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By
R. Velappan Nair

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GENERAL REMARKS ON INDIAN LEPTOCEPHALI*

BY R. VELAPPAN NAIR

(Central Marine Fisheries Research Station, Mandapam Camp)

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INTRODUCTION

THE seas around India are fairly rich in varieties of eels and, therefore, it is not surprising that several kinds of leptocephali have been recorded in recent years from the coastal waters. Confining our attention to the leptocephali collected from the Indian coastal waters only, it may be said that Kaup's account (1856) of *Leptocephalus acuticaudatus* and *Leptocephalus dussumieri* collected from Malabar, *Leptocephalus tænia* from India and Maldives and *Leptocephalus marginatus* from Pondicherry may be considered to be the pioneer attempt in this field. Kaup's account of these larvæ are very brief and the figures given by him serve to give an idea of the general appearance. Bertin (1935) re-examined the types of leptocephali described by Kaup which were kept in the Paris Museum and gave additional information about the different species. But Bertin's account shows that there is a mix-up of Kaup's type leptocephali in the Paris Museum and consequently it is difficult to decide whether his redescription of the species is applicable to the leptocephali collected from India. To cite instances, Kaup's description of *L. acuticaudatus* is based on a single specimen sent by Dussumier from Malabar while Bertin states that 2 specimens were sent by Dussumier from the Coromandel Coast. Similarly Bertin in his account states that Kaup has recorded 4 specimens of *L. dussumieri* in the Paris Museum whereas Kaup records only 3 examples of this species. Bertin further mentions that the single specimen of *L. dussumieri* sent by Dussumier from Malabar cannot be found in the collection. In regard to *L. tænia*, Kaup's material consisted of 8 examples of which 4 were sent by Dussumier—2 from India and 2 from Maldives. According to Bertin the collection contains only one specimen sent by Dussumier from Maldives which has become broken up into fragments making it impossible to measure it or count the myotomes. A single

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specimen of *L. marginatus* was sent to the Museum by Leschenault from Pondicherry under the name of Kouleny which according to Bertin is stuck on a glass and preserved dry so that it is rendered quite useless. It is seen from the above account that the Indian specimens of the 4 species of leptocephali which were collected more than a century back and described by Kaup were either misplaced or rendered useless with the exception of *L. acuticaudatus*. The information given by Kaup and Bertin about the place of collection of this leptocephalus also does not tally and, therefore, it is difficult to make out the exact origin of the specimen. However, based on their accounts, it is possible to refer *L. acuticaudatus* to its parent form, namely, *Uroconger lepturus* (Nair, 1946). Regarding *L. marginatus* and *L. tænia*, it may be stated that since the re-examination of the material has definitely shown that the Indian examples are no longer useful and Bertin's redescription of the two species is entirely based on material received from other places in the Atlantic and Pacific Oceans, his account cannot be considered as applicable to the Indian specimens. It is, therefore, found necessary to make use of Kaup's account and figures of these two species even though they lack many of the essential characters useful for identification. Ancona (1928) pointed out that *L. tænia* collected from the Indian Ocean is referable to *Ophisoma anago* (*Congrellus anago*) and it is highly probable that *L. marginatus* also belongs to the same species. There is close agreement in size, nature of the fins and colouration between these larvæ and the leptocephalus of *Congrellus anago* described by Gopinath (1946 and 1950) and Nair (1948). *L. marginatus* is obviously the edentulous stage in the metamorphosis where the vertical fins are better developed than in *L. tænia* which is believed by Kaup to show the vertical fins in the fresh state, even though the specimens in the Museum do not show any of the fins. Kaup records the absence of the pectoral fin in both the species. In the leptocephalus of *C. anago* the " pectorals are feebly developed " (Gopinath, 1950) and it is likely that in *L. tænia* the pectoral fins have shrivelled up due to imperfect preservation as in the case of its other fins. Kaup further states that in *L. marginatus* the fin rays have been noticed in the tail region only and this condition also shows a very close resemblance to the leptocephalus of *C. anago* where the " dorsal fin is very short with closely set developing fin rays, while the anal is slightly longer with rays well developed and prominent " (Nair, 1948). Regarding the pigmentation of *L. tænia* and *L. marginatus* Kaup mentions the presence of pigment cells on the dorsal and anal fins and in transverse rows under the lateral line. Gopinath (1950) records a similar pattern of pigmentation for the two vertical fins of the larva of *C. anago* and further states that " each intersegmental septum, along its lower half has a row of

small chromatophores arranged on it " which shows the almost perfect similarity in the mid-lateral pigmentation of *L. tænia*, *L. marginatus* and the leptocephalus of *C. anago*. It may be pointed out that the mid-lateral pigmentation composed of transverse rows of chromatophores is a characteristic feature of the larva of *C. anago*. This close agreement in the pigmentation taken in conjunction with the size and nature of the fins shows that the Indian specimens of *L. tænia* and *L. marginatus* studied by Kaup could belong to *C. anago* only. Ancona (1928) suggested that *L. dussumieri* belongs to the family Murænidæ owing to the absence of pectoral fins and this identification appears to be correct based on the other characters as well. Kaup described the larva as a " moderately elongated species, whose transverse muscular furrows are very fine, and not near each other " " with no dots either on the lateral line or along the edge of the belly " and the figure given by him tallies well with the general shape of the muræenid leptocephali. The absence of teeth in *L. dussumieri* indicates that it is in the early metamorphosing stage.

Day (1865) collected *Leptocephalus malabaricus* from Cochin and the brief description given by him is not adequate for its identification.

Southwell and Prashad (1919) described two new species of larvæ, namely, *Leptocephalus milnei* and *Leptocephalus vermicularis* collected in a small beam trawl at Doorakara, Sunderbans (Gangetic Delta). Owing to the similarity in the myotome number, *L. vermicularis* was considered by the subsequent workers as an advanced elver stage of *L. milnei* (Ancona, 1928; Nair, 1947; Gopinath, 1950; Jones and Pantulu, 1952). During the course of this comparative study, an important character relating to the length of the dorsal fin which was not mentioned by Southwell and Prashad, was detected from the illustrations. From the figures of the larvæ, it is seen that the dorsal fin in *L. milnei* is very long and occupies nearly the posterior $\frac{2}{3}$ of the larva while in *L. vermicularis* it is very short and occupies only the posterior $\frac{1}{4}$ of the larva. It is known that the length of the dorsal fin increases during metamorphosis and because of the shortness of this fin in *L. vermicularis*, it cannot be an elver stage of *L. milnei*, but belongs to a distinct species. Based on the study of the characters and body proportions it is now possible to say that *L. vermicularis* and *L. milnei* belong to the families Ophichthyidæ and Murænidæ respectively. The ophichthyid character of the former larva, which is nearing the elver stage, is seen from the shortness of the dorsal fin and in the characteristic arrangement of the chromatophores which are " specially collected in groups on the ventral surface of the body". The general shape, greater height and other body measurements taken in conjunction with the pigmentation which is " confined to the base of the vertical fins" and the absence of mid-lateral row of chromatophores show that

L. milnei belongs to the family Murænidæ. The larva, however, possesses pectoral fins which are very small and rounded and such rudimentary pectoral fins have been noted in other muræni d larvæ as well (Nair, 1947 and 1948; Jones and Pantulu, 1952).

