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Age Determination of Red-Spotted Trout (*Salmo macrostigma*) Inhabiting Munzur Stream, Turkey

Asiye Başusta,[1]* Nuri Başusta,[1] Rahmi Aydin,[2] Ebru I. Ozer[1] and Hulya Girgin[1]
[1]*Fisheries Faculty, Firat University, TR-23119 Elazig, Turkey*
[2]*Fisheries Faculty, Tunceli University, Tunceli, Turkey*

Abstract.- The goal of this study was to determine the best bone structure for age determination in *Salmo macrostigma.* During the study, comparative age determinations were performed on a total of 243 fish samples by using the operculum, suboperculum, preoperculum, interoperculum and vertebrae bony structures. In comparing the ages of five bony structures, the least agreement was 90.79% at the ages of the interoperculum-vertebrae and preoperculum-interoperculum. The most agreement was 99.59% at the ages of operculum-suboperculum. The biggest age difference amongst bony structures was 2. The clearest age ring was observed on the operculum and suboperculum bones.

Key Words: *Salmo macrostigma,* red spotted trout, age determination.

INTRODUCTION

Salmo macrostigma (Salmonidae) inhabits the altitudes from 50 (Sapanca Lake, Turkey) to 2,300 meters in rivers with waterfalls that have temperatures not exceeding 20°C (Geldiay and Balik, 1996). Specifically, they are spread throughout high-slope upper basins with pristine water quality. This is defined as the "trout zone" of rivers. *Salmo macrostigma* (known as mountain trout, stream trout, and spotted trout) is a salmonid species occurring in inland water habitats in northern Africa, southern Europe, western Asia and Anatolia (Tortonese, 1954; Geldiay, 1968; Geldiay and Balık, 1988; Alp *et al.*, 2003; Kara *et al.*, 2011)

It is the most economically important natural fish species and has a black-gray coloring with a shuttle-like body and flat sides. The dorsal fin is black-spotted and the caudal fin is cleft. It has a line of 10 to 12 large red spots which occur due to the clustering of small dots on the lateral line. Its reproduction season is from September to March (Geldiay and Balik, 1996; Karatas, 1990; Kucuk *et al.*, 1995; Alp *et al.*, 2003).

The age and growth are the most important tools for the population studies. Because, all the methods about population and stock assessment work essentially with age composition data. When a wrong age determination method is selected all the population components such as the age-length relationship, the growth parameters and age composition etc. are negatively affected (Polat *et al.*, 1999; Basusta *et al.*, 2013). Therefore, we need to know the most accurate age determination method for each fish species for an effective population and stock assessment study (Turkmen *et al.*, 2005).

Many comparative studies on age determination for fish have been carried out for several fish species (Ozdemir and Sen, 1983, 1986; Polat, 1987; Ekingen and Polat, 1987; Polat *et al.*, 2001). Basusta *et al.* (2012) reported the otolith dimensions-total length relationships of *S. macrostigma* from the Munzur Stream. No other study on the comparative age determinations on *S. macrostigma* has been found. So this is first comparative study on age determination of this species.

MATERIALS AND METHODS

A total 243 trout specimens, *S. macrostigma,* were monthly caught from various branches of the Munzur Stream between October 2010 and September 2011. They were transferred to Ecophysiology Laboratory in Fisheries Faculty, Firat University, Elazig, Turkey. Then, bony structures (operculum, suboperculum, preoperculum, interoperculum and vertebrae) were

* Corresponding author: agirgin@firat.edu.tr, asiyebasusta@gmail.com
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Table I.- **The distribution of bony structures according to age groups of *S. macrostigma* in the Munzur Stream, Turkey**

Bony structures	Age groups												Total
	II		III		IV		V		VI		VII		
	N	N%	N	N%	N	N%	N	N%	N	N%	N	N%	N
Operculum	4	1.65	49	20.16	114	46.91	48	19.75	21	8.64	7	2.88	243
Suboperculum	4	1.65	50	20.58	113	46.50	48	19.75	21	8.64	7	2.88	243
Preoperculum	5	2.06	59	24.28	109	44.86	43	17.70	20	8.23	7	2.88	243
Interoperculum	5	2.09	57	23.85	103	43.10	46	19.25	22	9.21	6	2.51	239
Vertebrate	7	2.88	59	24.28	104	42.80	45	18.52	21	8.64	7	2.88	243

