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Age Determination in Tropical Fish

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stract

his essay, translated and edited by D. Pauly from an article published 921 (*Altersbestimmung bei Tropischen Fischen*. Zoologischer Anzeiger 7-95), presents evidence that check marks on the hard parts of tropical s can be used for aging these, in spite of the small seasonal temperature other environmental oscillations prevailing in the tropics. The ideas ented in this article were over 50 years ahead of their time.

roduction

n modern fisheries research, aging of fishes is considered very important because it has been realized that a knowledge of age and growth rate of fishes is of great importance for many practical and scientific questions. Through age determinations, we have the means to ntify the age composition of a fish population, and it can determined to which degree the various age classes are ized by the fishery. Only an exact knowledge of the age of the fish allows inferences on the appropriateness of or the need for management measures such as closed seasons or minimum sizes. Only by comparing the annual growth of aged fish from different water bodies will the environmental (biotic and trophic) conditions be identified which are optimal for a given species.

Nowadays, various hard parts of the body of fish are used for aging. They can be used for this purpose because they show structures which are similar to the growth rings of trees which increase every year in a steady fashion and thus indicate age. Undoubtedly, rings are found on all hard parts of the body of fish, but they cannot all be seen with the same clarity. Scales, otoliths, vertebrae and opercula are used most often for age determination. Different hard parts are most appropriate for aging different species of fish. Thus, in haddock (*Melanogrammus aeglefinus*), age determination is best based on cleithra and vertebrae, in cod (*Gadus morhua*) on cleithra and in herring (*Clupea harengus*) on vertebrae. In sole (*Solea solea*), on the other hand, bone structures cannot be used. With otoliths as well as with other bones, it is often necessary to prepare thin slices, which are then very easy to interpret.

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Applying different methods on the same species and comparing their results increase the reliability of age determination. So we can compare, e.g., for plaice (*Pleuronectes platessa*), the results obtained from otoliths with those obtained from vertebrae. For herring, one can compare the result obtained from scales and vertebrae, while for tongue sole, one can compare results from scales and otoliths.

It has been shown long ago that the concentric rings in the hard parts of fish can be interpreted as annuli; this has been demonstrated through growth experiments in aquaria as well as through marking of wild fish. Explanations for the annual nature of these rings have been provided long ago and generally accepted - if only because of lack of contrary evidence. It was assumed that during the cool period the life functions of most fish decrease to a minimum and that, therefore, growth is also reduced. It was also assumed that annual fluctuations of metabolic level and of water temperature were the major factors explaining the occurrence of annuli. It is difficult to see what could be wrong with this interpretation, since in our temperate areas, these two factors do indeed vary together, and thus strongly suggest a causal link. In any case, all life processes which are important to fishes have an annual periodicity, as for example spawning and feeding. From these observations on the fishes of our temperate areas, it is easy to conclude that annual rings are caused by seasonal temperature variations. This led to the suggestion and later to the dogma that the scales of tropical fish should have no annuli. Evidence to the contrary is due to a superficial similarity. Nothing was stated, however, on possible reasons of this similarity.

To learn more on the possibility of age determination on tropical fishes, I have investigated a number of specimens of various size groups, from the fish collection in the Hamburg Zoological Museum. All these fishes could be aged. It is a pity that this investigation could not be performed right away with commercially important fish - our collection obviously does not have many large fishes and only small samples were available from any single place. All specimens discussed below were collected and preserved by Dr. Georg Duncker of the Zoological Museum, Hamburg.

Results

These specimens represent seven species one of which was sampled in marine water, the others in freshwater. Most interesting was the sample of *Rasbora vulgaris* (Table 1). The borders of the annuli on the scales are the same as in our local cyprinids: a clear line which does not necessarily follow the elementary rings [?]. Table 2 summarizes our age reading on another Malayan *Rasbora* species - unfortunately the sample was small.

Table 3 summarizes our data on a third *Rasbora* species; the sample led to the same interpretation as for *R. vulgaris*, although there is, in southwestern [Sri Lanka], a clear change from dry to rainy season while in [Peninsular Malaysia], temperature and climate do not vary much.

Table 4 presents our largest sample, on *Trichopodus trichopterus*, while Table 5 presents the available data on *Barilius guttatus*.

