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Studies on Length–weight Relationship and Condition Factor of Seven Commercially Important Freshwater Fish Species of Asejire Lake, Ibadan, Nigeria

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Abstract

Length-weight relationships provide information useful in estimation of standing stock biomass and compare the ontogeny of fish population from different water bodies for sustainable fish production. Hence, the length–weight relationships (LWR) and condition factor of seven endemic fish species in Asejire Lake were investigated. One thousand three hundred and eighty one (1,381) fish samples were collected from fisher's catch and identification and measurements of length and weight were made *in situ*. The weight (W) - length (L) relationships were estimated using the logarithmic form of the equation $W = aL^b$, while condition factor was determined following Fulton's equation $K = 100W/L^3$. The allometric coefficient *b* of the LWR in all the species was found to be negatively allometric ($b<3$) except female and combined sexes of *Labeo parvus* where the growth was positive allometric ($b>3$). The coefficient of determination (r^2) obtained which ranged from 0.601 (*Tilapia marie*) to 0.979 (*Labeo parvus*) revealed a high degree of positive correlation. Condition factor values were higher than one in all the seven species, and showed an overt variation with highest value in *Sarotherodon galilaeus* (4.037±0.41). However, all the fish species are in good condition for growth and survival in Asejire Lake. This study has therefore provided basic information on the growth pattern and general well-being of 7 fish species from Asejire Lake to update existing data for sustainable fishery management.

Keywords: Length-weight relationship, allometric, condition factor, freshwater fish species, Asejire Lake.

Introduction

Nigeria is blessed with vast stretch of inland water including lakes and reservoirs, harbouring populations of diverse fish species (Yem *et al*., 2011). These renewable resources make artisanal fishery sector the most important sector of fisheries contributing the major fish supply in the developing world (Olawusi-Peters *et al*., 2015). However some decades ago, inland water especially lake has come under increasing and considerable pressure from a variety of inter-linked human activities such as over-fishing, species introductions, industrial pollution,

eutrophication, and sedimentation (Muyodi and Hecky, 2009). Considering the importance of lake ecosystems to aquatic wildlife and human needs, any alteration of its environmental quality and water renewal rates has wide-ranging ecological and societal implications. Hence, according to Muyodi *et al*. (2011), effective and efficient management of the resource base is essential for the economic, social welfare and environmental quality of any nation.

The knowledge of the length–weight relationship in fisheries is highly crucial to fisheries management and ecology. Length-weight relationship (LWR) is a key factor in investigation of biology and management of fish species (Samat *et al*., 2008; Jamabo *et al*., 2009), with valuable information to evaluate the general health parameters of fish species (fatness, breeding and feeding states) and their suitability to the environment (Farzana and Saira, 2008) as well as provides clues to environmental changes and sustainable management of the stock (Efitre *et al*., 2009). However, growth parameters differ from species to species and from stock to stock within the same species depending upon the habitat conditions. Therefore, condition factors are used for comparing the condition, fatness, or well-being of fish, based on the assumption that heavier fish of a given length are in better condition (Tesch, 1968).

The significance of length-weight relationship and condition factor of fishes has stimulated a several works in different parts of Nigeria, analysing this relationship in both marine and freshwater fishes. Similarly, a good deal of work had been done on length-weight relationships and condition factor of fishes from Asejire Lake and environs (Kareem *et al*., 2015; Ayoade, 2011; Ayoola and Ajani, 2009; Ayoade and Ikulala, 2007; Omoike, 2004; Olaniran, 2003; Taiwo and Aransiola, 2001). The present study aims at providing latest scientific information on the length-weight relationships and condition factor of seven endemic species in Asejire Lake.

Materials and Methods

Study area

The study was carried out in Asejire Lake in Southwestern Nigeria. Asejire Lake lies 30 km east of Ibadan and has its source from River Oshun. It is located on latitude 07^{0}21'- 07^{0}26'N and longitude 04^{0}06'- 04^{0}10'E at an altitude of 137 m above sea level (Figure 1). The lake is Y-shaped with two unequal arms of the 'Y'.