The Ceylon leptocephali described by Deraniyagala (1934) consist of 9 varieties collected from the pearl banks in the Gulf of Mannar and Wadge Bank off Cape Comorin. Most of the larvæ were taken at night time with a dip net from the surface layers with the exception of Larva V which is a preleptocephaline stage obtained from an all-night townet collection made at the surface. He pointed out some of the important characters of the larvæ and tentatively assigned Larva I to Congridæ, Larva IV to *Muræsesox*, Larva VI to Ophichthyidæ, Larva VII to Moringuidæ and Larvæ VIII and IX to Muræsidæ. Deraniyagala assigned Larva IV to the genus *Muræsesox* on account of the rostral constriction and tubulate nature of the anterior nares. This identification was later confirmed by Jones and Pantulu (1952). The descriptive account of the larva given by Deraniyagala is too brief for comparison. However, the figures given by him show interesting features which are not generally found in any other Indian leptocephali and much less in those of *Muræsesox*. Deraniyagala mentions the presence of 3 short mandibular teeth in the larva, which obviously represent a few of the larval teeth, the others perhaps being shed prior to metamorphosis. The nature of the teeth and the important morphometric characters of the larva which have been calculated from the figures indicate that the larva corresponds to Stage II of *Muræsesox cinereus* (Nair, 1947). An interesting feature of Larva IV is the highly tubular nature of the anterior nostril which is seen clearly in the edentulous stage itself. None of the larval eels recorded so far from the Indian waters show this condition and in *Muræsesox* it becomes tubular in the elver stage only (Nair, 1947; Nair and Mohamed, 1960 *a* and 1960 *b*). It is also seen that the predorsal distance in Larva IV is higher than the preanal distance and these measurements are 50·4% and 49·6% respectively. In the corresponding stage of the 3 larvæ of *Muræsesox*, the predorsal distance is very short and it is only $\frac{1}{3}$ to $\frac{1}{4}$ of the preanal distance. The most significant difference is seen in the pigmentation of the Ceylon larva. The figure of the larva shows clearly that the mid-lateral chromatophores commence from the head region and the pigment cells are widely distributed at intervals of several myotomes. The figure also shows the presence of two more rows of pigment cells; one situated above the mid-lateral row and extending throughout the length of the larva while the other, found below the mid-lateral row, is confined to the posterior region of the larva. The presence of more than one row of body chromatophores has not so far been recorded in any other larvæ

occurring in Indian waters. These distinctive characters of Larva IV described by Deraniyagala, especially the presence of tubular anterior nostril in the leptocephalus stage itself and 3 longitudinal rows of pigment cells on the body, show that the larva does not belong to *Muræsox* but to some other group of eels. Larva V which was collected off Cape Comorin and described by Deraniyagala, is a preleptocephaline larval stage measuring 20 mm. in length. Even though the looped nature of the alimentary canal is not described by him, the figure shows clearly 9 loops in the alimentary canal and, therefore, it is assigned to the family Ophichthyidæ (Nair and Dharmamba, 1960).

All the leptocephali described by Nair from Madras (1946 and 1947) were obtained from the Madras plankton and in the case of *Muræsox cinereus* and *Muræna macrura* the correct identification was made possible by their metamorphosis in the Laboratory. *Uroconger lepturus* was identified by using the usual method of myotome and vertebral counts supplemented by the other important characters found common to the larva and the adult.

The leptocephalus of *Congrellus anago*, *U. lepturus*, *M. cinereus* and *Muræna* sp. were recorded from the Gulf of Mannar where they were observed to be present in good numbers in the shore seine catches which were operated at Kutikal Point, Rameswaram Island (Nair, 1948).

Nair and Bhimachar (1950) collected two preleptocephaline larvæ from Tholayiram Paar, one of the pearl banks situated off Tuticorin in the Gulf of Mannar. These preleptocephaline larvæ which represent very early stages, belong to the families Murænidæ and Ophichthyidæ (Nair and Dharmamba, 1960).

Gopinath's account (1950) of the leptocephali of the Trivandrum coast deals with 6 larvæ collected mostly from the fishermen's catches. Leptocephalus A and Leptocephalus F alone were obtained from the townet collections while the rest were obtained from the shore seines operated in the coastal waters. Out of the 6 larvæ described by him, 2 belong to *Congrellus anago* (Gopinath, 1946; Nair, 1948) and *Muræsox cinereus* (Nair, 1947). He referred Leptocephalus A and Leptocephalus C to the family Ophichthyidæ due to the presence of a free tail. Leptocephalus F described by him is also an ophichthyid as shown by the shortness of the dorsal fin, free nature of the tail and the characteristic pigmentation in the form of black patches. Leptocephalus E described by Gopinath shows characteristic murænid features in body proportions and in the absence of the mid-lateral

chromatophores about which he states that "the large elongate chromatophores found along the myocomma in most of the other species are wanting in this". The rudimentary nature of the pectoral fin is also recorded by him.

Jones and Pantulu (1952) collected the metamorphosing stages of *Muræenesox talabon* from the Burhabulong estuary in Orissa State along with 3 other murænid leptocephali and doubtfully assigned another murænid leptocephalus collected from the Hooghly estuary to *Muræna tile*. The larval stages assigned by them to *M. talabon* have been shown by Nair and Mohamed (1960 *b*) to belong to *Muræenesox cinereus* already described by Nair (1947). These authors (1954) provisionally confirmed the identification of the leptocephalus of *Muræna tile* and described its metamorphosing stages along with 2 growing stages of two other murænid leptocephali. The different murænid leptocephali described by these authors have been discussed in detail by Nair and Mohamed (1960 *e*). Jones and Pantulu (1955) described 5 varieties of ophichthyid leptocephali of which one is in the early preleptocephaline stage. Of the remaining 4 larvæ, one was collected from Madras, 2 from Travancore and the last one which they referred to *Pisoodonophis hijala* from the Orissa coast. The two Travancore larvæ were collected from the shore seine catches while that of *P. hijala* was collected in a sub-surface townet haul made in the coastal waters. The ophichthyid leptocephali from Madras are also believed to be obtained from townet collections.

