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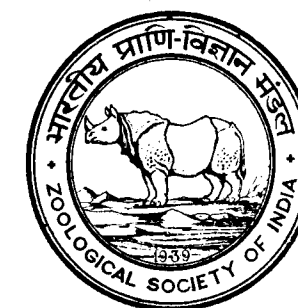
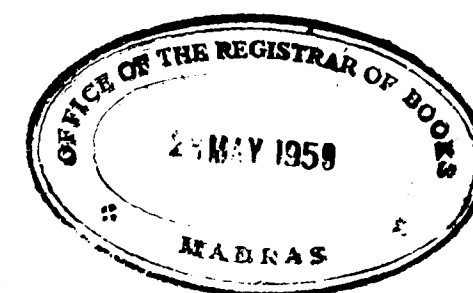
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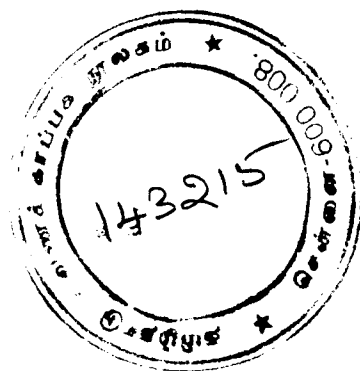
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**Chromosomes of Some Estuarine Basommatophorous
snails (Mollusca: Pulmonata) from Portonovo.**

BY R. NATARAJAN,
Department of Zoology and Marine Biology, Annamalai University.

(With 6 Text-figures)
(Communicated by Prof. R. V. SESHAIYA, F.Z.S.I.)

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Introduction

In a previous communication (Natarajan, 1958) the author reported on the chromosomes of three species of common Stylommatophorous snails of South India, belonging to the genus *Cryptozona*. The present paper deals with the chromosomes of three estuarine species of Basommatophora viz., *Melampus ceilonicus* Petit., *Cassidula* (*Cassidula*) *mustelinu* Deshayes and *Pythia plicata* Fer., belonging to the family Ellobidae. Only about fifteen species of Basommatophorous snails have been studied so far cytologically (Perrot, 1930, '34; Perrot and Perrot, 1938; Inaba and Tanaka, 1953; Inaba, 1953). Of these only one species i.e., *Melampus boholensis* belongs to Ellobiidae (Koslowsky, 1933, as cited by Makino, 1951). The present study was undertaken to fill the gap and also to know more about the prevailing cytological conditions in Basommatophora in general.

Material and Methods

All the species which are included in the present study were collected from swampy localities in the backwaters, adjacent to the Marine Biological Station, Portonovo, South India. The swamps are found as small islets with typical mangrove vegetation.

Specimens of *Melampus* occur very commonly and could be collected in large numbers. They are always seen in batches or groups adhering to the pneumatophores of *Avicennia* and *Sonneratia* sp., just above the water mark. The shell is about a centimetre in length, rounded in shape and dark coloured with different patterns of markings.

Specimens of *Cassidula* and *Pythia* occur singly, adhering to tree trunks and the stilt roots of the *Rhizophora*, high above the water mark. It is only with difficulty that a sufficient number of these snails could be collected for study. The shell of *Pythia* is laterally compressed, thin and with a pointed apex. Young shells are yellowish whereas the adult shells are dark coloured and there are no markings on the shell. The shell of *Cassidula* resembles that of *Melampus* but is very thick and twice the size of the latter.

The ovotestis of each of the three species was fixed in Sanfelice and Carony's fixatives which gave very good results. Iron alum, Crystal violet and Feulgen were used for staining the sections. Acetocarmine squashes of the ovotestis also proved to be very helpful for the study of different stages.

Observations

1. *Melampus ceilonicus* Petit.

In this form the chromosome number as determined from a study of the spermatogonial divisional stages is $2n = 36$. Fig. 1. represents

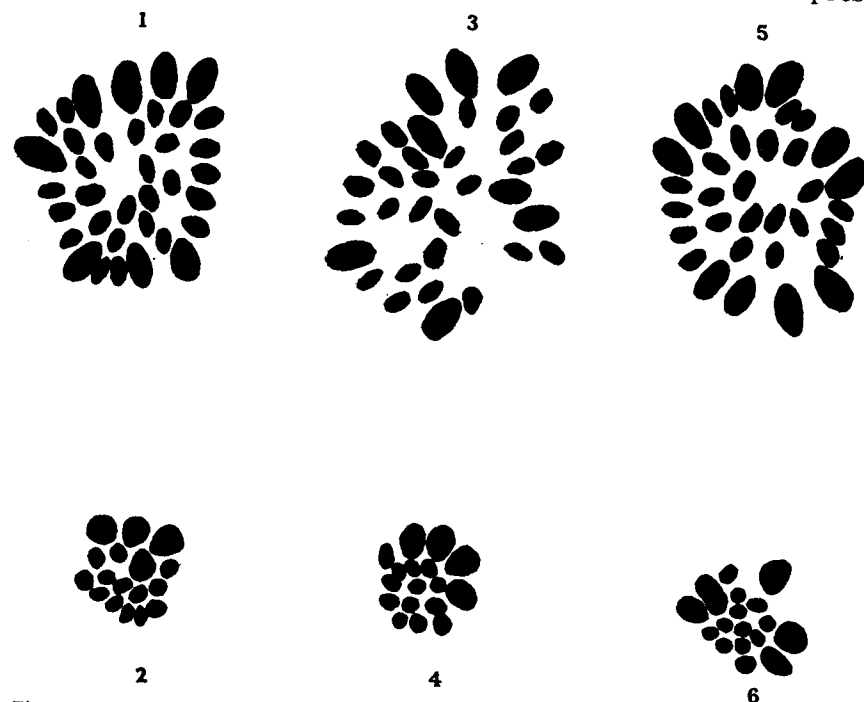


Fig. 1. Spermatogonial metaphase—polar view—in *Melampus ceilonicus* Petit.
Fig. 2. I—metaphase polar view in the same.

Figs. 3 & 4. Polar views of Spermatogonial and I—metaphase chromosomes respectively of *Cassidula (Cassidula) mustelina* (Deshayes).
Figs. 5 & 6. Polar views of spermatogonial and I—metaphase chromosomes respectively of *Pythia plicata* Fer. All figures are camera lucida drawings X ca 4000.

a spermatogonial metaphase plate in polar view wherein all the thirty-six chromosomes are short and rounded or oblong with no constrictions. There are eight big chromosomes in the complement and the rest are all smaller and of uniform size.

At I-metaphase there are eighteen bivalents with smooth outlines all of them appearing dot-shaped in polar view (Fig. 2). Four of them are bigger in size than the rest.

2. *Cassidula (Cassidula) mustelina* (Deshayes).

In this species the diploid chromosome number is 34. All the mitotic chromosomes are well condensed, short, rounded and without constrictions, as can be made out from Fig. 3. It will also be seen that eight of the chromosomes are big and the remaining are more or less uniformly small in size.

The seventeen bivalents of a I-metaphase in polar view are shown in Fig. 4. Of these four are distinctly bigger in size than the rest and lie towards the periphery of the metaphase plate.

3. *Pythia plicata* Fer.

Text-Fig. 5 represents the polar view of a spermatogonial metaphase of this species and 34 chromosomes could be well made out. As in the previous species, the mitotic chromosomes are short and rounded with no constrictions. The karyotype consists of ten bigger elements and twenty-four smaller ones. The bigger ones lie near the periphery of the metaphase plate while the smaller ones are distributed all over. During the metaphase of the first division, the five big bivalents lie peripherally and all the bivalents appear dot-shaped in polar view (Text-fig. 6).

Discussion

The present study of the chromosomes of three species of Basommatophorous snails representing three different genera of the family Ellobiidae shows that their karyotypes are on the whole very similar, being composed of rounded or oblong chromosomes without any constrictions. In all the three species the chromosomes can be grouped, according to size into a big set and small set. This feature is well shown especially by the I-metaphase bivalents.

At the same time each of the species studied has a distinctive and characteristic karyotype. In *Cassidula* and *Pythia* though the diploid chromosome number is the same, i.e., $2n = 34$, in the former there are eight bigger chromosomes in the karyotype whereas in the latter there are ten such chromosomes. In *Melampus*, the chromosome number is $2n = 36$ and there are eight big chromosomes in the complement.

<i>Melampus ceilonicus</i> Petit.	2n = 36	8 large	28 small
<i>Cassidula</i> (<i>Cassidula</i>)			
<i>mustelina</i> (Deshayes)	2n = 34	8 „	26 „
<i>Pythia plicata</i> , Fer	2n = 34	10 „	24 „

Another relevant point which calls for some comment is the question of the typical number of chromosomes in Basommatophora. Investigations on various other species by several authors and also the present study show that $2n = 32$ to 36 and this probably is the typical number. But there are two exceptions. In *M. boholensis* (Koslowsky, 1933) the chromosome number has been reported to be $2n = 16$, and for *Physa gyrina*, Mahoney (1940) has recorded the chromosome number as $n = 6$. Whether these two species are real exceptions can be decided only by a reinvestigation of their chromosome numbers.

Inaba (1953) has pointed out that there are marked differences between Baso and Stylommatophorous Pulmonates with regard to the number and morphology of chromosomes. In Stylommatophora, the diploid chromosome number varies between 50 and 64 and all the chromosomes are clearly metacentrics. In Basommatophora, the diploid chromosome number varies from 32 to 36 and all the chromosomes appear as acrocentrics. The present study and the previous one (Natarajan, 1958) on the chromosomes of three species of Stylommatophorous snails bear out these features.

Summary

1. The karyotypes of three representatives of Basommatophorous snails belonging to the family Ellobiidae have been studied. The chromosome numbers of these species have been reported for the first time.
2. $2n = 36$ in *Melampus ceilonicus* and $2n = 34$ in *Cassidula* (*Cassidula*) *mustelina* and *Pythia plicata*.
3. The spermatogonial chromosomes in all three species studied are rounded or oblong shaped with no constrictions, but the karyotype of each species is still distinctive.
4. The chromosomes of each karyotype can be grouped into two categories according to size.

Acknowledgements

I have pleasure in expressing my sincere thanks to Prof. R. V. Seshaiya, Professor and Director, Marine Biological Station, Portonovo, South India for suggesting the problem and for guidance and

encouragement. My thanks are also due to Dr. J. Jacob for reading through the manuscript and to Dr. H. Ray of the Zoological Survey of India, for help in the identification of the species. The award of a scholarship by the Ministry of Education, Government of India is also gratefully acknowledged.

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Abnormal Development in the Temperature-Treated Eggs of *Gasterosteus aculeatus* (L.); I Cleavage Abnormalities

BY H. SWARUP,
(Department of Zoology, University of Saugar, India.)
(With 2 Text-figures and 2 Tables.)

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Introduction

Normal cleavage can be disturbed by the use of chemicals such as colchicine (Keppel and Dawson 1939) urethan (Stroink 1951) and estradiol (Tondury 1943) which injure the mitotic spindles and chromosomes. Over-ripe eggs of amphibians show cleavage abnormalities which are attributed to cytoplasmic impairments (Witschi 1952). In the present experiments abnormal cleavage has been obtained in eggs which are treated with low and high temperatures.

The egg of *Gasterosteus aculeatus* has been described in detail by Thomopoulos (1953) and its normal cleavage by Swarup (1958).

Material and Method

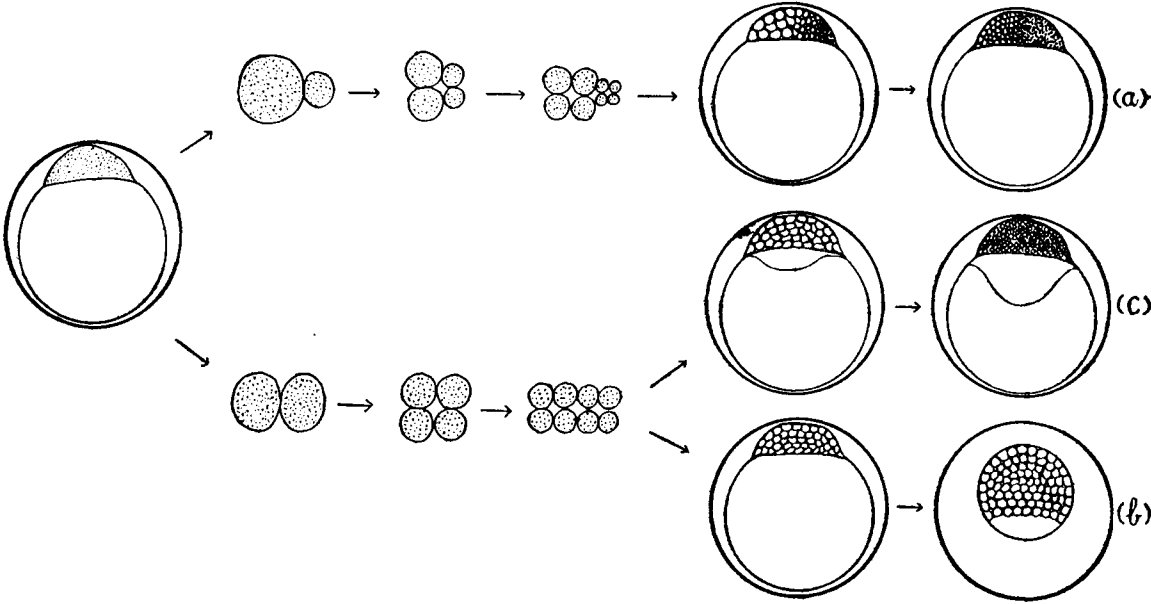
The eggs of *G. aculeatus*, a fresh water fish, measure 1.2 to 1.7 mm. in diameter. The main bulk of the egg is formed of transparent yolk, the cytoplasm proper being an extremely thin peripheral layer. The egg is covered over by a tough shell. After fertilization the shell separates from the egg proper creating the perivitelline space filled with its fluid. The cytoplasm now gradually accumulates at the animal pole as the blastodisc which subsequently undergoes cleavage.

The temperature treatment was provided by immersing the freshly fertilized eggs in water of requisite temperature for a known length of time.

Observations

Effect of heat and cold on the eggs:

For heat treatment of the eggs 32 experiments were performed involving 873 eggs and for cold 18 experiments involving 843 eggs. The results obtained are given in Tables 1 and 2.



Text-Fig. 1. Diagrams of cleavage abnormalities; (a) unequal division of the blastodisc, (b) and (c) inhibition of cleavage divisions.

It is evident from the Tables that both treatments produce abnormalities and that their frequency increases with the severity of temperature.

Unequal division of the blastodisc:

In normal development the first cleavage furrow divides the blastodisc into two more or less equal blastomeres. The earliest sign of

abnormal cleavage is seen when this division is unequal resulting in one large and one small blastomere (fig. 1a). Subsequent divisions subdivide these cells equally but the initial inequality results in one part of the early morula possessing large cells while the other part is made up of small cells. Later when the cells become more numerous and smaller this difference is unnoticeable. These eggs undergo gastrulation and form embryos which when squashed for chromosome analysis are found to be mostly haplo-diploid mosaics (figs. 2a and 2b). Some haplo-triploid mosaics are also produced.

Inhibition of cleavage divisions:

Another abnormality commonly seen is the inhibition of cleavage divisions at some stage of the morula. In this case the initial division of the blastodisc is normal and therefore subsequent divisions are all equal. The cleavage divisions may be arrested at the early morula stage and the yolk start diffusing into the perivitelline space. The yolk thus is gradually reduced in size and the cells of the morula spread



Text-Fig. 2. Microphotographs of a mosaic embryo at two places showing (a) diploid number of chromosome in metaphase mitosis and a diploid nucleus, (b) haploid number of chromosomes in metaphase mitosis and a haploid nucleus. 2560.

over it (fig. 1b). If on the other hand, the early morula goes on dividing further, a stage is reached when a subgerminal like cavity appears. The growth is now arrested and the yolk starts diffusing into this cavity (fig. 1c). Eggs with abnormalities shown in figures 1b and 1c invariably die though they may survive for hours and sometimes for one or two days. Unfertilized eggs when subjected to similar temperature treatments also show exactly the same abnormalities and therefore it is thought that the inhibition of cleavage divisions here is due to induced parthenogenetic development of the eggs.

Discussion

Mosaics have been produced by temperature treatment of the eggs in amphibians (Fankhauser 1945 and Fischberg 1947) and fish (Swarup

1956) but their early history has not been recorded. The initial cause for unequal division of the blastodisc is the presence of two groups of chromosomes in the blastomeres i.e. a haploid set and a diploid or triploid set. Fankhauser (1948) and Swarup (1959) have shown in the amphibians and fish respectively that the cell size is directly proportional to the number of chromosome sets present therein and therefore a haploid cell will be approximately $\frac{1}{2}$ the size of a diploid and $\frac{1}{3}$ the size of a triploid cell of the same species.

The cause of mosaicism can be due to some disturbance in the mitotic activity of the zygote nucleus or to the effect of one or more extra sets of chromosomes in the egg before cleavage. Humphries JR. (1956) has observed the formation of a haplo-diploid mosaic in temperature treated eggs of *Triturus viridescense* as a result of the failure of the sperm nucleus to fuse with the diploid egg nucleus. It is possible that the haplo-diploid mosaics in the present work also originated in the same manner.

Beatty (1957) has discussed in detail the various 'routes' which could lead to parthenogenetic development. Haploid individuals have been produced in fish (Swarup 1957) amphibians (Fankhauser 1945, and Fischberg 1948) and mouse (Fischberg and Beatty 1952, Edwards 1954) but they were either androgenous or gynogenous. Various reports of haploid parthenogenesis in vertebrates which have appeared are conflicting but now there seems to be clear evidence of the fact that in most cases the parthenogenetically induced eggs did not develop beyond the blastula stage (Swarup 1957). Therefore the present abnormalities of the inhibition of cleavage divisions seems to be due to parthenogenesis.

Summary

1. Cleavage abnormalities appear when the freshly fertilized eggs of *G. aculeatus* are subjected to high or low temperatures.
2. Two types of abnormalities are noticed; (i) unequal division of the blastodisc. and (ii) inhibition of cleavage divisions after a start has been made.
3. The first abnormality is due to the chromosome mosaicism which is mostly haplo-diploid. The second abnormality is due to parthenogenetic development of the eggs.

Acknowledgment

It is a pleasure to thank Sir Alister Hardy of the University of Oxford for facilities and Dr. M. Fischberg for guidance with whom the author worked.

TABLE 1. Summary of results of heat treatment of the eggs for 5 minutes

Temperature of treatment	Total eggs treated	Dead before cleavage	Survival	Normal cleavage	Abnormal cleavage	
					No.	%
32.5°C	98	23	75	73	2	2.6
33.0°C	182	40	142	138	4	2.8
33.5°C	267	94	173	99	74	42.7
34.0°C	290	60	230	120	110	47.8
35.5°C	36	13	23	0	23	100.0

TABLE 2. Summary of results of cold treatment of the eggs subjected to 0°C

Duration of treatment	Total eggs treated	Dead before cleavage	Survival	Normal cleavage	Abnormal cleavage	
					No.	%
$\frac{1}{2}$ hour	101	15	86	45	17	19.7
$1\frac{1}{2}$ „	132	16	116	65	51	43.9
$2\frac{1}{2}$ „	96	11	85	27	58	68.0
3 „	514	51	463	102	361	77.9

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Quantitative Study of the Amino acids in the Development of *Oryzias melastigma* (McClelland).

BY VIJAYAM SRIRAMULU,

(Department of Zoology and Marine Biology, Annamalai University).

(With 13 Text-figures and 2 Tables.)

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

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Introduction

In a recent paper on the qualitative changes in the pattern of amino acid distribution during the development of *Oryzias melastigma* the author (Sriramulu, 1959) pointed out the importance of a thorough understanding of the distribution of the amino acids during the development of different animal types in view of the contradictory findings reported by several investigators. In continuation of this study of the qualitative changes in the distribution of the amino acids in the development of *Oryzias melastigma* a study of the quantitative changes was undertaken, and these are dealt with in the present communication.

The literature on the study of the amino acids during development has already been reviewed by the author (Sriramulu, 1959) and reference will therefore be made only to papers having a bearing on the present study. Gustafson and Hjelle (1950, 1951) in their study on the amino acid metabolism of the developing sea urchin egg found that there was a little change during cleavage but during gastrulation there was a drop in free and a concomitant rise in protein-bound amino acids. Eakin *et al.* (1950) and Kutsky *et al.* (1953) observed fluctuations in the concentration of individual amino acids. Kavanau (1953) found that in the development of sea urchin the free amino acids fall into several groups with regard to quantitative changes but have no consistent pattern of change with regard to protein-bound amino acids, which decline continuously until hatching, when there is a sharp decline.

Later, Kavanau (1954) found in his studies of *Paracentrotus lividus* cyclic changes in protein-bound amino acids, indicating alternate period of yolk degeneration and protein synthesis.

Material and Methods

The protein-bound amino acids during the different stages of development were studied by the circular and two dimensional paper chromatographic technique using Whatman filter paper No. 1. For circular paper chromatography filter paper with 13 cm. diameter was used, and for the two dimensional chromatography 19 × 19 cm. paper was used. The procedure adopted by Giri *et al.* (1952) has been followed for the preparation of total acid hydrolysates, and for each stage of development fifty entire eggs were subjected to hydrolysis in 6N HCl. The first solvent system for the two dimensional chromatography consisted of n-butanol, acetic acid and water mixed in the ratio of 4:1:1 v/v/v. As a second solvent 80% buffered phenol (Block, 1952) was used. 0.5% ninhydrin in 95% acetone (w/v) was used as colour developing reagent.

The following procedure was adopted for the quantitative estimations of the amino acids. Each spot on the chromatogram was cut and eluted in 8.0 c.c. of a solution containing 7.2 c.c. of 80% alcohol v/v and 0.8 c.c. of 0.1% copper sulphate solution w/v. The optical density of the solution was determined with a 'Lumetron' colorimeter Model 401-A with 550/μ filter.

Control chromatograms of known quantities of amino acids were run simultaneously under identical conditions to locate the positions of the individual amino acids and to serve as standards for quantitative analysis.

The amino nitrogen in the corresponding stages of development was studied by the method of Pope and Stevens (1939).

Results

As shown in the author's previous study, in all, seventeen protein-bound amino acids can be recognised in the chromatograms of the hydrolysates of the developing eggs of *Oryzias melastigma*, viz., leucine and isoleucine, phenylalanine, valine, methionine, proline, tyrosine, alanine, threonine, glycine, serine, glutamic acid, aspartic acid, histidine, arginine, asparagine, ornithine and cystine. Of these methionine, tyrosine, histidine and ornithine vary in their occurrence in the different stages. The other amino acids are present in all the stages of development.

With regard to the quantitative changes, an increase in the concentration of all the amino acids occurs during gastrulation. Cystine shows 48.60% increase, tyrosine 43.30%, phenylalanine and arginine a little over 35%, leucines, aspartic acid and asparagine over 15%, but

less than 20% and the remaining less than 10% increase, valine showing the least (5.5%) increase.

A marked decline in the concentration of all the amino acids is observed at the time of hatching i.e., at 192 hours of development. Asparagine, leucines and aspartic acid show maximum decrease, by over 80%, valine and threonine by over 75% but less than 80%, arginine alanine and glutamic acid by 60% to 70% and the remaining show about 30% decrease.

At 48 hours of development a decline in concentration of all amino acids excepting phenylalanine occurs. The maximum decrease is shown by serine, ornithine and cystine. At 168 hours of development tyrosine disappears and all other amino acids excepting phenylalanine show a decrease in concentration. Serine alone shows less than 10% decrease, the others over 40%.

Phenylalanine shows an increase in concentration in all stages from gastrulation to 168 hours of development, decreasing only in 192 hours stage of development. At 54 and 120 hours of development the increase of phenylalanine in concentration is by over 400% and at 48 hours of development by 22%.

Amino acids other than phenylalanine fluctuate in their concentration, increasing in some stages and decreasing in others. The number of amino acids showing increase and decrease in concentration in different stages is as follows:—

Hours of development	Decrease	Increase
192	all	none
148	12	1
168	12	1
96	11	2
54	10	3
144	10	3
120	9	4
24	7	6
72	7	6

Most of the amino acids as may be seen from Text Figs. 1 to 6 have their peak concentration during gastrulation; cystine and leucines

in gastrulation and also in 24 hours stage; phenylalanine during 144 hours stage, and threonine and glycine during 96 hours stage.

The amino nitrogen content of the egg (Table II) is at its maximum at 72 hours of development and at the minimum at 96 hours.

It is evident that the concentration of protein-bound amino acids shows on the whole cyclic changes rising in some stages and falling in others. How far these are related to the changes of protein-bound amino acids of the yolk and whether there are alternate periods of yolk degeneration and protein synthesis are under investigation.

On the whole the present study lends support to Kavanau's observations on *Paracentrotus lividus*.

Summary

1. A quantitative study of the amino acids and amino nitrogen during the development of *Oryzias melastigma* (McClelland) has been carried out.
2. The different amino acids show fluctuations in quantity during development.
3. At gastrulation concentration of all the amino acids increases.
4. At the time of hatching (192 hours) there is a marked decline in the concentration of all amino acids.
5. At 48 hours of development there is decline in the concentration of all the amino acids excepting phenylalanine, which shows an increase in all stages from gastrulation to 168 hours.
6. Amino nitrogen content is at the maximum at 72 hours and at the minimum at 96 hours.

Acknowledgements

I am indebted to Prof. R. V. Seshaiya, Professor and Director, Marine Biological Station, Portonovo, for suggesting the problem, guidance and help. I am also thankful to the Ministry of Education, Government of India, for the award of a research scholarship.

TABLE 1—Quantitative changes in the protein-bound amino acids during the development of *Oryzias melastigma* (McClelland).

