ON THE LATERAL LINE SENSORY CANAL SYSTEM IN *CYNOGLOSSUS SEMIFASCIATUS* DAY

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Introduction

In the flatfishes of the family Cynoglossidae, the lateral line sensory canals—their presence or absence on either side of the body and the number of the canals when present—are used as a taxonomic character, and the mode of branching and general configuration of the lateral line sensory canal system presents a good deal of variation from species to species (Day, 1878; Norman, 1928 and 1934; Weber and Beaufort, 1929; Munro, 1955; Punpoka, 1964). It is also found that in almost all forms of the family these canals extend onto the different parts of the surface of the head region forming a system of variable degrees of complexity. No detailed descriptions of this canal system are available for the Indian flatfishes. Ochiai (1966) has worked on this system in some detail in the case of eight species of Japanese soles. The present paper gives a description of the lateral line system in the Malabar sole, *Cynoglossus semifasciatus* Day with an account of some abnormalities noticed, with a special reference to certain cases of ambicolouration and albinism.

Description of the Normal Lateral Line Sensory Canal System in *Cynoglossus semifasciatus*

The Malabar sole, *C. semifasciatus* has no lateral line on the blind side. Eight different canals of the sensory canal system are normally observed on the eyed side which is also the coloured side of the body. The nomenclature used here for these canals is based on their positions in the various regions of the body, following Ochiai (*loc. cit.*). These eight canals or lines are as follows: (*a*) the cephalodorsal line, (*b*) the dorsolateral line, (*c*) the supra-orbital line, (*d*) the mediolateral line, (*e*) the supra-orbital commissure, (*f*) the pre-orbital line, (*g*) the pre-opercular line and (*h*) the mandibulo-opercular line. The last mentioned canal is named the mandio-opercular line by Ochiai, but perhaps the term mandibulo-opercular may be more expressive and hence is used here. The anterior part of this canal

would correspond to the mandibular part of the hyomandibular canal of other bony fishes, the pre-opercular line corresponding to the pre-opercular part of that canal.

The mediodorsal line and the dorsolateral lines are the longest, running medially and near the base of the dorsal fin respectively, along the trunk and pre-caudal regions of the body. The mediodorsal line corresponds to the single lateral line present on each side in most bony fishes; it starts from about the middle of the length of the head (there being 10 to 12 scales between its origin and the opercular angle behind), and proceeds backwards usually as a more or less straight line right on to the caudal fin on which also it is continued for some distance as a trace. The dorsolateral line begins at roughly the same level as the mediolateral near the base of the dorsal fin, runs backwards (frequently with a slightly zig-zag course) and bends upwards near the caudal region ending as a trace on the posterior part of the dorsal fin usually between the 2nd and 7th rays from behind. These two canals form the lateral line system of the trunk and are connected anteriorly by a transverse line or canal named the supra-orbital commissure.

The other branches of the system in the head region are situated as follows:—The cephalodorsal line runs forward near the base of the dorsal fin more or less as an anterior continuation of the dorsolateral line, the junction between these two being marked by the junction also with them of the dorsal end of the supra-orbital commissure. There is a slight notch at this junction towards the dorsal fin. The supra-orbital commissure forms the link for the upper and the lower parts of the continuous canal system of both the trunk and the head. Proceeding forwards from a lower extension of the supra-orbital commissure and running above the orbit and below the cephalodorsal line is the supra-orbital line. This extends anteriorly over the snout and frequently curves down along the margin of the snout. There is no infra-orbital or sub-orbital canal. In front of the eyes over the snout to a side is a short curved line of the shape of a reversed *comma*; this is the pre-orbital line. As a rule, the cephalodorsal and supra-orbital lines do not meet anteriorly (the former usually ending a little behind the level of the anterior end of the latter), but occasionally they may unite over the snout and extend further down as a single line in the anterior region for a short distance. For *C. interruptus* of Japan, Ochiai (*loc. cit.*) has figured the pre-orbital line as joining the united canal of the cephalodorsal and supra-orbital lines to be continued further down as a single line. While such an occurrence has not been noticed in the present species, the normal condition of this character in species like *C. dubius* and *C. bilineatus* of our waters

