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INTRODUCTION

THE leptocephali of Indian waters have received very little attention till a decade back when the first attempt to metamorphose them in the laboratory was successfully accomplished (Nair, 1946 *a*, 1947). Since then the systematic study of the leptocephali of the coastal waters has received increasing attention in spite of the difficulties encountered in referring them to their adults and a few important papers have appeared in recent years. The leptocephalus of *Uroconger lepturus*, another common eel of the Madras coast, was identified by the myotome and vertebral counts taken in conjunction with the other distinctive characters shown by the larva and the adult (Nair, 1946 *b*). The occurrence of this leptocephalus along with those of *Congrellus anago*, *Muræsox cinereus* and *Muræna* sp. was recorded from the Gulf of Mannar (Nair, 1948). This was followed by an account of 3 types of eel eggs and 2 types of preleptocephaline larval stages collected from the same place (Nair and Bhimachar, 1950). Gopinath (1950) described 6 different leptocephali including those of *C. anago* described by him earlier (1946) and *M. cinereus* (Nair, 1947). Since the identification of the other 4 types of leptocephali in his collection was not possible, he described them as Leptocephali A, C, E and F and pointed out that the first 2 leptocephali belong to the ophichthyid group. Jones and Pantulu (1952) gave an account of the metamorphosing stages of *Muræsox talabon* and 4 murænid leptocephali collected from the Burhabulong and Hooghly estuaries in Orissa and Bengal respectively and doubtfully assigned one of them to *Muræna tile*. Later, these authors (Pantulu and Jones, 1954) described 3 varieties of murænid leptocephali collected from the Burhabulong estuary

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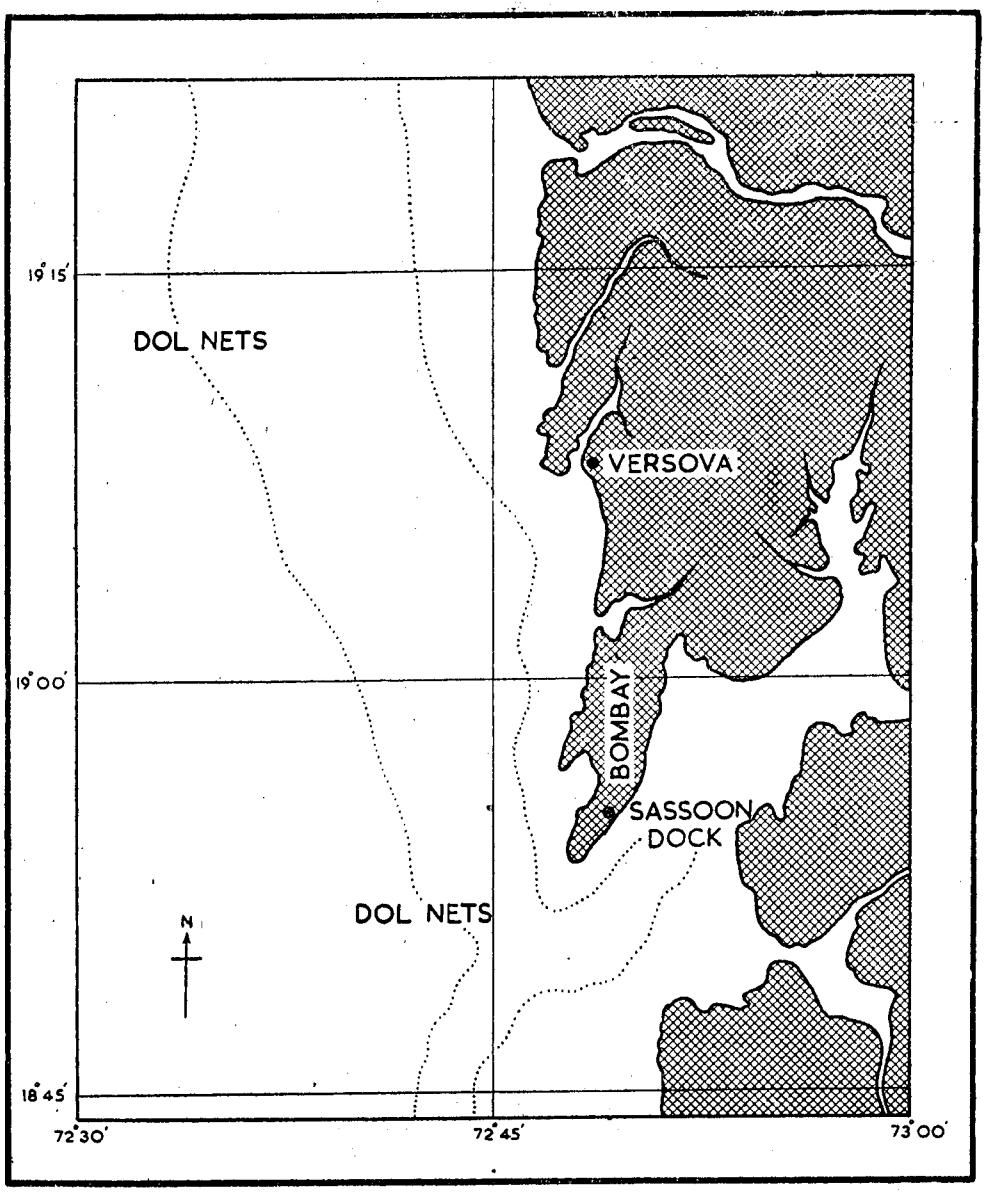
in Orissa. One of these larvæ was referred by them provisionally to *M. tile* and its metamorphosing stages were described by them. Recently, these authors (Jones and Pantulu, 1955) gave an account of 3 preleptocephaline larval stages of an ophichthyid eel together with descriptions of 4 ophichthyid leptocephali collected from Madras, Travancore and Orissa coasts and one was identified as that of *Pisoodonophis hijala*. Bapat (1955) while dealing with the eggs and larvæ of the Gulf of Mannar and the Palk Bay described an eel egg resembling Type II recorded previously from the former place by Nair and Bhimachar (1950). Recently Nair and Dharmamba (1960) described a few stages in the development of an ophichthyid egg collected from Lawson's Bay, Waltair.