Amino acids	Cleavage	Gastrulation	Hours of Development								
			24	48	54	72	96	120	144	168	192
Leucines	200.50	237.50	237.50	75.00	72.32	151.87	112.50	40.50	121.87	30.00	25.40
Phenylalanine	29.50	40.00	60.00	36.00	151.71	97.20	81.00	162.00	97.50	32.00	20.00
Valine	455.40	480.33	433.35	131.00	227.36	247.59	216.00	318.00	376.62	183.40	109.16
Methionine	325.00	340.00	—	—	—	—	275.00	—	—	204.00	—
Tyrosine	34.85	48.93	36.70	22.02	84.93	99.09	82.57	49.54	45.87	—	—
Alanine	480.30	522.60	186.60	134.40	226.80	126.06	168.00	211.68	252.00	179.20	168.00
Threonine	495.50	526.60	210.60	189.36	274.24	597.24	213.00	255.96	434.50	110.60	102.00
Glycine	320.70	354.60	620.60	186.20	615.60	790.02	139.00	323.19	299.25	292.60	221.66
Serine	985.20	1074.60	624.00	187.20	421.20	589.68	218.00	393.12	442.00	197.60	104.00
Glutamic acid	1124.70	1227.60	592.00	482.60	538.84	891.84	533.40	514.35	809.00	635.00	423.30
Aspartic acid	1295.80	1496.00	1428.00	448.80	629.48	660.96	244.00	1226.84	561.00	244.00	204.00
Histidine	258.40	264.00	—	—	—	—	—	—	—	—	—
Arginine	335.50	460.00	191.66	115.00	177.42	135.00	138.00	114.20	273.12	126.50	115.00
Asparagine	774.20	933.30	263.33	280.00	462.85	918.00	390.00	594.00	775.00	140.00	100.00
Ornithine	—	—	302.50	—	—	245.16	—	245.16	—	233.10	—
Cystine	75.60	106.60	106.60	64.00	64.57	86.60	48.00	86.60	40.00	32.00	53.33

Results are the average of three experiments and the quantity is expressed in micrograms/50 eggs.

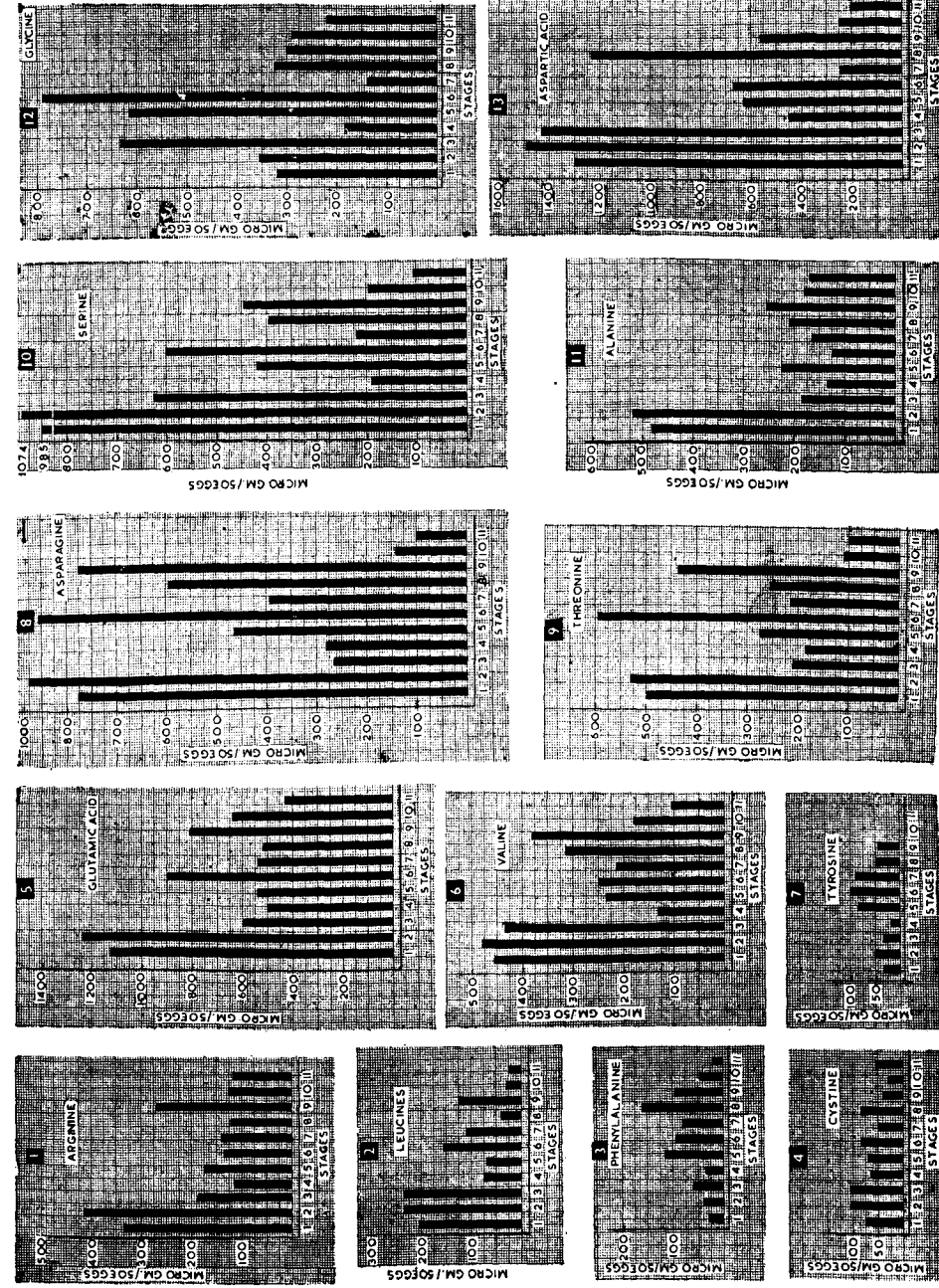
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Plate V



Text figs 1—13—Diagrams showing the concentration of the various protein-bound amino acids in the different stages of the development of *Oryzias melastigma*.

TABLE 2. Quantitative changes in the amino—N during the development of *Oryzias melastigma* (McClelland)

The quantity is expressed in μ gms./50 eggs.

No.	Stages	Amino—N
1	Cleavage	0.14
2	Gastrulation	0.21
3	24 Hours	0.19
4	48 Hours	0.19
5	54 Hours	0.23
6	72 Hours	0.42
7	96 Hours	0.13
8	120 Hours	0.15
9	144 Hours	0.33
10	168 Hours	0.16
11	192 Hours	0.15

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Notes on a Collection of Stomatopod Larvae from the Bay of Bengal, off the Mahanadi Estuary*

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(With 23 Text figures.)

(Communicated by Dr. B. S. Bhimachar.)

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Introduction

In Stomatopods the larvae differ so markedly from the adults that they have been described usually under different larval generic names. Though the general characters of the larvae of the various adult genera of stomatopods have been more or less defined (Claus, 1871,

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Brooks, 1886; Hansen, 1895, 1926; Giesbrecht, 1910; Foxon, 1932, 1939; Gurney, 1937, 1946), there is still much confusion. Most of the larvae belonging to any particular genus resemble one another so closely that it is virtually impossible to place them in their proper specific niches without rearing them to maturity (Townsend, 1953). While considerable descriptive work on larvae from several parts of the world has been done, this is generally considered an "unprofitable business" in the absence of reliable correlation with the adults (Foxon, 1939). Laboratory rearing of pelagic larvae collected in townets is generally very difficult and even recent workers (Townsend, 1953) have found it impossible as the period of survival of the larvae in captivity was very short. The present author has, however, fully demonstrated that with adequate care and regular feeding and renewal of water the larvae not only live in the laboratory aquaria for several days, but they also metamorphose into the post-larvae and grow rapidly to the adult size (Alikunhi & Aiyar, 1942, 1943, Alikunhi, 1944 a, b, 1950). Stomatopod larvae commonly occurring in the plankton from Madras have thus been exhaustively studied and correlated with their adult species on the direct evidence of rearing them to the adult stage (Alikunhi, 1952). The detailed descriptions and illustrations of the several identified larvae that resulted from the above studies enable easy and correct identification of these larvae at other localities also; and as several of these Madras species are widely distributed in the Indian seas and in the Indo-Pacific region in general careful study of collections of larvae from these localities should now lead to some useful information on the distribution and relative abundance of at least a few of them in the Indo-Pacific region.

The present report is justified on this account and is of interest as the collection is also from the Bay of Bengal though from a sector, a few hundreds of miles north of Madras.

Material for Study

During a three weeks' cruise of the I.N.S. Investigator, from the middle of January to the first week of February, 1953 on a hydrographical survey of the Mahanadi estuary, off the Orissa coast a number of

townet collections* were made in the sea, 4-7 miles off the estuary in the area lying between Lat. 20°3' and 20°5' and long. 86°8' and 86°9'.

The stomatopod larvae from the general townet hauls were carefully picked out and are available in 8 tubes as follows:—

No.	Location of station	Date	Time of haul	Tide
1.	Opposite South entrance	17-1-53	18.00-22.00	High
2.	do.	do.	—	—
3.	do.	22-1-53	16.00-18.30	Ebbing
4.	do.	do.	20.20-23.00	do.
5.	do.	27-1-53	18.30-20.30	High
6.	Mahanadi	28-1-53	10.24-12.24	Ebbing
7.	Opposite S. E. channel	2-2-53	20.00-23.00	High
8.	Tidal point	4-2-53	11.00-11.30	High

Excepting two collections the rest were taken either late in the evening or in the night. Though the exact time and duration of the hauls are known, as only portions of the total haul were preserved no inferences on the distribution and relative abundance of the larvae are possible. A qualitative account of the collection is therefore given in this paper together with descriptive notes of species or stages which are at present either unknown or are of interest otherwise.

The entire collection consists of 165 larvae representing 2 genera and 12 species as shown in Table I.

*The author is indebted to Dr. H. Srinivasa Rao, the then Chief Research Officer, Central Inland Fisheries Research Station, Calcutta for permission to work on this material. The townet collections were made on board the ship by Dr. V. G. Jhingran and Sri V. R. Pantulu, to whom thanks are due.

TABLE 1—Statement of Stomatopad larvae collected by I.N.S. Investigator during January–February 1953 from the Bay of Bengal off the Mahanadi Estuary.

Tube No.	Date	Total No. of larvae	SPECIES COMPOSITION											
			<i>S. latreillei</i>	<i>Squilla</i> sp. (<i>decorata</i> ?)	<i>Squilla</i> sp.?	<i>S. raphi-dea</i> ?	<i>S. hiero-glyphica</i>	<i>S. inter-rupia</i>	<i>S. oratoria</i> v. <i>inornata</i> ?	<i>S. holo-schista</i>	<i>S. nepa</i>	<i>Squilla</i> sp.	<i>L. maculata</i>	<i>Lysiosquilli</i> sp.?
1.	17-1-53	64	2	4	48	1	1	3	1	3	—	—	—	1
2.	17-1-53	44	2	—	19	6	—	5	11	—	—	—	—	1
3.	22-1-53	21	—	—	—	—	—	8	10	—	1	—	1	1
4.	22-1-53	29	1	—	21	—	—	4	—	—	—	2	—	1
5.	27-1-53	1	—	—	—	—	—	—	—	—	—	—	1	—
6.	28-1-53	3	3	—	—	—	—	—	—	—	—	—	—	—
7.	2-2-53	2	—	—	—	—	—	2	—	—	—	—	—	—
8.	4-2-53	1	—	—	—	1	—	—	—	—	—	—	—	—
Total ...		165	8	4	88	8	1	22	22	3	1	2	2	4

Descriptive Account**1. *Squilla latreillei* (Eyroux and Souleyet):—**

The eight larvae represent three stages as follows:—

(1) 3.50 to 3.67 mm., (2) 6.04 mm. and (3) 8.15 to 8.80 mm. in total length.

They agree in all details with the corresponding stages described from Madras (Alikunhi, 1952). While no larva in the final pelagic stage is available in the present collection the advanced larvae are distinguishable by the following features:—

- (i) The roughly triangular carapace, with a stout rostrum, divergent postero-lateral spines, only 1 + 2 spinules along lateral margin and none laterally directed.
- (ii) Raptorial dactylus even in the final pelagic stage with only one free tooth other than the terminal.

2. *Squilla* sp. (*decorata*?) (Larva, *Alimerichthus*

type) :— (Figs. 1-4)

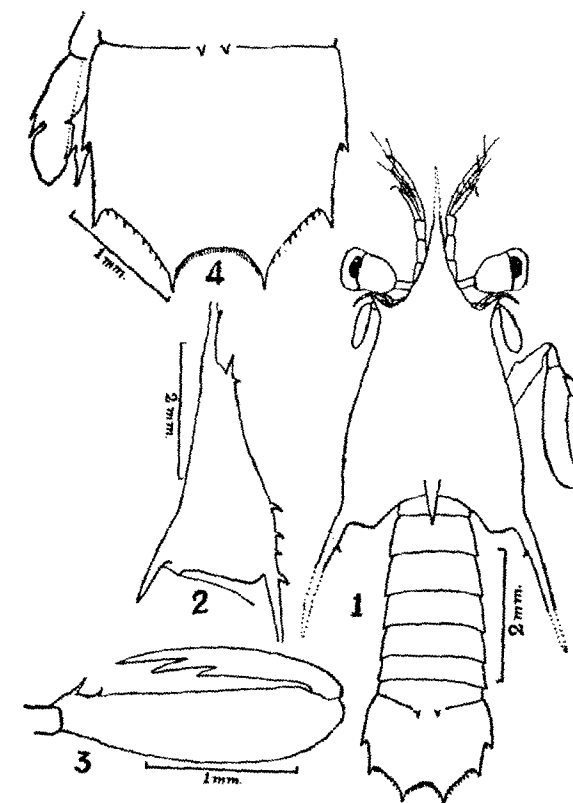
All the four specimens have the rostrum broken and measure, excluding rostrum, 8.7, 9.0, 9.06 and 9.34 mm. in length. None of these specimens is in the final pelagic stage. Measurements of the smallest and the largest of the four specimens are given below:—

	Specimen No.	
	(1)	(2)
	in mm.	
Total length excluding rostrum	8.7	9.34
Median length of carapace	3.45	3.93
Anterior width of carapace	2.00	2.01
Maximum width of carapace	3.30	3.29
Length of posterolateral spine	1.80	1.83
Eye: length of corneal portion	1.00	1.09
Eye: width of corneal portion	0.66	0.73
Telson: length	1.36	1.37
Telson: width	2.01	1.92

The carapace extends over the anterior half of the last thoracic segment (Fig.1). The rostrum and postero-lateral spines are moderately

long and stout and the tips of the diverging postero-laterals reach the level of the third abdominal segment. The antero-lateral spines are much shorter than the dorsal. The lateral margin of carapace bears 1 + 3-spinules, none of which is laterally directed or visible in the dorsal (Textfigs 1,2). The carapace is posteriorly vaulted prominently. One ventral spinule (probably more are present) is seen on the basal part of the rostrum.

The tip of the antennular peduncle is distinctly inferior to tip of rostrum. Eyes are not very conspicuous. The raptorial dactylus has two free teeth besides the terminal one, and indications of two more are seen beneath the larval shell. The abdominal segments are characteristically broad and stout as in typical *Alimerichthus* larvae.



The telson is distinctly broader than long. The submedian spines are longer than the intermediates. The denticles number 1 lateral, 8-9 intermediate and 19 submedians on each side. The tip of the uropod reaches almost to the base of the intermediate spines of telson (Textfig. 4). The exopod has 3 free spines and the outer spine of the ventral process is about a third of the length of the inner which has a smooth basal prominence.

Remarks:—In most of the features the larvae show a remarkable resemblance to the larvae of *S. latreillei*, but a careful comparison with the latter shows the following differences:

- (a) The lateral margin of carapace bears one additional spinule.
- (b) The raptorial dactylus has at least one free tooth more than in *S. latreillei*.
- (c) The eyes are smaller than in *S. latreillei*.
- (d) The anterior width of carapace being relatively more than in *S. latreillei* it is less triangular in shape than in the latter species.

The length of the four larvae would measure just over 11 mm. with rostrum. The condition of the raptorial limb, telson and uropods shows that it is almost in the final pelagic stage or perhaps a stage earlier. In total length, the final pelagic larvae would thus be of about the same size as the corresponding stage of *S. latreillei*.

In attempting to refer these larvae to an adult species the remarkable resemblance to the larvae of *S. latreillei* and the indications of only 5 teeth on the dactylus of the raptorial limb may be of some help. Being a true *Alimerichthus* larva it is fairly certain that it belongs to a species of the *Chloridella* or *fasciata* groups (Alikunhi, 1952). Of these groups the larvae of *S. latreillei*, *S. fasciata* and *S. lata* are known. The other species of these groups which have five teeth on the raptorial dactylus and which have been recorded from the Indian waters are *S. decorata* and *S. microphthalma* (Kemp, 1913). Both these species have been recorded from the Bay of Bengal but in *S. microphthalma* the raptorial dactylus has five teeth only in some specimens, the more common number being four. In *S. decorata* the dactylus has five well spaced teeth. It is also closely related to *S. latreillei*. As indications of five distinct and well-spaced teeth are seen in the raptorial dactylus of the larva which is also closely related to *S. latreillei*, it is probably reasonable to suggest that it belongs to *S. decorata*.

3. *Squilla* sp.? (Larva, *Alimerichthus* type)

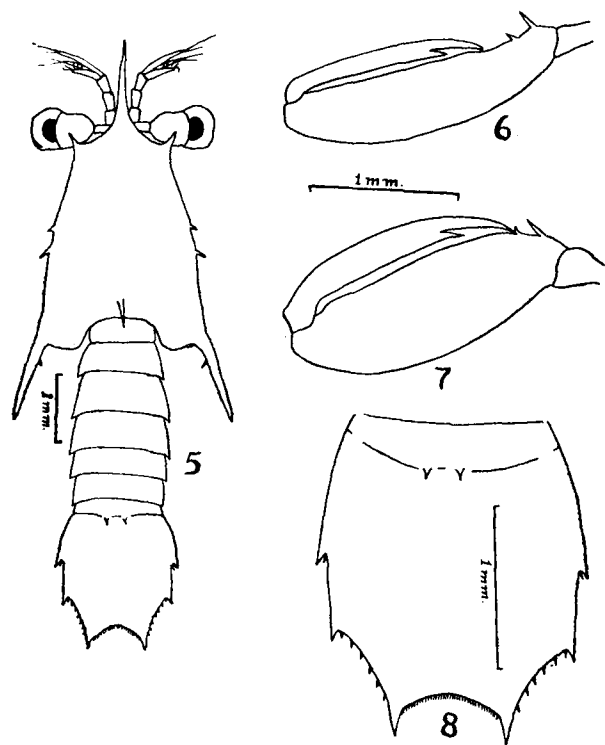
More than half the total number of larvae in the collection belongs to this species, but none of them is in the final pelagic stage. An almost complete series from the early *Alima* upto the final pelagic stage is, however, available and as these differ from the larvae of *S. latreillei*, *S. lata*, *S. fasciata* and probably of *S. decorata* described above a brief account of the different stages and the salient features of each is given below to facilitate their future identification.

TABLE 2. Detailed measurements (in mm.) of selected specimens representing the various stages in the collection.

Particulars	Specimens No.						
	1	2	3	4	5	6	7
Total length including rostrum	3.15	4.08	5.32	6.3	7.10	8.65	9.81
Length of rostrum	0.57	0.97	1.20	1.01	1.65	1.87	2.11
Carapace : median length	1.27	1.62	1.95	2.29	2.50	2.77	2.93
Carapace : anterior width	0.73	0.97	1.06	1.37	1.38	1.51	1.56
Carapace : maximum width	0.97	1.48	1.92	2.29	2.30	2.53	2.75
Length of ant. lat. spine	0.31	0.34	0.33	—	0.45	0.46	—
Length of post. lat. spine	0.49	0.78	1.06	1.13	1.47	1.43	1.46
Eye : length of stalk	—	0.27	0.34	—	0.39	0.43	—
Eye : length of corneal portion	—	0.49	0.67	0.73	0.79	0.94	1.01
Eye : width do.	—	0.34	0.43	0.46	0.57	0.63	0.73
Length of Raptorial dactylus	0.84	—	—	—	—	1.93	—
Telson : median length	0.57	0.49	0.84	1.09	1.23	1.42	1.56
Telson : width	0.55	0.79	1.08	1.28	1.42	1.72	1.83

The largest specimen in the series, 9.81 mm. long, is in an earlier stage than the final pelagic larva (Text-fig 5). It has the last thoracic segment exposed dorsally, the hind margin of the carapace extending over the seventh thoracic segment only. The carapace is relatively small and has 5 marginal spinules. The first of these is close to the anterolateral spine. The second and third are at about the middle of the lateral margin, and laterally directed, and therefore conspicuously seen in dorsal view. The third spinule is much more conspicuous than the second. The last two spinules are fairly large, ventrally directed and situated close to the posterolateral corner. The rostrum is longer than the posterolateral spine and bears 2 denticles ventrally. The posterolateral spines are slightly divergent posteriorly, have the tips reaching the level of the second abdominal segment and have each a spinule at about $\frac{1}{4}$ its length from the base. Anterolateral spines are almost as long as the dorsal which is continued forwards as a median carina.

The eyes are relatively large and conspicuous. The tip of antennular peduncle reaches half way to the tip of rostrum. The second antennular flagellum bears 4 groups of sensory hairs. The raptorial dactylus has one free tooth besides the terminal one (Text-fig. 6). Indications that with the subsequent moult the dactylus might have two free teeth besides the terminal one. The abdominal segments are broad and stout and have the posterolateral corners produced into acute spines. The sixth abdominal segment has a pair of submedian dorsal spines. The telson is relatively small. The submedian spines are the longest of the marginal spines of telson. The denticles number 1 lateral, 6-7 intermediate and 17-18 submedian on each side. The tip of uropod when directed backwards reaches the tip of the lateral spine of telson.



Larva, 8.65 mm. long:— (Text-fig 8).

The shape and spinulation of carapace are similar to the advanced larvae, though the first laterally directed spinule is a little smaller and the hind margin extends over the last thoracic segment. Tip of the posterolateral spines reaches the level of the third abdominal segment. The raptorial dactylus has one free tooth besides the terminal. Antennal endopodite projects beyond the tip of peduncle. The denticles of telson number 1 lateral, 7 intermediate and 19 submedians on each side. Exopod

of uropod has 2 free spines. The outer spine at the tip of the ventral process of uropod is about $1/6$ the length of the inner which has no distinct prominence at the broad base.

Larva: 7.20 mm. long:—(Text-fig. 9).

Shape and spinulation of carapace are similar to those in the 8.65 mm. long larva. Posterolateral spines are relatively longer and reach the level of the fourth abdominal segment. The antennal endopodite just reaches the tip of peduncle. Raptorial dactylus has no free tooth other than the terminal, though outlines of a second tooth are seen through the larval shell. Thoracic appendages 3-5 are well differentiated but not fully formed. The last three thoracic limbs are short, but bifid and segmented. Of the marginal spines of telson the submedians are still the longest. Denticles number 1 lateral, 7 intermediate and 17-18 submedians on each side. The uropod when directed backwards reaches halfway to the base of lateral spines of telson.

Larva 6.32 mm. long:—

General appearance including shape and spinulation of carapace is the same as in the 7.20 mm. long larva.

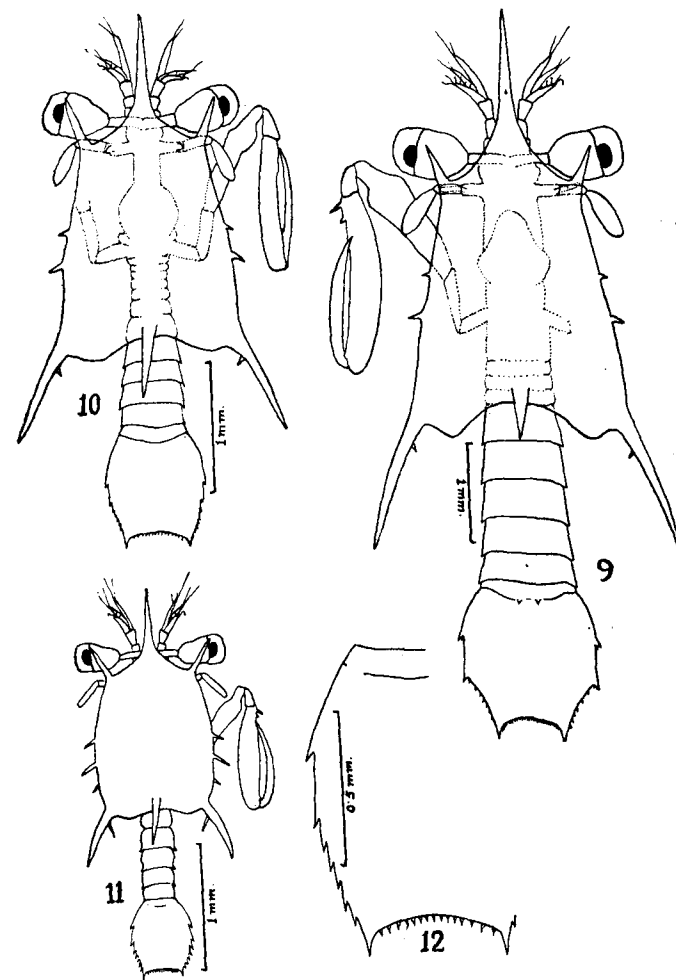
Larva 5.32 mm. long:—

Very similar to the 6.32 mm. larvae in general appearance; it has the hind margin of carapace extending over the anterior half of the first abdominal segment. Posterolateral spines diverge posteriorly and have their tips reaching the level of the fourth abdominal segment. Antennal endopodite is short and two segmented. Telson is relatively large. The submedian spines are conspicuous. Denticles number 1 lateral, 7 intermediate and 13-14 submedian on each side. The submedian dorsal spines on the sixth abdominal segment are rudimentary. Posterolateral corners of the first abdominal segment are rounded. Thoracic appendages 3-5 are fingerlike, unsegmented outgrowths. Short, bud-like, unsegmented rudiments of thoracic limbs 6-8 are visible, the rudiments on the sixth segment being smaller than those on the eighth segment. Uropod is short but bifid.

