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Aspects of the biology of *Labeo cylindricus* (Pisces: cyprinidae) in Lake Baringo, Kenya

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Abstract

Aspects of the biology of *Labeo cylindricus* from Lake Baringo were investigated, based on experimental beach seining and gillnetting between August and October 2007. The length–weight relationship indicated the species exhibited positive allometric growth (b = 3.7083), with a condition factor (K) of 0.84 ± 0.0298 S.D. Males dominated fish catches, with an adult sex ratio of males/females of 1:1.7. The fish length-at-50% maturity (Lm50) was 127.7 and 126.1 mm total length (TL) for males and females, respectively. Fish age and growth were determined from sagittal otoliths considered to be from the young-of-the-year. Clear circuli observed in the otoliths were used to determine fish age in days. Validation by oxytetracycline marking indicated that a single growth increment (1.1 ± 0.1 SE) is formed daily on fish otoliths. Fish length (TL mm) was correlated significantly with age (in days), TL = 1.398 Age + 26.523 (r^2 = 0.91). Fish growth was subsequently estimated to be 1.398 mm day^{-1}. The weights and ages (in days) of fish exhibited a significant ($P < 0.05$) power relationship defined by the equation: $W = 0.0003\ \text{Age}^{2.5804}$ (r^2 = 0.88). The results of this study provide parameters that, if appropriately monitored, can be used to predict responses of fish populations in Lake Baringo and elsewhere to human interventions (exploitation) and natural environmental change.

Key words

age, growth, maturity, otolith, spawning, young-of-the-year.

INTRODUCTION

The cyprinid *Labeo cylindricus* Peters, 1852 has a natural distribution across eastern, central and southern Africa, including the drainage basins of the Zambezi, Limpopo, Incomati and Usutu–Pongolo rivers, the Congo Basin and East African rivers. It is a freshwater benthopelagic potamodromous species that inhabits rocky habitats in rivers, lakes and reservoirs (Weyl & Booth 1999). The species is also found in Lake Baringo, a shallow Rift Valley lake in Kenya. Lake Baringo also is an invaluable habitat for six other freshwater fish species, namely *Oreochromis niloticus baringoensis* Trewavas 1983, *Labeobarbus intermedius* (Rüppell, 1835), *Barbus lineomaculatus* Boulenger 1903, *Clarias gariepinus* (Burchell 1822), *Protopterus aethiopicus* Heckel 1851 and *Poecilia reticulata* Peters, 1859 (Froese & Pauly 2011; Britton & Harper 2006; Mlewa & Green 2006). The *L. cylindricus* fishery is important for sustainable socioeconomic development of the communities surrounding the lake (Aloo 2002).

Most *Labeo* species are commercially exploited throughout Africa (Weyl & Booth 1999). Unlike its congeners, *L. cylindricus* is relatively small, attaining a maximum standard length of 40 mm (Lévêque & Daget 1984) and weighing up to 0.9 kg (Skelton 1993). The species exhibits a potamodromous behaviour, relying on river migration to complete its life cycle (Ogutu-Ohwayo 1990). It was previously thought that *L. cylindricus* is rare or threatened in Lake Baringo (Ramsar 2002). Its low (0.1%) contribution to total catch was attributed to the damming of the main perennial rivers flowing into the lake (Aloo 2002), a situation believed to have blocked spawning routes for the species. However, Britton and Harper (2006) found that, in spite of its absence in the commercial catches, the species was abundant in the lake. This finding provided impetus for further research on the

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species in Lake Baringo. This study presents aspects of population structure, maturity and early growth of the species in Lake Baringo. The availability of such biological information on the fish can be used directly, in a precautionary sense, to indicate changes in fish populations, and prompt any needed management actions.

MATERIALS AND METHODS

Specimens were collected by experimental fishing in Lake Baringo in August and October 2007 (Fig. 1). The shallow equatorial freshwater lake is located in the eastern arm of the Rift Valley, Kenya, between 0°32′ and 0°45′N, 36° 00′ and 36° 10′E, at an altitude of 975 m above sea level (Beadle 1932; Ssentongo 1974). It covers a surface area of approximately 137 km^2 (Mlewa *et al.* 2005).

