Received: 4 September 2019 | Revised: 25 December 2019 | Accepted: 7 January 2020
DOI: 10.1111/lre.12304

ORIGINAL ARTICLE

Lakes & Reservoirs WILEY

Biological aspects of *Schilbe intermedius* (Ruppell, 1832) in the Nyanza Gulf of Lake Victoria, Kenya

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Abstract

Silver butter catfish (*Schilbe intermedius*) is an indigenous fish species in Lake Victoria. It has a good economic value because of the quality and freshness of its flesh, increasing its demand for consumption. It is potamodromous, with its stock in the lake declining because of overexploitation by the use of illegal fishing gears at the river mouths on their way to spawning areas. Fish samples (321) were obtained from commercial gill net (1.5–3 in.) fishers within Nyanza gulf. The fish samples were weighed (g) and measured (cm), dissected and sex determined by visual inspection of the gonads. Ovaries for mature female fish specimens were preserved for analysis of fecundity. Fecundity was determined by the gravimetric technique. The mean (±*SE*) length and weight for all fish were 18.2 ± 0.2 cm TL and 51.9 ± 1.9 g, respectively. The female fish (20.0 ± 0.2 cm) were significantly ($F = 199.80$, $p < .05$) larger than the males (15.9 ± 0.1 cm). Similarly, the females (68.8 ± 2.6 g) were significantly ($F = 152.61$, $p < .05$) heavier than the males (30.93 ± 1.02 g). The overall sex ratio was 1.23:1.0 (female:male). The length frequency exhibited a unimodal distribution, with the modal class between 16 and 18 cm for either sex. The regression slope (b) of the length–weight relationship was 3.2, 3.1 and 3.0 for all fish, females and males. The absolute fecundity ranged from 6,510 to 59,818 eggs, with a mean of 34,473 eggs. The length at 50% maturity was estimated to be 16.0 cm (female) and 18.0 cm (male) fish. The mean length and size at maturity of *S. intermedius* have declined, likely attributable to fishing effects, changes in food resources, competition and predation. Thus, the present study provided relevant biological data of *S. intermedius*, which is currently limited for this region.

KEYWORDS
fecundity, maturity, relative condition, *Schilbe intermedius*

1 | INTRODUCTION

The most important commercial fish species in Lake Victoria until the 1960s were *Schilbe intermedius*, *Protopterus aethiopicus*, *Clarias gariepinus*, *Bagrus docmak*, *Momyrids*, *Labeo victorionus*, and the tilapiine species *Oreochromis esculentus* and *O. variabilis* (Ogutu-Ohwayo, 1990). When *Lates niloticus*, *O. niloticus*, *O. leucostictus*, *Tilapia zillii* and *T. rendalii* were introduced, the lake ecological system changed because of predation and competition for food (Yongo, Outa, Kito, & Matsushita, 2017). In the early 1990s, *B. docmak*, *C. gariepinus* and *S. intermedius* were the top predators in Lake Victoria (Corbet, 1961). Since then, however, the stocks of catfish species in the lake have continued to decline due to intense Nile perch predation, overfishing and changes in the lake conditions attributable to eutrophication (Goudswaard &

Witte, 1997; Yongo, Agembe, Outa, & Owili, 2018a). *Schilbe intermedius* has been documented as a commercially important fish species in a number of African countries, especially Botswana, Nigeria and Ghana (Abobi & Ekau, 2013; Uneke & Alionye, 2015). This fish was one of the commercial species in Kenya before the introduction of Nile perch (Goudswaard & Witte, 1997), although it is still being caught in small numbers. It has a good economic value because of the quality and freshness of its flesh, resulting in high pressures on its stock because of increased demands for consumption.