Table II.- **The comparison of age differences between bony structures of *S. macrostigma.***

Bony structures	Age difference						Total N
	0		1		2		
	N	N%	N	N%	N	N%	
Operculum-Suboperculum	242	99.59	1	0.41			243
Operculum-Preoperculum	225	92.59	17	7.00	1	0.41	243
Operculum-Interoperculum	227	94.98	11	4.60	1	0.42	239
Operculum-Vertebrae	225	92.59	17	7.00	1	0.41	243
Suboperculum-Preoperculum	226	92.62	16	6.56	2	0.82	244
Suboperculum-Interoperculum	227	94.98	12	5.02			239
Suboperculum-Vertebrae	226	93.00	16	6.58	1	0.41	243
Preoperculum-Interoperculum	217	90.79	21	8.79	1	0.42	239
Preoperculum-Vertebrae	222	91.36	20	8.23	1	0.41	243
Interoperculum-Vertebrae	217	90.79	22	9.21			239

removed for age determination from each fish. These bony samples were washed using distilled water and analyzed in 96% ethyl alcohol with a binocular microscope at magnification of 2X. The results were compared with each other and agreement or disagreement according to the differences in age was expressed as “N%” (Gokerti and Basusta, 2010). For each sample the same bony structure was used for age determination four different times and the bony structure with the lowest margin of error was identified. These readings were made by same person.

Mean age, standard error and ageing error were calculated. The significance differences among mean ages of bony structures were tested in the range of 0.05 significance level using nonparametric Kruskal Wallis Test (SPSS 21.0, IBM Corporation).

RESULTS

Age determination was performed on bony structures of 243 fish samples. The distribution of bony structures according to age groups is shown in Table I.

The lowest agreement in the compared bony structures was between preoperculum and interoperculum and between interoperculum and vertebrae with 90.79%. The highest agreement was between operculum and suboperculum with 99.59%. The maximum age difference was found to be 2 years in the compared bony structures (Table II). The clearest annual rings were observed in the operculum and suboperculum.

According to the data in Table III, mean ages of bony structures used for age determination showed no significant differences ($P>0.05$). Mean age, standard error and ageing error of different bony structures were found very close to each other.

There was no age difference in 242 samples and there was one age difference in only 1 sample between the operculum age and the suboperculum age (Fig. 1A). Operculum age-preoperculum age and operculum age-vertebrae age showed exactly the same pattern (Figs. 1A, 1D). A total of 225