The papers in this series dealing with the Bombay leptocephali were written by the senior author based on his study of a collection of larvae made by the junior author. These papers deal with the metamorphosis of *Muræsox talabonoides*, *Muræsox talabon* and *Uroconger lepturus* and descriptions of 5 leptocephali numbered serially I to V. Of these, Leptocephali I to III belong to Ophichthyidæ and Leptocephalus IV to Murænidæ while Leptocephalus V has not been identified.

MATERIAL AND METHODS

The material for these studies was collected from the 'dol' net fish catches landed at Versova and Sassoon Dock (*vide* Map) during the years 1952–56 with the exception of Leptocephalus III which was obtained from a plankton collection made at a distance of 20 miles west of Bombay on the 1st May 1953. Most of the leptocephali and elvers in the collection were obtained during the period April to June when shrimps dominated and formed more than 90% of the 'dol' net catches. The 'dol' nets are stationary nets which are fixed at a distance of about 10–15 miles off Bombay where the depth is about 10–15 fathoms. It is a long conical net the mouth of which is fastened to 2 huge wooden spikes fixed to the floor of the sea and is kept open by floats and ropes. The mesh size is greater near the mouth and diminishes towards the end and it varies from 10″ to less than ¼″. The net is worked entirely by the tidal current and it is reversed during the high and low tides. The net is, therefore, not selective in its action but traps all varieties of fish carried by the currents. The leptocephali picked out from these catches were fixed in 5% formalin in the field itself and sorted out later in the laboratory. Table I gives the place of collection, dates and number of larvæ and elvers collected from the 'dol' net catches.

The different stages, representing the growth and metamorphosis of the leptocephali dealt with in these papers, were selected arbitrarily to show the



Map showing the 'dol' net regions from where the material was collected.

important changes undergone during the transformation and an attempt has been made to divide the metamorphosis into 6 stages as proposed by Schmidt (1906) and Jespersen (1942). However, this was possible only in

TABLE I

Details of collection of Bombay leptocephali

Species	Date	Place	Number of lepto-cephalus	Number of elver
Muræsox talabonoides	14- 4-1952	Sassoon Dock	2	9
	15- 4-1952	,,	1	2
	29- 4-1953	,,	1	2
	1- 5-1953	,,	6	..
	21- 4-1954	,,	32	4
	22- 4-1954	,,	11	10
	23- 4-1954	,,	37	2
	20- 5-1954	,,	..	44
Muræsox talabon ..	1- 5-1953	Sassoon Dock	5	..
	21- 4-1954	,,	6	..
	23- 4-1954	,,	13	..
	15- 9-1954	,,	6	2
	5- 3-1955	,,	2	..
	9- 1-1956	Versova	1	..
Uroconger lepturus ..	9- 1-1954	Versova	48	13
	15- 9-1954	Sassoon Dock	3	7
	7-11-1954	Versova	3	..
Leptocephalus I ..	13- 9-1955	Versova	13	..
	24- 9-1955	Sassoon Dock	1	..
	9- 1-1956	Versova	29	..
Leptocephalus II ..	13- 9-1955	Versova	13	..
	9- 1-1956	,,	1	..
Leptocephalus III ..	1- 5-1953	Plankton off Bombay	1	..
Leptocephalus IV ..	9- 1-1956	Versova	1	..
Leptocephalus V ..	21- 4-1954	Sassoon Dock	1	..

the case of *Muræsox talabonoides* while in the others, the lack of representative and suitable specimens made it necessary to reduce the number of metamorphosing stages. All the growing and metamorphosing stages described in these papers are denoted with letters and numbers respectively.

In these studies emphasis has been given to the myotome number which is one of the chief characters for referring the leptocephali to their parent forms. The counting of the myotomes in all the larvæ was very simple but in *Uroconger lepturus* the caudal portion presented some difficulty and this was overcome by staining with eosin. While counting the preanal myotomes, if the vent happened to be below a particular myotome, this was also included under the preanal myotome number. In the descriptive accounts, due stress has been given to the morphometric characters and pigmentation which are found to be very helpful in the identification of the different larvæ and metamorphosing and elver stages. All the measurements given are in millimeter and they are also expressed as percentages of total length and length of head. The diameter of the eye and the length of snout are given as percentages of length of head while all the other measurements are given as percentages of total length and these percentages are given within brackets in the different tables. The dentition has also been studied in detail and the lower jaw in most cases presented some difficulty in counting the teeth present on it since its hind region is hidden by the upper jaw and this was overcome by keeping the mouth of the larva wide open with a small wedge-shaped glass bit.

A few abbreviations are used in the descriptive accounts and their full explanations are given below:—

Length	..	Total length from the tip of the snout to the end of the caudal fin.
Height	..	Maximum height including the vertical fins.
Head	..	Length of head from the tip of the snout to the gill opening.
Eye	..	Maximum diameter of the eye.
Predorsal distance	..	Distance between the tip of the snout and the origin of the dorsal fin.
Preanal distance	..	Distance between the tip of the snout and the anus.

I. The Metamorphosing Stages of *Muræsox talabonoides* (Bleeker)

Like the adult which mainly constitutes the eel fishery of the Bombay coast, the leptocephalus is very common in the Bombay