Classification

Altogether 47 different varieties of leptocephali have been recorded so far from the Indian coastal waters of which only those described by Kaup (1856), Day (1865) and Southwell and Prashad (1919) were given scientific names while the others were either correlated with the adults or designated by the different authors with letters and numbers, even though they could be given new scientific names. Out of these 47 varieties of leptocephali 7 are considered synonymous with other varieties as shown below:—

1. *Leptocephalus acuticaudatus* Kaup, 1856	Leptocephalus of *Uroconger lepturus*. Nair, 1946 and 1948; Nair and Mohamed, 1960 *c*.
2. *Leptocephalus tænia* Kaup, 1856	Leptocephalus of *Congrellus anago*. Gopinath, 1946 and 1950; Nair, 1948.
3. *Leptocephalus marginatus* Kaup, 1856	Do.

4. Leptocephalus of *Muræsox talabon*. Jones and Pantulu, 1952	Leptocephalus of *Muræsox cinereus*. Nair, 1947 and 1948; Gopinath, 1950.
5. Leptocephalus III. Jones and Pantulu, 1952	Leptocephalus II. Jones and Pantulu, 1952.
6. Muræna II. Pantulu and Jones, 1954	Leptocephalus of *Muræna tile*. Jones and Pantulu, 1952; Pantulu and Jones, 1954.
7. Muræna III. Pantulu and Jones, 1954	Do.

It is interesting to note that out of the 40 valid species, the following 8 leptocephali have been referred to their respective adults and the metamorphosis of 6 species has been studied in detail:—

1. *Uroconger lepturus*	.. Nair, 1946; Nair and Mohamed, 1960 *c*
2. *Muræsox cinereus*	.. Nair, 1947
3. *Muræna macrura*	.. Nair, 1947
4. *Congrellus anago*	.. Gopinath, 1946 and 1950; Nair, 1948
5. *Muræna tile*	.. Jones and Pantulu, 1952; Pantulu and Jones, 1954
6. *Pisoodonophis hijala*	.. Jones and Pantulu, 1955
7. *Muræsox talabonoides*	.. Nair and Mohamed, 1960 *a*
8. *Muræsox talabon*	.. Nair and Mohamed, 1960 *b*

All the remaining 32 larvæ have been referred to their respective families with the exception of 5 larvæ, namely, *Leptocephalus malabaricus* (Day, 1865), Larva II, Larva III and Larva IV (Deraniyagala, 1934) and Leptocephalus V (Nair and Mohamed, 1960 *e*). The family-wise grouping of the different unidentified leptocephali are given below:—

Family: OPHICHTHYIDÆ

1. *Leptocephalus vermicularis*, Southwell and Prashad, 1919.
2. Larva V, Deraniyagala, 1934.
3. Larva VI, Deraniyagala, 1934.
4. Larva II, Nair and Bhimachar, 1950.
5. Leptocephalus A, Gopinath, 1950.
6. Leptocephalus C, Gopinath, 1950.

7. Leptocephalus F, Gopinath, 1950.
8. Prolarva (Madras), Jones and Pantulu, 1955.
9. Leptocephalus (Madras), Jones and Pantulu, 1955.
10. Leptocephalus I (Travancore), Jones and Pantulu, 1955.
11. Leptocephalus II (Travancore), Jones and Pantulu, 1955.
12. Leptocephalus I, Nair and Mohamed, 1960 *d*.
13. Leptocephalus II, Nair and Mohamed, 1960 *d*.
14. Leptocephalus III, Nair and Mohamed, 1960 *d*.
15. Preleptocephaline Larva, Nair and Dharmamba, 1960.

Family: MURÆNIDÆ

16. *Leptocephalus dussumieri*, Kaup, 1856.
17. *Leptocephalus milnei*, Southwell and Prashad, 1919.
18. Larva VIII, Deraniyagala, 1934.
19. Larva IX, Deraniyagala, 1934.
20. *Muræna* sp. Nair, 1948.
21. Larva II, Nair and Bhimachar, 1950.
22. Leptocephalus E, Gopinath, 1950.
23. Leptocephalus I, Jones and Pantulu, 1952.
24. Leptocephalus II, Jones and Pantulu, 1952.
25. Leptocephalus IV, Nair and Mohamed, 1960 *e*.

Family: CONGRIDÆ

26. Larva I, Deraniyagala, 1934.

Family: MORINGUIDÆ

27. Larva VII, Deraniyagala, 1934.

Others

28. *Leptocephalus malabaricus*, Day, 1865.
29. Larva II, Deraniyagala, 1934.
30. Larva III, Deraniyagala, 1934.
31. Larva IV, Deraniyagala, 1934.
32. Leptocephalus V, Nair and Mohamed, 1960 *e*.

DISTRIBUTION

It is seen that the ophichthyid leptocephali are more common in the coastal waters and 16 larvæ have been recorded so far, including the 4 preleptocephaline stages described by Deraniyagala (1934), Nair and Bhimachar (1950), Jones and Pantulu (1955) and Nair and Dharmamba (1960) and the leptocephalus of *Pisoodonophis hijala* (Jones and Pantulu, 1955). Muræniđ larvæ are also common with 12 valid species recorded till now from the coastal waters and estuaries including the preleptocephaline stage recorded by Nair and Bhimachar (1950) and the leptocephali of *Muræna macrura* (Nair, 1947) and *Muræna tile* (Jones and Pantulu, 1952; Pantulu and Jones, 1954). Among the other leptocephali 3 belong to *Muræsox*, one each to *Uroconger*, *Congrellus*, Congridæ and Moringuidæ. Ophichthyid larvæ appear to be more common along the West coast as shown by the higher number of larvæ recorded from this coast. Out of the 12 known leptocephali, 8 are from the West coast of which 5 are from the Travancore coast and 3 from Bombay coast. The 4 ophichthyid larvæ recorded from the East coast are from the Gulf of Mannar and Madras, Orissa and Bengal coasts. On the other hand, the record of murænid leptocephali shows that they are more common on the East coast and out of the 11 valid species, only 3 are from the West coast collected from Trivandrum, Malabar and Bombay coasts while the 8 larvæ recorded from the East coast are from the Gulf of Mannar and Madras, Orissa and Bengal coasts. It is interesting to point out that, barring the 4 murænid leptocephali collected from the estuaries of Orissa and Bengal, all the others were from the coastal waters only. It is difficult to say with our present knowledge, whether the murænid leptocephali collected from these estuaries show an actual migration or whether they are brought into the estuaries from the coastal waters by the action of the tide. Some of the larvæ have been recorded from both the coasts and the leptocephalus of *Uroconger lepturus* appears to be a widely distributed species and it has been recorded in good numbers from Madras, Gulf of Mannar, Bombay and Malabar (?). *Muræsox cinereus* is also widely distributed and has been recorded from Orissa, Madras, Gulf of Mannar and Trivandrum. *Congrellus anago* appears to have a restricted distribution and it is recorded so far only from Pondicherry, Gulf of Mannar and Trivandrum and Maldives while the other recorded leptocephali are known only from the place of collection of the type specimens.