Schilbe intermedius, also known as Silver butter catfish, is an indigenous fish in Lake Victoria. It is classified in the Order Siluriformes and Family Schilbeidae. It is sexually dimorphic, with females growing larger than males (Merron & Bruton, 1988). It mainly inhabits shallow waters of the lake and the lower reaches of a river. It breeds throughout the year, with peaks in the rainy seasons when it migrates in schools into the river to spawn in flood water pools. *Schilbe intermedius* is an opportunistic predator, feeding across several trophic levels. It exhibits an ontogenetic shift in which juveniles feed on macroinvertebrates, while the adults feed on fish and aquatic plants, thereby reducing food competition (Merron & Bruton, 1988). They are potamodromous, with their stocks in Lake Victoria continuing to decline because of overexploitation by the use of illegal fishing gears at the river mouths as they swim to spawning areas, catching both mature and juvenile fish. Thus, the present study investigated some aspects of its biology, emphasizing its length–weight relationship, condition factors, size at maturity and fecundity, with such information being necessary for the effective management of the fishery.

2 | MATERIALS AND METHODS

Nyanza Gulf of Lake Victoria has several inflowing rivers, including the Nyando, Kisat and Kisian rivers. Fish samples (321) for the present study were obtained from commercial gill net (1.5–3 in.) fishers within the gulf from April to June 2019 from four sites, including Nduru, Usoma, Nyamware and Oseth. The samples were weighed (g) and measured for standard length (cm SL), fork length (cm FL) and total length (cm TL). The fish specimens were then dissected and sex determined by visual inspection of the gonads. The fish were classified into different maturity stages using a 1–6 gonadal maturity index, where stages 1 = inactive; 2 = active; 3 = active ripe; 4 = ripe; 5 = ripe running; and 6 = spent (Table 1). The fish at stage 3 and above were considered sexually mature for purposes of estimating their length at 50% maturity. The ovaries for fish specimens at stages 4 and 5 were preserved in 4% formalin and subsequently transported to the University of Eldoret Fisheries Laboratory for analysis of fecundity.

The length–weight relationship was estimated using the formula:

$$W = a \times TL^b \quad (1)$$

The relative condition factor was calculated as:

$$K = \frac{W}{a \times TL^b} \quad (2)$$

Fecundity was determined using the gravimetric method. All the eggs were weighed (0.001 g), and random samples were weighed and counted. The absolute fecundity (AF) was calculated using the formula described by Yongo, Olukoye, Makame, & Chebon, (2019):

$$AF = \frac{nG}{g} \quad (3)$$

where AF = absolute fecundity; n = number of eggs in sub-sample; G = total weight of the ovaries; and g = weight of sub-sample.

The average size at first maturity (L_{50}) referred to TL at which 50% of individuals in the fish population reach sexual maturity during the reproduction period. It was estimated by modelling the proportion of mature individuals to their respective length classes based on the logistic function:

$$P = \frac{1}{1 + e^{-a(L-b)}} \quad (4)$$

where P = proportion of mature fish by length class; L = total length class; and a and b are model parameter estimates of which $b = L_{50}$.

3 | RESULTS

The overall sex ratio was 1.23:1.0 (female: male). The mean (±*SE*) length and weight for all fish were 18.2 ± 0.2 cm TL and 51.9 ± 1.9 g, respectively (Table 2). The females (20.0 ± 0.2 cm TL) were significantly (F = 199.80, p < .05) larger than the males (15.9 ± 0.1 cm TL). Similarly, the females (68.8 ± 2.6 g) were significantly (F = 152.61, p < .05) heavier than the males (30.93 ± 1.02 g). The relative condition factor was equal to 1 for either sex and for all the sites. The length frequency exhibited a unimodal distribution, with the modal class between 16 and 18 cm TL for either sex (Figure 1a). The relationship between TL-FL and TL-SL is illustrated in Figure 1b and c, respectively, with the coefficient of determinations being 0.96. The regression slope (b) of the length–weight relationship for all fish was 3.16 (Figure 1d), indicating a positive allometric growth pattern. The fish exhibited a slightly positive allometric growth pattern for nearly all the sites (Figure 2), except for Usoma (Figure 2c). The value of the slope b was equal to 3.1 and 3.0 for female and male fish, respectively (Figure 3a and b). The absolute fecundity ranged from 6,510 to 59,818 eggs, with a mean of 34,473 eggs. The fecundity exhibited a positive correlation with the total length of the fish (Figure 3c, R^2 = 0.61). The length at 50% maturity was estimated to be 16.0 and 18.0 cm TL for female and male fish, respectively (Figure 3d).

