Journal of the Zoological Society of India

Abbreviation: *J. zool. Soc. India*

VOL. 9, No. 2 DECEMBER, 1957 PAGES 103-221

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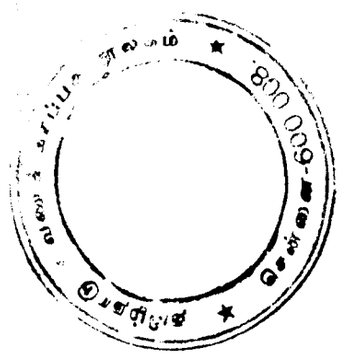

Water Conservation in *Uromastix Hardwickii* (Gray), with a note on the Presence of Mullerian Ducts in the Male

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(Communicated by Prof. M. L. BHATIA, F.Z.S.I.)

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Introduction

The Indian spiny tailed lizard *Uromastix hardwickii* is found in sandy areas with sand dunes and patches of xerophytic shrubs. The animals live in burrows about a foot and a half below the surface, where the earth is just moist. The combination of an upper layer of sand with a lower layer of clay or silt serves to retain some moisture in the desert areas. Through the upper sandy layer the rain water quickly percolates and is retained to some extent in the lower stratum of fine soil. This environment enables *Uromastix* to live without risk of desiccation.

The food of this lizard consists mainly of insects; sometimes it nibbles the shurbs present in its habitat. So the total intake of water by this lizard is mainly from the insects and to some extent from plant material. Since the animal lives in a somewhat moist habitat, its skin may also absorb some moisture as has been noticed by Willey in the case of *Moloch horridus* (the moloch), a highly spinescent lizard of the Australian sandy deserts. The conservation of water is achieved mainly by reabsorption of water from urine, which undergoes a process of dehydration and gets converted into a solid pellet before it is evacuated. In this respect it closely resembles the house lizard, *Hemidactylus* which has already been described by the author (1956). Fundamentally, the morphology and histology of the parts involved in the process of conservation of water are almost similar in both the cases. However certain interesting additional features have been noticed in *Uromastix* as compared with those of *Hemidactylus* and are recorded in this paper.

Material and Methods

Specimens of *Uromastix* were collected from open land round about Delhi. As the animal ordinarily remains buried underground, a good bit of earth has to be dug out to reach the burrow in which it actually lives. The position of the burrows can be spotted out from a number of holes on the surface of the soil. For catching the animal a stick is introduced into the hole till it reaches the burrow, and the earth around the hole is loosened and dug out till the actual burrow is struck upon. Then the animal which lies sluggishly in the burrow can be picked up by hand. Animals thus collected were kept in a cage in the laboratory with a layer of sand at the bottom of the cage.

For morphological studies of the urinary system the specimens were examined immediately after they were killed and also in a preserved condition. Most of the dissections were done under a binocular microscope. For the study of histology portions of the cloaca, bladder, kidney and the ureter were fixed in Bouin's fluid, and serial sections 6 to 8 μ thick were cut.

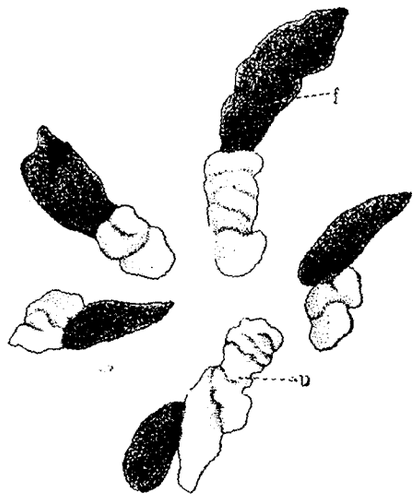

Fig. 1. *Uromastix hardwickii*. Solid pellets of urine shown attached to the faeces which is fibrous and black in colour. *f.*, faeces; *u.*, urine pellet.

Solid urinary pellets (Fig. 1) were collected from the cage where the lizards were kept and qualitative as well as quantitative analysis was carried out adopting the procedure described in a previous paper paper on *Hemidactylus* (Champaka, 1956).

Functional Morphology

The process of dehydration of urine is accomplished in the coprodaeal region of the cloaca in the same manner as already described in

the case of *Hemidactylus*. The presence of solid pellets of urine in the coprodaeum in almost all the specimens dissected indicates that dehydration of urine takes place in the coprodaeum. The coprodaeum is comparatively large and its lining has a number of folds which merge behind into a very well developed sphincter between the coprodaeum and the urodaeum (Fig. 2).

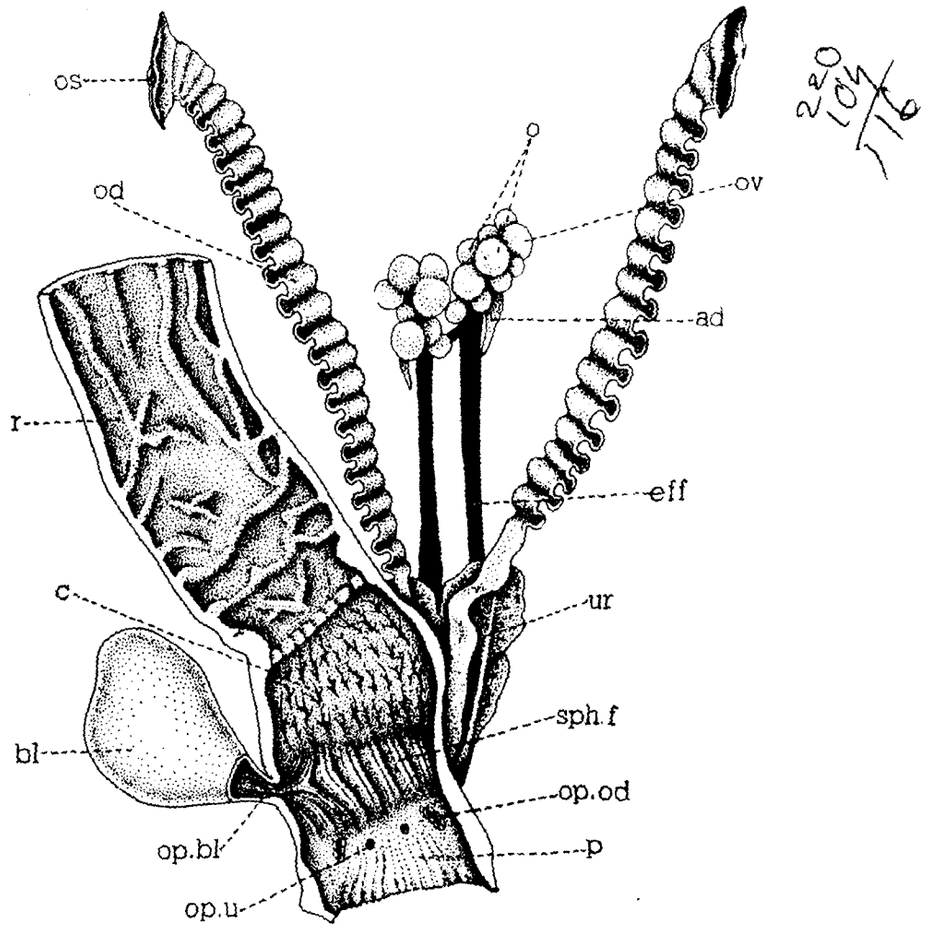

Fig. 2. *Uromastix hardwickii*. Dissection of the female urinogenital system.
ad., adrenal; *bl.*, bladder; *c.*, coprodaeum; *eff.*, efferent vessel; *o.*, *ova*; *od.*, oviduct; *op. bl.*, opening of bladder; *op. od.*, opening of oviduct; *op. u.*, opening of ureter; *os.*, ostium; *ov.*, ovary; *p.*, proctodaeum; *r.*, rectum; *sph.f.*, folds in the region of sphincter; *ur.*, ureter.

The ental lining in the region of the sphincter has a number of closely set folds which assume the shape of ridges and grooves. Each ridge or fold is also grooved at its summit, so that there are two sets

of grooves, deep grooves between the folds which are the primary grooves, and small grooves on each fold which are the secondary grooves.

The urinary bladder is essentially a urodaeal diverticulum and is ordinarily connected with the urodaeal chamber of the cloaca. It is functional in *Uromastix* and stores urine. It is worthy of note that in *Uromastix* the bladder opening is not exactly in the urodaeum, but situated in an antero-posterior direction in the centre of the region of sphincter. The bladder narrows into a duct, which before actually opening into the urodaeum is guarded by a sphincter and a valvular fold. The folds at the opening of the bladder also have at their summits the secondary grooves. Some folds directed from the urodaeum towards the bladder are broad on their urodaeal side and narrow down near the opening of the bladder. There are a few folds facing the coprodaeum which are broad at the opening of the bladder and narrow towards the coprodaeum. These folds seem to regulate the passage of the liquid urine in and out of the bladder respectively (Fig. 3.).

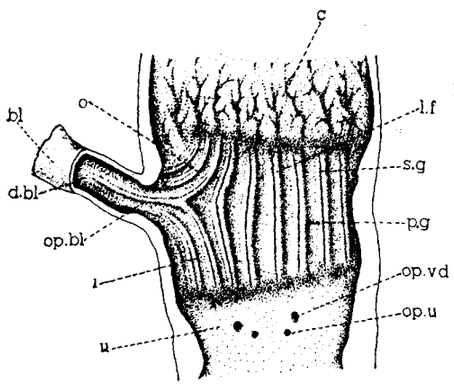

Fig. 3. *Uromastix hardwickii*. Diagrammatic sketch of the male coprodaeum and urodaeum showing the longitudinal folds and grooves in the region of the sphincter and the opening of the bladder. *bl.*, bladder; *c.*, coprodaeum; *d.bl.*, duct of bladder; *i.*, inlet to the bladder; *l.f.*, longitudinal folds; *o.*, outlet of bladder; *op.bl.*, opening of bladder; *op.u.*, opening of ureter; *p.g.*, primary grooves; *s.g.*, secondary grooves; *u.*, urodaeum.

The urodaeum is comparatively a small chamber into which both the urinary and genital ducts open. The urinary and genital ducts in the male *Uromastix* open independently, while in *Hemidactylus* they join before they open in a common urinogenital aperture situated on a papilla. Another point of difference is the absence of urinary papillae in both the male and female *Uromastix*, which in *Hemidactylus* are very prominent and are directed towards the coprodaeum.

The dorsal wall of urodaeum in the male (Fig. 4) is produced into two pouches, the *urodael diverticula*, which extend between the kidneys and the cloaca, a little above the region of the coprodaeum. Each diverticulum is notched at the top and appears slightly bilobed. The diverticula are highly muscular and in a freshly dissected specimen a slimy fluid could be extracted from inside these. A delicate duct in

the form of a white strand is attached to each diverticulum at the region of the notch. The ducts travel forward closely applied to the vas deferens of its respective side and are attached at the other end, near the base of each testis.

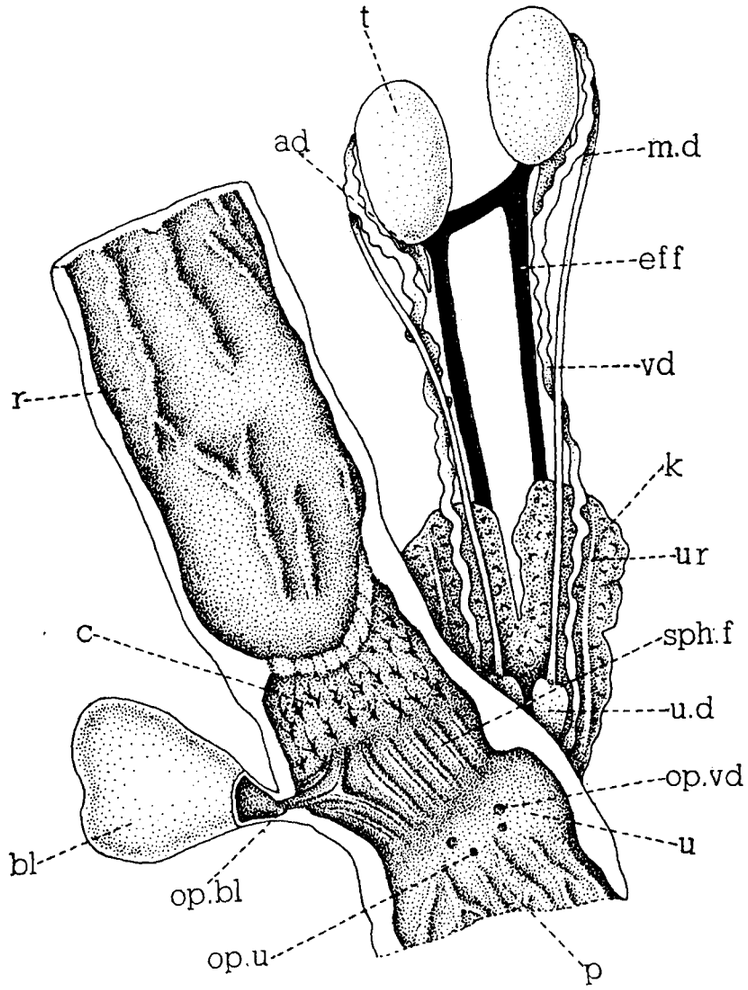

Fig. 4. *Uromastix hardwickii*. Dissection of the male urinogenital system.
ad., adernal; *bl.*, bladder; *c.*, coprodaeum; *eff.* efferent vessel; *k.*, kidney; *m.d.* Mullerian duct; *op.bl.*, opening of bladder; *op.u.*, opening of ureter; *op.vd.*, opening of vas deferens; *p.*, proctodaeum; *r.*, rectum; *sphf.*, folds in the region of sphincter; *t.*, testis; *u.*, urodaeum; *u.d.*, urodacal diverticulum; *ur.*, ureter; *vd.*, vas deferens.

The proctodaeum, the third chamber of the cloaca communicates to the outside through the cloacal aperture, bounded by the upper and

the lower lips of the cloaca. The histological elements of the coprodaeal region of the cloaca are almost the same as in *Hemidactylus* (Figs. 5 a & b). The essential feature is the presence of the epithelial lining with columnar, absorptive cells, each with a basal nucleus. The lining is produced into a number of uniformly distributed prominent villi. There is no differentiation into a smooth region and a region with folds like the coprodaeum of *Hemidactylus*. The muscle layers are fairly prominent but the lamina propria is like that in *Hemidactylus*.

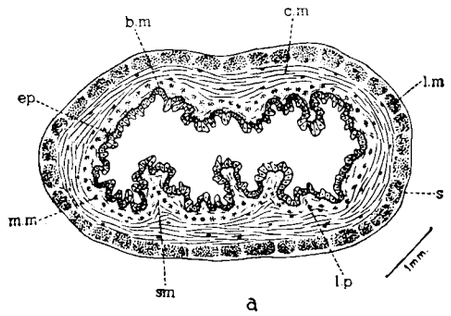

Fig. 5. *Uromastix hardwickii* (a) Transverse section of the coprodaeal region of cloaca. (b) a magnified view of a single villus. *b.m.*, basement membrance; *cap.*, capillary; *c.m.*, circular layer of muscles; *ep.*, epithelium; *l.m.*, longitudinal layer of muscles; *l.p.*, lamina propria; *m.m.* muscularis mucosa; *n.* nucleus; *s.*, serosa; *sm.*, submucosa.

The epithelial lining of urodaeum is unlike that of coprodaeum in that the cells are shorter in length and are not absorptive in nature. Each cell is cuboid and has a fairly large and more or less rounded nucleus. The urodaeal diverticulum has a thick circular layer of muscles and the epithelial lining in each diverticulum is highly folded. The cells are of a secretory nature and resemble the mucous cells. The ental border of some epithelial cells appear erupted and globules of some

secretory material are observed inside the lumen in sections. Various other cells appear vacuolated due to the presence of secretion within the cytoplasm.

The sections of the ducts (Fig. 6) that run along the vasa deferentia in the male *Uromastix* show a very narrow lumen. The epithelial lining has cuboid cells each with a fairly large nucleus and resemble the cells of the oviduct of female. There are two circular layers of smooth muscle fibres separated by a median longitudinal layer of muscle

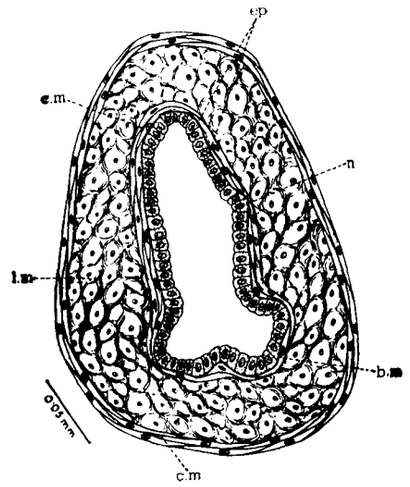

Fig. 6. *Uromastix hardwickii*. Transverse section of the vestigial Mullerian duct of male.

fibres. The longitudinal layer of fibres is comparatively very thick. Sections also show that the lumen of the duct is confluent with the urodeal diverticulum of its respective side.

The proctodaeum has the usual histological features, the cells are very short, and in some the nuclei are so large as to occupy the entire space within the cell, leaving only a thin peripheral cytoplasm in the cell.

The urinary bladder is thin-walled and has transitional epithelium. The muscle coat consists mainly of elastic fibres to which the bladder owes its elasticity. Transverse sections of neck of the bladder (Fig. 7) at the region of the opening show a valvular fold which probably controls the flow of urine into the bladder and out of it.

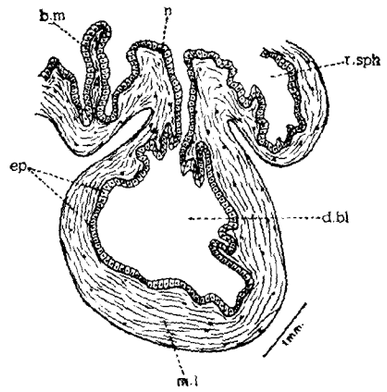

Fig. 7. *Uromastix hardwickii*. Transverse section of the duct of bladder showing the connection with the region of the sphincter. *b.m.*, basement membrane; *d.bl.*, duct of bladder; *ep.*, epithelium; *m.l.*, muscle layer with mixed fibres; *n.* nucleus; *r.sph.*, region of the sphinter.

The kidney has the usual histological features (Fig. 8). The glomeruli in the kidney of *Uromastix* are more numerous than in that of *Hemidactylus*, the ratio between the two being 10:8.

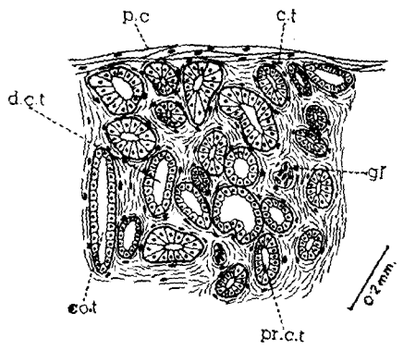

Fig. 8. *Uromastix hardwickii*. Transverse section of the kidney. *c.t.*, connective tissue; *co.t.*, collecting tubule; *d.c.t.*, distal convoluted tubule; *gl.*, glomerulus; *p.c.*, peritoneal covering; *pr.c.t.*, proximal convoluted tubule.

Detailed qualitative and quantitative analysis of the urinary pellets as stated was carried out and the results of the quantitative estimation are given below:

Moisture	7.183%
Ash	15.800%
Calcium	0.360%
Phosphorous	0.063%
Uric acid	69.000%
Allantoin	8.000%

There is a high percentage of uric acid in the urine as in *Hemidactylus* and urea is absent. Creatine and creatinine are present in traces, while hippuric acid is absent. The urine of this lizard has more or less a similar chemical composition, with a high percentage

of allantoin. Pryzelecki has reported the absence of allantoin in lizard urine, but in *Uromsatix*, as shown above, an appreciable quantity is present. This confirms the present author's view already stated with reference to *Hemidactylus*, that the occurence of allantoin is of importance as representing the line of purine metabolism and that it has to be accepted as one of the metabolic products of lizards.

Mechanism

The points that need elucidation are the association of urinary bladder with the urodaeum and of its opening a little away from the urodaeal chamber, and also the mechanism that controls the flow of liquid urine from urodaeum to a chamber in front of the coprodaeum, either directly or through the bladder.

The presence of the opening of bladder in the region of the sphincter and not in its original position has consequently brought about interesting changes in the entire morphology of the cloaca. As already stated, the folds in this region are so modified as to form inlets and outlets for the urine to flow in and out of the bladder. The secondary grooves narrow down as the corresponding folds narrow either towards the bladder or in the direction of the coprodaeum. This arrangement presumably helps in the process of sucking up of the liquid urine by a capillary action. The urine from the urodaeum is first sucked up into the bladder and then from the bladder into the coprodaeum.

The morphology and histology of the different parts of the cloaca and bladder indicate how the urine flows from urodaeum to coprodaeum through the bladder. When the fluid brought by the ureters reaches the openings into the bladder, the bladder dilates and this helps the flow of the urine into it. The pressure which the liquid urine exerts on its way to the bladder seems to act on the valvular fold in the neck of the bladder and closes the outlet facing the coprodaeum. After the bladder is full, the sphincter in the neck of the bladder by its contraction helps in the retention of urine in the bladder. When the bladder contracts, the liquid urine flows through the folds directed towards the coprodaeum.

Urine may also flow direct from urodaeum to coprodaeum without entering into the bladder. Longitudinal folds in the region of sphincter assist in this process and direct flow of urine is brought about by the same mechanism as in the case of *Hemidactylus*. Dehydration of urine takes place in the coprodaeum and it gets solidified there before it passes out along with the faeces.

Discussion

The urinary bladder is ordinarily a diverticulum of the urodaeum, but in *Uromastix* the opening of the bladder is midway between the urodaeum and the coprodaeum. This feature has involved a slight

modification of the structures. The folds in the region of sphincter between urodaeum and coprodaeum are evidently a contribution of the folds of coprodaeum and the anterior portion of urodaeum. This has in no way affected the position of the opening of bladder, though it appears to have slightly shifted from its real place. This device is to help in efficient functioning of the bladder.

It has already been pointed out that the bladder in *Hemidactylus* is an almost functionless organ because it has always been observed in a collapsed state with no trace of urine in it. It has, however, a large opening into the urodaeum, and also a valvular fold in its neck. Since very little urine is excreted at a time, an intermediate channel i.e., the urinary bladder becomes unnecessary and has therefore ceased to function. As the ureters open on prominent papillae, the flow of liquid urine is facilitated, the flow being direct from the urodaeum to coprodaeum. This is assisted by a number of other factors already described in my study of *Hemidactylus*. In *Uromastix*, however, in the usual course comparatively more water is available, and yet the water has to be conserved by dehydrating the urine, which has brought about such a complicated mechanism.

The occurrence of more glomeruli in the kidney of *Uromastix* and the presence of a large functional bladder indicates that quantitatively more liquid urine passes on to the cloaca than in *Hemidactylus*. This also explains the retention of a functional bladder and the availability of comparatively more water.

The position of the duct, which crosses the vas deferens ventrally and runs along it on the lateral side of the testis shows that in all probability it is the vestigial Mullerian duct. The entire duct is considerably raised above the level of Wolffian duct, and all along its length it is attached to a very thin and pigmentless peritoneal fold. The histology of the duct also lends support to the view that it is a vestigial Mullerian duct.

Gadow (1887) in his "Remarks on the cloaca and copulatory organs of the Amniota" has given a note on the presence of Mullerian ducts in the young males of crocodiles and of Wolffian ducts in the females. Rathke was unable to ascertain from the embryo of *Alligator sclerops* whether the canal running along the Wolffian body was a Mullerian duct. He was doubtful about the sex of the embryo. Gadow observed in a male specimen of *Alligator mississipiensis* about 25 cm. long a duct similar in position as in *Uromastix*. In another male specimen 33 cm. he found traces of it in the upper and lower ends while the middle portion was already obliterated. In the female alligator 29 cm. long he observed a Wolffian duct running along the edge of the ovary and the oviduct. A corresponding Wolffian duct is not present in the female *Uromastix*. In Chelonia the persistence of these ducts has been described by Van Wijhe, while in *Lissemys punctata*, which the author has studied (1956), these ducts were absent.

In the male *Uromastix* the presence of urodael diverticula secrets a slimy fluid is a noteworthy feature. This in all probability produces mucus which combines with the spermatic fluid as it passes out into the urodaeum. This may facilitate an easy transference of the fluid during copulation.

Summary

The morphology and histology of the cloaca of *Uromastix hardwickii* have been described.

The urinary bladder of *Uromastix*, unlike that of *Hemidactylus* is functional. Urine from urodaeum flows through the bladder into the coprodaeum. The folds in the region of the sphincter and opening of the bladder are accordingly modified and have grooves on their summits.

Acknowledgment

The work has been carried out under the supervision of Prof. M. L. Bhatia, Head of the Zoology Department, University of Delhi. I am thankful to him for his constant guidance.

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Contributions to the Cytology of Indian Anura (Amphibia): on the number and Morphology of the Chromosomes of Three Species of *Rana* (Ranidae)

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(Communicated by Professor R. V. SESHAIYA, M.A., F.Z.S.I.)

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Introduction

As remarked elsewhere (Natarajan, 1958 a,b) with the exception of Bole Gowda's (1948) work on *Uperodon systoma* there exists practically no detailed work on the chromosomes of Indian frogs. In the present investigation I have therefore made a detailed comparative study of the number and morphology of the chromosomes of three common South Indian forms, viz., *Rana hexadactyla* Lesson, *R. cyanophlyctis* Schneider and *R. tigrina* Daud. The chromosome number in *R. tigrina* has previously been recorded by Asana and Kharadi (1937) who, however, have not studied the morphology of the chromosomes in detail.

The study of the metaphase plates was made chiefly from the acetocarmine and Feulgen squashes of the testes, supplemented by sections stained in Iron alum, crystal violet and Feulgen. For fixation of the testes Sanfelice and Carnoy's fluids proved to be excellent.

Observations

1. *Rana hexadactyla.*

Spermatogonial metaphase: A polar view of the spermatogonial metaphase plate (Figs. 1 and 2) shows 26 chromosomes, all metacentrics. The larger chromosomes are seen lying towards the periphery with their arms pointing outwards and the smaller ones occupy the central area enclosed by the larger ones. A careful examination of the plate shows that the chromosomes lying close together are very similar in shape and size. This feature enables the identification of the chromosome pairs.

Fig. 1. Spermatogonial metaphase plate-polar view-*Ranahexadactyla*-Feulgen squash-Photomicrograph. X ca 2500.

Photomicrograph. X ca 2500.

Fig. 2. Photomicrograph showing the spermatogonial metaphase plate in *Rana cyanophlyctis*-polar view-acetocarmine squash. X ca 2500.

Fig. 3. Spermatogonial metaphase chromosomes of *Rana tigrina*-polar view-acetomine squash. X ca 3000.

A karyogram drawn from another squash preparation is shown in Fig. 3. All the 26 chromosomes resolve into 13 homologous pairs which may be arranged into two groups on the basis of their size. The first five pairs constitute a finely graded series of large chromosomes, while the remaining eight pairs constitute a group of smaller chromosomes, all of which are almost of the same size. The striking difference between the last pair of the large chromosomes (pair 5) and the first pair of the small chromosome (pair 6) can be easily observed. The ten large chromosomes are typically 'V'-shaped with arms of equal length and have median centromeres. The smaller chromosomes, though not characteristically 'V'-shaped, have two arms of equal length suggestive of median centromeres.

2. *Rana cyanophlyctis.*

Spermatogonial metaphase: Figs. 4 and 5 represent a polar view of a spermatogonial metaphase plate showing 26 metacentric chromosomes which resolve into 13 homologous pairs when arranged serially (Fig. 6). It may also be noted that the chromosome complement can be classed into two definite groups, viz., one group of larger chromosomes consisting of pairs 1, 2, 3, 4, and 5 a second group of smaller chromosomes comprising the pairs 6 to 13. Further critical analysis gives the following results. i. Three pairs of large chromosomes (pairs 1, 2 and 4) show inequality of arms and possess sub-median

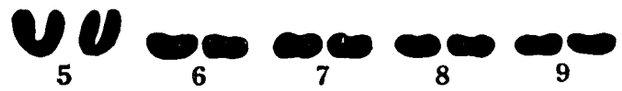
Fig. 4. Camera lucida drawing of Fig. 1 X ca 2000.
Fig. 5. Camera lucida drawing of Fig. 2. X ca 2000.
Fig. 6. Camera lucida drawing of Fig. 3. X ca 4000.

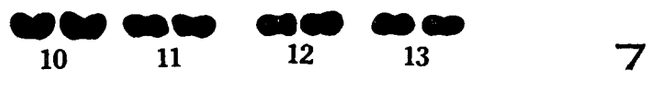
centromeres ii. Two pairs of large chromosomes (pairs 3 and 5) are 'V'-shaped with equal arms and median centromeres. iii. Eight pairs of smaller chromosomes (pairs 6 to 13) have equal arms and median centromeres.

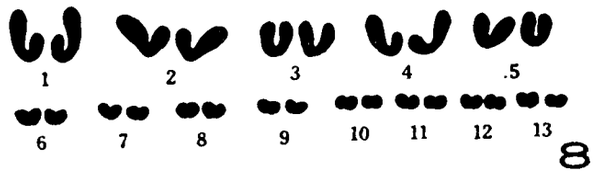
3. *Rana tigrina.*

Spermatogonial metaphase: The karyotype consists of 26 metacentric chromosomes as can be seen from Figs. 7 and 8. A karyogram is shown in fig. 9. As in the previous instances, the complement consists of five pairs of large and eight pairs of small chromosomes. On further examination, it can be seen that one pair of large chromosomes (pair 1) has median centromeres, four pairs of large chromosomes

(pairs 2 to 5) are with unequal arms and sub-median centromeres, and eight pairs of small chromosomes have median centromeres.







