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Validation of daily growth of African catfish *Clarias gariepinus* (Burchell 1822) young-of-the-year from Lake Baringo, Kenya

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Abstract

The African catfish (*Clarias gariepinus*) is widely distributed in Africa, where it is a major food fish. The species comprises a significant component of commercial fishery landings in Kenya, and elsewhere in Africa. Nevertheless, little information or data exist on its age and growth characteristics, which is necessary for its sustainable management. This study determined this information from the microstructure of lapillar otoliths of the young-of-the-year (YOY) of the species. Analysis of the otolith microstructure from fish of known age confirmed that one growth increment (circulus) was formed per day, forming the basis for their use to accurately age *C. gariepinus* YOY collected from Lake Baringo during the months of August and September 2007. The derived length–age relationship correlated significantly (Pearson Correlation, df = 53, $P < 0.05$), indicating that the YOY exhibited an average growth rate of 0.2285 cm day^{-1}. The largest specimen attained a total length of 40.5 cm in only 169 days. These results indicate that native *C. gariepinus* exhibits rapid growth, achieving a large size during the first year. Thus, they can be recommended for purposes of aquaculture.

Key words

growth, age, validation.

INTRODUCTION

The African Sharptooth catfish (*Clarias gariepinus* (Burchell 1822)) has an almost Pan-African distribution, ranging from the Nile River Basin to West Africa and from Algeria to Southern Africa (Cambray 2003). They inhabit calm waters of lakes and rivers, where they are among the large freshwater fishes, with total lengths up to 130 cm and weights over 30 kg (Bruton 1979; Cambray 2003). They also are common in floodplain swamps and pools, many of which are prone to seasonal drying. The species can survive the low dissolved oxygen concentrations in these habitats, using aerial respiration aided by their accessory air-breathing organs (Bruton 1979). *C. gariepinus* also is an important food fish exploited in both subsistence and commercial capture fisheries in many parts of Africa. It also is generally considered to be one of the most successful species for tropical aquaculture (Clay 1979).

The native population of *C. gariepinus* found in Lake Baringo, Kenya forms the basis of a commercial fishery, along with the indigenous *Oreochromis niloticus baringoensis* Trewavas 1983, *Barbus intermedius australis* (Banister 1973) and the translocated *Protopterus aethiopicus* Heckel 1851 (Mlewa & Green 2006). The fishery has a long history of commercial exploitation. The fishery production ranged from 500 to 600 t year^{-1} in the 1960s, declining to <200 t year^{-1} by the late-1980s. Since that time, the catch has fluctuated, leading to periodic closures of the fishery during seasons of low catch (Hickley *et al.* 2004).

Despite the ecological and commercial importance of this species, little data exist on its growth within its distribution range in Africa. Britton and Harper (2006) reported that the species exhibits allometric growth, based on length–weight relationships of specimens from

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Lake Baringo, Kenya. Information on the age and growth of this exploited fish population is a necessary input for rational management decisions for both capture fisheries and aquaculture. This study was meant to provide baseline information on age and growth of the young-of-the-year (YOY) of *C. gariepinus* in Lake Baringo, based on daily growth rings on otoliths. This study also observed and validated, for the first time, the formation of daily growth rings on otoliths of this species in a tropical lacustrine environment.

MATERIALS AND METHODS

Fish samples were obtained from Lake Baringo, a shallow equatorial freshwater lake with a surface area of approximately 137 km^2 located in the eastern arm of the Rift Valley, Kenya (Beadle 1932) (Fig. 1; Mlewa *et al.* 2005). The lake lies between 0° 32′ and 0°45′ N, 36° 00′ and 36° 10′ E at an altitude of 975 m above sea level (Ssentongo 1974). Lake Baringo has no surface outlet, with its 'freshness' being attributed to the presence of an underground outlet at its northern end (Beadle 1932).