TABLE 1 Maturity stages for *S. intermedius* classified according to Owiti and Dadzie (1989)

Stage	Male	Female
Stage 1	Immature: A pair of small, thread-like elongated organs with slightly serrated edges	Immature virgin: Colourless to translucent brown lanceolate and globular appearance occupies about 1/4 of body cavity
Stage 2	Developing: Translucent white testis occupying about 1/3 of body cavity	Developing virgin: Translucent, brown occupies about 1/3 of peritoneal cavity
Stage 3	Maturing: Testis more elongated, occupying about 1/2 of body cavity and white in colour	Maturing: Opaque brownish green in egg yolk ladened clearly visible to naked eye
Stage 4	Early ripening: Testis thick and straight	Ripe: Large opaque, brownish green; egg yolk ladened clearly visible to naked eye
Stage 5	Ripe: Testis thick and straight; mint out with slight pressure	Spawning: Translucent eggs easily extrude on slight pressure
Stage 6	Spent: Testis shrunken and flaccid; serrated edges revert to original sharp condition	Spent: Very flaccid, flabby and blood shot with thick whitish tough walls

TABLE 2 Descriptive statistics of length, weight and relative condition factor

Site/sex	*n*	SL (cm)	FL (cm)	TL (cm)	W (g)	K
Nduru	74	15.5 ± 0.4	16.4 ± 0.4	18.6 ± 0.4	57.73 ± 4.63	1.01 ± 0.03
Nyamware	93	15.5 ± 0.2	16.4 ± 0.2	18.3 ± 0.2	47.77 ± 2.36	1.00 ± 0.02
Oseth	66	12.8 ± 0.2	13.7 ± 0.2	15.3 ± 0.2	25.42 ± 1.61	1.00 ± 0.03
Usoma	88	16.5 ± 1.5	17.4 ± 0.4	19.2 ± 0.4	65.76 ± 3.86	1.01 ± 0.02
All sites	321	15.7 ± 0.5	16.3 ± 0.2	18.2 ± 0.2	51.85 ± 1.90	1.01 ± 0.01
Females	154	17.7 ± 0.8	17.9 ± 0.2	20.0 ± 0.2	68.82 ± 2.64	1.01 ± 0.01
Males	125	13.3 ± 0.1	14.3 ± 0.1	15.9 ± 0.1	30.93 ± 1.02	1.01 ± 0.02

Abbreviations: FL, fork length; SL, standard length; TL, total length; W, weight.

