Age and Growth of Three Species of Lake Victoria Fish Determined by Means of Otolith Daily Growth Rings

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Abstract

The sagittal otoliths of *Lates niloticus*, *Haplochromis obesus*, and *Oreochromis niloticus* from Lake Victoria were examined for daily growth rings using scanning electron microscopy. In the three species the increments were clear and thick enough to allow future studies with light microscopy. The daily nature of the increments seems supported by the rhythmic growth that were found.

Introduction

The dominant species in bottom trawl catches in Lake Victoria are *Lates niloticus*, *Rastrineobola argentea*, *Oreochromis niloticus*, and a multispecies complex of haplochromine cichlids. *L. niloticus* and *O. niloticus* were introduced to Lake Victoria causing important changes into the native lake fauna through predation and competition. The haplochromines used to dominate the fish community, but recently, *L. niloticus* has become dominant (Getabu 1987).

Age and growth studies are fundamental for biology population studies and to establish sound management policies. Until now, few growth studies on Lake Victoria fish are available, being mostly based on length-frequency analysis (Acere 1985; Getabu 1987; Asila and Ogari 1987). The growth of *L. niloticus* has been studied by means of scale interpretation, in other areas (Hopson 1972).

Daily growth rings in fish otoliths have provided a useful tool for precise age determinations (see Campana and Neilson 1985 and references therein); tropical fish age determination by means of otolith microstructure allows age determination when seasonal rings are not present (Morales-Nin 1987, 1992). The aim of the present contribution was to study the otoliths of the native *Haplochromis obesus* and of the introduced *L.* and *O. niloticus*, by means of scanning electron microscopy to establish their suitability for age determination.

Materials and Methods

The available sagittal otoliths were glued to brass discs and ground to obtain frontal sections at core level. Then, they were polished and acid-etched to reveal the growth increments. Two etching agents, EDTA and HCl, were employed. Acid etching with EDTA for 6 minutes offered the best results.

The sections were washed with distilled water and dehydrated with alcohol. Then, the brass discs were mounted with colloidal silver on the scanning electron microscope (SEM) holders.

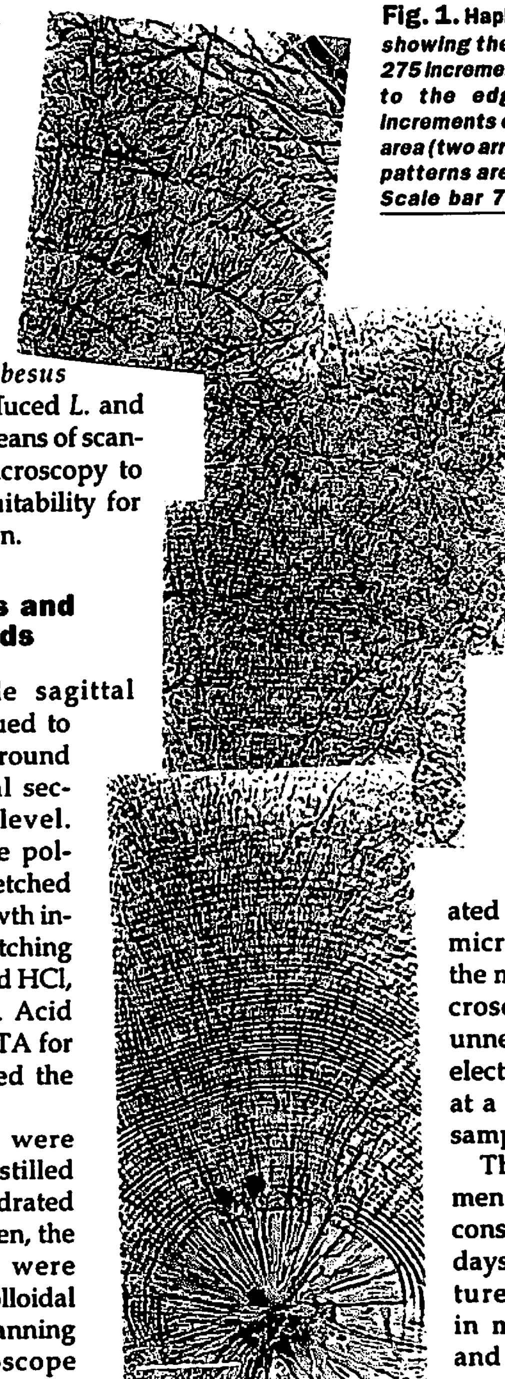

Fig. 1. *Haplochromis obesus* ***otolith showing the complete sequence of 275 increments from core (one arrow) to the edge. Note the diffuse increments comprised in the nuclear area (two arrows). Rhythmical growth patterns are found in all the otolith. Scale bar 75 mm.***

Samples were observed with a Hitachi scanning electron microscope at 15 Kv. The areas with clearer increments were selected and series of micrographs were taken from the core to the otolith edge. When the section was outside the core, the otolith was ground and prepared for a second observation. Increments were enumerated and measured on the micrographs. To correct the measurements for microscope distortion was unnecessary because the electron beam was placed at a right angle from the sample.