It is interesting to point out here that most of the leptocephali recorded so far, were collected from the shallow waters either from the fishermen's catches or inshore plankton collections during the months January to May

which perhaps constitute the period when the fully-grown larvæ enter the shallow coastal waters in large numbers and metamorphose into the elvers. This is clearly demonstrated by the paucity of toothed larvæ and the abundance of edentulous stages of species like *Congrellus anago*, *Uroconger lepturus*, etc. The abundance of metamorphosing leptocephali during this period also indicates the possibility that the Indian eels have a definite spawning period. There is no record of the eggs, preleptocephaline and early larval stages of any of the identified larvæ and there is no information about the time taken by the leptocephalus to reach the maximum size. Aiyer, Unny and Varkey (1944) noted the occurrence of eel eggs in the Madras plankton, but the details of the collection are not available. Similarly Bapat (1955) also recorded the presence of eel eggs in the plankton collections made from the Gulf of Mannar and Palk Bay without giving the dates of occurrence. However, the eggs and larvæ recorded from the Gulf of Mannar by Nair and Bhimachar (1950) and the Lawson's Bay by Nair and Dharmamba (1960) were collected in April and February respectively. The preleptocephaline stages described by Deraniyagala (1934) and Jones and Pantulu (1955) were collected in November and December respectively. Mature, oozing and spent individuals of *Muræsox talabonoides* were observed from January to April in the trawler catches made off Bombay. These stray records of the eggs and larvæ do not give any indication about the breeding season; but taken in conjunction with the gonadial condition noted in *M. talabonoides* suggest the possibility that the breeding season of Indian marine eels is likely to be from November to April. It is very unlikely that the leptocephali will reach the full growth within the spawning period itself, but on the other hand it is possible that the duration of the leptocephalus stage is about one year or more.

Morphometric and Other Characters

The Indian leptocephali show great diversity in size and the longest larva recorded so far is that of *Congrellus anago* which attains a maximum size of 158 mm. (Gopinath, 1950). The leptocephalus of *Uroconger lepturus* and a few ophichthyid larvæ like Leptocephalus I from Bombay (Nair and Mohamed, 1960 *d*) are also relatively long, but the smallest size recorded so far is seen in Larva VII (Deraniyagala, 1934) which measures only 42·5 mm. As a general rule the murænid leptocephali are very tall while those of *Muræsox* and *Congrellus* show moderate height only. The larva of *Uroconger lepturus* and those of the family Ophichthyidæ are relatively very short. The maximum height recorded so far is in Leptocephalus E of Gopinath (1950) which measures 19·1% or nearly 1/5th of the total length.

On the other hand, the minimum height of 4·1% is noticed in the ophichthyid Leptocephalus I collected from Bombay waters (Nair and Mohamed, 1960 *d*).

A similar comparison of the length of the head of the different leptocephali is rendered difficult owing to the fact that there are quite a few larvæ which show signs of metamorphosis and consequently possess higher values for the head due to its elongation. However, it is seen that the head of *Congrellus anago* is the smallest and measures only 2·8%. Generally the head of ophichthyid leptocephali is also short measuring only 3·4% as seen in the Leptocephalus F of Gopinath (1950) and Leptocephalus I (Nair and Mohamed, 1960 *d*). The head of the larva of *Uroconger lepturus* is of moderate length while those of *Muræenesox* spp. and Muræenidæ are usually long and the longest head is seen in the moringuid Larva VII of Deraniyagala (1934) which measures 9·5% (calculated from the description).

The length of the snout is very long in the genus *Muræenesox* where the maximum size of 44·0% is seen in the larva of *M. cinereus*. The snout is generally small in the family Muræenidæ and the smallest snout is seen in Leptocephalus I (Jones and Pantulu, 1952) and it measures only 18·0% of the head. This character varies from $\frac{1}{4}$ to $\frac{1}{3}$ the length of head in the larvæ belonging to the other families.

The diameter of the eye shows slight variation in the different leptocephali. In the leptocephali of the family Muræenidæ and those of *Congrellus anago* and *Uroconger lepturus*, the eye is about $\frac{1}{4}$ the length of the head, while in the family Ophichthyidæ and *Muræenesox* it is about 1/5th only. In actual size the eye of Leptocephalus V (Nair and Mohamed, 1960 *e*) shows the maximum diameter of 1·4 mm. while the smallest diameter of 0·5 mm. is seen in the muræenid Leptocephalus I (Jones and Pantulu, 1952), ophichthyid leptocephalus from Madras and the larva of *Pisoodonopthis hijala* from Orissa (Jones and Pantulu, 1955).

In regard to the number of teeth, the larva of *Uroconger lepturus* is peculiar in showing the highest number of 23/15 teeth. Very low number of teeth has been recorded in a few leptocephali, but owing to the very brief description of the larvæ given by the authors, it is difficult to say whether they belong to the larval set or whether they represent the rudiments of the adult set of teeth which are in the course of formation.

Individual variation in the myotome number is found in almost all the species and the range of variation is as low as one myotome in the case of Leptocephalus II (Nair and Mohamed, 1960 *d*) while it is very high in *Uroconger lepturus* and *Muræenesox talabon* with 19 and 10 myotomes respectively.

The range given for *U. lepturus* does not represent the normal condition since regeneration of the tail takes place in this species. The myotome number of species belonging to the same family overlaps only in the case of Leptocephali I and II (Nair and Mohamed, 1960 *c*) and in the larvæ of *Muræne-sox talabonoides* (Nair and Mohamed, 1960 *a*) and *Muræsox talabon* (Nair and Mohamed, 1960 *b*) and this is caused by the higher myotome variation found in Leptocephalus I and *M. talabon*. The maximum number of 223 myotomes is seen in the ophichthyid leptocephalus collected from Madras (Jones and Pantulu, 1955). Another ophichthyid larva, Leptocephalus C of Gopinath (1950) also shows a high number of 206 myotomes while in all the other leptocephali it is very much less excepting some murænid leptocephali and *Leptocephalus malabaricus* (Day, 1865). The minimum number of myotomes recorded for any Indian leptocephali is seen in Larva IX of Deraniyagala (1934) which shows only 101 myotomes. According to the myotome number, the different larvæ of the family Muræniдæ come under two groups. Leptocephalus of *Muræna macrura* (Nair, 1947), *Muræna* sp. (Nair, 1948), Leptocephalus I and Leptocephalus II (Jones and Pantulu, 1952) show high myotome number varying from 205–216. This group characterised by high myotome number may be appropriately termed as the ' macrura group ' after the species whose adult is known. The other group comprising of the leptocephalus of *Muræna tile* (Jones and Pantulu, 1952; Pantulu and Jones, 1954), *Leptocephalus milnei* (Southwell and Prashad, 1919), Larva VIII (Deraniyagala, 1934) and Leptocephalus E (Gopinath, 1950) possess low myotome number ranging from 120–126 and may be called the ' tile group ' after *M. tile*. Generally the ' macrura group ' shows more than 200 myotomes while the ' tile group ' shows less than 130 myotomes, the exceptions being *Leptocephalus dussumieri* (Kaup, 1856) and Leptocephalus IV (Nair and Mohamed, 1960 *e*) which exhibit an intermediate condition and Larva IX (Deraniyagala, 1934) which shows the lowest myotome number recorded so far. The characteristic pigmentation round the pupil of the eye of the ' macrura group ' and their absence in the ' tile group ' strengthens this grouping of the murænid larvæ. As a general rule the myotomes of murænid leptocephali are very narrow and compactly arranged while the broadest myotomes measuring as much as 1·5 mm. in width are seen in the leptocephalus of *Congrellus anago* (Nair, 1948).