Larva 4.08 mm. long:—(Text-fig 10).

Shape and spinulation of carapace are the same as in the larger larvae. However, the carapace appears relatively larger, covers the first abdominal segment completely, has the dorsal spines a little longer than the anterolaterals and has the posterolaterals greatly divergent posteriorly with the tip reaching the level of the telson. The eyes are relatively large. Antennal endopodite is just a bud-like unsegmented prominence. Thoracic limbs 3-5 are short and rudimentary. There is no trace of thoracic limbs 6-8. The posterolateral corners of the first

abdominal segment are rounded but subacutely pointed in others. Sixth abdominal segment is devoid of submedian dorsal spines. The uropod is an unsegmented short stump. Shape of telson is different from that in the larger larvae. The submedian space is very wide and the submedian spines long. Denticles number 0 lateral, 5 intermediate and 7-8 submedian on each side.



Larva, 3.15 mm. long:—(Text-figs. 11,12).

This is the earliest stage in the collection. This tiny larva has a somewhat different appearance from the advanced larvae. The carapace is quadrate in shape with the marginal spines quite prominent. The carapace has one ventral spinule. The anterolateral spines are long and slender, shorter than the dorsal spine but more than half the length of the posterolateral spines. The latter are markedly divergent, each having

a long prominent spinule near the base and with the tip reaching the level of the third abdominal segment. The lateral margin of carapace has the same number of spinules as in the advanced larvae but with the exception of the two terminal ones, they are laterally directed. The carapace covers all the thoracic segments dorsally. The eyes are conspicuous. There is no trace of the antennal endopodite and thoracic limbs 3-8. The first abdominal segment has the posterolateral corners rounded though in the next four they are subacutely pointed. There is no trace of the sixth segment. Telson is also somewhat quadrate in shape and has 5 intermediate and 7-8 submedian denticles on each side. There is no trace yet of the uropod.

Remarks:—

The advanced larva is a typical *Alimerichthus* and belongs to the 'unidens' group. In the presence of the laterally directed spinules on the margin of carapace it is immediately distinguished from the larvae of *S. latreillei*, *S. lata* and *S. decorata*, which do not have such spinules. In this feature the present larvae resemble the larva of *S. fasciata*. As the final pelagic stage is not represented in the present collection it is not possible to give the exact size of the final pelagic larvae but from the stage of development of the 9.8 mm. long larva it appears that it is not only not likely to be larger than the final pelagic larva of *S. fasciata* but might also be only about 12.0-12.5 mm. in total length. From the nature of the raptorial dactylus in the 9.8 mm. long larva it may be safely assumed that the final pelagic larva will have at least two free teeth, excluding the terminal one, on the dactylus a feature identical with that in *S. fasciata*. A detailed comparison of the relative size of the various parts of the body of the 9.8 mm. long larva with an almost similar size (9.3 mm. long) specimen of *S. fasciata* from the Madras collections show the following features in the former:—

- (a) the carapace is longer, less triangular in shape and with shorter rostrum and posterolateral spines,
- (b) there are two laterally directed spinules on either side of carapace which are seen conspicuously in dorsal view in place of the single such spinule in *S. fasciata*; the total number of spinules on the carapace margin is also one more than in *S. fasciata*.
- (c) the raptorial propodus is not so inflated or broad as in *S. fasciata* (Compare Figs. 6 & 7), and
- (d) the eyes are relatively smaller.

It is thus evident that the present larva does not belong to *S. fasciata*. Of the other larvae of the "Unidens" group with two laterally directed spinules on either side of the carapace the larva of *S. raphidea* is different by virtue of its larger size, shape and spinulation

of carapace and the absence of free teeth on the raptorial dactylus (Alikunhi, 1952). *Erichthus multispinosus* of Claus (1872, Fig. 12) at 10 mm. is in a much earlier stage of development than the present 9.8 mm. long larva and has quite a different carapace shape and spinulation. Besides, no free teeth other than the terminal one is seen on the raptorial dactylus of the former. The typical form of *Alima multispinosus* described from the Red sea, Arabian Sea and the Gulf of Oman by Forun (1939) is about 20 mm. long, has 2 prominent spinules projecting laterally from the margin of carapace on either side and has 4 free teeth, including the terminal one, on the raptorial dactylus. The present larva is not likely to attain that size at the final pelagic stage and appears to be different from the former in other features also.

In the absence of the final pelagic stage and consequently indications of early postlarval features it is extremely difficult to assign the present larva to any adult species. Its small size and typical *Alimerichthus* characteristics, particularly the possession of free spines on the raptorial dactylus, probably indicate that it belongs to a species of the *Chloridella* or *fasciata* groups. The larvae of *S. latreillei*, *S. lata*, *S. decorata* (?) and *S. fasciata* are already known in these groups. The remaining species of these groups recorded from the Bay of Bengal are *S. microphthalmus*, *S. gilesi*, (Kemp, 1913) and *S. Choprai* (Tweedie 1935). *S. gibba*, *S. miles* (Kemp, 1913) and *S. granti* (Stephenson, 1953) have also been recorded from the Western Pacific. Out of these species an *Alima* larva described by Foxon (1932) from the Great Barrier Reef material has been suggested to be the larva of *S. gilesi* (Alikunhi, 1952). Whether the present larva belongs to one of the remaining species or to an undescribed adult cannot be decided on the basis of information now available.

4. *Squilla harpax* De Haan (?) (Text-fig. 13).

Eight specimens of a species of *Alimerichthus* type larva, ranging from 6.41 mm. to 11.17 mm. in total length are provisionally referred to *S. harpax* (Tiwari and Biswas, 1952). The largest of the above larvae is in a much earlier stage than the final pelagic. Characters of neither advanced larvae nor early postlarvae are therefore available even for an approximate determination of the adult species to which it belongs. They are however referred to *S. harpax* on the basis of their general appearance and larval characters including size and stage of differentiation as compared to the final pelagic larva of *S. harpax* already known (Alikunhi, 1952, c.f. *raphidea*).

Three distinct sizes available in the collection measure as follows:—

Total length including rostrum	...	6.41	8.85	11.19
Length of rostrum	...	1.38	2.10	2.27
Carapace : median length	...	2.47	3.15	3.85
Carapace : anterior width	...	1.46	1.72	2.01
Carapace : maximum width	...	2.47	3.22	3.85
Length of ant. lat. spine	...	—	0.51	—
Length of post. lat. spine	...	1.37	1.95	2.33
Eye : length of stalk	...		0.75	
Eye : Corneal portion : length	...		0.91	
Eye : Corneal portion ; width	...		0.61	0.73
Telson : median length	...		1.35	1.55
Telson : width	...		2.07	2.20

As the abdominal segments are broad, the larva has a stout build. The carapace is large and covers all the abdominal segments posteriorly. The rostrum and postero-lateral spines are long and stout, the former with two ventral spinules and the latter widely divergent, each with a spinule at about a third of its length from base and with the tips reaching the level of the hind margin of the fourth abdominal segment. The dorsal spine is much longer than the anterolaterals which are short though acutely pointed. The lateral margin of carapace has 7 spinules—the first two near the anterolateral spine and ventrally directed, the third small, ventro-laterally directed and inconspicuous in dorsal view, being in a different plane than the fourth which is larger, laterally directed and prominently seen in dorsal view. The last three spinules are nearer the posterolateral angles and ventrally directed. The seventh spinule is rudimentary in the smaller larvae. There are thus two laterally directed spinules on each margin of carapace though one of them is small and inconspicuous.

The tip of the antennular peduncle hardly reaches half way to the tip of rostrum, but the flagella reach the rostral tip. The second flagellum carries five groups of sensory hairs. The eyes are relatively large. The raptorial dactylus has no free teeth other than the terminal one. The last three pairs of thoracic limbs are short, bifid and segmented, though sideways these reach less than halfway to the margin of carapace. Posterolateral corners of abdominal segments are subacutely pointed. The sixth abdominal segment is not fully differentiated though a pair of rudimentary submedian spines is present. Telson

is relatively large and markedly broader than long. The marginal spines are rather short and denticles number 1 lateral, 10 intermediate and 13 submedian on each side. The uropod when directed back reaches 2.3 the distance to the base of the lateral spines of telson. The exopod has just one free spine while the ventral prolongation has the tip just bifid.

Larvae 9.25 to 9.71 mm. long resemble the above in general appearance and in all important features, but consistent with their size show the maxillipeds 3-5, not fully formed and the peraeopods as short bifid projections. In the 8.85 mm. long larva the marginal spines of the carapace appear longer than in the advanced stage and the tips of the posterolateral spines reach the level of the fifth abdominal segment. The peraeopods are rudimentary. The antennal endopodite is small and three jointed.

The antennal endopodite is unsegmented; maxillipeds 3-5 are short, finger-like and undifferentiated; the peraeopods are bud-like stumps and the posterolateral corners of abdominal segments rounded in a specimen 7.05 mm. long. The number and arrangements of spinules of the carapace are, however, similar to those in the advanced larvae.

The smallest larva in the collection, 6.41 mm. long, shows a correspondingly earlier stage of differentiation than the 7.05 mm. long specimen.

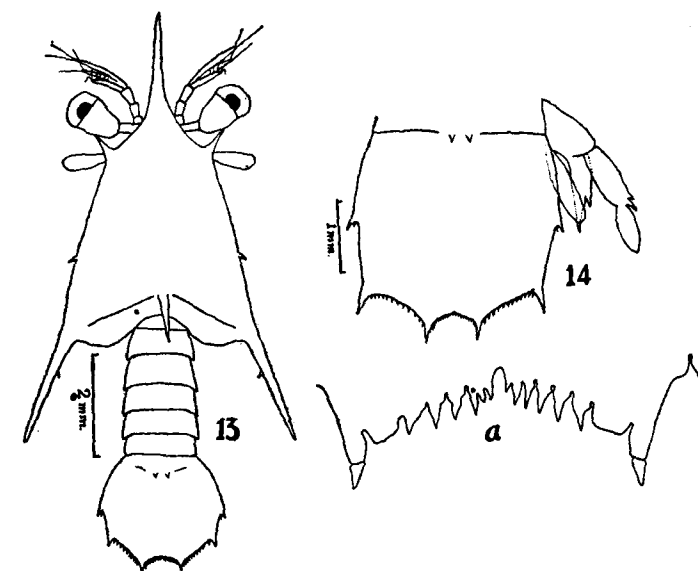
REMARKS:—

The short antenna—labral region and the stout abdominal segments indicate that these larvae belong to the *Alimerichthus* type. At 11.17 mm. the largest of the present larvae is in a much earlier stage than the final pelagic and on this basis it may be reasonably expected that at the final pelagic stage it might exceed a length of 15 or 16 mm. Even at the 11.17 mm. stage its carapace is almost as big or even bigger than that of the final pelagic larva of *S. fasciata* or the allied species described above. In the typical *Alimerichthus* larvae of the *Chloridella* and *fasciata* groups at least one free tooth other than the terminal one on the raptorial dactylus is present when they are 8.9 mm. long; in the present larva even at 11.17 mm. such a free tooth on the dactylus is absent. In the broad shield-like carapace and its marginal spinulation the present larvae resemble the larvae of *S. harpax* described from Madras (Alikunhi, 1952). Thus, the relatively large size, the larger shield-like carapace with more marginal spinules, the absence of free teeth on the raptorial dactylus, and the broad stout abdominal segments are features in which they differ from the typical small sized *Alimerichthii* of the *chloridella* or *fasciata* groups but agree with *Alimerichthii* of the *Pyramidalis* group. On this basis alone the present larvae have been referred to *S. harpax*.

5. *Squilla* (*Alima*) *Hieroglyphica* Kemp. (Fig. 14).

A single larva in the final pelagic stage and measuring 29.35 mm. in total length was obtained in the night collection on 17-1-53. This larva agrees in all essential features with the final pelagic larva of *Squilla hieroglyphica* (Alikunhi, 1944) obtained for the Madras waters. The present specimen measures as follows:—

Total length including rostrum	29.35 mm.
Length of rostrum	5.09 mm.
Median length of Carapace	12.00 mm.
Breadth of carapace at base of anterolateral spines	3.09 mm.
Breadth of carapace at base of Posterolateral spines	5.54 mm.
Length of anterolateral spines	1.00 mm.
Length of Posterolateral spines	3.86 mm.
Length of telson	2.73 mm.
Breadth of telson	3.09 mm.
Length of eye stalk	1.45 mm.
Length of corneal portion of eye	1.45 mm.
Breadth of corneal portion of eye	1.27 mm.



The rostrum has no ventral spinules and has the tip reaching beyond the tip of antennular peduncle. The second antennular flagellum has 14 groups of sensory hairs. The anterolateral spines of

carapace are longer than the dorsal spine, the posterolaterals are much shorter than the rostrum and are slightly divergent posteriorly, with the tips reaching the level of the second abdominal segment. There are 8 plus 3 spinules along the lateral margin of carapace, the 8th spinule being directed more sideways than the next. The antenna-lateral region of the body is telescoped and the abdominal segments with their acutely pointed postero-lateral corners are not very broad. The sixth abdominal segment has a pair of submedian dorsal spines. The telson is comparatively small for the size of the larva. Of the three pairs of marginal spines the intermediates are the largest (Fig. 14). Denticles of telson number 1 lateral, 11 to 13 intermediate and 16 submedian on each side.

Indications of the post-larval carapace and outline of the post larval telson are clearly seen through the transparent shell (Text-fig. 14 a). In this also the intermediate spines are seen longer than the laterals. The submedian spines have each a movable terminal joint. There are 10 intermediate denticles of which one nearest the intermediate spine and the corresponding one near the submedian spine are smooth and rounded. Submedian denticles are: an outermost large, blunt, rounded pair and six pairs of pointed spinous ones. In the uropod the ventral, bifid process has the outer spine about a fourth of the size of the inner which has a smooth though conspicuous basal prominence.

The raptorial dactylus shows through the chitinous covering outlines of five teeth including the terminal one.

REMARKS:—

Compared to the larva obtained from Madras waters (Alikunhi, 1944) the present specimen has slightly larger rostrum and a little shorter telson. In all other features including total length, the two specimens are practically identical. The nature and disposition of the marginal spines and denticles of telson in the post-larva as seen through the chitinous larval shell are identical with corresponding features of the Madras specimen (Alikunhi, Op. cit. Fig. 1 d). There is thus reasonable certainty that it belongs to *S. hieroglyphica*.

The present specimen is the second record of the species from the Bay of Bengal. It has been recorded from the Arabian Sea also (Kurian, 1947) and as pointed out in this connection (Alikunhi, 1947) the species does not appear to be so very rare in the Indian waters.

6. *Squilla Interrupta*:—(Text-fig. 15, page 143).

The species is fairly well represented in the collection and the 22 specimens are of the following stages:—

Early postlarva-metamorphosing—1 specimen.

Final pelagic larva—4 specimens.

Stages earlier to final pelagic—17 specimens ranging from 13.7 to 27.0 mm. in total length.

The final pelagic larva measuring 30.2 to 30.68 mm. in total length agrees in all features with the corresponding stage described from Madras (Alikunhi, 1952). As the earliest larva referred to this species measures 20 mm. in length (Lanchester, 1906) and as still earlier stages which may be referred to this species are available in the present collection a brief account of the same has been included in this report.

The early stages measure as follows:—

Particulars	1	2	3
Total length including rostrum	25.4	22.7	13.7
Length of rostrum	3.6	2.3	1.9
Carapace : medium length	8.8	3.4	4.8
Carapace : anterior width	3.0	2.9	1.9
Carapace : maximum width	5.4	5.1	2.9
Length of ant. lat. spine	1.2	1.0	0.73
Length of post. lat. spine	2.8	2.7	1.6
Length of raptorial propodus	4.8	4.5	2.9
Eye : length of stalk	1.5	1.5	1.3
Eye : length of corneal portion	1.4	1.3	0.9
Telson : length	3.8	3.4	2.4
Telson : width	3.8	3.2	2.2

In the smallest larva, 13.7 mm. long, the carapace extends over the anterior half of the sixth thoracic segment and the tip of the posterolateral spines reach the level of the hind border of the first abdominal segment. There are 6 + 3 spinules along the lateral margin of carapace, the last one near the base of the posterolateral spines being small and rudimentary. The antennal endopodite reaches the tip of antennal peduncle. Thoracic limbs 3-5 are not fully differentiated, while the last three are rudimentary, minute, unsegmented stumps. Telson is longer than broad and has one lateral, 9 intermediate and 15-16 submedian denticles on each side. The uropod is a short, bifid structure, not fully differentiated.

Except for differences due to their more advanced stage, larvae 22 to 25 mm. long, show almost identical features as the 13.7 mm. long larva. The number of spinules on the ventral side of the rostrum

gradually increases with size and by the 25 mm. stage the lateral margin of carapace has also 7 + 3 spinules as in the final pelagic stage.

7. *SQUILLA* sp. (*oratoria* var. *inornata*?) (Text-figs. 16-19).

Of the 22 larvae in the collection only one is in the final pelagic stage, while the remaining ones are much smaller. Detailed measurements of the various stages represented are as follows:—

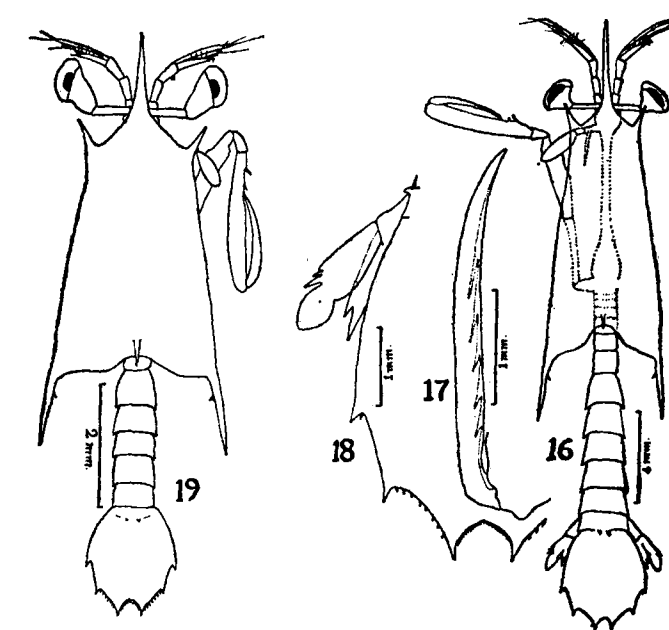
Particulars	1	2	3	4
Total length in mm. including rostrum	26.00	12.55	9.07	6.75
Length of rostrum	3.72	1.92	1.65	1.20
Carapace : median length	9.00	4.76	3.27	2.43
Carapace : anterior width	2.91	2.01	1.65	1.27
Carapace : maximum width	5.27	3.48	2.64	2.38
Length of ant. lat. spine	1.00	0.55	0.52	0.48
Length of post. lat. spine	3.00	2.10	1.27	0.97
Length of raptorial propodous	—	—	2.10	1.74
Eye : length of stalk	1.50	0.91	0.75	0.63
Eye : length of corneal portion	1.27	1.00	0.85	0.67
Telson : length	3.82	1.83	1.35	0.97
Telson : width	3.73	1.92	1.42	1.00

The 26.0 mm. long larva is in the final pelagic stage and has the long, somewhat narrow carapace posteriorly extending over the anterior 2/3 of the sixth thoracic segment (text-fig. 16). The rostrum which is devoid of ventral spinules is longer than the dorsal spine. The anterolateral spines are longer than the dorsal spine. The posterolaterals are slender, very slightly divergent posteriorly and have the tips reaching the level of the anterior half of the second abdominal segment. The marginal spinules on carapace number 7 + 3, none laterally directed.

The tip of rostrum is distinctly superior to tip of antennular peduncle. The second antennular flagellum has 14 groups of sensory hairs. The corneal portion of the eye is quite broad. The raptorial dactylus has no free tooth other than the terminal one but indications of six teeth are clearly seen beneath the larval shell (Text-fig. 17). The abdominal segments are narrow and have the posterolateral corners acutely pointed. The telson is relatively small, longer than broad, and has all the marginal

spines almost equally developed. Denticles number 1 lateral, 9 intermediate and 18 submedian on each side (Text-fig. 18). Tip of uropod when directed backwards does not reach the base of the lateral spine of telson. The exopod has three free spines. In the ventral process the outer spine is a little less than half the length of the inner which has no prominent basal tubercle.

In the 12.55 mm. long larva the carapace leaves the last thoracic segment exposed dorsally and the tips of the posterolateral spines reach the level of the fourth abdominal segment. The lateral margin of carapace has 4 or 5 + 3 spinules, the third and 4th being rudimentary. The last 3 pairs of thoracic limbs are short but segmented and bifid, reaching side-ways halfway to the margin of carapace. On the telson denticles number 1 lateral, 7 intermediate and 11-12 submedian on each side. The exopod of the uropod has one free spine and the tip of the ventral process is just bifid.



The 9.07 mm. long larva is practically identical with the foregoing specimen except for its earlier stage of differentiation. It has the thoracic limbs 3-5 almost normal but 6-8 are short and fingerlike. The ventral process of uropod is just a stump with its tip not bifid yet, while the exopod is unsegmented and without any free spine.

The shape and proportion of carapace in the 6.75 mm. stage are similar to the larger specimens and the carapace leaves the last thoracic segment exposed. The lateral margin of carapace has only 1 + 2 spinules with rudiments of a spinule between the anterolateral spine

and the first spinule. The last two spinules near the posterolateral corner are ventrolaterally directed. The antennal endopodite stops short of the tip of peduncle. Thoracic limbs 3-5 are not fully formed, while 6-8 are indicated only as small bud-like protruberances. Posterolateral corners of abdominal segments are subacute. The sixth abdominal segment is not fully differentiated and there are no rudimentary submedian spines. The submedian spines of telson are the longest and denticles number 1 lateral, 7 intermediate and 9 submedian, on each side. The uropod is a small unsegmented stump.

At the 7.2 mm. stage the carapace margin has (1) 1 (2) + 2 (1) spinules, those given in brackets being small and rudimentary.

REMARKS:—

In the general shape of the body the final pelagic larva shows some resemblance to the corresponding stage of *S. boops* (Alikunhi, 1952), but the smaller size, the absence of spinules on rostrum and indications of six teeth on the dactylus of the raptorial claw easily distinguish it from the latter species. The size and shape of carapace also distinguish it from the larvae of *S. nepa*, *S. holoschista*, *S. woodmasoni* and *S. interrupta*, all of which have six teeth on the raptorial dactylus. In the relative size and shape of carapace and telson the present larvae, however, show a remarkable resemblance to the pelagic larvae described by Komai and Tung (1929) from Tokyo Bay and ascribed to *S. oratoria*. This latter species has not been recorded from the Bay of Bengal but its variety *inornata* is commonly encountered and it is possible that the present larvae belong to this variety. According to Komai and Tung (1929) the largest pelagic larva of *S. oratoria* measures only 18.6 to 20.5 mm. in total length. The largest of the present larvae measures 26 mm. If it really belongs to *S. oratoria* var. *inornata*, as the striking similarity in appearance with the larvae from Japanese waters would seem to indicate, its larger size, details of spinulation of carapace and absence of spinules on rostrum would be distinguishing features.

In a recent contribution Townsley (1953) has tentatively assigned certain *Alima* larvae collected from Hawaiian waters to *S. oratoria*, but has not referred to the valuable paper by Komai and Tung (1929) on the larval development of that species. The larvae described by Townsley also appear to be quite different from those assigned to *S. oratoria* by Komai and Tung. The earliest stage described by Townsley is a *pseudozoea* measuring 5.5 to 8.0 mm. in total length. According to Komai and Tung at this size the larva of *S. oratoria* is an early *Alima* with body form quite different from that of the *pseudozoea* figured by Townsley. The second stage described and figured by Townsley measures 15 to 20 mm. in length. It represents a stage much earlier

than the final pelagic stage, as the last three thoracic appendages are represented by small buds only. As mentioned earlier the 9th stage or the final pelagic larva of *S. oratoria* measures only 16.0 to 18.7 mm. (Komai and Tung, op. cit.) and is in a much more advanced stage than the 15.20 mm. larva from Hawaiian water. Though this latter has a superficial resemblance to the Japanese larvae the spinulation of carapace and the earlier stage of differentiation indicate that it probably belongs to a different species. The third stage described by Townsley, measuring 45 to 60 mm. in length, appears to be in the final pelagic stage and by virtue of its large size alone is obviously a different species from that described by Komai and Tung who, it is interesting to observe, have referred two similar larvae (52 mm. and 44 mm. long excluding rostrum) obtained from the Tokyo Bay to *Alima emarginata*. It has already been shown that Komai and Tung have mixed up some larvae of *S. scorpio* in one or two stages ascribed to *S. oratoria* (Alikunhi, 1952). If the remaining stages really belong to *S. oratoria* it is clear from the above remarks that the larvae tentatively referred to that species by Townsley should actually belong to one or more different species.