seems to be comparable to *C. interruptus*. The pre-opercular line (in *C. semifasciatus*) is a more prominent vertical canal extending downwards (with a slight angulation along its course) from the posterior junction of the supra-orbital line with the extension of the supra-orbital commissure. Lastly, there is the mandibulo-opercular line which is a horizontal canal arising near the end of the lower jaw laterally, extending upwards and backwards for some distance and again curving downwards and backwards over the opercular region to a variable distance. Usually, this line does not reach the margin of the operculum though that may happen occasionally as an abnormality.

Figure 1 shows the various parts of the lateral line sensory canal system in a normal adult specimen of *C. semifasciatus*.

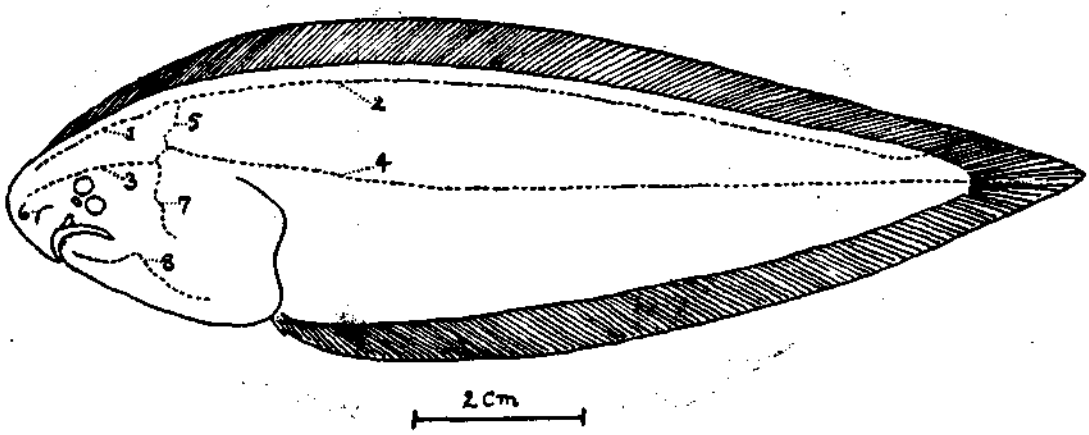

FIG. 1. The normal arrangement of different canals in the lateral line sensory canal system of *C. semifasciatus* (12·8 cm total length; Calicut. 28-10-1966). (Semi-diagrammatic drawing.)

Explanation of numbers and lettering : A—Albinoid or White area; D—Dorsal fin; L—Lateral line sensory canal; P—Pigmented area; V—Ventral fin; 1—Cephalodorsal canal; 2—Dorsolateral canal; 3—Supra-orbital canal; 4—Mediodorsal canal; 5—Supra-orbital commissure; 6—Pre-orbital canal; 7—Pre-opercular canal; 8—Mandibulo-opercular canal.

COMMON ABNORMALITIES NOTICED

The following main categories of abnormalities have been noticed in the lateral line system of *C. semifasciatus* at Calicut:

(1) *The occurrence of a break in the course of a line, and the re-growth or extension of the broken ends in different directions.*—Usually, this affects one of the longitudinal lines. Fig. 2 represents a case where the mediolateral line is divided into two parts at about the level of the opercular angle, and

the broken end of the anterior part extends upward in a curve, that of the posterior part extending downwards and backwards along the opercular margin after a double bend over the opercular angle. There are other abnormalities also in this case as stated below. Fig. 5 shows a case where a cut is noticed in the dorsolateral line in an almost corresponding