The predorsal distance also shows marked difference among the different leptocephali indicating that this character serves as a distinguishing feature of the leptocephali of at least a few families. The ophichthyid leptocephali invariably show the highest predorsal distance seen among the different leptocephali and this is clearly seen from the high value of 95·7% observed in

Leptocephalus III (Nair and Mohamed, 1960 *d*). Table II given by Nair and Mohamed (1960 *d*) shows clearly that in almost all the ophichthyid leptocephali the predorsal distance is above 90% of the length. The predorsal distance of the ophichthyid Leptocephalus A, Leptocephalus C and Leptocephalus F of Gopinath (1950) is not available; however, the dorsal fin is described as very short in these larvæ indicating that the predorsal distance is long as in the case of the other ophichthyid larvæ. This distance in the larva of *Congrellus anago* also is very long and measures 84·5% of the length (Nair, 1948). The predorsal distance in murænid leptocephali shows variation and it is nearly half the length of the larva in most cases. In the genus *Muræsox*, this distance is only about $\frac{1}{4}$ of the length with *M. talabonoides* showing the shortest distance of 17·0% recorded so far. The predorsal distance of Larva III of Deraniyagala (1934) is also very short and measures only 17·3% (calculated from the description).

The preanal distance which serves to indicate the relative length of the alimentary canal, is found to vary among the different larvæ. The longest preanal distance is seen in Larva I of Deraniyagala (1934) where it forms 92·6% of the length (calculated from the text-figure). The larva of *Muræna tile* (Muræna II of Pantulu and Jones, 1954) also shows a high value of 83·8%. In most of the other murænid larvæ this distance occupies more than $\frac{2}{3}$ the length of the larvæ. The preanal distance in the larva of *Uroconger lepturus* is also long and forms 73·2% of the length. This distance is about $\frac{2}{3}$ the length in *Congrellus anago* and *Muræsox* spp. while in the ophichthyid leptocephali it is generally short and extends only up to the middle of the larva. The shortest preanal distance is found in the ophichthyid leptocephalus from Madras (Jones and Pantulu, 1955) where it is only 38·1% of the length.

The highest number of preanal myotomes of 126 is seen in *Muræna* sp. (Nair, 1948) while the lowest number of 51 preanal myotomes is seen in Leptocephalus V (Nair and Mohamed, 1960 *e*). This, no doubt, is a variable character depending on the stage of growth as well as metamorphosis of the leptocephalus. The larvæ of Murænidæ comprising of both the 'macrura group' and 'tile group' generally show a high preanal myotome number in contrast with the relatively lower number found in the other families.

The alimentary canal of all the larvæ excepting those of the family Ophichthyidæ is of uniform thickness and takes a straight course. The characteristic features of the alimentary canal shown by the ophichthyid leptocephali are of diagnostic importance. The alimentary canal of most of the ophichthyid larvæ is straight and shows hump-like thickenings

at regular intervals except in Larva IV of Deraniyagala (1934), Leptocephalus A of Gopinath (1950) and Leptocephalus III (Nair and Mohamed, 1960 *d*) in which the alimentary canal shows a looped condition. Similar hump-like thickenings of the alimentary canal have also been observed in these 3 larvæ with looped alimentary canal and they are found at the angles of the loops. It is quite likely that the leptocephali with looped alimentary canal may belong to a distinct group from those possessing a straight alimentary canal with hump-like thickenings.

The paired pectoral fins and the median vertical fins show difference in shape and size which are useful in the identification of the different families as well as the species. The pectoral fin is of taxonomic importance in the identification of the leptocephali and elvers of the 3 species of *Muræsox*. In the larva of *M. cinereus*, the pectoral fin is perfectly circular and it becomes oval in the elver stage. The pectoral fin of *M. talabon* is oval in the leptocephalus and becomes long and pointed in the elver stage. This fin is long and pointed in the larval and elver stages of *M. talabonoides*. The presence of rudimentary pectoral fin has been shown in the larvæ of *Muræna macrura* (Nair, 1947), *Muræna tile* (Jones and Pantulu, 1952; Pantulu and Jones, 1954), etc., and it is likely that the other murænid leptocephali may also show the fin in the early larval stages. It may be mentioned that Schmidt (1913) pointed out that " all murænoids have larval pectoral fins, even those in which they disappear later; the time for their disappearance being very variable in different species". The pectoral fin of the leptocephalus of *Congrellus anago* is feebly developed with indistinct rays.

The dorsal fin is found to be extremely short in almost all the ophichthyid leptocephali and in some larvæ the posteriormost rays excepting the last few ones are slightly longer than the rest. The corresponding rays of the anal fins are also longer and consequently these regions of the two fins are slightly wider than the other regions of the fins. In Leptocephalus III (Nair and Mohamed, 1960 *d*) and Leptocephalus V (Nair and Mohamed, 1960 *e*) these rays are considerably longer than the others and show a uniform zig-zag curvature at their tips.

The anal fin in almost all the leptocephali commences just behind the anal opening and the only exception appears to be Larva VIII (Deraniyagala, 1934) belonging to the family Moringuidæ, where both the dorsal and anal fins are confined to the tail region.

The caudal fin is well developed in all the leptocephali of the different families except in the family Ophichthyidæ which is characterised by the absence of this fin.