A mosquito seine net (2 m deep; 50 m length) was used to catch fish at three sites along the shore of Ol Kokwa Island (Fig. 1). Three hauls were made at each site. Additional specimens were obtained from two fleets of multi-filament gillnets (mesh sizes ranging from 25.4 to 152.4 mm) set at three locations in the open lake. All fish were measured to the nearest millimetre total length (TL) and standard length (SL), weighed to the nearest gram and then dissected for sexing through visual examination of gonads. The gonads were categorized according to the developmental stages for the species, as described by Weyl and Booth (1999).

The fish size at 50% maturity was estimated for both sexes by fitting frequency of mature individuals (ripe or spent) by length, as stated by Weyl and Booth (1999). The length–weight relationship was calculated, using base-10 logarithm transformation of L-W data pairs and

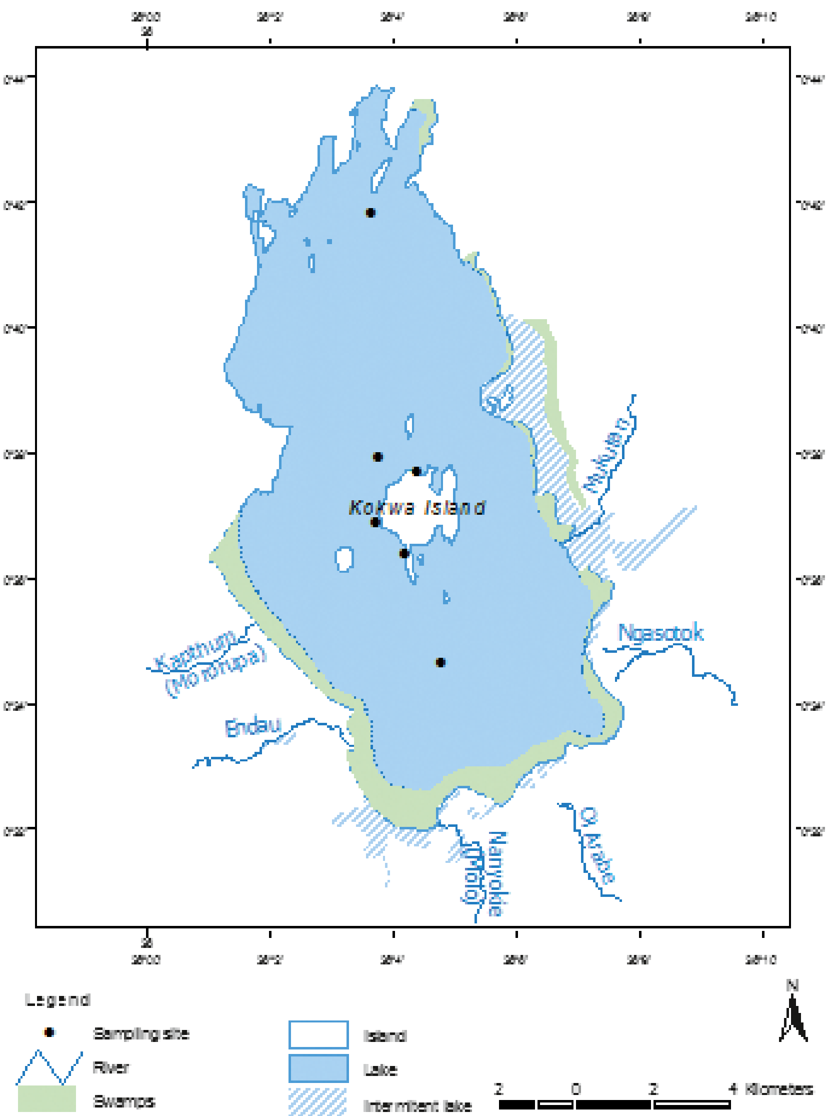

Fig.1. Location of Lake Baringo, its tributaries and sampling sites.

ordinary least square regression. To assess the stoutness of the fish, the condition factor was calculated using the following formula:

$$K = (W \times 1000)/L^3 \qquad (1)$$

where W = fish weight (grams) and L = length (mm). Growth studies were conducted through analysis of circuli on sagittal otoliths from fish considered to be young-of-the-year (YOY). One otolith was obtained from each individual fish and mounted on a serially labelled microscope slide. These otoliths were thin enough for transmitted light to pass through without prior sectioning. Unclear otoliths were ground gently, using a 6-μm lapping film, to improve clarity of circuli. Each otolith was observed under an inverted LEICA DM IRB microscope, and its image was acquired using the IM500 software. Otolith radii, area and number of growth increments were determined from the captured images. Growth increments were counted by two individuals, each making three counts.