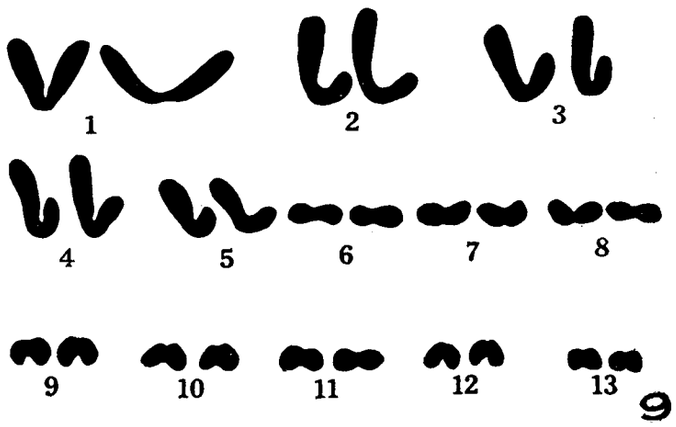


Fig. 7. Homologous pairs of spermatogonial chromosomes of *R. tigrina* serially arranged in order of size. X ca 3500
Fig. 8. Spermatogonial chromosomes of *R. cyanophlyctis* arranged in order of their size, serially, in homologous pairs. X ca 2500.
Fig. 9. Homologous pairs of spermatogonial chromosomes of R. tigrina serially arranged in order of size. X ca 4000.

Discussion

A study of the number and morphology of the chromosomes of the above three species of *Rana* belonging to the family Ranidae of the suborder Diplasiocoela, shows very clearly some fundamental similarities in the karyotypes of the different species investigated. The most striking one is the occurrence of metacentric chromosomes. Secondly, the chromosomes of each species examined fall into two well-defined groups. Yet another feature is the presence of the same number (2n=26) of chromosomes in all the forms examined.

The suborder Diplasiocoela holds the largest number of cytologically investigated species among Anura, and the diploid chromosome number in almost all the species of the family Ranidae is invariably 26 (Witschi, 1922, 1924; Iriki, 1932; Galgano, 1933; Sato, 1934; Prokofiewa. 1935; Wickbom, 1945; Matthey, 1949 and Makino, 1951.), the exceptions being only very few (Swingle, 1917, 1921; Durken, 1938). After a more thorough study Matthey (1949) has stated that the family Ranidae is 'remarkably homogeneous'. The present work has shown that the diploid chromosome number of 26 is uniform in all the three species of *Rana* examined and thus confirms the views of Matthey.

Wickbom (1950) has stated that the occurrence of only metacentric chromosomes in the suborders Anomocoela, Procoela and Diplasiocoela indicates that they are more specialised and stable cytologically whereas in the other two suborders, viz., Amphicoela and Opisthocoela acrocentrics are present and on this account they must be considered as primitive.

The present investigation and also the previous ones on the chromosomes of *Rhacophorus maculatus* Gray (Natarajan, 1958a) and *Bufo melanostictus* Schneider (Natarajan, 1958b) show clearly that the various species of Anura studied, belonging to the suborders Procoela and Diplasiocoela, are uniform and homogeneous from a cytological point of view. In all the forms examined, only metacentric chromosomes are seen occurring in two definite groups. Also, no heteromorphic pair or pairs of chromosomes occur in any karyotype. These facts which are indicative of the specialisation and also the stability of the karyotypes of the anurans described in the present study seem to justify Wickbom's views mentioned earlier, and also those of Seshachar (1941) and Matthey (1949), who have stated that Anura, in general, is a fairly homogeneous and stable group from cytological point of view.

Summary

1. The chromosomes of three species of Anura, viz., *Rana hexadactyla* Lesson, *R. cyanophlyctis* Schneider and *R. tigrina* Daud have been studied.

2. The diploid chromosome numbers of all the three species have been determined, and two of these determinations are new. In the case of R. tigrina, the figures and descriptions given by the previous authors have been verified and a more detailed study of the chromosome morphology has been made. The diploid chromosome number, is 26 in all the three species.

3. In all the forms only metacentric chromosomes are seen, no acrocentrics being present.

4. The chromosomes of each form fall into two well-defined groups —a larger and a smaller one.

5. No heteromorphism is seen in any pair of any karyotype, indicating thereby that the sex chromosomes are not distinguishable cytologically.

Acknowledgment

I wish to express my sincere thanks to Professor R. V. Seshaiya, Director and Professor, Marine Biological Station, Portonovo for suggesting the problem and also for guidance and instruction. My thanks are also due to the Ministry of Education, Government of India for the award of a scholarship.

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Authorship of Names of Indian Fishes Proposed in "Histoire Naturelle Des Poissons" by Cuvier and Valenciennes and Recorded By Day

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Introduction

It has been the practice to credit dual authorship to the new names proposed by Cuvier and Valenciennes in their monumental contribution to ichthyology, 'Histoire Naturelle Des Poissons', comprising of 22 volumes published from 1828-1849. Baron Cuvier passed away in 1832 while volume 9 was in press but Valenciennes who continued the work thereafter retained the name of his former senior colleague in the subsequent numbers of the series presumably as a mark of courtesy. Even from the beginning different sections of the work were under the individual responsibility of each of them and these have been indicated in the appropriate places in the text though not very prominently. Under the above circumstances it is not a correct procedure according to International Code of Zoological Nomenclature to add "Cuvier and Valenciennes" after the specific names. The convention of dual authorship is being broken gradually but "Histoire Naturelle Des Poissons" being a scarce publication is not accessible to many workers for reference. Bailey[1] has done a very useful service by making a critical study of the work and separating the portions contributed by each author. So far as Indian workers are concerned this has helped very little to solve the difficulty as 'Day's *Fishes of India* (1876-1888) and *Fishes* (1889) in the "*Fauna of British India*" Series, which are also comparatively scarce, still remain the standard books of reference and a comparison of all these publications for arriving at the correct authorship is by no means an easy task for many. Of the 1418 fishes described by Day, the names of 257 were those proposed for the first time in "Histoire Naturelle Des Poissons" and traditionally quoted under dual authorship. To make matters easy for those who are unfavourably placed so far as library facilities are concerned the species are listed below with the names of the author checked against each of them.

The genera and species as given in the *Fauna of British India, Fishes*, are retained though many of them have undergone nomenclatural revision. In the absence of a complete revision of Day's work it is felt that no useful purpose will be served in effecting changes in the

[1]Bailey, Reeve M .1951, *Copeia*, No. 3, August 31, pp. 249-251.

names coming under the authorship of Cuvier and Valenciennes only. Latest names of some common and economically important species which are known at present under specific names different from those recorded by Day are given as foot notes.

List of Indian fishes recorded by Day the names of which have been proposed by Cuvier and Valenciennes in "Histoire Naturelle Des Poissons"

Fauna of British India—Fishes Vol. I

Page.	Ser. No.	Name of Fish	Vol.[2]	Page[3]	Author.
1	2	3	4	5	6
117	123	*Clarias dussumieri*	XV	382	Valenciennes.
120	127	*Silurus cochinchinensis*	XIV	352	Valenciennes.
133	141	*Callichrous malabaricus*	XIV	353	(Valenciennes).
142[4]	152	*Pangasius buchanani*	XV	45	Valenciennes.
145[5]	154	*Silundia gangetica*	XV	49	Valenciennes.
156	165	*Macrones oculatus*	XIV	424	(Valenciennes).
160	169	*Macrones keletius*	XIV	411	(Valenciennes).
174	181	*Arius caelatus*	XV	66	Valenciennes.
176	184	*Arius venosus*	XV	69	Valenciennes.
178	186	*Arius subrostratus*	XV	62	Valenciennes.
184	195	*Arius nella*	XV	162	(Valenciennes).
188	201	*Arius dussumieri*	XV	84	Valenciennes.
221	238	*Lepidocephalichthys-thermalis*	XVIII	78	(Valenciennes).
235	267	*Nemachilus spilopterus*	XVIII	27	(Valenciennes).
262	296	*Labeo dussumieri*	XV	258	(Valenciennes).
273	315	*Osteochilus chalybeatus*	XVI	271	(Valenciennes).
275	317	*Osteochilus cephalus*	XVI	347	(Valenciennes).
287[6]	332	*Catla buchanani*	XVII	411	Valenciennes.
292	337	*Amblypharyngodon melettina*	XVII	304	(Valenciennes).
301	342	*Barbus chrysopoma*	XVI	165	Valenciennes.
303	346	*Barbus roseipinnis*	XVI	169	Valenciennes.
304	348	*Barbus micropogon*	XVI	188	Valenciennes.
316	373	*Barbus macrolepidotus*	XVI	280	(Valenciennes).

2 & 3. Volume and page in "Histoire Naturelle Des Poissons" in which the species referred to is described.

4. *Pangasius pangasius* (Hamilton)
5. *Silonia silondia* (Hamilton)
6. *Catla catla* (Hamilton)

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
322	384	*Barbus amphibius*	XVI	282	(Valenciennes).
323	386	*Barbus mahecola*	XVII	305	(Valenciennes).
324	387	*Barbus apogon*	XVI	392	Valenciennes.
329[7]	398	*Barbus stigma*	XVII	93	(Valenciennes).
330	400	*Barbus thermalis*	XVII	94	(Valenciennes).
333	407	*Barbus filamentosus*	XVII	96	(Valenciennes).
342	419	*Rohtee belangeri*	XVII	99	(Valenciennes).
349	429	*Barilius gatensis*	XVII	309	(Valenciennes).
357	441	*Danio chrysops*	XVII	308	(Valenciennes).
363	451	*Chela sardinella*	XVII	344	(Valenciennes).
372	463	*Clupea leiogaster*	XX	270	(Valenciennes).
373	464	*Clupea longiceps*	XX	273	(Valenciennes).
373	465	*Clupea fimbriata*	XX	359	(Valenciennes).
374	467	*Clupea lile*	XX	378	(Valenciennes).
377	472	*Clupea toli*	XX	435	(Valenciennes).
378	473	*Clupea melanura*	XX	441	(Valenciennes).
380	475	*Pellona filigera*	XX	322	Valenciennes.
381	479	*Pellona ditchela*	XX	314	Valenciennes.
383	484	*Pellona leschenaultii*	XX	311	Valenciennes.
384	485	*Opisthopterus tartoor*	XX	328	(Valenciennes).
391	497	*Engraulis dussumieri*	XXI	69	Valenciennes.
393	500	*Engraulis taty*	XXI	60	Valenciennes.
393	501	*Engraulis purava*	XXI	65	Valenciennes.
396	505	*Coilia reynaldi*	XXI	81	Valenciennes.
397	508	*Coilia quadrigesimalis*	XXI	83	Valenciennes.
397	509	*Coilia dussumieri*	XXI	81	Valenciennes.
399	511	*Dussmieria acuta*	XX	467	Valenciennes.
411	524	*Saurida nebulosa*	XXII	506	Valenciennes.
416	530	*Haplochilus lineatus*	XVIII	381	(Valenciennes).
418	532	*Belone melanostigma*	XVIII	450	Valenciennes.
419	533	*Belone annulata*	XVIII	447	Valenciennes.
423	538	*Hemirhamphus leucopterus*	XIX	48	Valenciennes.
424	541	*Hemirhamphus georgii*	XIX	37	Valenciennes.
425	543	*Hemirhamphus reynaldi*	XIX	39	Valenciennes.
425	544	*Hemirhamphus xanthopterus*	XIX	47	Valenciennes.
426	546	*Hemirhamphus limbatus*	XIX	44	Valenciennes.

7. *Puntius sophore* Hamilton

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
426	547	*Hemirhamphus dispar*	XIX	58	Valenciennes.
426	548	*Hemirhamphus buffonis*	XIX	48	Valenciennes.
429	551	*Exocoetus micropterus*	XIX	127	Valenciennes.
430	554	*Exocoetus poecilopterus*	XIX	112	Valenciennes.
430	555	*Exocoetus altipinnis*	XIX	109	Valenciennes.
431	557	*Exocoetus mento*	XIX	124	Valenciennes.
441	559	*Cromileptes altivelis*	II	324	(Valenciennes).
449	570	*Serranus diacanthus*	II	319	Valenciennes.
449	571	*Serranus sexfasciatus*	II	360	Valenciennes.
450	573	*Serranus erythrusus*	II	320	Valenciennes.
451	575	*Serranus corallicola*	II	336	Valenciennes.
452	577	*Serranus semipunctatus*	II	341	Valenciennes.
453	579	*Serranus dermochirus*	VI	513	Valenciennes.
453	580	*Serranus morrhua*	IX	434	Valenciennes.
454	581	*Serranus angularis*	II	35	Cuvier.
458	590	*Serranus boelang*	II	308	Valenciennes.
461	593	*Grammistes punctatus*	VI	504	Valenciennes.
462	595	*Diploprion bifasciatum*	II	137	Cuvier.
465	596	*Lutjanus sebae*	II	411	(Cuvier).
466	599	*Lutjanus annularis*	II	484	(Cuvier).
469	603	*Lutjanus biguttatus*	VI	507	(Valenciennes).
470	605	*Lutjanns lemniscatus*	II	240	(Valenciennes).
471	607	*Lutjanus rivulatus*	II	414	(Cuvier).
478	620	*Lutjanus marginatus*	II	425	(Cuvier).
479	621	*Lutjanus yapilli*	II	483	(Cuvier).
480	624	*Lutjanus madras*	VII	446	(Valenciennes).
481	625	*Lutjanus decussatus*	II	487	(Cuvier).
488	635	*Ambassis commersoni*	II	176	Cuvier.
490	639	*Ambassis thermalis*	III	493	Cuvier.
491	640	*Apogon multitaeniatus*	II	159	Cuvier.
493	644	*Apogon taeniatus*	II	159	Cuvier.
494	646	*Apogon quadrifasciatus*	II	153	Cuvier.
497	653	*Apogon maculosus*	VI	493	Valenciennes.
498	654	*Apogon nigripinnis*	II	152	Cuvier.
499	656	*Apogon auritus*	VII	443	Valenciennes.
499	658	*Apogon lineolatus*	II	160	Cuvier.
500	661	*Apogon orbicularis*	II	155	Cuvier.

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
502	664	*Chilodipterus quinquelineatus*	II	167	Cuvier.
503	666	*Dules marginatus*	III	116	Cuvier.
505	668	*Therapon puta*	III	131	Cuvier.
506	670	*Therapon theraps*	III	129	Cuvier.
507	672	*Therapon argenteus*	III	139	(Cuvier).
511	679	*Pristipoma dussumieri*	V	250	Cuvier.
512	680	*Pristipoma guoraca*	V	256	Cuvier.
517	687	*Diagramma griseum*	V	306	Cuvier.
518	690	*Diagramma punctatum*	V	302	Cuvier.
522	697	*Scolopsis monogramma*	V	338	(Cuvier).
523	698	*Scolopsis cancellatus*	V	351	(Cuvier).
526	703	*Synagris striatus*	VI	252	(Valenciennes).
528	705	*Synagris tolu*	VI	248	(Valenciennes).
529	707	*Synagris taeniopterus*	VI	246	(Valenciennes).
530	709	*Aphareus rutilans*	VI	490	Cuvier.
531	710	*Smaris balteatus*	VI	424	Valenciennes.
533	713	*Caesio chrysozona*	VI	440	Cuvier.
536	717	*Gerres oblongus*	VI	479	Cuvier.
537	718	*Gerres filamentosus*	VI	482	Cuvier.
538	721	*Gerres poeti*	VI	468	Cuvier.
539	722	*Gerres lucidus*	VI	477	Cuvier.
539	723	*Gerres limbatus*	VI	476	Cuvier.

Fauna of British India—Fishes Vol. II

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4[8]	5[9]	6
10	739	*Chaetodon ocellatus*	VII	229	(Cuvier).
25	757	*Upeneoides sulphureus*	III	450	(Cuvier).
27	761	*Upeneoides taeniopterus*	III	451	(Cuvier).
31	766	*Upeneus luteus*	VII	521	Valenciennes.
33	769	*Upeneus cinnabarinus*	III	475	Cuvier.
35	771	*Crenidens forskaelii*	VI	377	Valenciennes.

8 & 9: Volume and page in "Histoire Naturelle Des Poissons" in which the species referred to is described.

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
36	772	*Sargus noct*	VI	51	Valenciennes.
38	774	*Lethrinus cinereus*	VI	293	Valenciennes.
38	775	*Lethrinus karwa*	VI	311	Valenciennes.
40	777	*Lethrinus ornatus*	VI	310	Valenciennes.
51	791	*Cirrhitichthys fasciatus*	III	76	(Cuvier).
54	794	*Sebastichthys strongia*	IV	323	(Cuvier).
59	801	*Scorpaenopsis venosa*	IV	317	(Cuvier).
61	803	*Pterois zebra*	IV	367	Cuvier.
63	806	*Pterois radiata*	IV	369	Cuvier.
66	809	*Gymnapistus niger*	IV	415	(Cuvier).
67	810	*Gymnapistus dracaena*	IV	403	(Cuvier).
67	811	*Amblyapistus taenianotus*	IV	404	(Cuvier).
68	812	*Amblyapistus longispinis*	IV	408	(Cuvier).
82	827	*Nandus marmoratus*	VII	482	Valenciennes.
88	833	*Teuthis vermiculata*	X	126	(Valenciennes).
89	835	*Teuthis virgata*	X	133	(Valenciennes).
90	836	*Teuthis concatenata*	X	127	(Valenciennes).
90	837	*Teuthis margaritifera*	X	145	(Valenciennes).
90	838	*Teuthis sutor*	X	148	(Valenciennes).
93	841	*Myripristis botche*	III	181	Cuvier.
100	849	*Pempheris malabarica*	VII	308	Cuvier.
103	852	*Polynemus heptadactylus*	III	390	Cuvier.
103	853	*Polynemus xanthonemus*	VII	517	Valenciennes.
105	855	*Polynemus sexfilis*	VII	115	Valenciennes.
110	861	*Umbrina dussumieri*	IX	481	Valenciennes.
110	862	*Umbrina russellii*	V	178	Cuvier.
113	864	*Sciaena miles*	V	94	Cuvier.
114	866	*Sciaena sina*	V	122	(Cuvier).
116	869	*Sciaena axillaris*	V	113	(Cuvier).
117	870	*Sciaena albida*	V	93	(Cuvier).
120	874	*Sciaena belangeri*	V	120	(Cuvier).
121	875	*Sciaena semiluctuosa*	V	97	(Cuvier).
127	883	*Otolithus maculatus*	V	64	Cuvier.
129	885	*Otolithus argenteus*	V	62	Cuvier.
135	891	*Trichiurus savala*	VIII	251	Cuvier.
141	897	*Acanthurus matoides*	X	204	Valenciennes.
141	898	*Acanthurus gahm*	X	219	Valenciennes.

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
142	900	*Acanthurus melanurus*	X	240	Valenciennes.
146	906	*Naseus brevirostris*	X	277	Valenciennes.
151	909	*Caranx kurra*	IX	44	Cuvier.
152	910	*Caranx melampygus*	IX	116	Cuvier.
152	911	*Caranx jarra*	IX	109	Cuvier.
157	918	*Caranx boops*	IX	46	Cuvier.
160	921	*Caranx kalla*	IX	49	Cuvier.
160	922	*Caranx ire*	XIX	57	Valenciennes.
163	926	*Caranx oblongus*	IX	128	Cuvier.
167	931	*Caranx leptolepis*	IX	63	Cuvier.
174	938	*Chorinemus sancti-petri*	VIII	379	Cuvier.
174	939	*Chorinemus moadetta*	VIII	382	Cuvier.
176	941	*Chorinemus tala*	VIII	377	Cuvier.
176	942	*Chorinemus toloo*	VIII	377	Cuvier.
178	944	*Trachynohis russellii*	VIII	436	Cuvier.
184	950	*Psenes javanicus*	IX	264	Valenciennes.
187	953	*Equula dussumieri*	X	77	Valenciennes.
187	956	*Equula bindus*	X	78	Valenciennes.
189	957	*Equula blochii*	X	84	Valenciennes.
190	958	*Equula brevirostris*	X	83	Valenciennes.
190	959	*Equula lineolata*	X	86	Valenciennes.
193	963	*Equula oblonga*	X	85	Valenciennes.
196[10]	967	*Lactarius delicatulus*	IX	238	Valenciennes.
205[11]	976	*Thynnus thunnina*	VIII	104	Cuvier.
208	979	*Pelamys chiliensis*	VIII	163	Cuvier.
209[12]	980	*Cybium kuhlii*	VIII	178	Cuvier.
210	981	*Cybium interruptum*	VIII	172	Cuvier.
212	984	*Cybium lineolatum*	VIII	170	Cuvier.
217	990	*Uranoscopus guttatus*	III	305	Cuvier.
218	991	*Ichthyoscopus inermis*	III	310	(Cuvier).
219	992	*Percis punctata*	III	264	Cuvier.
221	994	*Percis hexophthalma*	III	271	Cuvier.
237	1009	*Platycephalus tuberculatus*	IV	258	Cuvier.
239	1012	*Platycephalus punctatus*	IV	243	Cuvier.

10. *Lactarius lactarius* (Bloch & Schneider)
11. *Euthynnus alletteratus affinis* (Cantor)
12. *Scomberomorus guttatus* (Bloch & Schneider)

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
240	1013	*Platycephalus serratus*	IV	259	Cuvier.
240	1014	*Platycephalus carbunculus*	IX	461	Valenciennes.
243	1017	*Dactylopterus orientalis*	IV	134	Cuvier.
255	1030	*Gobius criniger*	XII	82	Valenciennes.
258	1035	*Gobius biocellatus*	XII	73	Valenciennes.
261	1041	*Gobius tentacularis*	XII	128	Valenciennes.
261	1042	*Gobius actipinnis*	XII	80	Valenciennes.
264	1047	*Gobius elegans*	XII	58	Valenciennes.
265	1050	*Gobius albopunctatus*	XII	57	Valenciennes.
266	1052	*Gobius semidoliatus*	XII	67	Valenciennes.
275	1066	*Apocryptes rictuosus*	XII	151	Valenciennes.
278	1070	*Apocryptes dentatus*	XII	148	Valenciennes.
283	1076	*Boleophthalmus dussumieri*	XII	207	Valenciennes.
283	1077	*Boleophthalmus dentatus*	XII	208	Valenciennes.
289	1085	*Eleotris porocephalus*	XII	237	Valenciennes.
290	1086	*Eleotris muralis*	XII	253	Valenciennes.
291	1088	*Eleotris sexguttata*	XII	254	Valenciennes.
292	1091	*Eleotris tumifrons*	XII	241	Valenciennes.
298	1101	*Gobioides gracilis*	XII	166	(Valenciennes).
305	1112	*Callionymus lineolatus*	XII	307	Valenciennes.
306	1114	*Callionymus opercularis*	XII	305	Valenciennes.
308	1116	*Petroscirtes punctatus*	XI	286	(Valenciennes).
310	1120	*Petroscirtes cyprinoides*	XI	286	(Valenciennes).
310	1121	*Petroscirtes breviceps*	XI	283	(Valenciennes).
316	1131	*Salarias quadricornis*	XI	329	Valenciennes.
316	1132	*Salarias lineatus*	XI	314	Valenciennes.
318	1135	*Salarias dussumieri*	XI	310	Valenciennes.
318	1136	*Salarias periophthalmus*	XI	311	Valenciennes.
322	1143	*Salarias frenatus*	XI	342	Valenciennes.
322	1144	*Salarias vermiculatus*	XI	301	Valenciennes.
330	1154	*Cepola abbreviata*	X	403	Valenciennes.
332	1156	*Mastacembelus unicolor*	VIII	453	Cuvier.
335	1161	*Sphyraena jello*	III	349	Cuvier.
336	1163	*Sphyraena commersonii*	III	352	Cuvier.
337	1164	*Sphyraena obtusata*	III	350	Cuvier.
339	1167	*Antherina duodecimalis*	X	458	Valenciennes.
342	1170	*Mugil cunnesius*	XI	114	Valenciennes.

Page.	Ser. No.	Name of Fish	Vol.	Page	Author.
1	2	3	4	5	6
344	1172	*Mugil carinatus*	XI	148	Valenciennes.
347	1179	*Mugil dussumieri*	XI	147	Valenciennes.
348	1180	*Mugil subviridis*	XI	115	Valenciennes.
352	1188	*Mugil amarulus*	XI	133	Valenciennes.
352	1189	*Mugil labiosus*	XI	125	Valenciennes.
362	1202	*Ophiocephalus micropeltes*	VII	427	Cuvier.
368	1209	*Polyacanthus cupanus*	VII	357	Cuvier.
374	1216	*Regalicus russellii*	X	377	(Valenciennes).
381	1226	*Pomacentrus trilineatus*	V	428	Cuvier.
382	1227	*Pomocentrus trimaculatus*	V	441	(Cuvier).
384	1230	*Pomocentrus littoralis*	V	425	Cuvier.
388	1240	*Glyphidodon melas*	V	472	Cuvier.
388	1241	*Glyphidodon septemfasciatus*	V	463	Cuvier.
389	1242	*Glyphidodon coelestinus*	V	401	Cuvier.
389	1243	*Glyphidodon bengalensis*	V	458	Cuvier.
390	1244	*Glyphidodon antjerius*	V	481	Cuvier.
391	1247	*Heliastes lepidurus*	V	498	Cuvier.
397	1253	*Labroides dimidiatus*	XIII	136	(Valenciennes).
405	1 66	*Platyglossus dussumieri*	XIII	478	(Valenciennes).
407	1270	*Platyglossus nebulosus*	XIII	461	(Valenciennes).
411	1278	*Novacula punctulata*	XIV	73	Valenciennes.
421	1294	*Pseudodox moluccanus*	XIV	305	(Valenciennes).
425	1300	*Pseudoscarus aeruginosus*	XIV	257	(Valenciennes).
426	1301	*Pseudoscarus rivulatus*	XIV	223	(Valenciennes).
426	1302	*Pseudoscarus dussumieri*	XIV	252	(Valenciennes).
427	1304	*Pseudoscarus erythrodon*	XIV	255	(Valenciennes).

Summary

According to International Code of Zoological Nomenclature, the conventional practice of crediting dual authorship to the names of fishes first proposed by Cuvier and Valenciennes in their "Histoire Naturelle des Poissons" is not considered correct since the different sections were written under their individual responsibility. Of the 22 volumes of the above work published from 1828 to 1849, Baron Cuvier had share only up to the 9th volume which was in press at the time of his death in 1832. 257 species under the dual authorship of Cuvier and Valenciennes are recorded by Day in his *Fishes of India* (1876-1888) and *Fishes* (1889) in the *"Fauna of British India"* Series. Of these, Curvier is responsible for descriptions of 99 species and Valenciennes for 158 species. These are checked and listed with the appropriate author's name against each species.

Development of The Kidney in *Oryzias melastigma* McClelland

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(Communicated by Prof. R. V. SESHAIYA, F.A.Sc)

CONTENTS

Introduction

Several investigators have described the development of the kidney of teleosts. In particular, mention may be made of the accounts given by Emery (1880), Felix (1907), Guitel (1906), Pavelenko (1916), Strorer (1932), Maschkowzeff (1926), Brachet (1935), Fraser (1927) and Moghe (1945). Gray (1930, 1932) has given a complete account of the development of the Amphibian kidney. But the most important review of the development of the vertebrate kidney in recent years is by Fraser (1950) who has given convincing reasons for regarding the excretory system as a holonephros and that there is undoubted homogeneity of pro-, meso- and metanephros. Notwithstanding this homogeneity, Fraser has proposed the retention of the original terms pronephros mesonephros and metanephros, but with the proviso that the term pronephros should only be applied to the organ in larval anamnia and to that of few adult teleosts.

The points at issue in the development of the kidney of teleosts relate to (1) the origin of pronephric rudiments and archinephric duct, (2) which of these arises first, and (3) the origin of mesonephrogenous primordia, whether they arise from the intermediate cell-mass or as poliferations of the archinephric duct. Felix (1897) from his study on Salmon concluded that the pronephros and the duct arose from the lateral plate. Swaen and Brachet (1899) observed that the

duct and the pronephric chamber are made up of both somatic and splanchnic layers of the mesoderm. Maschkowzeff (1935) after studying the development of the kidney in Salmon, has stated that the lower wall of the nephrotome has become incorporated in the general body cavity and the duct grows out of the somatic or the dorsal wall of the pronephric chamber. Fraser (1950) has remarked that Maschkowzeff's intrepretation is the correct one notwithstanding the fact that the explanation is not convincing. The study of the developmet of the kidney in *Oryzias* throws light on these points and shows that the development of the kidney of teleosts falls into line with that of other vertebrates.

Material and Methods

Specimens of *Oryzias melastigma* are quite common and available in large numbers in ponds, ditches and paddy fields. The adult fish measures 2—3 cms. in total length and breeds throughout the year. Especially during the monsoon rains, large number of females with eggs suspended from the vent can easily be spotted out. An adult female lays 10—20 eggs measuring 1.0 — 1.2 mm. in diameter. The females carrying the eggs were caught by a hand-net and removed to the laboratory in a basin of water. The eggs were collected and kept in finger-bowls for the study of their development. At a temperature of 27°+1°C the eggs take usually eight days to hatch.

The eggs were examined alive periodically, and for purpose of sectioning closely graded stages of developing eggs were fixed in Zenker's fluid and Bouin's picro-formol. For the kidneys of post-embryonic and adult stages, Zenker's fluid and mercuro-formol gave better results than Bouin's fluid. Sections were stained in Delafield's haematoxylin and eosin and Heidenhain's iron alum haematoxlyin. Mallory's acid fuschin-aniline blue stain was also used to stain the sections.

To get a better understanding of the size, shape and course of the developing kidney tubules plastic reconstructions were made. Wax plates of 1 mm. thickness were prepared by mixing and melting bees wax, paraffin and rosin in the proportion of 6: 4: 2. With the help of a camera lucida the outlines of the kidney tubules in all the sections in which they were found were drawn on paper. The drawings were transferred to the wax plate by means of carbon paper and the necessary portions were cut out with a sharp scalpel. These were piled in the serial order and a steady pressure was applied to make the sections adhere to each other. The cut edges of the pieces were smoothed with a warm scalpel.

