaries in the hind wing easily distinguish it from *Baetis chandra*, sp. nov. which is distinguished by larger size, a blunt spur, and the presence of intercalaries in the hind wings. The absence of intercalaries in the hind wing easily distinguish *simplex* from *B. transiliensis* Brodsky from Central Asia.

Baetis punjabensis, sp. nov.

(Text-fig. 3)

Male imago.—Length of body 6 mm., wing 7 mm. Head light reddish brown ; turbinate eyes large and oval, stalk very short and upper surface dark brown in colour ; ocelli whitish ; basal antennal segments brown, basal segment short and broad, second longer. Thorax nearly uniformly dark brown. Coxae brownish. Wings hyaline, veins brown. In fore wing area around wing root and outer one-third of costal and subcostal areas slightly darker ; stigmatic area with 7 cross veins (Text-fig. 3*a*), simple or forked, with slight tendency to anastomose, aslant without granulations ; without any cross veins in the area immediately behind the stigmatic area ; the 1st cross veins between Sc—R_1, R_1—R_2, R_2 and the space immediately below it, not forming a straight line ; marginal intercalaries short, none in the 1st and only one in the 2nd space. Hind wing (Text-fig. 3*b*) 1.1 × 00.25 mm., with 3 veins, 2nd not forked, third short and running close to the hind margin and

ending about basal one-third of that margin, vein 1 and 2 not convergent distally, tip of margin rounded, no intercalaries ; costal projection present and not acute. Abdominal tergites 2-6 dull brown, posterior



TEXT-FIG. 3.—*Baetis punjabensis*, sp. nov.
(*a*). Stigmatic area of forewing. (*b*). Hind wing. (*c*). Genostyles.

margins not whitish, sternites practically of the same colour as tergites, segments 8 to 10 dark brown. Terminal filaments two. Genostyles brownish (Text-fig. 3*c*), basal segment short and broad, directed slightly

laterally and nearly as long as second, second evenly narrowed and without any tubercle on the inner side near the base, third segment long and of uniform breadth, slightly longer than second, fourth segment elongate and slightly more than one-third of the length of the third segment.

Holotype.—♂ imago from INDIA : 2 miles south of Ralha, (*Ca.* 10,000—11,000 ft. =3,048—3,353 m.) Kulu Valley, N. W. Himalaya ; 28. v. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2473/H8).

Remarks.—In the complete absence of intercalaries in the hind wing, the species resembles *Baetis simplex* (from Kothi), which is represented by female imagos only. It is, however, distinct from the latter in the having different general colour pattern as described earlier, in the spur of hind wing being blunt, the 1st and 2nd veins being not covergent distally, and finally, in the 1st cross veins between Sc—R_1, R_1—R_2, R_2 and the space below it in the forewing, not forming a straight line. In *Baetis simplex*, the spur of hind wing is acute, the 1st and 2nd veins of hind wing convergent distally, and the 1st cross veins between Sc—R_1, R_1—R_2, R_2 and the space below it in the forewing form more or less a straight line.

Baetis himalayana, sp. nov.

(Text-fig. 4)

Male subimago Length of body 7 mm.; wing 8 mm. Head dark brown ; turbinate eyes large and oval, stalk of moderate height, stalk and upper surfaces blackish mauve in colour ; basal antennal segment reddish brown, short and broad, second longer. Thorax dull brown with whitish lines dorsally, one median and two lateral, pleurites and sternites lighter. Legs light brown. Wings transluscent dusky, veins brown. In fore wing, stigmatic area (Text-fig. 4*a*) with 9 slanting cross veins, with a slight tendency to anastomose. Hind wing (Text-fig. 4*c*) 1·1 ×0·3 mm., with 3 veins, second bifurcated, 3rd quite short and running close to the hind margin and ending about basal one-third of that margin, tip of wing rounded, 3 intercalaries, one short and indistinct between 1 and 2, one long and one short in the fork of 2nd vein, costal projection prominent and narrow. Terminal filaments two, brownish. Genostyles (Text-fig. 4*e*) brownish, basal segment longer than broad, second segment broader than long, but about one-third in length to that of the first and with a distinct tubercle on the inner side near the base, third segment longer and of uniform width, about 3 times longer than the second, fourth segment roundish.

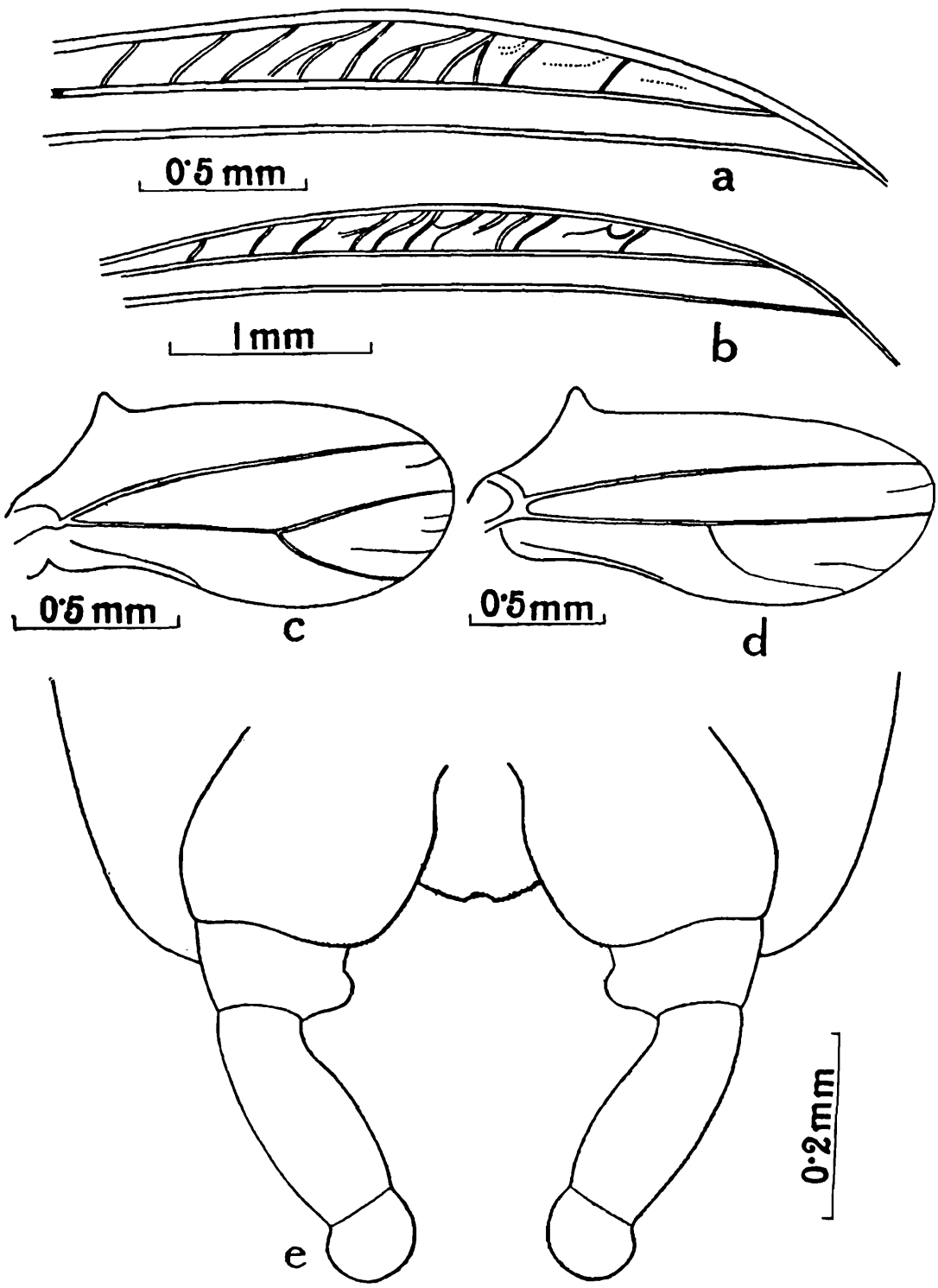
Female imago : Length of body 8 mm., wing 9 mm. Colour and pattern exactly like the male subimago. Wings hyaline (Text-fig. 4 *c, d*).

Holotype.— ♂ Subimago, INDIA : Sissu (*Ca.* 10,500 ft.=3,200 m.); Lahaul Valley, N. W Himalayas ; 10. vi. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2474/H8).

Allotype.— ♀ imago from INDIA : with the same data as holotype. In the Zoological Survey of India.

Paratypes.—2 male subimagos, 3 female imagos with the same data as the holotype. All in the Zoological Survey of India.

Remarks.—The species is generally characterised by having second vein of hindwing bifurcated and by its characteristic forceps, as described

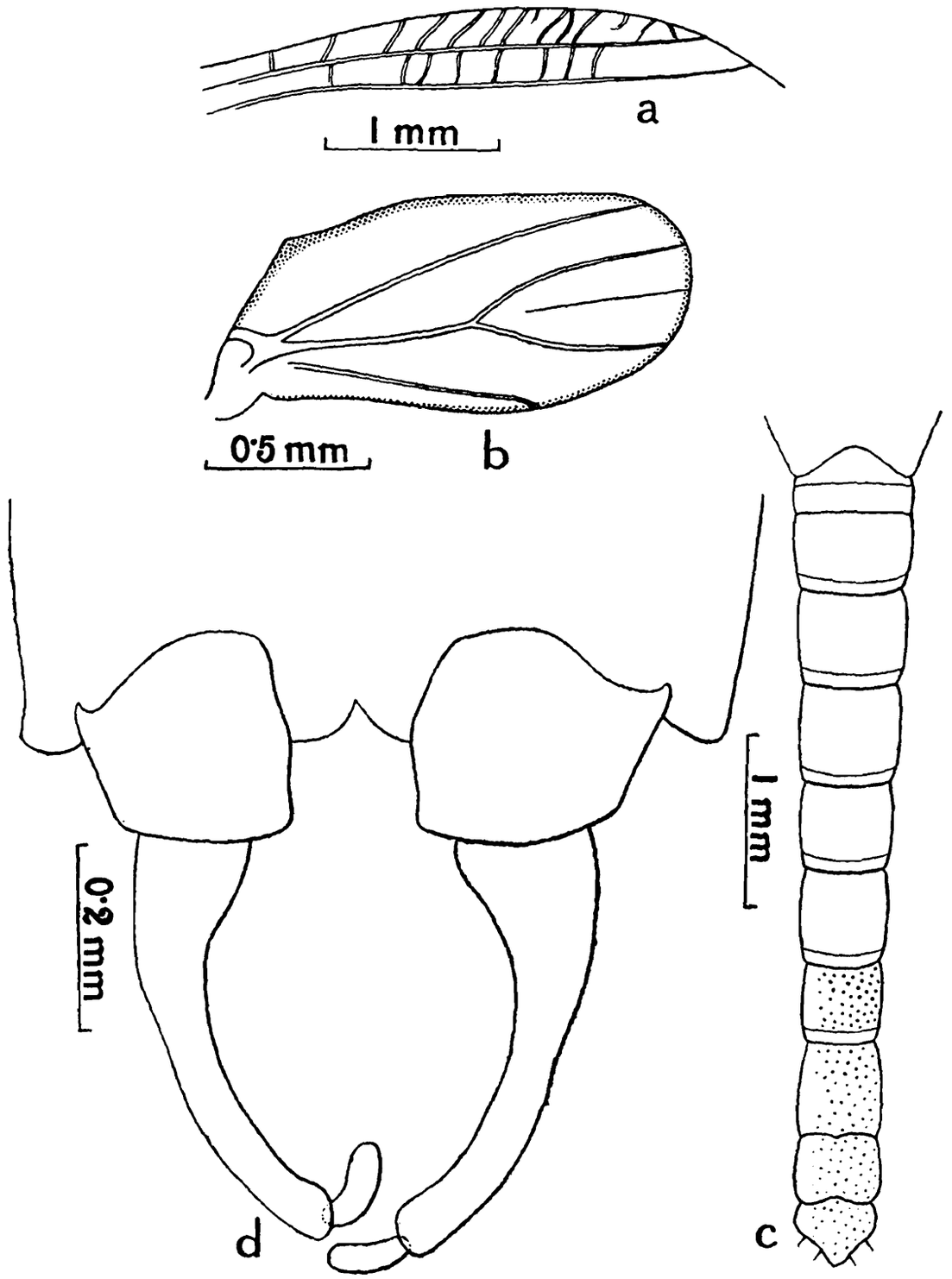


TEXT-FIG. 4.—*Baetis himalayana*, sp. nov.

(*a*). Stigmatic area of forewing of Holotype. (*b*). Same of allotype. (*c*). Hind wing of Holotype. (*d*). Hind wing of allotype. (*e*). Genostyles.

above. It resembles *Baetis bifurcatus*, described hereafter, in having bifurcated second vein of its hindwing. It is however, distinguished

from the latter by the different outline of the genostyles and by the absence of cross veins in the area below the stigmatic area of the fore-wing. The forked nature of second vein easily distinguishes it from *B. chandra,* described earlier.



TEXT-FIG. 5.—*Baetis bifurcatus*, sp. nov.

(*a*). Stigmatic area of forewing. (*b*). Hind wing. (*c*). Abdomen. (*d*). Genostyles.