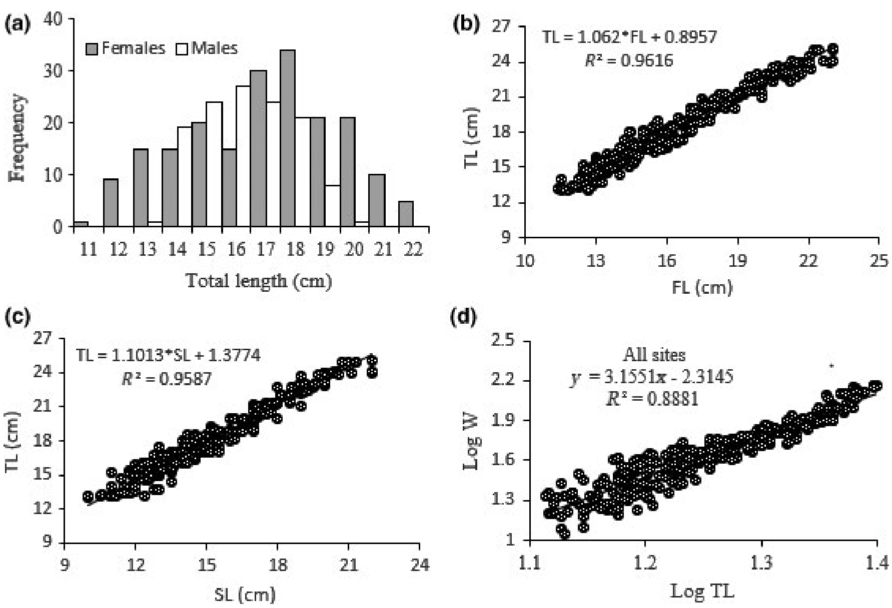

FIGURE 1 (a) Length-frequency distribution of male and female fish; (b) Total length-Fork length (TL-FL) relationship; (c) Total length-Standard length (TL-SL) relationship: and (d) Log TL-Log W relationship

4 | DISCUSSION

The female fish tended to grow larger than the males, a finding in agreement with that of (Merron & Bruton, 1988) who found larger female *S. intermedius* than males in Okavango Delta in Botswana. The results of the present study indicated that females dominated males (1.23:1.0), also in agreement with Uneke and Alionye (2015), who reported a sex ratio of 1.2:1 in favour of the females. The overall slope of 3.16 of the length–weight relationships is comparable to 3.30 for *S. intermedius* in the Olifants River in South Africa (Addo, Jooste, & Luus-Powell, 2014). The variations in *b* between study sites may be attributable to differences in the environmental conditions. The *b* value can be used as an indicator of food intake and may differ according to biotic and abiotic factors, food availability and habitat type (Yongo et al., 2017). Length–weight relationships for fish have been used extensively to provide

