

EDITORIAL

This issue of *Fishbyte-in-Naga* presents a 70-year-old gem I found buried in an obscure German journal, and which anticipates the present renewal of interest in seasonal marking on the hard parts of tropical fish as measures of their age and growth.

Erna W. Mohr's essay of 1921, on "age determination in tropical fishes", like the work of other pioneers of fishery science such as F.I. Baranov's, was largely ignored because it was too far ahead when published - in the wrong language.

Also, Ms. Mohr's scientific output peaked at a time when Science was even less welcoming of women than it is today. In our field, prejudice forced many of these pioneers to concentrate on *data analysis* rather than *field work* - a long-term benefit as it turns out, for our discipline has tended to suffer from overemphasis on the latter.

In this specific instance, Mohr's analysis addressed a number of early dogmas pertaining to the growth of tropical fishes, dogmas that are still among us. Indeed, their continued existence justifies reviving this paper, never cited in the "core" literature monitored by the Institute of Scientific Information, Philadelphia (incidentally, verifying the latter fact cost US\$25).

I have translated; but abstained from updating Erna Mohr's text. However, I have replaced old by the present names of countries [in square brackets, along with my few other inputs], deleted a photo that could not have been reproduced well, and added an abstract, as well as means and standard errors to the tables with length-at-"age"-data to facilitate further analyses.

I am aware that some of the ages given by Erna Mohr may not be accurate; estimating ages through seasonal marking on hard

parts (see, e.g., Manickchand-Dass (1990) for a case including full validation) is, however, cost effective, much more so than doing the same with daily rings. Therefore, "it is to be expected that once the exploration of daily rings, and what they can tell us about growth in larval and juvenile fish, have run their course, examination of seasonal rings on otoliths and perhaps other hard parts will become a routine tool in tropical fishery management" (Longhurst and Pauly 1987, p. 270).

I hope you will enjoy reading E. Mohr's articles (and the others in this issue as well!); all that is left for me is to add to the references below the other contributions of E. Mohr known to me. Would any reader care to let us know more about her?
D. Pauly

References

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Age Determination in Tropical Fish

ERNA W. MOHR^a

Abstract

This essay, translated and edited by D. Pauly from an article published in 1921 (*Altersbestimmung bei Tropischen Fischen*. *Zoologischer Anzeiger* 53:87-95), presents evidence that check marks on the hard parts of tropical fishes can be used for aging these, in spite of the small seasonal temperature and other environmental oscillations prevailing in the tropics. The ideas presented in this article were over 50 years ahead of their time.

Introduction

In 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 identify the age composition of a fish population, and it can be determined to which degree the various age classes are utilized 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.

^aAuthor's (past) institutional affiliation not available.

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.*

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

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

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

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

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

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

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	-	-	-

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

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

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

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

Table 5. Length-at-age data of *Barilius guttatus* Day.^a

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	-	-	-	-

^aSampled in the Pahang River [Peninsular Malaysia], from 6 to 14 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

^aSampled in freshwater, i.e., in the mouth of a river opening in Jacquinet 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	-

^aSampled in Rein Bay [Papua New Guinea], on 26 April 1909.

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

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

This deer lives only in small groups, sometime in pairs. The males, having no competition, do not need to fight other males and thus do not run the risk of damaging their antlers. Information of optimal reproductive period is rare, however, and usually not as reliable as needed for clear inferences in the biology of the animals concerned. However, where such information is available, they can be often interpreted in a manner different from that intended by the person who reported it. I have searched for a long time for information on the spawning seasons of tropical fishes, particularly with regard to the question whether spawning is limited to certain months, 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

^bPertwee, 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].