8. *Squilla Holoschista* Wood-Mason:—

Three specimens in the collection are:—

- (a) Two larvae in the final pelagic stage, 34.5 and 36.5 mm. long; with the post-larval carapace and telson indicated in both.
- (b) One metamorphosing larva, with the larval carapace dropped off but the rest of the moult incomplete.

The larvae agree in all details with the specimens described from Madras (Alikunhi, 1952).

9. *Squilla Nepa* Latreille (Bigelow):—

This common species is represented by a single larva in the final pelagic stage. It measures 23.4 mm. in total length and agrees in all details with the larvae described from Madras (Alikunhi, 1952).

10. *Squilla* Sp. (?) (Text-figs. 20-21).

This species is represented by two early *Alima* larvae in the first and second pseudozoea stages respectively. As advanced stages are not available no attempt has been made to refer them to any adult species but to facilitate future identification the two larvae are described and figured here:—

The two specimens measure as follows:—

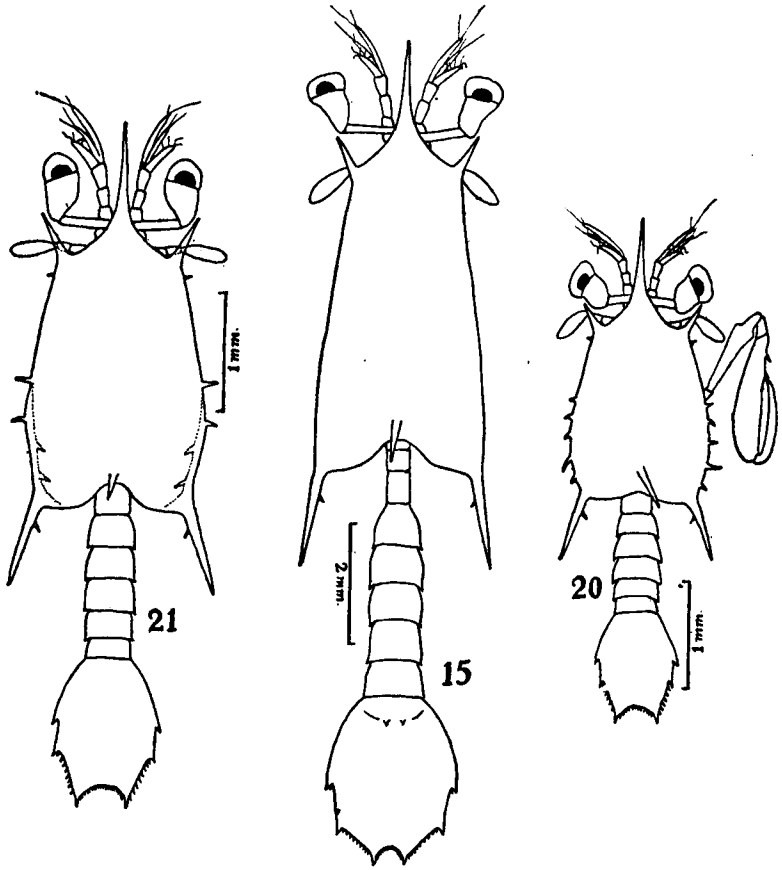
Particulars	1	2
Total length including rostrum in mm.	4.58	6.04
Length of rostrum	0.73	0.92
Carapace : median length	1.74	2.47
Carapace : anterior width	0.92	1.14
Carapace : maximum width	1.32	1.65
Length of ant. lat. spine	0.31	
Length of post. lat. spine	0.64	0.82
Eye : length of stalk		
Eye : length of corneal portion	0.46	0.55
Telson : length	0.73	1.00
Telson : width	0.68	0.92

In the smaller larva the carapace extends posteriorly over the seventh thoracic somite (Text-fig. 20). The anterolateral spines are almost half the length of the posterolaterals which diverge and have the tips at the level of the hind border of the second abdominal segment. The rostrum is long and slender. The dorsal spine is almost as long as the anterolateral. The lateral margin of carapace has 6 prominent spinules, all laterally directed. The fifth spinule is the longest of the lot. The antennular peduncle is short and reaches only half way to the tip of rostrum. There is no trace of endopodite on antennal peduncle. Thoracic limbs 3 to 8 are also absent. Posterolateral corners of abdominal segments are sub-acutely pointed. The sixth abdominal segment is not indicated and the uropods are also absent. The telson has 5-6 intermediate denticles on either side and 12 denticles between the two submedian spines. The larger specimen has the same general appearance as the smaller larva. The rostrum is still longer than the posterolateral spine. The anterolaterals are much longer than the dorsal and over half the length of the posterolateral spine. There are only five spinules on the margin of carapace the second and third directed laterally (Text-fig. 21). The antennular peduncle appears relatively longer than in the earlier stage. Antennal endopodite is just indicated as a smooth prominence. There is still no trace of thoracic limbs 3 to 8, the sixth abdominal segment and uropods. There are 8 to 9 intermediate denticles on each side of telson and between the two submedian spines the number of denticles has increased to twenty one.

REMARKS:—

Compared to the 6.75 mm. long larva tentatively assigned to *S. oratoria* var. *inornata* in this report the present specimen, 6.04 mm. long, is in a much earlier stage of differentiation. This would indicate that by the final pelagic stage the latter might attain a larger size than the former. The shape and spinulation of carapace also indicate that the present larvae are different from the former.

When the size and stage of development are considered in conjunction with the shape and spinulation of carapace it becomes difficult to identify the present specimens with any of the early *Alima* larvae so far described.



11. *LYSIOSQUILLA MACULATA* (Fabricius):—

This widely distributed and common species is represented by two larvae, measuring 22.0 and 23.0 mm. respectively in total length. Both the specimens are in the final pelagic stage as outlines of postlarval telson and carapace are seen clearly demarcated underneath the larval

shell. They agree in all details with the larva described from Madras Alikunhi, 1952).

REMARKS:—

In a recent paper Townsley (1953) has referred seven *Lysioerichthus* larvae collected from the Hawaiian waters to *Lysiosquilla maculata*. His identification of these larvae is based on an examination of post-larval forms and the adults of the same species occurring in the locality. The larvae measure 15 to 16 mm. in total length. Brooks (1886) Hansen (1926), Tattarsall (1906) Foxon (1939), Gurney (1946) and others have considered *Lysioerichthus duvaucelli* (Guerin) as the larva of *Lysiosquilla maculata*. The present author Alikunhi, 1952, (unpublished) has demonstrated by rearing *L. duvaucelli* in the laboratory to the adult condition that the larva is that of *L. sulcirostris* and that the larvae of *L. maculata* are closely similar to those of *L. duvaucelli*, though with some distinctive features. These larvae are 22 to 24 mm. in total length at the final pelagic stage. The larvae referred to *L. maculata* by Townsley are not only appreciably smaller but are also markedly different from the former in the relative size and spinulation of carapace and in the shape of telson. It is obvious that they are different from the Madras larvae and probably belong to a closely allied species.

12. *LYSIOSQUILLA* Sp. (Text figs 22-23).

The species is represented by four larvae—two of them in the final pelagic stage and measuring 12.82 and 14.0 mm. respectively in total length and two early *Erichthoidina*, measuring 3.48 and 3.50 mm. respectively in length.

All the larvae agree very well with *Lysiosquilla* (*Lysioerichthus*) sp. II described from Madras (Alikunhi, 1952) and there is no doubt that they belong to the same species. In both the specimens in the final pelagic stage a minute dorsal spine is seen at the hind border of the carapace. This is the only feature in which these larvae differ from the Madras specimens. The submedian space of telson is characteristically divided into three sections with the specific number of 6—1—4—1—6 denticles. The raptorial dactylus shows indications of 6 teeth beneath the chitinous shell. The post-larval telson, similarly indicated, is shown in figure 22. The submedian spines are terminally articulated, while, the lateral and intermediate spines are longer than in the larva. The submedian denticles are also longer than in the larva but their number and arrangement remain unchanged. A third intermediate denticle is indicated by an angular prominence between the two.

The *erichthoidina* larva is smaller than the smallest specimen (4.39 mm.) obtained from Madras. It resembles the latter in the relative size of carapace and in the shape and spinulation of telson (Fig. 23).

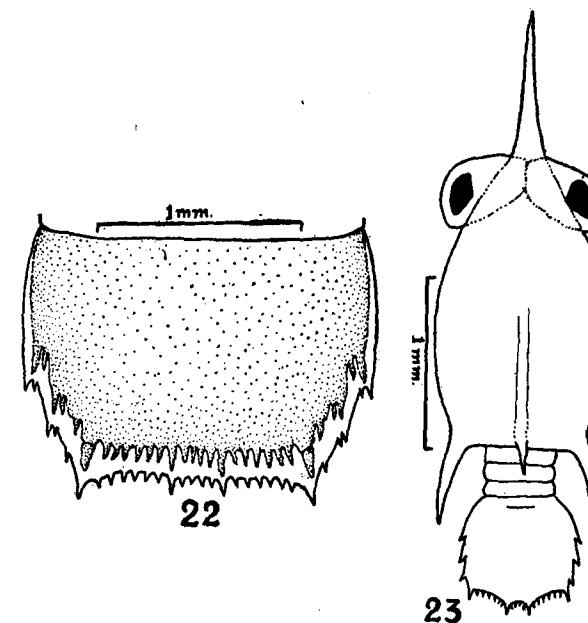
The eyes are sessile, the zoea spine appears a trifle longer than in the Madras specimen and it is continued forwards as a dorsal carina.

REMARKS:—

That the number and arrangement of denticles of telson form an important specific feature of the larvae has already been stressed (Alikunhi, 1952). Though on this character the present larvae may be considered different from those of *L. multifasciata*, *L. tigrina*, and *L. acanthocarpus* which have been positively correlated with the adults, their identification with an adult species, even on a tentative basis, is not possible without more specific information.

Conclusion

Squilla nepa which is the commonest species off Madras (Alikunhi, 1952) seems to be much less abundant off the Mahanadi estuary, situa-



ted over 700 miles north of Madras. *S. latreillei* appears to be as abundant as the Madras coast. On the other hand *Squilla* sp. (*Chloridella* or *fasciata* group) which was not encountered in the Madras plankton appears to be fairly abundant in this region. Differences in the relative abundance of particular species in different localities thus seem to be demonstrated in this group also.

The record of a second larva of *S. hieroglyphica* confirms the occurrence of this rare species in the Bay of Bengal and indicates that it

is perhaps not so very rare as has been believed hitherto. The almost complete series of larvae of *Squilla* sp. (*Chloridella* or *fasciata* group) described in this report will facilitate their identification in future, particularly since the adult species in all probability is likely to be a common Indian form.

As the larvae live under almost identical environmental conditions, the differences between larvae of related species are often slight (Ali-kunhi, 1952). Unless the larva is carefully described in detail several of these features which are remarkably constant and of utmost help in specific determinations, are often missed. The size of the larva and its stage of development are also important in this respect.

The need for some standardised description of stomatopod larvae is badly felt particularly because of the striking similarity between different types of larvae and if such a procedure is adopted some useful results may be expected even from descriptions of unidentified larvae.

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Asymmetry in the Striped Eyes of the Desert Locust *Schistocerca gregaria* (Forsk.)

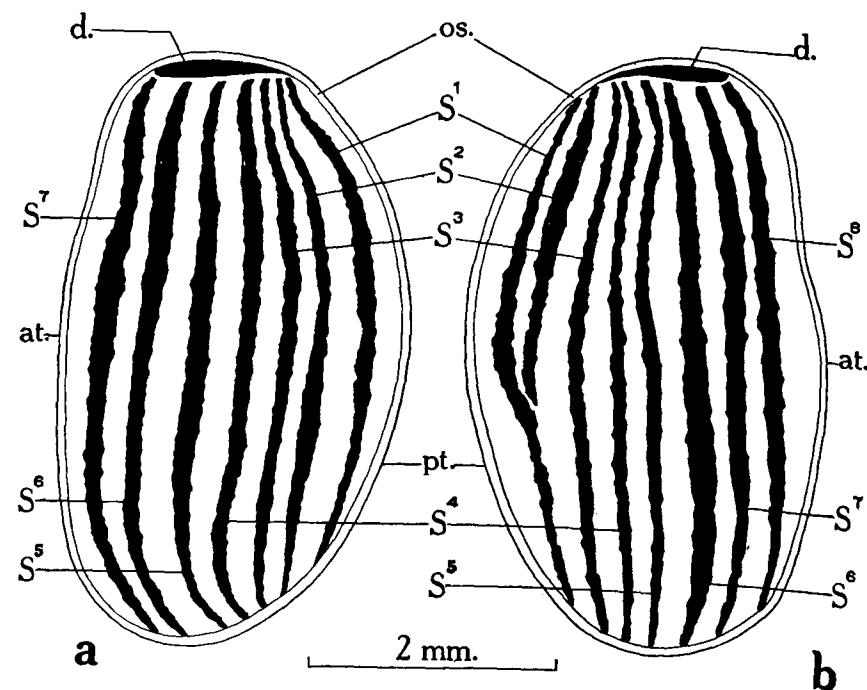
BY R. K. BHANOTAR, M.Sc.

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WITH 1 TEXT-FIGURE

(Communicated by Dr. M. L. ROONWAL, F.Z.S.I.)

In the *solitaria* phase specimens of the Desert Locust *Schistocerca gregaria* (Forsk.), the compound eyes are vertically striped with dark brown stripes, the usual number of stripes being either six or seven (Roonwal, 1936). Occasionally, individuals with five and eight stripes may occur (Roonwal, 1947). The post-embryonic development of the eye-stripes (Roonwal, 1947) and their physiological and behavioural significance (Roonwal, 1947, 1958) as well as their evolutionary importance (Roonwal, 1954) have been studied in recent years. So far, no asymmetry as regards eye-stripes had been recorded.



Side view of left and right compound eyes of *Schistocerca gregaria* (phase *solitaria*) female showing the 7 and 8-striped condition respectively. Female specimen, No. PPA 140, coll. D. N. Bahl, Nanujaba (Jodhpur Division, Rajasthan), 20. vi. 55.

(a) Left eye; (b) Right eye.

at., anterior side; d., dorsal spot; os., ocular sclerite; pt., posterior side; S₁—S₈, first to eighth eye-stripes.

Dec. 1958]

BHANOTAR: EYES OF THE DESERT LOCUST

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While studying a collection made by the Plant Protection Directorate in Rajasthan desert in western India during 1955, I found a female (No. PPA 140, locality: Nanujaba area, Jodhpur Division, Rajasthan; 20.vi.55) in which the left eye had 7 stripes and the right one 8 stripes (Text-fig. 1). In the 8-striped eye, Stripe Nos. 1 and 2 (*i.e.*, the two most posterior stripes) were clearly separated in the top half of the eye but fused for the rest of the length. The field population during the period of collection was about 8,500 individuals per square mile, which indicated a *solitaria* feature. The body-measurements and ratios of the specimen which are given below also indicated a *solitaria* character:—

Length of elytron (E), 64.5 mm.; length of hind-femur (F), 30.1 mm.; length of pronotum (P), 11.6 mm.; height of pronotum (H), 9.9 mm.; width of head in ocular region (O), 7.0 mm.; width of head at the genal level (C), 8.2 mm.

Ratios: E/F, 2.14; P/C, 1.41; C/O, 1.17; F/C, 3.67; H/C, 1.20.

Summary

In the *solitaria* phase the two compound eyes of the Desert Locust usually have 5-8 (mostly 6 or 7) vertical brown stripes, and the right and left eyes are symmetrical. A female specimen, from the 1955 Rajasthan Collection, with asymmetrical eyes is recorded here. The left eye is 7-striped and the right 8-striped.

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The Amino Acids of the Crystalline Style of *Telescopium telescopium* (Linn.)

(Gastropoda Prosobranchia)

BY S. SWAMINATHAN,

(Department of Zoology and Marine Biology, Annamalai University)

WITH 1 TEXT-FIGURE.

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

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Introduction

The alimentary canal of all Lamellibranchs with the exception of Septibranchs and of several herbivorous Prosobranch Gastropods is characterised by the presence of a crystalline style. The digestive functions of the crystalline style are well known. But the composition of the crystalline style, apart from the enzymes present in it, still needs investigation. In recent years, the chemical composition of the crystalline style of *Mactra sulcataria* (Reeve) was investigated by Hashimoto *et al.* (1954, 1955). These authors showed that the style consists of mucin with several component sugars. They also determined the amino acids in the acid hydrolysate of the crystalline style. Venugopalan (1956) studied the free and protein-bound amino acids of the crystalline style of *Sanguinolaria diphos* (Gmelin). Hashimoto *et al.* and Venugopalan have shown that the style is a mucin and not a globulin as suggested by Yonge (1932).

The amino acid composition of the crystalline style has not been studied in any gastropod so far. It would be interesting to know whether the amino acid composition of the crystalline style is the same in all species or whether it has any specificity. The present account deals with the free as well as protein-bound amino acids in the crystalline

Material and Methods

Specimens of *Telescopium* were obtained from the backwaters of Vellar estuary at Portonovo during low tide. The styles were dissected out from the style-sacs of the animals. For the determination of free amino acids the styles were put in 80% alcohol, ground in a mortar with quartz sand and centrifuged. To the supernatant liquid chloroform was added (1:3 v/v) and again centrifuged. The supernatant extract was taken for spotting.

For the study of the protein-bound amino acids the style was hydrolysed in 6N HCl for eighteen hours under reflux. After hydrolysis the contents were evaporated to dryness on a steam bath. A few drops of 10% isopropyl alcohol which served as a preservative was added to the residue and the extract used for spotting.

For quantitative analysis, both for free and protein-bound amino acids the styles were accurately weighed and the volume of extract was determined. Known micro-quantities of the extract were spotted with the aid of a micropipette.

Circular paper chromatography as adopted by Giri (1952) and also two dimensional ascending chromatography were adopted using Whatman No. 1 and 2 filter papers with 13 cm. diameter for circular and 20×20 cm. for two-dimensional.

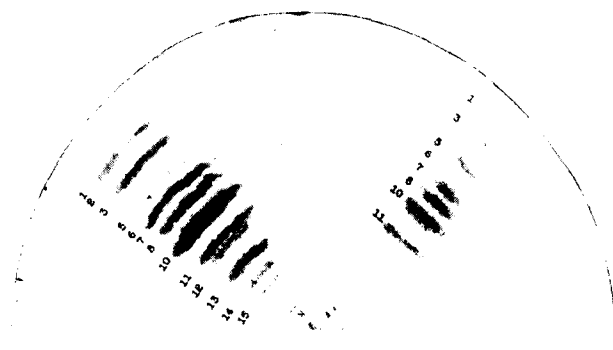
n-butanol-acetic acid-water mixture (4:1:1) and buffered phenol were used as solvents. 0.5% ninhydrin in 95% acetone was used as the colour developing reagent. The amino acids were identified by running a mixture of known and unknown samples (Giri and Rao, 1952) for circular chromatograms and from the positions of the amino acids in the standard and also from the R_f values of the individual amino acids previously calculated for two dimensional chromatograms. From these, overlapping amino acids in the circular paper were verified with the help of two dimensional paper chromatograms.

For quantitative determination, each band was cut out and eluted after colour development in a mixture of 75% alcohol and 0.1% copper sulphate solution (7.2 c.c. of alcohol and 0.8 c.c. of copper sulphate solution). The optical density of the resulting solution was read with the aid of a Lumetron Colorimeter with 550 μ filter. The quantity of the amino acids was calculated from the calibration curve drawn for each standard amino acid, and the quantity expressed in micrograms per gram of style material.

7L
Kg m2, N49 ZS N 58.10.2

Observations

Free amino acids:—There are eleven amino acids found in the free state in the style which appear in eight bands in the circular chromatogram. These are (1) leucines (2) valine (3) proline (4) tyrosine (5) alanine (6) threonine (7) glycine (8) serine (9) glutamic acid (10) aspartic acid and (11) asparagine. In the two dimensional chromatogram all these appear as distinct spots. Proline which is seen both in circular and two dimensional chromatograms disappears soon.



Text-Fig. 1. A. Chromatogram showing the free amino acids of the crystalline style of *Telescopium*. F. Free amino acids.

Protein-bound amino acids:—Fifteen amino acids are present in the hydrolysate of the style, and appear in twelve bands in the circular chromatogram, and all separately in the two dimensional chromatogram. Band 3 in circular represents only valine and band 14 represents only ornithine. The protein-bound amino acids include, in addition to those occurring as free amino acids, phenylalanine, arginine, histidine and ornithine which are not found as free amino acids.



B. Chromatogram showing the protein-bound amino acids. Pr. Protein-bound amino acids. K. Known amino acids.

Key to numbers in chromatograms.

1. Leucines 2. Phenylalanine 3. Valine 5. Tyrosine 6. Proline 7. Alanine 8. Glutamic acid and Threonine 10. Glycine. Serine and Aspartic acid 11. Asparagine 12. Arginine 13. Histidine 14. Lysine and Ornithine. 15. Cystine.

Discussion

The Amino Acid Composition of the Crystalline style of *Telescopium* differs from that of the other molluscs investigated so far.

With regard to the free amino acids, the crystalline style of *Telescopium* differs from that of *Sanguinolaria* in having aspartic acid, threonine, serine and asparagine, and in lacking cystine, arginine, histidine and phenylalanine. The free amino acids of the style of *Macra* have not been determined by Hashimoto (1955).

With regard to the Protein-bound amino acids, the style of *Telescopium* differs from that of *Sanguinolaria* in the absence of methionine, lysine, cystine and from that of *Macra* in the presence of leucine, valine, proline, and asparagine and in the absence of phenylalanine and cystine. It is interesting to note that the sulphur containing amino acid, methionine and cystine are present in both *Sanguinolaria* and *Macra* but are lacking in *Telescopium*.

A quantitative study of the amino-acid composition of the crystalline style in *Macra* and *Sanguinolaria* has not been made. In *Telescopium* the total amino acid content, inclusive of the free amino acids, is 0.84% of the wet weight of the style. Of this the protein bound amino acids constitute 0.8% and the free amino acids 0.04%. Among the free amino acids, glycine has the highest value, and leucines the lowest. Among the protein bound amino acids aspartic acid has the highest value, next comes threonine and then glutamic acid. Serine has the lowest value. The quantities of the free amino acids and protein bound amino acids are noted below in micrograms per gram (wet weight) of style material:—

Amino acids	Free	Protein-bound
Leucines	2.01	221.0
Phenylalanine	—	255.0
Valine	55.12	442.0
Tyrosine	63.00	34.0
Alanine	29.68	476.0
Threonine	66.80	1411.0
Glycine	74.20	85.0
Serine	10.60	578.0
Glutamic acid	26.50	1292.0
Aspartic acid	42.40	1564.0
Histidine	—	42.5
Arginine	—	731.0
Asparagine	21.20	765.0
Ornithine	—	195.5

Summary

The amino acid composition of the crystalline style of *Telescopium telescopium* (Linn.) has been studied and compared to that of *Sanguinolaria diphos* Gmelin. and *Mactra sulcataria* (Reeve).

The available data on the amino acid composition of the molluscan crystalline style show that this may be specific and not the same in all molluscs.

Acknowledgment

I have pleasure in expressing my grateful thanks to Prof. R. V. Seshaiya, Professor and Director, Marine Biological Station, Portonovo, for suggesting the problem and guidance.

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New species of the genus *Urocleidus* Mueller, 1934, from the gill filaments of some Indian Fishes

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(With 12 Text-figures).

(Communicated by Dr. B. S. Chauhan, F.Z.S.I.)

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Introduction

The genus *Urocleidus* was created by Mueller (1934), mainly for tetraonchids possessing (1) non-articulate bars, (2) non-articulate cirrus and accessory piece (at the base), and (3) dextral vagina. Muller (1937) created another genus *Haplocleidus*, which was similar to the genus *Urocleidus* in all respects, but differed only in having dorsal anchors conspicuously larger than the ventral anchors. Mizelle and Hughes (1938) discussed the validity of some North American Tetraonchinae genera and regarded the genus *Haplocleidus* as synonymous with *Urocleidus*. Sproston (1946) recognised the synonymy. Recently, however, Hargis (1952) has reinstated the genus *Haplocleidus* as a result of his study of some North American forms. He distinguished it from *Urocleidus* in (1) having dorsal anchors consistently larger than ventral anchors by an average of 0.03 to 0.04 mm., in length and, (2) having characteristic forked accessory piece. Jain (1958) as a result of study of some Indian species of *Urocleidus*, has again synonymised *Haplocleidus* with *Urocleidus*.

In an earlier communication Jain (1955) gave the earliest record of *Urocleidus* from India. Again he (1958) described 3 more new species of this genus from India and revised his form *Haplocleidus gomtius* (Jain, 1952) to *U. gomtius*. Thus, in all, there are 5 species of *Urocleidus* from India; two more are described in the present communication.

Urocleidus xenentodoni n.sp.

Host: *Xenentodon cancila* (Hamilton).

Location: Gill filaments.