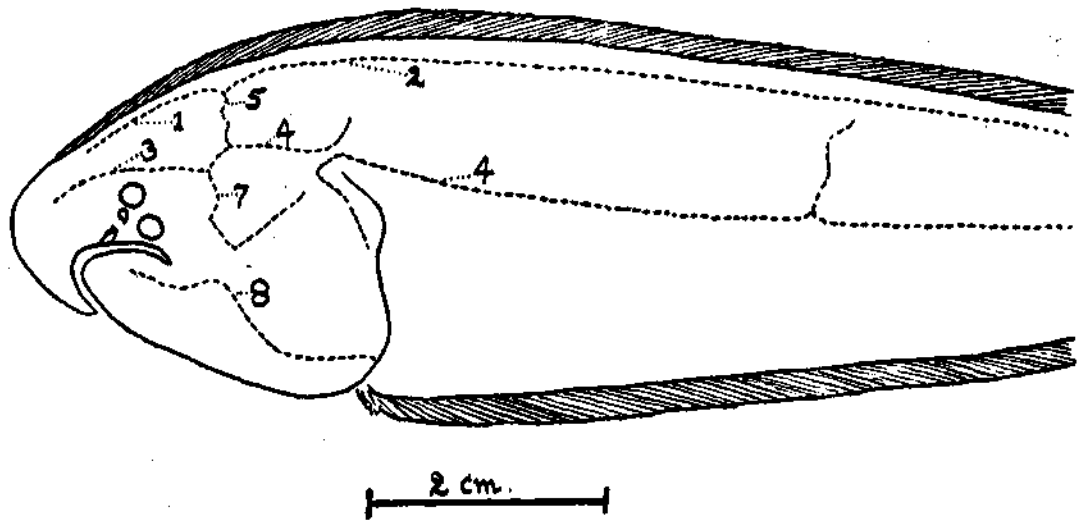

FIG. 2. Abnormality in the lateral line sensory canal system of *C. semifasciatus*.

position, the broken end of the anterior part growing upwards and backwards in a curve, while the cut end of the posterior part has grown downward and forward, also in a curve. Such breaks in the course of the canals can occur in any region and the extension of the broken ends may be in any direction. Discontinuities may also occur in the course of any of the canals without any extension of the broken ends in any direction. In the specimen represented in Fig. 6, the supra-orbital line has developed a discontinuity behind the region of the eye, the posterior part remaining normal in position while the broken end of the anterior part has extended backwards along and above its counterpart in an unusual course towards the supra-orbital commissure.

(2) *Extension of canals and growth of offshoots.*—By far the most frequent abnormality is the extension of one or more lines beyond the usual position. Growth of offshoots may also occur independently or combined with the extension of lines or any other abnormality. Fig. 2 shows the case of a transverse upward offshoot from the mediolateral line; it is also noticed in this case that the mandibulo-opercular line has extended up to the edge

of the operculum posteroventrally; the pre-opercular line has a straight extension upwards and backwards from its normal lower end. Extensions and offshoots can vary a great deal in length as well as in shape and combinations of these and other abnormalities may result in the formation of circles, triangles and other peculiar shapes in the composition of the network. Parts of canals may sometimes present a doubled appearance due to the mode of occurrence of an offshoot. Fig. 5 shows the cephalodorsal line ending in a hooklike formation anteriorly. Fig. 3 represents a specimen where the pre-opercular canal as well as the mandibulo-opercular canal have grown much beyond their normal positions, the former joining the latter while the latter reaches the opercular margin; in addition, the mandibulo-opercular line has developed a straight offshoot starting at about a third of its length from its anterior end, and proceeding downwards and backwards. Fig. 4 shows a case where an extra-link connecting the supra-orbital and pre-opercular lines encloses a triangular space between itself and the other two lines. Such formations are quite frequent.