In [Papua New Guinea], both fresh and marine fishes have been studied. Table 6 summarizes the data on *Ambassis commersonii*, while Table 7 summarizes the data on *Polynemus indicus*.

Discussion

The seven cases presented above, covering a wide variety of habitats, are sufficient to demonstrate that it is possible to age tropical fishes. Cycloid and ctenoid scales have been used for fishes from marine and freshwater, and from countries with strong seasonal changes of rainfall, as well as from countries with constant temperature and rainfall. These examples demonstrate that it is neither the alternance of seasons nor seasonal changes of temperature which caused the observed annuli. On the other hand, various observations show that when strong seasonal changes occur, the life functions of animals tend to follow these. This is not only true for fishes

Table 1. Length-age data of *Rasbora vulgaris* Dunker.[a]

Length (cm)	Age (years) 1	2	3
2	3	-	-
3	4	7	-
4	-	19	-
5	-	4	2
6		4	-
7		-	1
8		-	1
Means	2.57	4.15	6.80
s.e	0 11	0.07	0.69

[a]Sampled in a puddle near Kuala Lumpur [Malaysia], on 18 March 1901

Table 2. Length-at-age data of *Rasbora elegans* Volz.[a]

Length (cm)	Age (years) 1	2	3	4
1	9	-	-	-
2	3	-	-	-
5	-	1	-	-
8	-	-	1	-
10	-	-	-	1
Means	1.25	5	8	10
s.e.	0.06	-	-	-

[a]Sampled in a jungle brook of [Peninsular Malaysia], on February 1902.

Table 3. Length-at-age of *Rasbora daniconius* (Ham. Buch.).[a]

Length (cm)	Age (years) 2	3
4	1	
5	2	
8	-	2
Means	4.67	
s.e.	0.30	-

[a]Sampled in the Vakvella [River?], southwestern [Sri Lanka], from 7 to 9 August 1909.

Table 4. Length-at-age data of *Trichopodus trichopterus* Pall.[a]

Length (cm)	Age (years) 1	2	3
1	1	-	-
2	16	-	-
3	43	-	-
4	27	-	-
5	1	3	-
6	-	6	-
7	-	9	-
8	-	15	2
9	-	-	6
Means	3 13	7.09	8.75
s.e.	0.04	0.08	0.11

[a]Sampled in a pond near Kuala Lumpur [Malaysia], on 18-19 March 1901.

…e 5 Length-at-age data of *Barilius guttatus*

Length (cm)	Age (years) 1	2	3	4	5
2	2	-	-	-	-
3	11	-	-	-	-
4	15	-	-	-	-
5	1	-	-	-	-
8	-	1	-	-	-
13	-	-	1	-	-
19	-	-	-	1	-
21	-	-	-	-	1
Means	3.51	8	13	19	21
s.e.	0.08	-	-	-	-

…pled in the Pahang River [Peninsular Malaysia], …6 t… 4 June 1901.

Table 6. Length-at-age data of *Ambassis commersonii* C.V.[a]

Length (cm)	Age (years) 1	2	3	4
3	4	-	-	-
4	5	2	-	-
5	1	7	-	-
6	-	3	3	-
7	-	-	14	2
8	-	-	9	3
9	-	-	2	1
Means	3.70	5.08	7.36	7.83
s.e.	0.16	0.12	0.08	0.26

[a]Sampled in freshwater, i.e., in the mouth of a river opening in Jacquinot Bay [Papua New Guinea], on 19-20 December 1908.

Table 7. Length-at-age data of *Polynemus indicus* Shaw.[a]

Length (cm)	Age (years) 1	2	3
6	4	-	-
8	-	2	-
9	-	4	-
10	-	4	-
19	-	-	1
Means	6	9.2	19
s.e.	-	0.15	-

[a]Sampled in Rein Bay [Papua New Guinea], on 26 April 1909.

…also in much stronger fashion for terrestrial animals. So …example, young hippopotami are born in very different …es of the year depending on where in Africa the optimal …son occurs. This is also the case with all other animals. …wever, temperature itself can have an important effect; …is demonstrated by Budgett (in Brehm's *Animal Life*) with …ard to the spawning behavior of *Polypterus* in aquaria. …ese fishes, which stem from Africa, can be made to spawn …increasing the water temperature above 20°C.