Baetis bifurcatus, sp. nov.
(Text-fig. 5)

Male imago: Length of body 7·5 mm.; fore wing 6 mm. Head light reddish brown ; turbinate eyes large and oval, stalk of moderate

height, stalk and upper surface orange in alcoholic specimens, lower portion black ; ocelli whitish ; antennal segment brown, basal segment short and broad, second longer. Thorax uniformly dark brown ; sternites slightly lighter. Wings transluscent, longitudinal veins brown. Fore wing slightly darker around wing root and at outer one-third of costal and subcostal areas ; stigmatic area (Text-fig. 5*a*) with 10-12 cross veins, the latter with slight tendency to anastomose, somewhat aslant, and without granulations ; the subcostal area, immediately below stigmatic area with 7 cross veins ; marginal intercalaries short, none in the first and second space. Hind wing (Text-fig. 5*b*) 1·2×0·3 mm.; with 3 veins, vein 2 bifurcated, vein 3 quite short, running close to hind margin and ending at about basal two-thirds of the margin ; tip of the wing broadly rounded, with usually 2 intercalaries in the form of 2nd vein ; costal projection not well developed. Abdominal tergites 2-6 dull brown, posterior margins whitish ; sternites rather dull brown, segment 7—10 opaque, light brown, tergites shaded with indistinct darker pattern (Text-fig. 5*c*). Terminal filaments two, broken. Genostyles (Text-fig. 5*d*) brownish, basal segment short and broad, directed slightly laterally, nearly as long as the second ; second segment evently narrowed and without tubercle ; third segment long, uniformly wide, slightly longer than the second ; fourth segment oblong about one-third the length of the third segment.

Holotype.—♂ imago, INDIA : 2 miles south of Ralha, (*Ca.* 10,000—11,000 ft.=3,048—3,358 m.) Kulu Valley, N. W. Himalaya ; 28. v. 1955 (*A. P Kapur*). In the Zoological Survey of India (Reg. No. 2478/H8).

Paratypes.—2 male imagos with the same data as the holotype. Both in the Zoological Survey of India.

Remarks.—Baetis bifurcatus is easily distinguished from other species from India, by its vein 2 of the hind wing being forked and by its characteristic forceps. From its closest ally *Baetis festivus*, sp. nov., described below, it is distinguished by having 10-12 cross veins in the stigmatic areas and 7 cross veins in the area immediately below it and by the 10th abdominal segment being not of different colour than other segments. The forked nature of 2nd vein of hind wing separates it from Brodsky's *B. transiliensis* from Central Asia.

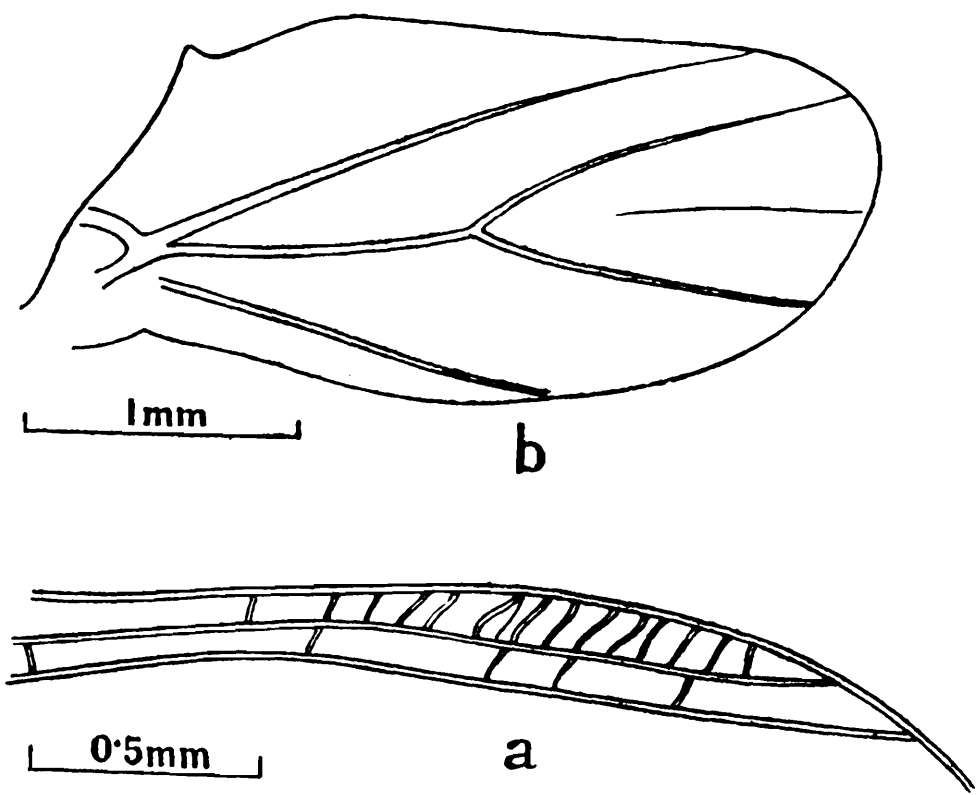
Baetis festivus, sp. nov.

(Text-fig. 6)

Female imago : Length of body 7·5 mm., wing 6.6 mm. Head brown ; oculi blackish ; ocelli whitish, basal two external segments brown, first broad and short, second longer. Thorax generally chocolate brown, metanotum posteriorly with whitish specks ; pleurites and sternites nearly of the same colour. Legs light brown. Wings transluscent, longitudinal veins pale brown, in fore wing area around wing root, costal and subcostal areas slightly darker. Stigmatic area (Text-fig. 6*a*) with 15 veins with slight tendency to anastomose, some aslant, no granulations ; immediately below stigmatic area, the subcostal

area with 5 cross veins, marginal intercalaries short, none in the first and second space. Hind wing (Text-fig. 6*b*) 1·2×0·4 mm., with 3 veins, costal projection not pointed, vein 2 bifurcated, vein 3 quite short and running close to the hind margin and ending at about basal two-thirds of the margin, tip of wing rounded, 2 intercalaries in the fork of vein 2. Abdominal tergites 9-6 golden brown, posterior margins whitish ; sternites slightly lighter, golden brown, segments 7—10 dark brown, 10th darkest. Terminal filaments two.

Holotype.—♀ imago, INDIA : 2 miles south of Ralha, (*Ca.* 10,000—11,000 ft.=3,048—3,353 m.), Kulu Valley, North-Western Himalaya ; 28. v. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2480/H8).



TEXT-FIG. 6.—*Baetis festivus*, sp. nov.
(*a*). Stigmatic area of forewing. (*b*). Hind wing.

Paratype.—A female imago with the same data as the holotype. In the Zoological Survey of India.

Remarks.—*Baetis festivus* is closely related to *Baetis bifurcatus*, in having the second vein of hind wing bifurcated. It is, however, easily distinguished from the latter by having 15 cross veins in the stigmatic area and 5 cross veins in the area immediately below it, and by the 10th abdominal segment being the darkest.

FAMILY ECDYONURIDAE

Genus **Epeorus** Eaton

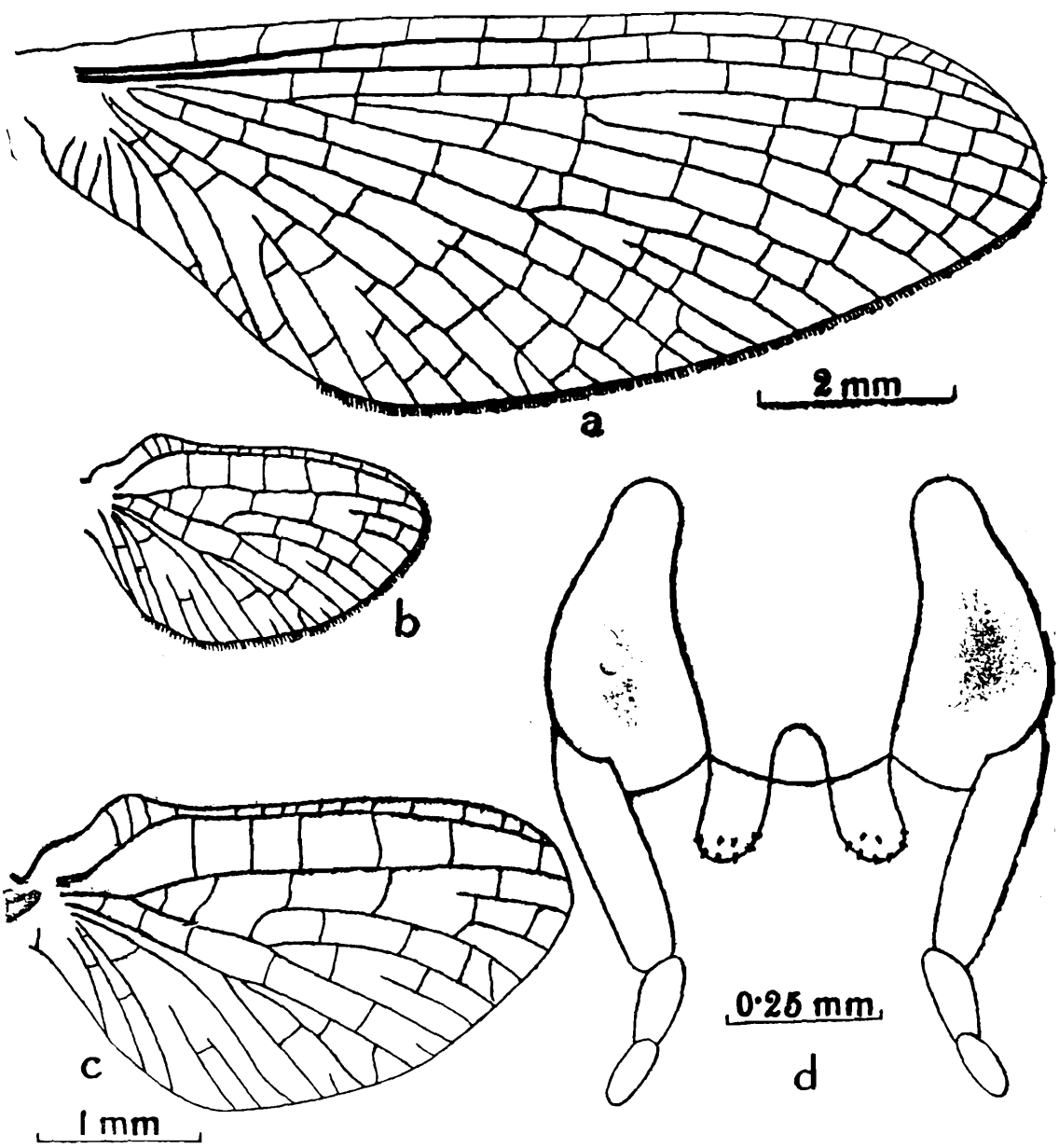
This holarctic genus has already been known from India and Nepal (In the latter from nymphs only). In India it has been recorded from adults as well as the nymphs. The latter are recorded from Kulu,

Kangra Valley, Ladakh (N. W. Himalaya) Pashok and Khasi Hills (E. Himalaya). So far the adults are known from only one species, *E. psi* Eaton, from "Kooloo" [kulu]. *E. lahaulensis*, sp. nov., from Lahaul Valley, N. W Himalaya is the second species to be recorded from India.

Epeorus lahaulensis, sp. nov.

(Text-fig. 7)

Male subimago.—Length of body 7.5 mm. ; wing 10 mm. General colour brown. Frontal margin of head paler ; eyes black, quite large,



TEXT-FIG. 7.—*Epeorus lahaulensis*, sp. nov.
(*a*). Forewing. (*b*). Hind wing. (*c*). Hind wing enlarged. (*d*) Genostyles with hooks on penes.

not contiguous apically ; ocelli lighter. Thorax uniform red brown ; pleurites and sternites much paler. Legs brownish ; proportions of fore leg femur : tibia : tarsus, 36 : 35 : 38 , 5 tarsal joints—9 : 8 : 8 : 7 : 6. Wings translucent brownish, veins brown. In fore wing (Text-fig. 7*a*) the costal space before bulla with 5 cross veins, slightly aslant ; stigmatic

area with 14 cross veins, simple and slightly aslant ; basal subcostal cross veins 3 ; below stigmatic area 10 cross veins ; two parallel pairs of cubital intercalaries, the pair nearer the hind angle longer. Hind wing (Text-fig. 7*b*, *c*) 3 × 1·8 mm. ; outer fork of RS (*Of*) present. Abdominal tergites brownish, each tergite darker posteriorly ; sternites much paler. Terminal filaments two. Genostyles 4 segmented, the first segment longest, fourth segment slightly shorter than third, the latter two combined being shorter than the second segment ; apical margin of genostyle base convex, as shown in Fig. 7*d* ; penes long, broad apically and slightly divergent laterally, spines present ventrally just below the apex.

Holotype.—♂ subimago from INDIA : Sissu (Ca. 10,500 ft.=3,200 m.) Lahaul Valley, N. W Himalaya ; 10. vi. 1955 (*A. P. Kapur*). In the Zoological Survey of India (Reg. No. 2507/H8).

