AGE DETERMINATION STUDIES IN FISHES BY MEANS OF SCALES WITH SPECIAL REFERENCE TO THE MALABAR SOLE*

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ONE of the outstanding achievements of fishery research during the last half-a-century has been the discovery and application of the method of analysis of the age composition of fish stocks based on the study of growth marks on scales, otoliths and in a few instances vertebræ or other bones. The scales are the most widely used for the purpose and the clue to the age of the fish as given by them is a zonation in their structure, there being 'winter' zones of limited or no growth alternating with 'summer' zones of normal growth and the former standing out as distinct growth rings. In general, while the scales of fishes in the temperate countries present a well marked zonation of this type, those of the tropical fishes seem to lack such distinct markings. In the temperate countries the scale method of age-determination has been used extensively in the case of a large number of species of food fishes.

In India, while work on the age-determination of fishes has been extremely limited, the work that has been done so far on *Hilsa ilisha* and *Sardinella longiceps* have given discouraging results. While some growth rings are known to occur in these two species, there is wide divergence of opinion regarding their exact significance and consequently it has not been possible to utilize them for age-determination. In *S. longiceps*, Hornell and Nayudu[1] have observed not more than two rings and mention that the period of arrested growth coincides with the period of plankton scarcity from January to April. Devanesan[2] reports many more than two rings and says, "an interpretation of them is beset with difficulties owing to want of collateral researches like marking experiments". But Nair[3] records three growth rings in the otoliths of this species and considers that the average life span of the oil sardine is about three years. In the case of *H. ilisha*, Hora and Nair[4] assume the annual nature of the rings and suggest that *Hilsa* has a life-span of 5 to 7 years. But Prashad, Hora and Nair[5] report as many as 8 rings and say, "though with the information available at present it is not possible to interpret the exact significance of the scale rings of *Hilsa*, we believe that they are formed not at regular intervals but whenever the conditions of life become unfavourable". Chacko and Krishnamurthi[6] suggest that the growth rings of *Hilsa* indicate the number of times the fish has spawned. Chacko, Zobairi and Krishnamurthi[7] and Sundara Raj[8] suggest that the transverse radii (and not the growth rings) give an indication of the age of the fish. Jones and Menon[9] state that though the number of these radii increases with the size of the scale and the length of the fish it is difficult to draw a correct relationship between the radii and the age of the fish. They are also unable to interpret the exact significance of the growth rings. Writing about these growth rings, Sundara Raj[10] states, "These growth rings on *Hilsa* are too numerous to be considered annual growth rings or 'annuli'. Consequently they cannot in the present state of our knowledge provide any evidence of age or rate of growth and must be discarded. This seems to be true also of other tropical fish. Thus to the fishery investigator in India this important clue to the age and rate of growth of fish is denied".

Under these circumstances it is considered worthwhile to report certain of our observations on the Malabar sole, *Cynoglossus semifasciatus* Day, made during the course of our studies on the biology of this species. *C. semifasciatus* is one of the top-ranking food fishes of the Malabar coast. We have noticed in the scales of this species, the occurrence of certain distinct annuli which appear to be formed regularly every year under the influence of the South-West monsoon and which can be used in age-determination and thus in the assessment of the year-class composition of the fishery. These annuli were first noticed in the latter part of 1949 in the scales of the larger individuals in the fishery and have since then been studied in detail. They resemble the annuli described for several flat fishes such as *Lophopsetta aquosa*,[11] *Platichthys stellatus*,[12] *Citharichthys sordidus*[13] and *Pleuronectes microcephalus*[14] and are distinct from the rest of the scale by the following features: (i) the narrowing of the sclerites and the closing up of the intervals between successive sclerites, (ii) the sclerites, wavy and broken up elsewhere, becoming continuous and nearly straight from radius to radius, (iii) an increaese in the number of