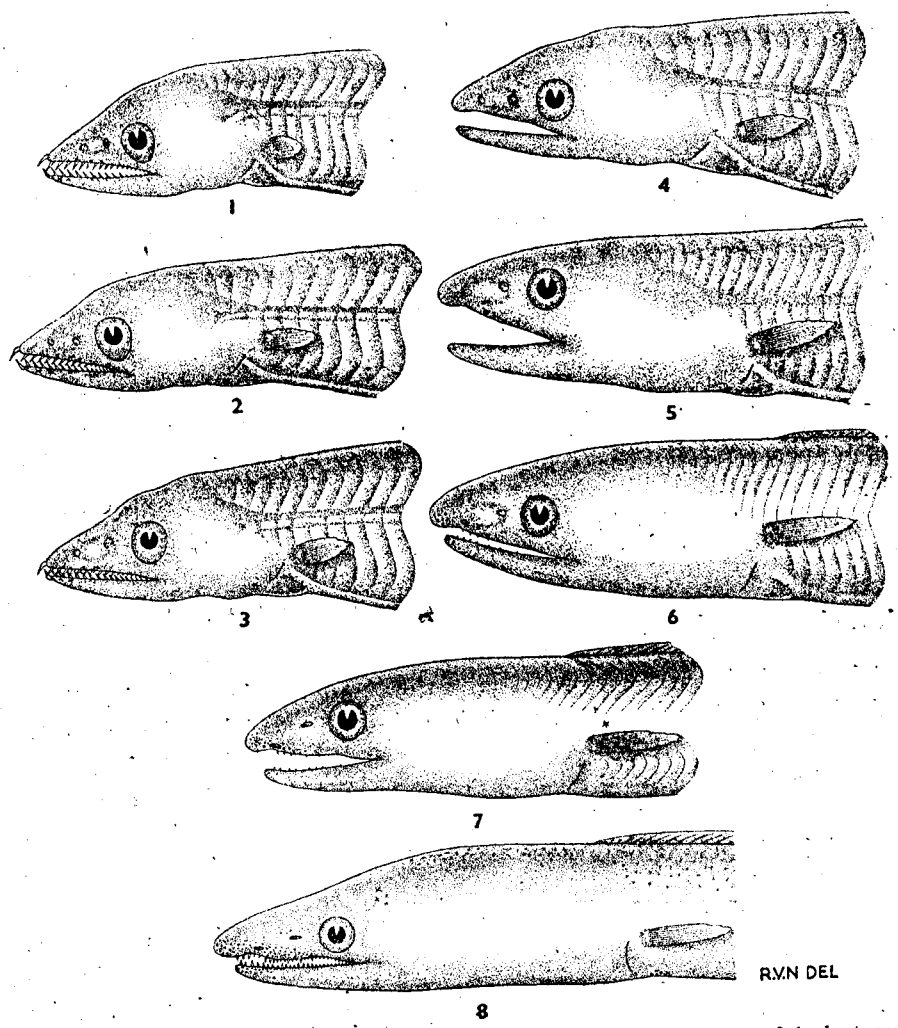
waters and all the larvæ and elvers in the collection were obtaine from the 'dol' net catches landed at Sassoon Dock only. They generally occur during the months of April and May and the larvæ are more abundant during the month of April. The majority of the specimens were in advanced stages of metamorphosis and out of the several specimens in the collection only 9 larvæ, including the growing stages, showed the complete set of larval teeth. The myotome variation found in the species is very low and the number ranged from 147 to 149 only.

Stage A (Text-Fig. 1).—The growing stages are extremely rare and only 2 specimens were collected on 1st May 1953 along with the metamorphosing stages and the smaller of the two is selected as the type of this stage.

The larva is short measuring 56·5 mm. in length, moderately thick and tapers conspicuously towards the head and the tail regions showing a characteristic spindle-shaped appearance. The maximum height is observed in the middle portion and it measures 5·5 mm. and is 10·3 times in length.

The head is fairly long and measures 4·5 mm. and is contained 12·6 times in length. The snout is moderately long, sharply pointed and is 3 times in head. The nostrils have differentiated and the anterior one is situated midway between the tip of the snout and the front border of the eye while the posterior one is in the middle of the interspace between the anterior nostril and the eye. The cleft of the mouth is nearly straight and extends up to the posterior border of the eye. Both the jaws are of about the same length and are provided with well-developed teeth which are directed forwards. The dental formula is $1 + 10 + 8 / 1 + 10 + 6$. Each half of the upper jaw is provided with a long, curved and pointed grasping tooth and two groups of teeth of unequal size. The first group is composed of 10 teeth which are also long and pointed and show gradual decrease in length backwards. The second set is composed of 8 short and conical teeth which are compactly arranged in the posterior third of the upper jaw. The lower jaw carries in each half a grasping tooth at its tip followed by two groups of teeth consisting of 10 and 6 teeth respectively. The teeth of these two groups are similar to those of the upper jaw in shape, size and arrangement. The eye is egg-shaped with the pointed portion directed downwards and it is 5 times in head.

The myotomes are distinctly seen and number 148 of which 92 are preanal in position. The alimentary canal is very long, straight and occupies nearly $\frac{3}{4}$ the length of the larva with the preanal distance 1·4 in length. The dorsal fin is long and its origin is above the 30th myotome. The predorsal distance is very short and it is 3·8 times in length.



TEXT-FIGS. 1–8. Head region of the growing and metamorphosing stages of the leptocephalus of *Muræsox talabonoides*, ×*ca.* 5·5.

The pectoral fin is very small and shows only indistinct rays. The vertical fins are well developed and possess distinct rays which show only slight variation in number in the different specimens. In the type specimen there are about 254 and 205 moderately sized rays in the dorsal and anal fins respectively. The caudal fin shows 8 distinct rays which are very long and about 4 times the length of the rays of the other vertical fins. The long caudal fin rays give a pointed appearance to the tail.

The pigmentation of the larva is feeble and the chromatophores are present in moderate numbers only. However, their arrangement shows a definite pattern which is quite distinct from that found in the leptocephalus of *Muræsox cinereus* (Nair, 1947) and *Muræsox talabon* (Nair and Mohamed, 1960), the other two species of the genus recorded from the Indian waters. This characteristic colouration has been noticed in all the larval metamorphosing and elver stages and as such it has considerable taxonomic importance in the identification of the larva of this species.

The head pigmentation is feeble and consists of 2 or 3 black pigment cells arranged along the margin of the middle portion of the upper jaw and 1 or 2 similar larger chromatophores in the heart region. The tip of the lower jaw is also provided with 1 or 2 highly branching black pigment cells.

The mid-lateral row of pigment cells commences from the 23rd myotome and the chromatophores are arranged in a line below the vertebral column. The pigment cells of this row are large, stellate and show an irregular distribution at intervals of 2–4 and even 5 myotomes. In the anterior region they are generally distributed at intervals of 3–4 myotomes while posteriorly they are arranged closer and usually every alternate myotome is provided with a chromatophore.