Remarks.—The species is distinctive by its colour and the shape of penes. Eaton in his monograph on the group in 1888 described *Epeorus psi* from " Kooloo ", [Kulu] Himalaya. Traver in 1939 gave a description of a male imago (in very poor condition) of an unidentified species of the genus from Kashmir. *E. lahaulensis* is different from *E. psi* in not having characteristic markings of the abdominal segments ; it is also different from the male imago described by Traver (as stated above), which has lobbed penes. In the new species described above the penes are not lobed apically and have short spines ventrally, just below the apical margin.

IV—Description of Nymphs

Family Leptophlebiidae

Genus **Paraleptophlebia** Lestage

This holarctic genus was hitherto not known from India. It is for the first time that the genus is being recorded from Manali (*Ca.* 6,000 ft. =1,829 m.), Kothi (*Ca.* 8,000 ft.=2,438 m.) and Ralha (*Ca.* 9,000 ft.= 2,743 m.) in N. W Himalaya of India from a few nymphs which seem to belong to two different species.

Paraleptophlebia sp. 1

A nearly mature ♂ nymph. Length of body 7 mm. ; terminal filaments missing. General colour brown on the darker side, ventral parts of body and legs paler. Body rather flattened. Head somewhat strongly depressed, longer than broad ; a big conspicuous white patch between the antennae, also dorsal to antennae ; eyes lateral ; basal two segments of antennae brown, rest yellowish. Mouth parts as in family Leptophlebiidae. Pronotum practically of the same width as the head. Mesonotum with two white spots posteriorly. Foreleg dark brown, mid and hind legs brown. Claws slender and pectinate.

Abdominal tergites 1—8 with conspicuous pattern. A median whitish streak, broadened at the posterior end of tergites ; a pair of submedian longitudinal spots on tergites 1—4 and 8, the spots elongated and directed laterally on tergites 5—7. Lateral spines present on segments 8 and 9, spine on the 9th longer but not more than 1/4 the length of that segment. Seven pairs of gills present on abdominal segments 1--7 ; all bifid and narrowly lanceolate ; gills of 1st pair similar in form to those of the following pairs.

Terminal filaments three, outer fringed on both sides.

Material examined.—1 ♂ nymph, INDIA : Manali (*Ca.* 6,000 ft.= 1,829 m.) Kulu Valley, N. W. Himalayas ; 23.v. 1955 (*A. P. Kapur*).

Remarks.—No species of *Paraleptophlebia* has been recorded earlier from India. The present nymph from Manali is the first Indian record of *Paraleptophlebia.*

Paraleptophlebia, sp. 2

Three nymphs. Length of body 6·5 mm. These are a little different from *Paraleptophlebia* sp. 1 in general colour, being brown, basal antennal segment being not dark and abdominal tergites being without any conspicuous markings.

Material examined.—3 nymphs from INDIA : as follows. Kothi (*Ca* 8,000 ft.=2,438 m.), Kulu Valley, N. W. Himalayas, 20.vi.1955 (*A. P. Kapur*), 1 nymph ; Ralha (Ca. 9,000 ft.=2,743 m.), Kulu Valley, N. W Himalayas, 26-27. v. 1955 (*A. P. Kapur*), 2 nymphs.

Family EPHEMERELLIDAE

Genus **Ephemerella** Walsh

This holarctic genus was hitherto known from Nepal (Ueno 1955) and India (Hora, 1930 ; Traver, 1939) from nymphs only. *Ephemerella indica* sp. n. has been described earlier in this paper from an adult caught at Ralha (*Ca.* 9,000 ft.=2,743 m.) in the Kulu Valley, Punjab. A few nymphs, of the genus *Ephemeralla* were collected from Manali (*Ca.* 6,000 ft.=1,829 m.) in the same valley. Apparently these examples also do not belong to *E. indica* but to some unidentified species of the genus.

Ephemerella sp.

Three nymphs, including one well grown ♂ nymph. Length of body 9 mm., excluding 6 mm. terminal filaments. General colour brown, lighter ventrally. Body somewhat arched dorsally. Head not flattened ; frontal shelf present, covering the mouth parts ; a notch on each side present, base of antenna lying in each notch, a short blunt projection present above base of each antenna on the inner margin, anterior to median ocellus ; a low rounded projection, the occipital tubercle, pre-

sent but very small ; eyes lateral. Pronotum wider than the head, quadrangular, a little widened posteriorly ; surfaces of pro-anal mesonota uneven. Hind legs longest, the forelegs shortest, femora rather flattened, anterior margin of fore femur toothed, tibial spines very small and blunt at tip, posterior margins of femora of middle and hind legs with small serrations, a few fine serrations also present on the posterior margin of femur, near the base.

Abdomen with short, postero-lateral spines on the middle and apical segments ; well-developed, paired submedian spines present on tergites 2—9, the two rows of spines converging, slightly towards the apical tergites. Five pairs of gills present on the abdominal segments 3—7, gills wholly dorsal in position and bilamellate, the 7th smallest, each anterior lamella obtuse ovoid, tracheation not distinct, each posterior lamella cut into many small loblets. Terminal filaments three, outer ones fringed on both sides. Described from a well grown male nymph.

Materials examined.—3 nymphs from INDIA : N. W Himalaya : Manali (*Ca.* 6,000 ft.=1,829 m.), Kulu Valley, 23. vi. 1955. (*A. P. Kapur*) 2 nymphs ; Manali to Kothi (*Ca.* 6,500 ft.=1,981 m.), on broad leaves of plant in the stream, 24.v.1955 (*A. P. Kapur*), 1 nymph.

Remarks.—The present nymphs do not seem to belong to the adult *E. indica*, described earlier from Ralha (*Ca.* 9,000 ft.=2,743 m.). From the areas adjoining N. W Himalayas, Brodsky (1930) reported adults and nymphs of *E. submontana* Brodsky but as he did not describe the nymphs, it is not possible to compare our material with the latter. The nymph of *Ephemerella* described by Traver (1939) from Ladakh (Kashmir State), seems to be close to our material which is, however, distinct from *Ephemerella* nymphs described by Ueno (1955) from Nepal, in having only roughened and irregular surfaces on the thorax and being devoid of distinct tubercles which are so characteristic of our material.

Family BAETIDAE

Genus **Baetis** Leach

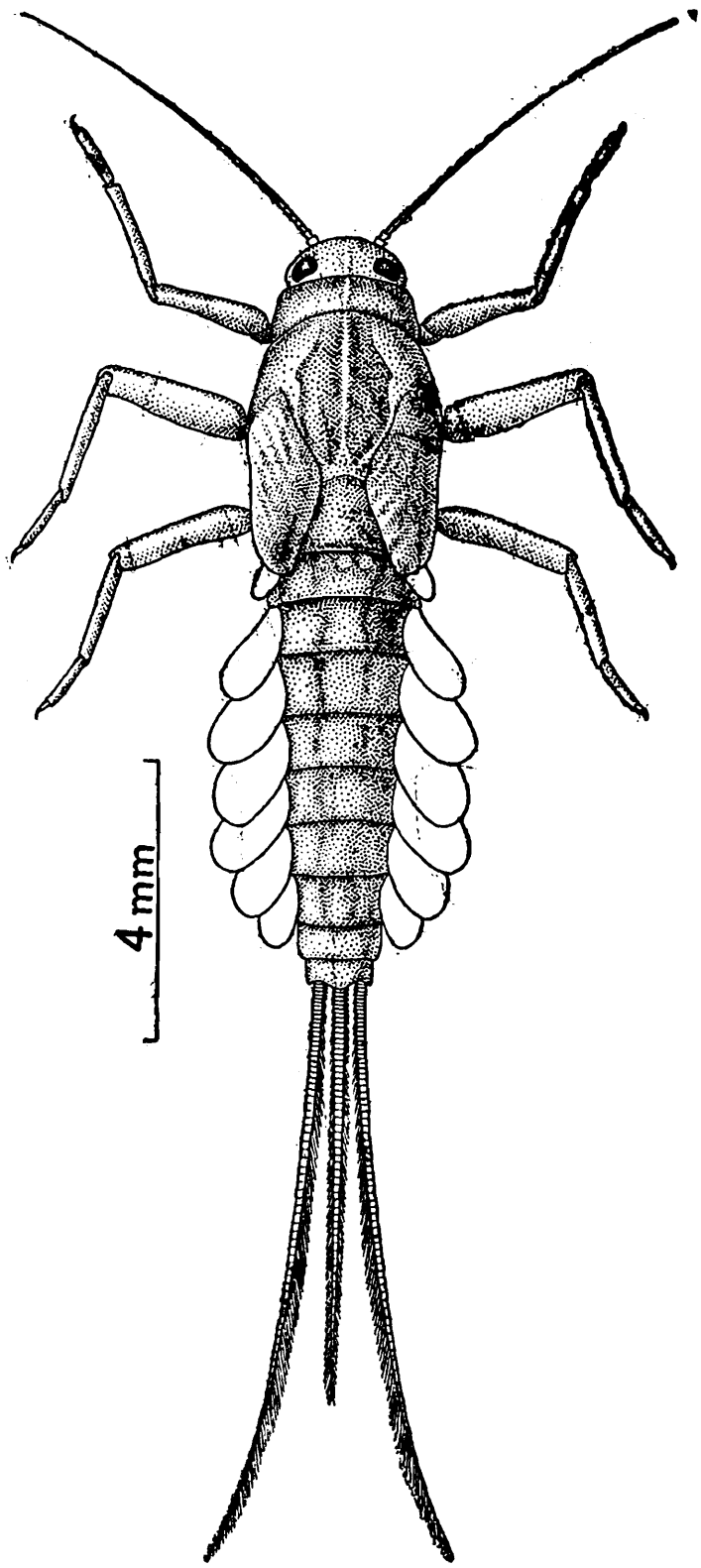
Hora (1930) recorded nymphs of *Baetis* spp. from torrential stream in India. Traver (1939) also reported nymphs of *Baetis* from Kashmir and Nepal. Here nymphs of a number of species of *Baetis* collected from most of the stations mentioned earlier in the Lahaul and Spiti Valleys are being dealt with. Of these the nymphs belonging to *B. chandra* and *B. simplex* could be definitely associated with the imagos or subimagos as a result of observation in the field and the camp laboratory, but the remainder of the nymphal material, presumably belonging to two hitherto unknown species, could not be associated with the adults.

Baetis chandra Kapur and Kripalani

(Text-figs. 8—10)

About 200 nymphs, mainly well developed ; an example of the latter with length of body 10 mm.; lateral terminal filament, 6 mm., medial

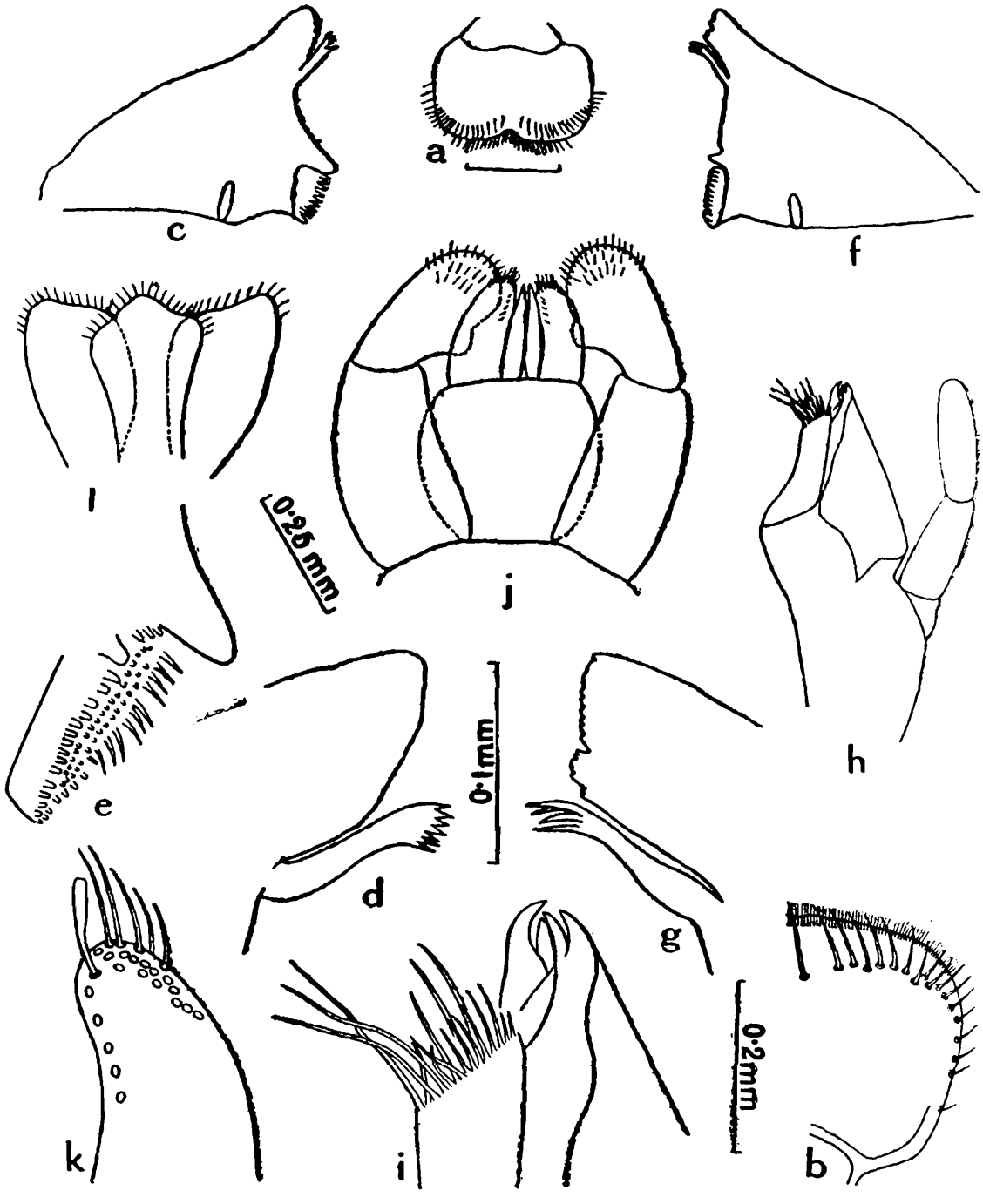
terminal filament ; 4 mm. body slender, not strongly flattened, streamlined ; brownish with the head and thorax darker and the venter paler (Text-fig. 8). Head directed downwards, slightly narrower than posterior margin of pronotum, antennae rather slender.