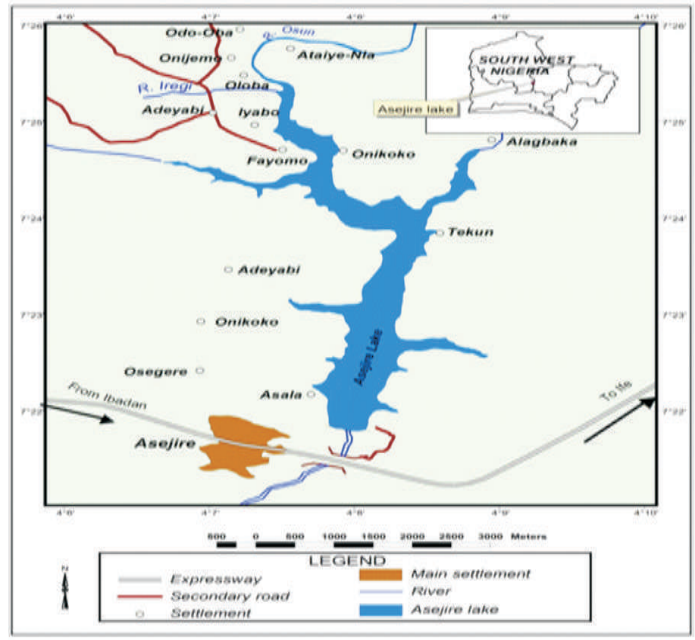

Figure 1. Map of Asejire Lake. Source: Geography Department 2016, University of Ibadan.

Its entire length is 19.5 km with catchment and impounded area of 7,800km² and 2,342 hectares, respectively. It has a normal pool elevation (water level) of 150m and maximum flood elevation of 152.4m with gross storage of 7,403 million litres (ADB, 2010).

Data collection and analysis

Samplings were carried out fortnightly in different landings sites between May and September, 2015. Fish species were collected directly from the artisanal fishermen catch, which use gill nets of various mesh sizes (15 to 60mm stretched mesh), bamboo traps and cast nets. The most frequently encountered fishing gear on the reservoir was gillnets that are used throughout the year. Gillnets are usually set during the afternoon at about 16:00 h (GMT) and lifted the following morning at about 07:00 h (GMT).Measurements were made *in situ* by the research team. Total and Standard length for each fish was measured to the nearest 0.1cm on a wooden measuring board (100 cm). Body weight was recorded with a precision balance (OHAUS Model CT 6000) to the nearest 0.1g. Species identification was based on Olaosebikan and Raji (2013), Idodo-Umeh (2003) and Reed *et al.* (1967) keys.

The LWR of fish was estimated by using the equation: $W= aL^b$, where W=weight in grams (g), L=standard length in centimeters (cm), *a* is a scaling constant and *b* is the allometric growth coefficient. After logarithmic transformation of this relation (log10 W=log10*a* + *b* log10 L), parameters (*a)* and (*b)* were determined via least squares linear regression (Zar, 1999).The condition factor was determined by using the equation, $K = 100W/L^3$ (Fulton, 1904). Where, K = condition factor; W = weight of fish (grams) and L = Length of fish (cm).The correlation coefficient (R) was estimated to determine the degree of linear relationship between the length and weight of the samples.

Data Analysis

Relationship between length and weight of the fish was examined by simple linear regression analysis in SPSS version 17 (SPSS Inc., Chicago, IL, USA).The statistical significance levels of r^2 and standard error SE of b ($P<0.001$) were calculated for all the seven species. Also, descriptive statistics such as mean, standard deviation, table and graphs were applied in Microsoft Office Excel (Window 7). All the statistical analyses were considered at significant level of 5% ($P<0.05$).

Results

The catch composition, sample size and length-weight parameters for seven (7) species belonging to five (5) genera, four (4) families comprising one thousand, three hundred and eighty-one (1,381) individuals are summarized in Table 1. The family with the highest number of species was Cichlidae, which had 3 species (*Tilapia marie*, *Tilapia guinensis* and *Sarotherodon galilaeus*) while 2 species were recorded by Alestidae (*Brycinus nurse and Chrysichthys auratus*). The other families which include Clarotidae and Cyprinidae had one species each (*Chrysichthys nigrodigitatus* and *Labeo parvus,* respectively). The sample size ranged from one hundred and twenty-eight (128) individuals for *C. nigrodigitatus* to two hundred and fifty-five (255) for *T. guineensis.* The observed maximum standard length among all individuals sampled during the study was 56.9 cm, which was found in *C. nigrodigitatus* having average standard length of 18.19±6.69 cm while the least standard length (7.0 cm) was obtained in *T. marie* with mean standard length of 11.26±2.78 cm. The smallest (15.0g) and biggest (600.0g) individual among sample was found in *C. auratus,* however the highest mean weight (118.14±91.00 g) was recorded in *T. guineensis*. It was determined that 52.93% of the overall species sampled were females (n=731) while 47.07% were males (n=650). This is an indication that the sampled population was female dominance. It was also observed the females were longer and larger than males.