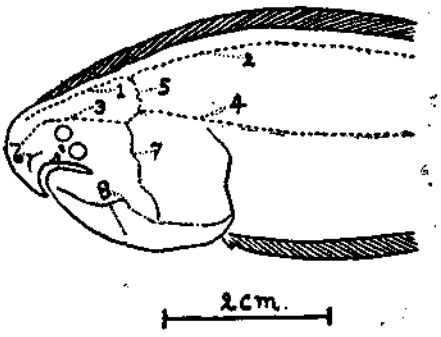

FIG. 3

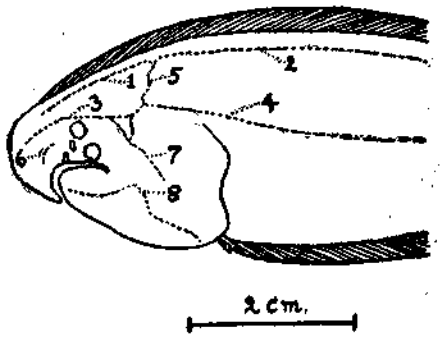

FIG. 4

FIG. 3. Abnormality in the lateral line sensory canal system of *C. semifasciatus* (15·0 cm total length; Calicut. 16–9–66. (Semi-diagrammatic drawing.)

FIG. 4. Abnormality in the lateral line canal system of *C. semifasciatus* (13·6 cm total length; Calicut. 16–9–1966). (Semi-diagrammatic drawing.)

(3) *Absence of the pre-orbital line and the shortening of the cephalo-dorsal and the supra-orbital lines.*—Included in this category are also cases where parts of a line may be missing due to injuries or other reasons. The cephalo-dorsal and supra-orbital lines are frequently shortened anteriorly (and similarly the mandibulo-opercular line at both ends) in small juveniles, the full system of canals being however often well formed at a size of around 4–5 cm (total length). The pre-orbital line is frequently absent with no apparent significance. While usually the cephal-odorsal and supra-orbital canals do not meet anteriorly, the former stopping short of the latter, quite frequently they

do meet as already stated, and may be produced into a single canal further down for a short distance. Figs. 2, 5, 6 and 7 show the absence of the preorbital line. Cases of albinism and ambicolouration are considered in the next section.

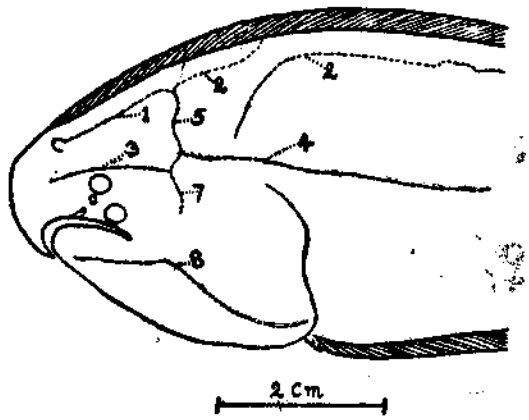

FIG. 5

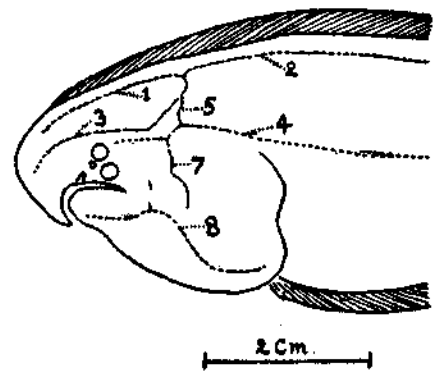

FIG 6

FIG. 5. Abnormality in the lateral line sensory canal system of *C. semifasciatus* (11·1 cm total length; Calicut. 14–10–1966). (Semi-diagrammatic drawing.)

FIG. 6. Abnormality in the lateral line sensory canal system of *C. semifasciatus* (11·7 cm total length; Calicut. 26–8–1966). (Semi-diagrammatic drawing.)