The regularity in the disposition of the chromatophores of the alimentary canal gives the larva a characteristic colouration. The pigment cells are arranged in groups at regular intervals on the ventral side of the alimentary canal in the form of conspicuous dark patches (Photograph 2). Generally 6–8 and occasionally 9 such pigment groups are seen and each group is composed of 4–25 chromatophores. In all the specimens, these groups occupy more or less the same position in relation to the myotomes, especially the first 6 groups which are situated in the aortic portion of the alimentary canal. The last two groups found in the post-aortic portion do not generally occupy the same position in the different larvæ since this region shows variations in length depending on the stage of growth of the larva. It is also seen that these two groups, especially the last one situated near the anus, become unrecognisable in the metamorphosing stages owing to the rearrangement of the chromatophores. In the type larva described here 8 pigment groups are present and the 6 aortic groups are found under myotomes 12–13, 20–21, 27–28, 33–34, 41–42 and 48–49. Of these, the second group situated below the liver diverticulum is large, conspicuous and composed of a large number of chromatophores while the others are relatively smaller with lesser number of pigment cells. The seventh group, which is the first post-aortic group, is not conspicuous in the type specimen owing to the diffuse arrangement of

the pigment cells below myotomes 70–74. The last group is situated in the terminal portion of the alimentary canal. In between these groups stray black chromatophores have also been noticed.

The pectoral and dorsal fins are unpigmented while a few scattered pigment cells are present at the base of the anal fin. Amidst the rays of this fin highly elongated chromatophores are found at irregular interval throughout its length. A few black branching chromatophores are present in the caudal fin.

Stage B (Text-Fig. 2).—This growing stage, like the preceding one, is extremely rare in the Bombay waters and only 3 specimens are present in the collection. This larva represents an intermediate stage between Stage A and the full-grown leptocephalus described under Stage I.

The spindle-shaped appearance is lost in this stage and the larva is moderately long and measures 73·5 mm. The height has increased proportionately and it is 5·8 mm. which is 12·7 times in length.

The head has elongated slightly and measures 4·9 mm. and it is 15 times in length. The snout is long and pointed and it is 2·9 times in head. The nostrils are seen distinctly and the anterior one is situated at a third of the distance from the tip of the snout to the eye while the posterior one is midway between the front margin of the eye and the anterior nostril. No change in the shape of the eye is observed in this stage and it is 4·9 times in head. There is no increase in the number of teeth, but the teeth formula is $1 + 10 + 8 / 1 + 16$ owing to the slight increase in the size of the teeth composing the second group of the lower jaw as a result of which the differentiation into two groups is no longer seen and all of them show a uniform reduction in length backwards.

The origin of the dorsal fin has shifted forwards and it is above the 28th myotome and the proportion of the predorsal distance in length has increased to 4·7 due to the lengthening of the larva. The alimentary canal does not show any change except in the shifting of the anus which is below the 90th myotome. There is only a slight reduction in the preanal distance which continues to be 1·4 times in length.

The pectoral fin has grown larger and it is long and pointed with indistinct rays. The vertical fins do not show any change and the dorsal and anal fins in the type specimen show 269 and 208 rays respectively. The caudal fin rays, which number 9 in all the specimens, have elongated considerably.

There is no change in the pigmentation of the larva and it generally conforms with that of the previous stage. The alimentary canal of the type specimen, described here, shows 9 pigment groups and the additional group is formed by the breaking up of the third pigment group into two distinct ones located below myotomes 25 and 28–29. Of these two groups, the first one is smaller in size while the second one is of the same size as the others in the series. The other five aortic groups of chromatophores are situated under myotomes 12, 18–19, 33–34, 40 and 46–47 while the two post-aortic groups show variation in their position in the different specimens and in the type specimen they are under myotomes 68–69 and 80–81. Unlike the condition found in the preceding stage, the last group is placed slightly in front of the vent while a few scattered pigment cells are present near the anal opening.

Stage I (Text-Fig. 3 and Photograph 1).—Full-grown leptocephalus with all the larval teeth intact is extremely rare and is represented in the collection by a few specimens only and they are more or less similar in the morphometric characters and show only slight variations in size and in the position of the anal opening.

The leptocephalus is thin and long with a pointed tail and it measures 81·0 mm. in length. The maximum height of 6·2 mm. is observed in the middle region and it is 13·1 times in length.

The head measures 5·3 mm. and it is 15·3 times in length. During the growth of the larva into the leptocephalus, the increase in the length of the head is not porportionate to that of the length but is somewhat slow as seen clearly from Table II which gives the morphometric characters of the different stages described here. The snout is long and pointed and it is 2·8 times in head. Unlike the head, the snout shows higher increase in length in all the growing stages. The eye is somewhat oval in shape and does not show any increase in size and it is 5·9 times in head. The nostrils are distinctly seen as small apertures and the posterior nostril is in front of the eye while the anterior one is midway between the tip of the snout and the posterior nostril. The cleft of the mouth continues to be straight and extends up to the hind border of the eye. Minor changes in the number of teeth are noticed in this stage and in some specimens the grasping tooth of the upper jaw is not seen and this is believed to be lost accidentally. A few specimens showed the full set of teeth in both the jaws and the dental formula in the full-grown leptocephalus is $1 + 10 + 9 / 1 + 16$. It is seen that one more tooth is added to the second group of the upper jaw thus increasing the total number in each half of the jaw to 20 teeth which do not show any change in size or arrangement.

