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Morphological features and length-weight relationships of *Sarotherodon galilaeus* from Oyan Lake, Southwestern Nigeria

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Abstract

Oyan Lake is one of the major sources of fish protein supply to many parts of Southwestern Nigeria. Investigation was conducted on the biometrics, length-weight relationship and condition factor of *Sarotherodon galilaeus* in Oyan Lake. Fish samples were obtained from fishermen using gillnets, hook and line, cast nets and traps. One hundred and thirty samples of *S. galilaeus* were collected for the study, comprising eighty-three (83) males and forty-seven (47) females with sex ratio of 1:0.57 (male:female). The mean total lengths for combined sexes, males and females were 15.5±0.15, 15.7±0.19 and 15.3±0.26cm while the mean total weights were 81.0±2.78, 83.8±0.56 and 75.9±4.70g, respectively. No significant difference ($p>0.05$) was observed between mean total lengths of males and females. However, mean weight of males was significantly higher ($p<0.05$) than females. Mean eye diameter (EYD) and length of caudal peduncle (LCP) were significantly higher ($p<0.05$) in females. The range of number of pectoral rays (PRA) (12-14), number of pelvic rays (PVR) (4-5), number of anal spines (ANS) (2-3) and number of pelvic spines (PEVS) (1, no range) were the same in both sexes. There was strong correlation between weight/total length ($r=0.93$) and total length/length of dorsal fin base ($r=0.72$), while there was no correlation between body depth/head length. The mean condition factor (k) were 2.07±0.02 (combined sexes), 2.08±0.03 (males) and 2.03±0.03 (females). Growth was isometric for both sexes: males, 3.24 and females, 3.06. The results suggested that Oyan Lake is suitable for *S. galilaeus*.

Introduction

Fish is one of the sources of cheap animal protein. According to FAO (2018), fish contributed 17% of animal protein consumed by the world population. Fisheries significantly contribute to income, livelihoods, food security and employment. Besides, it has socio-cultural benefits in some places. The family Cichlidae are dominantly freshwater fish, three genera (*Oreochromis, Sarotherodon and Tilapia*) are common, though Olaosebikan and Raji (2013) identified ten genera in Nigerian waters. They are exclusively associated with Africa and the Middle East (Trewavas 1983). They are particularly well known for having evolved rapidly into a large number of closely related but morphologically diverse species within large lakes (Meyer 2005). It is estimated that Africa alone hosts at least 1,600 species (Nelson 2006). Cichlids are highly abundant and commercially important in natural and man-made lakes in Nigeria. Generally, they differ greatly in size and taxonomic group (Olojo *et al* 2003) and are widely distributed throughout natural and artificial freshwater systems in tropical regions (Morales 1991; Akindele and Fagbuaro, 2022).

The study of fish species with preference to morphometric, length-weight relationship (LWR) and condition factor (k) is an important aspect of fish biology because this provides information on growth patterns, life span, age at maturity and stock composition. The analysis of LWR of a fish species could provide fundamental insights and serves as essential input into the study of the ecology, population dynamics and management of that species (Ighwela *et al* 2011; Alam *et al* 2014 and Gebremedhin *et al* 2021).

In fish biology, the condition factor is used to know the wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Bagenal 1978). Condition factor is also a useful index for monitoring of feeding intensity, age and growth rates in fish (Oni *et al* 1983) and the influence of both biotic and abiotic environmental conditions (Anene 2005).

Generally, it has been observed that there is a decline in fish production in Oyan Lake (Adeosun 2016) despite the introduction of commercial cage culture of cichlid species in the lake. This was evidenced by small size of individual fish and quantity of fish species landed by the fishermen. S*arotherodon galilaeus* is one of the major commercially important fish species in the lake. Previous studies on *S. galilaeus* in Oyan Lake include Adeosun (2016) that studied the food and feeding ecology. This study was carried out to evaluate

the morphological features and LWR of *S. galilaeus* in Oyan Lake in order to deepen understanding of the ecology and productivity of the species and provide vital information necessary for its sustainable management.

Materials and methods

Description of study area

Oyan Lake is a man-made lake located between latitude 7°15′N and longitude 3°16′E in Abeokuta North Local Government Area of Ogun State in Southwest Nigeria (Figure 1). It has a catchment area of approximately 9,000km² and it is on an elevation of 43.3m above sea level on the confluence of Oyan and Ofiki rivers, both tributaries of Ogun River (Ofoezie *et al* 1991). The major riparian fishing communities include Akiro, Apojola, Abule Sikiru and Abule Titun. It is influenced by a rainy season from March to October and dry season from November to February (Ofoezie *et al* 1991).