For micro-dissection of the developing kidney, embryonic and larval stages were stained in Borax carmine and alum carmine. After destaining in 70% acid alcohol the material was dehydrated and cleared in clove oil. The kidney was dissected out with the help of fine needles under a binocular microscope and mounted on a glass slide.

The Development of the Pronephros

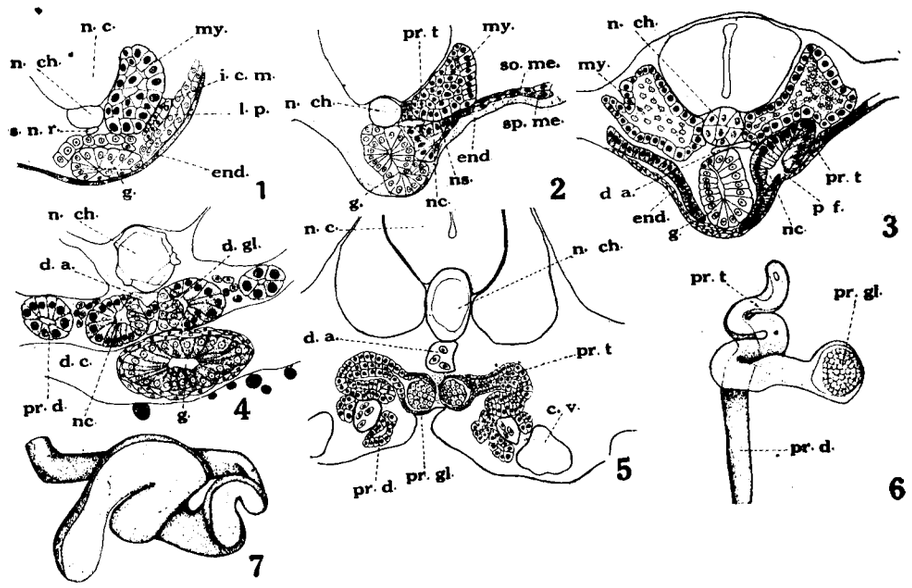
The earliest rudiment of the pronephros is clearly seen in an embryo of about 30 hours of development. Transverse sections of this stage show a well defined nerve cord, notochord and a gut rudiment. The mesoderm on each side is clearly differentiated into 10 mesoblastic somites. In the anterior region of the embryo, at the level of the III, IV and V msoblastic somites, intermediate cell-mass is well differentiated (Fig. 1) and has separated from the somites. In transverse sections passing through the same region in earlier embryos, the separation from the somites has not taken place. The intermediate cell-mass is situated on the ventro-lateral aspect of the somite between it and the lateral plate mesoderm. The intermediate cell-mass is not segmented at this stage or even in later stages, and 'nephrotomes' or segmented masses of nephrotomic plate are absent as in all other teleosts. The intermediate cell-mass has become arranged in two layers in the region of segments III, IV and V by the rearrangement of the cells into an upper somatic layer and a lower splanchnic layer. Behind segment V, the intermediate cell-mass extends to the X segment and even a little distance posterior to it, and is in the form of a more or less solid cord of cells. A narrow lumen appears in the solid cord of cells and thus the pronephric or archinephric duct is differentiated. The lumen first makes its appearance in the anterior region and gradually extends backwards at later stages. Typically in vertebrate development this lumen communicates on the one hand with the myocoel and on the other with the splanchnocoel. In the stage under discussion, the splanchnocoel has not made its appearance in the lateral plate mesoderm. The nephrotome, in the sense in which the term is employed by Fraser (1950), is differentiated from the intermediate cell-mass by the rearrangement of the cells. The future excretory organ is differentiated from the intermediate cell-mass. The ventral wall of the nephrotomic plate is closely applied to the somatic layer of the lateral plate mesoderm and shows a tendency to fuse with it.

In the region of the somites VI, VII, VIII and IX a few cells constituting the primordia of the mesonephros have already separated from the intermediate cell-mass. Each primordium contains a few cells and lies close to the pronephric duct. We will refer to this in detail while dealing with the development of the mesonephros.

The Differentiation of the Pronephric Tubule

The next stage examined was that of an embryo of about 42 hours of development with 16 mesoblastic somites. The ventral wall of the nephrotome has fused with the underlying somatic layer and the nephrocoel is very prominent (Fig. 2). The dorsal or somatic wall of the nephrotome has thickened in the region of the somites III, IV and V and bulges upwards as three prominent thickenings. But these

thickenings fuse together to form the primordia of the pronephric tubule very early in development. The nephrocoel is well developed in the nephrotome and it communicates with the narrow body-cavity that has



EXPLANATION TO FIGURES:

Fig. 1. A transverse section passing through the 4th somite of an embryo of about 30 hours of development to show the intermediate cell-mass in the form of a distinct group of cells on the ventro-lateral aspect of the myotome.

Fig. 2. A transverse section passing through the 3rd somite of an embryo of about 42 hours of development showing the nephrocoel in the nephrotome.

Fig. 3. A transverse section passing through the pronephric region of an embryo of about 42 hours of development to show the pronephric tubule arising from the dorso-lateral angle of the nephric chamber on the right side.

Fig. 4. A transverse section passing through the pronephric region of an embryo of about 84 hours of development to show the vascular tuft from the dorsal aorta invaginating the medial wall of the pronephric chamber or nephrocoel to form the glomus.

Fig. 5. A transverse section passing through the pronephric region of an embryo at about the time of hatching showing the pronephric tubule, the glomerulus and the pronephric duct.

Fig. 6. The pronephric tubule of the left side of a just hatched larva. Dissected and stained preparation

Fig. 7. Diagram of a plastic reconstruction of the pronephric tubule of an embryo of about 180 hours of development to show the shape and course of the tubule.

c.v., cardinal vein; *d.gl*, developing glomus; *d.c.*, dorsal chamber; *d.a.*, dorsal aorta; *end.* endoderm; g., gut; *i.c.m.*, intermediate cell-mass; *l.p.*, lateral plate; *my.*, myotome; *nc.*, nephrocoel; *ns*, nephrostome; *n.c.*, nerve cord; *n.ch*, notochord; *p.f.*, peritoneal funnel; *pr.d*, pronephric duct; *pr.gl.*, pronephric glomeruli; *pr.t.*, pronephric tubule; *so.me.*, somatic mesoderm; *sp.me*, splanchnic mesoderm; *s.n.r.*, subnotochordal rod.

appeared in the lateral plate mesoderm by means of a short peritoneal canal. The pronephric tubule arises from the dorso-laterl angle of the nephric chamber and curves upwards and outwards (Fig. 3). As stated

already, the archinephric duct is laid down behind the segment V before there is any indication of the pronephric tubule. The pronephric tubule joins the archinephric duct and opens into it. The pronephric duct at this stage extends as far as the XV somite and ends blindly. The tubule communicates with the nephric chamber by a narrow, ciliated nephrostome. The connexion between the chamber and body cavity is soon obliterated and the pronephric chamber is thus completely shut off from the body cavity.

At about 54 hours of development the blood circulation is well established and the dorsal aorta sends a branch on either side towards the pronephric chamber at the level of the pectoral limb buds. The branch terminates in a net-work of capillaries and the vascular tuft lies close to the medial wall of the pronephric chamber or nephrocoel. The medial wall of the chamber becomes flattened and later is invaginated by the vascular tuft (Fig. 4) to form the glomerulus. When the embryo is about 60 hours old, the pronephric chamber comes to lie dorsal to the peritoneal cavity by the development of the peritoneum on the ventarl side. The glomus completes its development at about 100 hours of development.

The further differentiation of the pronephric tubule consists in elongation and coiling of the tubule. The shape of the tubule, as seen in a plastic reconstruction in a 180 hours old embryo, is represented in Fig. 7. The arrangement is simple and the Bowman's capsules of the pronephric tubules (i.e. of the opposite sides) lie close to one another below the notochord along the median line of the embryo almost touching one another. The tubule opens on the one hand into the pronephric chamber and on the other into the segmental duct. The ducts establish an opening to the exterior when the embryo is about 50 hours old.

During the fourth to eigth day the pronephric tubule elongates further and becomes coiled. Fig. 5. and 14 represent the transverse sections of the kidney of an embryo at about the time of hatching through the pronephric chamber. The pronephric tubule of one side with the duct of a just hatched larva is shown in Fig. 6. At this stage the renal organ of the larva is constituted by a pair of pronephric tubules, one on each side, and lying in close proximity to each other just below the notochord. The Bowman's capsule on either side lies close to the dorsal aorta from which a small branch supplies the glomerulus. The tubule after leaving the capsule runs laterally outwards and is much coiled. The pronephric duct runs backwards and opens into a small urinary sinus situated near the anus, which in turn opens to the exterior on a urino-genital papilla.

Persistence of the Pronephos in the Adult

Goodrich (1930) observed that it is a remarkable fact that the pronephros remains functional in some adult teleosts like *Fierasfer, Zoarces* (Emery, 1880) and *Lepadogaster* (Guitel, 1906). An interesting feature

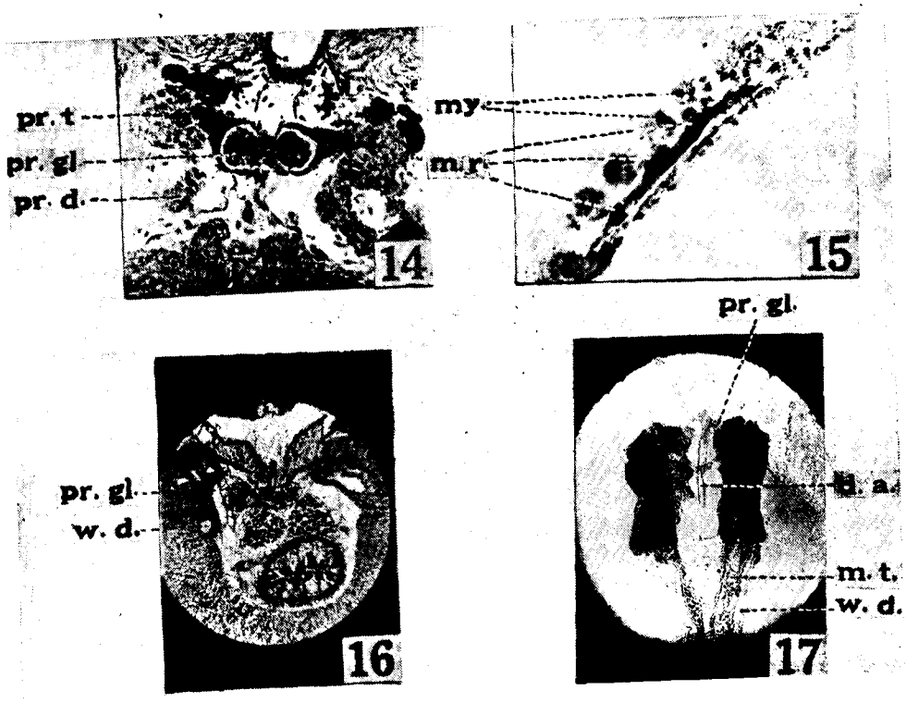


Fig. 14. Photomicrograph of a transverse section passing through the pronephric chamber of an embryo of about 180 hours of development showing the well developed glomeruli and the pronephric tubule.

Fig. 15. Photomicrograph of a sagittal section passing through an embryo of about 36 hours of development showing the pronephric duct and the mesonephric rudiments on the ventral aspect of the somites VI, VII, VIII and IX.

Fig. 16. Photomicrograph of a section passing through the anterior end of the kidney of *Oryzias melastigma* measuring 14.0 mm. in total length to show the persistence of the pronephros. The pronephric glomeruli are present on the median side of the definitive kidney.

Fig. 17. Photomicrograph of the anterior end of the kidney of a young adult measuring 9.0 mm. in total length showing the arterial connection of the pronephric glomeruli. *d.a.*, dorsal aorta; *m.r*, mesonephric rudiment; *m.t.*, mesonephric tubule; *my.* myotome; *pr.d.*, pronephric duct; *pr.gl.*, pronephric glomerulus; *pr.t* pronephric tubule; *w.d.*, Wolffian duct

of the renal organs of *Oryzias* is the persistence of pronephros in a functional state in the adult animal. The entire kidney with its blood vessels of a young adult measuring 9.0 mm. in total length is represented in Fig. 17. The pronephric glomeruli are clearly seen with their arterial blood supply. Fig. 16 is a photomicrograph of a section passing through the anterior end of the kidney of *Oryzias* measuring 14.0 mm. in total length showing the persistence of the pronephros. The pronephric glomeruli are present on the median side of the definitive kidney. In well grown specimens of *Oryzias* a pair of prominent pronephric glomeruli are present with well developed arterial connexions. A comparison of the condition obtaining in *Oryzias* with the description and illustrations given by Guitel (1906) for *Lepadogaster* confirms the view that the pronephros of *Oryzias* is functional. *Oryzias* has now to be added to the list of teleosts with persistent pronephros.

The Development of the Mesonephros

We have seen already that the earliest rudiment of the mesonephros appears in an embryo of about 30 hours of development in the region of the somites VI, VII, VIII and IX. A few cells constituting the primordia of the mesonephros have already separated from the intermediate cell-mass and lie close to a dorso-medial protuberance of the pronephric duct (Fig. 8). Figs. 9 and 15 represent sagittal sections passing through the somites VI, VII and VIII of an embryo of about 36 hours of development showing the mesonephric rudiments situated on the ventral aspects of the somites.

Felix (1897) states that the mesonephric tubules are derived from solid condensation of cells proliferated from the wall of the archinephric duct. Different views have been held regarding the origin of the mesonephrogenous primordia in the teleosts. Their close proximity to the pronephric duct led Felix to conclude that they were proliferated from the wall of the duct. Maschkowzeff (1935) investigated the development of mesonephros in *Acipenser* and *Salmo*. In the former, he derived the mesonephros from the nephrotome. In *Salmo*, he infers a similar derivation of the mesonephric tubules. But Fraser (1950), as mentioned before, remarks that Maschkowzeff's explanation is not altogether convincing, although his interpretation is the correct one. Moghe (1945), who investigated the development of mesonephros in *Thynnichthys*, traced the mesonephric tubule to a mass of cells lying at the base of the myotome, a position previously occupied by the intermediate cell-mass. In *Oryzias* the origin of the mesonephrogenous primordia is clear, being traceable quite definitely to the intermediate cell-mass at a stage when the pronephric duct has not yet differentiated.

A complete account of the development of the mesonephros in *Thynnichthys* has been given by Moghe (1945). So only a few salient features in the development of the mesonephros in *Oryzias* are given here to make the present account complete. In an embryo of about 36

hours of development, the intermediate cell-mass extends from the third segment to the thirteenth segment and the pronephric duct extends from the fifth segment to the ninth. The primordia of the mesonephros have

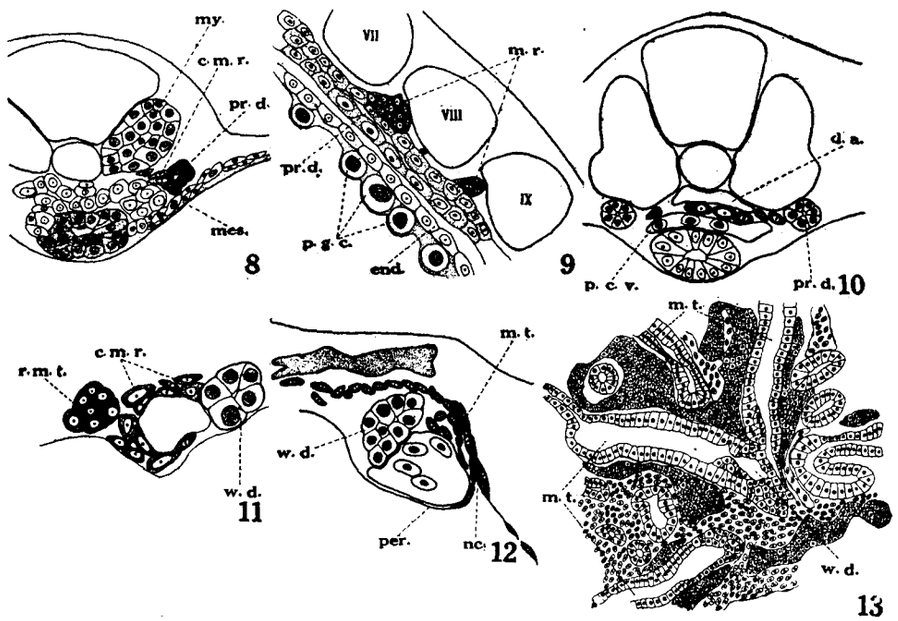


Fig. 8. A transverse section passing through the mesonephric region of an embryo of about 30 hours of development showing the primordium of the mesonephros lying close to the pronephric duct.

Fig. 9. A sagittal section passing through the somites VI, VII and VIII of an embryo of about 36 hours of development showing the primordium of the mesonephros.

Fig. 10. A transverse section passing through the mesonephric region of an embryo of about 48 hours of development showing the cells of the mesonephrogenous blastema extending from one pronephric duct to another between the cardinal vein and aorta.

Fig. 11. A transverse section passing through the mesonephric region of a newly hatched larva measuring 3.0 mm. in total length showing the condensations of the mesenchyme cells in the dorso-median aspect of the pronephric duct on the left side.

Fig. 12. A transverse section passing through the mesonephric region of a larva measuring 3.5 mm. in total length showing the blastema elongated and arranged in two layers. The lumen in the blastema communicates with the body cavity on the ventral side.

Fig. 13. A transverse section passing through the enlarged end of the kidney of an adult *Oryzias* measuring 28.0 mm. in total length to show a number of well-defined tubules opening into the Wolffian duct.

c.m.r., cells of the monephric rudiment; *d.a.*, dorsal aorta; *end.*, endoderm; *mes.*, mesoderm; *m.r.*, mesonephric rudiments; *m.t.*, mesonephric tubule; *my.*, myotome; *nc.*, nephrocoel; *per.*, peritoneum; *p.c.v.*, posterior cardinal vein; *p.g.c*, primordial germ cell; *pr.d.*, pronephric duct; *r.m.t*, right mesonephric tubule; *w.d.*, Wolffian duct.

also increased in number and are now found in each of the segments six to twelve, but do not show any marked difference in development in the different segments. Each primordium contains a few more cells

than in the previous stage, and as development proceeds the cells constituting the nephrogenous blastema increase still further and form a thin sheath or band surrounding the pronephric duct. In some sections the blastema cells extend from one pronephric duct to another between the cardinal vein and aorta Fig. 10). This stage corresponds more or less to the 'bridge cells' described by Moghe (1945). There is no appreciable difference in the development of the blastema cells on the right and left side of the embryo.

In a newly hatched larva, measuring 3.0 mm. in total length, the mesenchyme cells show a tendency to condense particularly in the dorso-median aspect of the pronephric duct. (Fig. 11). The condensations are compact and without a lumen at this stage. The mesonephrogenous condensations spread further in older stages, extend on to the dorsal side of the peritoneum and a lumen appears in the blastema. The blastema presently becomes elongated and its cells get arranged in two layers, somatic and splanchnic, with a lumen between. Its outer and ventral end reaches the coelomic epithelium and communicates with the body cavity by peritoneal funnel (Fig. 12). The connexion with the splanchnocoel is at about the level of the second vertebral segment. It soon becomes obliterated and the mesonephric tubule is separated ventrally from the body cavity by the peritoneal layer.

The next stage in the development of the mesonephric tubule consists in the differentiation and development of the Bowman's capsule. The differentiation of the capsule is similar to that of the capsule in the pronephric tubule. The wall of the nephrotome at the inner end becomes invaginated by a vascular tuft which is connected with the dorsal aorta and constitutes the glomus. The differentiation of the tubules progresses from the front backwards. In a larva of about 5.5 mm., three pairs of mesonephric tubules are differentiated and can be made out in the entire mounts of dissections of the mesonephros. The anteriormost pair alone is well developed and shows the Malpighian bodies. The second and third pairs are rudimentary, being in the form of club-shaped enlargements in the neighbourhood of the Wolffian duct.

As the larva grows in size, the mesonephric tubules increase in number and are much coiled. The mesonephric tubules of the anterior region are grouped together in the form of a triangular mass and constitute the head kidney of the adult. In a juvenile specimen of about 8.0 mm. in length the mesonephros extends over eight vertebral segments, the anus being situated in the twelfth segment. Secondary mesonephric tubules arise from condensations of mesenchyme cells, similar to those which give rise to the primary tubules. In an adult specimen measuring 27.0 mm. in total length the head kidney contains seventy Malpighian bodies.

The definitive kidney of the adult measures 8.0 mm. in length with an anterior enlarged, more or less triangular portion measuring about 2.0

mm. in length. The posterior portion of the kidney containing the mesonephric tubules is narrower and slender than the anterior portion. The Bowman's capsule of the mesonephric tubules in an adult kidney measures about 50 μ in diameter. In the head kidney of adult *Oryzias* there are in addition a few capsules which are larger in size and measure about 68 μ in diameter. As compared with this, the Bowman's capsule of the pronephric tubule is larger in size and measures 84. μ

Felix (1897) has described the degeneration of primary mesonephric tubules in *Salmon*. There is no degeneration of primary mesonephric tubules in *Oryzias*. A transverse section of the head kidney of a specimen measuring 28.0 mm. in total length (Fig. 13) reveals a number of well defined tubules with a rich supply of blood opening into the Wolffian duct and indicate their functional nature.

Acknowledgments

I have great pleasure in thanking Prof. R. V. Seshaiya for suggesting the problem and for guidance and instruction. I have also to thank the Annamalai University for the award of a research studentship for two years during which period this investigation was carried out.

Summary

1. The pronephros arises from a distinct intermediate cell-mass or unsegmented nephrotomic plate extending over segments III, IV and V.

2. The archinephric duct arises first and the pronephric tubules of which there is only one pair arise independently of the archinephric duct.

3. A very interesting feature of the renal organs of *Oryzias* is the persistence of pronephros in a functional state in the adult animal. A functional persistent pronephros has been known so far only in *Fierasfer*, *Lepadogaster* and *Zoarces*. *Oryzias* has to be added to this list.

4. The meonephrogenous primordia are clearly traceable to the intermediate cell-mass.

5. Secondary mesonephric tubules arise from condensations of nephrogenous tissue similar to those which give rise to the primary tubules.

6. There is no degeneration of primary tubules.

7. The development of both pronephric and mesonephric primordia in *Oryzias* conforms to the general plan of kidney development of vertebrates and is not aberrant. It also confirms the view that the vertebrate kidney is a holonephros, with a homogeneity of pro-, and mesonephros, as both develop from a continuous intermediate cell-mass.

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Ecological Study of the Great Indian Bustard *Ardeotis Nigriseps* (Vigors) [Aves: Otididae] in Kathiawar Peninsula, Western India

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With 1 Text-figure and 1 Plate

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

CONTENTS

Foreword

The Great Indian Bustard, *Ardeotis nigriceps* (Vigors) [Aves: Otididae], which was once very common in western India and elsewhere in the country, is now virtually on the verge of extinction. This paper on the ecology of the bustard by Shri R. S. Dharmakumarsinhji, who is an amateur ornithologist of long experience and also the Vice-President of the Indian Boar for Wild Life, is doubly welcome for two reasons. First, that a record of this vanishing species which, with some effort may still be preserved for future generations, is highly desirable. Secondly, field studies of Indian animals, and particularly of Indian birds, are extremely rare.

Shri Dharmakumarasinhji has studied not merely such biological phenomena as habits, food, courtship, breeding, etc., but has also suggested some useful measures for the protection of this vanishing bird.

I would particularly commend this paper to the members of the Zoological Society of India with the request that they might bring it

to the notice of students of zoology for the encouragement of field studies.

I sincerely hope that the paper will succeed in stimulating fresh interest in the preservation of this species.

The paper as originally written out by Shri Dharmakumarsinhji, was rather more extensive than the one presented here. I have, with the assistance of Dr. B. Biswas, revised and edited it to suit the requirements of a scientific journal.

M. L. ROONWAL,
President,
Zoological Society of India.
and
Secretary-General,
Indian Board for Wild Life.

Calcutta,
20*th September*, 1957.

History—Past and Present

The Great Indian Bustard, *Ardeotis nigriceps* (Vigors), is no doubt one of the most magnificient of India's game birds and is highly prized by sportsmen throughout India. The bird was formerly found in most part of India in suitable localities (Baker, 1921, pp. 167-169). The Kathiawar peninsula of western India is particularly suitable for the existence of this species. In the past it was found throughout this peninsula except in the forest areas of the Gir, Girnar and Barda Hills, and there was practically no grassland (*vids*) where it was not seen. Droves of 30 to 40 individuals could be observed in certain suitable habitats at most of the year. The bird was seldom shot or snared but afforded good sport to those who wished to stalk it. Fenton (1923, pp. 270-273) gave an excellent account of his days out for shooting it. More details of its habits and the manner in which it was hunted in various parts of India are given by a number of sportsmen, a summary of which will be found in Baker (1921, pp. 168-184).

Not until fairly recently was this bird persecuted causing its numbers to immediately dwindle. Even as late as the 1930's the bustard was seen in droves of 15 to 20 individuals in various parts of Kathiawar, and it was not considered uncommon all over the former State of Saurashtra. In some of the erstwhile princely State, the bird enjoyed strict protection and was recognized as an important and valuable game species, the shooting and trapping of which were allowed only by the special permission of the Ruler of the State. And hence, the bird was preserved and protected in most parts of Saurashtra. Heavy punishment was inflicted on people who were found infringing the laws and rules protecting the bird. A constant watch by the officially employed shikaris was maintained to ensure that all game species were adequately

preserved throughout their territories and the Great Indian Bustard enjoyed special protection. The organization of shikaris in these States was equivalent to a modern Wild Life Department except that very few or hardly any written records were maintained. The control of the game species was regulated by the Ruler himself through his personal staff. Guests who were generally sportsmen and friends of the Ruler, were invited for shooting. The shikaris were experienced men who knew their ground well and fully the habits and abodes of various game species. The sons of such experienced shikaris became, after training in the field, hereditary shikaris of the Rulers and were highly qualified to bear the responsibility of acting as game wardens.

With the disappearance of about 202 Shikar Departments, some of them very small indeed, consisting of a handful of shikaris and A. D. C.'s of the ex-Rulers of the large or small principalities as were found in the various States, the game species, particularly the prized and protected Great Indian Bustard, found no master. Consequently, the species was persecuted wherever it was found. However, prior to this and during the War years (1939-45) and after, when a large number of motor vehicles driven by military personnel and carrying firearms were active, the species had little chance of escape. Moreover, local poachers who had never been allowed to lift a gun towards the bird, now did so with impunity, so that large numbers of bustards were being destroyed. A comprehensive memorandum on the need of protection of wild life in Saurashtra was submitted by the writer in 1948 to the State Government, and subsequently, in 1950, wild life and game surveys were carried out by him for the Government of India. In both these reports I had fully emphasized the vital need of protecting the Great Indian Bustard. While these reports were being considered by the two Governments, the bustard was slowly and steadily being slaughtered. The reduction in its numbers was evident from observations made by the writer during his periodic visits to areas where it was seen and bred regularly. Each time fewer and fewer birds were observed. In 1952 all these facts were brought to the notice of the newly established Indian Board for Wild Life which discussed the question at length and recommended that the species should be completely protected. All the States in which the species was found adopted the recommendation and the bird was treated as "completely protected". This, by itself, does not give adequate protection and the bustard continues to be threatened with extinction.

Habitat

In Kahiawar there are grasslands, known as *vids*, found scattered throughout the area, which provide suitable habitats for the Great Indian Bustard. So many suitable habitats for it in such a small area are seen nowhere else in India. There are three distinct and characteristic habitats in which the bird is found, thus:—(i) Undulating hilly

plateau covered with grass and interspersed with bushes. (ii) flat country, with short grass and studded with the following species of plants:—'kerda' (*Capparis* sp.) 'jeepta' (*Triumfetta rotundifolia*), 'khip' (*Leptadenia spartium*), 'piloodi' (*Salvadoria* sp.), and sometimes lemon grass and cotton. (iii) Extensive flat marshy grassland of alkaline nature, or with semidesert patches. All these habitats may be bordered or hemmed in by agricultural land and the bustard frequently enters cultivated fields. Taking all these conditions into consideration it becomes clear that the bird prefers dry, well drained soil in contrast to wet, muddy ground or forest areas. It thrives well in a rainfall area of about 12-75 mm. (5-30 inches) in diverse types of country as already stated. Although not commonly met with on the sea coast, it has been recorded on hilly grass-country on the Kathiawar sea-board and even on the shore.

Climate:—In Kathiawar, the climate is dry with an avearge rainfall varying from 37-75 mm. (ca. 15-30 inches). The temperature in the hot weather may rise in certain areas to 47.8°C. (118°F.) but usually never goes much beyond 43.3°C (110°F.), whereas, on the coastal belt the temperature rises to a maximum of 34.4—38.9°C. (94-102° F.). The monsoon, which usually commences rather late, at the end of June or early in July, is erratic and ends generally in October. The cold weather is never very severe, normally not getting below 5.6°C. (42°F.) and frost is seldom encountered. The humidity is always greater on the coastal areas than inland.

Habits

The Bustard is normally solitary though there is no fixed rule regarding the numbers found together. Large droves are not met with now and even a herd of ten birds is very rarely seen. Cock bustards are seen singly or in pairs or in any number up to a dozen or more. Similarly hens may be seen solitary or a few together. It is rarely that both sexes are seen in equal number together, for they have a tendency to segregate except in the breeding season when the cock acquires a small harem; though the number of hens in the harem not always constant. Immature birds of both sexes which have not assumed full plumage gather in small droves and it then becomes difficult to tell the difference between groups of adult hens and those of young birds. The only distinctive character that one could recognize in the field to distinguish an adult female from younger birds is by the presence in the former of a black crown slightly tinged with buff.

As has already been said, the birds have a distinct tendency to segregate into different sexes, and when they are thus seen the difference in size between the sexes is obvious.