PIGMENTATION

The pigmentation of the leptocephali of the different families have been discussed in detail under the respective sections (Nair and Mohamed, 1960 *b*, 1960 *d*, 1960 *e*); however, the important features useful in the identification of the families may be mentioned here. The normal head pigmentation consisting of a few chromatophores on the upper jaw and also in the heart region, is present in most of the leptocephali of the different families except in *Congrellus anago*, the head of which is devoid of pigmentation. Head pigmentation of diagnostic importance is rare in Indian leptocephali and so far it is observed only in *Leptocephalus malabaricus* (Day, 1865), leptocephalus of *Uroconger lepturus*, ' macrura group ' of murænid leptocephali and in Leptocephalus IV (Nair and Mohamed, 1960 *e*). The head of *L. malabaricus* is " golden; lower surface orange. One line of yellow, spotted with green proceeds backwards from the eye; a second from the mouth; this last one also traverses the lower lip". The group of black chromatophores found below the eye is a characteristic feature of the leptocephalus of *U. lepturus* and this character together with the pointed and whip-like tail enables its easy identification. The 8-stellate chromatophores found around the pupil of the eye is recorded only in the ' macrura group ' and may prove to be a feature of this group of murænid leptocephali. The only exception is Leptocephalus I, about which Jones and Pantulu (1952) state that " as this specimen was examined only after a few months after it was collected it is difficult to say whether any chromatophores around the pupil identical to those occurring in specimens II and III were present". The groups of black pigment cells found on either side of the eye of Leptocephalus IV (Nair and Mohamed, 1960 *e*) give the head a prominent dark colouration and it is possible that it has specific significance.

The mid-lateral pigmentation is not generally found in the murænid leptocephali and also in Leptocephalus V (Nair and Mohamed, 1960 *e*). This pigmentation is very conspicuous in the family Ophichthyidæ even though variation in the number and arrangement of the pigment cells is found among the different species. The presence of post-anal and mid-lateral groups of chromatophores in Leptocephalus A of Gopinath (1950) and in Leptocephalus I and Leptocephalus II (Nair and Mohamed, 1960 *d*) are additional features found only in these larvæ. The mid-lateral pigmentation is moderate in the genera *Muræsesox* and *Uroconger* while in *Congrellus* it is in the form of transverse rows of chromatophores arranged along the lower half of the myocommas. Larva IV of Deraniyagala (1934) is peculiar in showing 2 more additional rows of chromatophores situated on either

side of the mid-lateral row of pigment cells. In Larva VII of Deraniyagala (1934) the mid-lateral pigmentation is absent, but in its place a few large stellate melanophores, whose number is variable, is seen along the lateral line.

The characteristic features in the pigmentation of the alimentary canal are of considerable importance in the identification of the families and even species. The difference in the pattern of pigmentation found within the same genus is clearly seen in the 3 larvæ of *Muræsox* (Nair, 1947; Nair and Mohamed, 1960 *a*, 1960 *b*) and to some extent in the larvæ of the family Ophichthyidæ, where the number of pigment groups on the hump-like thickenings of the alimentary canal and also those along the post-anal, mid-lateral line appears to indicate species variation only.

The anal fin in all the leptocephali is pigmented while the dorsal and caudal fins show variations in the pigmentation in the leptocephali belonging to the different families and sometimes within the same family itself.

Growth

There is no record relating to growth in leptocephalus except the 2 stages described by Pantulu and Jones (1954) for *Muræna tile* (Stages I and II of Muræna II and III). As in the case of *Uroconger lepturus*, a study of the changes undergone during the growth of this murænid larva is not possible with the single intermediate stage described by them. However, certain generalisations are possible as a result of the study of the different stages available in the case of *Muræsox talabonoides* (Nair and Mohamed, 1960 *a*) and Leptocephalus I (Nair and Mohamed, 1960 *d*). Among the morphometric characters, the increase in the length of the larva is rapid while the other body measurements do not generally show proportionate increase in the growing stages. On account of this, the height and length of head show decreasing percentages, in spite of their growth during this period. A similar decrease in the height is also seen in the metamorphosing stages consequent on the reduction in the height while the length of head increases considerably during the transformation. The marked change in their values in the different metamorphosing stages is also partly caused by the reduction in the length. The predorsal and preanal distances in the leptocephalus of *Muræsox talabonoides* show gradual reduction in the growing as well as metamorphosing stages. But in Leptocephalus I (Nair and Mohamed, 1960 *d*) no reduction of the predorsal and preanal distances is noticed in the growing phase since these distances also register proportionate increase and consequently their percentages are fairly constant during growth. It is likely that this feature is

found only in the family Ophichthyidæ since reduction in these distances is also seen in the leptocephali of *Uroconger lepturus* (Nair and Mohamed, 1960 *c*) and *Muræna tile* (Stages I and II of Muræna II and III, Pantulu and Jones, 1954). Contrasting conditions are found in regard to the length of the snout during the growth of the leptocephalus of *Muræsox talabonoides* (Nair and Mohamed, 1960 *a*) and Leptocephalus I (Nair and Mohamed, 1960 *d*). The former shows higher percentages during the growing phase, while its values decreases in the successive metamorphosing stages. The higher value for the snout no doubt is caused by its elongation which is not proportionate to that of the head. The length of the snout of Leptocephalus I (Nair and Mohamed, 1960 *d*) also records increase during the growing phase, but at a lower rate than that of the head and hence shows decreasing percentages. There is no change in the size of the eye, but its diameter shows decreasing percentage values in both the species during the growing phase and the values continue to decrease in *M. talabonoides* during the metamorphosing phase also, since the head elongates in both these phases.

It is interesting to note that the preanal number of myotomes is more or less constant in the growing stages of Leptocephalus I (Nair and Mohamed, 1960 *d*) while reduction is seen in *M. talabonoides* indicating that the anus migrates during the growing phase itself. This phenomenon is also observed in the leptocephali of *Uroconger lepturus* (Nair and Mohamed, 1960 *c*) and *Muræna tile* (Stages I and II of Muræna II and III, Pantulu and Jones, 1954). Normally leptocephali come under two categories depending on the migration of the anus; one showing the migration of the anus during the early larval growing phase while in the other the anus maintains a constant position throughout the larval growing phase. In both these categories the anus migrates anteriorly during the metamorphosing phase only. The leptocephalus of *M. talabonoides*, *U. lepturus* and *M. tile* present a condition in which the migration of the anus takes place even before attaining the full growth of the larva and this has necessarily to be considered as a metamorphosing migration coming under the second category since a shifting of the origin of the dorsal fin also takes place simultaneously. The ophichthyid Leptocephalus I (Nair and Mohamed, 1960 *d*) shows the normal condition found in many leptocephali where the anus maintains a constant position in relation to the myotomes during the growing phase and migrates only during metamorphosis. It is not clear whether the early anal migration noted in these species is caused by the tropical environment which is known to accelerate the metamorphosis of the leptocephali of *Muræsox cinereus* and *Muræna macrura* (Nair, 1947).

METAMORPHOSIS

The leptocephali immediately on reaching full growth begins to metamorphose which is the progressive replacement of the larval characters by the adult ones. The changes undergone in the different leptocephali, whose metamorphosis is known, have been given in detail (Nair, 1947; Nair and Mohamed, 1960 *a*, 1960 *b* and 1960 *c*). A comparative study of the changes in the metamorphosis of the leptocephali belonging to the same genus is possible in the case of *Mutænesox* and *Muræna* only.