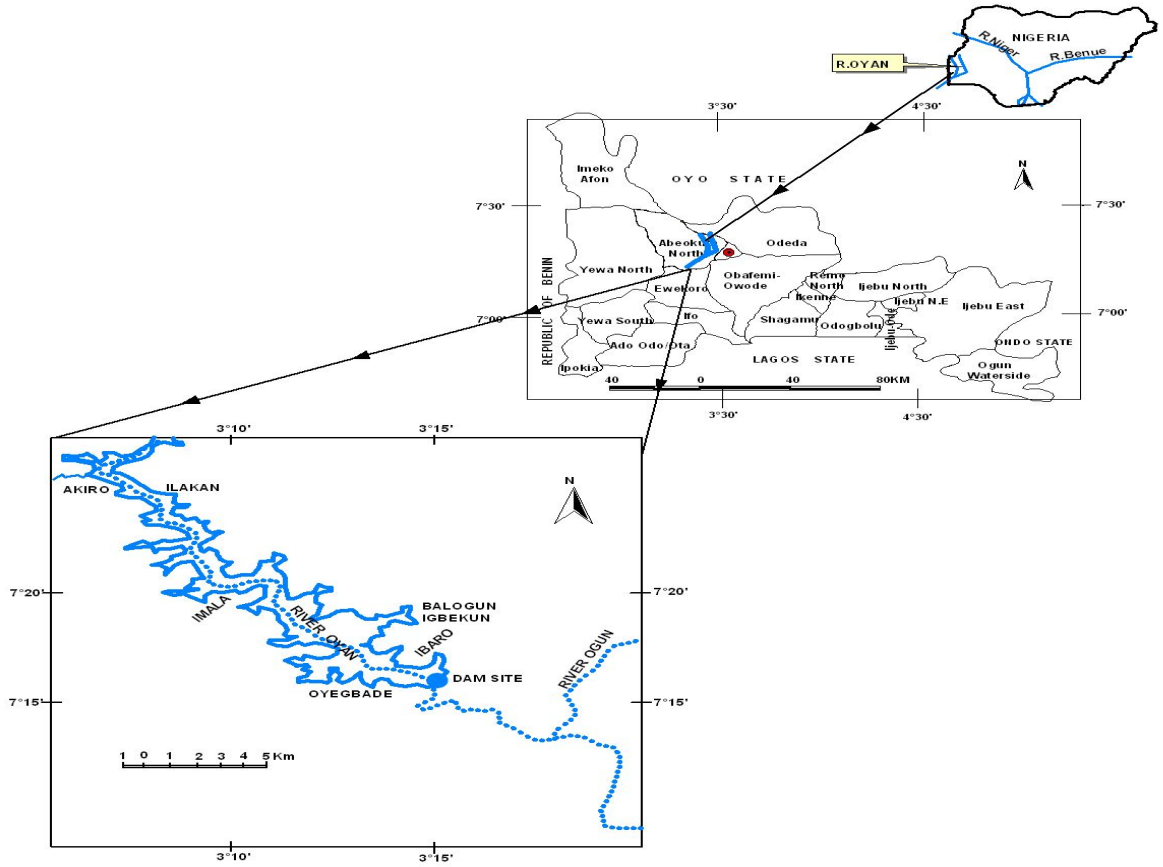

Figure 1. Map of Oyan Lake with an insert of maps of Oyo State and Nigeria

Oyan Lake is owned and managed by the Ogun-Osun River Basin Development Authority (O-ORBDA). It was primarily built to supply water for municipal use, generate electricity and dry season irrigation for agricultural crops. Capture fisheries activities were secondary at the inception. However, since its impoundment, fisheries activities have been on the increase and it is currently a major fish source leading to recent introduction of tilapia cage culture to boost fish supply from the lake.

Collection of fish samples

A total of one hundred and thirty fish samples of *S. galilaeus* were collected from fishermen at landing sites of the lake. Collected fish samples were stored in ice chest and moved to the laboratory for biometric analysis.