TEXT-FIG. 8.—*Baetis chandra* Kapur and Kripalani.
Dorsal view of Nymph.

Labrum (Text-fig. 9*a*) rather large, quadrangular, wider than long, with a shallow median notch on the rounded apical margin ; just inside

the apical margin there is a row of numerous plumose bristles, inserted closely together, and another row of bristles on the apical margin ; on the upper surface near the antetior margin there is a transverse row of stouter and longer bristles which reach the lateral margin on each side ; in all with about 17 bristles in the row (Text-fig 9*b*).

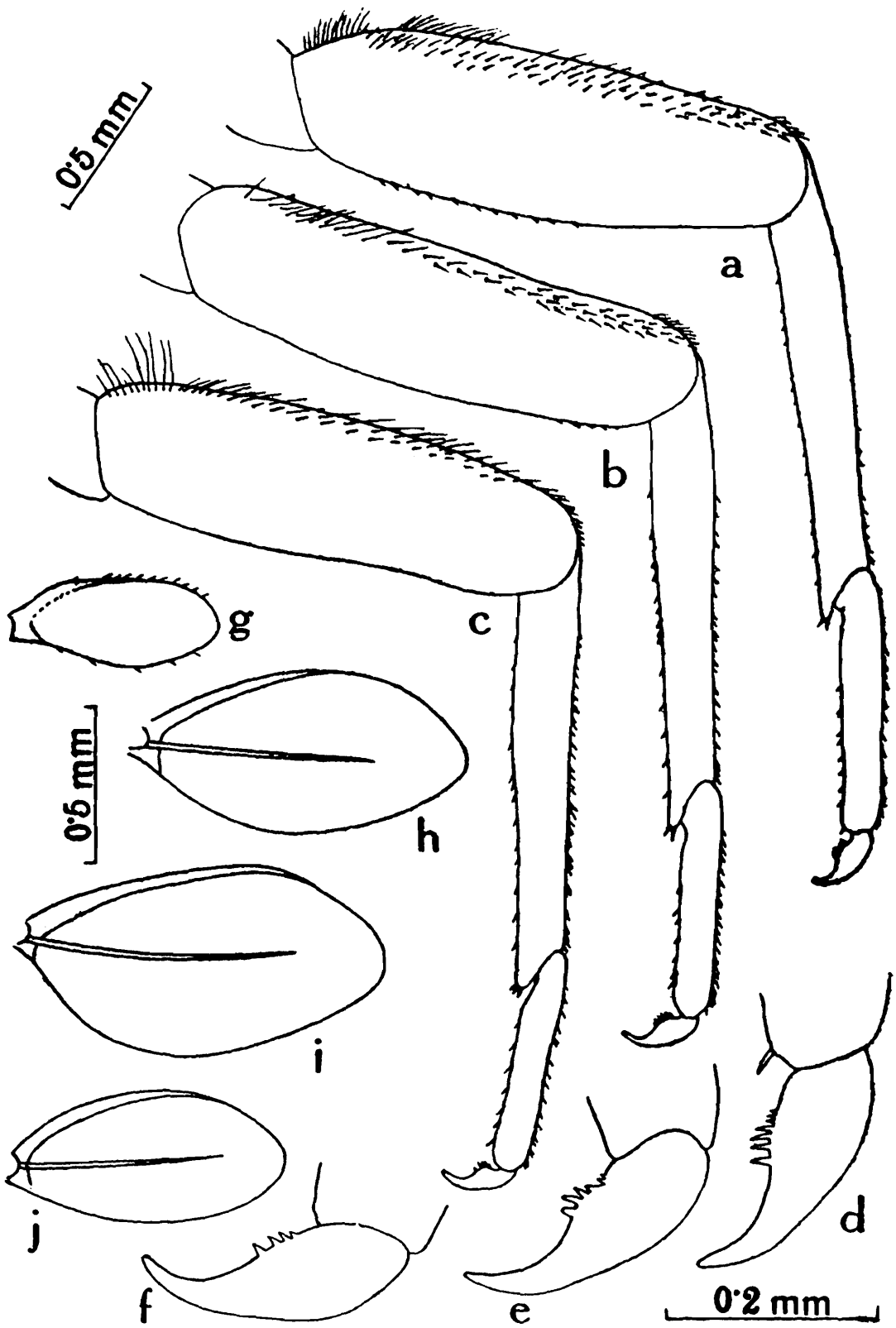


TEXT-FIG. 9.—*Baetis chandra* Kapur and Kripalani.

(*a*). Labrum. (*b*). Upper Surface of the right half of Labrum. (*c*). Left mandible. (*d*). Canine area. (*e*). Molar surface. (*f*). Right mandible. (*g*). Canine area. (*h*). Maxilla. (*i*). Apical part of galea-lacinea. (*j*). Labium. (*k*). Tip of paraglossa. (*l*). Hypopharynx.

Mandibles (Text-fig. 9*c-g*) robust and pyramidal in shape ; canines with very blunt teeth, those of the outer most longer and rather rounded ta apical margin. Prostheca of the left with seven teeth (Text-fig. 9*d*)

on its outer margin ; that of the right mandible more slender and with 4 teeth on its outer margin (Text-fig. 9*g*).



TEXT-FIG. 10.—*Baetis chandra* Kapur and Kripalani
(*a*)—(*c*). Fore, mid and hind legs. (*d*)—(*f*). Fore, mid and hind claws. (*g*)—(*j*). Gills 1, 4, 5 and 7 numbered from front.

Maxillary palp 3 jointed, not extending beyond the tip of galea-lacinia (Text-fig. 9*h*) ; terminal joint nearly as long as the proximal two

joints put together. Galea-lacinia terminates into 4 large and stout teeth (Text-fig. 9*i*) and two rows of long and short bristles on the apical margin.

Paraglossae of labium (Text-fig. 9*j*) extending slightly beyond glossae ; outer apical margin with 1—4 rows of feathered bristles , a well-spaced row of 5-6 long bristles inside the inner margin ; close to the outermost one a large clavate spine. (Text-fig. 9*k*). Labial palp 3-jointed, second joint with a blunt process on its inner distal corner , terminal joint rounded, tip with numerous spines and fine bristles. Median and lateral lobes of hypopharynx nearly equal in width (Text-fig. 9*l*).

Thorax with exactly same pattern as in the adult.

Legs (Text-fig. 10 *a-c*) brown with darker markings on the distal end of each femur ; distal end of tarsus and claw dark. The ratio, femur : tibia : tarsus , Fore-leg 61 : 44 : 28 ; mid leg 56 : 50 : 24 ; hind leg 55 : 45 : 22. A row of stout spines along the outer margin of each femur ; similar row of less stout bristles on outer margins of tibia and tarsus. A row of minute spines on inner margin of femur. Claws with 7 teeth on the inner margin (Text-fig. 10*d-f*).

Abdomen cylindrical, somewhat depressed, dorsum with pattern as in the adult.

7 pairs of gills (Text.-fig. 10 *g-j*) on segments 1—7. All simple lamellae, 1st and 7th much smaller than the others. Tracheation not distinct. Tails three, median shorter than outer ones, the former fringed with rather long hairs on both sides and the latter only on the inner side.

Described from a well developed nymph from Chhatoru.

Material examined.—Several nymphs from N. W Himalaya as follows: Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Spiti Valley ; 8 and 9. vi.1955 (*A. P. Kapur*), 44 nymphs ; Dorni Thach (*Ca.* 11,800 ft.=3,597 m.), Spiti Valley ; 12. vi. 1955 (*A. P. Kapur*), 82 nymphs , Chhatoru (*Ca.* 11,000 ft.=3,353 m.), Spiti Valley ; 15.vi.1955 (*A. P. Kapur*), 76 nymphs.

Remarks.- The imagos and subimagos of the species have already been described earlier Ueno (1955) described two different forms of nymphs of unnamed species of *Baetis* from Nepal ; one of these has three tails. The present nymphs can, however, be distinguished from Ueno's *Baetis* sp. (1) in the pattern of abdominal segments, and the shape of canine teeth and prostheca.

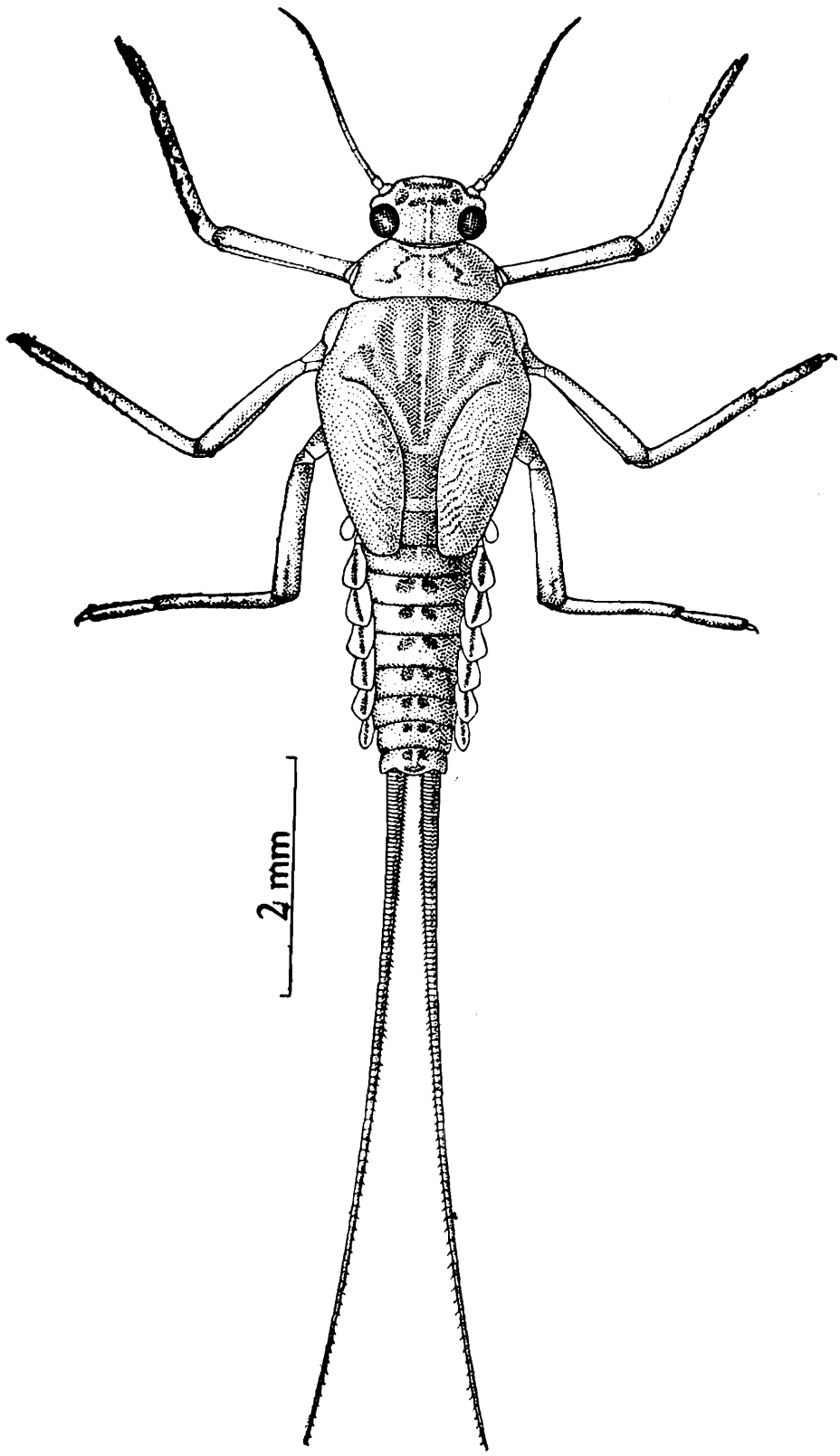
Baetis simplex Kapur and Kripalani

(Text-figs. 11-13)

Four nymphs, well developed , length of body 6 mm.; terminal filaments 6 mm. Body slender streamlined in form, and brown. Head directed downwards, slightly narrower than posterior margin of pronotum, antennae rather slender.