The birds do not, as a rule, prefer the vicinity of human habitation, but keep to barren open or grassy country where it is seldom

disturbed. But so much does it get used to human population that a stream of people passes by a bird at 50 yards, without disturbing it although normally the bird would walk out of the way and put as much distance between man and itself as quickly as possible.

The bustard becomes wary no sooner it feels that it is being stalked and any strange moment will immediately change the normal behaviour of the bird. Any forthright attempt to approach it will scare the bird. It has a fast walk and can move out of sight quickly. While walking away, it has a characteristic style of moving—the neck outstretched, the head held high at an angle of 45-50° and moving from side to side and the legs moving in a majestic style. These movements give the bird a graceful appearance. When suspicious, it takes much advantage of the cover available and if a man walks round the bird, it will also walk round the bush it has taken cover in, keeping a close watch from behind and revealing only its head. When approached directly it will stop and at once take to the wing. Suspicious birds will not allow man to approach closer than a hundred yards at the most. It is because of this wariness that it is considered a difficult bird to approach but, in truth, it is not shy where man makes no attempt to harass it. When driving in motor vehicles closing in, in circles, one can get as near as twenty-five yards and it can be easily shot. In a similar manner, camels, horses and even carts can also be used. Once, however, the bird is shot at, it becomes very difficult to approach it. When stalking the bird a remarkable thing about it is that it is seldom caught at a disadvantage for it keeps its adversary always in sight. In undulating country, where the sportsmen can take advantage of a low ridge or high ground from which the bird may, for the moment, have moved out of sight, any attempt to reach the high ground is invariably forestalled by the bird returning towards the high ground to take a better view and be at an advantage, in spite of the fact that it may have to walk towards the hunter. Similarly, in country studded with bushes, the bird may walk from bush to bush, keeping out of sight as much as possible and any hasty attempt to come closer will cause the bird to fly. The bird has a characteristic manner of walking zigzag and this it can do with imperceptible cunningness. When in high crops of millet or cotton, wily birds may sit down or walk under cover only to reappear at quite a different angle, eying the intruder carefully with the head cocked at an angle. Against predators such as jackals and wolves, the bird is very alert and is confident of flying away in time before it is attacked. It is seldom, if ever, killed by such animals, man being its only deadly enemy.

Description of the Sexes

Male:—The adult male stands with the neck outstretched about 105 cm. (ca. 3½ ft.) or more and when flying the wing span is over 240 cm. (ca. 8 ft.). It is recognized by its larger size, the thick white predators such as jackals and wolves, the bird is very alert and is corugations on the upper mandible and a fairly short and pointed bill.

Owing to the flabby nature of the chin and throat, its bill looks much shorter than it really is. The black feathers of the crown hang behind in a pointed crest. Young birds of the first year are similar in appearance and size as the adult female, only the crest being shorter. Male birds assuming adult plumage are intermediate in size, the head and neck appearing whiter and thicker than in adult females.

Female:—The female is easily distinguished from the male by her smaller size length about 90 cm.; ca. 3 ft. more slender neck which is finely vermiculated and hence darker, and by the smaller broken pectoral band which forms only a black bar on each side of the breast.

Call

The Bustard is a silent bird, except during the breeding season or when giving out its alarm call. The breeding song of the male is a low moaning deeply resonant sound, and can be heard some miles away in the early morning or late evening. The alarm call is a short *humm* or *hook* in a low key but rather full in volume. It is from this call that its name *hukna* in Gwalior (Madhya Pradesh) is derived. The Kathiawadi name *ghorad* is also onomatopoeic and denotes a resonant loud voice. The short alarm call bears resemblance to a short honk and is also reminiscent of that of the call of the Ruddy Sheld-duck. It is emitted repeatedly when the bird sees danger approaching. The female also sounds her alarm call mostly during the breeding season; this is a short grunt or *hook*. She also hisses loudly, raising her back feathers. Some sportsmen mention having heard a cackling call while the birds are feeding. The chick utters a sharp whistle when it is "freezing' in cover. This whistle, once recognized, betrays the chick which is otherwise very well hidden and impossible to spot as it matches the ground and is small enough to be concealed in short grass.

Seasonal Movements

The Bustard, as seen in Kahthiawar, keeps faithfully to its habitat as far as possible and only migrates to other areas for feeding or if persecuted. The ideal habitat is usually extensive and self-sufficient in food supply. The birds, as far as possible, keep to the same ground, walking often miles and covering long distances in their search for food. The line of direction they move in may not be straight as they are inclined to zigzag movements and walk in circles while feeding. Sometimes they fly to localities where there is abundance of food. For instance, they were seen alighting close to Cattle Egrets which were feeding voraciously on grasshopper and locust larvae. They will also fly to water and to patches of grass where they find their food regularly. They appear to be locally migrating, sometimes long distances, during the winter, when a pair or drove may be seen fiying fairly high, searching for favourable feeding areas. Birds are met with during the

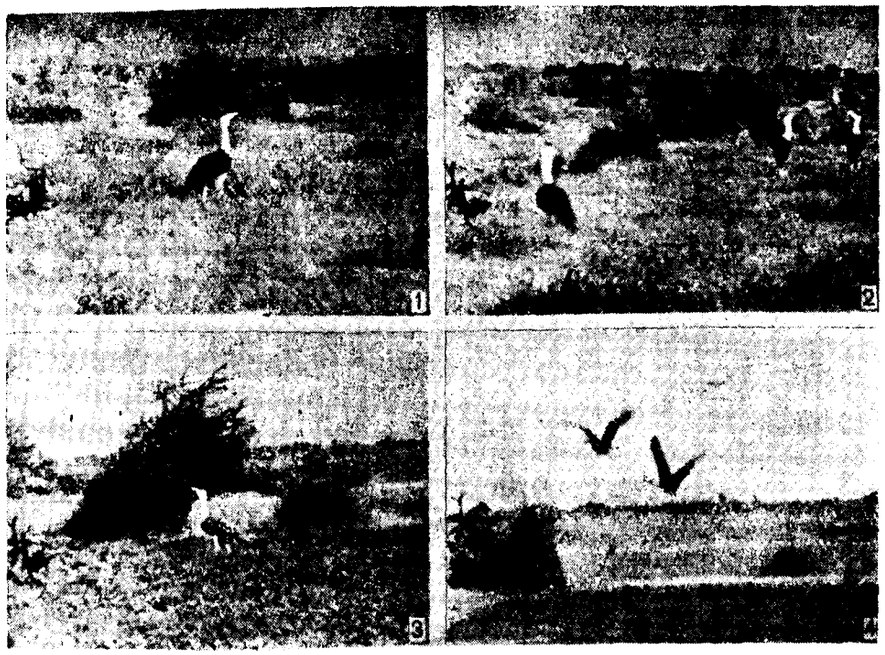
winter often in cotton fields. Sudden and erratic rainfall during the winter in certain localities will attract a bird or two, who go there in the hope of finding better food. Although the bird enjoys rainfall, it keeps away from areas of heavy rainfall. It is much attracted to areas where the locusts and the sand-lizards breed. Thus, moderate rainfall is essential for its survival, on account of the favourable conditions which propagate insects, reptiles, scorpions and even rodents.

During the monsoon the movements of the birds are largely for feeding and for establishing breeding territories, and since there is ample cover at the time the birds roam about a good deal. Like the Lesser Florican they migrate to certain grasslands, for breeding and both species may be seen together at this time. Unlike the Lesser Florican however, they rarely depart from the province, but return to areas where they are less disturbed during the major part of the year. If the birds are not harassed, they keep to the same *vidas* and habitats. There are instances where the same birds were watched for years in the same old localities where they remained undisturbed. Owing to this consistency of habit in a self-sufficient habitat, it is possible to convert such areas into a sanctuary, provided that a constant guard is kept over it. In the past, one could go to such an area and see at least a dozen or more bustards in an evening's drive. So regular are their habits of feeding that birds can always be seen on the move in the early morning or late evening during the hot or cold seasons. During the hotter part of the day, they invariably take their siesta under some bush or tuft of grass and lie low. The seasonal movements, therefore, are for two reasons, *viz.*, for feeding and for establishing breeding areas, the latter being essential areas in non-ideal habitats visited by them year after year. Eggs have been found in the same areas time after time. If constantly shot at or harassed, the birds may forsake the areas or *vids* for months and never return to it, according to the experience gained.

Flight

The flight of the bustard is a graceful, a slow wing-beat which carries it at a swift pace of about 50 miles per hour or more. While rising, it gets up with ease, often without even a step, and in flight the wing-beat is continuous without any gliding. A faint wing-patch seen on both sides of the wings is sometimes observable and the neck is kept outstretched; the legs remain folded up while rising and stretched out while flying. The height at which it flies is invariably low overland and a bird may be seen disappearing low over the horizon. The flight appears to be irregular, without formations, though in a definite direction, but while migrating they may assume a V-formation. When sighting suspicious objects, the birds swing away quite suddenly. When they are seriously disturbed, the flight is long, that is to say the birds do not alight until they are well out of sight, which may mean a flight

Dharmakumarsinhji



Explanation of Plate 1

The Great Indian Bustard, *Ardeotis nigriceps* (vigors) in Kathiawar, western India. (Photographs by author).

Fig. 1. Typical bustard country, with a cock bird.
Fig. 2. Three cock birds out to feed.
Fig. 3. A cook bird taking cover.
Fig. 4. Two birds taking off.

Explanation of Text-figure 1

Text-fig. 1. The Great Indian Bustard, *Ardeotis nigriceps* (Vigors) in Kathiawar, to show the typical walking pose.

of a few miles or more. When, however, they are merely lightly disturbed and not frightened, they may alight within a couple of hundred yards.

The young birds of under a year do not fly long distances and it can be only these juvenile birds that can ever be ridden down by horseback, the adult birds being impossible to chase or even to be kept in sight when they are in flight.

Food

The bustard is omnivorous, feeding on a great variety of food-stuffs, and this accounts for its being much more constant in its habits and habitat. The ideal habitat, therefore, is one where it can find adequate food throughout the year and where is least disturbed. The following is a summary of its food-stuffs:—

Animal food:—Insects (mostly locusts, grasshoppers and their larvae, beetles, crickets, mole-crickets and ants), centipedes, scorpions, worms, frogs, lizards, small snakes and mice. *Vegetable food*:—Shoots of vegetables, lemon-grass, mustard, wheat and grains of millets, fruits, berries of 'ber' (*Zizyphus* sp.), 'kards' (*Capparis* sp.) and 'piloo' (*Salvadora* sp.). Grit or small pebbles are swallowed to aid mastication. In grassland habitats, the principal food consists of locusts and grasshoppers and their larvae in grassland where these insects, as well as beetles, small lizards and snakes, are found throughout the year.

The competition for food by other forms of bird-life and animals is negligible. In the bustard's ideal habitat, the Lesser Florican (*Eupodoti indica*) is sarcely seen and in other habitats the grassland is so extensive and the food-supply so abundant during the monsoon that keen competition for food is not felt. From October to February, when large numbers of migratory birds, such as the crane arrive, very few of the latter ever settle down in the typical habitat of the Great Indian Bustard, but remain more localised in agricultural land and fallow land of the open type. Competition for food by such large birds as the crane is therefore, not felt. Birds such as the whimbrel (*Numenius phaeopus*), curlew (*Numenius arquatus*) and Black Ibis (*Pseudibis papillosa*), are seen but not in very large numbers, but their food is different; and this remark also applies to Rock Bush Quail (*Perdicula argoondah*) and the partridges (*Francolinus* sp.) which are really non-migratory birds. Of other ground birds, the Houbara (*Chlamydotis undulata macqueeni*) is seen; this bird could be a serious competitor to the bustard, but its numbers are generally very small. However, certain birds of prey, like the kestrel (*Falco tinnunculus*) and harrier (*Circus* sp.) may feed upon locusts and grasshoppers but they have never been seen devouring such insects on a large scale. The House Crow (*Corvus splendens*) would appear to be a more serious competitor, but, here again, I have never seen crows in large number

in the typical habitat of the bustard, even though they are inclined to gather in flocks. What might appear to be the most serious competitor of the bustard is the Cattle Egret (*Bubulcus ibis coromandus*), for during the year these birds will alight near cattle and feed voraciously upon grasshoppers and their larvae. Since their association with cattle is strong, the birds are not always found in the typical habitat of the bustard, but are more inclined to be seen on agricultural land close to farms. However, wherever grasshoppers and their larvae occur abundantly, the Cattle Egret is found feeding upon them and their presence often indicates to the Bustard the ready availability of its food supply. Owing to the abundance of insect life during the monsoon and after, there does not appear to be much, if any, competition for food. In the hot weather the food-supply may be a little difficult but a fair number of grasshoppers are still found in the *vids*.

Of the animals, the fox, hare, wolf, jackal, black-buck, chinkara and nilgai may be seen in the same area, but none of them compete for food-supply with the bustard. The fox may feed upon insects, lizards and gerbilles, but its food is mostly rodents which are found in abundance.

From November to June, when food is relatively scarce in the non-typical habitat, the bustards feed less voraciously and are usually out of breeding condition, seeking a livlihood from the vegetable crops, mustad fields, and fruits of *Zèzyphus* and *Capparis* and on certain black beetles and lizards. During the monsoon and just prior to it, when locusts start breeding, the bustards feed voraciously on them. The bird walks with head bent downwards, watching out for insects and other live food that it flushes; then it runs and snatches them up in its bill with great accuracy. In order to facilitate the finding of food, a number of bustards may walk in line, as if in a beat, so as to cover more ground. And yet, solitary birds are often encountered during the height of the breeding season. Separated birds may join together to form a feeding party. An ideal sample food-plot consisting of *Capparis*, short and extensive grasslands, *Triumfetta, Leptadenia* and *Zizyphus*, desert lizards, grasshoppers and locusts with some small snakes, is self-sufficient area for the whole year. In an area of six square miles in such a typical habitat as mentioned above, as many as four bustards could live happily. In an area of about 40 square miles, as many as 38 bustards were seen. This shows that bustards do not require a very extensive area for survival, provided that it has ideal feeding and cover. One such an area was mixed with agricultural land and had a population of about 1,000 human beings. In view of this, a sanctuary inclusive of human population of the size of 50 sq. miles could easily hold a dozen or more bustards. In the present circumstances and conditions, an area of 25 sq. miles of bustard habitat may hold six bustards only.

Today the feeding and breeding grounds of the bustard, during the monsoon is thereatened by the influx of cattle and of nomadic tribes who go hunting and shooting indiscriminately and slaughter anything that moves under their feet. Bustards are being shot and snared in their nests by certain communities. They cannot survive such an onslaught for long. The bird survives today not because it is a protected bird but because it cannot be got at to be shot so easily. Nevertheless, it falls a prey to trapping which is done with a bait of lizards attached to wire bent in the form of hooks. Cruel methods such as these, and snaring the hen birds on their nests is done at all times of the year.

Courtship

The male establishes a territory by selecting high ground from where he struts like a turkey cock, fanning his tail, lowering his neck-sac and emitting a low moaning call. He is, however, not a fighter and fighting among two cocks is not heard of though they will not call from or encroach upon the same displaying ground. However, at a distance of half a mile away another bustard cock may be heard calling triumphantly. The calling takes place very early in the morning or late in the evening even after dark. The birds become shy when they sight man, so the courtship can only be seen from a distance through a pair of binoculars. The calling birds, though pugnacious on their elevated ground, may be seen amicably walking and feeding soon after the hen birds have disappeared, though this is more frequently the case after the breeding season is over. As birds are so few now-a-days, it is difficult to work out the sex-ratio. The hen birds do not walk in a flock towards the male as might be expected but come one by one and it is seldom that a complete harem is seen, though often so described by shikaris and sportsmen. An assembly of one male with a few females is probable.

In the male the neck-sac is extended almost to the level of the ground during the breeding season, and this elongated, baloon-like sac waves about in the wind. The triangular head and the chin, throat and the pointed bill with round eyes, followed by the long white neck gives the bird a grotesque appearance.

Breeding

The bustard is polygamous, the cock mating with a number of hens. During the breeding season, which is usually from May to November, a cock may have as many as half a dozen wives. In the typical habitat where the rainfall is low and the ground flat, grassy and profusely studded with lowbushes having ideal food conditions, the breeding season is a long one. In other areas, birds breed from July to November and most eggs are laid in the months of August to October, when cover and food is at its height.

The hen after mating selects an undisturbed site to lay her single egg. In the typical habitat the bird may select a site in short grass, often close to a bush, where it can see danger approaching at all times, and when crouching can conceal herself completely, which she does excellently considering her large size. In other habitats, she selects tall thin grass, but never thick grass from which she cannot see danger approaching. The bustard lays only one egg and the female does all the incubation and rearing. The egg is thick-shelled and varies in colour from olive brown to reddish brown. It is oval in shape, bluntly tapering at both ends. The incubation period is not exactly known, but is not less than a month.

The mother bird hisses and raises her feathers in defence of the egg and will often attack goats or sheep when menaced, emitting short grunts. She will also feign injury by dangling her legs and flying as if wounded. She is a devoted mother to an equally devoted progeny. In the breeding season when hens start laying, one may find two eggs close to each other and this is the result of two hens laying close together.

It cannot be said exactly whether a hen bird lays every year. It is possible that she does, but there is no doubt that the young do not mature to breed the following year. It takes at least two years if not more, for the bustard to reach maturity.

The chick is buff with black markings on the crown and body and has the same characteristic habit of moving its head from side to side and the majestic walk as the parent. It emits a short whistle. Droves of young birds are often mistaken for a "small variety" by certain local people who do not recognize the difference in sex. The young is full-fledged in four months and can only fly short distances when hard pressed, and yet it keeps with the parent bird for a considerable time.

Measures for Protection

People who to-day persecute the bustard are nomadic tribes, the so-called sportsmen, the crop-protection or village poachers and the egg-collectors. The last named has now almost vanished. The pressure of nomadic folk who, feed on wild life, and the danger of crop-protection guns for the survival of bustard is so great that the birds are constantly being exterminated and the situation is grave. It is, however, possible to set aside areas as sanctuaries, provided a mobile wardenship is established and all crop-protection guns withdrawn. The *nilgai* (Blue Bull) is the only species which menaces the agriculturist in the bustard country, and this species can easliy be exterminated in such areas. The chinkara and the blackbuck occur only in low numbers as to cause no serious harm to the crops. There were sportsmen, if they deserve to be called by such a name, who shot two dozen bustards

in a day and a dozen and a half on the following day in an area of about 80 sq. miles from a car. There must have been more birds than those shot in the area. Those were the days, in a typical habitat for bustards, where complete protection to the species and other game was given. Nomadic tribes must either be prohibited from entering the area of bustard country or provided with wholetime work to distract them from their usual harmful activities. People must be convinced so as to realise the importance of protecting a rare species which is valuable in reducing harmful insect-pests of crops. The sportsmen must be convinced and controlled and the village poacher must be disarmed of effective weapons in areas where he may be in a position to directly affect the species. The bustard country must be recognized as a sanctuary where local co-operation to protect the bird is essential.

Secondly, a mobile Game Warden with local village workers to assist him as Assistant Game Wardens, are essential. Without this arrangement the thought of establishing a sanctuary is a danger to the species. The planning of such an area should be left to a responsible person who knows local conditions. The whereabouts of the proposed sanctuary must be kept a total secret until full co-operation and the staff and equipment is decided upon. Only after this should the area be declared a sanctuary by an enactment. A preliminary survey of the area could easily be done to ascertain how many bustards exist in the area, and since the birds are in a low numbers, this would not be very difficult. Harmful animals such as the *nilgai*, if any present in the area, could be driven out and destroyed soon after the sanctuary is established. The following conditions are imperative for the requirements a sanctuary for the bustard:—

1. The range must be extensive. It must have intensive food supply and cover so as to be conducive to the survival and propagation of the bustard.
2. The area must be safeguraded by strict control and by co-operation from the local agriculturists.
3. Crop protection guns must be withdrawn from the neighbourhood.
4. A service would have to be established to keep out the poachers, serve as a guide to visitors and for maintaining a a record of the number, habits etc. of the bustard.

For a bustard sanctuary, an area of 50 sq. miles or more in blocks or otherwise, containing the least amount of agricultural land and human population, with a nucleus of about half a dozen birds, is

a prerequisite. The following recurring expenditure for the necessary staff to safeguard the birds and the habitat would be needed:—

1. One Game Warden, at Rs. 200/- per month.
2. One Assistant Game Warden-cum-motor driver, at Rs. 100/- per month.
3. Six part-time village watchmen, at Rs. 25/- per month.
4. Monthly allowance for petrol, Rs. 90/-.

Thus, the monthly recurring expenditure would come to Rs. 540/-, or Rs. 6,480/- per year. The non-recurring expenditure will be as follows:

(1) One Jeep car Rs. 12,500/-.
(2) Living quarters for Game Warden: Rs. 12,000/-.
(3) Garage: Rs. 1,500/-.

The non-recurring expenditure would thus come to Rs. 26,000/-.

Such a sanctuary could be tried as an experiment. One area out of the many in which the bustard is found should be selected and would serve to protect the bird from extinction. In areas where certain towns lie close-by, the expenditure of establishing the living quarters for the Game Warden may not be required and thus a saving ensured. If this sanctuary is a success, other bustard Sanctuaries could be created in different parts of the Saurashtra.

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A Comparative Study of Protein-Bound Amino Acids in the Ovary and Pituitary of *Mystus seenghala* (Sykes)

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

CONTENTS

Introduction

A marked seasonal periodicity in egg-production is characteristic of most fishes (Hoar, 1957). It is also well known in a general way that the changes in the gonads are controlled by the pituitary hormones. Several investigations have been reported bearing on these two aspects of the reproductive physiology of fishes. We may mention in particular the studies of the gonadial cycles in salmon by Jones (1940), in *Hake* (Hickling, 1935), in *Trout* (Mric, 1923), in *Fundulus* (Mathews, 1938) and in the common Indian cat fish *Heteropneustes fossillis* (Bloch) by Ghosh and Kar (1952).

The parallel histological changes in the pituitary and the gonad during the gonadial cycle have also been studied by several authors in particular by Mathews (1939) in *Funduls*.

Sergan, Murray and Darssow (1954) have investigated the amino acid content during the different stages of maturity of the ovary of five speces of Pacific salmon, but without any reference to the changes in the pituitary.

We have no precise knowledge of the way in which the pituitary influences the gonadial activity. Hoar (1955) has pointed out that it is not likely that the same biochemical materials are operating in groups as widely separated as mammals and fish. The fact that fishes are unresponsive to many mammalian gonadotropins has been regarded by Hoar (1955) as indicating real chemical differences between mammalian pituitary and fish pituitry. There is thus need for chemical investigations

to understand the specificity of fish pituitary hormones as well as the biochemical links between the pituitary and gonadial activities.

As a preliminary step in analysing the biochemical links between the pituitary and gonad in fishes, I have been studying comparatively the changes in the amino acids of the corresponding stages of the pituitary and ovary in a few common freshwater and estuarine fishes of South India. The present account summarises the qualitative and quantitative changes of the protein-bound amino acids in three corresponding stages in the growth of the ovary and pituitary of the cat fish *Mystus seenghala.*

Material and Methods

The fishes were collected from the local ponds of Annamalainagar during the different seasons of the year and the ovaries and pituitary glands of three clear marked stages were used for the present study, adopting Bower's (1954) classification—Stage I. Immature virgin: ovaries very small—colourless. Stage II. Maturing: ovaries swollen—yellowish orange. Stage III. Mature: well swollen with thin tunica. Owing to the small size of the pituitary, it was not possible to take the different regions of the pituitary separately. So the entire gland had to be analysed for amino acids in the present investigation. For the determination of the protein-bound amino acids the ovary and pituitary were hydrolysed in 6N HCl for 18 hours. Circular paper chromatography as described by Giri (1952) was adopted for the study of amino acids, using Whatman paper Nos. 1, 2 and 20. Two dimensional chromatography was also adopted using Whatman Filter paper No. 1 of dimensions 25×25 cm. and 20×20 cm. Butanol-acetic acid-water mixture (4: 1: 1) and buffered phenol were used as solvents and 0.2% nihydrin in 95% acetone as the colour developing reagent. The amino acids were identified by running a mixed chromatogram as described by Giri and Rao (1952) by spotting both known and unknown samples in the same chromatogram.

In the case of the amino acids which failed to separate as distinct bands, multiple development was successfully employed in addition to two-dimensional chromatography. For quantitative determination, the tissue was accurately weighed, acid hydrolysis using 6N HCl was conducted, and the total volume of the hydrolysate was measured. The procedure adopted by Giri (1952) was followed. A known micro-quantity of the hydrolysate (0. 025 μl to 0.05 μl) was spotted with the aid of a micro-pipette. The chromatogram was developed in the usual way, using 0.5% ninhydrin in 95% acetone. Each band was cut out separately and eluted using 75% alcohol and 0.1% copper sulphate solution (7.2 cc of 75% alcohol and 0.8 cc of copper sulphate solution for each elution). The optical density of the resulting solutions was read, using

a Lumetron colorimeter (Model 401-A) with 550 mμ filter. The quantity of the amino acids was calculated from the calibration curve drawn for each of the amino acids individually.

Observations and Results

The results of the quantitative and qualitative analyses are shown in Tables I & II and in the diagram. The following are the qualitative findings.

(i) The ovary and pituitary have in common in all the three stages examined the following amino acids: leucine, isoleucine, phenylalanine, proline, alanine, glutamic acid and threonine, glycine, serine, and aspartic acid and histidine. (ii) The ovary has a total of eighteen different amino acids in the first or immature stage, twelve in the second stage and eighteen in the mature or III stage. (iii) The pituitary has in the first stage twelve amino acids, eighteen in the second, and sixteen in the third stage.

Thus, while the I and III stages of the ovary have a greater number of amino acids, it is the second stage of the pituitary that has the largest number, and the first stage has the least number.

(iv) The differences between the ovary and pituitary with reference to qualitative variations in amino acids are summarised below and can also be seen in Table I.

Amino acids	Stage of Ovary showing the amino acid	Stage of Pituitary showing the amino acid
Valine	II	I & II
Methionine	all	II & III
Tyrosine	all	I only
Hydroxyproline	none	II only
Asparagine	I & III	II & III
Arginine	I & III	all
Lysine	I & III	all
Ornithine	I & III	all
Cystine	I & III	II only

(v) It will be seen from the Table I that six of the amino acids present in the I stage of the ovary disappear in the second. All these reappear in the III stage.

(vi) In the pituitary four amino acids which are lacking in the first stage appear in the second. Three of these disappear in the third stage.

(vii) It may be particularly mentioned that cystine is present only in the second stage in the pituitary but in ovary it is lacking in the second but present in the first and third.

With regard to the quantitative results (Table II) the more important findings are:

i. Phenylalanine, tyrosine, and glutamic acid—threonine show a progressive increase in the ovary. The increase in phenylalanine is thirteen to fourteen times in the second and third stages respectively.

ii. In the pituitary phenylalanine and histidine show a progressive increase, the former showing much more than the later, though not to the same degree as in the ovary. Increase in histidine is also considerable.

iii. Speaking generally, the amino acids of the pituitary, with exception of phenylalanine and histidine, have their peak in the second stage, while many of the amino acids in the ovary have their peak either in the first or third stage. Alanine and asparagine, arginine and cystine have their peak in the first stage in the ovary. Histidine alone has a peak in the second stage in the ovary. Phenylalanine, tyrosine, glutamic acid—threonine have their peak in the first stage of the ovary.

The relatively greater number and quantity of amino acids in the second stage of the pituitary is indicative of the increased functional activity of the pituitary probably as a prelude to the maturity of the ovary. Further investigation is in progress.

Summary

1. A comparative study was made of the qualitative and quantitative changes of the amino acids in three corresponding stages of growth of the pituitary and ovary of *Mystus seenghala*.

2. Both in the pituitary and the ovary there is qualitative as well as quantitative variation of amino acids in different stages.

3. Cystine shows an interesting variation. In the ovary the first and the third (mature) stages have cystine, but in the pituitary this amino acid is present only in the intermediate stage. Thus the appearance of cystine alternates between pituitary and ovary.

4. Valine and methionine are present in the pituitary only in the third stage but in the ovary these are present in the first and the third stage.

5. Histidine is present only in the second stage of the pituitary.

6. Speaking generally the amino acids in the pituitary have their peak in the second stage with the exception of phenylalanine and histidine, which have their peak in the third stage. But in the ovary phenylalanine, tyrosine, glutamic acid-threonine have their peak in the third stage, histidine in the second, the rest i.e. alanine, asparagine, arginine and cystine in the first.

Acknowledgements

I am greatly indebted to Prof. R. V. Seshaiya, Director and Professor, Marine Biological station, Annamalai University, Annamalainagar for guidance and instruction, and to the Ministry of Education, Government of India for the award of senior research scholarship. I am also thankful to Sri. B. Seshadri and Sri. S. Swaminathan for help in the preparation of the diagrams.