The length-weight relationship parameters a and b, correlation coefficient (r^2), condition factor, and growth type (allometric or isometric) of fish species were presented in Table 2. Also, the graphical presentations of the LWRs for the combined sexes of all species studied are shown in

Table 1. Sample size and length-weight distribution of seven fish species collected in Asejire Lake

Family/specie	Sex	N	Standard length (cm)			Weight (g)		
			Mean±SE	Min	Max	Mean±SE	Min	Max
Alestidae:								
Brycinus nurse	M	113	15.35±1.59	11.0	20.0	65.94±21.66	26.0	177.0
	F	126	15.80±2.20	9.8	23.4	74.47±33.64	21.0	222.0
	CS	239	15.60±1.95	9.8	23.4	70.44±28.87	21.0	222.0
Chrysichthys auratus	M	107	15.26±4.08	9.8	34.0	69.68±68.17	15.0	508.0
	F	121	15.83±5.02	9.6	35.0	83.23±100.22	16.0	600.0
	CS	228	15.56±4.60	9.6	35.0	76.87±86.75	15.0	600.0
Claroteidae:								
Chrysichthys nigrodigitatus	M	53	17.28±7.45	9.6	56.9	78.32±50.13	24.0	300.0
	F	75	18.19±6.69	9.9	42.1	86.10±45.89	24.0	226.0
	CS	128	17.81±7.00	9.6	56.9	82.88±47.65	24.0	300.0
Cyprinidae:								
Labeo parvus	M	69	14.58±2.74	10.4	24.4	71.20±51.17	24.0	331.0
	F	81	15.27±3.39	10.2	27.5	85.54±71.46	24.0	453.0
	CS	150	14.96±3.12	10.2	27.5	78.94±63.15	24.0	453.0
Cichlidae:								
Tilapia mariae	M	72	11.26±2.78	7.0	19.7	58.94±42.86	16.0	266.0
	F	84	11.19±2.16	7.2	17.6	59.00±39.72	17.0	265.0
	CS	156	11.22±2.45	7.0	19.7	58.97±41.07	16.0	266.0
Tilapia guineensis	M	128	12.65±2.64	5.9	21.4	86.43±59.89	20.0	386.0
	F	127	13.85±3.32	8.5	23.0	118.14±91.00	24.0	480.0
	CS	255	13.25±3.05	5.9	23.0	102.23±78.44	20.0	480.0
Sarotherodon galilaeus	M	108	10.47±2.80	7.5	24.8	53.90±60.51	19.0	550.0
	F	117	11.68±4.54	7.6	27.5	86.92±108.95	19.0	548.0
	CS	225	11.10±3.84	7.5	27.5	71.07±90.39	19.0	550.0

Legend: *N* Sample size, *SE* Standard error, *Min* Minimum, *Max* Maximum, *M* Male, *F* Female, *CS* Combined sex, *cm*centimeter, *g* grams.

Fig. 1 – 7. The calculated allometric coefficients vary between 1.56 (*C. nigrodigitatus*) and 2.88 (B. nurse) in males, between 1.45 (*C. nigrodigitatus*) and 3.03 (*L. parvus*) in females and between 1.50 (*C. nigrodigitatus*) and 3.04 (*L. parvus*) in combined sexes. Meanwhile, an overall average regression value of 2.53±0.53 was determined for the sampled population. The *b* values of LWRs for female and combined sexes of *L. parvus* were greater than 3 indicating the positive allometric growth. For other species, *b* was less than 3, therefore gave negative allometric growth.However, *C. nigrodigitatus* showed an acute negative allometric growth.

All relationships were highly significant ($P<0.05$), with r^2values being greater than 0.601.The values of correlation coefficient (r^2) varied from a minimum of 0.601 in male *T. marie* to a maximum of 0.979 in female *L. Parvus*. 61.9% of the species had r>0.90, 23.8% had r^2 values between 0.80 - 0.90 while 14.3% had r^2 values lower than 0.80.