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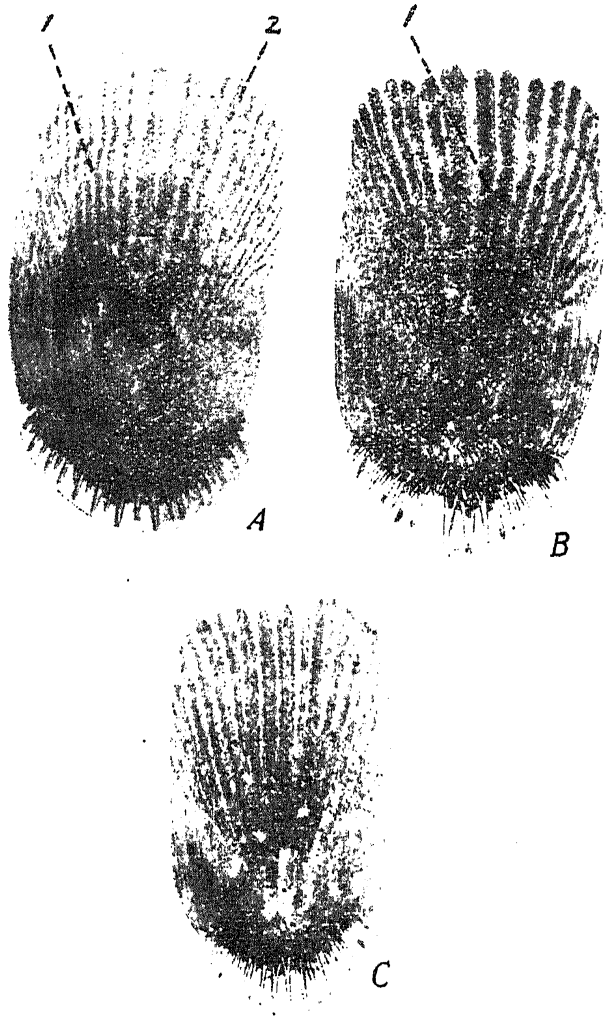
radii outward of the annulus, the new radii commencing just near the annulus, and (iv) the portions of the radii outward of the annulus being frequently not in a straight line with the portions inward of it, but inclined at an angle or even disconnected at the annulus. Photomicrographs A, B and C show scales of *C. semifasciatus* with two, one and no annuli respectively. Scales with more than two annuli have not been noticed so far. Several otoliths have also been examined but no rings have been noticed in them.



Photomicrographs of Scales of *Cynoglossus semifasciatus*.
A. Scale showing two annuli. ×10. (Female, total length 15·5 cm. ovary in stage V, captured on 17th January 1951). *B*. Scale showing one annulus. × 10. (Female, total length 15·6 cm., ovary in stage V, captured on 9th May 1951), *C*. Scale showing no annuli. ×10. (Female, total length 11. cm., ovary in stage III, captured on 9th May 1951).

The breeding season in the case of the Malabar sole is spread over a long period, starting from about October and continuing up to about May of the following year. There is thus a very short break in the recruitment of young ones to the fishery and except during the earlier months of the breeding season when the new recruits remain quite distinct from the members of the older generations, it is difficult to recognize the different age-groups by means of a length frequency curve as the modes in the latter do not stand out clearly. During the year 1950-51 however, it was possible to watch carefully the stock of the preceding pre-monsoon period during its passage through the fishery, by a study of periodical random samples taken during different months of the year. The following table summarizes the data relating to the occurrence of growth rings in random samples of this stock during the period September, 1950, to December, 1950.

As is evident from this table, the rings appeared gradually at the margins of the scales and growth occurred subsequently outside the rings. While the majority of the individuals examined in September had already developed the annuli by then, in others the appearance of the annuli was noticed only a little later. But in November out of 248 individuals, only two were without rings and of the others only two had 'closed' (that is, still not growing) margins. In December and subsequent months all individuals of the previous pre-monsoon generation without exception, revealed the presence of rings and 'open' (that is, growing) margins. Large numbers of individuals of the new post-monsoon generation (which were widely distinct from the rest until February) were also examined and found to have no annuli at all. No rings were found on the scales of the new recruits during the year 1949-50 also, and no 'closed' margin phase occurred in individuals of any size before the monsoon season.