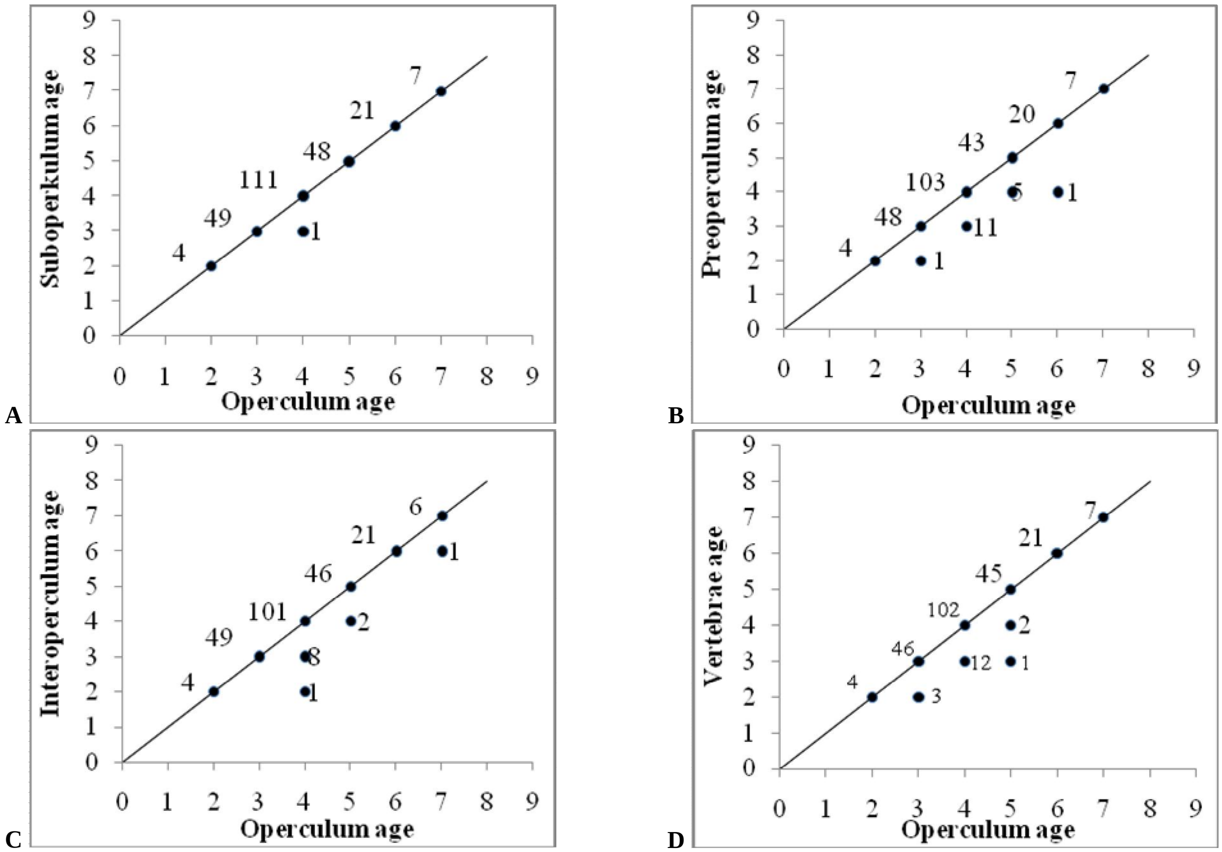

Fig. 1. Operculum age relationship with suboperculum age (A), pre-operculum age (B), inter-operculum age (C) and vertebrae age (D) of *Salmo macrostigma.*

Table III.- Mean age, standard error and ageing error calculated from age reading in different bony structures of *S. macrostigma* in the Munzur Stream, Turkey.

Bony structures	n	Mean age	Standard error	Ageing error
Operculum	243	5.201	0.065	1.012
Suboperculum	243	5.197	0.065	1.015
Preoperculum	243	5.123	0.066	1.036
Interoperculum	239	5.150	0.067	1.041
Vertebrate	243	5.123	0.068	1.064

Nonparametric Kruskal Wallis Test was applied and no significant differences were found among the mean ages of different bony structures (Chi-square=1.786, df=4, P=0.775)

samples showed no age differences. Other 17 samples and 2 samples showed 1 and 2 age differences, respectively. Between the operculum age and interoperculum age (Fig. 1C), no age differences were found in 227 samples. Only 11 samples showed 1 age difference and 1 samples showed 2 age difference. Between the suboperculum age and preoperculum age (Fig. 2A), no age difference was found in 226 samples. One age difference in 16 samples and two age difference in 1 sample was observed. Figure 2B shows that there is no age difference in 227 samples and there is one age difference in 12 samples between the suboperculum age and interoperculum age. According to Figure 2C, there was no age difference in the 226 samples. There is one age difference in 16 samples and two age difference in one samples between the suboperculum age and vertebrae age. Between the preoperculum age and interoperculum age (Fig. 3A). no age difference was observed in 217 samples, one age difference were determined in 21 samples and two age difference were found in one samples. No age difference was read in 222 samples, 20 samples showed one age difference and only one sample showed two age difference between the preoperculum age and vertebrae age (Fig. 3B). Between the interoperculum age and vertebrae age (Fig. 4), 217 samples showed no age difference and 22 samples showed one age difference.