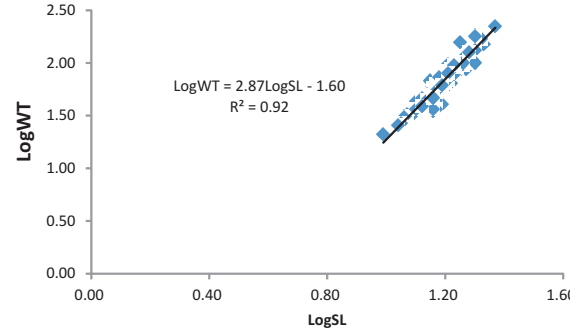

Figure 1: Regression curve for *Brycinusnurse* (Combined sexes)

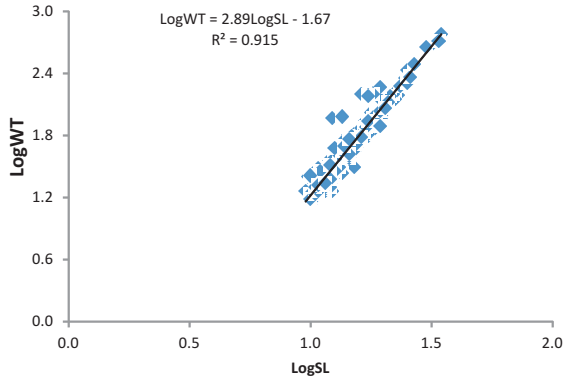

Figure 2: Regression curve for *Chrysichthys auratus* (Combined sexes)

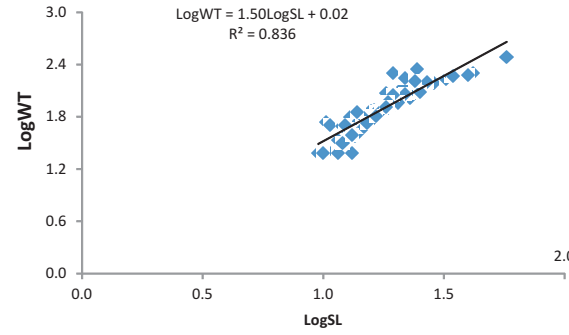

Figure 3: Regression curve for *Chrysichthys nigrodigitatus* (Combined sexes)

Table 2. Condition factor and Regression Coefficient for Length-weight relationship of fish species from Asejire Lake

Species	Sex	a	b	r^2	MSE (b)	K	Growth
B. nurse	M	- 1.61	2.88	0.927	0.0367	1.762±0.21	-A
	F	- 1.58	2.86	0.908	0.0553	1.781±0.49	-A
	CS	- 1.60	2.87	0.920	0.0473	1.774±0.36	-A
C. auratus	M	- 1.64	2.87	0.888	0.1088	1.634±0.15	-A
	F	- 1.69	2.90	0.934	0.0963	1.610±0.29	-A
	CS	- 1.67	2.89	0.915	0.1019	1.622±0.38	-A
C. nigrodigitatus	M	- 0.07	1.56	0.806	0.1084	1.772±0.12	-A
	F	0.09	1.45	0.863	0.0819	1.661±0.19	-A
	CS	0.02	1.50	0.836	0.0937	1.670±0.30	-A
L. parvus	M	- 1.76	2.76	0.972	0.0404	2.032±0.69	-A
	F	- 1.73	3.03	0.979	0.0388	2.061±0.58	+A
	CS	- 1.74	3.04	0.978	0.0381	2.040±0.11	+A
T. mariae	M	- 0.54	2.13	0.601	0.1820	3.942±0.64	-A
	F	- 1.05	2.64	0.746	0.1298	3.905±0.27	-A
	CS	- 0.76	2.35	0.665	0.1569	3.918±0.33	-A
T. guineensis	M	- 1.09	2.69	0.917	0.0730	3.808±0.54	-A
	F	- 1.34	2.93	0.977	0.0465	3.774±0.71	-A
	CS	- 1.23	2.83	0.952	0.0620	3.801±0.28	-A
S. galilaeus	M	- 0.98	2.58	0.897	0.08667	4.021±0.66	-A
	F	- 1.07	2.68	0.956	0.08201	4.067±0.62	-A
	CS	- 1.05	2.66	0.939	0.08435	4.037±0.41	-A

Legend: *a* intercept, *b* slope, *r* correlation coefficient, *MSE (b)* mean standard error of the slope, *K* mean condition factor , *+A* positive allometric growth, *-A* negative allometric growth.
The lowest condition factor (K) (1.610±0.29) was recorded in *C. auratus* while the highest value (4.067±0.62) was observed in *S. galileaus*. There were little variations in condition factor with sex.