Labrum rather large (Fig. 12*a*), quadrangular, wider than its length, with a shallow median notch on the rounded apical margin ; just inside the apical margin a row of numerous plumose bristles inserted closely, and another row of bristles on the apical margin ; on the upper surface

near the anterior margin a transverse row of stouter and longer bristles which reach the lateral margin on each side, about 17 in total number (Text-fig. 12a).

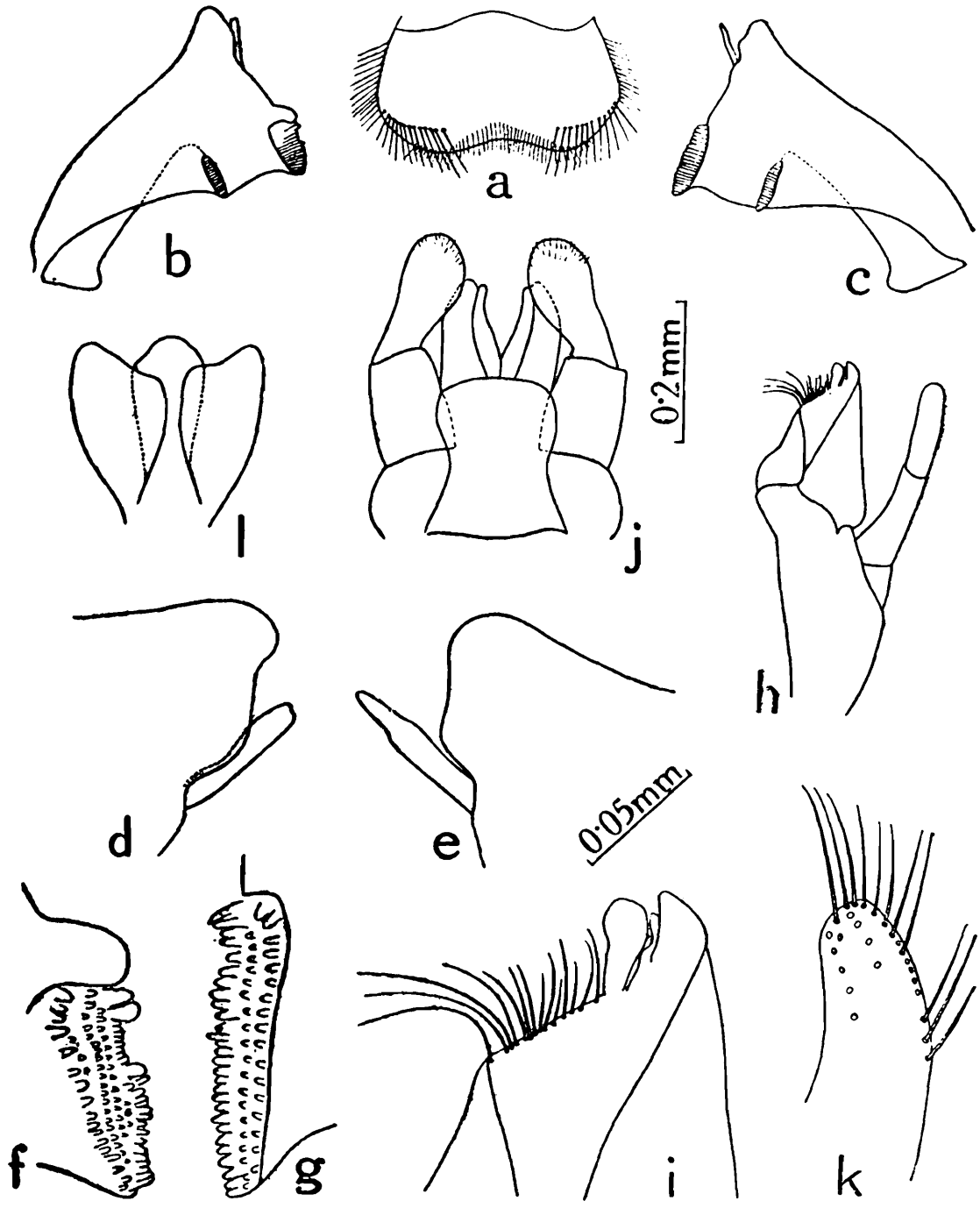


TEXT-FIG. 11.—*Baetis simplex* Kapur and Kripalani
Dorsal view of Nymph.

Mandibles robust (Text-fig. 12*b-g*) and pyramidal in shape ; canines with indistinct teeth, the outermost rounded, prostheca of the right with 2

blunt teeth on its outer margin, that of the left more slender and bluntly pointed at tip.

Maxillary palp (Text-fig. 12*h*) three-jointed, not extending beyond galea-lacinia ; terminal joint nearly as long as the 2nd joint. Galeae-



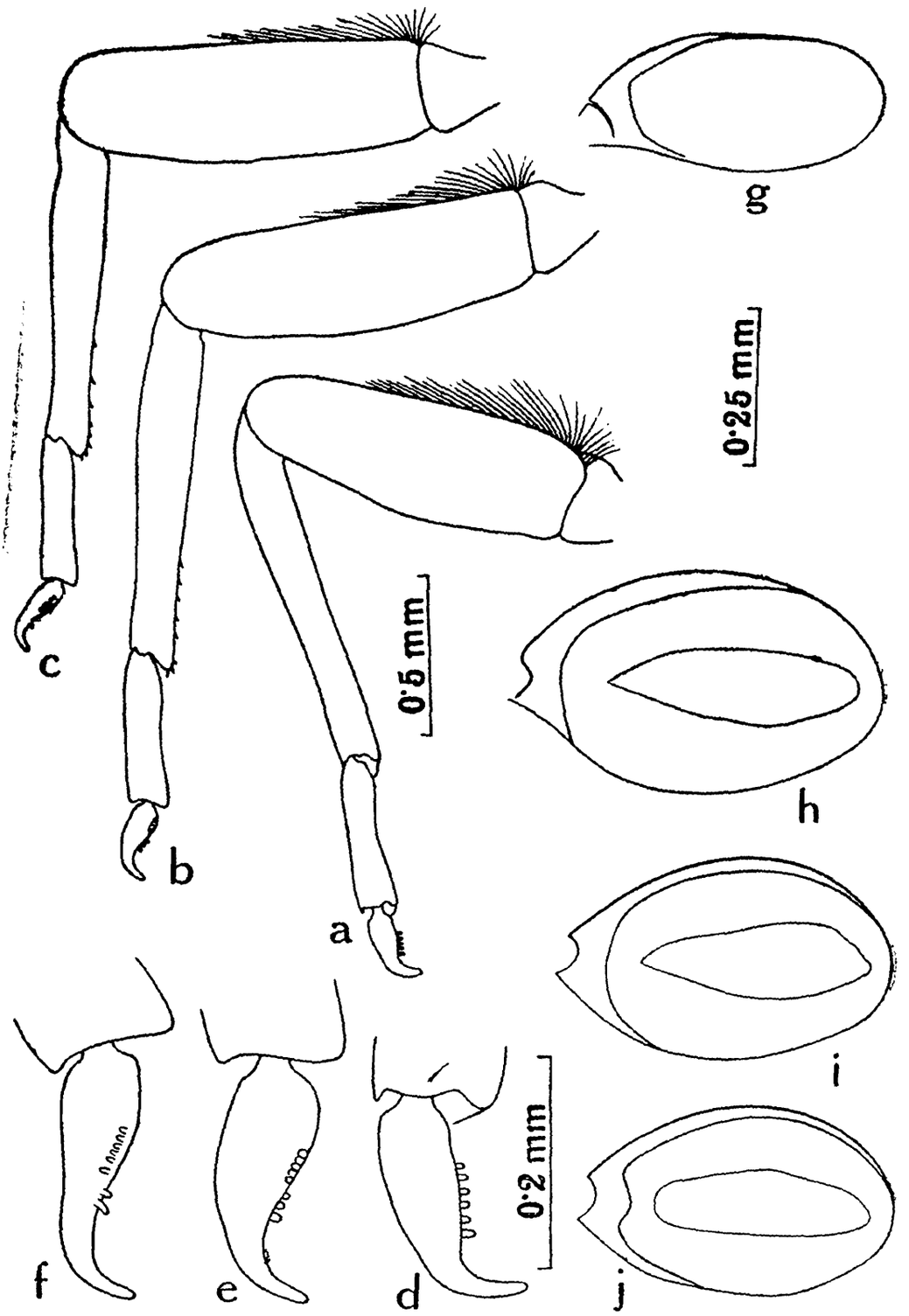
TEXT-FIG. 12.—*Baetis simplex* Kapur and Kripalani

(*a*). Labrum. (*b*). Left mandible. (*c*). Right mandible. (*d*)—(*e*) Left and right canine areas. (*f*)—(*g*). Left and right molar areas. (*h*). Maxilla. (*i*). Apical part of galea-lacinia (*j*). Labium. (*k*). Tip of paraglossa. (*l*). Hypopharynx.

lacinia terminates into four large and stout teeth (Text-fig. 12*i*) and two rows of long and short bristles on the apical margin.

Paraglossae of labium extending slightly beyond glossae (Text-fig. 12*j*) ; outer margin beset with feathered bristles arranged in 1—3 rows ; a well spaced row of 5—6 long bristles inside the inner margin

(Text-fig. 12*k*). Labial palp 3, jointed without second joint any blunt process ; terminal joint rounded, tip beset with numerous spines and



TEXT-FIG. 13.—*Baetis simplex* Kapur and Kripalani

(*a*)—(*c*). Fore, mid and hind legs. (*d*)—(*f*). Fore,, mid and hind claws. (*g*)—(*j*). Gills 1, 4, 6 and 7 numbered from front.

bristles (Text-fig. 12*j*). Median lobe of hypopharynx slightly narrower than the lateral ones (Text-fig. 12*l*).

Legs (Text-fig. 13*a-c*) brown, distal ends of femur and tibia and the claws darker. The ratio femur : tibia : tarsus in fore leg is 57 : 59 : 26 ; mid leg 61 : 58 : 24 and hind leg 61 : 56 : 24. Along the outer margin of each femur a row of stout bristles, similar row of less stout bristles on outer margins of tibia and tarsus. A row of minute spines on the inner margin of femur. Claws with 7-8 teeth on inner side (Text-fig. *d-f*).

Abdomen depressed, dorsum brown, no characteristic pattern, posterior margins of all terga darker till 9th, 10th tergum lighter.

Seven pairs of gills, all simple lamellae, the 1st smallest. Tracheation not distinct (Text-fig. 13 *h-j*).

Two terminal filaments brown and fringed on inner side only.

Described from one of the well grown examples.

Material examined.—4 nymphs from INDIA : N. W Himalayas : Kothi (*Ca.* 8,000 ft.=2,438 m.), Kulu Valley, 20.vi.1955 (*A. P. Kapur*).

Remarks.—The imagos of the species have already been described earlier. It is however, distinct from the nymph of *Baetis chandra*, in possessing only two termial filaments, different colour pattern, and in detailed structure of the mouth parts.

Other *Baetis* species

There are a number of *Baetis* nymphs, collected from the following localities, which cannot be associated with any described species and which being mostly in very immature stages, have not been described further These may belong to one or probably more, species.

Material examined.—Several nymphs from INDIA : N. W Himalayas : Manali (*Ca.* 6,000 ft.=1,829 m.), Kulu Valley, 25. vi. 1955. (*A. P. Kapur*) 2 nymphs ; Kothi (*Ca.* 8,000 ft.=2,438 m.), Kulu Valley, 20. vi. 1955. (*A. P. Kapur*) 15 nymphs ; Ralha (*Ca.* 9,000 ft.=5,743), Kulu Valley, 26. v. 1955. (*A. P. Kapur*) 4 nymphs ; Two miles N. E. of Ralha (*Ca.* 11,000 ft.=3,353m,.), 27. v. 1955. (*A. P. Kapur*) 23 nymphs , Near source of Beas river (*Ca.* 11,000 ft.—12,000 ft.= 3,353 m.-3,658 m.), 2. vi. 1955 (*A. P. Kapur*), 7 nymphs ; Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Spiti Valley, 8. vi. 1955. (*A. P. Kapur*) 7 nymphs ; Sissu (*Ca.* 10,500 ft.=3,200 m.), Lahaul Valley, 10, vi. 1955. (*A. P. Kapur*) 4 nymphs ; Purana Khoksar Nalla (*Ca.* 13,000 ft.=3,962 m.), 17. vi. 1955. (*A. P. Kapur*), 3 nymphs.

Family ECDYONURIDAE

Genus **Ecdyonurus** Eaton

This holarctic genus has been known from India (adults & nymphs) and Nepal (nymphs only). In India the adults have been reported from ' Hindusthan ', Assam (E. Himalaya) and Bengal. Hora (1930) recorded nymphs of this genus from ' hill streams of India ' Many nymphs of one species are now being recorded from Manali (*Ca.* 6,000 ft.=1,829 m.), Kothi (*Ca.* 8,000 ft.=2,438 m.), Ralha (*Ca.* 9,000 ft.=2,743 m.), and Ganddapur (*Ca.* 11,000 ft.=3,353 m.).

Ecdyonurus sp.

36 nymphs of various stages. Body 11 mm. General colour brown abdomen with darker pattern, legs and ventral surface lighter. Body distinctly flattened.