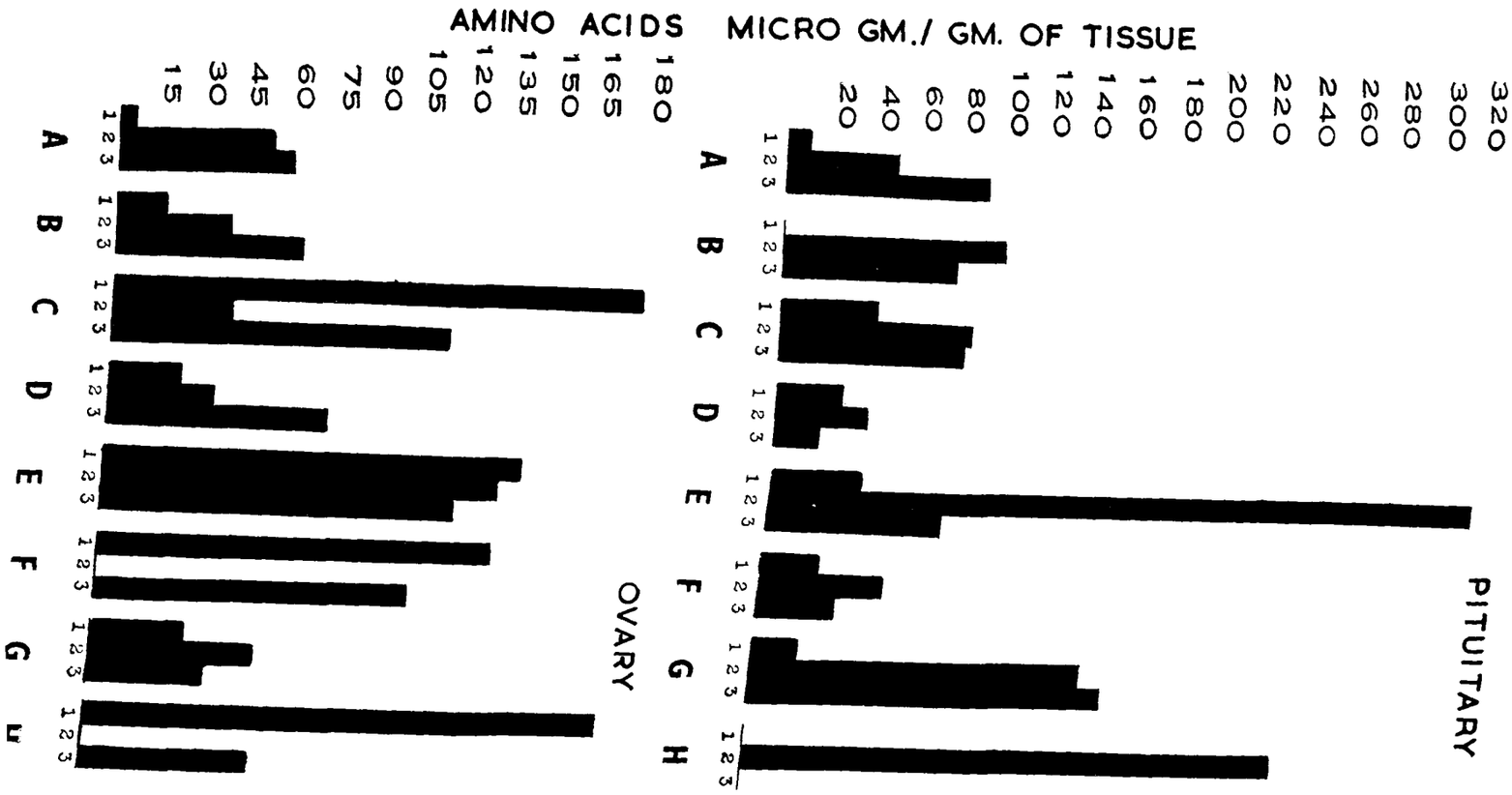

TABLE 1—Qualitative distribution of Protein-Bound Amino Acids in the ovary and Pituitary of *Mystüs seenghala* (Sykes)

Amino acids	Ovary			Pituitary		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
1. Leucine and Isoleucine	+	+	+	+	+	+
2. Phenylalanine	+	+	+	+	+	+
3. Valine	+	−	+	−	−	+
4. Methionine	+	+	+	−	+	+
5. Tyrosine	+	+	+	−	+	+
6. Proline	+	+	+	+	+	+
7. Alanine	+	+	+	+	+	+
8. Threonine	+	+	+	+	+	+
9. Glutamic acid	+	+	+	+	+	+
10. Hydroxyproline	−	−	−	−	+	−
11. Glycine	+	+	+	−	+	−
12. Serine	+	+	+	+	+	+
13. Aspartic acid	+	+	+	+	+	+
14. Asparagine	+	−	+	−	+	+
15. Arginine	+	−	+	+	+	+
16. Histidine	+	+	+	+	+	+
17. Lysine	+	−	+	+	+	+
18. Ornithine	+	−	+	+	+	+
19. Cystine	+	−	+	−	+	−
Total No. of amino acids:	18	12	18	12	18	16

TABLE 2—Quantitative distribution of amino acids in different stages of ovary and pituitary of *Mystus seenghala*.

Amino acids	Ovary			Pituitary		
	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
Phenylalanine	4·28	52·44	59·07	8·49	48·16	90·12
Tyrosine	17·13	38·97	64·44	—	105·20	78·86
Alanine	180·85	38·97	117·40	42·45	86·00	84·39
Glutamic acid and Threonine	27·27	37·21	73·17	39·37	41·39	19·77
Asparagine	139·17	131·10	117·40	39·62	323·36	78·86
Arginine	128·46	—	102·30	25·47	55·04	33·79
Histidine	27·83	52·44	37·59	19·81	151·36	163·32
Cystine	171·28	—	53·70	—	240·88	—

Quantity of amino acids expressed in micro-grams per gram of tissue.

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On The Bionomics of *Sardinella gibbosa* (Blkr) off Waltair Coast

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CONTENTS

Introduction

The true sardine belonging to the genus *Sardina*, is confined to the temperate waters. In the Indian waters the group is represented by 8 distinct species of *Sardinella* of which three are very common, namely *S. longiceps*, *S. gibbosa*, and *S. fimbriata*. *S. longiceps* contributes to a valuable fishery on the west coast while *S. gibbosa* has a restricted distribution and occurs in shoals on the Andhra Coast and in Gulf of Mannar region (Devanesan, 1932 and Panikkar, 1949). *S. fimbriata* occurs along both the coasts of India (Nair, 1951).

Of these three species, the study of the biology of *S. gibbosa* is comparatively incomplete. Devanesan (1932) investigated the food and feeding habits of *S. gibbosa* from the Gulf of Mannar area and Chacko (1946 and 1949) worked on the biology of *S. gibbosa* and its food and feeding habits from the same region. Sekharan (1955) worked on the Choodai fishery comprising *S. albella* and *S. gibbosa* from Mandapam area. Hornell and Nayudu (1924) gave a detailed account of the biology of *S. longiceps* of the Malabar coast. Devanesan and Chidambaram (1953) made a brief reference to the bionomics of *S. longiceps*. Nair (1952), gave a detailed account of the condition of the oil Sardine fishery of the west coast, and the factors influencing the movements of

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the fish. Bapat and Bal (1950) studied the food of *S. albella* from Bombay waters and Vijayaraghavan (1953) worked on the food of Madras Sardines.

Material and Methods

Specimens of *Sardinella gibbosa* were obtained from the fishermen's catches, and care was always taken to get a random sample of the catches and also to get the collections to the laboratory in as fresh a condition as possible.

The total length (from the tip of the snout to the end of the dorsal fluke of the caudal fin) as well as the standard length (from tip of snout to the end of the silvery area on the caudal peduncle) of each fish was measured to the nearest millimetre. All calculations were based on the standard length.

The fishes were subsequently wiped and dried between folds of filter paper and weighed to the nearest gram on a platform balance. After measuring the length and weight of each fish they were cut open and the extent of feeding was recorded by noting visually the state of distension of the stomach and the amount of food contained in it. The stomach was carefully removed and the contents were analysed by the points methods (Hynes, 1950). Each item of food was allotted points based on the size of the organism as well as its abundance. All the points gained by each food item were summed up and converted to percentages, to find out the general composition of the food of all the fish examined during the different months. In allotting the points, the fullness of the stomach was also taken into account. The sex and maturity of the specimens were determined by the condition of the gonads according to the maturity scale adopted by the International Council for the exploration of the sea, (Hjort, 1914).

Seasonal Abundance of the Sardines off Waltair

From the available data based on rough estimates of the landings it has been observed that in the year 1953-1954, the fishery extended from November to June, with its peak in February and May with a gradual rise from November and an abrupt fall in the quantity of catches after June. In the year 1954-1955 the season commenced from November onwards reaching its height in December and January with a gradual decline thereafter. In both the years the fishery was very poor during the period of July to October. Generally speaking the sardine fishery off Waltair extends from November to June with the peak period from December to May. The seasonal fluctuations vary from year to year.

Food and Feeding Habits

Analysis of the stomach contents of *S. gibbosa* (Table 1) shows that its food is mainly composed of Malacostracan (25.2%) and Entomostracan (46.45%) items, besides teleosteans (10.5%), molluscan

larvae (5.5%), diatoms (4.1%) and miscellaneous food items (3.75%). The remaining 5.5% of the stomach contents was made up of sand grains.

On the basis of the relative numbers of fish that ingested the different types of organisms the following picture (Table 2) was obtained. Copepods were found in about 66.1% of the stomachs examined; and the Malacostracan crustaceans in 51% of the stomachs. Teleostean remains, though forming a fair amount of the total volume of food were found in about 23% of the stomachs only, while gastropod larvae occurred in 38% of the stomachs. The above account indicates that small organisms like copepods and gastropod larvae, though forming a small percentage in volume in the composition of the food of *S. gibbosa*, are more often consumed than the Malascostracans and fish larvae.

The average volume of food per stomach for the period of investigation was 37.3% ; and for the respective months of the period the average volume of the food was as follows:—

September.	10%	February.	30.5%
October.	20%	March.	85.1%
November.	40%	April.	60.5%
December.	48%	May.	15.0%
January.	54%	June.	10.0%

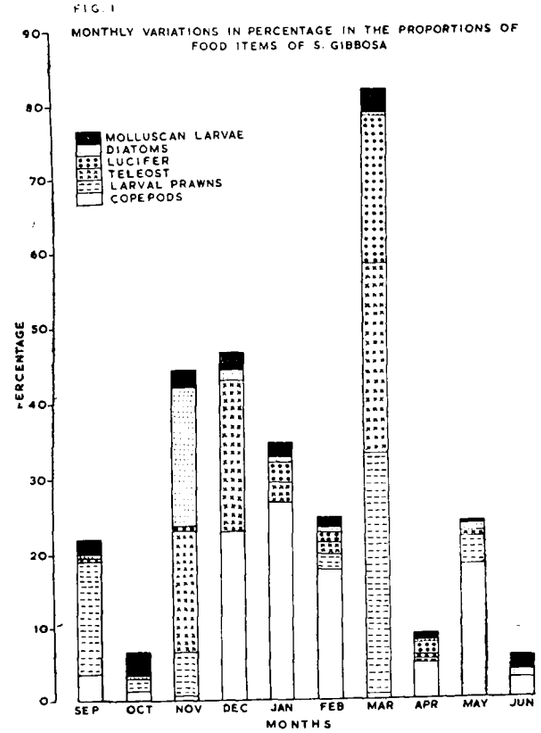
The relative incidence of the different types of organisms in the food of *S. gibbosa* is shown in Table 1. It will be seen that young prawns, larvae of *Acetes* sp. and *Alpheus* sp. were the commonest organisms, forming a very large proportion of the food throughout the year. These were the predominant food organisms in 99% of the stomach contents examined in March, when the first spawning period occurs. In February these types of food items were insignificant in the stomachs examined.

Diatoms: *Coscinodiscus* forming 4.8% of the total food items was the only diatom that was observed during the period of study excepting January and March. The peak periods of this diatom in the plankton fall in October and April.

Copepods: Copepods belonging to genera *Undinula, Centropages, Eucalanus, Euterpina, Corycaeus, Oncaea, Macrosetella,* and *Oithona* have been noticed in the stomach contents and the calanoids constituted by *Undinula, Centropages* and *Eucalanus,* formed 56% of the copepod item. These organisms were very abundant from December to February and also in May. They were at the minimum in November and March. From November to January there was a progressive increase, followed by a decline in February and March. There is again a rise in April followed by a peak in May. Among the Calanoids, species of

Labidocera and *Pontella* were also occasionally seen. The abundance of Calanoids in the stomach contents was related to their occurrence in the plankton in large numbers. Of the other copepods, *Macrosetella* sp. occupies an important place, being present in the stomach contents almost throughout the year. It was found in maximum numbers in December, when it occurred in swarms in the plankton. The other

FIG. 1



important copepod in the dietary was *Oncaea,* which was found in large numbers in May and June, when they were 'also abundant in the plankton. Copepods that were met with occasionally in the stomach contents were species of *Euterpina, Corycaeus,* and *Oithona,* their number in the stomach contents being generally related to their abundance in the plankton. Species of *Temora, Candacia, Miracia, Pleuromamma* and *Pachysoma* were occasionally seen in the gut contents.

Other crustaceans: *Lucifer* forms an important item in the diet of *S. gibbosa* being found in the stomachs of the fish examined from November to April, with its peak numbers in March when these organisms were observed in swarms in the local plankton. *Mysis* stage of decapod larvae was observed in the months of March, April and

May only. *Alima* larvae were noticed in the stomachs examined in December and January. The other crustaceans observed in small quantities were *Megalopa*, Amphipods, Isopods and Brachyuran remains. Crustacean remains that were in an advanced stage of digestion were met with very often.

Mollusca: The bulk of the molluscan item is composed of gastropod larvae forming 83.6% of the total molluscan component. These constituted 17.85% of the volume of the total food items in November. During the other months they were scarce in the stomach contents. Bivalve larvae forming only 14% of the Molluscan item were found in September, November, Ferbuary, May and June. Petropods, forming the remaining Molluscan item were observed in the stomachs in December and April.

Teleost: Fish forms an important item in the diet of *S. gibbosa* during November, December and March. In the months of November and December, they occurred in 55% and 40% respectively of the stomachs examined and all those which could be identified were found to be post-larvae of *Anchoviella* sp. During the above months *Anchoviella* sp. abounds in coastal waters. During the other months only remains of teleosts mostly Clupeid scales of a large size, were present, being probably accidental inclusions.

Miscellaneous: Polychaetes were always in an advanced stage of digestion whenever they were found in the stomachs. The setae were the only remains that were left. A *Sipunculid* was observed in a single stomach in the month of November. Sand grains, which are probably accidental inclusions, formed a regular item in the stomach contents of *S. gibbosa*.

Relation Between Food and Plankton

Samples of surface plankton available in the laboratory were utilised for comparison with the items of food in the stomachs to find out their relationship. As the sardines were caught from the surface waters, the horizontal hauls of plankton fairly showed the food environment of the fish. As far as possible, plankton samples collected on the same day when the fish sample was obtained, were taken into consideration. In Table 4 the food organisms have been arranged in the order of their abundance in the stomach contents and compared with the organisms of the plankton arranged in their order of abundance. Estimation of the relative abundance of the various organisms in the plankton was made by the points method. In this way only a general relationship could be made out.

Considerable variation in the abundance of the food items in the plankton sample from that of the stomach contents was observed, and

only a few organisms of the plankton sample were represented in the stomachs. This perhaps shows that *S. gibbosa.* is a selective feeder, preferring only certain of the food organiims available in the plankton.

Length Weight Relationship and its value as an Index of the Spawning Season

Menon (1950) Pillay (1954) and Sarojini (1956) have correlated fluctuations in the ponderal index with the attainment of maturity and spawning in *Gadus minutus, Mugil tade,* and *Mugil parsia* respectively. The average weight for each centimeter length group, of either sex, in each month, was used for computing the ponderal index for separate centimeter length groups of both males and females. The ponderal index was worked out from the formula used by Hickling (1930), Menon (1950) and Pillay (1954) viz. $K=W/L^3\times100$, where 'W' is the weight of fish in grams, 'L' is the length of the fish in centimeters, and 'K' is the ponderal index to be calculated. The average values of 'K' in relation to the length of the fish of either sex are given below.

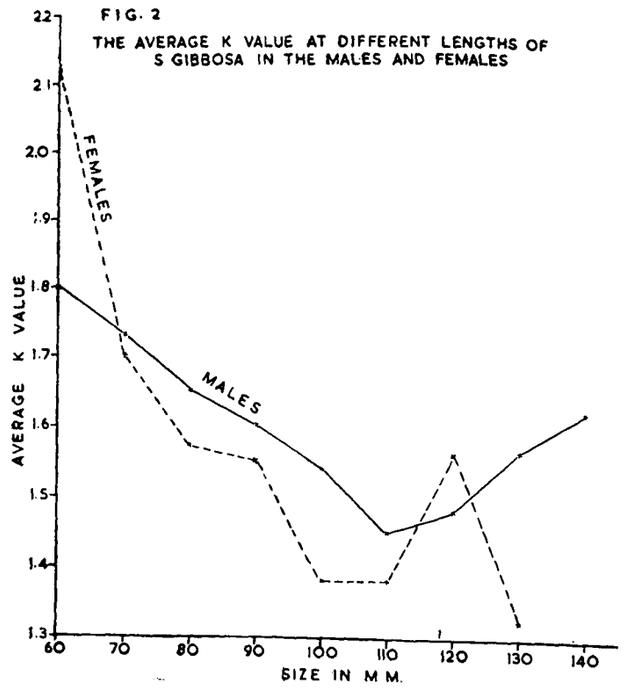
Centimetre group.	Female.	Male.
6	2.119	1.901
7	1.695	1.732
8	1.570	1.653
9	1.556	1.596
10	1.385	1.357
11	1.382	1.452
12	1.562	1.481
13	1.332	1.538
14	—	1.624

Ponderal index for the whole sample in each month for either sex is as follows:—

Month	*Female*	*Male.*
September	1.268	1.262
October	1.521	1.390
November	1.455	1.400
December	1.548	1.652
January	1.667	1.798
February	1.495	1.639
March	1.977	1.670
April	—	2.055
May	—	—
June	1.578	1.648

These average values of 'K' in relation to the length of the fish of either sex have been plotted as two curves in Fig. 2. From the graph it is seen that the 'K' values progressively decrease with increase

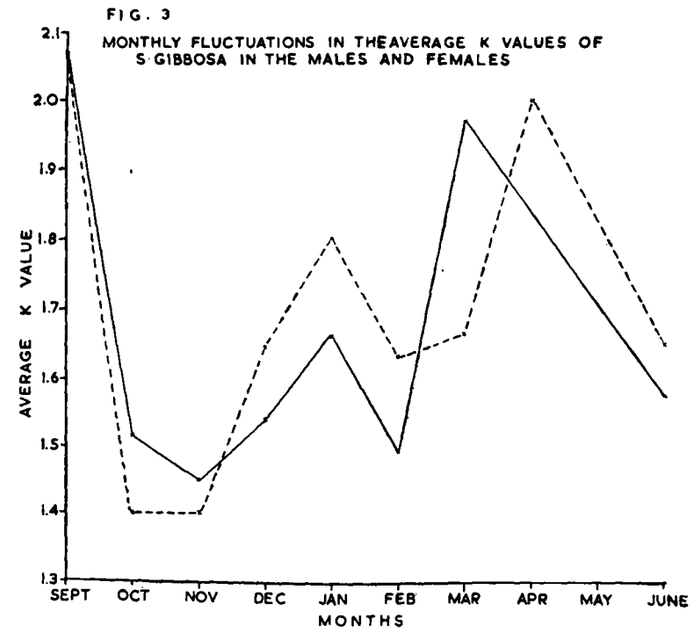
FIG. 2



in length up to about 11 cm. in both the sexes and thereafter it shows a marked rise in the males, and females also, but in the females an inflexion of the curve in the 'K' values was noticed at 12 cm. of length. If the point of inflexion of the curve is indicative of the length at first maturity as shown by Hickling (1930), Menon (1950), Pillay (1954) and Sarojini (1956), the females attain maturity at an average length of 11 cm. to 12 cm. Some evidence in support of such a conclusion has been afforded by the fact that the smallest females with maturing eggs in the ovary were about 11 cm. to 12 cm. size.

The mean 'K' values for the samples in successive months are plotted in Fig. 3. The decline in the value denotes the beginning of

FIG. 3



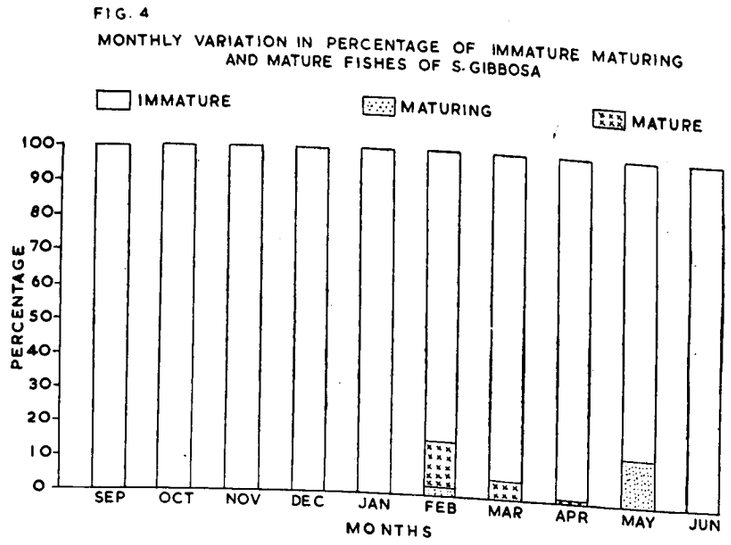
spawning in the species, since the increased metabolic strain is known to manifest itself in maintaining a lower level of conditions. It will be seen from the figure that the condition factor was at its height in September with a steep fall in October. This primary low 'K' value before spawning period was interpreted by Menon (1950) as due to the growth of the fish in linear dimensions which obviously reduces the 'K' value. Thereafter there was a steady increase till it reached another maximum in March in the case of females, and April in the case of males. The data for May of the two sexes could not be obtained as

the fish observed showed no distinguishable gonads, probably on account of their being in a spent condition. But up to June the values are considerably high. The above account roughly indicates that the spawning period of the fish commences in March or April and extends probably up to May and June. This observation is in conformity with the evidence obtained from ova maturation studies and the seasonal occurrence of eggs presumed to belong to *S. gibbosa* in the plankton collections.

Maturity and Spawning

The specimens obtained from September to January were all in an immature state (Fig. 4) with the condition of their gonads in stage I

FIG. 4

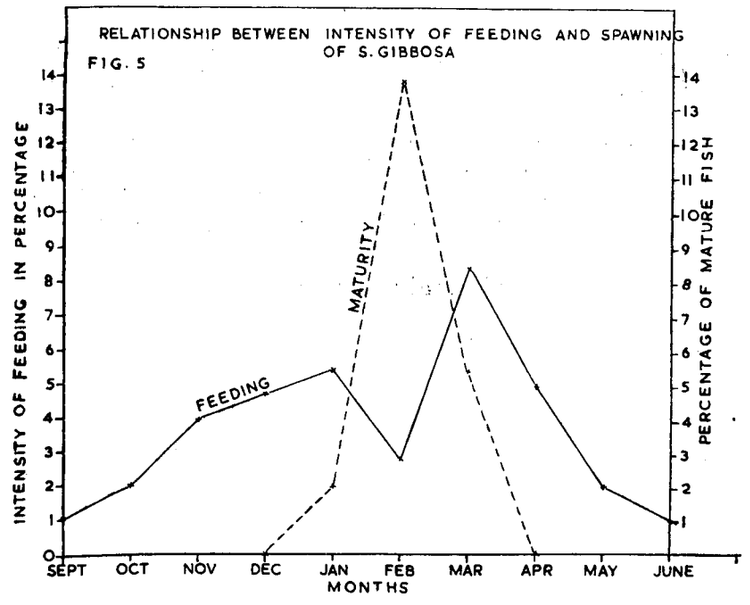


(Table 5). The gonads of most of the fishes were indeterminate and even in those where they were noticed they were in the form of small, thin transluscent ribbons lying behind the middle of the body cavity. The length of the gonads ranged between 3 mm. and 11 mm. The side range of the specimens during the period was between 51 mm. and 110 mm. The mature specimens suddenly appeared by the end of February (Fig. 5) and continued till early March. The percentage of mature males was greater than mature females during the period. Similar observations were made by Hornell and Nayudu (1924) in the case of *S. longiceps*, where they mentioned that the development of the gonads took place with a phenomenal vigour in May, when 20% of the males

were swollen to what it seemed their full extent. This might be due to the migration of ripening females seawards beyond the normal range of fishermen's operations.

The presence of mature specimens in May indicates that the spawning period of the fish extends from February to May. This is confirmed by the presence of eggs of *Sardinella* sp. in the plankton collections from February to June, 1954. The size at first maturity of the sardines was found to be between 110 mm. and 120 mm. (Table 5). Fully mature specimens have not been observed at any time of the year under study. The spent survivors start returning to the inshore waters along with the new generation from April onwards when, fishes of size

FIG. 5



range between 30 mm. and 138 mm. were observed in catches of the same net. Juveniles of *Sardinella gibbosa* appeared in the fishermen's catches from October to February of 40 mm. to 76 mm. size range. This may indicate that the fish has a prolonged spawning period.

Migrations

It is known that the migration of fishes is generally for spawning or for feeding purposes. Hornell and Nayudu (1924) traced the migration of *S. longiceps* in relation to the spawning and feeding habits of the fish. They observed that the fish leave in April the inshore waters

for the offshore waters for spawning and the spent fish and juveniles return to the inshore waters for feeding. Vijayaraghavan (1950) correlated the food factors and migration of a few Clupeids off the Madras coast. He found that when the season began i.e. July to August, the Clupeids were observed to be very active feeders, and that by about February the mature fish left the coastal waters for the spawning grounds The present investigation reveals that *S. gibbosa* migrates to the offshore spawning grounds beyond the normal range of fishermen's operation in early February, when they are about 110 mm. in length and attain their first maturity. After spawning, the post-larval fishes and juveniles of the size of 30 mm. to 89 mm. start returning to the coastal waters in April.

Parasites

The entozoic parasites encountered in the stomachs of *S. gibbosa* were the Trematodes *Aponurus* sp. and *Hemiurus* sp., of which the former was more common. The infection by *Aponurus* sp. was very intense in the fish during the month of February when it was found in the washing of the stomach contents in the majority of the fish examined. Nematode parasites were met with occasionally. Of the ectozoic parasites *Caligus* sp. was noticed in the buccal cavity of a few fish.

General Observations

There has been much speculation about the method of feeding of Sardine. Kishinouye (1907) indicated that *Sardinops melanosticta* shows a certain degree of selection in its diet by means of the gill rakers. Hornell and Nayudu (1924), John and Menon (1942), Nair and Chidambaram (1951) and Nair (1954), who worked on *S. longiceps* of the west coast, have all described its food as consisting of plankton, predominantly phytoplankton, and they inferred that they are filter feeders in habit. This is ascribed to the abundance of phytoplankton in those localities. Devanesan (1932) and Chacko (1946 and 1949) observed that the food of *S. gibbosa* is mainly composed of the macro-organisms like copepods. Devanesan and Chidambaram (1953) and Vijayaraghavan (1953) noticed that the principal food of sardines is crustaceous in nature and Vijayaraghavan further says that fishes of *Sardinella* sp. "can be described as surface feeders and may be called plankton predators".

During the course of the present analysis of the stomach contents of *S. gibbosa* (Table 1), it was noticed that the macro-organisms of the plankton like young prawns, *Lucifer*, large crab zoaea, and post larval fish were more common than the smaller entomostracans. Whether these planktonic organisms which served as food were selected by the fish, or whether the fish passively allowed the water containing the

plankton to pass through the gills straining it by means of the close set, long gill-rakers, which are best adapted for this function, requires elucidation. The presence of the larger crustaceans and young fishes which are active swimmers, implies that the sardines exercise a definite action of capture "involving quick efforts on the part of the fish". Besides, it is quite possible that the fish seeks the regions where small organisms like the Entamostracans and Molluscan larvae abound, and owing to their great preponderance in the waters, it obtains its food by mere straining as indicated by the presence of copepods in large numbers during the months of December, January and February in the stomachs, which shows selective action in the feeding habit of the fish.

From the examination of the stomach contents it is evident that the sardine is onnivorous and ingests a variety of organisms differing greatly in size. However there seems to be some preference for certain types of organisms available in the plankton. Table 4 shows the relative abundance of the different types of food organisms in the plankton and in the stomachs of the fish. There is no complete correspondence between the planktonic compositon and stomach contents with respect to the relative abundance of the different types of organisms. Smaller organisms like copepods larval crustaceans and diatoms, were found to conform to some extent with their abundance in the plankton, but the larger organisms such as fish larvae and young prawns were observed more frequently in the stomachs than in the plankton. Young prawns and fish larva were found in the stomchs of some sepcimens measuring above 90 mm in length showing thereby that the fish capable of capturing them in the sorrounding waters consumed them. Such instances also indicate that the fish exercises a certain power of selection and does not swallow indiscriminately any plankton organisms which may come in its way. An examination of the stomachs of a large number of young sardines from 30 mm. to 90 mm. shows that the food of young fishes does not differ very much from the older fish.

The results of a study of the intensity of feeding (Table 3) show definite phases of feeding activity. The average intensity of feeding per stomach has been plotted against the respective months as a curve (Fig.5) Fish that have just spawned, and the juveniles of the new generation were very often found gorged with food, in the months of March and April. This period was followed by a period from May to September, when the intensity of feeding was the lowest and it coincided with the later part of summer and the beginning of rainy season, when there is also a sudden fall in the abundance of zooplankton from its peak in the middle of May. The temporary absence of Sardines in the coastal waters in the months of July and August, and its scarcity in the months of September and October may be due to the poor plankton in these months. This period was colsely followed by a gradual rise in the intensity of feeding till January, after which there was a slight

fall coinciding with the height of spawning. In the month of February and March, when the maximum percentage of mature specimens was obtained, the average volume of food per stomach was 30. 5%, and full stomachs and stomachs gorged with food were observed during this period only (Table 3 and Tble 5), which shows considerable feeding activity at the time of spawning.

Summary and Conclusions

Studies on the food and feeding habits of *S. gibbosa* show that the fish is predominantly a zoopalnkton feeder, and that selective feeding is exercised, involving active efforts on the part of the fish, though the fish is generally believed to be a filter feeder.

Maturity and spawning studies based on the condition of the gonads, ponderal index of the fish, and the seasonal occurrence of eggs in the plankton show that the spawning period of the fish commences in the month of February and probably extends over a prolonged period. The size at first maturity of the fish was found to be between 110 mm. and 120 mm. The fish probably migrates to the off shore waters for spawning, as no mature specimens were obtained in the fishermen's catches. After spawning was over the young juveniles start returning to the inshore waters in the month of April.