The number of increments in each sample was considered as the age in days due to the daily nature of the increments in most fish (Campana and Neilson 1985). This age is only approximate,

Fig. 2. *Growth increments in H. obesus otolith. A: thick increments in the nuclear area, B: rhythmic growth patterns. Scale bar: A: 38 mm, B: 60 mm.*

first increment formation is not known, though known to generally occur at first feeding (Brothers et al. 1976; Radtke and Dean 1982). Consequently, the error introduced might be unimportant for fishes that are relatively old.

Results and Discussion

Sagittal structure in all the species was similar to that normally found in teleost otoliths, exhibiting a recurring pattern of formation consisting of daily growth increments around a larval nucleus (core). Each increment comprised two elements, a continuous or incremental unit in which aragonite microcrystals predominated, and a discontinuous unit in which organic

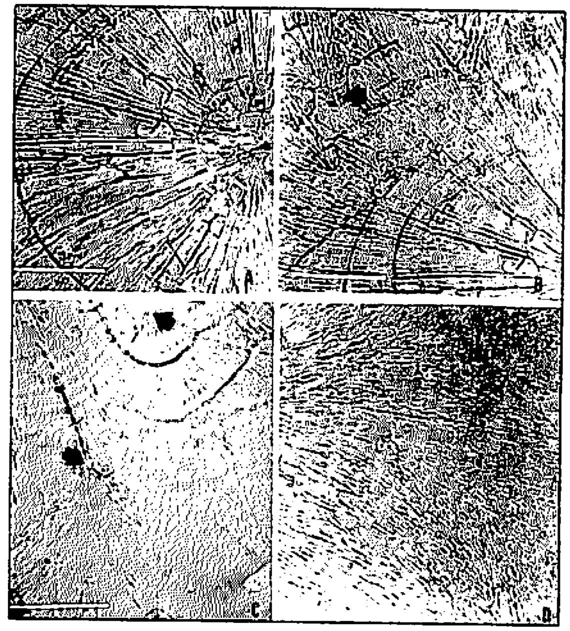

Fig. 3. *Growth increments in Oreochromis niloticus. Note the accessory growth centers (arrows). The core is clearly visible in A and the nuclear increments in A and B. The decrease of increment thickness with age is shown in D. Scale bar: A and D: 86 mm, B and C: 100 mm.*

material predominated (Morales-Nin 1987). The discontinuous units appear in the SEM micrographs as grooves due to their lower density which causes their preferential dissolution when etched (Figs. 1 to 4).

Haplochromis obesus

The otoliths of *H. obesus* showed very clear increments with thick discontinuous units. First, eight diffuse thick increments (7.95 µm in average, s.d. 0.54 µm) were laid around a core 16.8 µm wide (Fig. 1). There increments were laid down posteriorly for five months, with an average thickness of 3.90 µm (s.d. 0.336 µm). Finally, thinner increments of 1.96 µm (s.d. 0.195 µm) were formed (Fig. 1). Rhythmic growth patterns of 7, 12-14 and 28 increments were found in all otoliths (Figs. 1 and 2).

The increments were enumerated twice in the micrographs. The coincidence of the increment enumeration was high (98%), thus, the increments were consistently interpreted. The mean increment numbers in each fish are given in Table 1.

Oreochromis niloticus

The otoliths of this species showed less well developed increments due to a more uniform crystalline structure, consisting of poorly defined discontinuous units (Fig. 3).

The otoliths are characterized by a nuclear zone composed by 20 increments (s.d. 4.16) with an average thickness of 9.95 µm (s.d. 1.32 µm). A growth discontinuity, probably related to larval metamorphosis, surrounds this area (Fig. 3). The increments laid down posteriorly are thinner, with an average width of 4.27 µm (s.d. 0.67 µm). Accessory growth centers are found in some otoliths corresponding to an age of 3-4 months.

