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Validation of the Scales for Age Determination in a Cyprinid, *Scardinius erythrophthalmus* (L., 1758)

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Abstract: In this study, scales were used to find out timing of annulus formation in *Scardinius erythrophthalmus* and following assumptions were tested; the existence of periodical marks, the ability to identify these marks correctly and to convert the number of marks into age. Time of annulus formation was derived from annual changes of opaque and hyaline zones on scale margins. Scales exhibited opaque and hyaline zones whose combination was formed once a year. Opaque zones appeared formed from July to February and the hyaline ones from March to June. A procedure is described to assess age by using the number of annuli, the condition of the scale edge and the capture data. The results of this study would be a useful guide for this species and also for other cyprinid species which is suitable for similar ageing techniques to improve precision of the age determination of fish.

Key words: Scale, age determination, *Scardinius erythrophthalmus*, validation

INTRODUCTION

Age and growth studies are important for problems associated with management of fisheries. Determination of age in fish helps in determining the age at maturity, studying the population dynamics, estimating the growth and optimizing the harvesting time[1]. Age determination of fish from scales, otoliths and other structures is a matter of routine with most exploited fish stocks. However, counting annual rings is open to many uncertainties. Validation of annulus formation in the selected structure is needed to avoid misageing[2].

Age validation techniques include monitoring of fish of known age, statistical inferences (e.g. analysis of length-frequency modes, analysis of increment widths, monitoring of strong year classes, etc.) and marginal-increment analysis[3]. However, monitoring of a population of fish known age require long time and is quite expensive method[1]. Hence, the best validation method for annulus formation of fish seems to be marginal growth analysis[4,5]. One of the main problems in ageing is to select the more suitable and accurate structure. Scales, otoliths, fin rays and other skeletal structures have been used for age determination in fish. Among these, scales have been frequently used because of the convenience of preparation and observation[6-9].

Rudd, *Scardinius erythrophthalmus* (L.) is a littoral species, which lives in or near the vegetation zone[10]. It is wide-spread species in Europe, Black Sea and Azov Sea[11]. In many habitat of its distribution range, it is often one of the dominant fish species. Age and growth studies of the rudd is of importance, since mass removal of rudd and other cyprinids has become a popular method in restoring eutrophicated lakes in Europe[12,13]. Such projects usually include studies on the possible growth responses of the target species.

Although there have been several studies on the age and growth of the rudd using the scales[14-18], these studies have not included any analysis for validation of annulus formation. The objective of this study was therefore to validate scales for aging the rudd, one of the most abundant members of fish assemblages in the north-west of Turkey. In particular, we attempt to detect annual formations in scales to meet following assumptions; a) the existence of periodical marks in the selected structure; b) the ability to identify these marks correctly (including discrimination from "false" marks) and c) the ability to convert the number of marks into age.

MATERIALS AND METHODS

Scales of 657 specimens of rudd (13-35.8 cm) were collected monthly using gill-netting between July 1999 and October 2001 from Lake Sapanca. Lake Sapanca is located in north-west of Turkey. It has oligothrophic character and is used as drinking water and recreational

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area[19]. Except than rudd, *Rutilus rutilus* (L.), *Blicca bjoerkna* (L.) and *Vimba vimba* (L.) are the most common fish species in the lake[20].

Scales were taken between the lateral line and the dorsal fins. About six to ten scales from each specimen were placed on a 1 mm thick polycarbon plastic plate and pressed at a roller press. Prepared plates bearing the prints of scales were read using a Microfish Reader[21]. It was not necessary to clear them because with this ageing method the scales had clearly defined opaque zones alternating with hyaline zones due to only prints of scale appears on the polycarbon plate. The distal portion of each hyaline zone was considered the annulus. The term annulus is associated with the hyaline zone that is formed once a year in calcified structures of fishes growing in temperate climates[22]. The areas of complete growth for each year were represented by the combination of one opaque zone and a subsequent hyaline zone. The number of annuli of the whole scale was counted along the longest antero-posterior axis on the scale.

We applied the marginal increase analysis method to validate age[23,24]. This technique encompasses qualitative and quantitative examination of the scale edge over the growth period. The percentage of the scale with opaque or hyaline zones on the edge was estimated the width of two most external zones of growth were measured (each opaque zone of the last annulus) and the relative width of the Marginal Increment (MI) was calculated as the ratio of the width of the actual growth zone to the width of the previous year's growth zone.

RESULTS AND DISCUSSION

Opaque and hyaline zones in the whole scale were clearly visible (Fig. 1). For both sexes, hyaline zones were observed in the edge of the scales throughout the year (Fig. 2), but the proportion of scales with a hyaline zone showed an unimodal annual cycle. Over 80% of the scales exhibited a hyaline zone in April and May (Fig. 2). The scale growth appeared at a minimum between February and May and increased significantly between June and September. The time of capture influenced significantly the amount of opaque material at the edge of the scale (ANOVA $p<0.001$).

Marginal increment analysis showed that a single annulus was formed during the end of the winter of each year. Scales from fishes collected in March showed that formation of a new annual ring had begun, while June scale samples showed that the annual ring had formed for both sexes (Fig. 3).