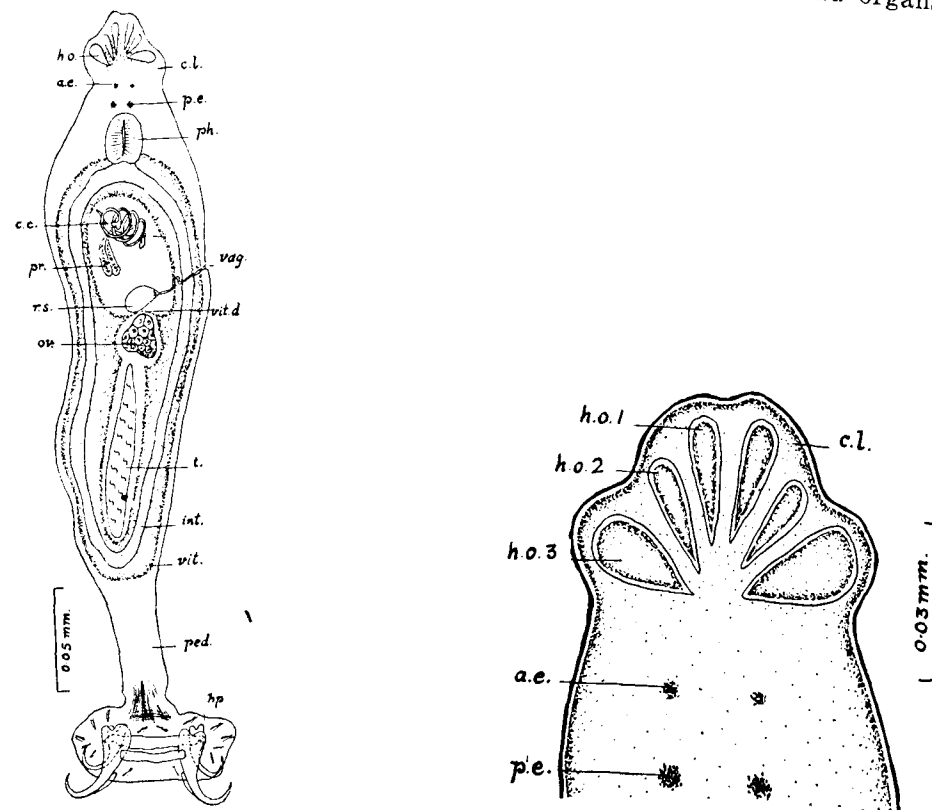
Locality: Lucknow, India.

Host specimens examined: 20.

Host specimens found infected: 6.

Number of trematodes examined: 8.

Description:—Elongated tetraonchids (Fig. 1), 0.35-0.56* long, 0.042-0.06 wide at cephalic lobes and 0.05-0.09 in maximum body width. Two pairs of cephalic lobes (Fig. 2) bearing three pairs of head organs.



Figs. 1 to 6. *Urocleidus xenentodoni* n.sp.

Fig. 1. Entire worm, dorsal view a.e.-anterior eye-spots, c.c.-copulatory complex, c.l.-cephalic lobe, h.o.-head organ, hp.-haptor, int.-intestine, ov.-ovary, p.e.-posterior eye-spots, ped.-peduncle, ph.-pharynx, pr.-prostate glands, r.s.-receptaculum seminis, t.-testis, vag.-vagina, vit.-vitellaria, vit.d.-vitelline duct.

Fig. 2. Anterior end of the worm, showing head organs, a.e.-anterior eye-spots, c.l.-cephalic lobe, h.o.1 to h.o.3-head organs, p.e.-posterior eye-spots.

* All measurements are in mm.

Each head organ, a conical body with rounded distal end and conical proximal extremity. Eye-spots, in two pairs, anterior and posterior, the latter with a larger number of melanistic granules. Pharynx, oval, 0.025×0.02 . Intestine, bifurcate, crura confluent posteriorly.

Haptor (Fig. 3), somewhat rectangular, 0.08-0.15 long, 0.04-0.065 wide. Peduncle, long and slender. Armature of the haptor (Fig. 4) consists of 2 pairs of anchors, a dorsal and a ventral bar and 7 pairs

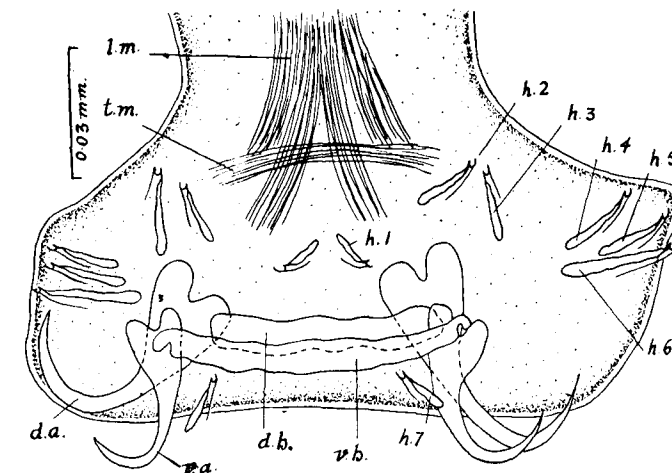


Fig. 3. Haptor, ventral view. d.a.-dorsal anchor d.b.-dorsal bar, h.1 to h.7-hooks, l.m.-longitudinal muscle fibres, t.m.-transverse muscle fibres, v.a.-ventral anchor, v.b.-ventral bar.

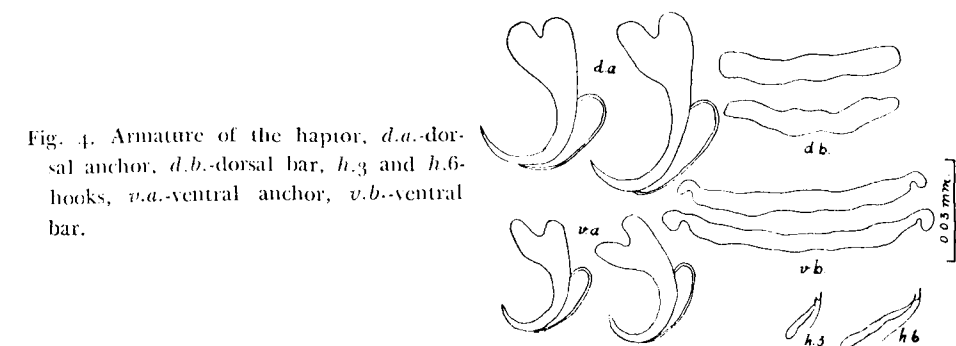


Fig. 4. Armature of the haptor, d.a.-dorsal anchor, d.b.-dorsal bar, h.3 and h.6-hooks, v.a.-ventral anchor, v.b.-ventral bar.

of hooks. Dorsal anchor with short blunt superficial and similar deep root; single wing, arising from the middle of the shaft, not reaching upto the points. Length of dorsal anchor 0.045-0.047; width of base 0.02-0.022. Dorsal bar, straight, transverse shaft, 0.053-0.055 long. Ventral anchors similar in shape to dorsal anchors but smaller, each 0.034-0.038. long. Ventral bar, straight transverse shaft with knobbed extremities, 0.075-0.083 long. Hooks sickle-shaped, each consisting of

elongated base, shaft, sickle-shaped portion and appposable piece. The dimensions are as follows:—I pair, 0.012-0.013; II pair, 0.015-0.017; III pair, 0.018-0.021; IV pair, 0.021-0.022; V pair, 0.018-0.021; VI pair, 0.027-0.03; VII pair, 0.014-0.015.

Testis (Fig. 1), elongated, median, intercaecal, 0.076-0.084 long, 0.01-0.015 wide. Copulatory complex (Fig. 5) consists of spirally coiled cirrus and small leaf-like accessory piece. The spiral has 3 loops, maximum diameter 0.023; base of the cirrus swollen. Accessory piece, attached to cirrus, 0.014-0.015 long. A pair of prostate glands (Fig. 5) open at base of cirrus, one has coarsely granular and other hyaline fluid. Vesicula seminalis not clear. Ovary, pre-testicular, trilobed, 0.02-0.023 $\times$ 0.018-0.024. Vagina (Fig. 6), dextral, chitinised, consisting of long

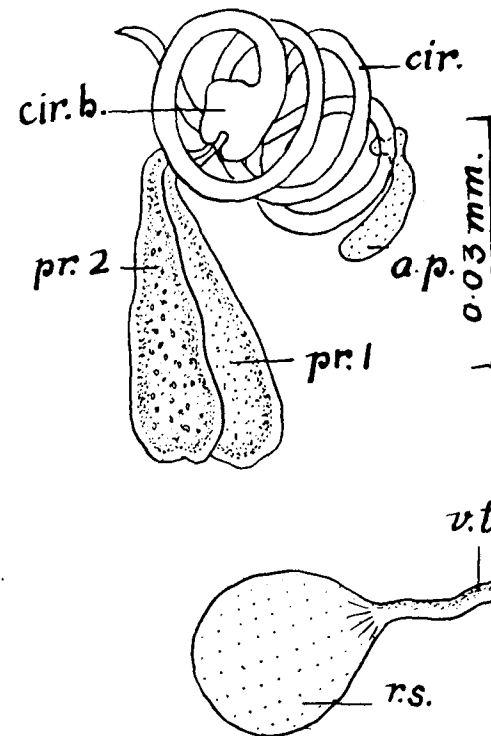


Fig. 5. Copulatory complex. a.p.-accessory piece, cir.-cirrus, cir.b.-base of cirrus, pr.-1 and pr.-2. prostate glands.

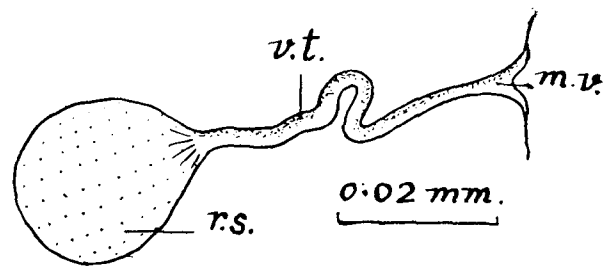


Fig. 6. Vagina. m.v.-mouth of vagina, r.s.-receptaculum seminis, v.t.-vaginal tube, vaginal tube and pear-shaped receptaculum seminis. Vitellaria densely spread from pharynx to caecal union; vitelline ducts join near receptaculum seminis. No egg was observed in the specimens studied.

Discussion:—The present form shows closest affinities with *U. fundulus* Mizelle, 1940 and *U. seculus* Mizelle and Arcadi, 1945, but can be clearly distinguished from both in several important characteristics. The looped nature of the cirrus, characteristic shape of the accessory

piece and ventral bar, are characters which clearly separate the present form from these species. The new form is named *U. xenentodoni*, after the host.

Urocleidus rhyncobdelli n.sp.

Host: *Rhyncobdella aculeata* (Bloch).

Location: Gill filaments.

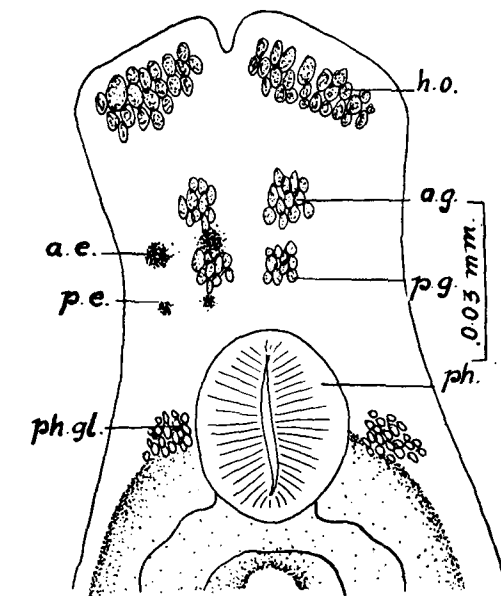
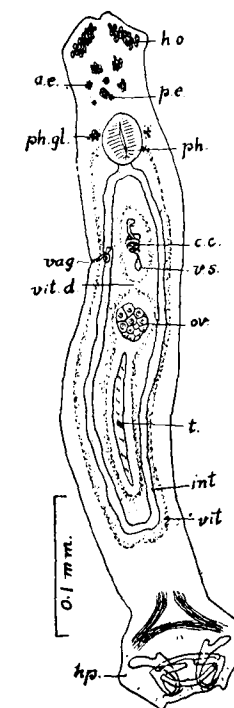
Locality: Lucknow, India.

Host specimens examined: 1.

Host specimen found infected: 1.

Number of trematodes examined: 4.

Description:—Elongated tetraonchids (Fig. 7), 0.44-0.53 long, 0.065 wide at cephalic lobes and 0.082 in maximum body width. Cephalic lobes poorly defined. Head organs (Fig. 8) disorganised, scattered on



Figs. 7 to 12. *Urocleidus rhyncobdelli* n.sp.

Fig. 7. Entire worm, ventral view. a.e.-anterior eye-spots, c.c.-copulatory complex, h.o.-head organs, hp.-haptor, int.-intestine, ov.-ovary, p.e.-posterior eye-spots, ph.-pharynx, ph.gl.-pharyngeal glands, t.-testis, vag.-vagina, vit.-vitellaria, vit.d.-vitelline duct, v.s.-vesicula seminalis.

Fig. 8. Anterior end of the worm, showing head organs. a.e.-anterior eye-spots, a.g.-anterior group of glands, h.o.-head organs, p.e.-posterior eye-spots, p.g.-posterior group of glands, ph.-pharynx, ph.gl.-pharyngeal glands.

either side of cephalic lobes. Eye-spots, two pairs, anterior and posterior, latter with larger number of melanistic granules. Characteristic glands, in two pairs, situated near the eye-spots. Function of these glands cannot be assigned with certainty, but probably, like the melanistic granules, they are light sensitive. Pharynx, oval, 0.029×0.035 . Pharyngeal glands, situated on both sides of pharynx, consist of small rounded bodies. Intestine, bifurcate, crura confluent posteriorly.

Haptor (Fig. 9), hexagonal, 0.06-0.075 wide, 0.1-0.112 long. Peduncle, short, stout. Armature of haptor (Fig. 10), consisting of 2 pairs of anchors, two bars and 7 pairs of hooks. The two pairs of anchors are greatly dissimilar in shape. Dorsal anchor consisting of stout base, shaft and hollow recurved point. Base of anchor bifurcate; has an expanded superficial and short blunt deep root. A wing provided on each anchor, starting from shaft reaches upto the point. Length of dorsal anchor 0.042-0.045, width of base at origin of roots, 0.01 and width at roots 0.026-0.027. Dorsal bar, straight transverse shaft,

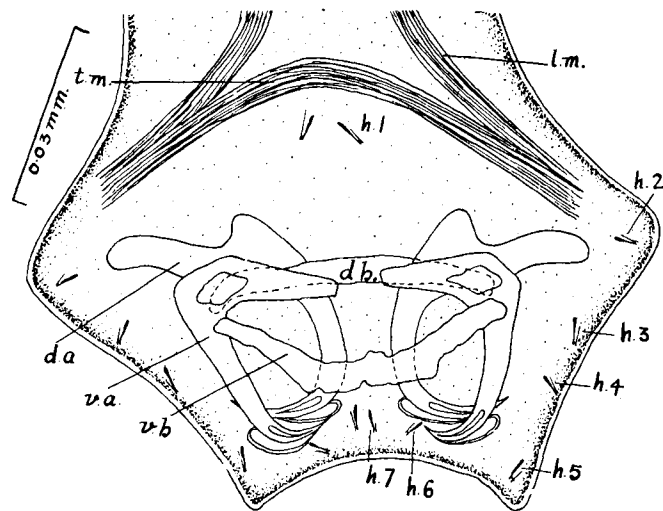


Fig. 9. Haptor. *da*-dorsal anchor, *db*-dorsal bar, *h.1* to *h.7*-hooks, *lm*-longitudinal muscles, *tm*-transverse muscles, *va*-ventral anchor, *vb*-ventral bar.

extremities slightly drooping downwards, 0.052-0.055 long. Ventral anchor, peculiar C-shaped, consisting of base, shaft, and hollow recurved point. Each anchor provided with one wing, reaching upto the point; base of anchor peculiarly shaped, long superficial root but no deep root. Each ventral anchor 0.03-0.033 long, 0.01 wide at base. Ventral bar, bow-shaped, irregular margins, 0.049-0.052 long. All 7 pairs of hooks similar in shape and size, 1 to 5 are marginal ventrally, 6 and 7 are

medial dorsally. Each hook sickle-shaped, consisting of base, shaft, sickle-shaped portion and appposable piece; 0.004-0.006 long.

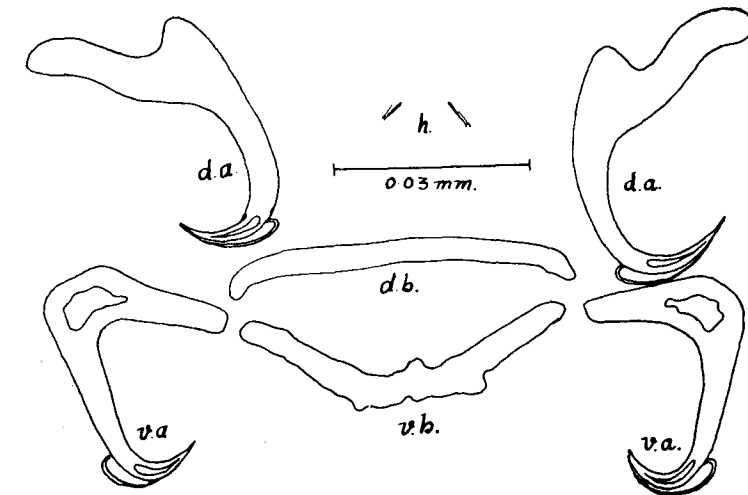


Fig. 10. Armature of the haptor. *da*-dorsal anchor, *db*-dorsal bar, *h*-hook, *va*-ventral anchor, *vb*-ventral bar.

Testis (Fig. 7), median, slender, intercaecal, 0.096-0.12 long. Vesicula seminalis (Fig. 11), chitinised, pear-shaped, located at base of cirrus. Copulatory complex (Fig. 11), consisting of coiled cirrus and elongated accessory piece, both articulated distally. Cirrus with 4-coiled loop; accessory piece, bearing 3 teeth distally, maximum diameter 0.023. Accessory piece, bearing 3 teeth distally, each 0.007-0.008 long. Ovary, rounded, 0.02-0.026 in diameter. Vagina (Fig. 12, extral, tubular, chitinised; mouth of vagina funnel-shaped

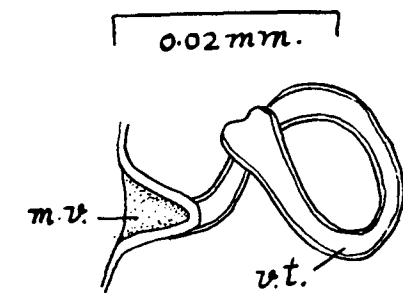
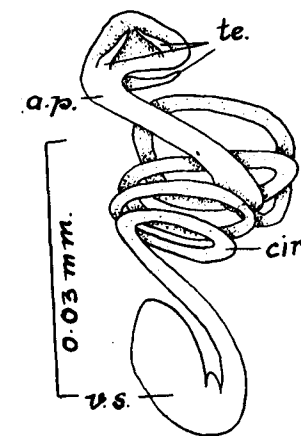


Fig. 11. Copulatory complex, *a.p.*-accessory piece, *cir*-cirrus, *te*-teeth, *v.s.*-vesicula seminalis.

Fig. 12. Vagina. *m.v.*-mouth of vagina, *v.t.*-vaginal tube.

and vaginal tube thick-walled. Receptaculum seminis and egg not observed in any specimen studied. Vitellaria spread from pharynx to caecal union; vitelline ducts join just anterior to ovary.

Discussion

The present form shows closest affinities with *U. adspectus* Mueller, 1934 and *U. xenentodoni*, but can be clearly distinguished in important characters. It stands apart from both these species in (1) shape of the dorsal and ventral anchor bases, (2) shape of ventral bar, and (3) shape of the accessory piece. The new species is named *U. rhyncobdelli*, after the host.

Musculature of haptor:—One interesting point about the two new species described above is that both show quite clearly some muscles of the haptor. The muscles of haptor of *U. xenentodoni* (Fig. 3) consist of two pairs of longitudinal and a single band of transverse fibres, whereas *U. rhyncobdelli* (Fig. 9) has a long recurved transverse and a pair of longitudinal muscle bands.

Trematodes recovered by refrigeration technique of Mizelle (1936, '38), were left in a mixture of glycerine and clear water for about 20 minutes. These were, then, examined individually on slides covered with coverglass. This technique proved very useful for the study of musculature of haptor. Probably these muscles accord the movements of haptor armature for attaching the trematode to the tissues of the gill filaments, while the parasite feeds by the mouth. In a separate communication the method of feeding and locomotion of these trematodes are being discussed.

Key for the identification of the Indian species of the genus *Urocleidus* Mueller, 1934 :—

- | | | | |
|--|-----|---|-----------------------------------|
| 1. A pair of supporting bars present in haptor | ... | 2 | |
| Supporting bars absent | | 5 | |
| 2. Cirrus thrown into loops | | | |
| Cirrus not thrown into loops | ... | 3 | |
| | | 4 | |
| 3. Cirrus consists of 16-19 loops, accessory piece flower-like | | | <i>U. polyspiralis</i> Jain, 1958 |
| Cirrus consists of 2 loops, accessory piece consisting of two claw-like bodies | | | <i>U. vachuis</i> Jain, 1958 |

- | | |
|--|---|
| 4. Dorsal and ventral anchors nearly equal in size, accessory piece prong-like | <i>U. notopteri</i> Jain, 1955 |
| Dorsal anchors nearly 3 times the ventral anchors, accessory piece not prong-like | <i>U. gomtius</i> (Jain, '52) Jain, 1958. |
| 5. Cirrus thrown into loops | ... 6 |
| Cirrus not thrown into loops | <i>U. recurvatus</i> Jain 1958 |
| 6. Dorsal and ventral anchors nearly identical in shape, accessory piece without teeth | <i>U. xenentodoni</i> n. sp. |
| Dorsal and ventral anchors dissimilar in shape, accessory piece bears teeth | <i>U. rhyncobdelli</i> n. sp. |

Summary

Two new species of the genus *Urocleidus* Mueller, 1934, namely *U. xenentodoni* and *U. rhyncobdelli*, recovered from *Xenentodon cancella* (Hamilton) and *Rhyncobdella aculeata* (Bloch), respectively, have been described from India. The trematodes were recovered from the gill

filaments. The new forms come nearer to North American forms, than most Indian species of this genus, in the absence of supporting bars. The copulatory complex of each species is characteristic and distinguishes them from other species. The synonymy of the genus *Haplocleidus* with *Urocleidus* is supported. A note on the muscles of the haptor and a key for the identification of Indian species is appended.

Acknowledgements

The present work was carried out in the Department of Zoology, Lucknow University. The author is grateful to Professor M. B. Lal for constant encouragement and valuable criticism in the course of the work. Acknowledgments are also due to the Government of India for providing a research training scholarship to carry out the present work, which is part of my approved Ph. D. thesis.

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Animal Remains of 12th Century A.D. from Sarnath in Uttar Pradesh, India

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With 1 Text-figure and 2 Plates.

(Communicated by Dr. M. L. Roonwal, F.Z.S.I.)

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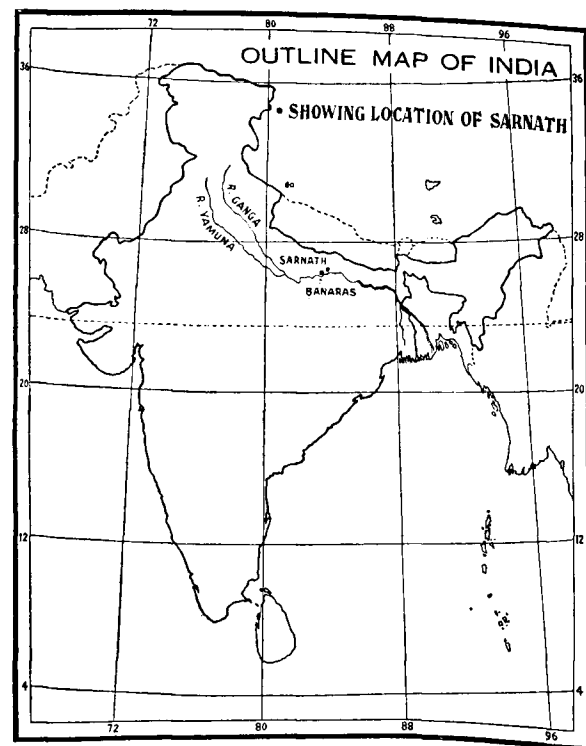
Introduction

This paper deals with the collection of the animal remains from Sarnath (near Varanasi, Uttar Pradesh, India) made by the Archaeological Department of the Government of India during the field season of 1943. The skeletal remains were found while excavating a drain from Monastery No. IV, at Sarnath (about 5 miles from Varanasi) in Banaras the courtyard between first and the second gateways of the temple built by Kumardevi in the 12th Century A.D. The excavation of this site was previously carried out by the late Shri D. R. Sahani and Sir John Marshall in 1906-07, and also in the year 1921.

These animal remains are mostly fragmentary and fragile. The organic material of the bones has disappeared to a great extent and they are impregnated with inorganic material. Even the long bones, such as the humerus, radius, femur, tibia and cannon bones, are either broken or fragmentary. Most of the bones consist of fragments only and hence are unsuitable for measurements, etc.

The animal remains from Sarnath resemble in general in their species those of Harappa described by Prashad (1936) as well as with the

1946 Harappa collection of animal remains recently worked by Nath (unpublished report), and also with those of Mohenjodaro (Sewell & Guha, 1931), Hastinapura (Nath, 1955 and Maski (Nath, 1957). The single find of the charred remains of the hare, *Lepus ruficaudatus* Geoffroy from Sarnath is however, noteworthy, as there is no record of any remains of this animal from Harappa, Mohenjodaro and Hastinapur so far.



As in the case of Anan (Duerst, 1908), Mohenjodaro, Harappa, Hastinapura and Maski, there is a large number of bones which belong to young animals, indicating thereby that the people practised a full-fledged domestication of these animals.

Only 12 species are represented in the Sarnath collection. As compared with Harappa and Mohenjodaro, this number is very small which is evidently due to limited excavation. In this report each individual fragmentary bone, is represented by the registered number as entered in the Excavation Register of the Archaeological Survey of India, along with particulars of the "find spot", i.e., the actual location of the bone in the trench of the Monastery No. IV area, indicated at particular depth from the surface level.

