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Age Determination and Annulus Formation of Crucian Carp (*Carassius gibelio*) Inhabiting Egirdir Lake and Bafra Fish Lake, Turkey

ABSTRACT

Age determination and annulus formation of the crucian carp (*Carassius gibelio*) obtained from Egirdir Lake between March 2001 and January 2003 and Bafra Fish Lake between January 2000 and September 2002 were evaluated by examination of scales, otoliths, vertebrae, opercular bones, and subopercular bones. The precision of age estimation was derived by percentage of reader agreement and coefficient of variation (CV). The highest agreement (70.3%) and lowest CV (7.0%) were with otoliths for Egirdir Lake specimens; in Bafra Fish Lake specimens, the highest agreement and lowest CV were with vertebrae 62.9% and 8.1%, respectively. We found that the most reliable bony structure for age determination varied in different populations of this species. Marginal increment analysis showed that annulus formation occured during October-April.

The crucian carp (*Carassius gibelio*) is distributed in eastern Asia-Siberia, is widespread throughout Europe (Kottelat 1997), and has commercial importance for fishing. Despite its importance, there is inadequate published information about its age determination and aging growth increments on bony structures. Therefore, we undertook an evaluation of the reliability of several bony structures for aging of *C. gibelio*.

Between January 2000 and September 2002, 173 specimens were collected from Bafra Fish Lake (41°36'N, 36°04'E), a eutrophic lake; 283 specimens were collected from Egirdir Lake (38°15'N, 30°52'E), an oligotrophic lake, between March 2001 and January 2003. Scales, otoliths, vertebrae, and opercular, and subopercular bones were removed and cleaned by appropriate procedures (Chugunova 1963). Scales were viewed under magnification with transmitted light; otoliths, vertebrae, and opercular and subopercular bones were also viewed under magnification but with reflected light. Ages were assigned based on annual mark counts. Accuracy of repetitive readings was evaluated by percentage agreement for assigned age among the first, second, and third readings by the same reader. In addition, the coefficient of variation (CV) was used to assess consistency in repeated age determinations (Campana 2001). Marginal increment, estimated as the distance between the outer edge of the outermost annual ring and the periphery of structures, were measured to the nearest 0.01 mm; this measurement was always made along the same axis of the bony structures.

Growth rings were not of the same character in individuals from the two lakes, especially with regard to otoliths. Otoliths from Bafra Fish Lake samples had smooth distal surfaces but did not include any circuli or annuli. Proximal surfaces had irregular shapes. In contrast, the samples from Egirdir Lake were as usual with regular ring deposition. The irregular deposition in Bafra Fish Lake samples precluded their use in age determination, and these specimens were excluded from the aging process.

In Egirdir Lake specimens, vertebrae and scales had problematic characteristics. Alternating broad opaque and narrow translucent zones around the centers of the vertebrae were observed. Some of the samples had double rings, which were spaced too close together to be annuli. This type of double ring was accepted as one annulus. Marks on scales were typically clear and easy to read in younger fish, but age determination

from the scales of older fish was difficult. The annulus interpretation of scale readings was affected by a high frequency of false annuli, particularly in younger fish, and hampered evaluation due to crowding of marks at the scale edge. In addition, many fish had a thick and pitted scale center, which obscured early marks, and regenerated scales.

Different structures from the same crucian carp often did not give the same age estimate. For all comparisons (Table 1), the highest agreement among three readings for Egirdir Lake specimens was with otoliths (70.3%), and the lowest was for opercular bones (17.6%). In Bafra Fish Lake specimens, the highest agreement was 62.9% in vertebrae; the lowest was 14.1% in subopercular bones. Furthermore, bony structures with the lowest CV for Bafra Fish Lake and Egirdir Lake specimens were vertebra (8.1%) and otolith (7.0%), respectively.

The bony structures were investigated in order to define the yearly variation of percentage of opaque and translucent edges (Fig. 1). The vertebrae displayed alternating opaque and translucent zones in Bafra Fish Lake specimens. A cyclical trend in the marginal increment state was evident, with the first opaque formation at the edge occurring in April. Opaque margins reached a maximum in July and remained at full percentage in the following months, with frequency of translucent edges increasing in October. All of the samples revealed hyaline edges at their outer margins from October to March. Thus, this fish in Bafra Fish Lake has only one rapid annual growth period, and it corresponded to the summer months. The specimens (n=173) from Bafra Fish Lake ranged in age from age 2 to age 7; the dominant group was age 3 (31%).

Otoliths displayed alternating opaque and translucent zones in Egirdir Lake specimens. The first opaque formation at the edge of otoliths occurred in April. The opaque margins reached a maximum in July and remained at full percentage in the following months. All of the samples revealed hyaline edges at their outer margins from October to March. Thus, as with the fish of Bafra Fish Lake, these crucian carp had just one rapid annual growth period in the summer months. The specimens (n=283) ranged in age from age 0 to age 6, and dominant group was age 2 (29%).

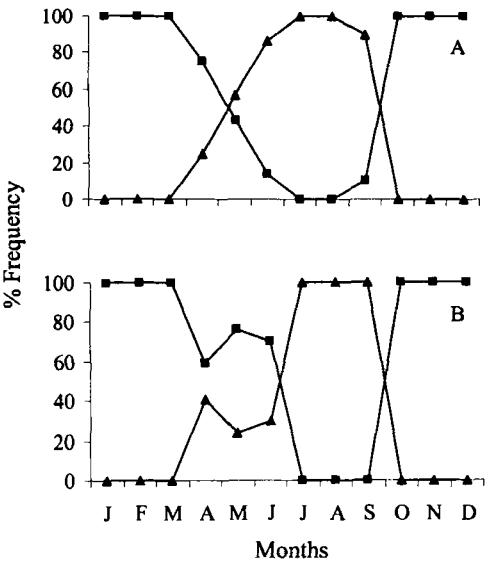

Figure 1. The monthly percentage of opaque and hyaline ring changes in the marginal zone of *C. gibelio* vertebrae and otoliths sampled Bafra Fish Lake (A) and Egirdir Lake (B), respectively (--▲-- opaque ring --■-- hyaline ring)

Table 1. Precision among age readings by the same interpreter on all bony structures of *C. gibelio* from two Turkish lakes.

Lake	Structure	n	% of full agreement	CV (%)	SE
Egirdir	Scale	283	32.8	17.2	0.7
	Vertebra	283	47.1	22.6	0.8
	Otolith	283	70.3	7.0	0.5
	Opercular bone	283	17.6	27.2	0.7
	Subopercular bone	283	25.5	25.7	0.6
Bafra Fish	Scale	173	32.1	25.2	0.8
	Vertebra	173	62.9	8.1	0.6
	Opercular bone	173	21.0	22.5	0.7
	Subopercular bone	173	14.1	19.7	0.7

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