A total of 10 fish (ranging in size from 30 to 70 mm) were immersed in 25 mg oxytetracycline hydrogen chloride OTC. HCL kg^{-1}. The fish were then kept in tanks for 4 days before otolith removal. Each of the otolith was then observed under UV light, using a *LEICA ZOOM 2000* microscope, to sight the fluorescent OTC mark. Rings outside this mark on each otolith were counted and recorded. These were used to determine the frequency of growth ring formation.

RESULTS

A total of 444 specimens were used for morphometric and reproductive biology analyses. The size structure of the specimens exhibited a normal distribution (Fig. 2), with most fish being in the 150–200 mm size classes. Males dominated catch, with an adult sex ratio of males/females of 1:1.7 ($P < 0.001$). The largest mature male and female were 250 and 225 mm TL, respectively. The length-at-50% maturity (Lm50) was 127.7 and 126.1 mm TL for males and females, respectively (Fig. 3). The length–weight relationship exhibited a b value of 3.7083 (Fig. 4), being significantly different from the mean exponent 3 ($P < 0.05$). The average condition factor (K) was 0.84 ± 0.0298 SD.

Forty-three otoliths were used for growth studies. They were derived from specimens ranging from 61 to 232 mm TL, with a mean of 90.8 mm (± 4.6 SD). Fluorescent bands were observed in otoliths marked with OTC. The average count of increments formed outside the fluorescent band was 2.7 (SD = 0.3), indicating that one increment was formed per day on the fish otoliths (mean increment = 1.1 ± 0.1 SE).

Otolith images exhibited characteristic clear alternating dark and light bands of distinctly spaced circuli (Fig. 5), which were then used to estimate the age of fish in days. A Kruskal–Wallis test showed no significant difference (df = 2, $P = 0.9554$, df = 2, $P = 0.9987$) for increments of the two readers, while the Wilcoxon test ($P = 0.11841$) showed no difference between counts of

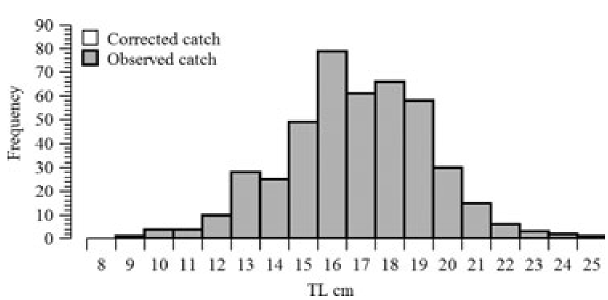

Fig. 2. Length frequency distribution of *Labeo cylindricus* from Lake Baringo.

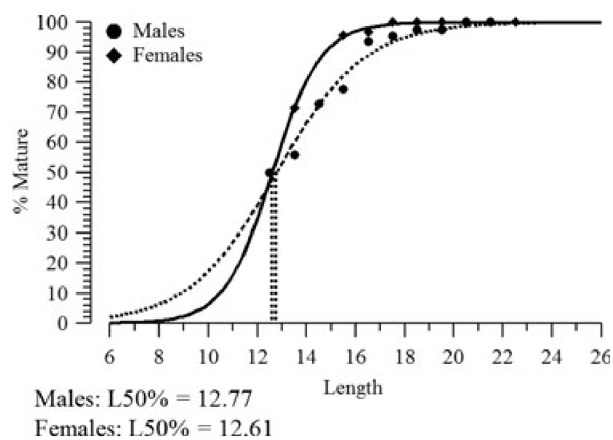

Fig. 3. Logistic ogives fitted to percentage of sexually mature *Labeo cylindricus* males and females from Lake Baringo (L50% = total length-at-50% maturity).

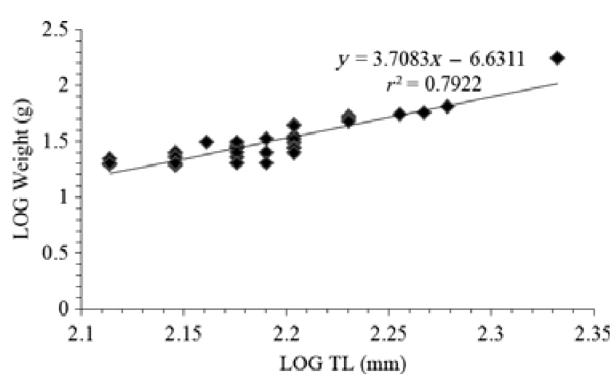

Fig. 4. Length–weight relationship of *Labeo cylindricus* from Lake Baringo ($n = 444$).