THE LATERAL LINE SYSTEM IN "AMBICOLOURED" "ALBINOID" AND "STAINED" SPECIMENS

Particularly interesting in the study of the lateral line canal system in *C. semifasciatus* has been the mode of occurrence and distribution of these canals in certain ambicoloured and albinoid specimens. Complete ambicolouration and albinism appear to be very rare in this species but partial ambicolouration and albinism of various degrees and various combinations of these have occasionally been noticed. Observations of such instances indicate that in this species, the development of ambicolouration or albinism seems to be associated with an extra development of the lateral line sensory canal system or its disappearance respectively. The illustration in Fig. 7 is a case where the eyed side has developed no pigment over most of the body (partial albinism) and there is no lateral line in this albinoid portion of the body; but the posterior part of the body has a normal pigmented area where the two lateral lines of the trunk, namely, the mediolateral and the dorsolateral lines are developed in their usual positions; the head is pigmented incompletely and here also the branches of the lateral line system are reduced to three isolated short canals in place of the usual arrangement. In

another specimen illustrated in Fig. 8, the blind side has developed a normal colour pattern (characteristic of the eyed side) in the posterior region and lateral lines are developed only in this part and not over the rest of the body of that side; the canal corresponding to the dorsolateral line is following a

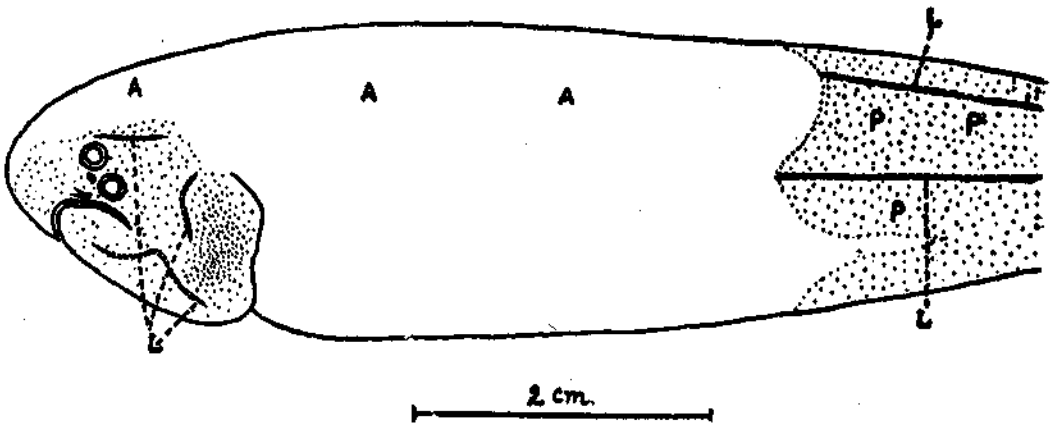

FIG. 7. Abnormal lateral line system of the eye side in a partially albinoid specimen of *C. semifasciatus* (9·9 cm total length; Calicut. 4–1–1963). (Semi-diagrammatic drawing.)

normal course but the mediolateral line bends around a white patch and ends abruptly after a short distance beyond the bend; it is as if the white patches