…Some tropical animals, especially those from areas with …ong seasonal cycles, follow the seasonality of their original …bitats even after they are transferred to another area. Thus …example, transplanted Indian deer (*Axis axis* Erxl.) have …ir young at a season which is not optimal in our latitudes. …is has led to a failure to introduce this animal into Germany …he young are born in winter, during a period that is so …from the optimum that they simply die. This deer is an …imal which in its original habitat lives in large herds; but …ring the reproductive season the males fight against each …her. This they can do only when their antlers are fully …own; this is probably the reason why these deers have been …able to adjust their reproductive season in our climate. On …e other hand, a close relative of this deer (*Axis alfredi* Scl.) …haves very differently. According to information from Mr. …eck from the Berlin Zoological Garden, the female *A. alfredi* …imals are always ready for mating. In the [Philippines] …here this species originate, there are no marked seasons …d therefore there is no need for a distinct reproductive …ason either.

…This deer lives only in small groups, sometime in pairs. …he males, having no competition, do not need to fight other …ales and thus do not run the risk of damaging their antlers. …formation of optimal reproductive period is rare, however, …d usually not as reliable as needed for clear inferences in …e biology of the animals concerned. However, where such …formation is available, they can be often interpreted in a …anner different from that intended by the person who …ported it. I have searched for a long time for information …the spawning seasons of tropical fishes, particularly with …gard to the question whether spawning is limited to certain …onths, but have not found much that could be used. What little could be found (for example that young immature fish tend to swim in schools even when the adults do not school) argues indeed for the annual occurrence of regular spawning periods.

A.H. Pertwee[b], based on observation of spawning in *Lates calcarifer*, suggested that some fishes may alter their spawning season from year to year. He did not consider, however, that a spawning season may last several months. In fact, the feature that the spawning season of freshwater fishes is not limited to one month does not even argue against the idea of an annual periodicity. Our fishes in temperate water also spawn over different months, yet spawning still occurs at annual intervals. Fishes which display parental care do not appear to have well-defined spawning seasons. An example from the tropics is given by *Ophiocephalus striatus* of which reliable persons (Willey; Duncker) report that small fishes of all stages of development may be found at any time of the year. This could be due to the fact that animals with parental care generate, for their young, conditions which resemble those under which domesticated animals live - something which could be described as "self-domestication".

Since the assumption must be rejected that annuli can be formed only by changes of seasons and/or temperature, the question is "what is the actual cause?". Finding an answer to this is quite difficult.

One thought which immediately comes to mind is to consider the rings in question to be spawning checks. Salmonid scales for example, are true receptories of information and one can tell the entire life history of a salmonid from its scales. Thus, the closely packed sclerites of the central zone of Atlantic salmon recall its freshwater phase, and indicate whether this lasted one or several years. Then, there is a deposition of sclerites at wider intervals, suggesting migration, which may reoccur at annual intervals. Indeed, spawning leaves such clear marks on scales that these can be identified even by untrained observers. When a salmon survives its first spawning (which is not necessarily the rule), the next spawning ring can be identified. Spawning occurs at one year of age only in a few temperate species of fish. Since the first annual

[b]Pertwee, A.H. 1913. Notes on the freshwater fishes of Ceylon. Spolia Zeylandica 8, Colombo.

ring is already formed at the end of the first year, this ring obviously cannot be a spawning ring. It could perhaps be argued that the sexual excitation of the spawning fish is somehow communicated to the younger fishes. However, the immature fishes form distinct schools which do not mingle with spawning schools. Also, when a young fish can be found near or in a spawning school, it is abnormally advanced, and already able to join in spawning activities.

Other hypotheses brought forward to explain the occurrence of annual rings can be refuted in similar fashion such that only negative evidence can be presented here with regard to this problem. However, even if the [occurrence] of annual growth rings in tropical fishes cannot be explained scientifically, it will still be useful to know that the available methods to investigate fish in our temperate waters can be applied in the tropics, especially in view of the fact that there seems to be an interest in developing fisheries in [Northern] Australia and [Indonesia].