Systematic Account

(a) INVERTEBRATA

Phylum Mollusca

CLASS (GASTROPODA)

FAMILY CYPRAEIDAE

1. *Monetaria monata* (Linn.) (Pl. VI, Fig. 1)

(The Money Cowry)

No. 215; 32 N. 54 W; 7 ft. Three shells of cowries.

These three specimens of cowries correspond in structure and configuration to the Money Cowry, *Monetaria monata*, present in the collections of Zoological Survey of India. This cowry replaced the old barter system and is also used as an ornament. Maximum length 16 mm.; maximum breadth 12 mm.

2. *Cypraea ? pallida* Gray (Pl. VI, Fig. 2)

(The Cowry)

No. 215; 32 N. 54 W; depth 7 ft. One shell of cowry.

This single shell is slightly damaged at the posterior end and resembles to a large extent *pallida* Gray. Maximum length 21 mm.; maximum breadth 14 mm.

CLASS (PELECYPODA)

Order Eulamellibranchia

FAMILY UNIONIDAE

3. *Parreysia* sp. (Pl. VI, Figs. 3 & 4)

(The Freshwater Mussel)

No. 215; 32 N. 54 W; depth 7 ft. Fragment of a valve.

This single fragment is very eroded, broken and worn out and is, therefore, difficult to place specifically. These freshwater mussels have a wide range of distribution in northern India. Its photograph, along with that of one from Harappa (3689, Mound AB; Extensions of Pits I & II; Square P 24/23; depth 8' 8") in the collection of the Department, is reproduced in Pl. VI, Figs. 3 and 4 respectively for comparison.

The maximum breadth of the fragment of a valve from Sarnath is 18 mm., whereas the maximum breadth of the intact and complete specimen of a valve from Harappa is 30 mm.

(b) VETEBRATA
CLASS REPTILIA
Order Chelonia
FAMILY TRIONYCHIDAE

4. *Lissemys punctata* (Bonnaterre), forma *typica* (Pl. VI, Fig. 5)
(The Common Soft-shelled Box Turtle)

No. 11/1943. One fragment of epiplastron.

This single fragment is undoubtedly of a medium-sized individual of *L. punctata* forma *typica*. It resembles in pattern and vermiculations those of Mohenjodaro (Sewell & Guha, 1931, p. 663), Harappa (Prashad, 1936, p. 14) and Hastinapura (Nath, 1955, p. 108). Its photograph, along with that of one from Harappa (5556, Mound F; Great Granary area; square K 9/5; depth 12 ft. 6 inches) in the collection of the Department, is reproduced in Pl. VI, Figs. 5 and 6 respectively for comparison.

In size the maximum length of the fragment of epiplastron from Sarnath is 49 mm. whereas the maximum length of an intact specimen of epiplastron from Harappa is 69 mm.

5. *Chitra idica* (Gray) (Pl. VI, Fig. 7)
(The Soft-shelled River Turtle)

Area of Antiquity No. 49. One fragment of hypoplastron.

This single fragmentary piece resembles in pattern and vermiculations those of Harappa (Prashad, 1936, p. 14), Mohenjodaro (Sewell & Guha, 1931, p. 663) and Hastinapura (Nath, 1955, p. 108). Length 30 mm.; width 26 mm.

6. *Batagur baska* (Gray) (Pl. VI, Figs. 8 & 9)
(The Batagur)

Area of Antiquity No. 49. Fragment of plastron.

No. 110, depth 3 ft., 10 inches. Fragment of the carapace.

These fragments correspond to those of Mohenjodaro (Sewell & Guha, 1931, p. 664) and Harappa (Nath, unpublished report) as well as to the recent specimens in the Zoological Survey of India. The dorsal and ventral views of a plastron excavated at Sarnath are figured in Pl. VI, Figs. 8 and 9 respectively. Size of plastron: length 89 mm.; breadth 75 mm.

CLASS MAMMALIA
Order Artiodactyla
FAMILY BOVIDAE

7. *Bos indicus* Linn. (Pl. VI, Figs. 10 & 11)

(The Zebu or Domestic Humped Cattle of India)

- No. 104; 51 W, 7½N; depth 6 ft. & 4½ inches. Fragment of an astragalus.
No. 60/28; 7W, 149N; depth 3 ft., 6 inches. Fragment of the shaft of femur.
No. 118/28; 7W, 149N; depth 3 ft. 6 inches. Three fragments of left tibia; 2nd upper molar; 2nd upper premolar.
No. 81/28. Fragment of the shaft of radius.
No. 181/28; 10N, 20W; depth 6 ft., 4 inches. Distal fragment of the shaft of femur; fragment of the shaft of metatarsus; distal fragment of the shaft of right radius.
No. 107/28. Proximal fragment of tibia.
No. 191/28. Head of right humerus.
No. 151/28. Fragment of the proximal extremity of radius; distal extremity of left humerus; fragment of the proximal shaft of right metatarsal; distal extremity of the left humerus.
No. 214/28. Fragment of the shaft of humerus.
No. 134/28. Nine fragments of distal ends of femur; fragment of right femur.
No. 8; 46 × 10 × 3; depth?. Fragment of a molar tooth; left lower 2nd molar.
No. 105; 64W. 50N; depth 6 ft. 3 inches. Fragment of the shaft of a tibia.
No. 107. Proximal fragment of right metatarsal. Fragment of right tibia; eleven fragments of the shaft of metatarsal of young ones.
No. 451. Twelve fragments of femur of young ones.
No. 116; 32N. 54W; depth 7 ft. Left astragalus of a young one.
No. 103; 46W. 14N; depth 5 ft. to 5 ft. 6 inches. Nine fragments of the shaft of a humerus.
No. 80. Fragment of the shaft of radius.
No. 300. Four fragments of the shaft of metatarsal.
No. 110. Proximal fragment of femur; fragment of the medial condyle of femur.
No. 13/1943. Distal portion of left humerus.
No. 31/2328; 119 × 30; depth (?). Incomplete shaft of metatarsus; fragment of the shaft of 3rd and 4th metatarsals.

The remains of the Humped Cattle listed above, including the long bones, are very fragmentary; they mostly belong to young individuals and are of no use for exact measurements.

The limb bones too are fragmentary. The photographs of some of the better preserved specimens, such as those of the astragalus and the distal fragment of humerus, are reproduced in Pl. VI, Figs. 10 and 11 respectively. Maximum length of astragalus 62 mm.; maximum breadth of distal fragment of humerus 65 mm.

The remains of the Humped Cattle from Sarnath, which have been carefully examined, closely resemble the smaller, humped, short-horned variety found from Mohenjodaro (Sewell & Guha, 1931, p. 654), Harappa (Prashad, 1936, p. 37) and Hastinapura (Nath, 1955, pp. 110-114). From the close structural resemblance between the skeletal remains excavated at Sarnath and those of the modern domestic Humped Cattle of India in the collection of the Department, it is clear that the Sarnath remains are of the same species as those of the domesticated cattle now met with in India.

8. *Bos (Bubalus) bubalis* Linn. (Pl. VI, Figs. 12 & 14)
(The Indian Domestic Buffalo)

No. 719/28. Left scapula with a part of blade.

No. 166/28. Fragment of the shaft of left radius without distal extremity.

No. 243/28. Ten proximal fragments of a left femur.

No. 89/28. Fragment of the shaft of radius.

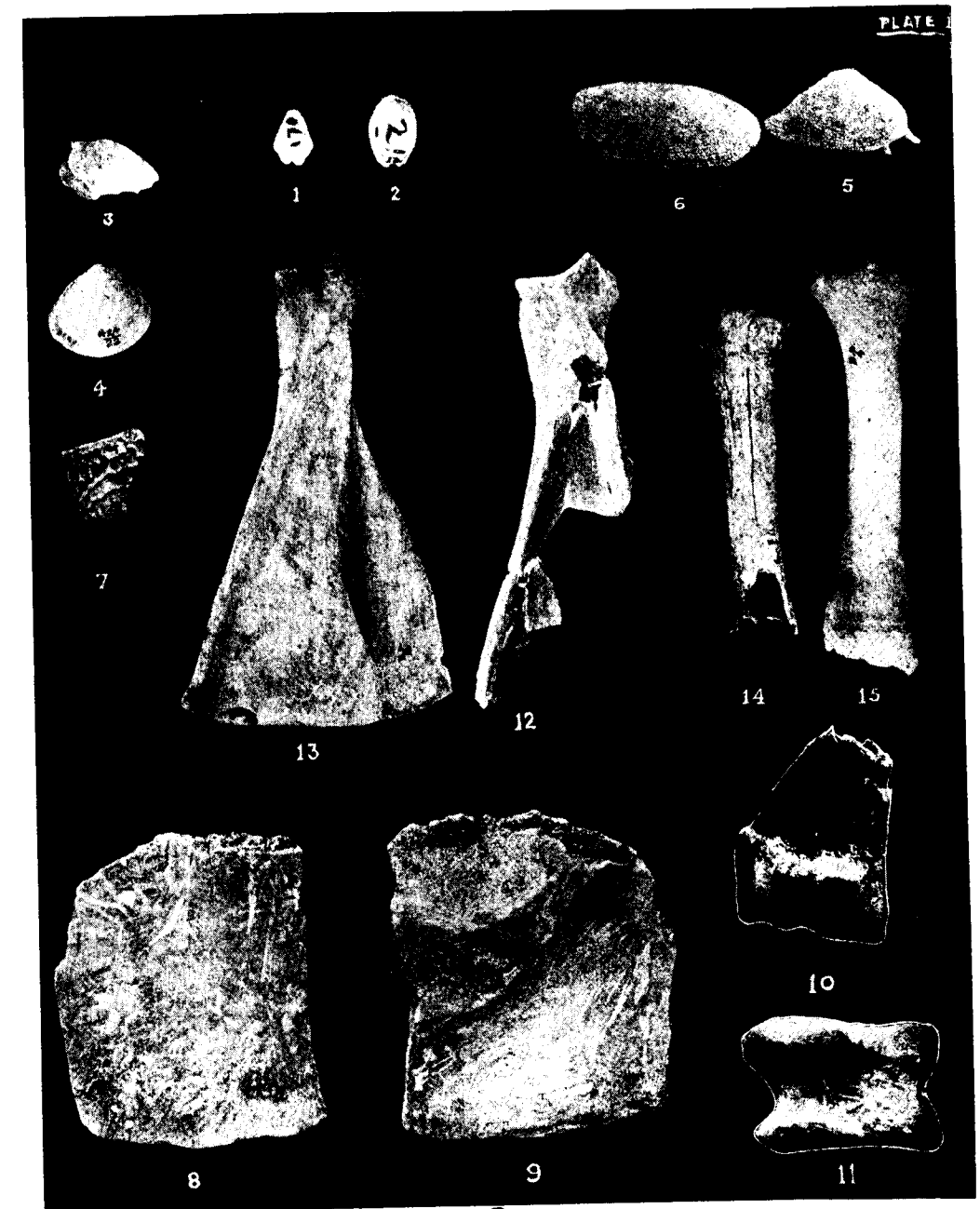
None of these bones is complete and no measurements can, therefore, be taken for comparison with those of other forms. However, the photographs of the better preserved fragments of bones, such as those of the scapula and radius along with those of the modern specimens, are reproduced in Pl. VI, Figs. 12, 13, 14 and 15 for comparison. The maximum length of the fragment of scapula from Sarnath along the glenoid border is 326 mm. and its maximum width at the proximal end 81 mm., while the maximum length of an intact and complete modern specimen of a scapula in the Department is 348 mm. and its maximum width at the proximal end 77 mm. The length of the proximal shaft of a fragmentary radius (Pl. VI, Fig. 14), is 261 mm., while the total length of a radius of a modern specimen (Pl. VI, Fig. 15) is 295 mm.

The find of a limited number of fragments of bones of *Bos (Bubalus) bubalis* indicates that the inhabitants probably did not maintain large herds of the Indian buffalo as compared with *Bos indicus*.

These remains of the buffaloes show very close structural resemblance with those of the modern domestic buffalo in India. They are

Bhola Nath :

PLATE VI



also similar to those of Mohenjodaro (Sewell & Guha, 1931, p. 654), Harappa (Prashad, 1936, pp. 32-37) and Hastinapura (Nath, 1955, p. 115).

9. *Ovis vignei* Blyth, race *domesticus* (Pl. VII, Figs. 1-4)
(The Domestic Sheep)

- No. 11/128; 7W. 149N; depth 3 ft. 6 inches. Fragment of the 2nd phalanx.
No. 216/28. A fragment of the lower jaw with 1st, 2nd and 3rd molar teeth.
No. 141/15. Shaft of right femur without proximal & distal ends.
No. 211. Fragment of the shaft of metatarsal; distal fragment of left humerus; several fragments of the shaft of humerus.
No. 12/1943; 41 ft. away from eastern wall of Monastery III; depth 3 ft. 2 inches. Distal extremity of left humerus.

The teeth of the lower jaw available do not show any special peculiarities and generally resemble those of the recent domestic sheep. The photograph of the fragment of the lower jaw is reproduced in Pl. VII, Fig. 1; its maximum length is 62 mm., while the length of the tooth-row of the same is 44 mm.

The limb bones too are very fragmentary. The photographs of some of the better preserved specimens are reproduced in Pl. II, Figs. 17, 18 and 19, along with that of a modern specimen. The maximum breadth of a distal fragment of humerus from Sarnath, (Pl. II, Fig. 2) is 26 mm. The maximum length of a shaft of right femur without proximal and distal extremities shown in Pl. VII, Fig. 3, from Sarnath is 133 mm., while the length of the shaft of a femur in a modern specimen of sheep in the Department (Pl. VII, Fig. 4) is 128 mm., and its total length 161 mm.

Fragments of bones from Sarnath closely resemble those of the remains of sheep from Harappa (Prashad, 1936, pp. 49-50 and Hastinapura (Nath, 1955, p. 116). They are also closely akin to modern domesticated race of sheep.

10. *Capra hircus aegagrus* Erxleben (Pl. VII, Figs. 5-7)
(The Domestic Goat)

- No. 66; 138N. 51W; depth 4 ft. and 6 inches. Fragment of an astragalus.
No. 246/28. An incomplete right ramus of the mandible without body (*corpus mandibulae*), coronoid process and condyle.
No. 11/1943; 41 ft. away from Eastern wall of Monastery IV; depth 3 ft. 2 in. Proximal fragment of femur with head and trochanteric fossae, distal epiphysis of metacarpal of an young one.

These remains are fragmentary. The teeth of the lower jaw available resemble closely those of the modern domesticated goats. They also resemble those of the remains of the goats from Harappa (Prashad, 1936, pp. 47-48). The photograph of the fragment of the lower jaw is reproduced in Pl. VII, Fig. 5; its maximum length is 110 mm., while the length of its tooth-row is 64 mm.

None of the limb bones available is complete and no measurements can, therefore, be taken for comparison with those of other forms. The photographs of the better preserved fragments of a femur and a distal metacarpal fragment of the femur measure 29 mm. in maximum length, while the distal metacarpal epiphysis measures 20 mm. in its maximum breadth.

Fragments of bones from Sarnath closely resemble those of the remains from Harappa (Prashad, 1936, pp. 47-48) and Hastinapura (Nath, 1955, p. 117). They also resemble closely the modern Indian domesticated race of goat.

Order Proboscidea
FAMILY ELEPHANTIDAE

11. *Elephas maximus* Linu (Pl. VII Fig 8)
(The Indian Elephant)

Sarnath No. 133. One 2nd left upper molar tooth.

The only remains available of the Indian Elephant, *Elephas maximus*, from Sarnath is a single left upper 2nd molar tooth. In structure and pattern it resembles that of a specimen of the modern elephant in the collections of the Zoological Survey of India. Its crown is slightly worn out. Maximum length of tooth 159 mm.; maximum height 125 mm. The remains of the Indian elephant were also recorded from Mohenjodaro (Sewell & Guha, 1931, p. 653), while Nath has recorded its remains recently from Hastinapura (Nath, 1955, p. 109) and Harappa (unpublished report).

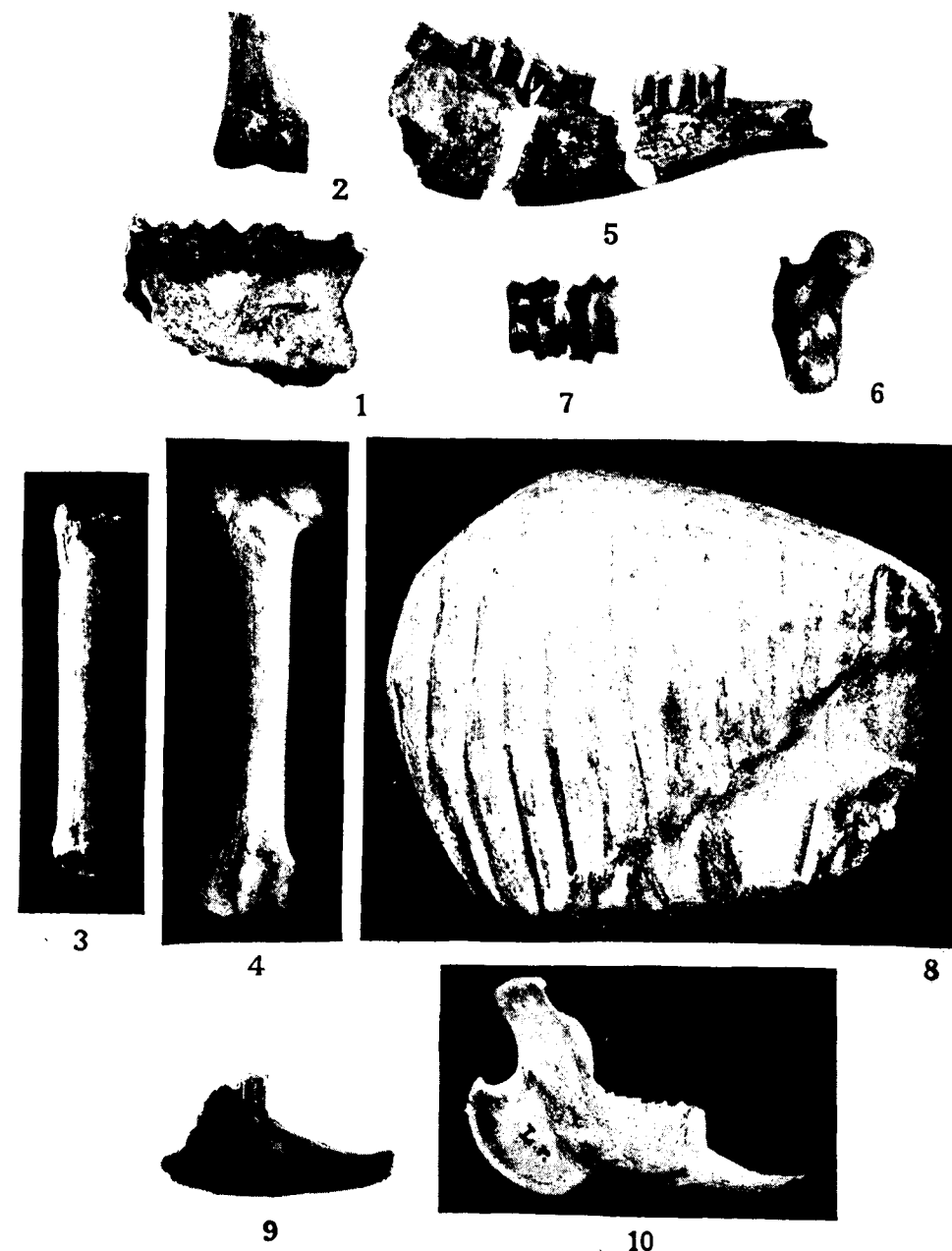
Order Lagomorpha
SUBORDER DUPLICIDENTATA
FAMILY LEPORIDAE

12. *Lepus ruficaudatus* Geoffroy (Pl. VII, Fig. 9)
The Common Indian Hare

No. 118/28; depth (?). Fragment of the right horizontal ramus of mandible with 1st molar tooth and without body (*corpus mandibulae*), condyle and coronoid process (charred).

Bhola Nath :

PLATE VII



This partly charred specimen resembles very closely, both in structure and configuration, that of a subadult specimen of *Lepus ruficaudatus* present in the collection of the Department. Its photograph is reproduced, along with that of a subadult modern specimen, in Pl.VII, Figs. 9 and 10. The maximum length of this fragmentary piece from Sarnath is 43 mm., while the total length of the right ramus of mandible of a modern specimen of hare in the Department (Pl.VII, Fig. 10) is 55 mm.

The find of a fragment of a bone of *Lepus ruficaudatus* from Sarnath is noteworthy. There is no record of the remains of this animal from Harappa and Mohenjodaro so far.

Summary

This paper deals with a collection of animal remains, obtained while digging a drain from Monastery No. 4, at Sarnath (near Varanasi, Uttar Pradesh, India) during the field season of 1943. The date assigned to this collection of animal remains from the above-mentioned spot is the 12th century A.D. The number of species of animals represented in this collection is 12, as follows.—*Monataria monata* (Linn.); *Cypraea? pallida* Gray, *Parreyssia* sp., *Lissemys punctata* (Bounaterre) forma *typica*; *Chitra indica* (Gray); *Batagur baska* (Gray); *Bos indicus* Linn.; *Bos (Bubalus) bubalis* Linn.; *Ovis vignei*, race *domesticus*; *Capra hircus aegagrus* Erxleben; *Elephas maximus* Linn.; *Lepus ruficaudatus* Geoffroy.

Acknowledgement

I wish to express my thanks to Dr. M. L. Roonwal, Director, Zoological Survey of India for kindly going through the paper and suggesting improvements.

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Explanation of Plate VI

The number mentioned after the scientific name represents the Registered No. of the bone in the Excavation Register of the Dept. of Archaeology of the Government of India. The other particulars, *i.e.*, "32N. 54W, depth 7 ft." denote the "find spot", *i.e.*, the actual location of the find in the trench of Monastery No. 4 area, found at the depth of 7 ft. from surface level.

Fig. 1. *Montaria monata* (Linn.). No. 215; 32N. 54W; depth 7 ft. (below surface level). One shell of a cowry. Excavated at Sarnath.

Fig. 2. *Cypraea pallida* Gray. No. 215; 32N. 54W; depth 7 ft. below surface level. One shell of a cowry. Excavated at Sarnath.

Fig. 3. *Parreyssia* sp. No. 215; 32N. 54W; depth 7 ft. below surface level. Fragment of a valve. Excavated at Sarnath.

Fig. 4. *Parreyssia flavideus* (Benson) var. *trigona* Benson Right valve from Harappa; No. 3689.

Fig. 5. *Lissemys punctata* (Bonnaterre) forma *typica*. Fragment of a epiplastron. No. 11/1943. Excavated at Sarnath.

Fig. 6. *Lissemys punctata* (Bonnaterre) forma *typica*. Left complete and intact epiplastron from Harappa; No. 5556.

Fig. 7. *Chitra indica* (Gray). Fragment of hypoplastron. Area of Antiquity No. 49. Excavated at Sarnath.

Figs. 8, 9. Dorsal and ventral views of the fragment of a plastron of *Batagur baska* (Gray). Area of Antiquity No. 49. Excavated at Sarnath.

Bos indicus Linn.

Fig. 10. Fragment of the left distal humerus. No. 13/1943. Excavated at Sarnath.

Fig. 11. Left astragalus of a young one. No. 116; 32N. 54W; depth 7 ft. Excavated at Sarnath.

Fig. 12. Fragment of the left scapula. No. 719/28. Excavated at Sarnath.

Fig. 13. Left scapula of a modern specimen in the Deptt. of Anthropology.

Fig. 14. Proximal fragment of the left radius. No. 166/28. Excavated at Sarnath.

Fig. 15. Left radius of a modern specimen in the Dept. of Anthropology.

Explanation of Plate VII

The number mentioned after the scientific name represents the Registered No. of the bone in the Excavation Register of the Dept. of Archaeology of the Government of India. The other particulars, *i.e.*, "32N. 54W; depth 7 ft." denote the "find spot", *i.e.*, the actual location of the find in the trench of the Monastery No. 4 area, obtained at the depth of 7 ft. from the surface level.

Ovis vignei Blyth

Fig. 1. Fragment of lower jaw. No. 216/28. Excavated at Sarnath.

Fig. 2. Distal fragment of the left humerus. No. 211. Excavated at Sarnath.

Fig. 3. Shaft of the right femur without proximal and distal extremities. No. 141/15. Excavated at Sarnath.

Fig. 4. Left femur of a modern specimen of domestic sheep in the Dept. of Anthropology.

Capra hircus aegagrus Erxleben

Fig. 5. An incomplete ramus of mandible. No. 246/28. Excavated at Sarnath.

Fig. 6. Proximal fragment of femur with head and trochanteric fossa. No. 11/1943; 41 ft. away from the Eastern wall of Monastery No. 4; depth 3 ft. 2 inches. Excavated at Sarnath.

Fig. 7. Distal epiphysis of a metacarpal of a young one from the same size as in Fig. 6.

Elephas maximus Linn.

Fig. 8. One 2nd left upper molar tooth. Sarnath No. 250. Excavated at Sarnath.

Lepus ruficaudatus Geoffroy

Fig. 9. Fragment of the right horizontal ramus of the mandible. No. 118/28. Excavated at Sarnath.

Fig. 10. Right ramus of the mandible of a subadult modern specimen in the Deptt. of Anthropology.

The Circulatory System of *Natrix piscator piscator* (Schneider) (Reptilia: Ophidia)

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With 7 Text-Figures

(Communicated by Dr. B. S. CHAUHAN, F.Z.S.I.)