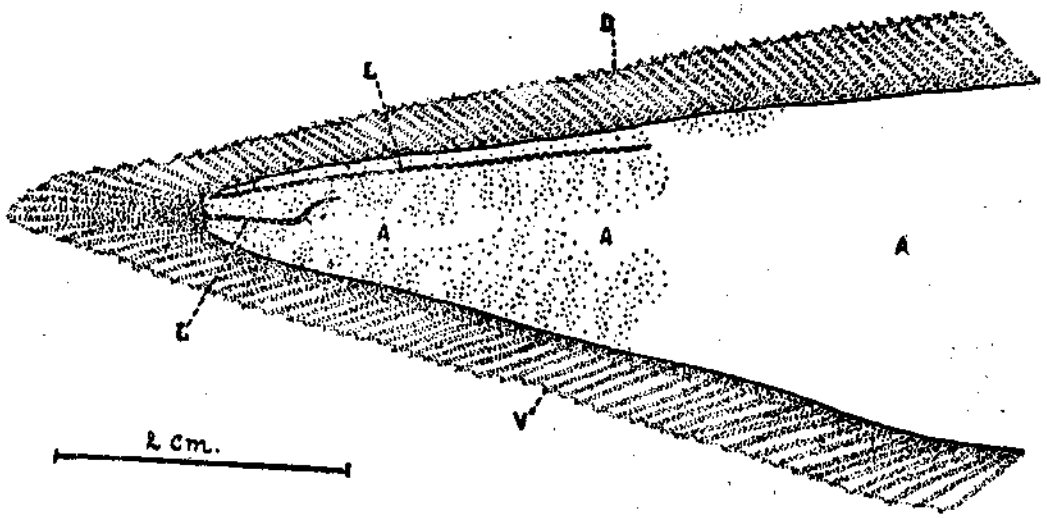

FIG. 8. Abnormal lateral line system of the blind side in a partially ambicoloured specimen of *C. semifasciatus* (11·9 cm total length; Calicut. 6–9–1965). (Semi-diagrammatic drawing.)

interrupting the pigmentation in this region of the body have interfered with the normal course of the mediolateral line in this specimen. Individuals have also been noticed where the posterior part of the eyed side has lost the pigment or is albinoid, this being associated with one or both of the above canals becoming faint if they do not completely disappear. In cases of slight whitening or mere "staining" (Norman, 1934) no disappearance or extra-formation respectively of the lateral line canals is usually noticed.

Discussion and Conclusions

The present view regarding the function of the lateral line sensory canal in fishes is that it is a 'mechano-receptor' or mechanical sense organ (Jenkins, 1936; Ommaney, 1965), or a 'distant-touch receptor' (Norman, 1963; Lagler, Bardach and Miller, 1962). Raj (1958) did some work on the mode of functioning of the lateral line system as a mechano-receptor organ in the cat-fish *Macrones seenghala*. After a brief discussion about the function of this system in fishes, Lagler, Bardach and Miller (*loc. cit.*) conclude that the lateral line system may inform the fish of localized disturbances caused by small currents, by mechanical vibrations below 100 cps, or by irregular non-violent displacement of the surrounding water; "the system is also involved in 'distant touch' location of moving objects such as predators or prey or in the sensing of fixed objects which reflect the water movements brought about by the moving fish itself." Very recently Ochiai (*loc. cit.*) seems to have done some detailed work on the lateral line sensory canal system and also the related nervous system in eight species of Japanese soles.

All flat-fishes are known to be generally demersal in habit but some of them have no lateral line canals on the blind side while some others do have them on that side also. Whether this variation within the group has anything to do with any possible variation in the nature and degree of demersal living is not clear, but Kyle (1923, p. 116), while discussing the metamorphosis of certain flat-fishes, states thus: "that these fishes swim on the side after metamorphosis has nothing to do with the demersal habit as such; it is due to lack of proper balance.....the lateral line system of the blind side is relatively weakened, sometimes totally destroyed by the changes in the head region. The fish swims and lies on its side because it must, not because it has learned to do so."

From the account given in the previous sections it is clear that *C. semifasciatus* has an elaborate system of sensory canals on the surface of

the body and obviously the function of these canals would be the same as in other fishes. A noticeable feature in this species is the occurrence of abnormalities in this canal system which may show various forms of loops, curves, branches, etc., in different parts of the body. No plausible explanation could be given for this occurrence. It is likely that most of the abnormalities except those caused by injuries, etc., may be of the nature of fortuitous variations only. No particular correlation of the degree of pigmentation and the development of extra branches could be traced in these cases of abnormalities, though in normal specimens, the impression one gets after the examination of a large number of specimens is that the canals tend to be marked very well in the strongly pigmented ones.