Head flattened about 1½ times as wide as long, frontal margin rounded frontal portion of median ocellus paler. Pronotum short, slightly wider than head, with dilated and rounded lateral margins which are prolonged behind and fused to the sides of mesonotum. Legs paler than body with 1 dark band on the upper surface of femora which are flattened.

On each abdominal segment 2—7 there is a central dark rather, triangular marking end on either side of median line on tergite 5 there is a pale, v-shaped area towards the hind margin, the shape of this area breaks up into 3 spots on the 6th tergite, on the 7th tergite the three spots, are very pale and on tergite 8 and 9 they become large and triangular on either side ; the 10th tergite nearly dark.

Seven pairs of gills on abdominal segments from 1-7, all lamellate. with filamentous gills, except the 7th which consists of lamellae only ; the first pair the smallest and rather lanceolate in shape, lamellae 2—6 broadly oval, margins of each lamella fringed and with sparse, minute bristles.

Terminal filaments three, nearly equal in length and a little longer than the body. Described from a specimen from Kothi.

Material examined.— 36 nymphs from INDIA : N. W Himalaya :

Manali (*Ca.* 6,000 ft.=1,829 m.), Kulu Valley, 23 and 25. vi. 1955, (*A. P. Kapur*), 8 nymphs ; Kothi (*Ca.* 8,000 ft.=2,438 m.), Kulu Valley, 20, vi. 1955, (*A. P. Kapur*), 8 nymphs ; Ralha (*Ca.* 9,000 ft.=2,743 m.), Kulu Valley, 20. v. 1955, (*A. P. Kapur*), 16 nymphs , 2 miles S. of Ralha. (*Ca.* 10,000 ft.—11,000 ft.=3,048 m.—3,353 m.), 29. v. 1955, (*A.* P. *Kapur*), 18 nymphs ; Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Spiti Valley, 8. vi. 1955, (*A. P. Kapur*), 1 nymph.

Remarks.—The nymph agrees in general with *Ecdyonurus* sp. 1 described by Ueno (1955, p. 308), but differs from it in the absence of the three typical spots on the head, the first gill being not longer than the 7th, and by the absence of the small lanceolate apical appendage of gill lamallae.

Genus **Iron** Eaton

This holarctic genus has already been reported from India from nymphs only. Hora (1930) recorded them from Himalaya and Khasi Hills and Traver (1939) from Kashmir State. The genus is now being recorded from Manali (*Ca.* 6,000 ft.=1,829 m.), Kothi (*Ca.* 8,000 ft.= 2,438 m.), Ralha (*Ca.* 9,000 ft.=2,743 m.), near source of the Beas river (*Ca.* 11,000 ft.= 3,353 m.), Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Sissu (*Ca.* 10,500 ft.=3,200 m.), Khoksar (*Ca.* 10,800 ft.=3,292 m.), Purana Khoksar Nalla (*Ca.* 13,000 ft.=3,962 m.) in the north-western Himalaya.

Iron sp.

A large number of nymphs from 8 stations. Body 8 mm., terminal filaments 6 mm. General colour brown, without conspicuous markings. Body strongly flattened ventrally, slightly convex dorsally. Head flattened $1\frac{1}{2}$—$1\frac{3}{4}$ wider than long, frontal margin almost straight, frontal and lateral margins of head enlarged, covering the mouth parts. Labrum rather small. A triad of spines on tip of galea and lacinia. Pronotum not wider than the head, lateral margins slightly dilated from the anteroir to the middle. Legs slightly lighter than body. Femora flattened, femoral flange short and blunt. Postero-lateral spines on abdominal segments 1—7 short. Abdominal segments with a pair of submedian spines on the segments 1—5 ; a single median spine on 6—9th. Paired spines on tergite 1 and 2 very short, and separated by a wide space, those on segment 3 longer and closer. Progressively longer and closer together on tergites 4 and 5. The single spines on tergites 6—9 rather long and stout and directed backwards. 7 pairs of gills on segments 1—7, consist of lamellar and fibrillar portions, each overlaps the one behind it· Gills of 1st and last pairs meet beneath the body of nymph. Described from a ♀ nymph from Ganddapu.

There is a considerable variation in the number of paired and single spines. Paired spines may be present at the maximum on the first nine segments and at the minimum on the first five segments. A careful examination of the material seems to show that the number of paired spines gradually decreases in older of nymphs.

Material examined.—Several nymphs from INDIA : N. W Himalayas Manali (*Ca.* 6,000 ft.=1 ,829 m.), Kulu Valley, 23. vi. 1955. (*A. P. Kapur*). Kothi (*Ca.* 8,000 ft.=2,438m.), Kulu Valley, 20. vi. 1955. (*A. P. Kapur*). Two miles N. E. of Ralha (*Ca.* 11,000 ft.=3,353 m.), 27. v. 1955. (*A. P. Kapur*). Two miles S. of Ralha (*Ca.* 10,000—11,000 ft. =3,048 m.—3,353 m.), 28. v. 1955. (*A. P. Kapur*). Near source of the Beas river, 11,000 ft.=3,353 m., 2. vi. 1955. (*A. P. Kapur*). Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Lahaul-Spiti Valley, 8 & 9. vi. 1955. (*A. P. Kapur*). Sissu (*Ca.* 10,500 ft.=3,200 m.), Lahaul Valley, 10. vi. 1955 (*A. P. Kapur*). Khoksar (*Ca.* 10,800 ft.=3,292 m.), Lahaul Valley, 11. vi. 1955. (*A. P. Kapur*). Purana Khoksar Nalla (*Ca.* 13,000 ft.=3,962 m.), Lahaul-Spiti Valley, 17. vi. 1955. (*A. P. Kapur*).

Remarks.—These nymphs differ from those of typical *Iron* in possessing median spines on the abdominal segments. As suggested by Traver (1939), they might belong to an undescribed genus of Ecdyonuridae (Heptageniidae). She designated these as " double spine *Iron* ally"

Genus **Ironopsis** Traver

This nearctic genus is being recorded from India for the first time from Kothi (*Ca.* 8,000 ft.=2,438 m.), Ganddapu (*Ca.* 11,000 ft.=3,353 m.) and Chhatoru (*Ca.* 11,000 ft.=3,353 m.) in the N. W Himalayas.

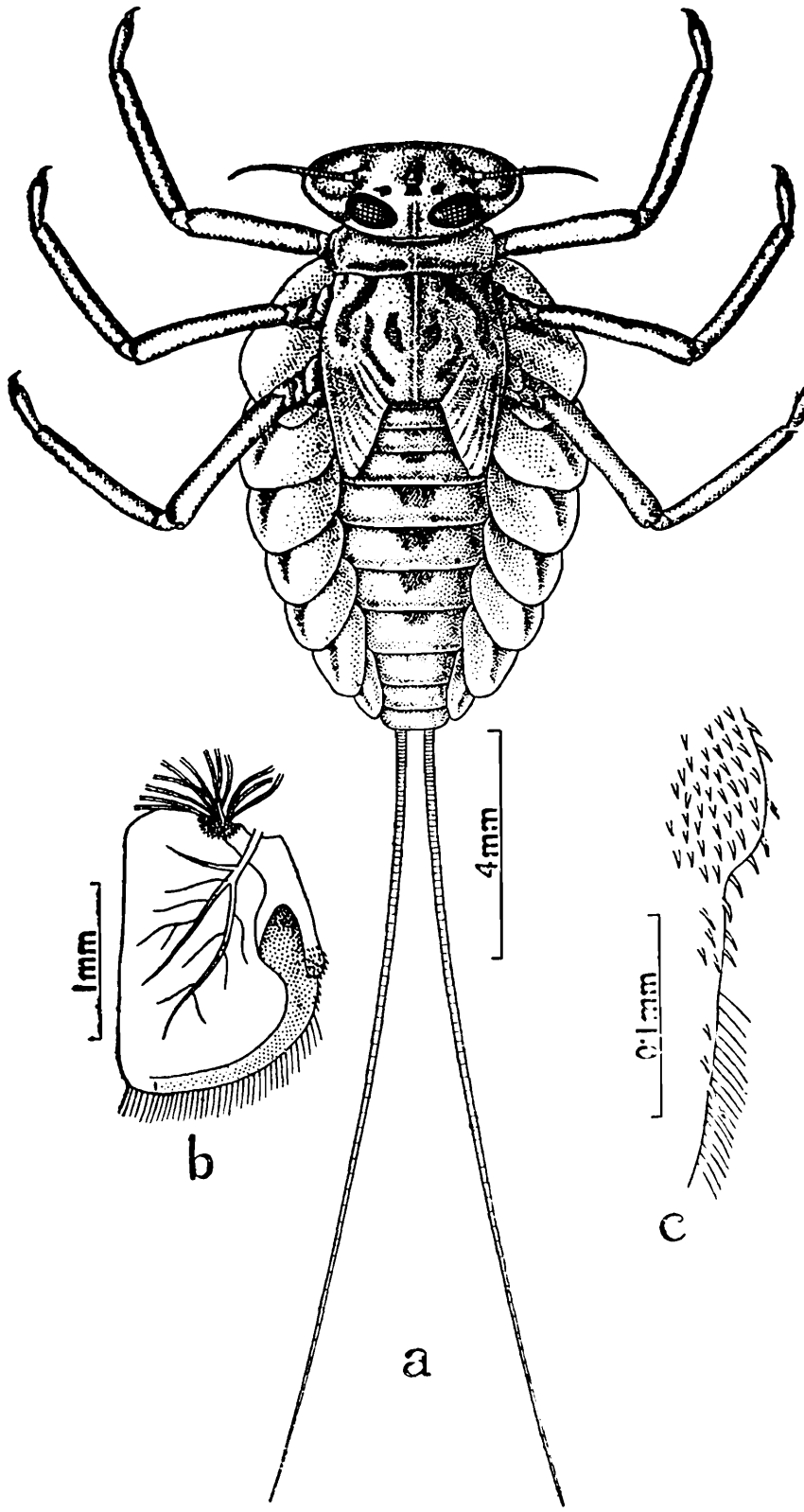
Genus **Ironopsis** Traver

Ironopsis sp. 1

(Text-figs. 14—16)

25 nymphs, some nearly mature. Body 14 mm., terminal filaments 16 mm. General colour brown.

Body (Text-fig. 14*a*) slightly convex dorsally, flattened ventrally. Head large and flattened. Frontal and lateral margins of head expanded, covering the mouth parts completely.

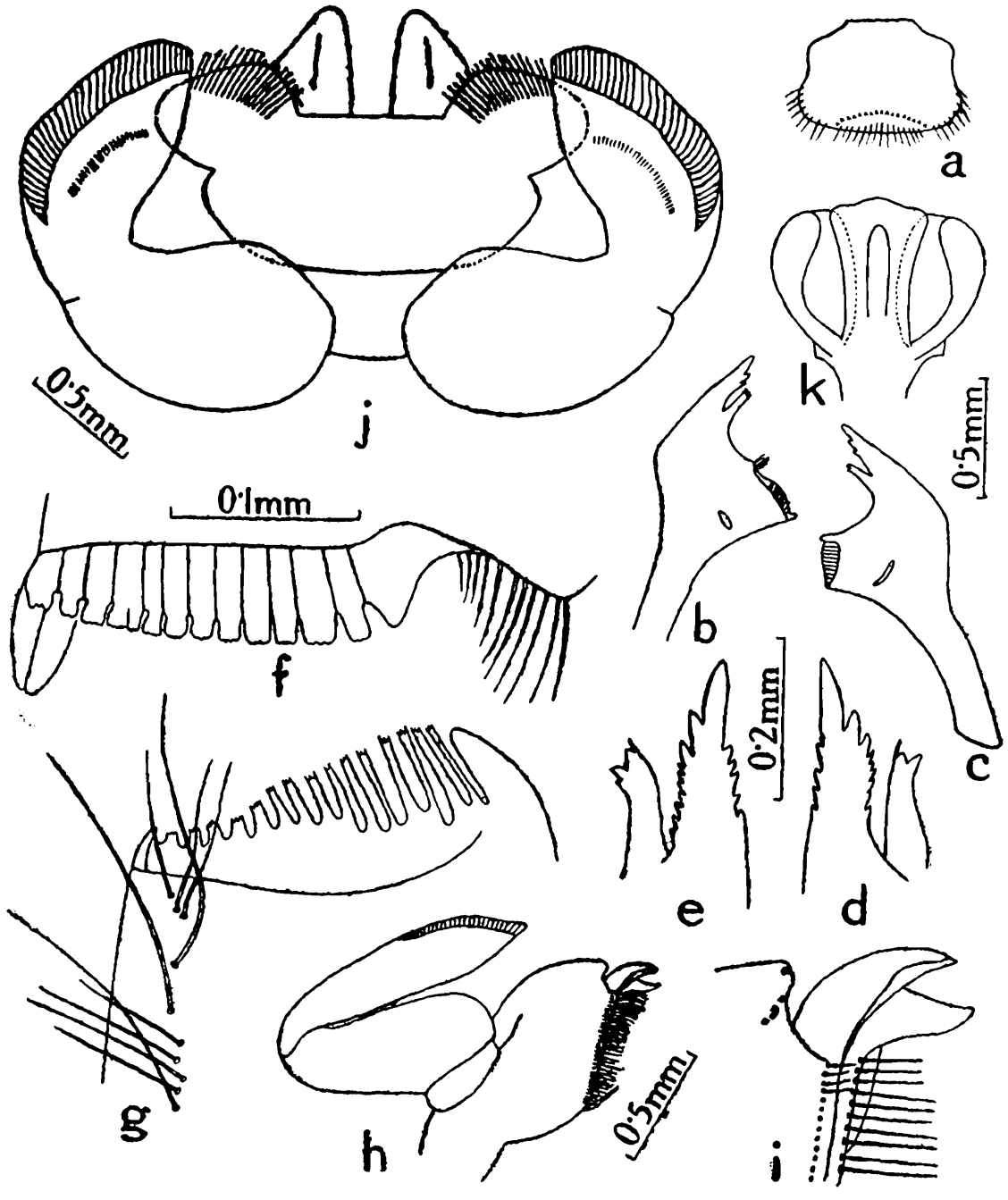


TEXT-FIG. 14.—*Ironopsis* sp.
(*a*). Dorsal view of Nymph. (*b*). Ventral view of gill No. 2.
(*c*). Part of gill Magnified to show spines.