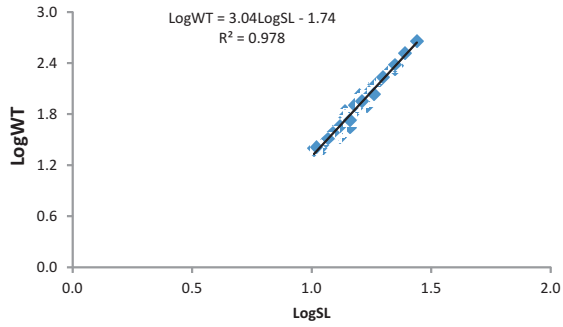

Figure 4: Regression curve for *Labeoparvus* (Combined sexes)

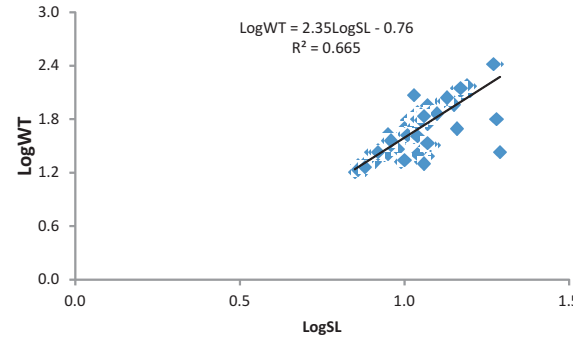

Figure 5: Regression curve for *Tilapia mariae* (Combined sexes)

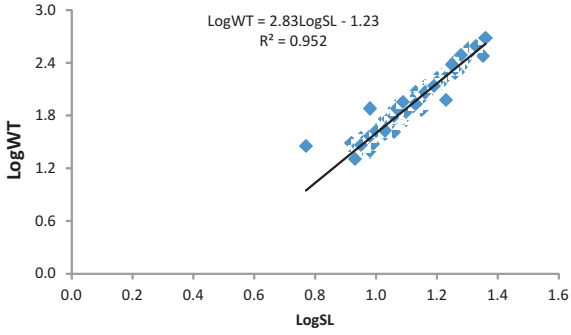

Figure 6: Regression curve for *Tilapia guineensis* (Combined sexes)

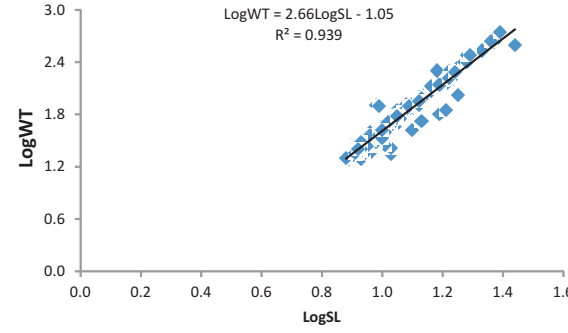

Figure 7: Regression curve for *Sarotherodon galilaeus* (Combined sexes)

Discussion

Data on the length and weight of fish have commonly been analyzed to yield biological information. Anene (2005) remarked that the LWR is very important for proper exploitation and management of the population of fish species.In the present study, the length-weight distributions of fishes from Asejire Lake showed considerably large variations in fish sizes indicating an efficient gill nets operation. A total of 1318 specimens were collected with most data comprising large samples and thus were considered reasonably representative and reliable. The smallest sample size corresponded to the infrequent species and the largest samples belonged to those which were frequently encountered in large numbers.Sample size obtained from this study is similar to the work of Egbal *et al*. (2011) who studied the length-weight relationships (LWR) and condition factors of six fish species in Atbara River and Khashm el-Girba reservoir. The authors recorded a total of 1118specimens of varying sizes. Sample size achieved from this study is also comparable to what obtained from works done by Khan *et al*. (2011) and Kumolu-Johnson and Ndimele, (2010).

The overall species sampled had more females (52.93%) than males, an indication of female dominant population. This is consistent with the work of Kareem *et al*. (2015) and Dan-Kishiya (2013) who reported the female dominance population in Erelu Lake, Oyo and Lower Usuma Reservoir in Abuja, respectively. The results showed that females were longer and heavier than males for all sampled species. This is in agreement with the findings of Kareem *et al*. (2015) who found longer and heavier females in the sample population of *Chrysichythys nigrodigitatus* and *Schilbe mystus*. In line with these findings, Le Cren (1951) explained that females are heavier than males of the same length probably becauseof difference in fatness and gonadal development.