Laboratory procedures

In the laboratory, meristic and morphometric measurements were taken and recorded. Individual fish was weighed to the nearest 0.1g using top loading scale (Camry, model: EK5350). The morphometric characters measured were standard length (SL), total length (TL) and body depth (BD) to the nearest 0.1cm with a measuring board. Other measurements were snout length (SNL), eye diameter (EYD), head length (HLT), length of dorsal fin base (LBD), length of pectoral fin (LPF), length of pelvic fin (LPVF), length of anal fin Base (LAB), length of caudal peduncle (LCP) and depth of caudal peduncle (DCP) using digital vernier caliper to the nearest 0.1mm. Meristic characters investigated were number of dorsal rays (DRA), dorsal spines (DOS), pectoral rays (PRA), pelvic rays (PVR), pelvic spines (PEVS), anal rays (ARA) and anal spines

(ANS). Individual fish was genitally examined to determine the sex.

Data analysis

Descriptive and inferential statistics software in Statistical Package for Social Sciences (SPSS, version 20) and Microsoft Excel (graphical representations) were used to analyze the data. Student t-test was used to detect significant difference between the sexes. Correlation analysis was performed to reveal the relationship between the measured variables. Detected outliers were removed according to Froese (2006).

Length-weight relationship was determined by linear regression using logarithmic equation:

log W=log a + b* log L (Sparre and Venema 1992; Froese 2006)

where W=weight (g), L= total length (cm), a=y-intercept (constant), b=slope of the graph.

The growth coefficients, b-values, for male, female and combined sexes were tested if they were significantly different from 3 which is the isometric growth.

$t = [3 - (b\_calculated)] / SE_b$ (Sokal and Rohlf 1998)

Where t=t-test, b_calculated=b value of the regression, SE_b = standard error of b.

The condition factor (k) was calculated according to Pauly (1983):

$k = 100 \times \{WT / (L^3)\}$

where k=condition factor, W=weight (g), L=total length (cm).

Sex ratio of the fish specimen was expressed as:

$$Sex\ Ratio = \frac{Number\ of\ male}{Number\ of\ female}$$

Results

Eighty three (83) of the 130 specimens of *S. galilaeus* examined were males and 47 were females, giving a sex ratio of 1:0.57 (male:female). The WT of the specimen for combined sexes, male and female ranged between 33.2-175.2g (mean = 81.0±2.78g), 34.8–175.2g (mean: 83.8±0.56g) and 33.2-152.9g (mean: 75.9±4.70g), respectively as shown in Table 1. The TL were 11.9-19.5cm (15.5±0.15cm), 11.9-19.5cm (15.7±0.19cm) and 12.1-19.3cm (15.3±0.26cm) for combined sexes, male and female fish, respectively. The range of values of the meristic characters (PRA, PVR, PEVS and ANS) were the same in male and female fish except the number of anal rays (ARA) where the minimum was 9 and 10 rays in male and female, respectively.

The results of the regression analysis of length-weight relationship of combined sexes, male and female are graphically depicted in Figures 2, 3 and 4, respectively. The b-values (growth coefficient) obtained were 3.18, 3.24 and 3.06 for combines sexes, male and female, respectively. The values are not significantly different (p>0.05) from 3. The regression coefficients (r) for combined sexes (0.95), male (0.94) and female fish (0.95) were high and positive. The coefficient of determination (R^2) followed similar pattern and were 0.90 (combined sexes), 0.89 (male) and 0.91 (female), respectively. The mean index of well-being (condition factor) of fish were 2.07±0.02 (combined sexes), 2.08±0.03 (male) and 2.03±0.03 (female) for *S. galilaeus* of Oyan Lake (Table 1). No significant difference in condition factor was observed between male and female fish. High positive correlation values 0.93, 0.74, 0.78 and 0.72 were observed between (WT/TL), WT/SL, SL/TL and TL/LDB, respectively (Table 2). However, no correlation (r=0) was established between SL/EYD and BD/HLT.