But of particular interest are the cases of partial ambicolouration and albinism. These instances seem to indicate that the development of normal pigmentation on the blind side and the loss of the same on the eyed side cause the development of an extra portion of the sensory canal system or the disappearance of part of the existing one respectively. The author has not come across any references in the literature regarding the influence of the pigmentation over the degree of development or the presence or absence of sensory canals in the flat-fishes, though there are many references to ambicolouration and albinism (*see* Norman, 1934). The only flat-fish in which ambicolouration has been described from India in detail so far is *Brachirus pan* (Hamilton) (Jones and Menon, 1950; Pradhan and Pradhan, 1962). This is a case where a lateral line canal would be present on both sides of the body even normally, and the ambicoloured specimen also has apparently a normal lateral line system on both sides. Norman (1934, p. 26) states that where ambicolouration is partial no other variations in the structure of the fish are noticeable, but that cases of complete ambicolouration are nearly always associated with other variations in the line of asymmetry, these variations being associated with the scales also. He states: "Examples of Lemon sole and Dab sole have been described in which the blind side was nearly entirely pigmented, but the fish were said to be normal in other respects. It is possible that closer examination would have revealed at least minor modifications of the scales, etc."*

C. semifasciatus is therefore probably a rare case where even partial ambicolouration and partial albinism are associated with other changes.

* Two more cases of ambicolouration [in *Bothus ovalis* (Regan) and *Cynoglossus lida* (Bleeker)]. have very recently been recorded from India [J. E. Sivaprakasam, *JBNHS*, 63 (3), pp. 758–759, 1966] but have not thrown any light on the lateral line question.

While various theories have been forwarded to explain ambicolouration, it would appear that none of these has yet been found satisfactory. Norman feels that on the evidence of available data, ambicolouration perhaps merely represents variation in the direction of the originally bilaterally symmetrical condition of the ancestors of the flat-fishes. The mode of occurrence of the lateral line system in the partially ambicoloured and albinoid specimens would perhaps indicate a functional relationship between the two factors, any increase in the normally pigmented area often meaning an increase in the total sensory surface of the canal system also, this naturally resulting in an increased ability in the fish for the performance of the concerned function How the increase in the sensory area caused by the various abnormalities described above would affect the fish remains an open question as no correlation between the degree of pigmentation and the increase of the sensory area can be postulated in these cases. It is quite possible that all these variations including those of partial ambicolouration and albinism are only results of aberrations in genetic factors.

The specimens used in the various illustrations in this paper (eight in all) are preserved in the reference collections of the Central Marine Fisheries Research Institute in the Headquarters Museum at Mandapam.

Summary

This paper gives an illustrated description of the normal lateral line sensory canal system in *Cynoglossus semifasciatus* Day, and also of certain abnormalities noticed in the species, with a special reference to certain cases of partial ambicolouration and albinism.

Eight sensory canals are noticed in the species. These are: the cephalo-dorsal, the dorsolateral, the supra-orbital, the mediodorsal, the pre-orbital, the pre-opercular and the mandibulo-opercular lines and the supra-orbital commissure.

The main abnormalities that were noticed related to: (1) the occurrence of breaks in the course of the canals with or without the extension of the broken ends, (2) growth of offshoots, extension of canals beyond their usual end limits and various combinations of these, (3) absence of the pre-orbital line and the shortening of the cephalo-dorsal and the supra-orbital lines.

Where the normal colour pattern of the eyed side was developed on the blind side, the sensory canal system was also found developed in the pigmented area, the extent of the system being limited to that of the pigmented area

itself (in the region of the normal location of the mediodorsal and the dorsolateral lines). In specimens with partial albinism the albinoid areas showed a tendency to have either ill-developed or no sensory canals. "Stained" individuals showed no modifications in the lateral line system.

It is suggested that all these abnormalities including the cases of partial ambicolouration and albinism may only be the results of aberrations of genetic factors.

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* Not consulted in full.