TABLE II

Measurements of Muræsox talabonoides

	Stage A	Stage B	Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI
Total length ..	56·5	73·5	81·0	85·0	83·5	78·0	77·5	78·5
Maximum height ..	5·5 (9·7)	5·8 (7·9)	6·2 (7·7)	5·9 (6·9)	5·7 (6·8)	4·8 (6·2)	3·3 (4·3)	3·0 (3·8)
Predorsal distance ..	14·8 (26·2)	15·8 (21·5)	13·8 (17·0)	10·8 (12·7)	8·8 (10·5)	8·1 (10·4)	7·8 (10·1)	9·3 (11·8)
Preanal distance ..	40·5 (71·7)	51·5 (70·1)	46·2 (57·0)	38·1 (44·8)	31·3 (37·5)	28·0 (35·9)	27·0 (34·8)	26·5 (33·8)
Length of head ..	4·5 (8·0)	4·9 (6·7)	5·3 (6·5)	5·7 (6·7)	7·3 (8·7)	7·6 (9·7)	7·8 (10·1)	10·0 (12·7)
Length of snout ..	1·5 (33·3)	1·7 (34·7)	1·9 (35·8)	1·9 (33·3)	2·0 (27·4)	2·1 (27·6)	2·1 (26·9)	2·5 (25·0)
Diameter of eye ..	0·9 (20·0)	1·0 (20·4)	0·9 (17·0)	0·9 (15·8)	1·0 (13·7)	0·9 (11·8)	0·9 (11·5)	0·9 (9·0)
Total myotomes ..	148	148	149	148	149	149	146*	146*
Preanal myotomes ..	92	90	74	58	51	46	44*	42*
Predorsal myotomes ..	30	28	21	16	13	11	8*	8*

* Vertebræ.

In the type specimen 149 myotomes are present and the vent is situated below the 74th myotome. The anterior position of the vent shows that the anal migration has commenced even before the onset of metamorphosis which is generally indicated by the shedding of the larval teeth. Further, the highest preanal myotome number is reached in this species during the growing stage itself and its reduction in the full-grown leptocephalus makes this character of doubtful taxonomic importance in the identification of the larva. The most backward position of the anus is seen in Stage A where it is below the 92nd myotome while in Stage B it is below the 90th myotome. In the full-grown leptocephalus the anus occupies a far anterior position, below the 74th myotome, showing considerable reduction in the number of preanal myotomes and also the length of the alimentary canal indicating clearly that anal migration precedes metamorphosis. The origin of the dorsal fin also shows a forward migration and it is above the 21st myotome in this stage. This character also, like the preanal myotome number, is not useful for the identification of the leptocephalus of this eel. The predorsal distance is contained 5·9 times in length. The anal opening is slightly behind the middle of the larva and the preanal distance is 1·8 times in length.

The pectoral fin is long and pointed with distinct rays. The dorsal and anal fins show 267 and 205 rays respectively while the caudal fin in the type specimen possesses 10 distinct rays.

The pigmentation of the full-grown leptocephalus is moderate when compared with that of the larvæ of the other two species of *Muræsox*. The leptocephalus does not show any significant change in the pigmentation from that of the growing stages. In this type specimen also the alimentary canal shows 9 groups of chromatophores of which 7 are located below the aorta while the remaining 2 are behind it. These groups are found below myotomes 11–12; 20, 25, 29, 33, 40–41, 47, 62–63 and 69–70. The additional group observed in this specimen is situated below the 29th myotome. The second post-aortic pigment group is near the anal opening.

Stage II (Text-Fig. 4 and Photograph 1).—This is the edentulous stage indicating the commencement of metamorphosis and the only noteworthy difference from Stage I is the complete shedding of all the larval teeth.

A very slight reduction in height, which measures 5·9 mm., has taken place and it is 14·4 times in length. The head measures 5·7 mm. which is 14·9 times in length. The snout is 3 times in head and in this respect resembles the condition found in Stage A. The eye is oval in shape and it is 6·3 times in head.

The myotomes are distinct and their number in the type specimen is 148. There is considerable reduction in the length of the alimentary canal and the vent, which is below the 58th myotome, is slightly in front of the middle with the preanal distance 2·2 times in length. The origin of the dorsal fin has also shifted anteriorly and it is above the 16th myotome, with a proportionate reduction in the predorsal distance which is 7·9 times in length.

The paired and vertical fins do not show any change in this stage.

There is no major change in the pigmentation except the slight variation brought about by the reduction in the length of the alimentary canal. Only 6 pigment groups are seen in this stage and they are situated below the aorta under myotomes 13, 18–19, 26–27, 32–33, 38 and 45–46. In this stage the alimentary canal is slightly shorter than the aorta and consequently the chromatophores of the 2 post-aortic groups have become scattered and are found near the end of the gut and some of them are in a circle round the anal opening.

Stage III (Text-Fig. 5 and Photograph 1).—This metamorphosing stage is somewhat opaque due to the reduction in height and increase in thickness. The caudal portion of the larva tapers conspicuously and ends in the pointed tail. The maximum height of 5·7 mm. is at the region of the anus and the height is 14·6 times in length.

The head has elongated and is somewhat cylindrical in shape. The length of the head is 7·3 mm. which is 11·4 times in length. The snout, on the other hand, does not show proportionate increase and it is 3·7 times in head. It is bluntly rounded with a constriction at its tip and projects beyond the lower jaw. The eye in this stage is somewhat circular and it is 7·3 times in head.

Both the vent and the origin of the dorsal fin show further anterior shifting and they are situated opposite myotomes 51 and 13 respectively. The origin of the dorsal is in advance of the tip of the pectoral fin with a very short predorsal distance which is 9·5 times in length. The vent is situated at about the anterior third of the larva and the preanal distance is 2·7 times in length.

The pectoral fin has become slightly longer and the vertical fins are better developed and more prominent in this stage. The caudal fin is provided with 10 rays which have become elongated.

Pigmentation remains unchanged and due to the opacity of the metamorphosing larva, the chromatophores in the heart region are not clearly visible while the body pigmentation is seen distinctly. The six prominent

groups on the alimentary canal are seen opposite the myotomes 13, 19, 27–28, 34, 41 and 48. The other groups are not distinct and their chromatophores are found on either side of the anal opening.

Stage IV (Text-Fig. 6 and Photograph 1).—In this stage the metamorphosing larva has become almost opaque due to the thickening of the body. There is also great reduction in the height which now measures only 4·8 mm. and it is 16·3 times in length.