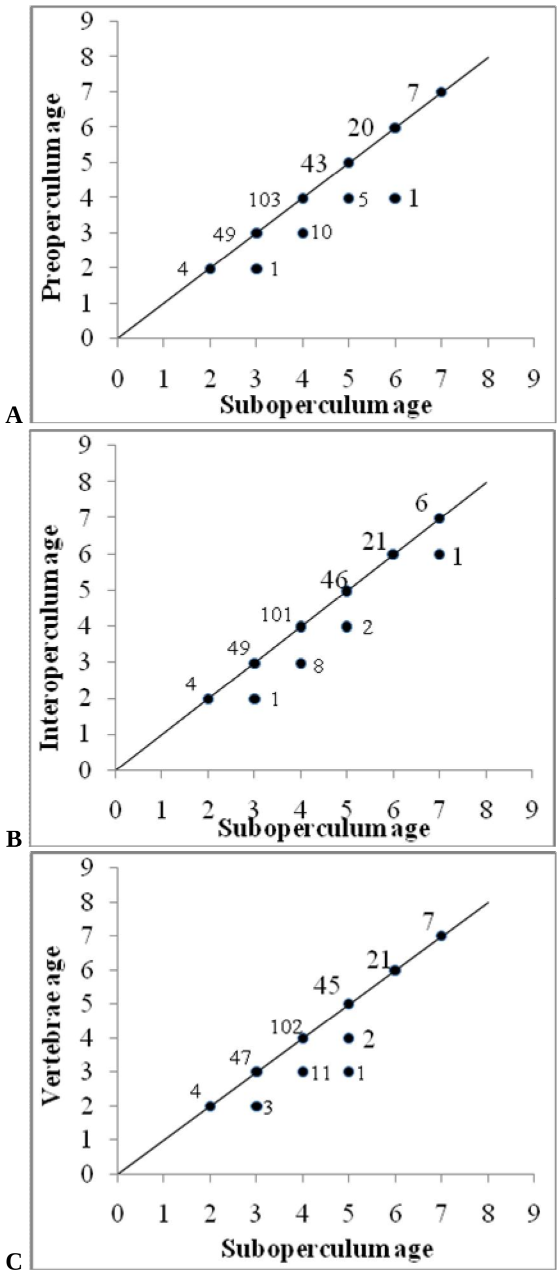

Fig. 2. The relationship of sub-operculum age with pre-operculum age (A), inter-operculum age (B) and vertebrae age (C) of *Salmo macrostigma.*

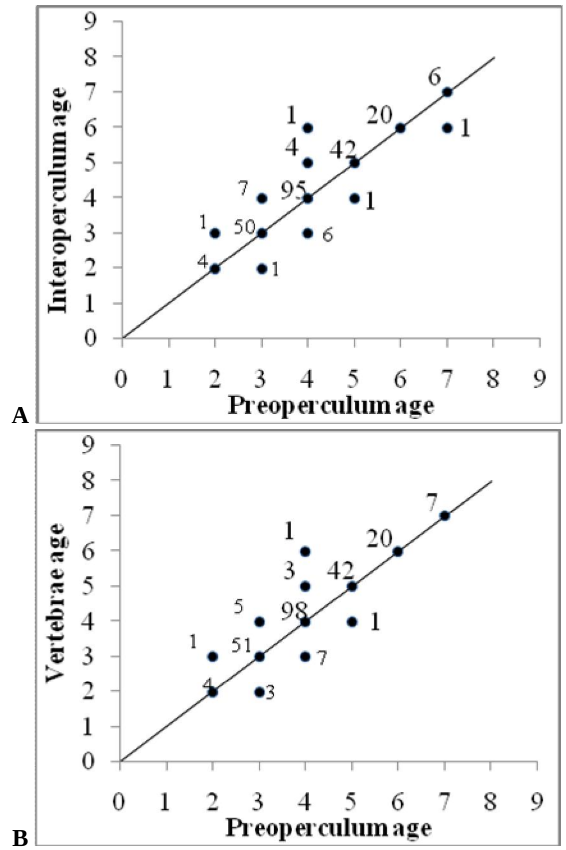

Fig. 3. Relationship of pre-operculum age with interoperculum age (A) and vertebrae age (B) of *S. macrostigma*.