No significant variation has been noted in the metamorphosis of the leptocephali of *Muræenesox cinereus* (Nair, 1947), *Muræenesox talabonoides* (Nair and Mohamed, 1960 *a*) and *Muræenesox talabon* (Nair and Mohamed, 1960 *b*) and all of them show the reduction in height and proportionate thickening of the body, the shifting of the vent and the origin of the dorsal fin to an anterior position, the lengthening of the head and the gradual acquisition of the adult colouration. However, it is interesting to point out that these changes occur in the different larvæ in varying degrees indicating perhaps specific differences. Tables II and III (Nair and Mohamed, 1960 *a*) and Table I (Nair and Mohamed, 1960 *b*) show the morphometric characters of the different stages in the metamorphosis of the 3 species and it is seen that the reduction in height during metamorphosis is more or less uniform in all the larvæ with the elver showing the minimum height. The larva of *M. cinereus* records only a minimum reduction by 46·3% of the larval height while *M. talabonoides* and *M. talabon* show greater reduction. The latter species shows the maximum reduction by 64·1% and it may be mentioned here that in the elver, the height of the body is much lower than that of the head. *M. talabonoides* also shows a fairly high reduction of the larval height by 50·6%. It is interesting to note that the two shorter larvæ show more reduction in height than the taller *M. cinereus*. It may be recalled that the predorsal distance is highest in the larva of *M. talabon* while it is lowest in *M. talabonoides*. In the elver stage the maximum predorsal distance is seen in *M. cinereus* while *M. talabonoides* continue to show the minimum distance. It is seen that the maximum reduction of the predorsal distance by 51·4% is seen in *M. talabon* while *M. cinereus* and *M. talabonoides* show reduction by 44·5% and 30·6% respectively. The maximum preanal distance is observed in the elver of *M. talabon* while that of *M. talabonoides* shows the minimum distance. However, the maximum reduction in the preanal distance is seen in *M. talabon* where the original length is reduced by 50·3% while *M. cinereus* and *M. talabonoides* show a reduction by 48·2% and 40·7% respectively.

The head and snout of all the 3 species show fairly uniform increase during the transformation into elver and the greatest snout and head lengths continue to be present in *M. cinereus* while they are shortest in *M. talabonoides*. On the other hand, a complete reversal in regard to the diameter of the eye is seen in the 3 species. It may be mentioned that *M. talabon* possesses the largest larval eye with the smallest eye in *M. cinereus*. In the elver, the eye of *M. cinereus* is the largest while that of *M. talabon*, the smallest among the 3 species. The anterior nostril of *M. talabon* is tubulate though not conspicuous as in the case of *M. cinereus* while in *M. talabonoides*, its tubulate nature is not distinct even in the advanced elvers.

The changes in the shape of the pectoral fin during metamorphosis also show interesting features suggesting that they are useful in the identification of the metamorphosing stages as well. The pectoral fin of the larva of *M. cinereus*, as pointed out earlier, is perfectly circular and it becomes oval in the elver stage. The pectoral fin of *M. talabon* is oval in the larval stage and becomes long and pointed in the elver while that of *M. talabonoides* is pointed and long in both the larval and elver stages. It is seen that the pectoral fins of the leptocephali show a gradation from circular to linear shape in the 3 species.

Even in the assumption of the adult colouration, *M. talabon* occupies an intermediate position only. In *M. cinereus* indications of the adult colouration are seen in the metamorphosing stages while the elver becomes uniformly brownish-black on the dorsal side. In *M. talabon*, the chromatophores on the dorsal side of the elver are somewhat uniformly scattered giving that side a light brown colour while in *M. talabonoides* the pigmentation of the elver is very light and the chromatophores, which are comparatively fewer in number, are widely scattered giving the elver a faint brown colour to the dorsal side.

A similar comparative study of the metamorphosis of the two larvæ of *Muræna macrura* (Nair, 1947) and *Muræna tile* (Pantulu and Jones, 1954) is made easy since only 5 more or less similar stages have been described for both the species. A perusal of Tables I and II which give the characters of the different metamorphosing stages of the two species, shows that considerable reduction in length and height takes place and the reduction in the latter is about the same in both the species.

There is great reduction in the predorsal distance in *M. macrura* by about 78·4% of the larval distance while this reduction is only by 62·3% in *M. tile*. On the other hand, the reduction of the preanal distance is higher in *M. tile*

TABLE I

Measurements of Muræna macrura (*Nair*, 1947)

	Stage I	Stage II	Stage III	Stage IV	Stage V
Total length ..	93·0	77·0	80·0	78·5	69·0
Maximum height	13·0	11·5	8·5	6·5	4·5
(including fins)	(14·0)	(14·9)	(10·6)	(8·3)	(6·5)
Maximum height	12·5	11·0	8·0	6·0	3·0
(excluding fins)	(13·4)	(14·3)	(10·0)	(7·6)	(4·3)
Predorsal distance ..	50·0	40·0	40·0	30·0	8·0
	(53·8)	(51·9)	(50·0)	(38·2)	(11·6)
Preanal distance ..	62·0	53·0	53·0	46·5	32·0
	(66·7)	(68·8)	(66·3)	(59·2)	(46·4)
Length of head ..	4·0	5·0	5·5	6·5	9·0
	(4·3)	(6·5)	(6·9)	(8·3)	(13·0)
Length of snout* ..	1·3	1·6	1·6	1·5	1·3
	(32·5)	(32·0)	(29·1)	(23·1)	(14·4)
Diameter of eye* ..	0·9	1·1	1·0	0·8	0·7
	(22·5)	(22·0)	(18·2)	(12·3)	(7·8)
Total myotomes ..	216	..	..	..	..
Preanal myotomes ..	120	120	120	103	..

* Calculated from the text-figures.