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Introduction

No detailed accounts of the circulatory system of Indian snakes are available beyond the description of the arterial system of *Ptyas mucosus* by Ray (1934) and of both arterial and venous systems of *Hydrophis caeruleus* by Bal and Navathe (1949). Recently, in a series entitled "The arterial system in Ceylon snakes" de Silva has published the arterial system of *Naja naja naja* (1953) and *Natrix piscator asperrimus* (1955). The circulatory system of the common British grass snake, *Tropidonotus natrix* has been worked out in detail by O'Donoghue (1912). His exhaustive account of the circulatory system and the general paucity of such work on Indian snakes have prompted the present authors to undertake a detailed study of circulatory system of *Natrix piscator* which is a common fresh water snake of North Karnatak.

Material and Methods

Specimens of *Natrix piscator piscator* were collected round about Dharwar (North Karnatak, Mysore State) and were kept alive in an aquarium in the laboratory. For purposes of dissecting the arterial system a few specimens were injected with latex solution. Injection methods were found to be unsuitable for the study of the venous system. Hence freshly killed specimens were dissected for the study of veins. Figures have been drawn in such a way as to form a continuous series from one end of the trunk to the other.

The Heart

As the structure of the heart of *Natrix piscator* has already been described in detail by Mathur (1946), only its salient features have been mentioned here.

The heart consists of two auricles and an incompletely divided ventricle. It is situated at a considerable distance from the head and disposed slightly towards the right side. de Silva (1955) records that in the different specimens of *Natrix piscator asperrimus* dissected by him the position of the heart was variable, lying to the left or right or even obliquely. It is enclosed in a pericardium within which it lies freely, there being no gubernaculum cordis as is common with snake hearts. The so called sinus venosus is situated on the dorsal aspect of the right auricle and receives two precaval and a single postcaval vein. The thin walled auricles are unequal in size, the right one being much larger than the left. In *Natrix piscator asperrimus* deSilva (1955) records the presence of a diverticulum on the antero-dorsal margin of the right auricle. In *Ptyas mucosus* (Ray, 1934) a diverticulum has been described as being borne by the left auricle. The presence of a diverticulum is not a feature common to the heart of snakes. Mathur (1946) opines that the formation of a diverticulum is brought about by the presence of coagulated blood within the auricle. We are, however, of the opinion that a diverticulum is caused by the constant pressure of one or the other of the aortic arches on the auricles. Ray (1934) has expressed a similar opinion. The ventricle is somewhat oval in shape and very unsymmetrical. The apex is bluntly conical. The cavity of the ventricle is divided into a large left-dorsal cavum dorsale and a small right-ventral cavum pulmonale by an incomplete and horizontal interventricular septum. Mathur (1946) has referred to this septum as the muscular ridge. It is complete and more or less vertical in the apical portion of the ventricle but becomes incomplete dorsally and assumes a typically horizontal position in the basal portion of the ventricle. About the middle of the cavum dorsale are seen two opposable vertical ridges termed dorsal and ventral septoid processes by Mathur (1946). These two septoid processes become continuous with one another posteriorly and divide the cavum dorsale into a left cavum aorticum and a right cavum venosum. Such median vertical muscle strands have been referred to as the 'muscular ridge' by Rau (1924) and as the 'vertical septum' by Leene and Vorstman (1930). The latter authors believe that this vertical septum has a significant role to play in the formation of the complete interventricular septum of the crocodiles. We have, however, found that this vertical septum is nothing but the most prominent and median of the many vertical ridges that extend from the wall in this region of the ventricle. (Kashyap, 1955).

The Aortic Arches

The three aortic arches arise close to each other from the base of the ventricle, ventrally. The pulmonary arch is the posterior most to arise. It forms the anterior continuation of the cavum pulmonale and after its emergence gradually curves towards the dorsal aspect of the right systemic arch. After leaving the heart it runs alongside the oesophagus and enters the right lung at its anterior end. The left lung is absent. Within the lung the pulmonary artery runs right up to the posterior end and gives off numerous branches that end in a fine capillary net work in the substance of the lung. As in *Tropidonotus natrix* (O'Donoghue, 1912) and *Ptyas mucosus* (Ray, 1934) there is no tracheal branch from the pulmonary artery. In *Hydrophis caeruleus* (Bal and Navathe, 1949), however, the presence of a tracheal artery has been reported. In *Naja naja naja* (de Silva, 1953) too, no tracheal artery is given off by the pulmonary artery but there is a remnant of the left pulmonary artery in the form of a closed cylindrical sac measuring about 5 mm. A similar rudimentary left pulmonary artery has been described by O'Donoghue (1912) in *Tropidonotus natrix*. In *Natrix piscator asperrimus* also, deSilva (1955) does not mention any tracheal artery but has described in detail the presence of right and left ligamentum Botalli connecting the pulmonary arch with the right and left systemic arches.

The left systemic arises slightly in front of the pulmonary arch and towards the right side. It gently curves round to the left side as it runs forward. Beyond the level of the auricles it bends towards the dorsal side, curves round the oesophagus and trachea and unites with the right systemic arch to form the dorsal aorta. On its way, it gives rise to three very delicate oesophageal arteries (Fig. 1, oes. a.) supplying blood to the oesophagus. There appears to be a good deal of variation regarding the number, position and distribution of these tiny vessels among the different snakes that have been studied. In *Tropidonotus natrix* (O'Donoghue, 1912) there are two small branches, both of which supply the oesophagus. In *Ptyas mucosus* (Ray, 1934) there is only a single branch arising very near the junction of the two systemic arches and dividing into three branches, parietal, oesophageal and tracheal, supplying blood to the lateral body wall, oesophagus and trachea respectively. In *Hydrophis caeruleus* (Bal and Navathe, 1949) the left systemic arch does not bear any branch at all. In *Naja naja naja* (de Silva, 1953) there is a single slender oesophageal artery which was found to be absent in most of the specimens dissected. In *Natrix piscator asperrimus* (de Silva, 1955,) its number varies from one to three.

The right systemic arch arises from the base of the ventricle dorsal to the pulmonary and left systemic arches. It is seen to run along the right side of the left systemic arch and diverge from it just

anterior to the auricles. It gives rise to the primary carotid trunk and runs a little forward before curving backwards in order to meet the left systemic arch to form the dorsal aorta. At the point where it curves round, it gives off an anterior vertebral artery, which in its turn gives off three intercostal branches to the vertebral column and finally enters the vertebral musculature in the mid-dorsal line (Fig. 1, ant. vert. a.). The right systemic arch does not give rise to any branch which supplies the oesophagus and the trachea.

In *Tropidonotus natrix* (O'Donoghue, 1912) the anterior vertebral artery gives rise to from 3 to 7 intercostal vessels to the vertebral column and one or more branches to the oesophagus before disappearing into the vertebral musculature. In *Ptyas mucosus* (Ray, 1934) the anterior vertebral artery gives off a considerable number of intercostals varying from 6 to 17. From most of these arise branches which supply blood to the oesophagus. Some proximal intercostals give off fine branches to the trachea also. In *Hydrophis caeruleus* (Bal and Navathe, 1949) the anterior vertebral artery gives off a series of intercostals varying in number from 16 to 24 and towards its anterior end it breaks up into several fine oesophageal arteries. There are no tracheal branches at all. In *Naja naja naja* (de Silva, 1953) the anterior vertebral artery gives rise to 20-22 parietals or intercostal arteries. Before it disappears in the musculature near the head it gives off a branch to the floor of the pharynx. de Silva (1953) associates this prominent anterior vertebral artery with the formation of a hood in *Naja*. It should, however, be noted that in *Hydrophis caeruleus* (Bal and Navathe, 1949) where there is no hood, the vertebral artery is big and gives off 16-24 parietal arteries. Thus *Natrix piscator piscator* shows a reduction in the number of intercostal arteries arising from the anterior vertebral artery and a total absence of the tracheal branches.

Beyond the anterior vertebral artery the right systemic arch gives off two branches, the parietal arteries, which run towards the body wall (Fig. 1, par. a.). There are no branches to the oesophagus from this part of the systemic arch. With respect to the vessels arising from the right systemic arch beyond the anterior vertebral artery in different snakes there is no agreement. *Tropidonotus natrix* (O'Donoghue, 1912) bears five parietal arteries and one or two small oesophageal arteries in this region. In *Ptyas mucosus* (Ray, 1934) the number of parietals (termed 'intercostals' by Ray) vary from 2 to 5 and any of these may give off branches to the oesophagus or the trachea. In *Hydrophis caeruleus* (Bal and Navathe, 1949) the right systemic arch does not give rise to any branch in this region. In *Naja naja naja* (de Silva, 1953) also there are no parietal arteries in this region while in *Natrix piscator asperrimus* (de Silva, 1955) there are one to six parietal arteries and a solitary oesophageal artery which may often be absent.

The Anterior Arteries

A single carotid artery originates from the right systemic arch and runs along the left side of the oesophagus and trachea until it reaches the posterior region of the head. On the basis of its position this artery is considered as the left carotid artery (Fig. 1, l. car. a.). The right carotid artery is nearly always wanting in the snakes. Soon after

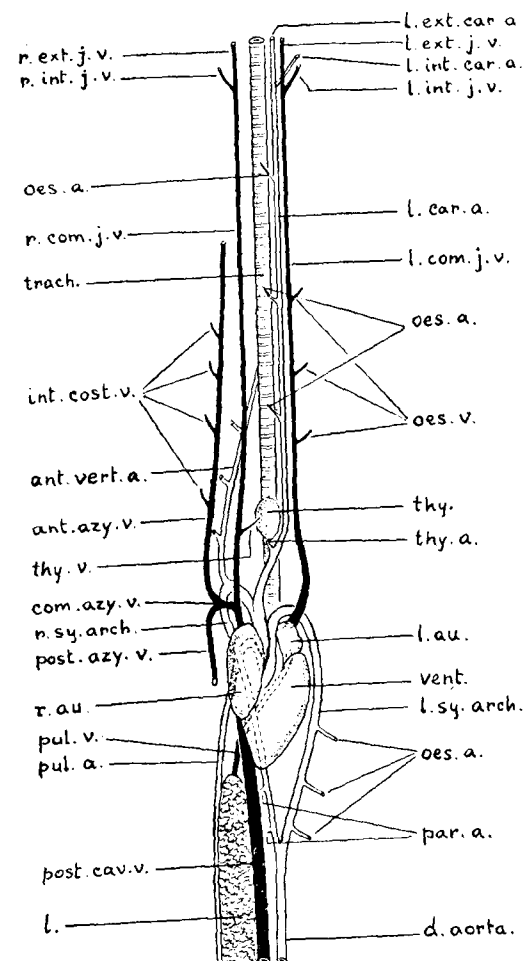


Fig. 1. *Natrix piscator piscator*—The heart, anterior veins and arteries.

its origin the left carotid artery gives off a small branch, the thyroid artery, which supplies blood to the thyroid gland (Fig. 1, thy. a.). This small vessel is looked upon, by some authors, as the remnant of the right carotid artery. Regarding the presence of the thyroid artery *Natrix piscator piscator* agrees with other snakes that have been studied. In *Naja naja naja* (de Silva, 1953) there is a single left common carotid

artery which gives off branches to the thyroid, thymus, oesophagus, trachea and the fat bodies. In addition there is also a small thyroid artery arising from the right systemic very near the left common carotid. This may represent the right common carotid artery. In *Natrix piscator asperrimus* (de Silva, 1955) there are two carotid arteries arising from a common trunk. The right common carotid is reduced and supplies branches to the thyroid, thymus and fat bodies. The left common carotid artery is well developed and its distribution is as in *Naja naja naja*.

The left carotid artery gives off, more anteriorly, 3 to 4 slender branches which supply the oesophagus and the trachea. Just posterior to the head, the left carotid artery divides into the external and internal carotid arteries. The external carotid supplies blood to the upper and lower jaws, tongue and the surrounding muscles while the internal carotid enters the cranium and supplies the brain. It should be noted that in respect of the possession of oesophageal and tracheal branches, *Natrix piscator piscator* resembles *Tropidonotus natrix* (O'Donoghue, 1912), *Ptyas mucosus* (Ray, 1934), *Naja naja naja* (de Silva, 1953) and *Natrix piscator asperrimus* (de Silva, 1955) while *Hydrophis caeruleus* (Bal and Navathe, 1949) stands apart in that its left carotid artery does not give off any branches to the oesophagus and the trachea.

The Posterior Arteries

The dorsal aorta runs medially just ventral to the vertebral column up to the level of the cloaca, beyond which it enters the haemal canal and is continued along the tail as the caudal artery. Along its course, the dorsal aorta gives off a number of branches which can be described in an antero-posterior sequence as follows.

(a) The Parietal Arteries

The parietal arteries (Figs. 2-4, par. a.) form a more or less regular series of branches going to the body wall. These are unpaired and enter the body wall in the mid-dorsal line, a feature characteristic of most colubrine snakes. Further, as in most colubrine and viperine snakes, in *Natrix piscator piscator* too, these arteries do not split into two branches before entering the body wall. From the beginning of the dorsal aorta up to the cloaca, there are about 64 parietal arteries in *Natrix piscator piscator*. Regarding the arrangement and distribution of these vessels *Natrix piscator piscator* closely resembles *Tropidonotus natrix* (O'Donoghue, 1912) in which also they are unpaired and enter the body wall in the mid-dorsal line. A similar condition is seen in *Naja naja naja* (de Silva, 1953) and *Natrix piscator asperrimus* (de Silva, 1955). Thus the situation in *Natrix piscator piscator* also contradicts Beddard's belief that the median entry of the parietal arteries is an exclusive feature of the viperidae. In *Ptyas mucosus* (Ray, 1934) in spite of its being a colubrine snake, the parietal (intercostal) arteries

are in two well defined sets, the anterior and posterior, differing from one another in many respects. The anterior parietals are unpaired and enter the body wall on the left side of the mid-dorsal line, while the posterior parietals are paired and enter the body wall on both sides. Each one of the latter gives off a fine twig to the viscera. In *Hydrophis caeruleus* (Bal and Navathe, 1949) the parietals are referred to as the vertebral arteries and there are about 12 of them in the middle part of the body. Information regarding their presence or absence in the posterior part of the body and the mode of distribution is not available. In *Naja naja naja* (de Silva, 1953) there are as many as 75 parietal arteries and in *Natrix piscator asperrimus* (de Silva, 1955) their number varies from 45 to 66.

(b) *The Oesophageal, Hepato-oesophageal and Gastric Arteries*

The purely oesophageal arteries which do not exceed four in number as in *Tropidonotus natrix* (O'Donoghue, 1912) and *Ptyas mucosus* (Ray, 1934) are situated anterior to the liver (Fig. 2, oes. a.) whereas the purely gastric arteries, numbering four, are found behind the posterior extremity of the liver (Fig. 2, gast. a.). Between these two sets of vessels and situated in the region of the liver are about 17 hepato-oesophageal arteries (Fig. 2, hep. oes. a.) supplying blood to the oesophagus and the liver. The last gastric artery is termed the lienogastric and it supplies the blood not only to the stomach but also to the spleen and gall bladder (Figs. 2 and 3, lien. gast. a.). The distribution of the branches of the lienogastric artery is similar to that of *Tropidonotus natrix* (O'Donoghue, 1912) and *Ptyas mucosus* (Ray, 1934) except that in the latter snakes it supplies the pancreas also. In *Hydrophis caeruleus* (Bal and Navathe, 1949) it supplies the liver as well. In *Naja naja* (de Silva, 1953) and *Natrix piscator asperrimus* (de Silva, 1955) there are two feeble oesophageal arteries and respectively 22 and 15 hepato-oesophageal arteries and 4 and 3 gastric arteries. A lienogastric artery is absent in the former and the superior mesenteric artery supplies the spleen, pancreas and the gall bladder.

(c) *The Superior Mesenteric Artery*

The superior mesenteric artery (Fig. 3, sup. mes. a.) is a very large vessel arising from the dorsal aorta, posterior to the gastric arteries, and giving rise to a number of branches which convey blood to parts of intestine and pancreas. It runs further as far as the posterior end of the right ovary to supply the intestinal coils and the fat bodies. The superior mesenteric artery in *Natrix piscator asperrimus* (de Silva) has a similar distribution. In *Naja naja naja* (de Silva, 1955), as already mentioned, the superior mesenteric artery functions as the lienogastric too.

(d) *The Genital Arteries*

In *Natrix piscator piscator* the vessels supplying blood to the paired ovaries and testes arise at different levels as in *Tropidonotus natrix*

(O'Donoghue, 1912) and *Ptyas mucosus* (Ray, 1934). In *Hydrophis caeruleus* (Bal and Navathe, 1949) the two ovarian arteries arise from the same point and in the male the two spermatic arteries are the branches of a common vessel which supplies the right kidney and the intestine as well. The sequence of the genital vessels in *Natrix piscator piscator* is as follows.

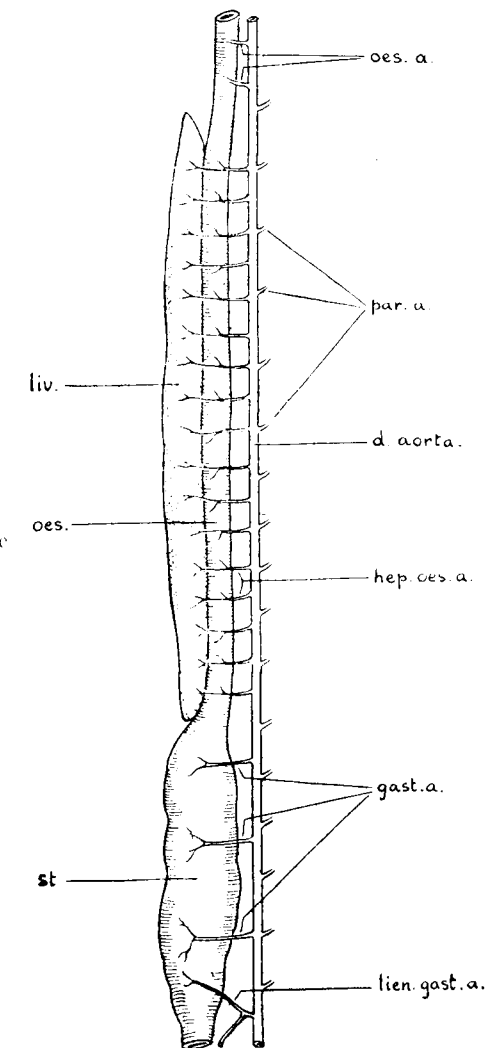


Fig. 2. *Natrix piscator piscator*—The dorsal aorta— anterior division.

(i) *The Right ovarian Artery* (Fig. 3, r.ov.a)

Some of the branches of this vessel also supply the supra-renal body right oviduct and fat body as in *Tropidonotus natrix* (O'Donoghue, 1912).

(ii) *The Right Spermatic Artery*

This vessel is similar in distribution to the right ovarian artery of the female. It supplies the right testis, supra-renal body and the vas deferens.

(iii) *The Right Oviducal Arteries* (Fig. 3, r.ovid.a)

Anterior to the right kidney, the dorsal aorta gives rise to two branches which supply blood to the right oviduct and fat bodies. In *Ptyas mucosus* (Ray, 1934) there are 2 to 4 oviducal arteries while in *Tropidonotus natrix* (O'Donoghue, 1912) and *Hydrophis caeruleus* (Bal and Navathe, 1949) there is no separate oviducal branch arising from the dorsal aorta.

(iv) *The Right Spermiducal Arteries*

Anterior to the right kidney, arise two spermiducal arteries which supply blood to the right vas deferens. The number of spermiducal arteries differ from snake to snake, there being 3 to 10 in *Ptyas mucosus* (Ray, 1934) and only one in *Tropidonotus natrix* (O'Donoghue, 1912). Navathe, 1949) there is a single spermiducal vessel on the left side while there is none on the right.

The left ovarian (Fig. 3, l.ov.a) and oviducal (Fig. 4, l.ovid.a) as also the left spermatic and spermiducal vessels are more or less similar to the corresponding vessels of the right side and arise in a sequence, beyond the first inferior mesenteric artery. In *Naja naja naja* (de Silva, 1953) separate right and left oviducal arteries are present while in *Natrix piscator asperimus* (de Silva, 1955) the oviducts are supplied by branches of the ovarian arteries.

(e) *The First Inferior Mesenteric Artery*

The first inferior mesenteric artery (Fig. 3, 1st. inf.mes.a.) supplies the intestine, just posterior to the right ovary or testis as in *Tropidonotus natrix* (O'Donoghue, 1912) and *Ptyas mucosus* (Ray, 1934). In *Hydrophis caeruleus* (Bal and Navathe, 1949), *Naja naja naja* (de Silva, 1953) and *Natrix piscator asperimus* (de Silva, 1955), however, the first mesenteric artery arises as a branch of the urino-genital artery in the male and as an independent vessel from the dorsal aorta in the female.

(f) *The Second Inferior Mesenteric Artery*

The second inferior mesenteric artery (Fig. 4, 2nd.inf.mes.a.) arises from the dorsal aorta about the middle of the right kidney and supplies blood to the intestine. In the male of *Hydrophis caeruleus* (Bal and

Navathe, 1949) the second inferior mesenteric artery is seen to arise from a common vessel which also sends a branch to the right kidney, while in the female it arises separately.

(g) *The Renal Arteries*

There are five renal arteries, two of which supply blood to the right kidney (Fig.4, r.ren.a.) and the rest to the left Kidney (Fig. 4,

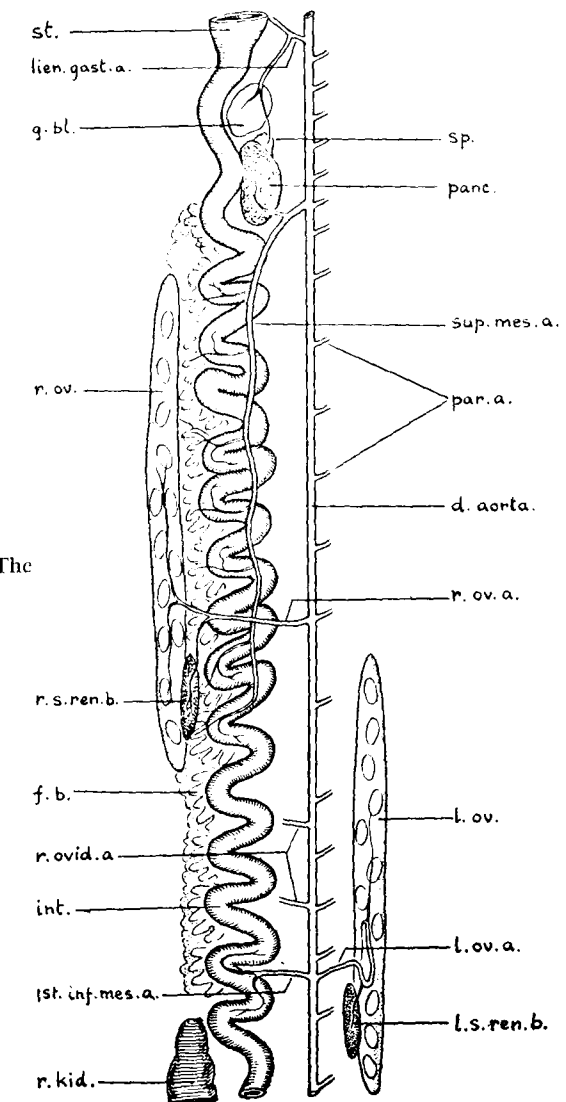


Fig. 3. *Natrix piscator piscator*—The dorsal aorta—middle division.

l.ren.a.) as in *Tropidonotus natrix* (O'Donoghue, 1912). The right renal arteries are between the second and third inferior mesenteric arteries

while the left renal arteries arise more posteriorly. *Hydrophis caerulelescens* (Bal and Navathe, 1949) has four right renal arteries and five left renal arteries. In *Naja naja naja* (de Silva, 1953) there are two renal arteries on the right side and from one to three arteries on the left. In *Natrix piscator asperimus* (de Silva, 1955) there are two to five arteries on the right and two to four arteries on the left side.

(h) The Third Inferior Mesenteric Artery

The third inferior mesenteric artery (Fig. 4, 3rd inf.mes.a.) springs from the dorsal aorta at the level of the posterior end of the right kidney and takes the blood to the intestine.

It may be recorded here that there are slight variations regarding the number of inferior mesenteric arteries among the different snakes. They are four in *Tropidonotus natrix* (O'Donoghue, 1912) and *Hydrophis caerulelescens* (Bal and Navathe, 1949), three in *Naja naja naja* (de Silva, 1953) and *Natrix piscator asperimus* (de Silva, 1955). In the last named snake the number is sometimes reduced to one.

(i) The Rectal Arteries

The rectal arteries (Fig. 4, rect.a.) form a series of five vessels arising behind the renal arteries and supplying blood to the posterior portion of the alimentary canal. The number of rectal arteries varies considerably in the different snakes that have been studied. *Tropidonotus natrix* (O'Donoghue, 1912) and *Naja naja naja* (de Silva, 1953) possessing only one, *Ptyas mucosus* (Ray, 1934) five to ten, *Hydrophis caerulelescens* (Bal and Navathe, 1949) two and *Natrix piscator asperimus* (de Silva 1955) six.

The Venous System

For the sake of description the venous system has been divided into anterior and posterior portions.

The Anterior Venous System

The anterior venous system comprises of the two precaval veins and their tributaries. These vessels drain blood from the head region into the sinus venosus. The common jugular veins that join the precavals are formed, on both sides, by the union of the external and internal jugular veins. The external jugular vein (Fig. 1, r.ext.j.v., l.ext.j.v.) brings blood from the lower jaw and floor of the buccal cavity while the internal jugular vein (Fig.1, r.int.j.v., l.int.j.v.) brings blood from the brain.