Overall, the results confirmed the presence of one opaque zone followed by a hyaline zone in the scale of the

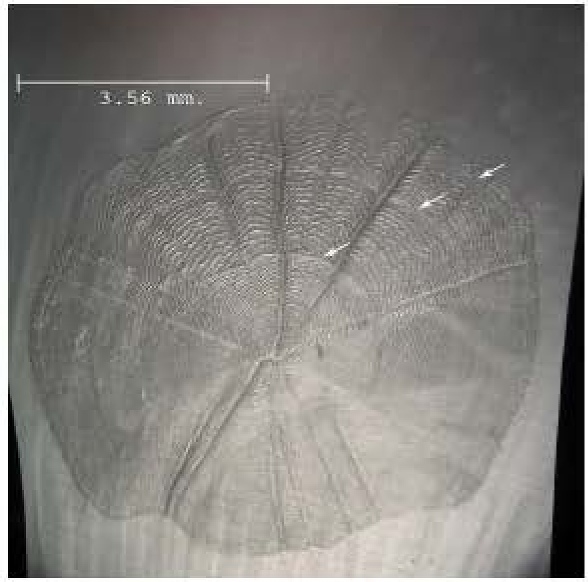

Fig. 1: A view of the whole scale of *S. erythrophthalmus* showing growing zone and annulus formation under microfish reader, pressed on polycarbon plate. The scale is from 3 years old female, 15.9 cm total length, captured in Lake Sapanca. The white arrows indicate each annulus

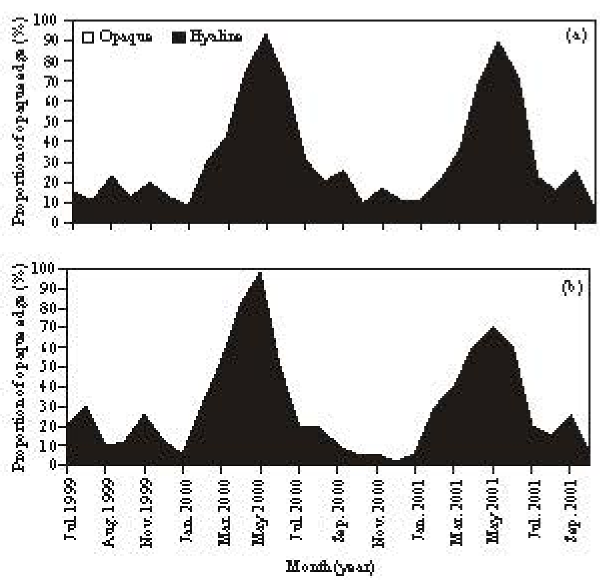

Fig. 2: Monthly changes in proportion of the rudd scales of opaque edge from Lake Sapanca; (a) Female (b) Male

rudd and that the combination of both is formed once a year. Tesch[25] listed six criteria which identify true annual rings, although he noted that false rings may exhibit one

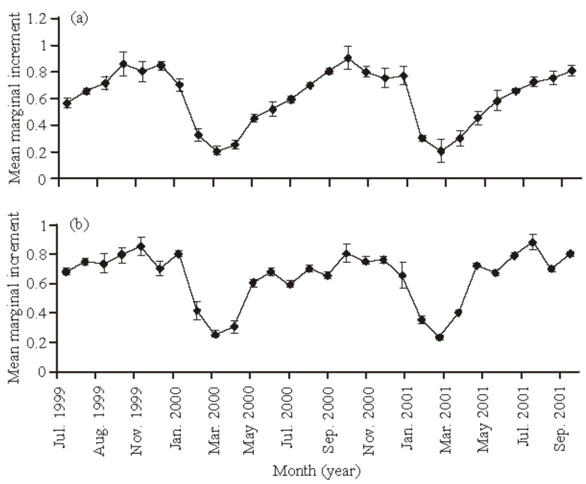

Fig. 3: Monthly changes in the marginal increments of the rudd scales from Lake Sapanca; (a) Female (b) Male

or more of these criteria. Probably percentage of occurrence frequency of false rings has increased with increasing age of fish. The formation of a false ring in the scales of rudd can closely resemble a true annulus. This difficulty could result from periods of slow growth resulting into formation of annuli so close to each other that in a number of scale samples of older fish. In these kinds of cases, the annuli were difficult to discern each other[18]. However, in our observations, false hyaline zones were apparent, but they were easily detectable because they were similar to those of the annuli and mostly found near the annuli. Moreover, they did usually not form a complete ring. A few false zones also occurred in the areas above and below the nucleus which can be considered as larval check[26].

The formation of the annulus in calcified tissues is complete when the hyaline zone, which forms once a year, is followed by opaque material[22]. This corresponded to the minimum marginal growth values detected for our rudd population. Since, besides marginal growth, we included the periodical interpretation of the edge's appearance (opaque or hyaline percentages), we were able to determine the timing of the formation of two zones: the opaque zone was formed from July to February and the hyaline zone was formed from March to June. Further observations on the reproduction of the rudd in this lake suggest that reproduction extends from early May to late June[27].

Once the rings were counted (annuli) they were converted into age. This last step is referred by Francis[28] as the interpretation of the edge. This implies a decision on the moment (or date) when the most external ring counted was formed. The conversion of the number of rings into age implies considerations on the relationship between this date and two previous dates, i.e. time of capture and birth date[29]. For this purpose, we took 1st January as the birth date for the rudd which may not necessarily coincide with the date of natural birth. Consequently, the precise age of each individual fish was determined taking following criteria into account: a) if the scale had an opaque edge, the age was equal to the number of annuli, regardless of the date of capture, b) if the scale had a hyaline zone, estimating the age depended on the date of capture as follows: if fish came from the July to December, the age was equal to the number of annuli with a posterior opaque zone and if the fish came from January to June age was equal to the number of annuli with a posterior opaque zone plus one.

To conclude, when the age determination of the rudd from its scales is considered, these results should be taken into account to improve precision of the age determination of this species and because its ageing strategy is similar to that of many other cyprinid species, it is possible that these inferences would also be useful for other cyprinid species.

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