A total of 54 *C. gariepinus*, ranging in size from 9.0 to 40.5 cm total length (TL), with a mean of 22.16 cm ± (1.41 SE), caught by multi-filament gillnets were purchased from fishers at designated commercial fish landing beaches (Fig. 1). Each fish was assigned a serial number, measured for TL and standard length (SL) to the nearest 0.1 cm and weighed to the nearest gram (g). The head of each fish was cut and sectioned dorsal-ventrally, using surgical blades to expose the three pairs of otoliths, following the methodology of Cailliet *et al.* (1986). Lapillar

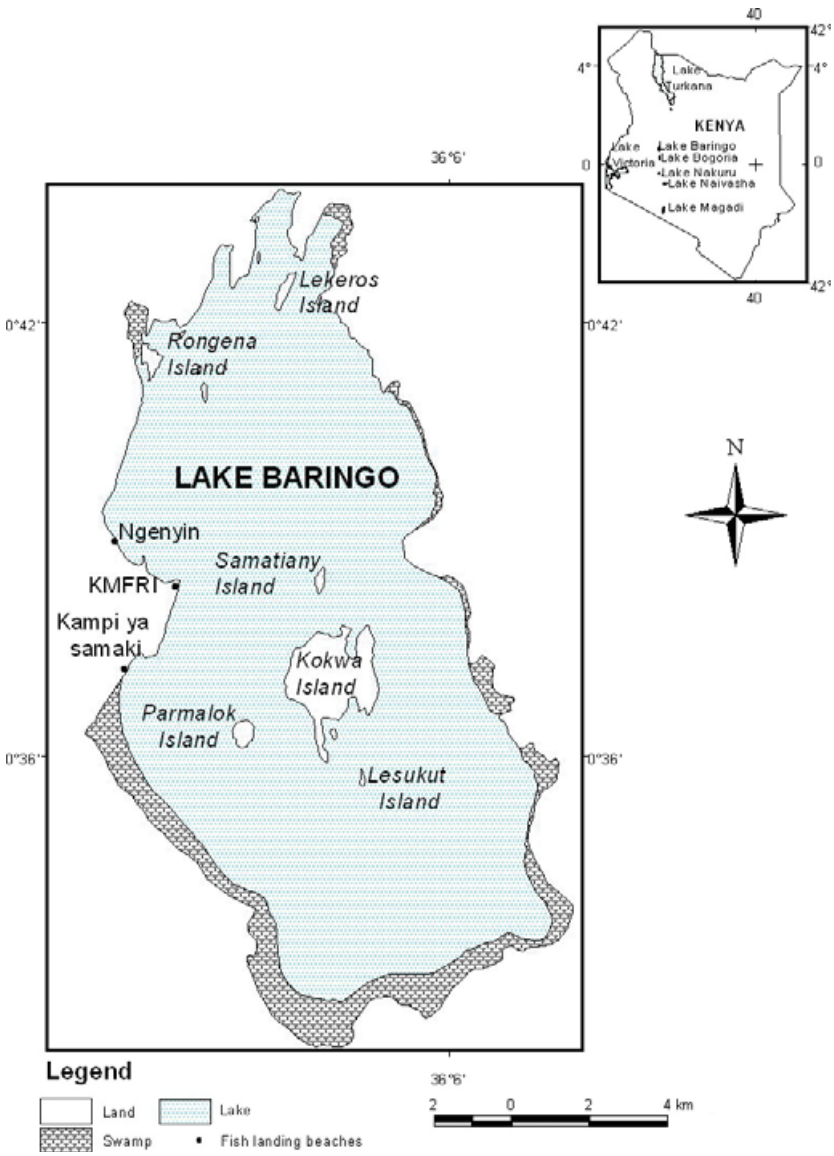

Fig. 1. Map showing fishing landing beaches in Lake Baringo where specimens for the present study were obtained (top right is map of major Kenyan lakes).

otoliths were then carefully removed with forceps and mounted on serially labelled microscope slides, using clear nail paint. The mounted slides were allowed to dry, and each otolith was ground gently with a fine grinding paper, to clarify growth rings. The ground otoliths were observed under a Leica DM IRB stereo microscope (under 40×, 100× and 200× magnification) and their images acquired using the IM500 Leica software for counting growth increments.

C. gariepinus fry of known age (23 days) were obtained from the Department of Fisheries and Aquatic Science hatchery at Moi University. This facility is located between 0°03′ and 0°55′N, 34°50′E at an altitude of 2180 m above sea level (Nyamweya *et al.* 2010). Ten fry (3.3–3.6 cm TL) were sacrificed and their otoliths removed and prepared as described for fish from the wild. The number of growth increments on otoliths of the fish was compared to their age in days. A *t*-test ($\alpha = 0.05$) was used to determine whether there were significant differences in the mean values of the observed and actual ages.