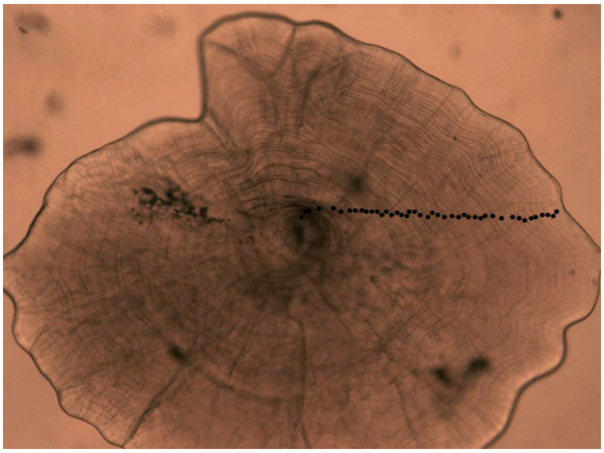

Fig. 5. Pictomicrograph of sagittal section of otolith of *Labeo cylindricus* (TL = 87 mm) from Lake Baringo (● = total number (43) of circuli counted).

the two readers. The TL exhibited a significant ($P < 0.05$) strong positive linear relationship with the age of fish (Fig. 6), as described by the equations: TL = 1.398 Age + 26.523 ($r^2 = 0.91$). The age ranged between 31 and 138 days. Most specimens (40) were <90 days, while only three were more than 90 days old. The weight and age of fish exhibited a significant ($P < 0.05$) power relationship (Fig. 7), as defined by the equation: $W = 0.0003$ age (days)$^{2.5804}$, $r^2 = 0.88$.

DISCUSSION

Britton and Harper (2006) indicated that *L. cylindricus* is abundant in Lake Baringo. This finding, however, was not reflected in commercial fish landings, with this species only accounting for about 0.06% of the total catches (Aloo 2002). The rarity in commercial catches might have formed the basis for classifying the species as threatened (Ramsar 2002). Its vulnerability was largely attributed to

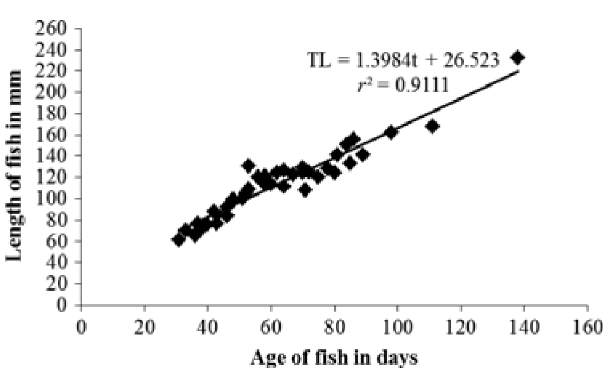

Fig. 6. Relationship between total length and age (t) of *Labeo cylindricus*, estimated from lapilli otolith of the species from Lake Baringo ($n = 43$).

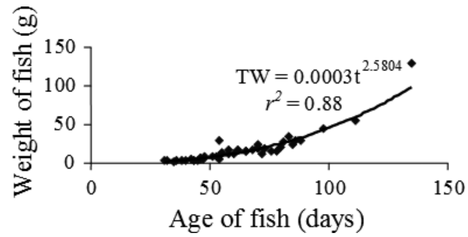

Fig. 7. Relationship between weight and age (t) of *Labeo cylindricus*, estimated from lapilli otolith of the species from Lake Baringo ($n = 43$).

the perceived interference of the spawning migration routes by the damming of the Molo and Perkkera rivers, the only perennial rivers flowing into the lake. The low (0.06%) contribution to the local fishery reported by Britton and Harper (2006) could be explained by the current use of a minimum legal gillnet of 88.9 mm mesh size. This type of gear is undoubtedly not able to catch the slender *L. cylindricus* (Skelton 1993; Britton & Harper 2006), thereby leaving it relatively unexploited in Lake Baringo. The abundance of the potamodromous species, in spite of the interference of its spawning migration routes, might be indicative of a change in its reproduction strategy in the lake.