The intensity of the feeding activity based on the average volume of food per stomach of the fish can be divided into three stages:— (a) active feeding which synchronizes with the period just after spawning in the months of March, April and May; (b) a low intensity of feeding which coincides with a fall in the abundance of plankton in the coastal waters, and (c) a subsequent gradual rise in the intensity of feeding till January.

The trematode parasites *Aponurus* sp. and *Hemiurus* sp., Nematode parasites and a copepod parasite belonging to the species of *Caligus* were found to be parasitic on *S. gibbosa*.

Acknowledgments

We express our thanks to Sri R. Velappan Nair for having gone through the manuscript critically and for offering some valuable suggestions.

TABLE 1—**Volumetric percentages of the food components of** *Sardinella gibbosa*

Name of the Food item.	MONTHS										Average percentage for the year.
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Crustaceans											
Malacostraca	—	2.27	17.60	2.15	16.50	5.31	54.29	9.55	4.38	1.80	11.300
Larval Prawns	—	1.50	6.75	—	—	1.98	32.63	—	3.50	—	4.600
Stomatopod	—	—	—	1.65	0.62	—	—	—	—	—	0.230
Megalopa	—	—	—	0.25	1.21	—	0.21	1.38	—	—	0.300
Crab	—	—	—	—	—	—	—	—	0.09	—	0.009
Mysis	—	—	—	—	—	—	0.32	1.56	0.20	—	0.210
Lucifer	—	—	0.60	0.10	0.32	1.30	20.26	2.13	—	—	2.500
Amphipod	—	—	0.10	—	0.10	1.32	—	—	—	—	0.150
Isopod	—	—	0.05	—	—	0.02	—	—	—	—	0.007
Decapod Larvae	—	—	—	—	—	0.08	—	1.66	—	—	0.174
Other Crustacean remains	—	0.77	10.10	0.15	14.25	0.61	0.86	2.83	0.60	1.80	3.200
Entomostraca	3.50	1.40	10.80	43.36	53.11	31.64	15.60	7.42	36.76	5.35	20.800
Copepods	—	—	5.90	21.61	26.38	16.93	7.95	1.49	18.36	2.65	10.600
Calanoids	—	—	3.30	11.05	18.90	12.62	6.66	0.68	6.44	—	5.960
Euterpina	—	—	—	1.83	0.25	—	0.33	0.56	2.47	0.13	0.560
Corycaeus	—	—	0.05	0.25	5.63	0.37	—	—	0.54	0.50	0.730
Oncaea	—	—	0.25	1.23	0.37	0.65	0.03	0.13	6.61	2.03	1.130
Oithona	—	—	—	—	0.13	0.15	0.63	—	0.26	—	0.120
Macrosetella	—	—	1.30	7.15	1.10	3.06	—	0.13	2.04	—	1.470
Temora	—	—	—	0.10	—	—	—	—	—	—	0.010
Candacia	—	—	—	—	—	0.08	—	—	—	—	0.008
Miracia	—	—	—	—	—	0.08	—	—	—	—	0.008
Pluromamma	—	—	—	—	—	—	—	0.50	—	—	0.050
Pachysoma	—	—	—	—	—	—	—	0.50	—	—	0.050
Copepod remains	3.50	1.4	—	—	—	—	—	—	—	—	0.490
Cypris Larva	—	—	—	1.15	0.35	0.70	—	3.45	0.05	—	0 570
Teleost	0.50	—	16.25	18.85	0.40	0.16	19.95	0.20	0.72	—	5.700
Eggs	0 50	—	—	—	0.10	0.16	—	—	0.72	—	0.150
Anchoviella	—	—	16.25	18.85	0.30	—	19.95	0.20	—	—	5.600
Polychaetes	—	—	—	0.05	—	1.10	5.60	0.38	—	—	0.113
Molluscs	0.25	0.40	18 50	1.42	0.70	0.63	0.54	0.25	0.76	0.93	2.500
Gastropod Larvae	—	0.40	0.65	0 39	0.70	0.63	—	—	0.76	0.13	0.350
Bivalve Larvae	0.25	—	17.85	0.48	—	—	0.54	—	—	0.80	2.090
Pteropod	—	—	—	0.55	—	—	—	0.25	—	—	0.080
Sipunculid	—	—	0.25	—	—	—	—	—	—	—	0.025
Coscinodiscus	2.30	3.40	2.25	2.30	2.10	1.62	—	3.20	1.14	0.13	1.850
Sand	1.60	5.00	4.25	10.90	—	—	1.51	1.56	0.50	—	2.530

TABLE 2—Monthly frequency of the stomachs of *S. gibbosa* containing the listed food components.

Name of the Food item	Months										Average percentage for the year
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
Copepods	45	58	65	70	93.75	75	66	45	100	44	66.2
Malacostraca	—	41.5	50	35	81.25	37	99	99	28	38.5	51
Fish eggs and Larvae	—	—	55	40	6.25	1	60.5	18	47.6	—	22.8
Mollusca	9	16.6	65	45	31.25	22	27.5	18	5.6	66	38.14
Diatoms	36	99	55	55	—	22	—	81	87.8	55	49.1
Miscellaneous	18	—	5	5	6.25	1	11	18	—	—	6.42

TABLE 3—Statement showing the monthly frequency (in percentage) in the condition of feed of *S. gibbosa*.

Month	Frequency (in percentage) of specimens with stomachs							
	Gorged	Full	¾ full	½ full	¼ full	with little Food	with very little Food	Empty
September	—	—	—	—	—	—	100.00	—
October	—	—	—	—	—	81.00	19.00	—
November	—	5.5	12.49	15.16	40.15	26.16	—	—
December	—	5.0	10.00	—	55.00	10.00	20.00	—
January	—	—	31.25	25.00	37.50	6.25	—	—
February	4.16	—	8.88	9.16	10.76	16.78	43.69	3.75
March	—	35.9	29.06	21.36	13.66	—	—	—
April	—	—	—	56.25	25.00	18.75	—	—
May	—	—	7.00	2.50	11.08	30.92	46.07	2.5
June	—	—	—	—	—	12.50	39.28	48.2

TABLE 4—**Relationship Between Plankton and Food of** *S. Gibbosa*

Food organisms arranged in their order of abundance				Size range of fish examined in cm.
in the stomachs		in the Plankton		
Date (1)	Name of Organism (2)	Date (3)	Name of Organism (4)	(5)
31-10-53	*Coscinodiscus* Copepods Crustaceans remains Gastropod larvae	29-10-53	*Coscinodiscus* *Acartia* *Eucalanus* *Centropages* *Oithona* *Euterpina* Medusae *Sagitta*	8.8 to 11.8
13-11-53	Gastropod larvae Larval prawns Calanoids *Labidocera* Fish scales *Coscinodiscus* *Macrosetella* Other crustaceans Bivalve larvae Amphipod *Lucifer*	12-11-53	Diphyes *Sagitta* *Canthocalanus* *Paracalanus* *Corycaeus* *Macrosetella* *Eucalanus* *Tuterpina* *Oithona* *Oncaea* *Acartia*	6.8 to 11.4
28-11-53	*Anchoviella* Crustacean remains Larval prawns *Coscinodiscus* Megalopa Lucifer *Macrosetella* Calanoids	26-11-53	*Macrosetella* *Oithona* *Oncaea* *Centropages* *Acartia* Fish eggs *Salpa*	5.1 to 12.0
2-12-53	*Anchoviella* Stomatopod larvae *Coscinodiscus* Calanoids *Euterpina* *Corycaeus* Cypris larvae	2-12-53	*Coscinodiscus* Calanoids *Macrosetella* *Corycaeus*	9.0 to 12.2

TABLE 4—(*Contd.*)

Food organisms arranged in their order of abundance				Size range of fish examined in cm.
in the stomachs		in the Plankton		
Date (1)	Name of Organism (2)	Date (3)	Name of Organism (4)	(5)
9-12-53	Calanoids Macrosetella Corycaeus Megalopa Cypris larvae	9-12-53	Calanoids *Coscinodiscus* *Corycaeus* *Onceaea* *Macrosetella*	7.2 to 12.2
29- 1-54	Calanoids *Corycaeus* Decapod larvae *Macrosetella* Bivalve larvae Stomatopod larvae *Oncaea* Cypris larvae Gastropod larvae *Oithona*	29- 1-54	*Sagitta* *Undinula* Lucifer Calanoids *Corycaeus* *Oithona* *Macrosetella* *Oncaea* Bivalve larvae Gastropod larvae	5.2 to 7.6
4- 2-54	*Macrosetella* *Undinula* Megalopa *Oncaea* *Oithona*	4- 2-54	Calanoids Decapod larvae *Oithona* *Corycaeus* Gastropod larvae	5.5 to 6.9
11- 2-54	*Undinula* *Macrosetella* Lucifer *Oncaea* *Corycaeus* *Sapphrina* Labidocera	11- 2-54	Calanoids Decapod larvae Fish eggs *Oithona* *Corycaeus* *Macrosetella* Lucifer	7.1 to 8.7
15- 2-54	Cypris Bivalve larvae Calanoids *Euterpina* *Corycaeus* *Macrosetella* *Oithona* Nauplius (copepod)	15- 2-54	Calanoids Decapod larvae Gastropod larvae Bivalve larvae Fish eggs *Oithona* *Corycaeus* *Euterpina*	5.4 to 7.2

TABLE 4—(*Contd.*)

Food organisms arranged in their order of abundance				
in the stomachs		in the Plankton		Size range of fish
Date (1)	Name of Organism (2)	Date (3)	Name of Organism (4)	examincd in cm. (5)
24- 2-54	Larval prawns *Euterpina* *Coscinodiscus* Calanoids Diatoms *Oithona* Nauplius (copepod)	24- 2-54	Gastropod larvae Bivalve larvae Diatoms Lucifer Prawn larvae Decapod larvae *Oithona* Calanoids	10.3 to 13.4
25- 2-54	*Anchoviella* Polychaetes Megalopa *Coscinodiscus* Calanoids Decapod larvae *Corycaeus* Fish eggs Bivalve larvae	25- 2-54	Megalopa Cypris larvae *Lucifer* *Oithona* Bivalve larvae Gastropod larvae Polychaetes *Euterpina*	9.2 to 13.1
4- 3-54	Larval prawns Calanoids Clupeid scales *Oithona* *Euterpina* Megalopa *Oncaea*	4- 3-54	*Lucifer* Calanoids Gastropod larvae *Oithona* Decapod larvae Zoaea Bivalve larvae	6.0 to 10.6
9- 3-54	*Anchoviella* *Lucifer* *Labidocera* Euphausids Teleost remains Polychaete remains	8- 3-54	*Pleurobrachia* *Lucifer* Zoaea Sagitta Megalopa Fish larvae	6.5 to 7.5
12- 5-54	*Oncaea* Calanoids *Euterpina* *Macrosetella* Bivalve larvae Fish eggs *Euterpina*	11- 5-54	*Oncaea* Calanoids *Sagitta* Larval prawns Fish eggs *Euterpina* *Centropages*	11.5 to 13.5
15- 5-54	Larval prawns *Coscinodiscus* Calanoids *Corycaeus* *Oncaea*	16- 5-54	*Oithona* *Acartia* *Oncaea* *Temora*	11.0 to 13.5

TABLE 5—Relationship between monthly condition of gonads and size range and state of feed of *S. gibbosa*.

Months	State of maturity of gonad	% of the fish	% of the males	% of the females	% of fish of indistinguishable sex	Size range of males in cm.	Size range of females in cm.	Size range of fish of indistinguishable sex. in cm.	State of feed
September	I	100.00	25.02	33.36	41.70	8.9–11.6	10.7–11.7	8.8–11.1	1.00
October	I	100.00	7.70	69.30	23.10	11.80	8.1–10.7	8.3– 8.9	2.00
November	I	100.00	25.00	55.00	20.00	5.1–11.7	7.9–11.9	6.8– 9.8	4.00
December	I	100.00	33.32	38.08	28.56	7.2–11.7	7.2–11.9	7.1–11.1	4.80
January	I	100.00	31.78	4.54	63.56	6.6– 7.6	7.6-	5.2– 7.1	5.40
February	I	84.24	17.36	32.90	49.74	5.4– 6.9	6.1–11.1	5.4– 7.2	3.33
	II	1.56	100.00	—	—	11.5–12.0	— —	— —	2.50
	V	13.43	60.00	40.00	—	11.1–12.0	10.3–11.1	— —	3.33
March	I	94.35	—	41.30	58.70	— —	6.0– 8.2	6.0– 7.9	8.02
	V	5.50	100.00	—	—	10.6	— —	— —	9.00
April	I	100.00	79.70	9.80	9.90	3.0– 8.9	3.0– 8.4	7.6	6.05
May	I	77.70	65.78	14.30	20.02	11.1–13.0	11.1–13.5	11.5–12.0	1.69
	II	17.76	75.00	25.00	—	11.6–14.1	11.4–13.8	— —	1.32
	III	4.44	100.00	—	—	13.5	— —	— —	3.01
June	I	100.00	67.50	27.50	5.00	9.7–13.7	6.4–13.5	10.5–13.0	1.00

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Seasonal Variations in the Total Biomass and Total Organic Matter of the Plankton in the Marine Zone of the Vellar Estuary

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

CONTENTS

Introduction

The Vellar Estuary at Portonovo (Madras State. lat. 11° 29'N., long. 79° 49'E.), which has an open bar throughout the year, has a marine zone extending for over a mile up the river. This is characterised by the absence of vertical haloclines and by the predominance of the neritic waters at high tide.

The hydrology and biology of the marine zone of the estuary were investigated by me during the year 1953—1954. As a part of this programme of study, the seasonal and tidal variations in the total biomass and total organic matter of the plankton in what Ruttner (1953) has termed the "settling volume of net-catches' were determined. This was chiefly with a view to obtaining relative information regarding the planktonic element indigenous to the marine zone and that which dominates at high tide due to the influx of sea water.

The study of an ecosystem involves three levels, (1) the trophic level giving the pyramid of production, (2) the 'living weight' with the pyramid of biomass and (3) the pyramid of numbers. The concept of biomass, originally used by Petersen (1922), and later by Zenkowitch (1931) and Bogorov (1934), is related to the population of organisms in a definite or unit area or volume as estimated by the total weight and determined at some particular moment. The study of biomass may be at

species level, or as in the present study, at community level. Allee *et. al.*, (1950) have pointed out that few complete biomass studies are available.

Riley (1938) has shown that the total organic matter may show a parallel variation to that of chlorophyll units which have been used frequently as measure of productivity. This suggests that the amount of total organic matter has a bearing on the problem of organic production. Organic production is "the amount of organic material which by the activity of the organisms is synthesized in a volume of water or synthesized from inorganic substances in unit area" (Sverdrup, *et. al.*, 1949). The estimation of organic production is, however, a very complex problem. The determination of standing crop, the biomass per unit volume, or chlorophyll content of filter residues, can at best be only rough approximations, as Ruttner (1953) pointed out.

Studies bearing on the productivity of Indian waters have been few. Ramamurthi (1953) studied the seasonal variations of phytoplankton estimated as chlorophyll units. Prasad (1956) has correlated the changes in the nutrient salts with the variations in phytoplankton of inshore waters of Mandapam.

In the present study the total biomass and total organic matter in the plankton collections were estimated during the different months.

Material and Methods

Plankton collections were made with a tow-net made of organdie with 29 meshes per linear centimeter and one metre in length and with a diameter of 40.4 cm. at the mouth and tapering at its lower end to a narrow band of thick cloth, 6 cm. in diameter for the attachment of a bottle. Collections were made under identical conditions twice a week. During January, February, and early part of March 1954, tri-weekly collections were made. The collected plankton was preserved with 5% formalin and then filtered through a Buchner funnel using a weighed filter paper (Whatman No. 42). The plankton residue was finally washed with distilled water and then desiccated for two to three days. The residue was dried in an open air bath at 90°C. and was weighed repeatedly after drying, till successive weights were found identical. After deducting the weight of the filter paper, the constant dry weight is obtained, and this stands for the biomass. According to Bogorov (1934) this gives a truer picture of biomass.

For determining the organic matter the dried plankton was incinerated in a weighed crucible and the ash weight was determined. The difference between the ash weight and the constant dry weight gives the total organic matter.

Owing to the difficulty of accurately determining the volume of water filtered through the net, the values for both total biomass and total organic matter in the present study are *expressed per* 600 *ml. of the 'settling volume of the plankton net-catches'*. These values give an idea of the relative changes in the total biomas and total organic matter.

Along with these estimations of total biomass and total organic matter, hydrological data like temperature, salinity, oxygen content, phosphate content etc., were collected during July 1953 to June 1954, with an interruption during October and November when there were heavy rains and floods.

Results

Tables I and II, and the graphs represent the data collected during the investigation. The total biomass and total organic matter at high tide as well as low tide show a marked seasonal variation. During July, August and September, the values for total biomass at high tide are below 0.4500 gms. per 600 ml. of plankton concentrate, and for total organic matter below 0.2500. From December to February there is a gradual increase, and in March there is a rapid rise. This is followed by a fall in April, and during May the values rise to a maximum and thus a major peak is observed during this month. In June there is an abrupt fall. The variations at low tide also follow the same general plan.

Discussion

The total biomass, as stated above, has two peaks, a minor one in March and a major one in May. It will be seen from the graphs that the peak in March is higher at high tide than at low tide, and the rise from December is also more steep. This is due to the great influx of marine organisms at high tide, which in this month include large swarms of pteropods. The peak for total biomass in May is practically the same at high tide as at low tide.

With regard to the total organic matter also the peak at high tide in March is higher than that at low tide. This again is due to the influx of pteropod swarms observed at high tide during this month. At low tide the swarms drift into the sea.

The biomass and organic matter have parallel major peaks both at high tide and low tide. The peak for organic matter is slightly higher at low tide than at high tide. From this the following inferences can be drawn:—1. During May there is a constant plankton population in the marine zone of the estuary, idependent of the influx of the neritic plankton at high tide, and (2) that its density is higher at low tide resulting in a greater settlement volume of the plankton net-catch. This will be explained later on.

The state of affairs is different in other months. There is a marked difference during March between the biomass peak and the organic matter peak which is greater at low tide. The difference at high tide is

due to the fact that in the total dry weight of the plankton the calcareous shells of the pteropod swarms account for a good deal of the weight. But in total organic matter this is excluded and there is therefore no close correspondence between biomass and organic matter.

These conclusions find support in the data relating to plankton counts made with the plankton microscope, and shown in Table II. From the table the following points may be noted.

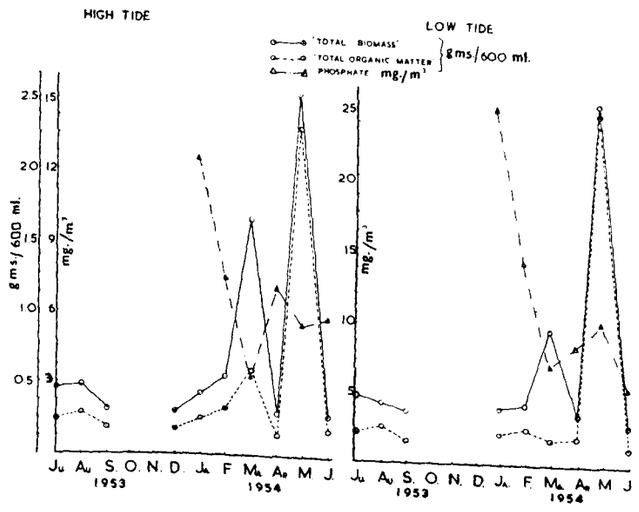

Fig. 1. Graph showing the seasonal changes in the biomass and organic matter of the plankton net catches and phosphate content of water during July 1953 to June 1954.

1. In March there is a very large number of pteropods at high tide and about a tenth of the swarm evidently lingers at low tide.

2. The phytoplankton is greater (about one and a half times) at low tide than at high tide. This means that there is an endemic phytoplankton population in the estuary which becomes less concentrated at high tide. The increase at low tide is not due merely to the addition of the residual high water plankton that might be left behind; for, a reference to table II will show that the zooplankton at low tide is considerably lower than at high tide. It is only the phytoplankton that shows a remarkable increase at low tide.

3. The phytoplankton bloom in the estuary is seen in May, and the 'settling volume' of phytoplankton in the net catch is therefore much greater at low tide. Further, during this month copepods and other crustaceans are faily abundant even at low tide in the estuary while pteropods are entirely lacking. Hence the peak of organic matter

at low tide is slightly higher than that at high tide when the influx of sea water probably lessens the concentration of the population of the phytoplankton in the estuary.

The variations in the phosphate content in relation to the total organic matter, are represented in the graphs. It will be noticed that at high tide there is an inverse relationship between the variations in phosphate content and total organic matter. The relation to biomass is not of much importance, as it is only the total organic matter that counts in a discussion of the organic production. An inverse relationship between phosphate content and phytoplankton has also been observed by me in the marine zone (Seshadri, 1955). Investigators in different-regions of the world have observed similar relationships (Atkins, 1926; Marshall and Orr, 1927; Harvey *et. al.*, 1935; Braarud and Bursa, 1939; Riley, 1939, 1941 and 1947 and Prasad, 1956). Riley (1941) has explained that the total amount of plankton present at the peak of bursts corresponds roughly to the initial concentration of the nutrients. In the present investigations high phosphate values were observed at high tide during April (7.7 mg./m.^{3}) and these may be related to the peak in total biomass and total organic matter during the succeeding month, that is, May.

But at low tide this inverse correspondence between phosphate content and total organic matter does not hold good. At high tide neritic waters dominate in the marine zone and the relationship observed between phosphate content and total organic matter is that which obtains in neritic waters. But at low tide the estuarine hydrological features predominate.

Studies on the phosphate content of the marine zone of the estuary (Seshadri, 1955) have shown that there is an appreciable amount of interstitial phosphate (23.7 m. gm./gm. of silt) and that at low tide the phosphate content of the waters of the marine zone is higher (e.g. during February 24th the low tide reading shows 12.50 mg./m.^{3} of phosphate content while on 25th. at high tide it is 5.85 mg./m^3). These features apparently affect the relationship between phosphate content and organic matter.

Thus the study of the total biomass and total organic matter helps an analysis of neritic and estuarine elements of the plankton of the marine zone of the estuary.

Summary

1. The total biomass and total organic matter in the 'settling volume of the plankton net-catches' show tidal and seasonal variations.

2. An analysis of these variations has shown that the plankton in this zone has a considerable endemic phytoplankton element at low tide. At high tide the neritic fauna is brought in by the influx of neritic waters.

3. The total biomass shows a minor peak in March and a major peak in May at high tide as well as at low tide. The organic matter shows similarly two peaks at high tide, but the low tide has only the major peak.

4. The biomass and organic matter peaks are parallel at high tide but at low tide the correspondence does not exist, in March. This is due to the disappearance at low tide of most of the pteroped swarms which come in at high tide.

5. The major peak for organic matter is slightly high at low tide. This is due to an endemic phytoplankton population in the estuary which has a greater density at low tide, but at high tide when there is the influx of sea water the 'settling volume of the phytoplankton in the net-catch' is less dense.

6. The variations in the phosphate content at low tide and high tide are discussed in relation to the variations in the organic matter.

Acknowledgments

I have great pleasure in expressing my indebtedness to Prof. R. V. Seshaiya, Director and Professor, Marine Biological Station, Porto-novo, for suggesting the problem, guidance and instruction. My thanks are also due to Sri S. Swaminathan and Sri V. Sriramulu, for help in preparing the typescript.

TABLE 1—*Monthly Mean data of Total Biomass, Total Organic Matter and Phosphate content 1953–1954.*

	July	August	Sep.	Dec.	Jan.	Feb.	March	April	May	June
High tide										
Phosphate content mg./m³	—	—	—	—	12·96	8·49	3·45	7·70	5·00	5·50
Total biomass gms./600 ml.	0·444	0·4787	0·3131	0·2963	0·4223	0·5312	1·6320*	0·2878	2·5366*	0·2817
Total organic matter gms./600 ml.	2·380	0·2883	0·1820	0·1769	0·2542	0·3223	0·5906*	0·1335	2·2835*	0·1882
Low tide										
Phosphate content mg./m³	—	—	—	—	24·85	14·14	7·00	8·40	10·00	5·50
Total biomass gms./600 ml.	0·4792	04·602	0·3723	—	0·3968	0·4139	0·9479*	0·3630	2·5894*	0·2914
Total organic matter gms./600 ml.	0·2250	0·2675	0·1635	—	0·2281	0·2599	0·1872	0·2306	2·4779*	0·0815

* Values showing the peak.

TABLE 2—*Monthly Mean data of plankton counts 1953-1954.*

High tide

	July	August	Sep.	Dec.	Jan.	Feb.	March	April	May	June
Phytoplankton	9,140	5,326	1,670	39,250	71,731	106,490	98,096*	452,295	2,925,865*	20,327
Copepods	11,987	20,589	16,384	34,340	24,693	22,096	12,940	5,540	8,370	29,507
Other crustaceans	4,280	1,120	4,242	1,580	3,229	2,694	1,606	2,630	1,750	4,193
Pteropods	—	60	15	—	107	639	34,857*	73	—	—
Total Zooplankton	17,036	27,352	25,927	37,311	31,777	29,841	56,549	10,228	11,395	35,422

Low tide

Phytoplankton	3,200	—	—	—	29,274	47,353	149,600*	1,124,340	4,100,640*	3,502
Copepods	6,760	13,770	13,350	—	13,130	7,720	2,860	4,080	1,400	5,960
Other crustaceans	760	3,093	6,610	—	707	2,060	270	3,980	1,180	2,913
Pteropods	—	5	—	—	—	1,467	3,800*	—	—	—
Total Zooplankton	7,920	18,550	24,961	—	15,075	16,354	7,810	9,361	3,685	10,359

* Values at peak.

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An Experimental Study on Thanatosis in *Armadillidium vulgare* (Latreille)

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CONTENTS

Introduction

Thanatosis (or death-feigning) is well developed in many animals particularly in insects. An immovable posture is assumed by the animals when feigning death. In the present paper an experimental study has been made on the death-feigning of an arthropod, *Armadillidium vulgare* (Laterille).

Material and Methods

Specimens of the land crustacean *Armadillidium vulgare* (Latreille) were collected from the fields and kept at room temperature in a muslin-topped square glass jar containing some earth and wet pieces of rotten wood. The earth and the pieces of wood were maintained moist.

The effect of the stimuli caused by the following materials in evoking thanatosis was investigated.

I. *Air*—A hollow glass rod drawn into a fine point was used for blowing air.

II. *Cotton*—A little cotton was wrapped and tightened at the end of a glass rod, which was pointed at the end in order to facilitate the application to a particular region of the body.

III. *Brush*—A camel hair brush pointed at the end by removing some side hairs.

IV. *Thread*—A piece of thread, a bit thick, was tightened at the end of a rod and was glued at the free end in order to make it a little hard.

V. *Pencil*—The flat end of the pencil was used for evoking thanatosis in wood lice. This was the hardest source of stimulus employed.

In order to study the effect of Ultra-violet light a mercury discharge lamp was used as the source of the light.

The experimental crustaceans were allowed individually to remain undisturbed for a reasonable time before determining the duration of thanatosis, as handling the specimens before applying a stimulus makes them exicited and unresponsive to the stimulus. Also as the behaviour of the wood lice varies with humidity and as they cannot stand low humidity, the following method was adopted in order to keep them separately and provide them with 100% humidity and other natural conditions during the experimental period.

Round tin boxes were used each containing five 7 cms. Whatman filter papers spread on a circular perforated zinc plate having the same diameter as the inside of the box and resting on three petridishes filled with water. The specimens were allowed to move separately in these boxes, for 24 hours on the filter papers covered by muslin-topped metal rings to avoid the pre-handling effect. In order to facilitate observations the filter papers with the specimens were kept about 2 inches below the mouth of the box by placing the petri dishes on a hard cardboard disc placed on three rubber stoppers. Some moist earth and a piece of rotten wood, which had been previously soaked in water for a number of hours, were placed on the filter papers. To maintain a sufficiently high humidity the box was covered by glass plate with two holes for ventilation. The specimens were then thrown into the state of thanatosis by exercising a slight pressure with the flat end of the pencil on the ventral side of the body and the duration of thanatosis state was recorded. The time of termination of thanatosis was noted at the moment when unrolling occurred. Filter papers were kept moist throughout the experimental period.

While studying the effect of light illumination, a device was needed to prevent the heat of the bulb reaching the experimental animals. For this reason the special apparatus and the experimental method followed previously (Saxena 1956) were used with the following modifications:

The wood lice, while still in the tin boxes confined individually within the funnels, were exposed to illumination. The conditioning was done by keeping the boxes in the dark for 24 hours. The pieces of wood were removed before subjecting the wood lice to light, so as to prevent their hiding under the wood, and the earth provided was in very small quantity so that they were not able to bury themselves in order to escape from light. As the mercury discharge lamp does not radiate much heat, the lamp was placed above the experimental wooden box completely covering the circular hole of the box. While working

with long exposures, the cold water of the trough was changed at intervals, depending on the light intensity in order to keep it sufficiently cool. The illuminations were measured by a commercial photometer in Log. foot lamberts.

To ascertain the age, the specimens collected about two months ago were used for experiments. All the experiments were performed at constant temperature except the one in which the effect of various temperatures was studied. The durations of thanatosis in all the experiments were transformed by the square root transformation method in order to make the distribution of data more nearly normal and so to make the variance in any group of observations independent of the mean. The mean transformed durations of large number of specimens were plotted on the graph.

Experimental Results and Discussion

I. *A General Study of Thanatosis.*

(i) *Induction of thanatosis.*

A light pressure on the ventral side and sometimes a fall from a height of 2 or 3 inches will bring about this motionless state and induce the characteristic roll-up into a ball-like shape. Some individuals were found very susceptible even to the lightest touch on their bodies. A slight pressure by the flat end of a pencil on the ventral side has been used for inducing thanatosis in the present work.