Discussion

The maximum total weight of *S. galilaeus* recorded in the present study is higher than 92.0g, 93.3g and 113.52g reported by Kumolu-Johnson and Ndimele (2011) in Ologe Lagoon, Nigeria and Amoo and Komolafe (2016) in Strabag Lake, Nigeria and Elorm (2019) in Bontanga Reservoir, Ghana. However, it was lower compared with the report of Olanrewaju *et al* (2016) on Asejire Lake, Nigeria. Abdul *et al* (2010) documented an average weight of 452.53±2.09g in Ogun Estuary, Nigeria while Olopade *et al* (2018) reported a maximum total weight of 363g in New Calabar River, Nigeria. Odulate *et al* (2013) and Odulate (2015) reported significantly higher (p>0.05) mean weight in male *Oreochromis niloticus* (212.1±5.8g) and *Coptodon zilli* (83.5±7.75g) than female fish in Oyan Lake, Nigeria with an average weight of 90.7±3.4g and 166.2±4.75g for both species, respectively. Adeosun (2016), Olopade *et al* (2018) and Elorm (2019) recorded highest total length of 19.1cm in Oyan Lake, Nigeria, 25.3cm in New Calabar River, Nigeria and 17.4 cm in Bontanga Reservoir, Ghana for *S. galilaeus,* respectively. While Olanrewaju *et al* (2016) documented maximum standard length of 24.8cm for *S. galilaeus* in Asejire Lake, Nigeria. The mean total length and weight of 27.07cm and 452.53g were documented in Ogun Estuary (Abdul *et al* 2010). In Asejire lake, Ero and Opa reservoirs, Oladimeji *et al* (2020) reported mean head length of 38.32±0.46, 34.46±0.68 and 47.1±1.05mm for *S. galilaeus*. Also, they noted range of dorsal spines 15-17 (Opa and Ero reservoirs), 16-17 (Asejire lake) and anal fin rays of 10-12 (Opa reservoir), 8-13 (Asejire lake) for *S. galilaeus*. However, the range of pectoral rays (PRA), pelvic rays (PVR) and anal spines (ANS) in male *S. galilaeus* was the same in the female fish in Oyan Lake, Nigeria. Oladimeji *et al* (2020) documented the anal spines for *S. galilaeus* in Asejire lake, Ero and Opa reservoirs, Nigeria. The variations observed in measured morphological characters of *S. galilaeus* might be due to differences in ecological systems, natural production in terms of food availability, water quality and season. During early developmental stages in aquatic ecosystems, the prevailing environmental conditions

can influence the morphology and phenotype of the organism (Pinheiro *et al* 2005).

Table 1: Morphomertry of *Sarotherodon galilaeus* from Oyan Lake, Ogun State, Nigeria

	Female			Male			Combined sexes		
	Mean±SE	Max	Min	Mean±SE	Max	Min	Mean±SE	Max	Min
WT	75.9±4.7	153	33.2	83.8±0.56	175	34.8	81.0±2.78	175	33.2
SL	11.7±0.20	14.9	9.4	12.1±0.21	18.2	2.7	11.9±0.15	18.2	2.7
TL	15.3±0.26	19.3	12.1	15.7±0.19	19.5	11.9	15.5±0.15	19.5	11.9
BD	5.5±0.33	17.5	3.6	5.3±0.15	15.9	3.9	5.4±0.15	17.5	3.6
SNL	7.11±0.20	9.62	4.25	7.20±0.14	10.1	5	7.17±0.12	10.1	4.25
EYD	11.61±1.68	88.7	7.64	9.61±0.13	12.4	6.66	10.33±0.62	88.7	6.66
HLT	38.95±0.77	54.2	25.2	38.50±0.90	60	4.86	38.66±0.64	60	4.86
LDB	69.43±1.08	85.9	55.9	70.37±1.17	94.1	14.4	70.03±0.84	94.1	14.4
LPF	47.97±1.10	68.5	36.1	46.31±0.04	66.5	33.7	46.91±0.57	68.5	33.7
LPVF	36.98±1.00	60	18.5	36.18±0.57	51.7	22.1	36.47±0.51	60	18.5
LAB	24.11±0.77	45.6	16	22.55±0.46	38	7.64	23.11±0.41	45.6	7.64
LCP	14.79±0.71	32	9.72	14.76±0.49	39.8	8.24	14.77±0.40	39.8	8.24
DRA	12.19±0.07	14	12	12.26±0.05	14	12	12.24±0.04	14	12
DOS	15.96±0.03	16	15	15.99±0.01	16	15	15.98±0.01	16	15
DCP	19.42±0.59	30.8	11.2	20.60±0.47	44.1	14	20.17±0.37	44.1	11.2
PRA		14	12		14	12		14	12
PVR		5	4		5	4		5	4
PEVS		1	1		1	1		1	1
ARA		13	10		13	9		13	9
ANS		3	2		3	2		3	2
k	2.03±0.03	2.4	1.6	2.08±0.03	3.3	1.7	2.07±0.02	3.3	1.6