The head has elongated and its general shape very nearly approaches that of the adult head. The lengthening of the head is conspicuous in the post-orbital region while the snout shows only very slight increase in length. The head measures 7·6 mm. which is 10·3 times in length while the snout is 3·6 times in head. The upper jaw is longer and projects beyond the lower and shows the rostral constriction clearly. Several minute, conical and backwardly directed teeth, representing the adult set of teeth, have appeared as small protuberances in both the jaws. There is no change in the position of the nostrils except in the slight shifting of the anterior one towards the border of the upper jaw. The eye also does not show any change in size or in shape and it is 8·4 times in head.

The myotomes in this stage could be made out only with some difficulty owing to the opacity of the larva. However, reflected light was found to be helpful in counting their number and the type specimen showed 149 myotomes. The anus has shifted further anteriorly and it is below the 46th myotome. The alimentary canal is short and the preanal distance is contained 2·8 times in length. The origin of the dorsal fin also shows a forward shifting and it is above the 11th myotome and in a line with the base of the pectoral fin. There is slight reduction in the predorsal distance and it is 9·6 times in length.

The fins do not show any change except for the slight increase in the length of the pectoral and caudal fins.

The pigmentation shows some variation from that of the preceding stage. A few small brown pigment cells have appeared at the tip of the snout. The body pigmentation is fairly prominent, particularly along the mid-lateral line and the alimentary canal. Some of the pigment cells of the mid-lateral series and of the caudal portion have become elongated and are arranged along the myocommas. The reduction in the length of the gut has resulted in the further fusion of the posterior groups of pigment cells of the alimentary canal and in this stage the 5 anteriormost ones alone are seen distinctly and they are situated opposite myotomes 12, 18, 26, 35 and 40. The chromatophores of these groups have become compactly arranged rendering them very

conspicuous in this stage. Due to the shifting of the anus the chromatophores of the succeeding groups have merged to form a single group which is in the form of an irregular short streak on either side of the terminal portion of the alimentary canal and the anal opening, very much like the condition found in *Muræsox talabon* (Nair and Mohamed, 1960). Several minute chromatophores have appeared along the periphery of the middle portion of the dorsal fin while its extremities are practically devoid of pigment cells. In addition to the chromatophores in the caudal fin, a few more black pigment cells have appeared along its fin rays.

Stage V (Text-Fig. 7 and Photograph 1).—In this stage the metamorphosing larva has become completely opaque, the leptocephaline shape is almost lost and the cylindrical shape of the elver is assumed. The height is more or less uniform in the anterior region while posteriorly it decreases markedly. The height is 3·3 mm. which is 23·5 times in length.

The head has also undergone changes in shape and resembles the adult head excepting in colouration. The length of the head has increased to 7·8 mm. which is 9·9 times in length. The snout does not show any appreciable change in length and it is 3·7 times in head. It is pointed and its tip projects far beyond that of the lower jaw. The rostral constriction is conspicuously seen in this stage. The anterior nostril has become slit-like while the posterior one appears as an oval aperture and both of them do not show any change in their relative positions. The gape of the mouth is longer in this stage and extends behind the eye by about half its diameter. The teeth have grown slightly longer and they are distinctly seen as conical, pointed and incurved projections. The eye continues to be of the same shape and size and is contained 8·7 times in head.

The myotomes could not be made out in this stage and alizarin preparation showed 146 vertebræ excluding the hypural bones. The vent shows a further forward migration and it is below the 44th vertebra with the preanal distance 2·9 times in length. The origin of the dorsal fin has also shifted anteriorly and it is opposite the 8th vertebra. The origin of the dorsal is in advance of that of the pectoral fin and it is opposite the gill opening. The predorsal distance is 9·9 times in length.

The fins do not show any noticeable change except for the slight increase in the length of the pectoral and caudal fins.

A slight intensification of the general pigmentation is seen in this stage. Several minute brown chromatophores have appeared in the snout along the border of the upper jaw giving a light-brown colouration to this portion.

The mid-lateral row of pigment cells is seen very prominently. The pigmentation of the alimentary canal is also conspicuous and the 5 pigment groups present in this stage are located below vertebræ 12, 18, 25, 36 and 42. As in the previous stage, the chromatophores of the other groups have become compactly arranged to form two short prominent streaks on either side of the terminal portion of the gut as well as the anus. These 6 conspicuous congregations of black chromatophores give a characteristic spotted appearance to this stage. Several additional brown chromatophores have appeared along the border of both the dorsal and anal fins giving their edges a light-brown colouration especially in the posterior region.

Stage VI (Text-Fig. 8 and Photograph 1).—The elvers which represent the final phase in the transformation of the leptocephalus resemble the adult in every respect excepting in colouration. The assumption of the adult colouration is somewhat slow and is acquired only in the growing elvers. Voracious feeding is observed in this stage and most of the specimens in the collection showed their stomachs gorged with shrimps, *Acetes*, etc.

The body has become perfectly cylindrical with the height uniform in the anterior region while posteriorly it tapers imperceptibly into the pointed tail. The maximum height of the elver is only 3·0 mm. and it is 26·2 times in length which is about $2\frac{1}{2}$ times the proportion found in the leptocephalus.

The head has become very long and measures 10·0 mm. and it is 7·9 times in length which is nearly twice the proportion seen in the larva. The shape of the head shows some changes in the orbital and post-orbital regions brought about by the reduction in its height. The snout is pointed and shows considerable increase in length, but not proportionate to that of the head and it is 4 times in head. The rostral constriction has become very distinct and conspicuous in the elver stage. The posterior nostril is in the form of a moderately long slit in front of the eye while the anterior one which is also slit-like is situated behind the notch of the snout about midway between the posterior nostril and the tip of the snout. It may be pointed out here that the anterior nostril in *Muræsox cinereus* becomes distinctly tubular even in the elver stage (Nair, 1947; Text-Fig. 6) while their tubulate nature is hardly made out even in the advanced elvers of this species. In the juveniles measuring over 20 cm. in length the tubular nature of the nostril is not seen distinctly. The eye is perfectly circular and it is 11·1 times in head. The cleft of the mouth of the elver is longer and extends behind the eye by about $\frac{3}{4}$ its diameter. The teeth which have become longer and stronger show differential growth and some of them have already become double the size of the others indicating that they ultimately form the canine teeth of the adult.