The increments showed numerous subdaily units (Fig. 3), which render the interpretation of increments rather difficult and caused a lower agreement between readings (coincidence 85%). All the studied fish were less than one year old (Table 1).

Table 1. Age in days (number of increments) and length of the studied fish (XX indicates otoliths that could not be aged).

Haplochromis obesus Length (cm)	Age (days)	*Lates niloticus* Length (cm)	Age (days)	*Oreochromis niloticus* Length (cm)	Age (days)
7.6	200	6.4	80	5.8	101
7.7	162	11.0	105	6.7	271
8.1	180	13.7	XX	6.9	260
8.7	XX	19.5	203	7.1	280
9.0	207	20.4	XX	8.8	XX
9.2	XX	21.7	XX	9.0	305
9.5	275	22.2	225	9.0	XX
9.5	280	23.2	250	9.9	XX
10.1	343	24.7	XX	-	-
10.5	369	-	-	-	-

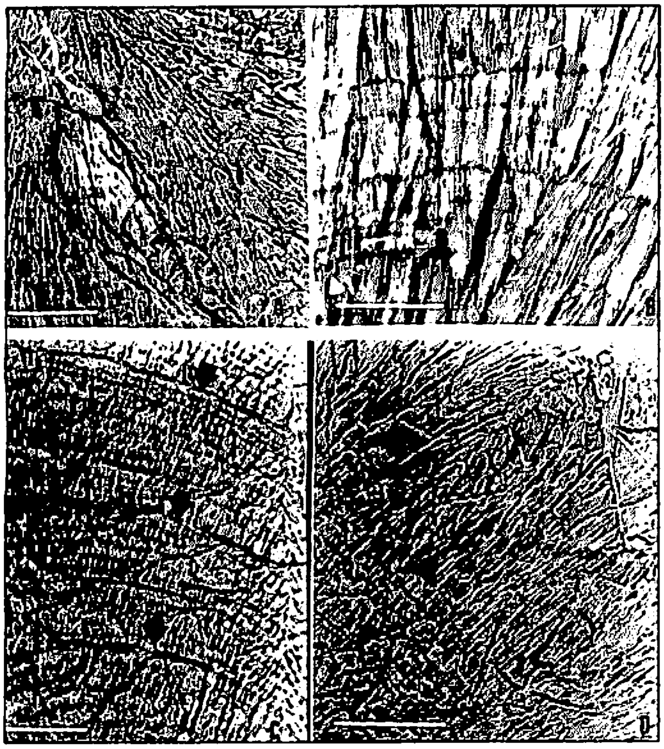

Fig. 4. ***Otoliths of* Lates niloticus *showing the core (arrow in A) and growth rhythms (B and C, 14-increment groups are marked with arrows in C). Scale bar: A and D: 75 mm, B: 136 mm, C: 60 mm.***

Lates niloticus

The thick otoliths of this species have a curvilinear growth plane making it very difficult to obtain a complete increment series in one section. Age interpretation was possible only in smaller fish (<24 cm).

The increments are thick (4.87 μm in average, s.d. 0.733 μm) with 2-3 subunits and rhythmical growth patterns of 6-7 and 12-14 increments (Fig. 4).

The fish were 2 to 5 months old, corresponding to a length interval of 16 cm (Table 1).

Overall, the presence of rhythmic growth patterns of 7, 14 and 28 increments supported the daily nature of the increments (see Campana and Neilson 1985). Patterns of cyclic grouping of the daily growth increments are common in other species and are usually related to environmental fluctuations related to lunar cycles, e.g. tides (Pannella 1980); they are not found in species held in stable, controlled experimental environments (Gutiérrez and Morales-Nin 1986).

Increment width is a function of the growth rate (Gutiérrez and Morales-Nin 1986); consequently all the fish studied here were in the active, juvenile growth phase. *H. obesus* registered three growth phases in their otoliths; an initial one, corresponding to the larval period, a second one of about 5 months and a final one with less intense growth rate. These phases may correspond to ontogenic or habitat changes (Morales-Nin 1987). The other two species only showed a constant decrease in the increment thickness, which can be related only to the decreasing of growth rate with size.

The use of scanning electron microscopy allows to determine the presence of even the thinnest increments. However, the cost of the process and the time necessary to study the samples made this method appropriate only for a first study of the otoliths (Morales-Nin 1987, 1992). Once the increment width in the studied otoliths has been shown to be over the detection limit of the light microscope (1 μm), the use of some semiautomatic device coupled with light microscopy would allow to determine the age with ease and to study enough data to establish the growth parameters with precision.

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