WT = weight, SL = standard length (cm) TL = total length (cm), BD = body depth (cm), SNL = snout length (cm), EYD = eye diameter (mm), HLT = head length (mm), Length of dorsal fin base (LDB), LPF = length of pectoral fin (mm), LPVF = length of pelvic fin (mm), LAB = Length of anal fin base (mm), LCP = length of caudal peduncle (mm)., DRA = number of dorsal rays, DOS = number of dorsal spines, DCP = depth of caudal peduncle (mm), PRA = number of pectoral rays, PVR = number of pelvic rays, PEVS = number of pelvic spines, ARA = number of anal rays, ANS = number of anal spines, k = condition factor.

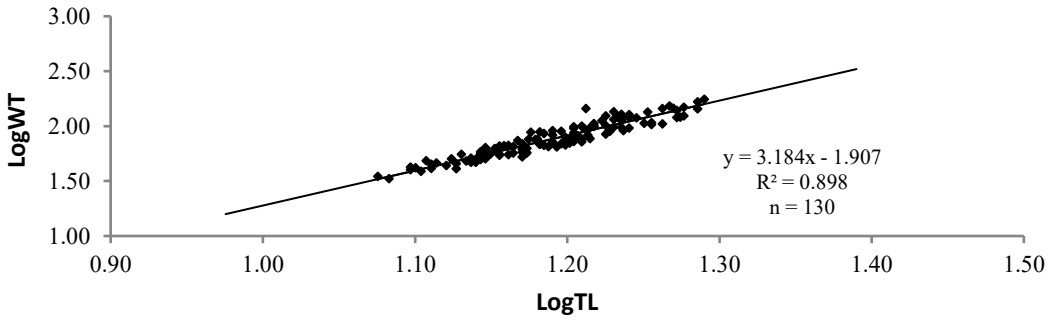

Figure 2. Length-weight relationship of *Sarotherodon galilaeus* (combined sexes) from Oyan Lake, Southwestern Nigeria

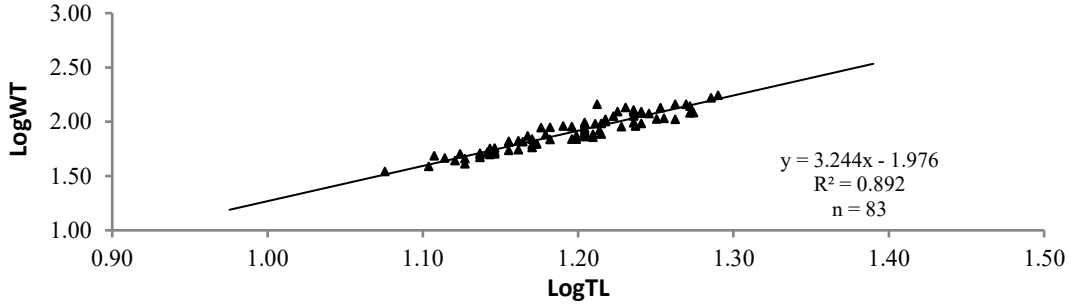

Figure 3. Length-weight relationship of male *Sarotherodon galilaeus* from Oyan Lake, Southwestern Nigeria

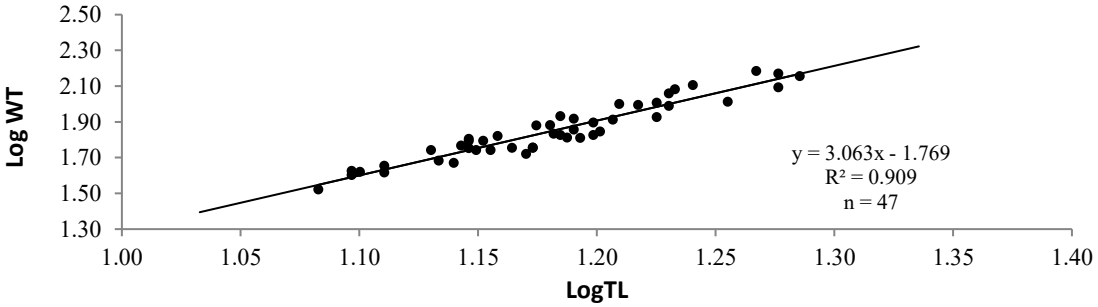

Figure 4: Length-weight relationship of female *Sarotherodon galilaeus* from Oyan Lake, Southwestern Nigeria.