TABLE II

Measurements of Muræna tile (*Pantulu and Jones*, 1954)

	Stage I	Stage II	Stage III	Stage IV	Stage V
Total length ..	62·5	61·0	60·0	55·0	53·0
Maximum height ..	11·6	7·2	6·8	4·5	4·1
	(18·6)	(11·8)	(11·3)	(8·2)	(7·7)
Predorsal distance ..	25·0	21·0	19·0	8·3	8·0
	(40·0)	(34·4)	(31·7)	(15·1)	(15·1)
Preanal distance ..	51·5	47·5	47·0	27·0	26·0
	(82·4)	(77·9)	(78·3)	(49·1)	(49·1)
Length of head ..	4·2	5·0	5·1	6·0	7·2
	(6·7)	(8·2)	(8·5)	(10·9)	(13·6)
Length of snout ..	1·0	1·3	1·0	1·3	1·2
	(23·8)	(26·0)	(19·6)	(21·7)	(16·7)
Diameter of eye ..	0·9	0·8	0·8	0·7	0·6
	(21·4)	(16·0)	(15·7)	(11·7)	(8·3)
Total myotomes ..	124	124	124	124*	124*
Preanal myotomes ..	97	92	90	64†	58†
Predorsal myotomes ..	42	39	39	15†	12†

* Vertebræ without urostyle. † Vertebræ.

than in *M. macrura* and the values are 40·4% and 30·4% respectively. *M. macrura* also shows marked elongation of the head and snout while this is only moderate in the case of *M. tile*. Unlike the condition found in the metamorphosis of the other leptocephali where the size of the eye remains more or less constant, the metamorphosis of these two murænid leptocephali is peculiar in showing the actual reduction in the size of the eye. The eye becomes smaller in the successive stages in both the species and the smallest eye is seen in the elver. The most noticeable difference in the metamorphosis of the two leptocephali is in regard to the migration of the anus. In the case of *M. macrura* the anterior shifting of the anus takes place rather late during the metamorphosis and is seen in Stage IV only. *M. tile* shows the normal condition where the anal migration, even though seen in the growing stage itself, continues in the successive stages of metamorphosis. The elvers also show differences in the pigmentation which no doubt depends on the adult colouration. In both the species the adult pigmentation is seen to develop in Stage IV and the elver of *M. macrura* is uniformly brownish-black while that of *M. tile* is very light and the pigmentation is confined to the dorsal margin of the body and the lateral lines.

ELVERS

The different elvers of the eels whose metamorphosis is known, show certain characteristic features, which depict to some extent, the condition found in the adult eels. Among the 6 species, the elver of *Uroconger lepturus* is long and measures 88 mm. while that of *Muræna tile* is very short and measures only 53 mm. (Table III). But the latter elver shows the maximum height of 7·7% while it is as low as 3·3% in *Muræsox talabon* the head of which is higher than the body. Even though the different elvers show more or less uniform head length, the snout length shows variations and it measures 30·6% in *Muræsox cinereus* while it is only 14·4% in *Muræna macrura*. The diameter of the eye also shows slight variation and the maximum of 12·0% is seen in *U. lepturus* while the minimum of 7·8% is seen in *M. talabon* and *M. macrura*. The predorsal distance is short in all the elvers and in some it is shorter than the length of the head while the preanal distance in all the elvers is about a third of the length excepting in *M. macrura* and *M. tile* where it forms nearly half the length of the elver.

The elver of *M. macrura* is uniformly brownish-black and that of *M. cinereus* also shows a similar colouration, but the ventral side of the head and abdomen are unpigmented. The elver of *U. lepturus* is uniformly brown in colour with a black border for the vertical fins while those of the other species show only a light colouration.

TABLE III

Measurements of the different elvers

	Muræenesox talabonoides	*Muræenesox talabon*	*Muræenesox cinereus*	*Uroconger lepturus*	*Muræna macrura*	*Muræna tile*
Total length ..	78·5	84·5	62·0	88·0	69·0	53·0
Maximum height ..	3·0 (3·8)	2·8 (3·3)	4·5 (7·3)	3·8 (4·3)	4·5 (6·5)	4·1 (7·7)
Predorsal distance ..	9·3 (11·8)	10·5 (12·4)	8·5 (13·7)	11·5 (13·1)	8·0 (11·6)	8·0 (15·1)
Preanal distance ..	26·5 (33·8)	28·8 (34·1)	21·0 (33·9)	27·5 (31·3)	32·0 (46·4)	26·0 (49·1)
Length of head ..	10·0 (12·7)	11·5 (13·6)	8·5 (13·7)	10·8 (12·3)	9·0 (13·0)	7·2 (13·6)
Length of snout ..	2·5 (25·0)	2·9 (25·2)	2·6 (30·6)	2·8 (25·9)	1·3 (14·4)	1·2 (16·7)
Diameter of eye ..	0·9 (9·0)	0·9 (7·8)	0·9 (10·6)	1·3 (12·0)	0·7 (7·8)	0·6 (8·3)
Preanal vertebræ ..	42	48	43	44	103	58

Schmidt (1912) suggested the broad division of eels into two groups; one which spawns over great depths and produce specialised larvæ with a long alimentary canal and the other which spawns in relatively shallower waters with larvæ possessing short alimentary canal. Bertin (1926) while discussing the anal migration in leptocephali suggested the formula $(a_2 - a_1)/t \times 100$, where 'a_2' and 'a_1' are the preanal myotomes and preanal vertebræ before and after anal migration respectively and 't' the total number of myotomes or vertebræ for the species. Gopinath (1950) applied this formula for the leptocephali described by him for determining the spawning grounds of the adults as suggested by Schmidt and stated that " there are two distinct groups, one with a high percentage amplitude value consisting of *M. cinereus*, *C. anago* and E, and another group with a low percentage value consisting of A, C and F. Probably the first group of *M. cinereus*, *C. anago* and E may belong to eels which spawn far from the coast, while A, C and F might belong to species which spawn in shallow waters". It is not clear how Gopinath managed to calculate the percentage amplitude of the 4 unidentified leptocephali also without a knowledge of the preanal vertebral number of the elver or the adult. The percentage amplitude of anal migration of all

the leptocephali whose metamorphosis has been worked out are given in Table IV. It is seen that the anal migration varies from 8% of the total number of myotomes in *Muræna macrura* to 36% in *Uroconger lepturus* while

TABLE IV

Percentage amplitude of anal migration

Species	Preanal myotomes in lepto-cephalus	Preanal vertebræ in elver	Total myotomes in lepto-cephalus	Percentage amplitude of anal migration
Muræenesox cinereus ..	78	43	138	25
Muræenesox talabonoides ..	92	42	149	34
Muræenesox talabon ..	80	48	150	21
Uroconger lepturus ..	122	44	218	36
Muræna macrura ..	120	103	216	8
Muræna tile ..	97	58	124	31

the others record a fairly high value, which in some is above the value of 26% found in the American eel, *Anguilla rostrata*. Further it may be pointed out that the time taken for metamorphosis of the leptocephali of *Muræenesox cinereus* with a value of 26% and *M. macrura* with a value of 8% is about 10 days under laboratory conditions suggesting that the time taken for the vent to assume the adult position is about the same irrespective of its position in the leptocephali of Indian waters. Therefore, the differences in the percentage amplitude of anal migration are not useful in indicating the breeding grounds of marine eels living under tropical conditions. However, judging from the paucity of eggs, preleptocephaline stages, growing and even toothed leptocephali in the coastal waters, it is considered likely that the breeding grounds of the marine eels of Indian waters are situated away from the coast and the full-grown leptocephali generally enter the foreshore waters in the edentulous condition, where the metamorphosis is completed in a very short time.

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