The growth rings occurring in the scales of fishes in the temperate countries are indicative of seasonal differences in growth and are obviously related to the regularly occurring seasonal

TABLE I

		September	October	November	December
1	Total number examined ..	405	81	248	102
2	Number with no rings ..	45	16	2	0
3	Number with one ring and 'closed' margin	178+23 (not clear)	9+2 (not clear)	0+2 (not clear)	0
4	Number with one ring and 'open' margin	124+15 (,,)	46+1 (,,)	234	95
5	Number with two rings and 'closed' margin	12+4 (,,)	1	0	0
6	Number with two rings and 'open' margin	1+3 (,,)	6	8+2 (not clear)	7

differences in the environmental factors. The general lack of growth rings in the scales of the tropical fishes as well as the indistinctness of and the difficulty in the interpretation of such marks of growth check as do occur in some of the species must be mainly due to the fact that the seasonal differences in the tropical countries are neither similar to nor so well marked as in the temperate countries. There is some evidence to show that the growth rate of fishes suffers a decrease and rings tend to be formed in the scales whenever environmental conditions such as for instance, food and temperature, are unfavourable.[15,16] In some Indo-Chinese species of fishes Chevey[17] has noticed growth rings in the northern but not in the southern region and he attributes this to temperature differences between the two areas; he also records[18] some exceptional species from Cochinchina in which the growth rings are found and considers that the rings are caused by the rhythmical occurrence of favourable and unfavourable conditions of nourishment in the environment. The usefulness of the rings found in the scales of any fish for age-reading would therefore depend upon the frequency and the cyclical regularity with which conditions unfavourable to the growth of the species occur in its environment.

Along the Malabar coast, the environmental conditions in the inshore sea during the monsoon months (June to August), are quite distinct from those during other months of the year, and are characterised by a sharp fall in salinity and temperature, a high turbidity and turbulence and above all by the sea bottom becoming severely depleted of the organisms which form the chief food of *Cynoglossus*. The last point has been brought out clearly by our studies of the feeding habits of the Malabar sole and by the study of the bottom fauna near Calicut by one of us (G. S.). The change in the environmental conditions seems to occur regularly every year more or less during the same period and thus the events are regularly cyclical. It seems reasonable under these circumstances to conclude that the annuli mentioned above are annual rings formed under the influence of the South-West monsoon season and it would be appropriate to name them *monsoon rings*. The main factor causing the formation of these rings appears to be the lack of food leading to starvation. They are not spawning marks because even individuals that have clearly not yet reached the first spawning stage show them, provided they do not belong to the current year's brood.

Our studies of the scale rings of *C. semifasciatus* indicate that no individuals of this species which have survived more than two monsoon seasons occur in this area and that fish which have passed through two monsoon seasons themselves form a very insignificant part in the fishery. These studies also indicate that during the 1949-50 and 1950–51 fishery seasons the great majority of the soles contributing to the fishery were the direct result of previous season's spawning, the catches of the peak period (September-November) being traceable to the stock of post-larvæ and young soles occurring in the area during the months preceding the monsoon. Whenever the fishery extends beyond the usual season, that is, into the pre-monsoon months of the next calendar year, the bulk of the catches of these later months is likely to consist of recruits of the same season. While it is yet too early to reach any far-reaching conclusions as to the application of these results, a systematic collection of data for some more years should prove to be of considerable value in evolving suitable methods for the management of this important fishery.

It is suggested that annuli similar to those seen in *C. semifasciatus* are likely to occur in other species of the area, especially if they are mainly dependent on the bottom fauna for food. It also seems reasonable to assume that a search for annual scale rings would be worthwhile, even in the tropical countries, wherever the environmental conditions differ markedly and regularly between one part of the year and another.

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