None of the myotomes could be made out in the elver and alizarin preparation showed the presence of 146 vertebræ excluding the hypural bones. The anus shows further forward shifting and it now occupies the adult position under the 42nd vertebra. The preanal distance is also reduced and it is 3 times in length. The origin of the dorsal fin in relation to the vertebra does not show any change and it continues to be above the 8th vertebra indicating that the adult position is reached in the previous stage itself. The origin of the dorsal fin is far in advance of that of the pectoral fin and also the gill opening and consequently the predorsal distance is shorter than the length of the head. However, this distance in the elver is longer than that of the previous stage owing to the lengthening of the head and it is 8·4 times in length.

The pectoral and caudal fins have become longer and more pointed and resemble those of *Muræsox talabon* (Nair and Mohamed, 1960). The lateral line is seen distinctly in the elver.

The elver shows certain changes in the general pigmentation which more or less conform with the pattern of colouration of the adult. The larval pigmentation is conspicuously seen in the elver and the retention of this colouration even in the advanced elver is highly helpful in its identification from those of the other two species. The brown pigmentation at the tips of the jaws and the ventral border of the snout has become prominent due to the addition of several minute chromatophores. The dorsal side of the snout and the interorbital region are free from chromatophores. A few scattered pigment cells have appeared in two groups on the dorsal side of the head in front of the dorsal fin.

On either side of the dorsal fin, several uniformly distributed brown dendritic pigment cells have appeared giving a faint-brown colouration to the dorsal side of the elver. These pigment cells are more numerous in the anterior region while they are somewhat diffusely scattered in the tail region with the caudal extremity free from chromatophores. The mid-lateral pigmentation, comprising of large, black pigment cells, is conspicuously seen as a row of dots distributed at equal intervals just below the lateral line. Some of the pigment cells in the tail region are linear in shape and are placed transversely. This row does not extend up to the tail of the elver.

The type elver shows 6 prominent pigment cell groups on the ventral side of the alimentary canal. Of these 6 groups, the first 5 constitute the original larval groups while the last one situated near the anus is a composite one formed by the fusion of the other larval groups of pigment cells. The chromatophores of this group encircle the anal opening of the elver.

The edges of both the anal and dorsal fins are brown in colour due to the appearance of numerous, finely branching, brown chromatophores which merge with one another to give a uniform colouration. These pigment cells are more abundant in the posterior region of these fins giving them a dark-brown colour. The anteriormost regions of both these vertical fins are without any chromatophores.

REMARKS

The foregoing account which deals with 2 growing stages and 6 metamorphosing stages of the larva of *Muræsox talabonoides* shows clearly the changes undergone during the two phases in its life-history. The marked increase and decrease in the length of the larva noticed during the growing and metamorphosing phases respectively are seen clearly from Table II which gives the morphometric characters of all the different stages. The height shows uniform reduction in all the stages due to the increase in length of the growing stages and decrease in length and height of the metamorphosing stages. A similar reduction in the predorsal and preanal distances and the size of the eye is also noticed in these two phases. The head, on the other hand, shows gradual reduction in length during the growth of the larva while it progressively increases in the different metamorphosing stages. This is due to the differential rate of growth of the head and the body seen in the growing and metamorphosing stages. It is seen that the growing stages show a higher rate of lengthening of the body than that of the head while the metamorphosing stages show reduction in body length and the elongation of head length. On the contrary the snout length increases in the growing stages and decreases in the metamorphosing stages. It may be pointed out that the increase in the length of the snout is higher than that of the head during the growing period while the opposite condition is seen during the metamorphosing period. As a result of the disproportionate growth during the two phases, the shortest head length and the longest snout length are seen only in the full-grown leptocephalus.

Another interesting feature observed during the growing period is the anterior migration of both the anus and the origin of the dorsal fin which takes place even before the leptocephalus reaches its full growth. This phenomenon has been observed in a few other Indian leptocephali as well and in this respect some of the Indian leptocephali differ from those of the temperate waters where the migration of the anus takes place only after the full growth of the larva is reached. It is likely that this acceleration in the metamorphosis is caused by the higher temperature conditions of the tropical waters.

The leptocephali of *Muræenesox talabonoides* and *Muræenesox cinereus* (Nair, 1947) differ markedly both in external and morphometric characters (Tables II and III). The most striking difference is in the height which in *M. cinereus* is considerably greater giving it the typical leaf-like appearance. The height of *M. talabonoides* is only half that of *M. cinereus* and consequently presents a linear and elongated appearance. In the full-grown leptocephalus of *M. talabonoides*, both the predorsal and preanal distances are shorter than those of *M. cinereus*. The head in these two species shows only slight difference in length. However, the snout in *M. talabonoides* is shorter than that of *M. cinereus* while the eye in the former is larger than that of the latter. The total myotome number in *M. talabonoides* is 149 which is higher than that of *M. cinereus* with a difference of 11 myotomes. Similarly, the vent in the full-grown larva of *M. talabonoides*, even though not comparable in view of its shifting in the growing stages itself shows slight difference in position from the condition found in *M. cinereus*. These two species differ in the number of teeth also and *M. talabonoides* shows 20/17 while *M. cinereus* possesses a lower number of 15/15 teeth only. The shape of the pectoral fin also aids in the identification and it is long and pointed in *M. talabonoides* while it is circular in *M. cinereus*.

Apart from these differences in general shape and body proportions, the pigmentation of the two larvæ shows striking differences. There is close similarity in the arrangement of the pigment cells in the head region of these two species. It may, however, be pointed out that the tip of the lower jaw is provided with a few chromatophores in *M. talabonoides* while such pigment cells are not present in *M. cinereus*. The arrangement of the mid-lateral chromatophores in the two species is also helpful in the identification and the number of pigment cells is much less in *M. talabonoides* since they begin from the 23rd myotome only and are widely spaced while in *M. cinereus* the row commences from the 17th myotome and all the succeeding myotomes are provided with pigment cells. The most important difference is found in the grouping of the chromatophores along the alimentary canal in *M. talabonoides* in the form of 6–9 dark patches while they are distributed along the entire length of the alimentary canal in *M. cinereus* without any regularity in their arrangement (Photograph 3). This character, as stated earlier, was successfully used in the identification of not only the leptocephalus, but the metamorphosing stages and even the advanced elvers.