The left common jugular vein (Fig. 1, l.com.j.v.) runs parallel to the left common carotid artery and passes ventral to the left systemic arch

in order to open into the left precaval vein. It does not receive any tributary from the thyroid gland as in *Tropidonotus natrix* (O'Donoghue, 1912) and *Hydrophis caerulelescens* (Bal and Navathe, 1949). In all the three snakes the left common jugular vein receives small branches bringing blood from the oesophagus (Fig. 1, oes. v.).

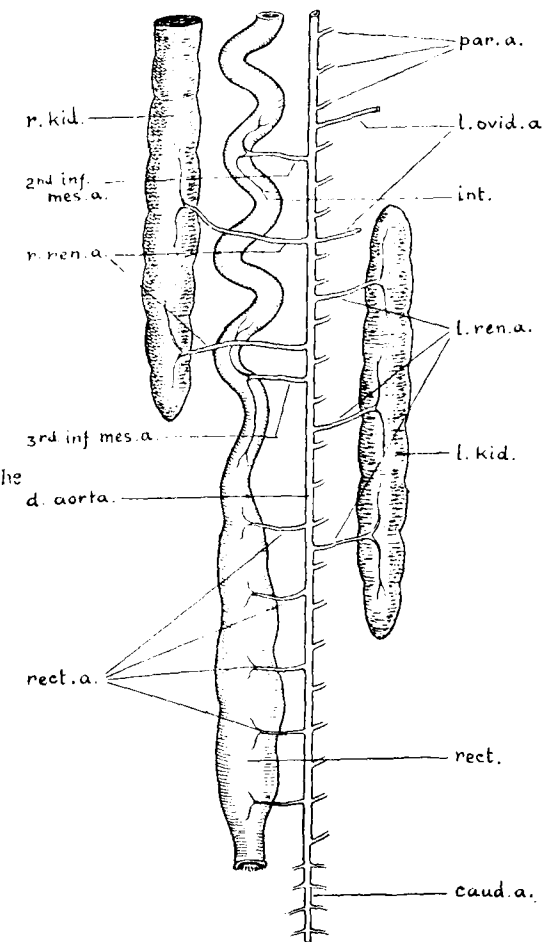


Fig. 4. *Natrix piscator piscator*—The dorsal aorta—posterior division.

The right common jugular vein (Fig. 1, r.com.j.v.) is similar in disposition to the left common jugular vein except that it receives the large common azygos vein (Fig. 1, com.azy.v.) in a level with the anterior end of the right auricle. It also differs from the left common jugular vein in possessing a thyroid branch as in *Hydrophis caerulelescens* (Bal and Navathe, 1949). In *Tropidonotus natrix* (O'Donoghue, 1912) there is no thyroid branch for the right common jugular vein. Further, unlike as in *Hydrophis caerulelescens* (Bal and Navathe, 1949), the right common jugular vein of *Natrix piscator piscator* does not receive any veins from

the vertebral column. In this respect it resembles *Tropidonotus natrix* (O'Donoghue, 1912).

The common azygos vein (Fig. 1, com.azy.v.) is a short trunk which opens into the right precaval vein along with the right common jugular vein. It is formed by the union of an anterior and a posterior azygos vein. A common azygos vein is found in *Tropidonotus natrix* (O'Donoghue, 1912) and *Hydrophis caerulescens* (Bal and Navathe, 1949) also.

The anterior azygos vein (Fig. 1, ant. azy.v.) is situated in front of the heart and between the oesophagus and the vertebral column and extends from the beginning of the neck up to the heart. It collects blood from the dorsal body wall by means of three to five intercostal veins (Fig. 1, int.cost.v.) all of which are situated to the right of the vertebral column. It does not receive any branch from the oesophagus. In *Tropidonotus natrix* (O'Donoghue, 1912) there is, in addition, a branch coming from the oesophagus.

The posterior azygos vein (Fig. 1, post.azy.v.) is a shorter vessel than the anterior azygos and also the homologous vein of the lizards. It originates at about the level of the middle of the ventricle and runs forward to meet the anterior azygos vein. A similar vein is found in *Tropidonotus natrix* (O'Donoghue, 1912) and *Hydrophis caerulescens* (Bal and Navathe, 1949).

The Posterior Venous System

The Pulmonary Vein

The pulmonary vein (Fig. 1, pul.v.) arises on the left side of the lung and runs parallel to the postcaval vein. It passes ventral to the right systemic arch and over the horizontal portion of the left precaval vein to open into the left auricle. Both the lung and the pulmonary vein are single, as the left lung and the left pulmonary vein are absent as in other snakes. *Hydrophis caerulescens* (Bal and Navathe, 1949) a tracheal branch has been seen to join the pulmonary vein. No such branch is found in *Natrix piscator piscator* and *Tropidonotus natrix* (O'Donoghue, 1912).

The Caudal Vein

The caudal vein (Fig. 7, caud.v.) arises far behind, in the tail, and runs inside the haemal canal alongside the caudal artery. Just posterior to the cloaca, the caudal vein divides into two renal portal veins.

The Renal Portal Veins

Each renal portal vein (Fig. 7, ren.port.v., l.ren.port.v.) on reaching the kidney, runs along the latter's outer margin giving out numerous branches to that organ. The renal portal vein is joined, on each side by three or four branches bringing blood from the ureter and the genital duct (Fig. 7, r.ovid.v., l.ovid.v.). Parietal veins (Fig. 7, par.v.) numbering

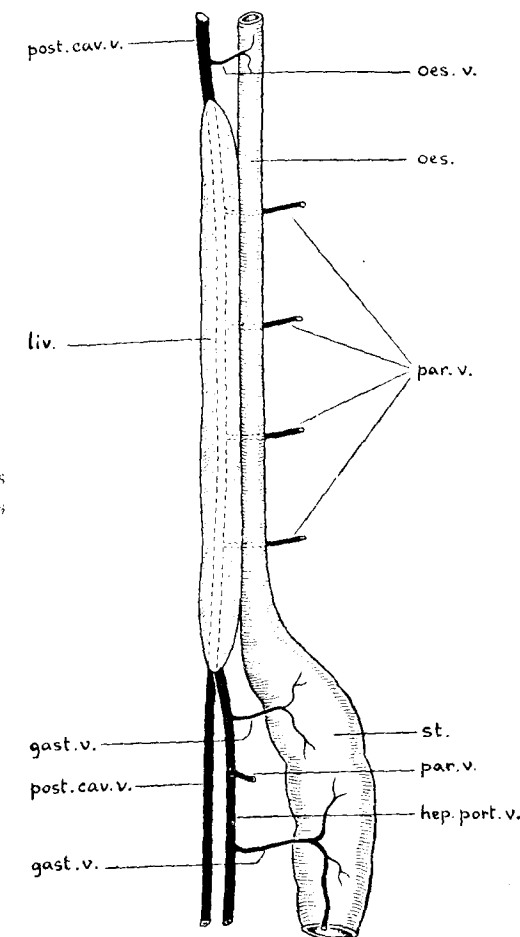


Fig. 5. *Natrix piscator piscator*—Veins in the region of the liver, oesophagus and stomach.

about three to six also open into the renal portal veins. Each renal portal vein gives off a dorsal branch (Fig. 7, t.) just anterior to the cloaca, which joins its fellow from the other side to form the hepatic portal vein (Fig. 7, hep.port.v.). The right renal portal vein is longer than the left one, due to the slightly anterior position of the right kidney.

The Right Renal Vein

The right renal vein (Fig. 7, ren.v.) emerges on the mesial aspect of the right kidney and after running for a short distance, in front of it, joins the left renal vein to form the postcaval vein (Fig. 6, post.cav.v.). It receives four or five parietal veins (Fig. 6, par.v.) from the body wall, anterior to the kidney. In *Tropidonotus natrix* (O'Donoghue, 1912) there are no parietal veins opening into the right renal vein while in *Hydrophis caeruleus* (Bal and Navathe, 1949) there are, besides the parietal, two oviducal or deferential veins.

The Left Renal Vein

The left renal vein (Fig. 7, l.ren.v.) also arises on the mesial aspect of the left kidney. It receives three left ovarian veins (Fig. 6, l.ov.v.) from the left ovary and the supra-renal body. In the male, it receives a single vein from the left supra-renal body and none from the testis. Like the right renal vein, it also receives two parietal veins (Fig. 6, par.v.).

The two renal veins correspond, in position, to the *venae renales revehentes* found in the lizards. Further, they resemble more closely the *venae renales revehentes* of the internal type, there being, however, no transverse connecting vessels.

The Postcaval Vein

The postcaval vein (Fig. 6, post.cav.v.) is formed by the union of the two renal veins. It runs anteriorly along a groove on the ventral aspect of the liver and finally opens into the sinus venosus. It receives the following vessels in an antero-posterior sequence.

The Oesophageal Veins

Soon after the emergence of the postcaval from the liver it is joined by one or two oesophageal veins (Fig. 5, oes.v.) bringing blood from the anterior part of the oesophagus.

The Parietal Veins

During the passage of the postcaval through the liver along a groove on its ventral aspect, it receives four parietal vessels (Fig. 5, par.v.). Further posteriorly, about the middle of the right ovary the postcaval vein receives two more parietal veins (Fig. 6, par.v.).

The Right Ovarian and Oviducal Veins

Opposite the right ovary, the postcaval is joined by four or five ovarian vessels (Fig. 6, r.ov.v.). The last of these vessels brings blood

from the supra-renal body also. Behind the level of the right ovary, the post-caval receives about three to four oviducal veins (Fig. 6, r.ovid.v.).

The Left Ovarian Vein

A single left ovarian vein joins the postcaval opposite the second right oviducal vein (Fig. 6, l.ov.v.).

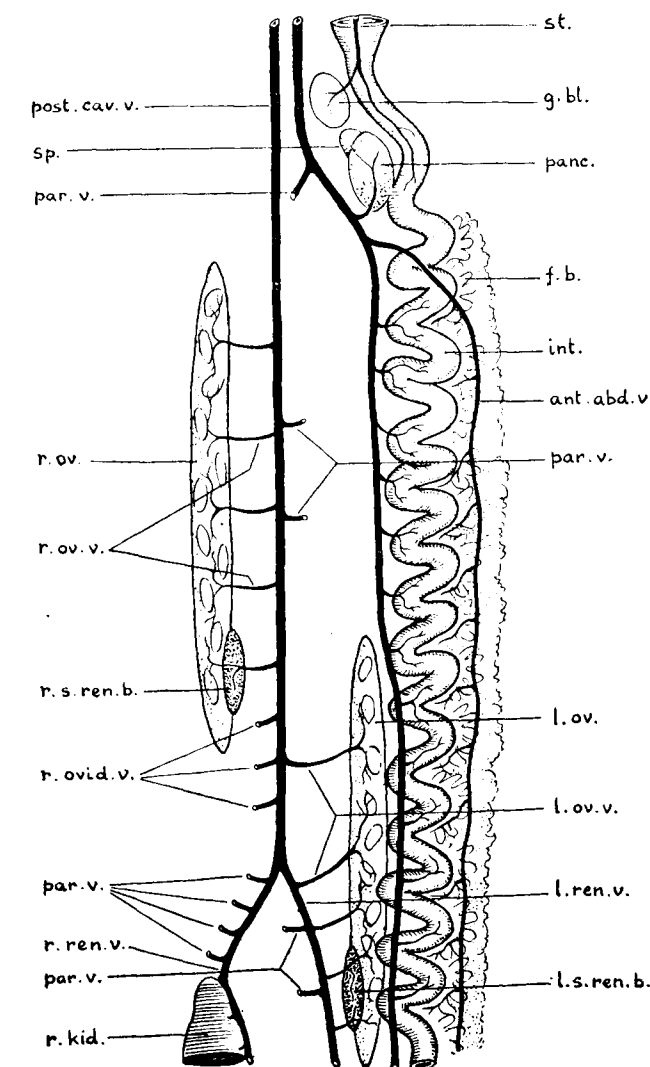


Fig. 6. *Natrix piscator piscator*—Veins in the region of the intestine, ovaries and fat bodies.

In the male, the disposition of the spermatic and the deferential veins, in this region, is more or less similar to that of the ovarian and oviducal veins.

The Hepatic Portal System

The hepatic portal system consists of the hepatic portal vein (Figs. 5, 6 and 7, hep.port.v.) and the several branches from the alimentary canal and associated glands that go to form it. The hepatic portal vein takes its origin far back in the peritoneal cavity, as a lateral offshoot of the renal portal vein as already referred to. Soon after its formation it runs forward on the dorsal aspect of the alimentary canal collecting blood from it through many small branches. Before entering the liver it runs parallel to the postcaval for some distance. A few branches bring blood to it from the gall bladder, spleen and pancreas. It also receives two parietal veins in its anterior portions. The nature of the hepatic portal system in *Natrix piscator piscator* is very similar to that of other snakes. Though the connection between the renal portal vein and the hepatic portal vein would cast some doubt regarding the latter's identity, it should be noted that the hepatic portal vein described here is the only vein that collects the blood from the alimentary canal and conveys it to the liver.

The Anterior Abdominal Vein

The anterior abdominal vein (Fig. 6, ant.abd.v.) is represented, in *Natrix piscator piscator*, as in other snakes, by an independent vessel that runs through the fat bodies, collecting blood from them by means of small branches and finally opening into the hepatic portal vein at about the level of the duodenum. This vessel appears to be similar to the epigastric vein of the bird but opens into the hepatic portal vein instead of opening into the hepatic vein like the former.

Summary

1. The heart lies slightly towards the right side, at a considerable distance from the head. It consists of two thin-walled auricles and a thick walled ventricle which is incompletely divided into large left-dorsal and a small right-ventral cavity. The two auriculo-ventricular apertures lie in the large dorsal cavity.
2. Only the left carotid artery is present and a small branch supplying blood to the thyroid gland may be considered as the sole representative of the right carotid artery.
3. Only the right pulmonary artery and vein are present.

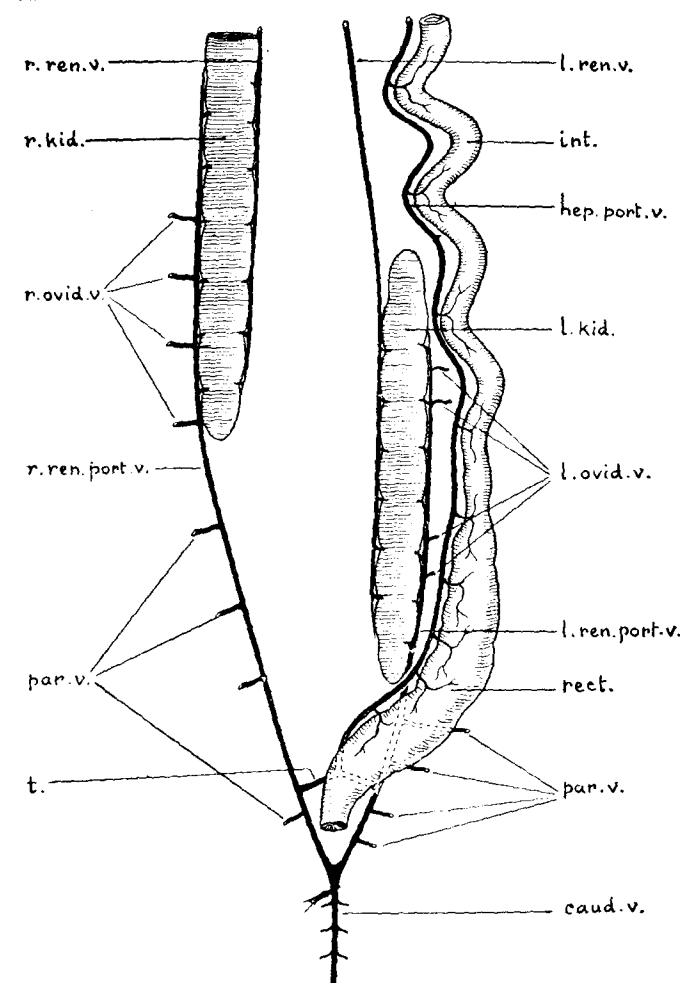


Fig. 7. *Natrix piscator piscator*—Veins in the region of the rectum and kidneys.

Abbreviations
vertebral artery, caud.a., caudal artery. caud.v., caudal vein. con-azj.v. common azygos vein. d.aorta., dorsal aorta. f.b. fat body. g.bl. gall bladder. gast.a. gastric artery. gast.v., gastric vein. hep.oes.a., hepato-oesophageal artery. hep.port.v., hepatic portal vein. int., intestine. int.cost.v., intercostal vein. inf.mes.a., inferior mesenteric artery. l., lung. l.au., left auricle. l.car. a. left carotid artery. l.com.j.v., left common jugular vein. l.ext.car.a., left external carotid artery. l.int.car. a., left internal carotid artery. l.ext.j.v., left external jugular vein. l.int.j.v., left internal jugular vein. l.kid., left kidney. l.ov., left ovary. l.ov.a.r. left ovarian artery. l.ov.v., left ovarian vein. l.ovid.a., left oviductal artery. l.ovid.v., left oviductal vein. l.ren.a., left renal artery. l.ren.v., left renal vein. l.s.ren.b., left supra-renal body. l.sy.arch., left systemic arch. liv., liver. lien.gast.a., lienogastric artery. oes., oesophagus. oes.a., oesophageal artery. oes.v., oesophageal vein. panc., pancreas. par.a., parietal artery. par.v., parietal vein. post.azy., posterior azygos vein. post.cav.v., postcaval vein. pul.a., pulmonary artery. pul.v., pulmonary vein. r.au., right auricle. r.com.j.v., right common jugular vein. r.ext.j.v., right external jugular vein. r.int.j.v., right internal jugular vein. r.kid., right kidney. r.ov., right ovary. r.ov.a., right ovarian artery. r.ov.v., right ovarian vein. r.ovid.a., right oviductal artery. r.ren.a., right renal artery. r.ren.v., right renal vein. r.ren.port.v., right renal portal vein. r.s.ren.b., right supra-renal body. r.sy.arch., right systemic arch. rect., rectum. rect.a., rectal artery. sp., spleen. st., stomach. t., tributary which joins the hepatic portal vein with the renal portal. thy., thyroid gland. thy.a., thyroid artery. thy.v., thyroid vein. trach., trachea.

4. The parietal arteries which arise along the length of the dorsal aorta are unpaired and enter the body wall in the mid-dorsal line as in most colubrine and viperine snakes.

5. The common azygos vein is present on the right side and is formed by the union of the anterior and posterior branches.

6. The hepatic portal system is connected with the renal portal vein by means of two small vessels as in other snakes.

7. The anterior abdominal vein is a small and independent vessel collecting blood from the fat bodies and opening into the hepatic portal vein.

Acknowledgement

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Malformation in the Azygos vein and Inferior Vena cava of the Field Rat, *Tatera Indica* Hardw

BY V. VICTOR GLADSTONE

&

(MISS A. S. PANDYAN)

(Government Arts College, Madras)

(Communicated by Prof. P. K. MENON)

With 3 Text-figures and one plate

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Introduction

The field rat, *Tatera indica* Hardw. is generally dissected as a mammalian type by students of Zoology in several colleges. The arrangement of veins in this species is very similar to what has been described in *Mus norvegicus albinus* (Greene, 1955) and *Rattus rattus rattus* Linnaeus (Ekambaranatha Iyer, 1956). The inferior vena cava is formed by the union of the common iliac veins and courses forward to the heart along the middle line of the body, receiving on its way the renal and hepatic veins. Finally it enters the right atrium along with the vena cava superior. The azygos vein in the rat is left-sided, in contrast to the dominant right-sided azygos in most mammals, and joins the left vena cava superior.

Abnormality

In one of the specimens given for dissection an interesting abnormality was observed. The inferior vena cava in this specimen after receiving the renal veins in the usual manner, joined not the right-atrium but the left vena cava superior.

Another abnormality was related to the azygos vein. There was no discrete azygos vein. This latter structure presumably formed the anterior

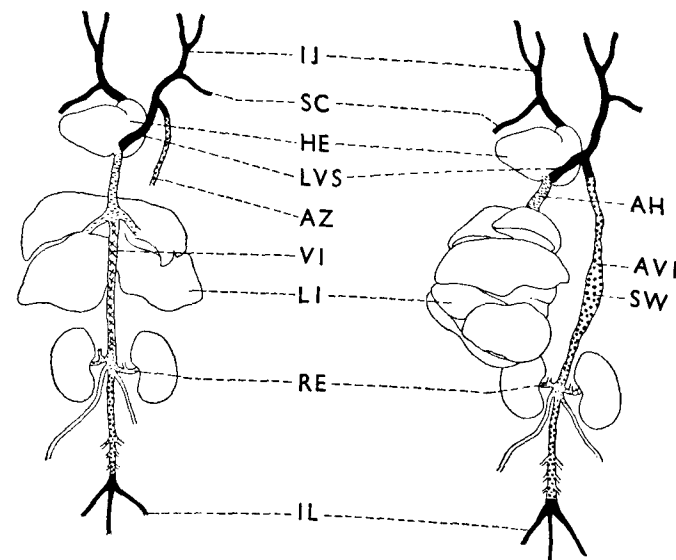
portion of the inferior vena cava. The point of junction of the inferior vena cava and the azygos seemed to be indicated by a swelling.

The hepatic vein also showed an abnormality, for it was not connected with the inferior vena cava, but remained as a separate vein running forward from the liver and opening into the right atrium of the heart along with the left superior vena cava. This is a natural consequence of the major abnormality.

Thus, the opening of the inferior vena cava, into the superior vena cava, and not into the atrium, and the absence of a connection between the hepatic vein and inferior vena cava are the chief abnormal features.

Explanation

These features may be regarded as the result of a developmental defect. It is known that during development the vena cava inferior is normally formed by the anastomosis, consolidation and regression of many embryonic vessels (Text figs. 1 & 3). It is composed of 1, a hepatic



Text fig. 1 Normal
Text fig. 2. Abnormal

I.J., Internal jugular vein; SC, Subclavian vein; HE, Heart; LVS, Left venacava superior; AZ, Azygos; VI, Vena cava inferior; LI, Liver; RE, Renal; IL, Iliac vein; AH, Abnormal hepatic; AVI, Abnormal vena cava inferior; SW, Swelling.

segment, 2. pre-renal segment formed from the subcardinal, 3. renal segment comprising of anastomosis between the sub cardinal and supra cardinal veins, 4. a supra cardinal segment from the lumbar portion of the supra cardinal vein, and 5. a posterior cardinal iliac anastomosis.

Gladstone & Pandian

PLATE VIII

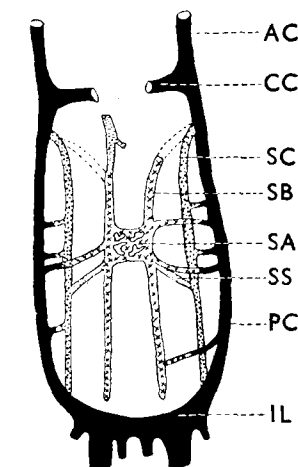


Photograph showing the abnormal condition

The abnormality described already has probably resulted in the following manner. The whole azygos, formed from the anterior portion of the left posterior cardinal and the left supra cardinal, has united with the vena cava inferior at the place where it is formed by the subcardinal

Text-Fig. 3. Diagram showing embryonic veins. (After Nelsen, modified).

AC, Anterior cardinal; SC, Supracardinal; SB, Subcardinal; SA, Subcardinal anastomosis; SS, Sub-supracardinal anastomosis. PC, Posterior cardinal; IL, Iliac anastomosis of the posterior cardinals.



anastomosis. The prerenal segment which should normally develop from the subcardinal has failed to develop in this instance. The hepatic segment has, however, remained separate with a distinct connection to the heart.

This abnormality did not apparently interfere with the normal functioning of the blood vascular system, as the animal had a normal appearance and did not show any trace of any effect of the vascular abnormality.

Summary

A malformation of the azygos vein and inferior vena cava in *Tatera indica* Hardw. has been described. The absence of any discrete azygos, the connection of the inferior vena cava to the superior vena cava and not the atrium, the direct connexion between the hepatic vein and heart are the abnormalities that have been noticed. Explanation for these abnormalities in terms of development has been suggested.

Acknowledgement

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The First All-India Congress of Zoology sponsored by the Zoological Society of India is proposed to be held at Jabalpur (M.P.) at the invitation of the University of Jabalpur. from the 24th to the 29th of October 1959.

Particulars will be available from Dr. B. S. Chauhan, Zoological Society of India, 34, Chittaranjan Avenue, Calcutta-12.

NOTICE

Members of the Zoological Society of India are requested to send their membership subscription of the Society for the year 1958-59 and arrears, if any, to the Hony. Treasurer at an early date.

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

Manuscript of the proposed Who's Who of the members of the Society and a bibliography of their publications is going to the press for printing. Information by members and others interested for the proposed Catalogue-list of Indian Zoologists by the Society may kindly be expedited, so that it could also go for printing soon.

Orders for publications of the Zoological Society of India like the *Journal of the Zoological Society of India*, the *Bulletin* Nos. 1 & 2, the *Year-Books*, *Indian Zoological Memoirs* (initiated by late Prof. K. N. Bahl) No. 6 on *Palaemon* by Dr. S. S. Patwardhan, second edition (1958); No. 7 on *Salmacis* by Prof. R. Gopala Aiyar, 1938 and No. 3 on *Ostrea cucullata* by Prof. P. R. Awati, 1931; the *Indian Journal of Helminthology*, reprints of a few papers of the Indian Helminthologist, the late Dr. G. D. Bhalerao, etc. could also now be placed with **Dr. B. S. Chauhan, Hony. Treasurer,** Zoological Society of India, 34, Chittaranjan Avenue, Calcutta-12 (India)

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