(ii) *Posture during death-feigning.*

The posture assumed by *Armadillidium vulgare* in the form of a ball is quite unlike that of the insects. After mechanical stimulation the anterior and posterior ends gradually move inwards with the antennae tightly pressing against the head and gradually moving into the convexity formed by the pereion and pleon. Simultaneously the legs also begin contracting and by the time they completely fold in, the gradually moving anterior and posterior ends join with each other and the animal assumes a ball-like shape. In rare cases, incomplete rolling into a ball-like shape, probably due to an incomplete thanatosis has also been observed.

(iii) *Termination of thanatosis.*

A gradual termination has been observed in *A. valgare* which begins with slow unrolling of the body. The antennae and the legs simultaneously get into motion and peep out of the following convexity during the process of unrolling.

(iv) *Apparent insensibility to pain while in the death-feint.*

While in thanatosis state the crustaceans do not show any symptom of pain, even if they are pricked by the needle. De Gur also supported this observation.

(v) *Thanatosis in response to various stimuli.*

50 specimens taken from a collection were divided into 5 batches of 10 each. The period of thanatosis of the individuals of the batches A, B, C, D, and E was determined by applying the stimuli, air, cotton, brush, thread and pencil respectively on the ventral side. The results reveal that there is an increase in response with softer to harder stimulus. The maximum response of 9.23 sec. received was to the pencil stimulus, the hardest in the series, and there was no response to air stimulus. These observations suggest that there is a relation between the length of the period of thanatosis and the intensity of stimulus. The possibility of this correlation has also been pointed out by Weiss (1947), (Fig I).

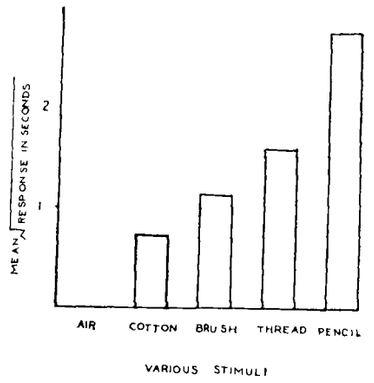

Fig. 1 - Effect of various stimuli.

(vi) *Effect of continuous application of the stimulus on thanatosis.*

If the wood lice is compelled to repeat the performance of death-feigning, a gradual decrease in the length of the period of thanatosis is observed. Ten wood lice collected from the field were allowed to lead a normal life for 24 hours within the rings. Each specimen was subjected to the series of applications of the stimulus (pencil) until it failed to show thanatosis or showed it for a very short period. Fifteen applications of the stimulus were required, when the majority of specimens failed to feign (Fig 2). A gradual fall in the response with the increase in the number of applications has been observed. The fall was of 8 seconds on 15th application of the stimulus. The wood lice were in an excited stage after a number of repeated applications of the stimulus.

When in this state they cannot be induced to exhibit thanatosis. This stage, which was also observed by Kozanshikov (1931) while working on

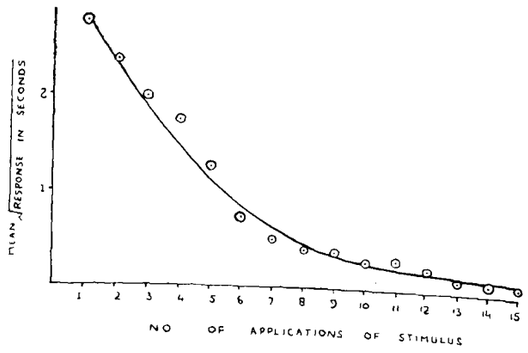

FIG 2. EFFECT OF CONTINUOUS APPLICATIONS OF STIMULUS

Lochmaea caprae L., may be because of the fatigue stage reached by the specimens after a number of applications.

II. *Effect of Physical Factors.*

(i) *Duration of thanatosis as affected by light illuminations.*

Light exposures also affect the death-feigning response of wood lice. The experiments were designed to study the effect of different light illuminations, different exposures of the same light illumination, and the effect of Ultra-violet light.

Effect of different light illuminations.

3 batches of 10 wood lice each, were subjected to 3 different illuminations of 0.65, 1.2, and 1.4 Log-Foot Lamberts and the response was recorded, which shows that the duration of thanatosis of 10.4 seconds on exposure to an illumination at 0.65 Log-Foot Lamb. falls to 3.98 seconds at the exposure of 1.4 Log. Ft. Lambs. Hence it appears that the period of thanatosis is inversely proportional to the light intensity. Similar results were obtained by Holmes (1906) while working on *Ranatra*. Under a high intensity of light most of the specimens did not show death-feigning at all. This may be due to the excitement caused by the light stimulation (Fig. 3).

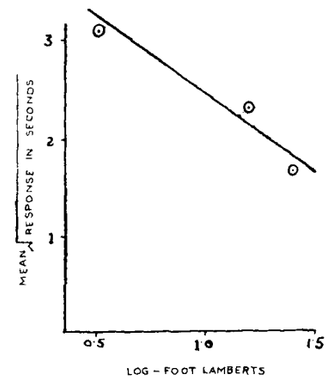

Fig. 3 - Effect of different light illuminations.

Effect of different exposures of light illuminations.

In this case again the steady fall in the duration of thanatosis was observed on increasing the time of exposure to light of the same intensity. 10 wood lice showed a period of 8.68 seconds on their exposure for two hours to an illumination of 0.7 Log. Ft. Lamb. against the period of 3.52 seconds on an exposure for 6 hours to the same light intensity (Fig. 4).

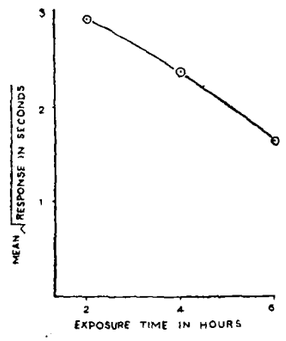

Fig. 4 - Effect of different exposures of constant illuminations

Effect of Ultra-violet light.

Wood lice appear to be sensitive to Ultra-violet light. A fall in the duration of thanatosis was recorded on exposing 30 wood lice, divided into 3 equal batches, to Ultra-violet light for 1, 2, and 4, hours. It was

also observed that the longer exposures excite the wood lice much more than the shorter ones, as the duration of thanatosis of 7.9 seconds at 1 hour exposure falls to 2.8 seconds at 4 hours exposure. This result is in accordance with several scientists (Luz & Ritchmyer 1922, Bertholg 1931-32, Hess 1920*b*, Peterson & Haeussler 1928), who demonstrated the sensitivity of some arthropods to Ultra-violet light. (Fig. 5).

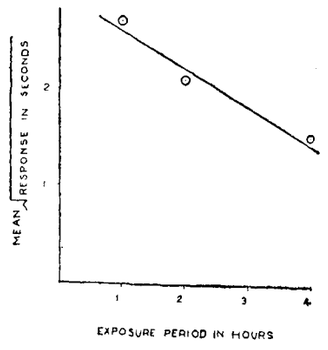

Fig. 5 - Effect of Ultra-violet light at different exposures

(ii) *Duration of thanatosis as affected by temperature.*

The results of the various experiments performed with *A. vulgare* show that the duration of thanatosis diminishes with increase in the temperature. The periods of thanatosis recorded at the temperatures of 15°C, 20°C, and 25°C were 24.2, 8.92, and 6.12 seconds respectively. This finding agrees with the results obtained by Holmes (1906). *A. vulgare* showed nervous excitability at high temperature while they were inactive at low temperature (Fig. 6).

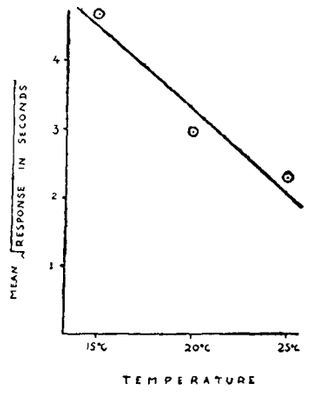

FIG.6. THANATOSIS AT DIFFERENT TEMPERATURES

Death-feigning, which is widely common among animals specially among arthropods, has not yet been clearly understood and requires a detailed investigation. The work may be pursued to study what part of the nervous system is connected with this response of the animals, and what role the sensitivity of the different parts of the body play.

Summary

Thanatosis may be induced in *A. vulgare* by applying a hard stimulus like the flat end of pencil. The animal rolls up into the shape of a ball and lies motionless during thanatosis. The termination of thanatosis is gradual beginning with the slow unrolling of body.

There exists a relation between the intensity of the stimulus and the duration of death-feigning.

By compelling the wood louse to feign death continously, a fatigue stage is reached, when it does not respond in the normal way.

A decrease in the duration of thanatosis and the excitement among specimens of *A. Vulgare*, result on their exposure to brighter illumination or when they are exposed for longer periods to the same illumination.

Armadillidium vulgare is sensitive to Ultra-violet light.

Temperature affects the duration of thanatosis which decreases at high temperatures.

Acknowledgments

The author wishes to thank Prof. D. S. Srivastava, Head of Zoology Department, Saugar, for his suggestions during the preparation of the manuscript.

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On Some Abnormal Sharks Preserved at the Marine Biological Station, West Hill*

BY M. D. MENON

While going through the various collections of fishes at the museum of the Marine Biological Station, West Hill, an opportunity was available to examine four interesting and abnormal specimens of sharks amongst them. A fifth specimen was given to me by Sri U. Sundar Kini, Oil Chemist, Government Shark Liver Oil Factory, Kozhikode. These five interesting abnormalities are described in this paper. One of these has already been recorded by me in 1945 and a popular note on it was published then.(1)

The five specimens recorded are the following:—

1. Double monster of the shark—*Scoliodon palasorrah* (C).
2. Double monster of the shark—*Carcharhinus temminckii* (M.H.)
3. The split headed monster of *Carcharhinus menisorrah* (M.H.)
4. Pug snouted fused eyed *Hypoprion macloti* (M.H.)
5. Thumb snouted Albino of the shark *Carcharhinus dussumieri* (M.H.)

I. *Double monster of Scoliodon palassorah—Fig.* 1

The specimen was secured from the womb of one specimen of *Scoliodon palasorrah* measuring 3'9" in length along with four other normal embryos on 12th October 1945.

External features. The monster measures 245 mm. It appears to be the union of two equal embroys. The two members are united just at the region of the 5th gill cleft. There are five gill clefts for each head on its outer side whereas on the inner edge where the 2 heads have united, there are only 4 separate gill clefts on each head

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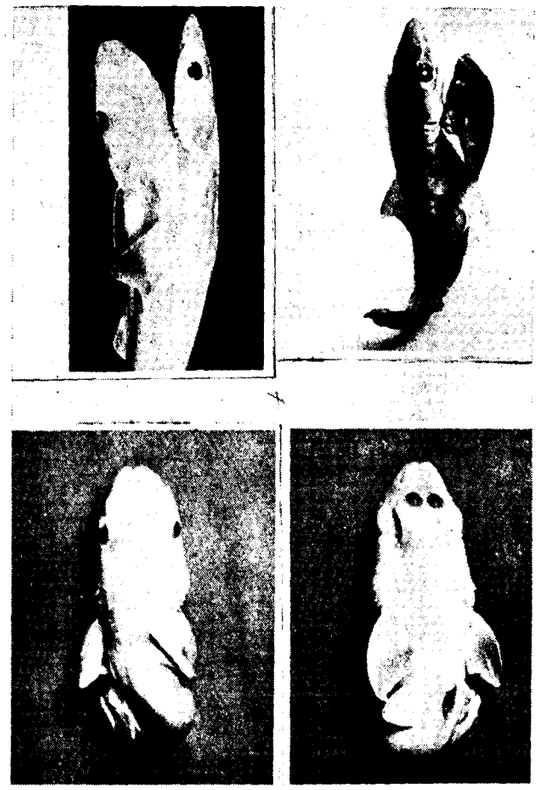


Fig. 1. Double monster of *Scoliodon palasorrah.*
Fig. 2. Double monster of *Carcharinus temminckii.*
Fig. 3a. Split headed monster of *Carcharhinus menisorrah*-Dorsal view.
Fig. 3b. Split headed monster of *Carcharhinus menisorrah*-Ventral view.

the 5th gill cleft being common to both. The monster has two distinct and separate anterior dorsal fins and two posterior dorsals of similar size and shape. There are only one pair each of the pectorals and ventrals. The anal also is not doubled. The caudal is single but there are two ridges on its dorsal side. Only a single placental chord was present entering between the pectorals. It would thus appear that the two members of the union maintained their separate individuality dorsally in the external features whereas ventrally the union seems to have been complete. All the external features of the head are normal, each head having the usual characters in normal shape and position. In the X-ray photograph of this specimen it is seen that both the individuals are having separate vertebral columns until just before the caudal pit where they coalesce together. As the monster is viewed with the dorsal aspect of the heads facing the viewer, it is seen that the head of the left partner is united with the right partner at an angle of 40°. From the cranium of the left partner the vertebral column runs down at the same angle towards the vertebral column of the right partner. But at about the level of the pectoral fins these two vertebral columns run straight down parallely until the caudal pit where they fuse together and form one caudal portion of the column.

Internal organs—Fig. 4. The internal viscera show the following peculiarities. There are two stomachs each lying on either side of the body cavity. The stomach of the left partner (i.e., when viewed from above) is slightly larger than that of the right partner. The duodenum of the two stomachs open into a common median intestine. The duodenum of the right partner opens on the dorsal aspect of the intestine while that of the left partner opens on the ventral aspect. The median intestine passes into a rectum. There is only a single anal opening. The liver is paired, i.e., there are 4 lobes of the liver. The right lobe of the right liver mass and the left lobe of the left one are long and narrow, whereas the left lobe of the right one and the right lobe of the left one are very small and lie close to each other. The right lobe of the right liver mass is larger than the left lobe of the left one. The gall bladder is single and it is embedded in the left lobe of the left mass. The spleen and pancreas are duplicated and lie in the respective duodenal lobes. The right pancreas is slightly smaller in size than the left one. There are two bile ducts. The right one opens behind the

junction of the right duodenum and the intestine. The yolk sac opens at the front end of the intestine. There are 2 hearts, each one situated adjacent to each other in one pericaridal cavity, but separated by a

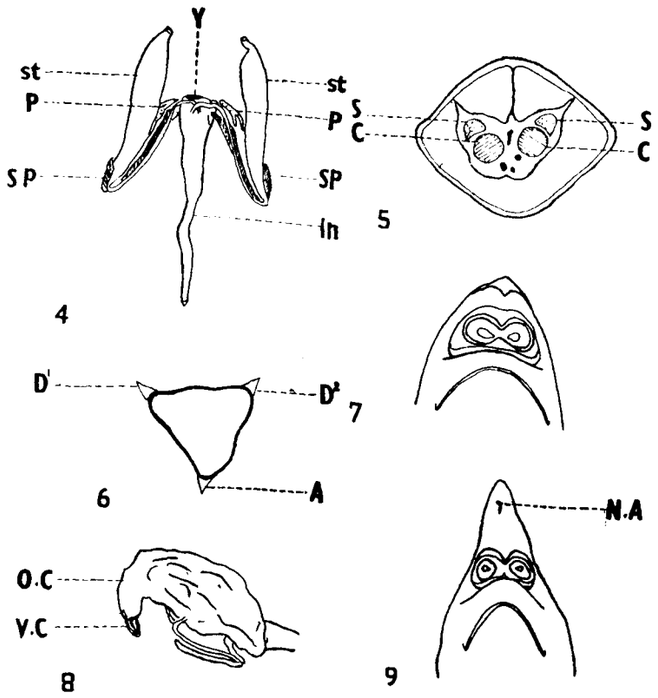


Fig. 4. Showing diagrammatically the alimentary canal system of the double monster *Scoliodon palasorrah* *St.*—Stomach; In.-Intestine; P.-Pancreas; *Sp.* Spleen; *Y.*-Opening of the internal yolk sac.

Fig. 5. Hand section of the double monster across body just behind second dorsal. S.-Spinal cords, C.-Centra.

Fig. 6. Diagrammatic section across the body of the double monster *Carcharhinus temmincki* to show the Disposition of the fins D^1, First dorsal fin; D^2, Second dorsal fin; A.-Anal.

Fig. 7. Ventral view of the head of *Hypoprion macloti* M. H. to show the fusion of the ornea.

Fig. 8. Diagrammatic representation of the cranium of *Hypoprion macloti* reconstructed from X-ray photograph. O.C., Olfactory capsule, V.C., Ventro-medium cartilage.

Fig. 9. Ventral view of the head protion of *Carcharhinus dussumieri* M.H. showing the fusion of the eyes and the location of the nasal aperture. N.A., Nasal aperature.

thin septum. The posterior walls of the chambers are cartilaginous. In the arterial system the variations are only those consequent to the presence of 2 stomachs, 2 liver masses, 2 pancreas and 2 spleens. The two dorsal aorate join together in the middle of the abdominal cavity

slightly posterior to the region of the pectoral fins. The urinogenital system is not duplicated. There is only one set of these and it follows the usual type.

A hand section across the tail slightly behind the posterior dorsals is shown diagrammatically in Fig. 5. It is seen that the two members retain their identities as far as the centrum, spinal cord and

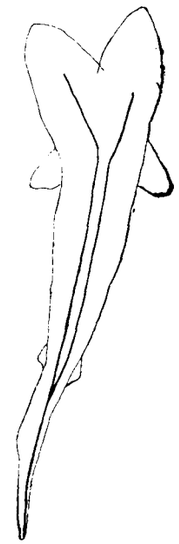


Fig. 10. Showing the disposition of the vertebral columns of the double monster *Scoliodon palasorrah*.

haemal arches are concerned. The actual union of these takes place slightly further down at the limit of the caudal pit as is seen in the X-ray photograph. (Fig. 10).

The monster thus appears to be the union of two embryos. But unlike the one described by Ford (1930) the two embryos appear to be of like and similar nature. The identity is still further expressed in the normal nature of the general pigmentation.

2. *Double monster of Carcharhinus temmincki—Fig.* 2.

This specimen appears to be formed of the fusion of two partners unequal in size, one of 130 mm. and the other of 120 mm. When viewed dorsally with the heads away from the viewer the right partner is the smaller one. The snout of the left partner is normal. That of the right partner is slightly curved to the right creating a puggy nature and the snout tip is slightly to the right of the median line. The eyes, nasal apertures and mouths are normal. Externally the fusion seems to have been ventrolaterally at the level of the pectoral. The bigger

left partner has 5 gill clefts on either side. The smaller right partner has only 4 gill clefts on either side. Again the bigger left partner has 2 pectorals, the right pectoral being very much reduced in size and placed at the junction of the two heads. The right partner has only one pectoral, the right one, well developed and similar in size and shape as the left pectoral of the left partner. Each partner has the first and second dorsal fins. The ventrals are only one pair for the monster. There is only one anal fin. Posterior to the fusion of the 2 heads the body of the monster is fairly triangular in cross section. In Fig. 6 the disposition of the various fins are diagrammatically represented.

The caudal presents a peculiar condition. It appears to be that of the smaller right partner with the characteristic upper and lower lobes. On the left side of the upper lobe of this caudal there is a ridge for its full length with a small fringe on it. This appears to be the upper lobe of the caudal of the left partner.

Internal viscera. The alimentary canal of this monster presented a similar condition to that in the specimen of *Scoliodon palasorrah*, described earlier. The stomach of this right partner was smaller than that of the left partner. The duodenum of the left partner opened ventrally at the anterior end of the intestine and the duodenum of the right

Fig. 11. Showing the disposition of the vertebrai columns of the double monster of *Carcharhinus temminckii*.

partner on the dorsal aspect. The intestine has a normal spiral valve. All the digestive glands like pancreas, liver and spleen are duplicated. The liver mass of the right partner is very much reduced in size and is much smaller than the livermass of the right partner. There are two hearts and the two dorsal aorate join together just at the region of the pectoral

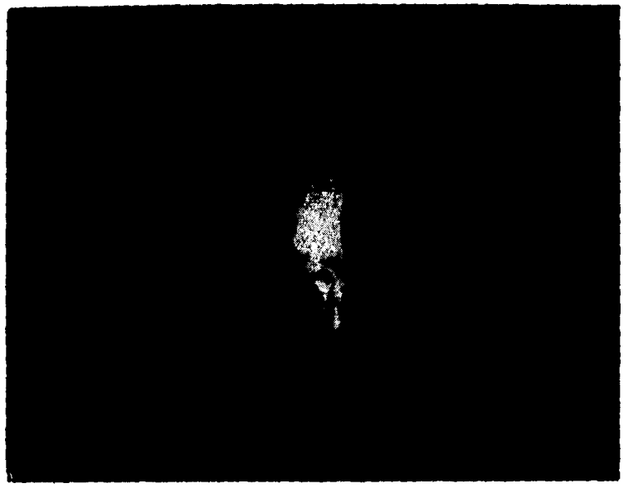


Fig. 12.

Fig. 13.

Fig. 12. Pug snouted *Hypoprion macloti*-Ventral view of the full specimen.

Fig. 13. Pug snouted *Hypoprion macloti*-ventral view of the head portion to show the fusion of the eyes.

fins. In Fig. 11 a diagrammatic representation of the disposition of the vertebral columns of the specimen is given. This has been taken from the X-ray photograph of the specimen. It can be seen that the vertebral column of the right specimen bends towards the vertebral column of the left partner and almost fuses with it. Bt from this position it diverges slightly away and runs down in slight convolutions and fuses with the vertebral column of the partner just behind the region of the second dorsal fins.

3. *Split headed monster of Carcharhinus menisorrah Figs* 3a. *and* 3b.

This is a 290 mm. long specimen coiled around at the post-anal region. The specimen was given to me by Sri U. Sundar Kini, Oil Chemist, Government Shark Liver Oil Factory, Kizhikode, from the small collection of sharks that are displayed at the Factory. No data on the parent of the specimen or on the date and place of capture, etc., are available. The specimen is a very interesting one in that unlike the two described above, this appears to be more a case of cephalic fission than that of post cephalic fission. Actually the two heads are not separate and distinct as is in the previous cases. The mouth, the eyes and the nasal aperture are all duplicated. It appears to be rather a case of incomplete halving of the cephalic region, all the characteristics duplicating but the two halves remaining fused. The left eye of the left half and the right eye of the right half are normal in shape and position and are situted on either sides of the "combined" head. The right eye of the left half and the left eye of the right half are pulled down ventrally on either side of the medioventral line of the combined head. The right nasal aperture of the right half and the left nasal aperture of the left half of the head are normal in nature and disposition. The right nasal aperture of the left half and the left nasal aperture of the right half are normal in shape but are placed in a ventrolateral position on the head. The head in a cross section presents a rhomboidal shape, with the broad end dorsally. The mouths are separate. The upper jaw in each half is placed ventrolaterally. But the lower jaw is pulled down ventrally and at right angles to the upper jaw and the lower jaws appear as two protuberant humps placed on either side of the medioventral line.

The dorsal fins, ventral fins, pectorals, pelvics and the anal are all normal in shape and disposition as in the case of a single individual. The gill clefts also are only 5 in number on either side of the specimen. The two lobes of the caudal fin are separate and quite distinct. The caudal ends in the upper lobe. The lower lobe is situated in the loop of the coil of the tail portion and is very curved.

Internal viscera. The two mouths open into one and the same buccal cavity. There is a single pharynx and from there onwards the alimentary canal has the characteristics of a single individual. The heart also is single and there is only a single dorsal aorta.

4. *Pug snouted Hypoprion macloti* (*M.H.*)—*Figs.* 12 and 13.

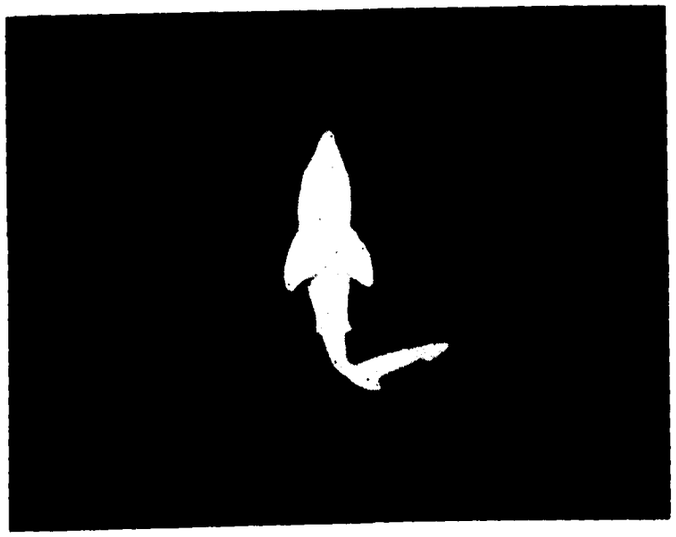
This specimen is a female 230 mm. long. It was secured on 9—11—1948 from the womb of its mother which was 2′ 10″ long. This monster has its snout very much shortened. The two eyes are displaced and are situated midventrally just in front of the mouth. The two eyes are fused together to form the monstrosity.

External characters. The colour of the formalin preserved specimen is greyish in the upper half of the body and dull pinkish in the lower half. The caudal has black posterior and lower edges. The first dorsal shows a slightly blackish edge. All the other fins have a light edge. In the disposition and nature of fins the specimen exhibits all the type characteristics except the complete absence of the anal.

The preoral portion of the head is very much shortened and curved above the eyes forming a small hump, and it stops in a point just in front and above the fusion of the eyes.

The eye. The eyes are fused together forming one big eye ball. The fused eye is located ventrally beneath the cervical hump and just in front of the mouth above the upper jaw. There are 2 separate pupils in the middle of two cornea. Though the cornea appears separate, they too are fused in the middle (vide Fig. 7). Normally the iris, in the type is strongly pigmented. But in this monster specimen it is completely without any pigment and is whitish in colour. There is only one long nictitating membrane.

In the X-ray photograph it is noticed that the cranium is bent at its anterior end. The olfactory capsules are very much reduced and almost negligible. The dorsolateral cartilages are bent and very disproportionately reduced. The ventro-median cartilage is also shortened and runs almost straight down (vide Fig. 8).



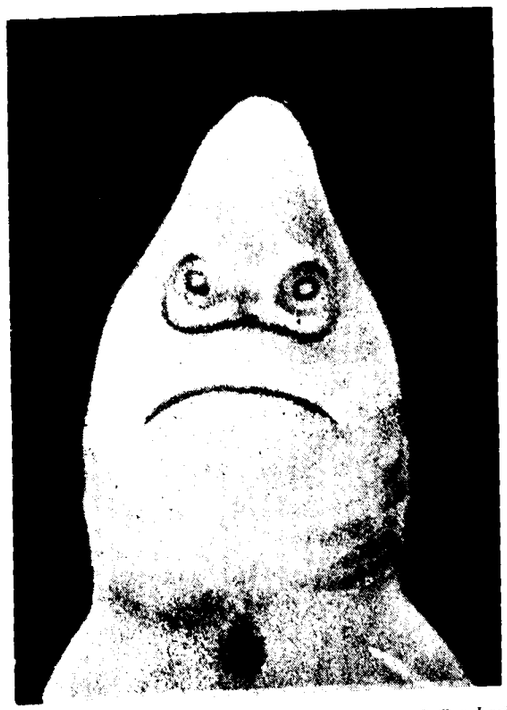


Fig. 14. The Thumb snouted albino of *Carcharhinus dussumieri* Ventral view of the full specimen.

Fig. 15. The Thumb snouted albino of *Carcharhinus dussumieri* ventral view of the head portion of the eyes.

There is no difference from the type in the internal viscera. It appears that this malformation is probably the result of undue compression of the anterior end of the embryo in the uterus bending down the region. As a result of this undue compression the developing eyes got squeezed under the hump and got fused together.

5. *Thumb snouted albino of Carcharhinus dussumieri. Figs.* 14 *and* 15.

As in the case of the previous specimen here also the eyes are displaced. They are situated ventrally just in front of the mouth and opposed to each other. But unlike the previous specimen the two eye balls are separate and they fuse on their sides over a small area only. The cornea and the pupils are all separate. Both the eyes are without pigments in the major portion. Only the pupil is edged black. The nictitating membrane is single but has a deep notch in the middle of its edge. The snout is prolonged above the eye and is thumb shaped. It is a bit spongy to the touch. The nasal apertures are minute and are situated anteroposteriorly at either ends of a small longitudinal line beneath the spongy snout, nearer to its tip than to the eyes (vide Fig. 9). The internal viscera and other external features do not show any departure from the type.

In the X-ray the cranium does not show any abnormalities. Only the dorsolateral cartilage of the rostrum shows a slight bent at its beginning in keeping with the curve of the thumb like snout.

Acknowledgments

My thanks are due to Sri U. Sundar Kini for kindly lending me the specimen of *Carcharhinus menisorrah*. I am also deeply indebted to the X-ray centre, Kozhikode-2, for the beautiful X-ray photographs they took of the five specimens.

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Life History and Feeding Habits of *Cynoglossus lingua* (Ham. Buch.)

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CONTENTS

Introduction

We do not have complete chronological accounts of the life histories of most tropical fishes. Accounts of the food and feeding habits of the earliest larval stages are fewer. Hence a full account of the life history and feeding habits of this flat fish (*Cynoglossus lingua*) studied in the laboratory at Madras is herewith presented.

Material and Methods

This fish, which is of market value all along the South Indian Coast, grows to a length of 23.5 cm. and is landed by using dredge nets. The material for the present study consisted of 82 eggs picked from inshore plankton collections made during May and June of 1956.