The relationship between length and weight of the fish was described by a power relationship, $W = aL^b$, where W is weight, L is length, and *a* and *b* are constants (Ricker 1973).

RESULTS

The length–weight relationship for the species was described by the equation W = 0.006 TL2.9301 (Fig. 2). The determined length exponent $b = 2.93$ from the relationship was not significantly different (*t*-test, df = 1, $P > 0.05$) from the isometric exponent value of 3.

Alternating dark and light bands were observed in all lapillar otoliths (Plate 1). The mean number of growth increments on otoliths of fish from the Fish Farm was 22.8 (±0.2 SE), which did not differ significantly from the known mean age of 23 days (Table 1). The results indicated that no significant difference in actual age and number of growth increments on otoliths (*t*-test, df = 18, $P > 0.05$). Thus, the validation procedure indicated a single growth increment was formed daily on lapillar otoliths of *C. gariepinus*.

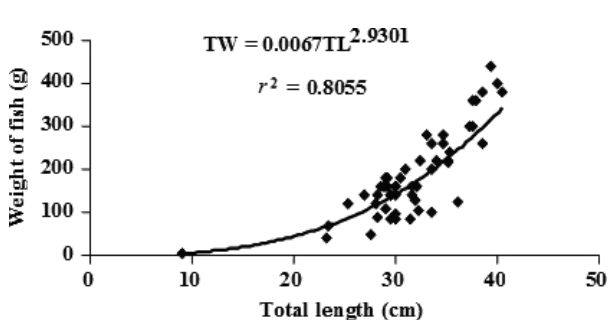

Fig. 2. The length–weight relationship of young-of-the-year *C. gariepinus* from Lake Baringo, Kenya.

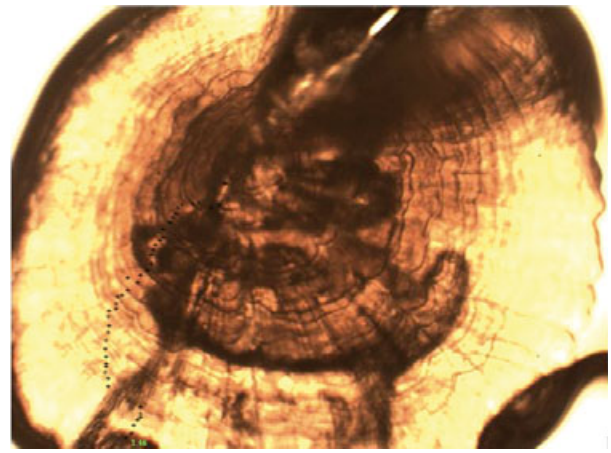

Plate 1. Pictomicrograph illustrating a lapillar otolith of 9.0 cm total length (TL) *C. gariepinus* from Lake Baringo, Kenya. (+ indicates counted circuli; total of 46).

Table 1. The observed number of circuli on otoliths of *Clarias gariepinus*.of known age

Fish number	Age (days)	Observed number of Circuli
1	23	23
2	23	22
3	23	23
4	23	23
5	23	23
6	23	23
7	23	21
8	23	23
9	23	23
10	23	24
Mean		22.8 (±0.2 SE)
t-test		df = 18, $P = 0.22$

The fish age expressed in days exhibited significant (Pearson Correlation, df = 53, $P < 0.05$) relationships with TL and SL, as described by the equations: TL = 0.2285 t + 1.5103 ($r^2 = 0.82$) and SL = 0.2013 t + 1.5989 ($r^2 = 0.83$; Fig. 3). Most specimens (63%) were aged between 120 and 169 days. An average growth rate of 0.2285 cm day^{-1} for the species was observed from the total length–age relationship (Fig. 3). The fish weight and age exhibited a significant (Pearson Correlation, df = 53, $P < 0.05$)

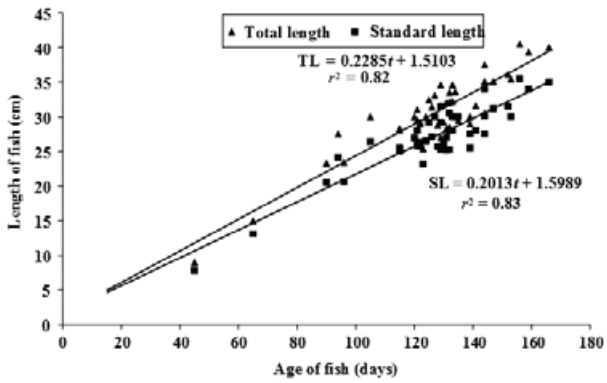

Fig. 3. The relationship between length and age (*t*) of *C. gariepinus*, estimated from lapillar otolith samples from Lake Baringo, Kenya.