Table 2: Correlation of morphomeric characters of *Sarotherodon galilaeus* from Oyan Lake, Ogun State, Nigeria

	WT	SL	TL	BD	SNL	EYD	HLT	LDB	LPF	LPVF	LAB	LCP
WT	1											
SL	0.74	1										
TL	0.93	0.78	1									
BD	0.17	0.11	0.12	1								
SNL	0.63	0.46	0.60	0.17	1							
EYD	0.02	0.00	-0.02	-0.01	-0.01	1						
HLT	0.32	0.27	0.36	0.00	0.34	-0.01	1					
LDB	0.71	0.61	0.72	0.16	0.54	0.02	0.31	1				
LPF	0.55	0.47	0.59	0.15	0.53	0.03	0.47	0.50	1			
LPVF	0.44	0.46	0.51	0.01	0.40	0.01	0.29	0.50	0.67	1		
LAB	0.49	0.44	0.53	0.31	0.42	0.02	0.20	0.52	0.47	0.51	1	
LCP	0.65	0.48	0.52	0.32	0.53	0.01	0.22	0.52	0.33	0.35	0.51	1

WT = weight, SL = standard length (cm) TL = total length (cm), BD = body depth (cm), SNL = snout length (cm), EYD = eye diameter (mm), HLT = head length (mm), LPF = length of pectoral fin (mm), LPVF = length of pelvic fin (mm), LAB = Length of anal fin base (mm), LCP = length of caudal peduncle (mm).

The isometric growth reported in this study corroborated the results of Olopade *et al* (2018) and Elorm (2019). However, the result differs from the report of Abdul *et al* (2010) and Olele (2010) who both documented that *S. galilaeus* in Ogun Estuary and Onah Lake, Nigeria exhibited negative allometric growth. Negative allometric growth was obtained in similar work carried out by Odulate *et al* (2013) and Odulate (2015) on other cichlids: *O. niloticus*, and *C. zillii,* in Oyan Lake. In Asejire Lake, Ajagbe *et al* (2016) obtained regression coefficient (b) values of 2.85, 2.89 and 2.88 respectively for male, female and combined sexes of *C. zillii,* which indicate negative allometric growth. Ayoade and Onibonoje (2013) reported positive allometric growth for male *S. galilaeus* and negative allometric growth for female fish in Eleyele Lake, Nigeria. Difference in the growth pattern can be due to difference in sex, maturity stages, seasonality; time of day, food eaten or available to the fish, changes in the specific gravity and shape of the body contour (Prasad and Anvar 2007; Abdul *et al* 2016).

Condition factor is an index of the well-being of the fish in the aquatic ecosystem, which shows how conducive the environment is to the survival, growth and overall development of the fish in the habitat. There was no significant difference ($p>0.05$) between the mean values of condition factor of the different sexes. The result of mean condition factor obtained was similar to the report of Gbaguidi and Adite (2016) and Olopade *et al* (2018) on *S. galilaeus* in man-made lakes in Benin Republic and New Calabar River, Nigeria, respectively. In an earlier study, Alhassan *et al* (2015) reported condition factors of 3.66, 4.88, 4.29 and 4.51 for the cichlids; *O. niloticus*, *Hemichromis fasciatus*, *S. galilaeus* and *C. zillii,* respectively in Golinga River, Ghana. These values were higher than those obtained in

the present study. The values of condition factor observed in the present study suggest that the aquatic ecosystem of Oyan Lake is good environment for *S. galilaeus* to thrive. Differences in the results could be due to differences in water quality parameters and natural productivity of the aquatic ecological systems (Odulate *et al* 2013, Irigoyen-Arredondo *et al* 2016).

Conclusion

The study revealed that the range of each of the characters, number of pectoral rays (PRA), number of pelvic rays (PVR), number of pelvic spines (PEVS) and number of anal spines (ANS) in male and female *S. galilaeus* were the same. The growth of the fish in the lake is isometric. The high condition factor is an indication of favourable habitat for the survival and growth *S. galilaeus* in Oyan Lake.

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