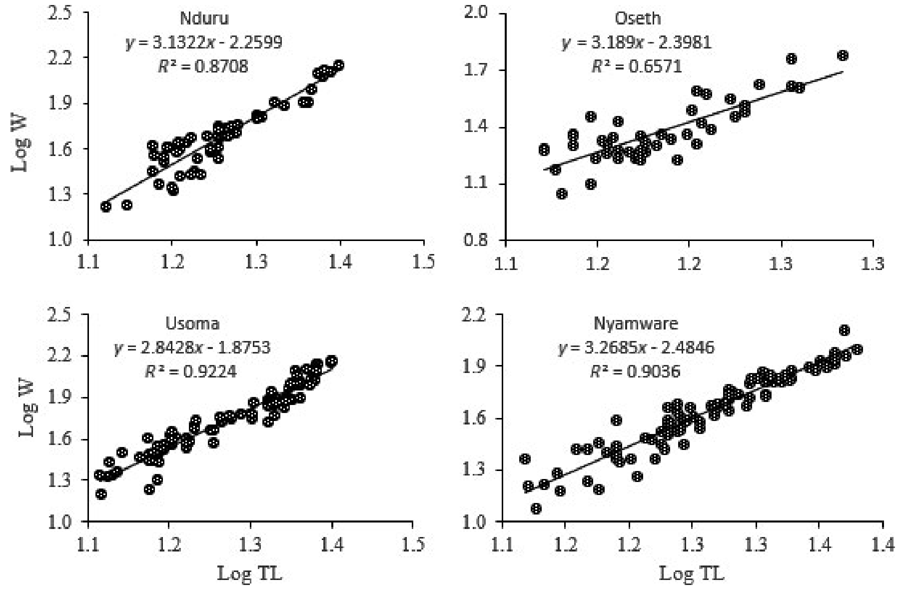

FIGURE 2 Log TL-Log W (TL-W) relationship from the four sites

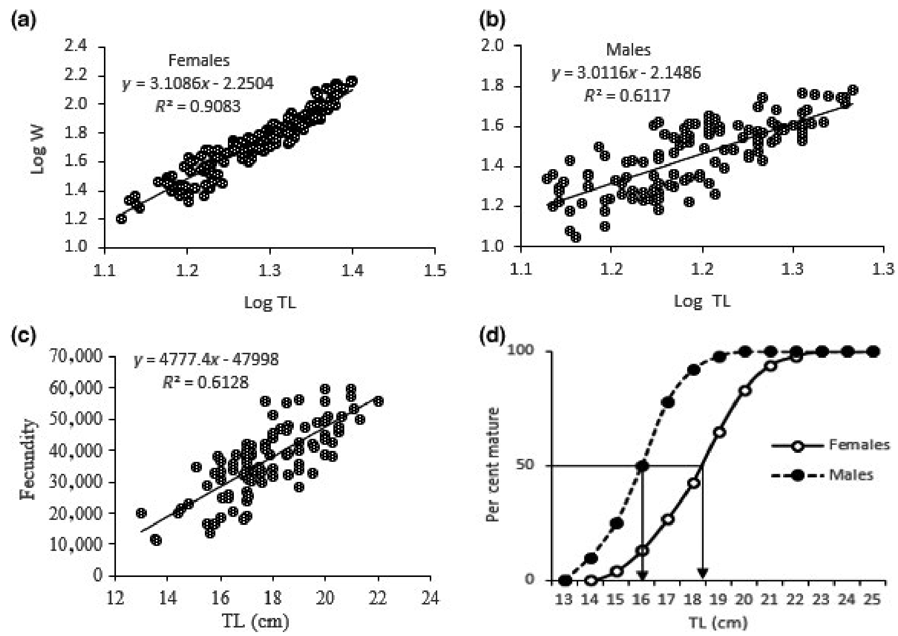

FIGURE 3 (a) Log TL-Log W relationship for female fish; (b) Log TL-Log W relationship for male fish; (c) Fecundity-TL relationship; and (d) Length at 50% maturity for male and female fish

information on the condition of fish and their isometric or allometric growth (Yongo, Outa, Kito, & Matsushita, 2018b). The values of the condition factor for the present study indicated the fish were not in good condition, since these values were not within the range of 2–4 recommended by Bagenal and Tesch (1978) for freshwater fishes. This finding could be attributable to the available food resources and poor environmental conditions observed in the gulf. The condition factor is strongly influenced by both biotic and abiotic environmental conditions and can also be affected by factors such as sex, season, age and the maturity status of the fish (Edah, Akande, Ayo-Olalusi, & Olusola, 2010).

The length of *S. intermedius* has greatly declined over time. In the early 1990s, *S. intermedius* in Lake Victoria grew to a larger length of up to 42 cm FL and weighed 1,190 g (Goudswaard & Witte, 1997), being attributable to food availability and low fishing pressures on the stock during those periods. Although *Schilbe intermedius* previously used to feed on haplochromine species, the haplochromine species in the lake declined since the introduction of Nile perch because of intense predation. After the depletion of haplochromines, the Nile perch started feeding on other fish species, including *S. intermedius* (Goudswaard & Witte, 1997). Changes in food, competition and predation by Nile perch affected the growth of *S. intermedius* (Ogutu-Ohwayo, 1990), with the fish observed to mature at smaller sizes. The reduced size at maturity may be a strategy to maximize reproductive success (Yongo, Outa, et al., 2018b). The overall fecundity of 34,473 eggs found in the present study was higher than the 22,421 eggs reported by Montcho, Chikou, Lalèyè, and Linsenmair (2011). The high fecundity is an adaptive strategy associated with maximizing fish per capita population increase. In conclusion, *S. intermedius* in the Nyanza Gulf of Lake Victoria has exhibited a reduced mean length and size at maturity, with such observations possibly indicating increased fishing pressures.

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How to cite this article: Mutethya E, Okoth S, Yongo E. Biological aspects of *Schilbe intermedius* (Ruppell, 1832) in the Nyanza Gulf of Lake Victoria, Kenya. *Lakes & Reserv*. 2020;25:44–48. https://doi.org/10.1111/lre.12304