Labrum (Text-fig. 15*a*) rather small, about 12 times as wide as long, antero-lateral margins rather angulate ; a shallow excavation on the

median line, along the almost straight anterior margin ; a little inside it are a few hairs, behind which is a regular row of small teeth (Fig. 15*a*).

Mandibles (Text-figs. 15 *b-g*) slender in basal half ; canines two in number, the inner about three-fourths as long as the outer ; both distinctly scoop-shaped, their margins more or less crenate. Lacinia represented by 4-5 hairs ; without fringe of hairs along lacinial region ; with a row



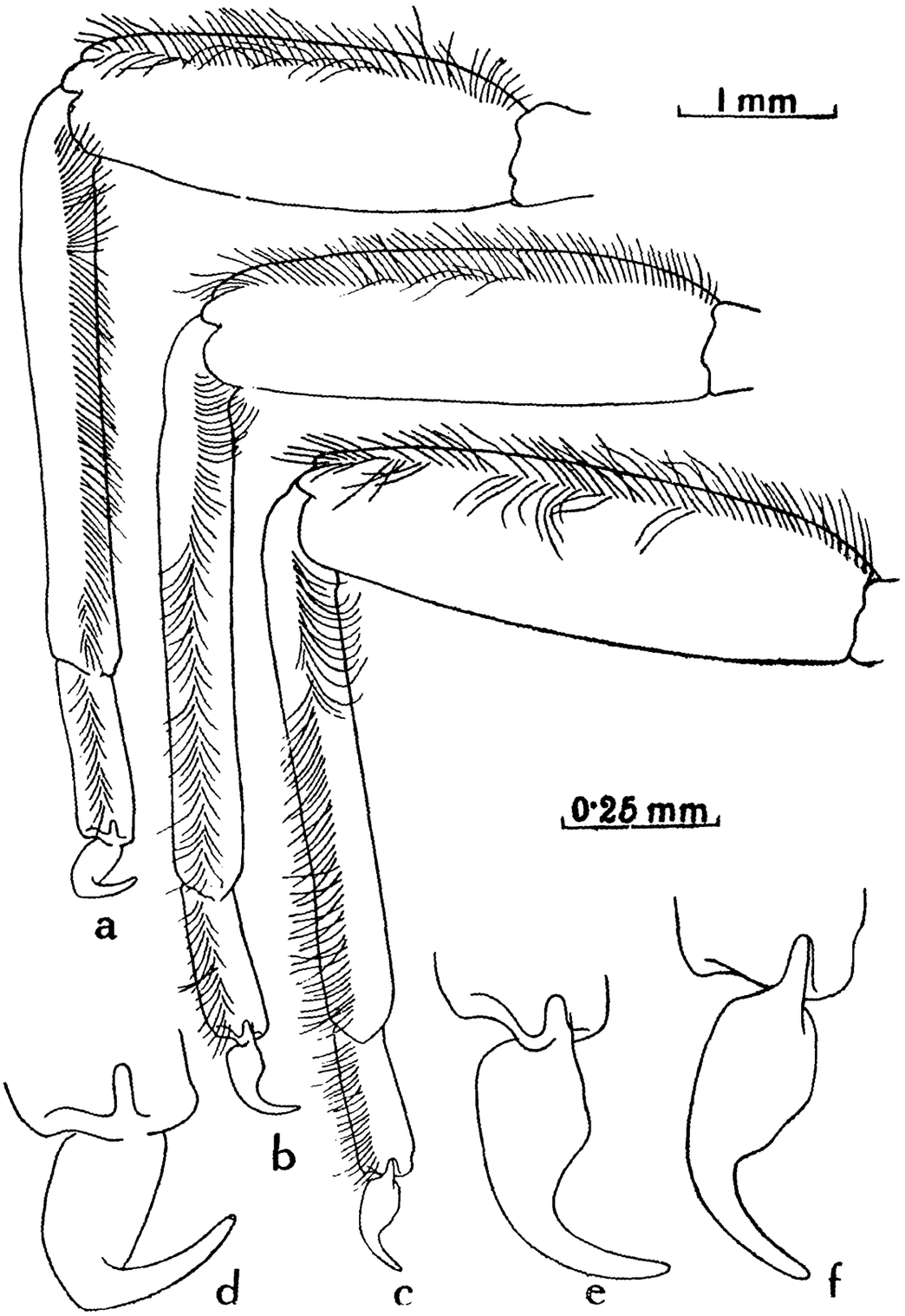
TEXT-FIG. 15.— *Ironopsis* sp.

(*a*). Labrum. (*b*)-(*c*). Left and right mandibles. (*d*)-(*e*). Canine areas. (*f*)-(*g*). Molar areas. (*h*). Maxilla. (*i*). Apical part of galea-lacinia. (*j*). Labium. (*k*). Hypopharynx.

of 7—8 bristles beneath each molar surface and a thick row near the base of the outer canines.

Maxillary palp two-jointed (Text-fig. 15*h*), distal joint thickly set with spines in the apical portion. A triad of stout spines, each slightly incurved present at the inner apical margin of galea-lacinia ; a group

of 5—7 slender spines present near their base. On the inner margin of galea-lacinia there are two rows of bristles, one of which is on the margin



TEXT-FIG. 16.—*Ironopsis* sp.
(*a*)—(*c*). Fore-, mid- and hind-legs. (*d*)—(*f*). Fore-, mid- and hind-claws.

and the other at a short distance behind and parallel to the latter. (Text-fig. 15*i*).

Labial palps short and broad, two jointed ; distal joint bearing about 20 series of pectinate spines on the outer margin. Glossae conical, divergent apically, rather widely separated at base, bearing 7-8 long to short spines on the inner margin, near the apex (Text-fig. 15*j*).

Median lobe of hypopharynx (Text-fig. 15*k*) rounded, slightly longer but somewhat narrower than the lateral lobes which are somewhat dilated distally and rounded at the apex.

Pronotum not wider than head, antero-lateral margins rounded. Legs yellowish brown, with a fringe of long hairs on the outer margins of femur, tibia and tarsus; femoral flange (apical extension of femur) blunt. Claws with 3 lateral pectinations near the apex (Text-fig. 16*d-f*).

Abdominal segments with a prominent ridge of rather long hairs along the mid-dorsal line of all tergites. Extensions of postero-lateral margins of segments very short and blunt.

Gills of the first segment very large ; anterior lobes greatly expanded, meeting beneath the body of nymph ; intermediate pairs of gills very well developed and overlapping. A much thickened oblong pad on the ventral surface of anterior margin bears a short thumb-like projection (Text-fig. 14 *b-c*). Gills of the 7th pair meet beneath the body ; fibrillar portion of gills short ; two terminal filaments present.

Described from a nymph from Chhatoru.

Material examined.—Several nymphs from the N. W Himalaya as follows.

Ganddapu (*Ca.* 11,000 ft.=3,353 m.), Lahaul Spiti Valley, 8. vi. 1955. (*A. P. Kapur*) 5 nymphs ; Chhatoru (*Ca.* 11,000 ft.=3,353 m.), Lahaul Spiti Valley, 15. vi. 1955. (*A. P. Kapur*) 20 nymphs.

Remarks.—Ironopsis Traver is so far known only from N. America. Although closely related to the genus *Iron* it is easily distinguished from the latter by the prominent ridge of rather long hairs along the mid-dorsal line of all tergites. It is being recorded from India (Ganddapu and Chhatoru, N. W Himalaya) for the first time.

Ironopsis sp. 2.

A well developed ♀ nymph. Body 15 mm. ; terminal filaments 14 mm. General colour dark brown. It has all the typical characters of *Ironopsis*. It differs from the fore-mentioned species from Chhatoru and Ganddapu in colouration and relative size.

Material examined.—I ♀ nymph from INDIA : Kothi (*Ca.* 8,000 ft. =2,438 m.), Kulu Valley, 20. vi. 1955. (*A. P. Kapur*).

V—Remarks on adaptations and geographical distribution

Adaptations.—Hora (1930) in his paper entitled " Ecology, bionomics and evolution of the torrential fauna with special reference to the organs of attachment ", discussed in considerable detail the adaptations of nymphs belonging to the families Ecdyonuridae (Heptageniidae), Baetidae and Ephemerellidae in India. Our material of nymphs also belongs to these three families and to the family Leptophlebiidae. According to him the genera *Ecdyonurus*, *Heptagenia*, *Epeorus*, *Iron* and *Rhithrogena* of the

family Ecdyonuridae, form a homogenous group as these have a profile adapted to afford little resistance to a rapid flow of water while facing the stream. He gave detailed descriptions of the body form and various organs of attachment in the genera mentioned above and concluded that as the swiftness of the current increases the gill lamellae have better frictional pads and seem to have evolved in the following order : *Ecdyonurus* and *Heptagenia*, *Epeorus*, and then *Iron*. He believed *Rhithrogena* to have secondarily inhabited currents less swift and less oxygenated than those inhabited by *Iron*. Hora further found the nymphs of *Baetis* in different habitats in the hill streams and observed that these cling to rocks and weeds with the help of their powerful claws and have stream lined bodyform which was better developed in some species than in others. His material of nymphs of Ephemerellidae was collected from swift streams and he observed several characters by which the nymphs seemed to be adapted to the said environment but as his material was not determined even up to the genus, it may be inadvisable to refer to it further in any detail.

Brodsky (1930), working on nymphs of Ephemeroptera from Tashkent and neighbouring areas, stated that while the genera *Iron* and *Rhithrogena* were components of mountain torrent communities, the genera *Ephemerella* and *Baetis* were found in less rapid streams and the genus *Ecdyonurus* inhabited lower course of mountain streams. Imanishi's (1940) findings on the Ephemeropteron nymphs in the torrential streams of Japan generally agree with those of Brodsky. Ueno (1955), working on the material from Nepal, considered the nymphs of *Rhithrogena* to be representatives of the fauna of the cold water, spring-fed brooks at a much greater altitude, *Ca.* 650-700m., where the Mayfly fauna consisted of nymphs of *Ephemerella*, *Baetis*, *Ecdyonurus* and *Epeorus*.

In so far as the collection of nymphs under report is concerned, it appears that between *Ca.* 6,000 ft (=1,829m.)and *Ca.* 9,000 ft. (=2,743m.), the streams have representatives of the genera *Paraleptophlebia*, *Ephemerella*, *Baetis*, *Ecdyonurus*, *Iron* and *Ironopsis*. In the streams beyond 9,000 ft., the nymphs of *Paraleptophlebia* and *Ephemerella* were not collected and were probably absent. Nymphs of these two genera and of *Baetis* attach themselves to rocks, etc., with the help of their well developed claws and are able to swim in running water. *Baetis* nymphs have stream-lined body and are able to swim actively in fast running water. Nymphs of the remaining genera, namely *Ecdyonurus*, *Iron* and *Ironopsis*, have flattened body shape and have gills modified for the purpose of attachment to stones in torrential streams. The gills in *Ironopsis* are obviously better adapted for the purpose as these have better developed spinous pads than is the case in *Ecdyonurus* or *Iron*.

Geographical distribution.—The material reported upon earlier in this paper is of some interest from the point of geographical distribution of Mayflies in India.

Of the imagos and subimagos, the species described as *Ephemerella indica* and recorded from the Kulu Valley, is of special interest as the holarctic genus *Ephemerella* Walsh was hitherto known from India and Nepal from nymphs only. The nymphs were first recorded by Hora (1930) from Dalhousie and Chamba in the Punjab, by Traver (1939) from Ladakh (N. W Himalaya) and by Ueno (1955) from Nepal. *E*

indica was obtained from Ralha at an altitude of about 2,743 m. (-9,000 ft.) but a few nymphs, of apparently another species of *Ephemerella*, were also collected from relatively lower altitute of about 1,829 m. (=6,000 ft.) at Manali.