The metamorphosing stages of the leptocephalus of *M. talabonoides* show the gradual assumption of the adult characters and the pattern of changes seen in this species generally tallies with that found in *M. cinereus*.

TABLE III

Measurements of Muræsox cinereus (*Nair*, 1947)

	Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI
Total length ..	81·0	73·0	67·0	68·0	61·0	62·0
Maximum height (including fins) ..	11·0 (13·6)	8·0 (11·0)	7·5 (11·2)	7·0 (10·3)	6·0 (9·8)	4·5 (7·3)
Maximum height (excluding fins) ..	10·0 (12·3)	6·5 (8·9)	5·0 (7·5)	4·5 (6·6)	3·0 (4·9)	2·8 (4·5)
Predorsal distance ..	20·0 (24·7)	11·5 (15·8)	10·0 (14·9)	9·0 (13·2)	7·5 (12·3)	8·5 (13·7)
Preanal distance ..	53·0 (65·4)	31·0 (42·5)	25·0 (37·3)	27·0 (39·7)	21·0 (34·4)	21·0 (33·9)
Length of head ..	5·0 (6·2)	6·0 (8·2)	6·5 (9·7)	6·5 (9·6)	7·0 (11·5)	8·5 (13·7)
Length of snout* ..	2·2 (44·0)	2·3 (38·3)	2·1 (32·3)	2·2 (33·8)	2·1 (30·0)	2·6 (30·6)
Diameter of eye* ..	0·7 (14·0)	0·8 (13·3)	0·8 (12·3)	0·9 (13·8)	0·7 (10·0)	0·9 (10·6)
Total myotomes ..	138	..	..	..	..	..
Preanal myotomes ..	78	50	44	43	..	..

* Calculated from the Text-Figures.

However, in *M. talabonoides* indications of the adult colouration are laid in the elver stage only while in *M. cinereus* they are clearly noticeable on the body even during the metamorphosing stages and the pigmentation of the elver generally resembles that of the adult. The slow appearance of the adult colouration in *M. talabonoides* is due to the fact that this species is somewhat lighter in colour and grows to a larger size than *M. cinereus*. The anterior nostril in *M. cinereus* becomes distinctly tubular in the elver stage while its tubular nature is not even indicated in the elver of *M. talabonoides* and the advanced elvers present in the collection do not also show this character distinctly.

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EXPLANATION OF PLATE

PHOTOGRAPH 1. The six stages in the metamorphosis of *Muræsox talabonoides*. About natural size.

PHOTOGRAPH 2. A group of pigment cells on the alimentary canal of *Muræsox talabonoides*.

PHOTOGRAPH 3. The scattered pigment cells on the alimentary canal of *Murænesox cinereus*.

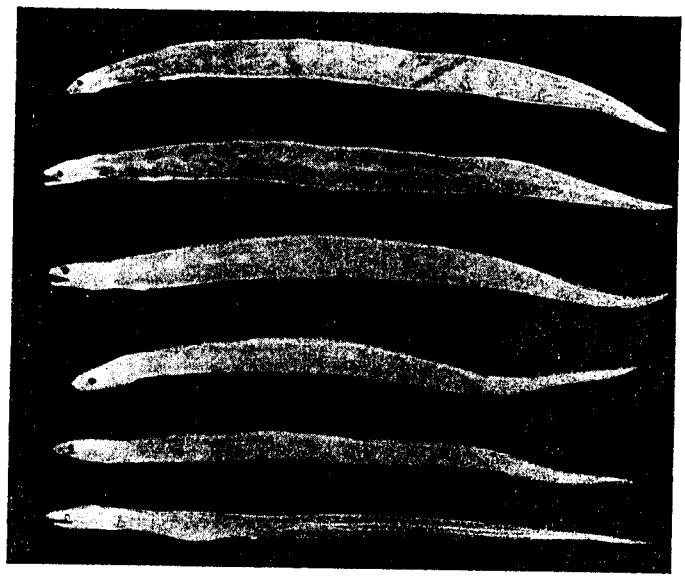

PHOTO. 1

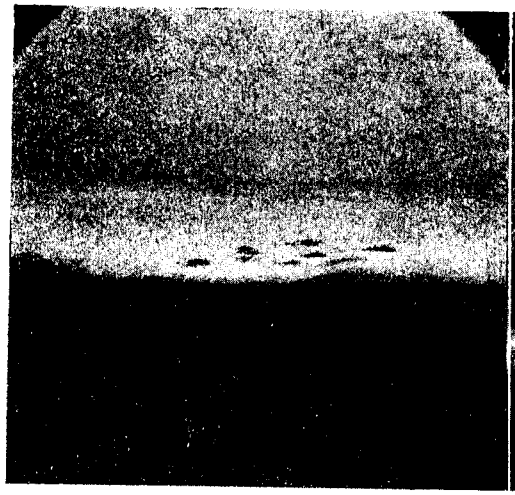

PHOTO. 2

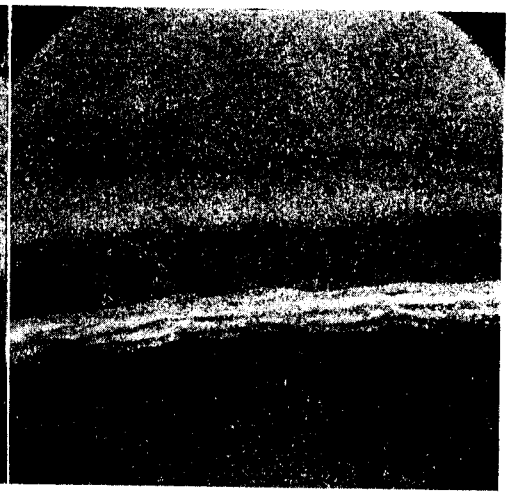

PHOTO. 3