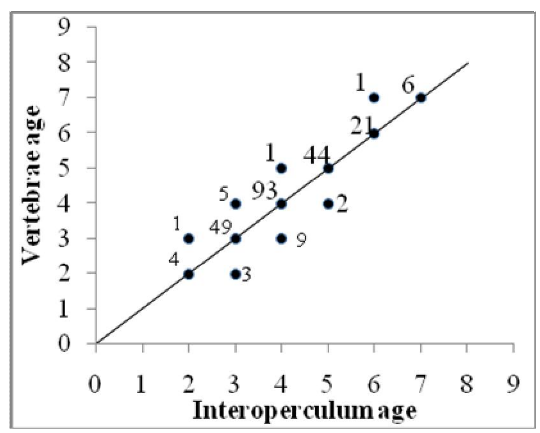

Fig. 4. The interoperculum age-vertebrae age relationship of *S. macrostigma.*

DISCUSSION

The maximum age differences between

compared bony structures were found at two years of age. The lowest agreement in the compared bony structures was between preoperculum-interoperculum and interoperculum-vertebrae with 90.79% and the highest agreement was between operculum-suboperculum with 99.59%. The clearest annual rings were observed in the operculum and suboperculum. In determining the age of this species, the operculum was followed by suboperculum with close reliability.

The opercula were found the most suitable structures for age determination due to having a flat structure and being easily removed from gill covers. This allowed easy cleaning and storing. In this study, although the vertebrae showed homogeneous ring characters and was no risk to remove from the fish for age reading purposes, the maximum clarity in age reading was observed in the operculum and suboperculum.

In contrast, Gumus (1998) referenced that there were few false rings on the vertebrae of the mirror carp and that the character of the rings was clear and obvious. Gumus (1998) indicated that this was an extremely reliable structure for both verification and age determination studies.

Yilmaz and Polat (2002) reported on shad living in the Black Sea that the vertebra was the most ideal bony structure for age determination. Polat and Isik (1995) reported that vertebrae were the most appropriate bony structures for age determination with minimum errors. These were followed by scales with close reliability. Polat *et al.* (2001) noted on comparative age determination of *Pleuronectes flesus luscus* living in the Black Sea that the minimum error and the maximum reliability were achieved with vertebrae among the bony structures.

Ekingen and Polat (1987) suggested that the otolith was the most appropriate bony structure for comparative age determination of *Capoeta capoeta umbla* living in Keban Dam Lake. Aydin and Sen (2002) reported that they observed the most clear annual rings on otoliths in their study on age relationships between right and left sides of the same bony structures of *C. c. umbla* living in the Lake Hazar. Sen (1993) reported on comparative age determination of *Chalcalburnus mossulensis* living in Keban Dam Lake. He states that the clearest annual rings were observed on otoliths.

It was observed that the most reliable bony structures for age determination in *S. macrostigma* were operculum and suboperculum in terms of the percentage of agreement (high), average percentage error (low), and coefficient of variation (low). It was also observed that the age that was the closest to the overall average age was determined on the operculum. It was concluded that it would be more appropriate to collect the age related data from the operculum and suboperculum.

A bony structure that is appropriate for age determination of a population may not be appropriate for another population. The results of age determination of a fish using different bony structures may often differ from each other. This study concludes that when an age determination study is to be conducted, a preliminary study should be done for each type of fish. This is important for both identification of the fish and its bony structures and reduction of age-related study problems.

In conclusion, it was found that all bony structures examined in this study were reliable for age determination in *S. macrostigma*. However, we recommend the operculum and suboperculum due to the maximum clarity in age reading.

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