The genus *Baetis* Leach which is widely distributed in the holarctic, neotropical and Indo-Australian regions, was first recorded from India (" Hindostan ") by Eaton (1888) who however, did not give any specific identification of his material and named it as " *Baetis* sp." Hora (1930) recorded nymphs and adults (not specifically determined) from Kashmir and Ladakh in the N. W Himalaya. Gillies (1949) described two species of *Baetis* from Poona (Bombay State), one from Poona and Hoshangabad (Madhya Pradesh) and three from Darjeeling district (Northern West Bengal). Ueno (1955) also recorded nymphs of " *Baetis* spp." from Nepal. The six new species described in this paper, from Kulu Sub-Division (including the Kulu, Lahaul and Spiti Valleys) in the north western Himalaya are of interest from the geographical point of view, in that the specifically determined material of the genus was not known from there earlier. *Baetis* is apparently a wide-spread genus in India and may be found in most places with fast running to torrential streams.

Epeorus Eaton is an holarctic genus which has already been recorded from India and Nepal. Eaton (1888) described *E. psi* Eaton from, " Kooloo " in the N. W Himalaya and it is worth noting that our material of *E. lahaulensis* also comes from the neighbouring valley of Lahaul in the Kulu Sub-Division. Traver (1939) also recorded a male imago of *Epeorus* sp. from Ladakh in the N. W Himalaya, while Hora (1930) recorded its nymphs from both the western and eastern Himalaya (Khasi Hills) and from Palni Hills in southern India. More recently Ueno (1955) recorded its nymphs from Nepal.

Among the new records from India based on nymphs only may be mentioned two species of *Paraleptophlebia* Lestage which is essentially holarctic in distribution. It is being recorded from Manali (*Ca.* 6,000 ft.= 1,829 m.), Kothi (*Ca.* 3,000 ft.=2,438 m.), and Ralha (*Ca.* 9,000 ft.= 2,743 m.) in the N. W Himalaya. The allied genus *Leptophlebia* Westwood is, however, already known from N. W Himalaya from one nymph (*vide* Needham, 1909). *Ironopsis* Traver (1935), a nearctic genus, is likewise being recorded for the first time from India and is represented by nymphs of two distinct species of the genus. Several nymphs of these species were collected from Kothi (*Ca.* 8,000 ft.=2,438 m.) in the Kulu Valley and from Ganddapu (*Ca.* 11,000 ft.=3,353 m.) and Chhatoru (about the same altitude) in the Lahaul-Spiti valley of the Kulu Sub-Division. It may, however, be stated that the allied genus *Iron* Eaton, is already known from the Himalaya from nymphs only (Hora, 1930 ; Traver, 1939).

VI—Summary

The paper deals with Mayflies (Ephemeroptera) of the north-western Himalaya in the Kulu Sub-Division of the Punjab, India. The following eight new species are described from imagos or subimagos. (1) *Ephemerella indica* from Ralha (*Ca.* 9,000 ft.=2,743 m.) Kulu Valley. (2) *Baetis chandra* from Chhatoru (*Ca.* 11,000 ft.=3,353 m.) Chandra

River, Lahaul-Spiti Valley and Kulu Valley. (3) *Baetis simplex* from Kothi (*Ca.* 8,000 ft.=2,438 m.) in Kulu Valley. (4) *Baetis himalayana* from Sissu (*Ca.* 10,500 ft.=3,200 m.) in Lahaul Valley. (5) *Baetis Punjabensis*. (6) *Baetis bifurcatus* and (7) *Baetis festivus*, all from near Ralha (*Ca.* 10,000 ft.—11,000 ft.=3,048m.—3,353 m.) in Kulu Valley. (8) *Epeorus lahaulensis* from Sissu (*Ca.* 10,500 ft.=3,200 m.) Lahaul Valley.

Detailed descriptions of the nymphs of the following genera or species, as the case may be, are given. Two species of *Paraleptophlebia* Lestage ; one species of *Ephemerella* Walsh ; *Baetis chandra* Kapur and Kripalani ; *Baetis simplex* Kapur and Kripalani and several other undetermined species of *Baetis* ; one species each of *Ecdyonurus* Eaton and *Iron* Eaton, and two species of *Ironopsis* Traver.

Some remarks are offered on the geographical distribution and adaptation to life in the fast running and torrential streams at high altitudes of the north-western Himalaya. All the genera recorded are either holarctic or nearctic except *Baetis* which occurs also in the neotropical and Indo-Australian regions. The species described are of endemic origin. The genus *Ephemerella* Walsh, hitherto known from India from nymphs only, is now recorded from the imago, while the genera *Paraleptophlebia* Lestage and *Ironopsis* Traver are recorded, from nymphs only, for the first time from India.

VII—ACKNOWLEDGEMENT

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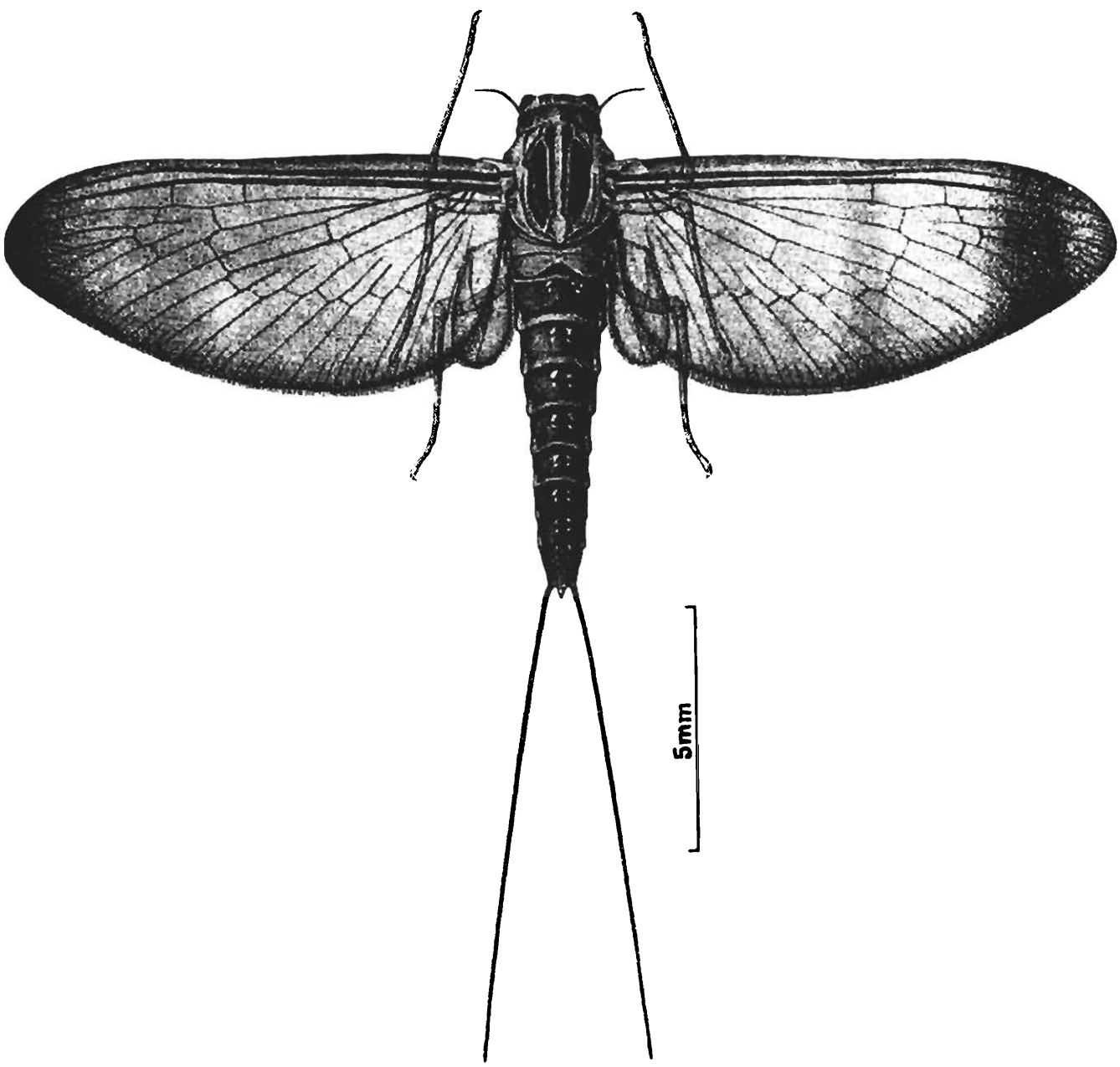
PLATE 7

Baetis chandra Kapur & Kripalani, sp. nov. (♂ subimago)



Baetis chandra, sp. nov. (♂ subimago)

ZOOLOGICAL SURVEY OF INDIA

34, CHITTARANJAN AVENUE,

CALCUTTA-12.

Officers and Scientific & Technical Sections as on 30th June, 1961.

Director	.	**Dr. M. L. Roonwal**
Deputy Directors	.	**Dr. M. S. Mani** **Dr. A. P. Kapur**
Administrative Officer		**Shri D. G. Mookerjea**

Scientific Divisions and Sections

I. Invertebrate Division

Superintending Zoologist — **Dr. B. S. Chauhan**

1. **Protozoology Section**	Zoologist : Shri K. K. Mahajan	Shri K. K. Mahajan (Officer-in-Charge)
2. **Helminthology Section**	Zoologist : Dr. P. D. Gupta	Dr. P. D. Gupta (Officer-in-Charge)
3. **General Non-Chordata Section**	Zoologist : Vacant	Shri K. S. Pradhan (Officer-in-Charge)
4. **Crustacea Section**	Zoologist : Shri G. Ramakrishna Asstt. Zoologist : Shri S. Biswas	Shri G. Ramakrishna (Officer-in-Charge)
5. **Mollusca Section**	Zoologist : Dr. H. C. Ray Asstt. Zoologist : Shri A. S. Rajagopalaiengar	Dr. H. C. Ray (Officer-in-Charge)

II. Entomology Division

Superintending Zoologist . Vacant

1. **Insect Section**	Zoologist : Shri K. S. Pradhan Asstt. Zoologist : Shri G. Mathai Asstt. Zoologist : Shri K. V. Lakshminarayana	Shri K. S. Pradhan (Officer-in-Charge)
2. **Arachnida Section**	Asstt. Zoologist : Vacant	Dr. A. P. Kapur (Officer-in-Charge)
3. **Termite Research Scheme** . .	Jr. Research Officer : Shri O. B. Chhotani	
4. **Locust Research Scheme**	Vacant	

III. Lower Chordata Division

Superintending Zoologist . . Vacant

1. **Marine Fish Section** .	Zoologist : Dr. A. G. K. Menon	Dr. A. G. K. Menon (Officer-in-Charge)
2. **Fresh-water Fish Section**	Zoologist : Dr. K. C. Jayarama-krishnan Asstt. Zoologist : Shri M. A. S. Menon	Dr. K. C. Jayarama-krishnan (Officer-in-Charge)
3. **Protochordata and Amphibia Section**	Zoologist : Km. M. B. Kripalani	Km. M. B. Kripalani (Officer-in-Charge)

IV. Higher Chordata Division

Superintending Zoologist . Dr. K. K. Tiwari

1. **Reptilia Section**	Zoologist : Shri M. N. Acharji	Shri M. N. Acharji (Officer-in-Charge)
2. **Birds Section**	Zoologist : Dr. B. Biswas	Dr. B. Biswas (Officer-in-Charge)
3. **Mammals and Osteology Section**	Zoologist : Vacant Asstt. Zoologist : Shri G. U. Kurup	
4. **Prehistoric Zoology Section**	Asstt. Zoologist : Shri Bhola Nath	Shri Bhola Nath (Officer-in-Charge)

V. Other Scientific and Technical Branches

1. **Taxidermy and Museum Section** .	Curator : Shri B. S. Lamba Asstt. Curators : Shri A. K. Mukherjee Shri Syed Mohammed Ali	Shri B. S. Lamba (Officer-in-Charge)
2. **Marine Survey Unit**	Zoologist : Dr. A. Daniel	Dr. A. Daniel (Officer-in-Charge)
3. **Soil Zoology Unit**	Zoologist : Dr. P. D. Gupta	Dr. P. D. Gupta (Officer-in-Charge)
4. **Animal Population Studies Unit** .	Zoologist : Dr. R. S. Pillai Asstt. Zoologist : Shri R. K. Bhanotar	Dr. R. S. Pillai (Officer-in-Charge)
5. **Documentation Unit**	Documentation Officer : Dr. Koshy Methew	Dr. Koshy Mathew (Officer-in-Charge)

VI. Regional Stations

1. **Eastern Regional Station, Z. S. I., Shillong**	Zoologist : Dr. K. Reddiah	Dr. K. Reddiah (Officer-in-Charge)
2. **Western Regional Station, Z. S. I., Poona**	Zoologist : Shri B. K. Tikader	Shri B. K. Tikader (Officer-in-Charge)
3. **Central Regional Station, Z. S. I., Jabalpur**	Zoologist : Shri H. Khajuria	Shri H. Khajuria (Officer-in-Charge)
4. **Northern Regional Station, Z. S. I., Dhera Dun**	Zoologist : Shri T. D. Soota	Shri T. D. Soota (Officer-in-Charge)
5. **Desert and Gangetic Plains Regional Station, Z. S. I., Jodhpur**	Zoologist : Dr. A. K. Datta	Dr. A. K. Datta (Officer-in-Charge)
6. **Southern Regional Station, Z. S. I., Madras**	Zoologist : Shri T. G. Vazirani	Shri T. G. Vazirani (Officer-in-Charge) (On transfer from Headquarters)