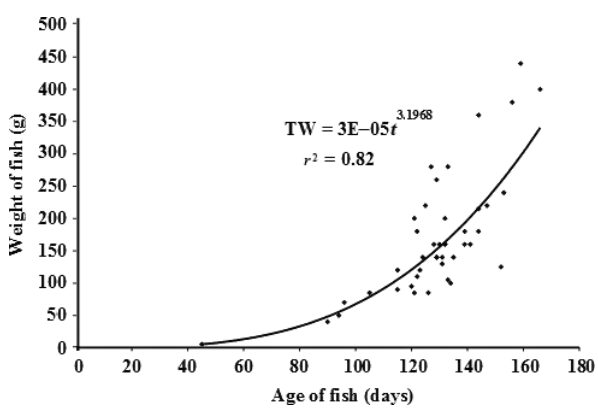

Fig. 4. The relationship between weight and age (*t*) of *C. gariepinus*, estimated from lapillar otolith samples from Lake Baringo, Kenya.

power relationship, as described by the equation: $W = 0.00003t^{3.1968}$ ($r^2 = 0.82$; Fig. 4).

DISCUSSION

The length exponent (*b*) value of 2.93 for the length–weight relationship was not significantly different from the value of 3, suggesting the species exhibits isometric growth. This is contrary to the findings of Britton and Harper (2006), who reported positive allometric growth for the species in the same lake. The difference might be related to the sample size and size range of the specimens used in the two studies. The findings of Britton and Harper (2006) were based on a smaller sample of 19 specimens, ranging in size from 16.5 to 44.3 cm. In one study of two *C. gariepinus* populations from Bangweulu Swamps and Lake Kariba, however, Kolding *et al.* (1996) reported isometric growth for the Bangweulu Swamp, and positive allometry for the Lake Kariba fish population. Such differences in length–weight growth patterns could reflect temporal and spatial variations related to environmental effects on the growth of fish (Pitcher & Hart 1994).

Lapillar otoliths were found to be reliable in the present study, because their growth increments were thick and spaced sufficiently apart to be easily resolved from each other. Validation of the temporal periodicity of growth increments on lapillar otoliths, using known-age fish, indicated that one growth increment was formed daily on otoliths. This finding is consistent with that of Jones (1986), who reported that 'many validation studies have, on average, determined that increments are daily in periodicity,' thus substantiating the choice of the method adopted in this present study. The significant length–age and weight–age relationships determined in this study are useful information for future studies directed to the age structure of the African catfish population in Lake Baringo. The total length–age relationship, however, had a stronger r^2 value. Thus, fish length was the more dependable estimator of age of this species and should preferably be used in future studies directed to describing the age structure of *C. gariepinus* populations in Lake Baringo.

C. gariepinus are known to be slow-growing and long-lived (Bruton 1979; Cambray 2003). However, the growth rate recorded for the YOY in this current study is very high, compared to that of other fish species in Lake Baringo (Nyamweya 2009). This observation can explain why the species coexists with *O. niloticus* in many ecosystems (including Lake Baringo), whose YOY is known to outcompete other juveniles by exhibiting rapid growth (Fryer & Iles 1972). Given the reported high growth rate and big sizes attained by *C. gariepinus* YOY, they are potential species for aquaculture development. If adopted for aquaculture, the successful propagation of the African Sharptooth catfish could help mitigate the dwindling catch rates in the wild, thereby ensuring food security, and improving the livelihoods of the impoverished residents in the Lake Baringo basin.

CONCLUSIONS

This study showed that the lapillar otoliths of *C. gariepinus* had clearly discernible growth increments, with a daily rate of deposition useful for ageing the species. Fish length was a better predictor of age of *C. gariepinus*, compared to its weight. Fish growth, estimated for the first time for the Lake Baringo population, suggests the species YOY exhibits high growth rates and, therefore, has good potential for aquaculture to supplement the dwindling capture rates.

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