The length–weight relationship indicated the species exhibited positive allometric growth. Similar growth ($b = 3.010$) for the species in Lake Baringo was reported by Britton and Harper (2006). Other water bodies also reported positive allometric growth for the same species, an example being Lake Chicamba in Mozambique, as reported by Weyl and Booth (1999). However, the low condition factor reported for the species is suggestive of undernourished or stressed fish. This could be a consequence of overcrowding, occasioned by underexploitation of species or by inadequate food (algae) in the lake (Schagerl & Oduor 2003), which is the main diet for *L. cylinrdicus* (Konings 1990).

Clear circuli were visible on *L. cylindricus* sagittal otoliths. These structures were thin and narrowly spaced towards the margins of otoliths. All the circuli, however, were easily read without prior grinding of the otoliths. Validation of the temporal periodicity of growth increments, using OTC marking, indicated that one growth increment was formed daily on the otoliths. The results indicated the species exhibits rapid growth (1.3984 mm day^{-1}) attaining up to 200 mm and over 100 g in only 120 days. This implies the species attains length-at-50% maturity in approximately 65 days (Figs 3 and 6). Similarly, Weyl and Booth (1999) reported that the species exhibits rapid growth in Lake Chicamba, Mozambique.

This study provides population parameters (size structure; sex ratio; length–weight relationship; condition factor; age; growth rate) for *L. cylindricus* stocks in Lake Baringo. It will be necessary to monitor trends of these biological parameters, examine the factors influencing them and predict the responses of fish populations to human interventions (exploitation) and natural environmental change, to advise policymakers regarding sustainable exploitation of this fish species in Lake Baringo and elsewhere.

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REFERENCES

Aloo P. A. (2002) Effects of climate and human activities on the ecosystem of Lake Baringo. In: East African Great Lakes: Limnology, Paleolimnology and Biodiversity (eds E. Odada & D. Olago) pp. 335–47. Kluwer Academic Publishers, Dordrech, Netherlands.

Beadle L. C. (1932) The waters of some East African lakes in relation to their fauna and flora. *J. Linn. Zool. Soc.* **38**, 157–211.

Britton J. R & Harper D. M. (2006) Length-weight relationships of fish species in the freshwater Rift Valley lakes of Kenya. *J. Appl. Ichthy.* **22**, 334–6.

Froese R. & Pauly D. (eds) (2011) FishBase. World Wide Web Electronic Publication, http://www.fishbase.org, version (06/2011).

Konings A. (1990) Ad Konings's Book of Cichlids and all the Other Fishes of Lake Malawi. T.F.H. Publications, Inc., Neptune City, NJ, USA, pp. 495.

Lévêque C. & Daget J. (1984) Cyprinidae. In: Checklist of the Freshwater Fishes of Africa (CLOFFA), vol. 1 (eds J. Daget, J.-P. Gosse & D. F. E. Thys van den Audenaerde) pp. 217–342. ORSTOM, Paris and MRAC, Tervuren.

Mlewa C. M. & Green J. M. (2006) Translocation of marbled African lungfish, *Protopterus aethiopicus* (Telostei: Protopteridae), and its fishery in Lake Baringo, Kenya. *J. Aquat. Scie.* **31**, 131–6.

Mlewa C. M., Green J. M. & Simms A. (2005) Movement and habitat use by the marbled African lungfish *Protopterus aethiopicus* Heckel 1851 in Lake Baringo, Kenya. *Hydrobiologia* **537**, 229–38.

Ogutu-Ohwayo R. (1990) The decline of the native fishes of Lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*. *Env. Biol. Fish* **27**, 81–96.

Ramsar (2002) Information Sheet on Ramsar Wetlands (RIS). Ramsar, Kenya, Lake Baringo. Available at http://ramsarris_kenya_baringo1.htm

Schagerl M. & Oduor S. O. (2003) On the limnology of Lake Baringo (Kenya): II. Pelagic primary production and algal composition of Lake Baringo, Kenya. *Hydrobiologia* **506–509**, 297–303.

Skelton P. H. (1993) A Complete Guide to the Freshwater Fishes of Southern Africa. Southern Book Publishers, Halfway House, Gauteng, South Africa.

Ssentongo G. W. (1974) On the fishes and fisheries of Lake Baringo. *Afr. J. Trop. Hydrobiol. Fish* **3**, 95–105.

Weyl O. L. F. & Booth A. J. (1999) On the life history of a cyprinid fish *Labeo cylindricus*. *Env. Biol. Fish* **55**, 215–25.