The growth parameter values of *b* for *C. nigrodigitatus* varied from 1.45 to 1.56 while

others (*B. nurse*, *C. auratus*, *L. parvus*, *T. mariae*, *T. guinensis* and *S. galilaeus*) had their *b* values ranging from 2.13-3.04. Except for *C. nigrodigitatus,* the calculated allometric coefficient *b* fell within the normal range of 2 – 4 as reported by Bagenal and Tesch (1978) for most fishes. These results suggest that all sampled species except female and combined sexes of *L. parvus* show non-isometric or negative allometric growth i.e. the fish do not grow in proportion to the length but the increase in weight occurs with much smaller increments with increase in the length of the fish. However, female and combined sexes of *L. parvus* exhibited positive allometric growth.

These findings show a similar trend with earlier studies involving fish species from different water bodies as reported by Dan-kishiya (2013) in Lower Usuma Reservoir, Kumar *et al.* (2013) in Gomti River Lucknow, Khan *et al.* (2011) in River Ganga, Imam *et al*. (2010) in Wasai Reservoir, Kumolu-Johnson and Ndimele (2010) in Ololge lagoon, Ayoade and Ikulala (2007) in Eleyele lake. Furtherance to this, similar allometric growth pattern was also reported for *L. parvus* (3.055), *T. guinensis* and *S. galilaeus* (2.815) by *Konan et al*. (2007) in coastal rivers. Offem*et al*. (2009) and Ayoade and Ikulala (2007) also reported non-isometric growth of 2.20 and 2.80, respectively for *S. galilaeus*. Conversely, positive allometric growth patterns were reported for *C. nigrodigitatus* (3.042) by Fafioye and Oluajo (2005), *T. marie* (3.3; 3.098) by Offem *et al*. (2009) and Konan *et al*. (2007) and *C. auratus* (3.4) by Offem *et al*. (2009). The coefficient of determination (r^2) ranged from 0.601 (*T. marie*) to 0.979 (*L. parvus*), 61.9% of 21 regressions presented r^2 values higher than 0.90. All linear regressions were statistically significant ($P<0.05$). The calculated Standard Error of b (SE) ranged from 0.0367 to 0.1820, thus indicating a tendency towards positive allometry, which is in accordance with the majority of fish species (Froese, 2006). This result is in agreement with previous studies on different fish species from Nigeria water bodies (Kareem *et al*., 2015; Dan-kishiya, 2013; Lawson *et al*., 2013; Imam *et al*., 2010; Offem*et al*., 2009; Ayoade and Ikulala, 2007).

The condition factors (K) of the seven fish species ranged between 1.610±0.29 and 4.067±0.62, and this show that these fish species are above average condition within the lake (Wade 1992). Also, there is no significant difference ($p>0.05$) in condition factor between sexes of individual species. A closer examination of the condition factors therefore revealed that 57% of the fish species had their K values outside the range (2.9-4.8) recommended as suitable for matured fresh water fish by Bagenal and Tesch (1978). Anene (2005) however remarked that this could have been caused by adverse environmental factors. Generally, when consider season of the year, maturity stages, body size and feeding habits of individual species, all the fishes examined were in good condition. This suggests that the condition of Asejire Lake is suitable to fish well-being in the lake. The mean K value recorded for these fish species in Lake Asejire compared favourably with the findings of Dan-kishiya (2013) in Lower Usuma Reservoir, Ibrahim *et al.* (2012) in Kontagora Reservoir, Obasohan *et al*. (2012) in Ibiekuma Stream and Ekelemu and Samuel (2006) in Lake Ona.

Conclusion

The study revealed that length-weight distributions of fishes from Asejire Lake showed considerably large variations in length and body weight of female dominant population. It was alsoestablished that females were longer and heavier than males in all sampled species. These fish species had negative allometric growth except female and combined sexes of *L. parvus* that exhibited positive allometric growth. Strong association between length and weight exists in all the fish species. All the fish species are in good condition for growth and survival in Asejire Lake. This study has therefore provided basic information on the growth pattern and general well-being of seven fish species from Asejire Lake to update existing data for sustainable fishery management.

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