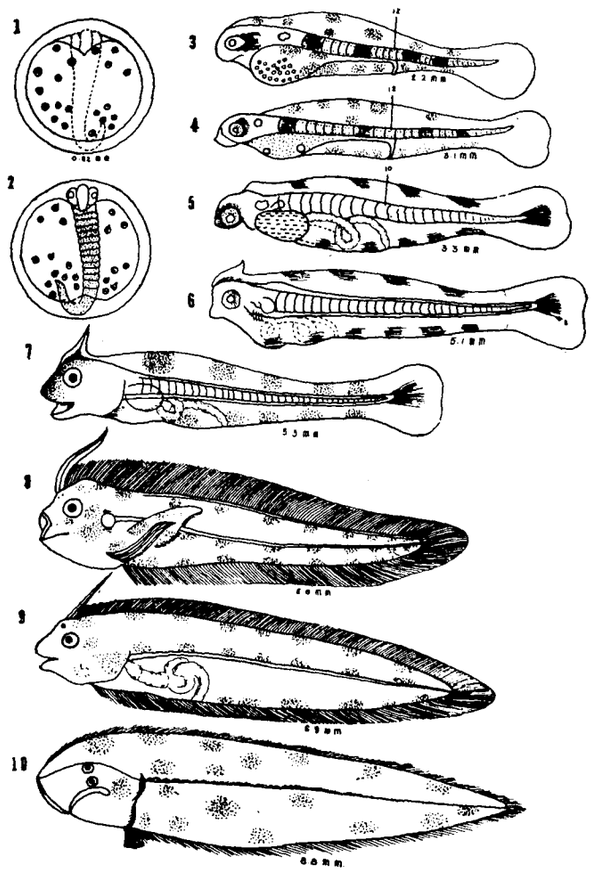
Since in a tropical place like Madras the Laboratory temperature ranges as high as 28 C to 35 C., the larvae had to be reared in a chamber 3' × 3' × 3' cooled by evaporation of water from thick wet cotton covering it. By adjustment of a fan ventilating the room, the temperature was maintained fairly constant. Dishes containing the larvae were left within the chamber and removed only for observation and attention. It was found that the larvae of *Cynoglossus lingua* throve best between 22 C and 25 C.

The larvae were fed with live organisms gathered from fresh plankton hauls each day, and in a few cases cultures were maintained. To

minimise the danger from ciliates' attack, sea water was boiled and left overnight to regain the normal gaseous content and was filtered and aerated several times before use. Dishes and pipettes were cleaned chemically and stocked in bottles of distilled water.

The Eggs and Larvae

The eggs were collected at about 8-30 a.m. and had an average diameter of 0.92 mm. They were perfectly spherical and transparent, and a faint outline of the embryo could be made out. In the yolk,



which was clear and unsegmented, about 20 yellowish oil gloubles were found arranged in such a way that more were in the posterior region than in the anterior region (fig. i). About six hours later, i.e., at 2 p.m. (fig. 2.) the embryo appeared more distinct and marked by a few black

spots. The eyes, a few myotomes, as well as a functional heart were noticeable. The constant wriggling of the embryo not only made the egg spin on its axis but later burst the egg membrane and hatch the embryo out of the egg.

The Newly Hatched Larvae:—(*Fig*: 3).

All the 82 eggs were hatched into healthy pro-larvae, 2.2 m.m long. They lay at the bottom of the glass containers with the yolk facing downwards, and at even the slightest disturbance they darted from place to place. The oil gloubles occupied the ventral region of the yolk over which the head was curved downward. The eyes were unpigmented. Black pigment spots were noticed in the yolk mass as well as along the margin of the dorsal and ventral fin folds. Yellow pigment cells appeared around the hind rim of the eye. There were also two patches of yellow cells arranged on the lateral sides of the body in front of the anus and two behind it. The anus was visible below the 12th myotome. The auditory vesicle was situated in front of the 1st myotome.

Larvae 18 *Hours after Hatching*:—(*Fig.* 4).

By 9 a.m. next day three of the pro-larvae had died and the rest measured 3.1 m.m. in length. The yolk appeared much reduced and only a single large oil glouble was left occupying the posterior end of the yolk sac. Yellow pigment cells were seen over the yolk sac and over the eyes. Pigmentation of the rest of the body was the same as in the previous stage.

Larvae 42 *hours after Hatching*:—(*Fig.* 5).

On the morning of the 3rd day after hatching all the 79 pro-larvae had survived. They were very active and had grown to a length of 3.3 m.m. The yellow chromatophores had increased in number and covered the eye, though the iris still remained unpigmented. They spread over the yolk sac which had shrunk in size, and obscured the oil glouble. The black pigment cells so conspicuous along the dorsal and ventral fin folds in the previous stage, disappeared and were substituted by yellow chromatophores. Nevertheless the larvae were transparent. Fin-rays appeared in the caudal region and the ventral fin was formed. The auditory vesicle was larger. There was no indication of the mouth but the anus had shifted forward to lie behind the 10th myotome.

The Post Larvae: Feeding Habits and Metamorphosis

Larvae 48 *Hours after Hatching*:—(*Fig.* 6).

In the afternoon of the 3rd day after hatching the yolk was completely absorbed and the pro-larvae became post-larvae. During this

transition period nearly 8 pro-larve died. The remaining 71 larvae had a length of 5.1 mm. The most distinguishing feature of the post-larvae, namely the tentacle-like structure at the anterior end of the dorsal fin fold, made its appearance as a small growth. The pigmentation and other features of the pro-larvae remained unchanged in the post-larvae. However, the yellow chromatophores were replaced by reddish brown cells. Though the yolk was completely absorbed, the larvae did not feed when several items of planktonic food were offered. The causalties were therefore not due to the non-availability of food. Since 71 out of 79 larvae survived, the physico-chemical condition of the sea water could not have been responsible. It is probable that the casualities were due to physiological defects of the individuals.

Larvae 72 *Hours after Hatching*:— (*Fig.* 7).

By the morning of the fourth day the post-larvae had grown to 5.3 mm. in length. The tentacle was soft and had grown in length and a single ray was seen extending throughout its length. The eyes were silvery while the iris was black. The mouth was well formed and opened into the alimentary canal. The number of reddish brown cells increased deepening the colouration of the dorsal and ventral find folds. Black pigment cells appeared in the front part of the head. Except for the appearence of fin rays in the dorsal fin and growth in size of the body no other change was observed during the next 5 days.

As before, the post-larvae were supplied with copepod nauplii, adult copepods, cirripede larvae, polychaete larvae, molluscan larvae, *Trichodesmium* sp., *Nitzschia* sp. and *Coscinodiscus* sp. These post-larvae which had not fed on any food so far, began to feed for the first time. Their stomachs examined under low power showed that the food consisted of only copepod nauplii and diatoms, possibly because the larvae which were only 5.3 mm. long could feed only on smaller-sized food. Another batch of 30 larvae were left in a finger bowl containing fresh unassorted plankton. After an hour the stomach contained only copepod nauplii and diatoms. There was no change in the diet for the next 5 days.

Larvae-10*th Day after Hatching*:—(*Fig.* 8).

All the 71 larvae had grown to a length of 6.8 mm. and had become relatively wider and thinner. The dorsal and the anal fins were confluent with the caudal. The 1st three rays of the dorsal fin were markedly longer and the finger shaped process became now conspicuous and slender. The myotomes could be made out only with difficulty since the larvae had become less transparent and more pigmented. A third row of reddish brown patches appeared along the middle regon in addition to the dorsal and ventral rows. There were also a few patches on the head.

Though the larvae had fed so far only on copepod nauplii, they were supplied with these as well as adult copepods, (*Oithona rigida, Paracalanus* sp., *Corycaeus* sp., *Acartia* sp. *Pseudodiaptomus* sp. and *Temora* sp.), naupli of *Balanus amphitrite*, larval bivalves collected from plankton and polychaetes. Examination of the stomach contents showed that they had fed on adult copepods only. Copepod nauplii and diatoms which formed their diet previously were not found in any of them. To verify this further, diatoms and copepod nauplii were counted and placed in a container along with these post-larvae for a period of 2 hours. The larvae did not feed on any of them, whereas the moment adult copepods were introduced, the larvae attacked and consumed all of them. Another lot of 20 larvae were supplied with fresh concentrated unassorted plankton. After 2 hours. examination of the stomach content of living larvae as well as 12 killed for the purpose, reavealed that they had fed only on adult copepods.

Larvae 11th Day after Hatching:—(Fig. 9).

The 11 days old larvae were not very different from the previous stage except in the body being 6.9 mm. long and relatively much wider. The eyes were black and shining but the left eye had shifted so far to the dorsal edge of the head that its lens could be seen only when viewed from the right side. The pigmentation was almost the same as in the previous stage. The larvae were swimming about actively, but as the evening approached, they became less active and were seen resting on the bottom of the vessel and did not feed on any of the food items supplied till they metamorphosed.

On the morning of the 11th day, the larvae were observed to rest on their right sides periodically. The pigment cells on this side decreased in number and disappeared in a few hours. Correspondingly the upper side (the left side) appeared darker owing to the increase in the number of pigment cells which were arranged uniformly. The larvae measured 6.9 mm. in length. The mouth exhibited a lop-sided development and the right eye had shifted to the left side of the body.

On the morning of the 12th day, the body had increased in length by only 0.2 mm. but was wider and flatter. The tentacle like specialisation of the anterior fin rays of the dorsal fin so characteristic of the post-larvae, were now conspicuous by their absence while the fin rays had increased to 150 in the dorsal fin and to 105 in the anal fin. These changes constituting metamorphosis indicated the end of the pot-larval period and the beginning of the juvenile stage which is marked by several taxonomic features of the adult (Fig. 10). The fish could be identified as *Cynoglossus lingua* since it had the fin ray formula. D 150 V 4 A 105 C 89 L. 1.95 indicated by Weber and Beaufort (1929). Out of 59 juveniles 12 were reared in the laboratory for another 14 days till they measured 15.3 mm. The remaining 42 were used for experiments on their feeding habits.

Juvenile and Its Feeding Habits

As soon as the metamorphosis was completed, the juveniles settled at the bottom of the vessel and seldom moved. They were supplied with the usual food organisms collected from the plankton (copepods, cirripede larvae, larval bivalves and diatoms). The larvae did not feed the whole day. The next morning it was observed that the larvae began to be active and fed on dead copepods and other dead organisms such as bivalves and polychaetes which were at the bottom of the container. Thus the metamorphosed juveniles did not feed on living organisms for about two days.

Two days later, fresh concentrated plankton was supplied and it was found that the diet of the juveniles now included adult copepods (*Oithona rigida, Oithona robusta, Labidocera* sp., *Corycaeus* sp., *Eucalanus* sp., *Pontellopsis* sp., *Acartia* sp. *Schmackeria* sp., *Paracalanus* sp. and *Pseudodiaptomus* sp.), young prawn, larval penaeid, brachyuran larvae, *Lucifer, Acetes* larvae, cirripede larvae and molluscan larvae. Teleostean eggs and larvae were not found in the stomachs even though a large number were present in the plankton.

Feeding Habits of Juveniles Collected from the Sea

The youngest juvenile collected from the sea measured 20.5—22.5 mm. long and did not differ from the 7.1 mm. long juvenile reared in the laboratory. The stomach contents of the 21 juveniles collected showed that they had fed mostly on organisms from the bottom; 39.8% of the food were composed of bivalves, 29.2% polychaete larvae, 20% foraminiferan and the rest 11% consisted of copepods and other unidentifiable digested matter.

Feeding Habits of Adult

The diet of the adults of the species was studied from 59 specimens. The fishes examined ranged between 70—235 mm. in length. Except two all had food in the stomach. Examination of the stomach contents, showed that the adults had fed on bottom living forms such as *Citharichthys* sp. and *Solea* sp., *Eunicids, Scyllids, Noneonella, Elphidium, Rotalia* sp., *Spiroloculina, Biloculina* and *Triloculina* and considerable amounts of lamellibranch and gastropod shells. A large amount of mud was also found inside the stomach of these fishes. It is probable that the mud, of which forminiferan shells formed part, was taken along with bottom living polychaetes. In one or two cases, copepods were also recorded inside the stomach. Decayed and dead fish remains were often met with in the stomach contents of these fishes.

Remarks:—

The early larvae, which are pelagic like the larvae of sedentary forms in general, are plankton feeders. Kyle (1923) and Norman (1934)

who have given details of metamorphosis have not commented on the change in the feeding habits. At the onset of metamorphosis, the post-larvae sink down to the bottom but this change in their habitat is not immediately accompanied by a change in diet. For, during the entire period of metamorphosis the post-larvae are less active and do not feed. At the conclusion of metamorphosis when the post-larvae have become juveniles and have assumed adult features their diet consists of dead creatures available at the bottom. It is very likely that in the natural habitat the juveniles would have continued to live on bottom food. Therefore their feeding on live plankton when reared in flat dishes in the laboratory cannot be taken as evidence of feeding near the surface. Since the in-shore waters of Madras are very shallow (5-50 fathoms) the adults which are bottom feeders are easily landed dredge nets throughout the year.

A comparison with the life history of temperate species of flat fishes is made difficult because Holt (1893), Cunnigham (1896) Kyle (1913 and 1921), Ehrenbaum (1909), Norman (1926 B, 1927 A & B & 1934), Townsend (1936) and Rapson (1940) who have given an account of the development of flat fishes have not given chronological details. It is probable however that development from the pro-larvae to the juveniles, which is covered in 12 days in the present form, may take a much longer period in the colder seas.

Summary

1. The eggs and the pro-larvae of *Cynoglossus lingua* are described.
2. The absorption of yolk, the change in colour, the number of pre-anal myotomes and the growth in size of these pro-larvae which become changed into post-larvae are described. The details of the food they take at every stage are given.
3. An account of the metamorphosis of post-larvae into juveniles is given.
4. The juveniles are described and their diet analysed and contrasted with those of the adults.

Acknowledgment

I wish to thank Dr. C. P. Gnanamuthu, Director University Zoology Research Laboratory, Madras, for suggesting this problem and for his guidance and encouragement throughout the period of investigation. I am also thankful to Dr. S. Krishnaswamy, senior lecturer, for having helped me in identifying the copepods. I am grateful to the syndicate of the Madras University for the award of a research fellowship during the course of the investigation.

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Dendrothripiella stannardi sp. nov. (Thysanoptera Terebrantia) from Kodaikanal Hills (S. India)

By T. N. ANANTHAKRISHNAN,
Professor of Zoology, Loyola College, Madras-31.

CONTENTS

Introduction

Bagnall (1927) erected the genus *Dendrothripiella* for Dendrothrips-like forms, with *D. phyllireae* Bagnall as the type, and having 7-jointed antenna with joints 5-7 forming a compact unit. Shumsher (1942), in erecting the subgenus *Projectothripoides* for dendrothripiellid forms with abdominal segments 1-8 bearing an almost complete ciliary fringe, included *Dendrothripiella jasminum* R & M, under the subgenus *Dendrothripiella* s. str., in which the ciliary fringes, when present, are restricted to the tergite of the eighth abdominal segment. Only two species of *Dendrothripiella* Bagnall are so far known to occur in India. *Dendrothripiella* (*Dendrothripiella*) *jasminum* R & M and *Dendrothripiella* (*Projectothripoides*) *pandai* Shumsher. Present records show that except for two further species from England—*D. phyllireae* & *D. decor* Bagnall, the genus has a very poor representation, and as such the new species which is described below on the basis of fairly rich collections is of interest.

The material described below was collected during a survey of the Thysanoptera of Ooty and Kodaikanal hills. My thanks are due to the ministry of Education, Government of India for a grant-in-aid of the research. To Dr. L. J. Stannard (Jr) of Illinois Natural history Survey, is due a deep sense of gratitude for his ready help at all times and particularly in examining this material. This species is named after him as a token of the author's regard.

Dendrothripiella stannardi sp. n.

Macropterous female:

Total body length 0.952-1.064 mm. General body colour, brown, with some yellowish pigment. Head, antennal joints 1, 2 and 5-7 brown, 3 and 4 of a lighter hue; thorax brown, suffused with yellow at sides of prothorax and across anteromedian and posteromedian regions of

pterothorax. Abdomen dark grey brown, more yellowish brown at middle; wings pale brown, with a colourless area at base; all femora and tibiae brown, except apex of hind tibia which is pale; all tarsi pale; eyes black, ocelli with red pigment.

Head, wider than long, being 77-84μ long at middle, 126-133μ wide across cheeks; head at base with clear, transverse striae. Cheeks with a distinct notch, behind eyes, practically straight, crenulate, with a pointed postocular bristle 10-13μ long. Eyes large, longer than cheeks, 49-54μ long, 42μ wide and 48μ across interocular region. Ocelli well developed, triangularly disposed, anterior ocellus 22μ apart from poste-

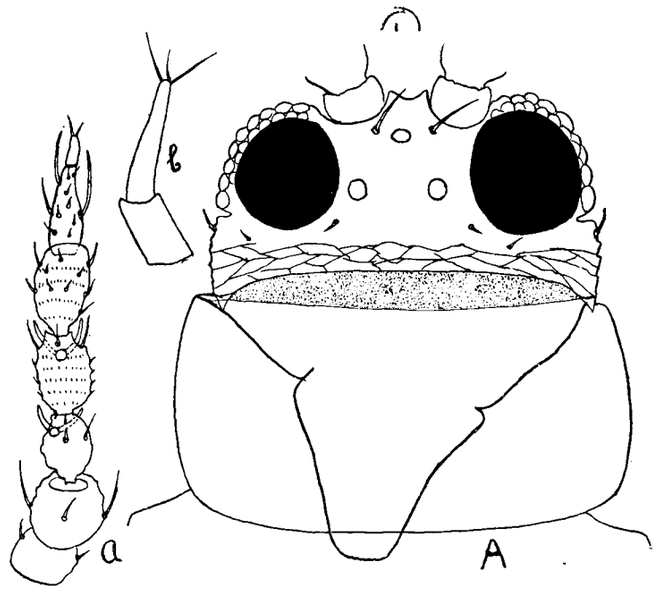
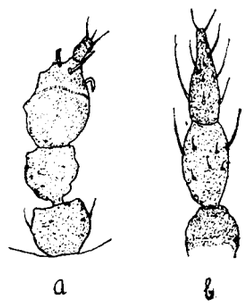


Fig. 1. *Dendrothripiella stannardi* sp.n.
A—head and Prothorax of Female.
a—antenna of female.
b—maxillary palp.

rior ocelli which are 28-32μ apart. Antenna 7-jointed, about 2½ times head length; joint 1 normal, more or less rectangular; 2, large almost spherical; 3, distinctly smaller than 4 and pedicellate, 4 and 5 barrel-like, 6 penicillate, 5-7 forming a compact unit. Sense cones on 3 and 4 well developed, forked.

Measurements of antennal joints: length (width) in μ: 16-19 (21-22); 32 (25-26); 26-32 (19); 32-35 (16-19); 32-35 (19); 34-38 (10-13); 10-13 (3).



a b

Fig. 2. *anomalous antennae of Dendrothripiella stannardi* sp.n.
a—entire antena.
b—joints 6 & 7 fused.

Mouth cone 96-112μ long, 126-140μ wide at base and 22-28μ at tip, reaching a little beyond the base of prosternum. Maxillary palpi 2-jointed, individual joints measuring 16 and 19-22μ long; labial palpi, 13 μ long.

Prothorax transversely elongate, a little longer than head, about 90-98μ long, 154-166μ long at anterior margin and 168-186 μ at posterior margin, inclusive of coxae. Surface smooth, without prominent bristles, not even the postangulars; pterothorax, 210-266 μ long, maximum width across mesothorax, 224-238 μ; metafurcae (lyra) enlarged, characteristic of the genus. Wings: forewings with straight hind margin, foremargin

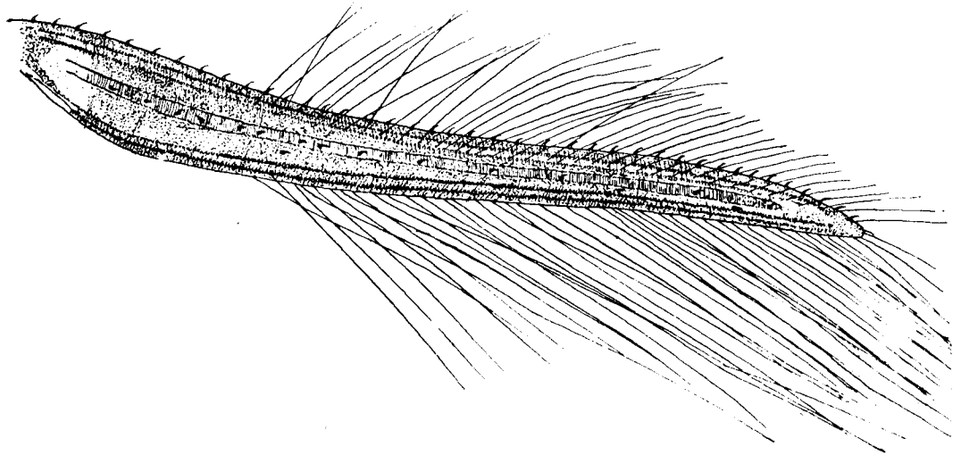


Fig. 3. *Forewing of female.*

curving to meet the apex of the hind margin, 714-756μ long, 84-98 μ wide at base, 42-56 μ at middle and 35-42 μ at tip. Fringes on costal side inserted much below margin; posterior fringes, very long, reaching a maximum length of about 308μ. Upper vein prominent, not fused with costa; lower vein absent, but with a few scattered setae; numerous microsetulae on surface. Wing setae very weak; chaetotaxy: costa 38-40; upper vein 14-15, scattered; lower vein region with 3 scattered setae.

Abdomen broad at base, widest across segments 4 and 5; abdominal segments distinctly reticulate; sternites with a median pair of well developed bristles 48 μ long, arising from 'socneted areas', as in figure.

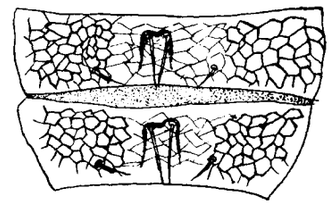


Fig. 4. *Dendrothripiella stannardi* sp.n. Abdominal sternites 4& 5.

Segment IX 98 μ long, with two pairs of well developed bristles arranged in a row, each measuring 45-48 μ long. Segment X short, about 42-48μ long 56-58 μ wide at base and 45 μ at apex. Bristles on X short, about 13-19 μ long. Ovipositor, 160-165 μ long.

Measurements of the Holotype $\overset{\circ}{+}$ (*Macropterous*)—All measurements in μ unless otherwise specified.

Total body length, 0.952 mm.; head, length 77; width across eyes 128; across cheeks 140; eyes, length, 54; width, 42; interocular space 48; antennal joints, length (width): 19 (21); 26 (32); 29 (18); 32 (19); 32 (19); 35 (12 at base and 6 at apex); 10 (3). Prothorax, length at middle, 90; width at anterior margin, 154; across posterior margin, inclusive of coxa 168; pterothorax, length, 210; maximum width 224; length of IX abdominal segment, 98; width at base, 112; length of X, 42; width at base, 56; ovipositor, 160.

Habitat: 10 females on sheaths of a liliaceous plant, Bryant's Park, Kodaikanal (6,500 ft.) 21-3-1957. T. N. A. No. 291. 6 females on Cinchona leaves, Perumalmalai hills, Kodaikanal, (7,000 ft.) 20-3-1957.

Dendrothripiella (*Dendrothripiella*) *stannardi* sp.n. is a true dendrothripiellid, in view of the presence of enlarged metafurcae (lyra of Priesner), fringe cilia of forewings straight, not wavy, reticulations on the abdomen and one segmented tarsi. From *D. jasminum* R. & M., it differs in every respect, viz., in the body coloration, nature of antennal joints with joint 3 shorter than 4, style shorter than joint 6 and in the

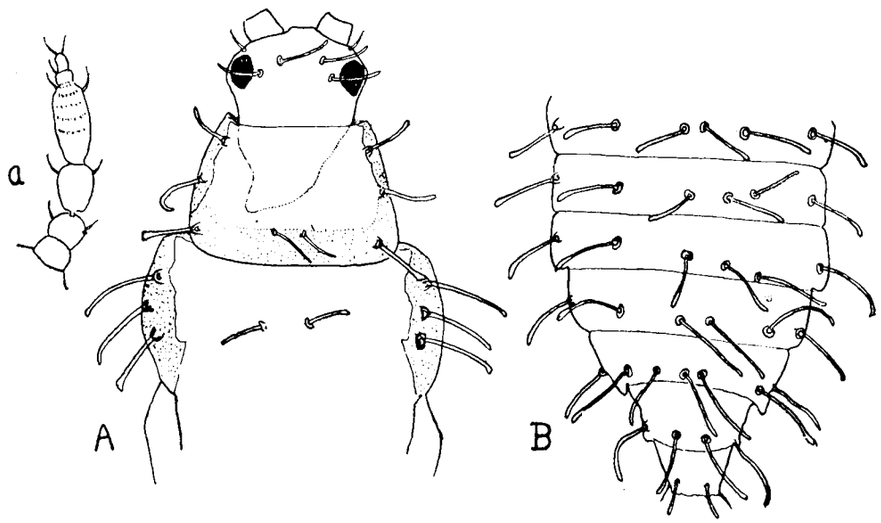


Fig. 5. *Dendrothripiella stannardi*: sp.n. -II instar larva.
A—head and prothorax.
A—antena.
B—terminal abdominal segments.

wing chaetotaxy. On the other hand, *stannardi* sp.n. is more allied to *phyllireae* Bagnall and *decoris* Bagnall, since this also has style shorter than 6th joint. *Phyllireae* has a short postangular pronotal bristle, absent in *stannardi* and *decoris*. From *decoris*, *stannardi* is distinguished by the distinctly shorter third antennal joint which even inclusive of the stem is shorter than joints 4 and 5. In addition, the details of body coloration and chaetotaxy also reveal the differences.

Key to species of *Dendrothripiella* s. str.

1. Style longer than 6th joint. 2
   Style distinctly shorter. 3
2. Joint 5, shorter than 3 and 4. Yellow species. *jasminum* R. & M.

3. Prothorax with a small posteroangular bristle; joints 3 and 4 of antenna subequal; 5 shorter. *phyllireae* Bagnall.
   Prothorax without posteroangular bristle. 4
4. Antennal joints 3-5 clear yellow; joints 3, 4 and 5 subequal, exclusive of stem of 3. *decoris* Bagnall.
   Joints 3 and 4 light brown, 5-7 dark brown; joints 4 and 5 subequal; 3, inclusive of stem distinctly shorter than 4 and 5. *stannardi* n.sp.

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FORTHCOMING PAPERS

The following papers will be published in the next issue of the journal: Vol. X-No. 1

SITA ANANTARAMAN and KRISHNASWAMY, S., Tetraphyllidean Larvae in the Marine Copepod, *Eucalanus pseudattenuatus* Sewell, from Madras Coast.

NATARAJAN, R., Contributions to the Cytology of Indian Anura (Amphibia): Studies on the Spermatogenesis of Three Species of *Rana* (Ranidae).

TAMPI, P. R. S., The Anatomy of *Armandia leptocirris* Grube.

RAMAMOORTHY, K., Chromosomes of *Viviparus dissimilis* (Muller) and *Viviparus bengelensis* (Lamarck) (Prosobranchia-Gastropoda).

DAS, G. M. and SEN GUPTA, N. Observations on the Pink Mite, *Acaphylla theae* (Watt) Keifer, Of Tea in North-East India.

KRISHNAMOORTHI, K. P., Changes in the Free Amino Acids in the Different Stages of Ovary of Fish: *Labeo fimbriatus* (Bloch) *Mystus seenghala* (Sykes) and *Boleophthalmus boddaerti* (Day).

RANGARAJAN, K., Diurnal Tidal Cycle in the Vellar Estuary.

NARAIN KHATTAR, Morphology of Head Capsule and Mouth Parts of *Schizodactylus monstrosus* Don. (Orthopetra).

ROONWAL, M. L., Address of the President to the Annual General Meeting of the Zoological Society of India held at Madras on the 7th January, 1958.

THOMAS A. MORRILL, The 'Field' Concept of Organic Evolution.

ERRATA to:

Roonwal, M. L. 1958. The Tata Medal Lecture: Recent researches on population dynamics and evolutionary problems in the Desert Locust, together with a new theory of gregarization in locusts. *J. Zool. Soc. India*, Calcutta, 9 (1) [June 1957], pp. 72-96, 1 pl.

Page 73, line 28.—*For* "production", *read* "prediction".

Page 74, line 25.—*For* "Orthopetra", *read* "Orthoptera".

Page 74, line 32.—*For* "*sotitaria*", *read* "*solitaria*".

Page 76, line 9.—*For* "Volkonsy", *read* "Volkonsky".

Page 78, line 25.—*For* "assist", *read* "assists".

Page 79, bottom line.—*For* "occurs", *read* "occur".

Page 81, line 13.—*For* "atleast", *read* "at least".

Page 91, line 8.—*For* "population", *read* "populations".

Page 91, line 24.—*For* "*v de*", *read* "*vide*".

Page 93, bottom line.—*For* "and Ford" *read* "and Ford., E.B.".

Page 94, line 8.—*For* "1940", *read* "1944".

Page 94 line 28.—*For* "95", *read* "98".

Page 94, line 37.—*For* "xi", *read* "xiv".

Page 95, line 9 from bottom.—*For* "449", *read* "446".

Page 96, line 9 from bottom.—*For* "*nu. ce.*", *read* "*nu. cc.*"

Page 96, line 2 from bottom. *For* "*t.p.*,", *read* "*t.p.*,".

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First All-India Congress of Zoology

(Sponsored by the Zoological Society of India)

The proposed First All-India Congress of Zoology sponsored by the Zoological Society of India which was to be held from October 31 to November 6, 1958 at Calcutta, had to be postponed. Fresh dates will be announced soon.

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* No. 1, *the Year-Book*, *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).

ACKNOWLEDGEMENTS

The Zoological Society of India wishes to acknowledge with many thanks the donations and the grants in-aid received for publications of its Journal, etc., particularly from the following :

National Institute of Sciences of India ; Indian Councial of Agricultural Research ; Government of Bihar ; Universities of Madras, Annamalai and Travancore ; Messrs. Burmah-Shell Oil Storage and Distributing Co. of India, Ltd., etc.

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Printed by Sri S. Sriraman
at Commercial Printing & Publishing House, 46, Armenian Street, Madras-1.
Published By the Zoological Society of India CALCUTTA-12.
Editor: Prof. R. V. Seshaiah