An Account of Fisheries Development in the Republic of Djibouti with Notes on the Growth and Mortality of Three Species of Groupers^a

A. DARAR

Abstract

A brief description of fisheries development in Djibouti is given, with emphasis on the major constraints that have to date limited the increase of fishing effort. Estimates of L_{∞} obtained through Wetherall plots are presented for three important demersal species caught off northern Somalia and landed in Djibouti: the groupers *Cephalopholis sonnerati*, *Epinephelus chlorostigma* and *E. areolatus* (Fam. Serranidae). These are combined with estimates of the growth performance index ϕ' to calculate K values, subsequently used for the construction of length-converted catch curves. The estimate of mortality thus obtained suggests that these stocks are lightly fished.

Introduction: the Fisheries of Djibouti

The Republic of Djibouti, with coastlines bordering on the Red Sea and the highly productive Gulf of Aden (Fig. 1), appears to have a considerable fisheries potential.

The shelf, along the coastline of about 350 km, covers an area of nearly 2,500 km², and consists of both softbottom and coralline areas, with the former predominating (Bouhleb 1988). A potential yield of 1,200 t·year⁻¹ has been estimated for softbottom demersal fishes, and of 2,000 t·year⁻¹ for small pelagics (clupeoids, mackerels) to which may be added 70 t·year⁻¹ of sharks and 150 t·year⁻¹ for miscellaneous marine groups (coral reef fishes, cephalopods, crustaceans).

This potential is not realized. Indeed, in Djibouti, fishing is a marginal activity: most Djiboutians have pastoralism as cultural background, and beef is much more preferred than fish. Thus, commercial fishing activities have difficulties establishing themselves, and what little fishing is done is for subsistence and/or is highly seasonal, and aimed at spawning aggregations.

In view of these constraints, the Government of Djibouti established a plan for the development of small-scale fisheries three years after its independence (from France), which occurred

in 1977. This led to a number of development programs funded by external agencies (United Nations Development Programme, Food and Agriculture Organization, International Fund for Agricultural Development and the US Agency for International Development), through the Djiboutian Directorate for Livestock and Fisheries. These various programs led to some permanent and some temporary results, notably:

- the organization of fishers through a cooperative (Association Cooperative de Pêche Maritime), contributing about 80% of the total catch;
- the establishment of a fisheries training school (Centre de Formation de Pêcheurs Professionnels);
- the rebuilding and expansion of the (small-scale) coastal fishing fleet, meant to exploit areas in the north and south of the Gulf of Tadjourah, the fishing grounds north of Obock, as well as the fishing grounds from Djibouti City to the Somali border (Fig. 1);

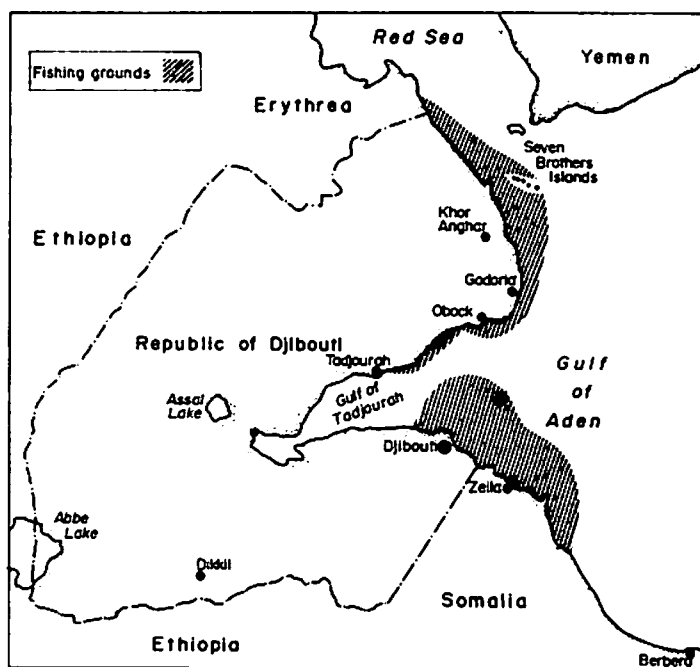


Fig. 1. Map of Djibouti and northern Somalia, showing locations mentioned in text.

^aWritten during a study stage at ICLARM headquarters from 19 March to 21 April 1993.