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Growth Pattern, Diet and Tropical Niche Breadth of the Nile Silver Catfish, *Schilbe mystus* (Linne 1758) in Asejire Lake, Southwestern, Nigeria

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ABSTRACT

Schilbe mystus is a valued endemic fish species in the Nigerian freshwater, with great potential for culture. Nevertheless, controlled rearing is currently rare due to the lack of knowledge on its food and feeding habits besides other factors. Therefore, growth, food and feeding habits of *S. mystus* in Asejire Lake were investigated for six months (July to December, 2018). A total of 105 specimens (86.00±14.30 g) were collected from fishers. Samples were sexed and grouped according to sizes. Length-weight relationships (LWR) and condition factor were assessed using standard procedures. Gut contents and niche breadth (Bi) were analyzed and quantified using a standard approach. In addition, qualitative and quantitative variations in diet were determined according to sex, size and seasons. Data were analyzed using descriptive statistics, chi-square and multiple linear regressions. The LWR indicated negative allometry growth with 'b' value of 2.87 and coefficient of determination (R^2) of 0.85. The condition factor of *S. mystus* was 1.32±0.26, sex ratio of 1:1.23 (♂: ♀) with size distribution ranged from 9.40 cm to 29.70 cm. Dietary analysis showed that *S. mystus* is a europhagous feeder and a benthic omnivore. Insects, crustaceans and planktons constituted the major food items. Furthermore, significant differences in feeding habits of *S. mystus* occurred according to sex, size and seasons. The Bi value was high (2.15), indicating a trophic generalist. Hence, this research was conducted to provide key information necessary for formulation of artificial diet for *S. mystus* under captivity.

INTRODUCTION

The development of aquaculture in Nigeria has been steady in the last three decades. It increased considerably from a small base of 16,119 in 1995 to 307,000 metric tons in 2016 **(FDF, 2011; FAO, 2018)**. Aquaculture continues to show a promise for a more rapid expansion to fill the gap created by the decline in capture fisheries. However, growth in aquaculture industry in Nigeria is mostly dominated by catfish farming, *Clarias gariepinus* **(Williams *et al.*, 2007)**, despite over 300 indigenous, cultivable freshwater fish species **(Olaosebikan & Raji, 2013)**. The domination of *C. gariepinus* requires more attention because the consumer's choice is unduly limited. **Kpogue *et al.* (2012)** stressed that the development in aquaculture could only be sustainably achieved through the farming of arrays

of endemic species in inland waters. Hence, species such as *Schilbe mystus* needs to be considered as aquaculture candidate.

The freshwater Nile silver schilbeid catfish, *Schilbe mystus*, (Order: Siluriformes, Family: Schilbeidae) is one of the most dominant fish species in Nigeria inland waters. It prefers standing or slowly flowing open water of lakes, ponds, rivers, and shallow swamps where vegetation is present **(Zengeya, 2016)**. It can grow up to a length of 70 cm and a weight of 250 g **(Azeroual *et al*., 2010)**, with good quality food fish of white and very tasty flesh serving as delicacy for many low-income earners **(Reed *et al*., 1967)**, especially in riverine communities. *Schilbe mystus* is a column and surface feeders; feeding on fish, insects, crustaceans, ostracods, snails, seeds, leaves, roots, diatoms, algae, and fruit **(Omondi & Ogari, 1994; Ayoade *et al*., 2008; Zengeya, 2014)**.

According to **Kareem *et al*. (2019)**, the emanating need to culture fishes for protein consumption for the teeming rapidly growing populations in the developing countries have made it necessary to intensify studies on the food and feeding habits of the African freshwater fishes. Moreover, it is noted that the successful domestication of any fish species demands a thorough knowledge of its diet and dietary habits. The knowledge of food and feeding habits enables farmers to have clear understanding of the fish's dietary requirements to formulate appropriate feeds under culture **(Malami *et al*., 2004)**. As pointed out by **Fagade (1978)**, the analysis of the stomach content of fish is a useful guide to form artificial diets in fish culture. Further, the food and feeding habits of fish species may differ in time, space as well as different stages of growth **(Hardy, 1924)** and this would, in turn, pinpoint the importance of detailed study of food and feeding habits.

Many studies have been carried out on the food and feeding habits of this commercially important fish species. These include the works of **Omodi and Ogari (1994), Fawole (2002), Oso *et al*. (2006), Ayoade *et al*. (2008), Malami and Magawata (2010)**. However, a review of literature showed paucity of information on the food and feeding habits of *S. mystus* from Asejire Lake in the last decade. Therefore, there is a need to investigate the food and feeding habits of *S. mystus* to enhance its aquaculture potentials.

MATERIALS AND METHODS

Study area

Asejire Lake, with a surface area of 24 km^2, is located in Egbeda local government, Oyo State, Nigeria (Fig. 1). The main body of the lake lies about 30 km east of Ibadan, between latitudes 7º21'30" – 7°21'50" N and longitudes 4°07'30" – 4°08'10" E, at an altitude of 137 m above sea level. It was formed by a dam constructed across River Oshun in 1960. The lake is Y-shaped with two unequal arms: the long arm is River Osun, while the short is River Oba **(Ayodele, 1979)**. The lake is fed by two rivers, River Osun and its main tributary River Oba. Its entire length is 19.5 km, with catchment and impounded area of 7,800 km^2 and 2,342 hectares, respectively. It has a normal pool elevation (water level) of 150 m, and maximum flood elevation of 152.4 m with gross storage of 7,403 million liters. It has gross storage capacity of 7,403.4 million liters per day, while its discharge capacity is 136.26

million liters per day **(Ayodele, 1979)** with maximum water capacity of about 675 m^3. The reservoir sustains a thriving artisanal fisheries industry, and serves as a source of water for domestic and industrial use. It is rich in diverse fish resources, and located in a tropical derived savannah climate with two clearly marked wet seasons between April and September, and dry seasons between November and March. Remarkably, fishing activity is prominent in the reservoir.

Sample collection

Samples (n = 105) were collected using cast nets and surface gill nets over a period of 6 months; from July to September 2018 (wet season) and October to December 2018 (dry season). Samples were anaesthetized at the collection site, preserved in 5% neutral formalin and transported to the Wet Laboratory of Aquaculture and Fisheries Management Department, University of Ibadan for further examination. Fish caught were identified according to **Olaosebikan and Raji, (2013)**.

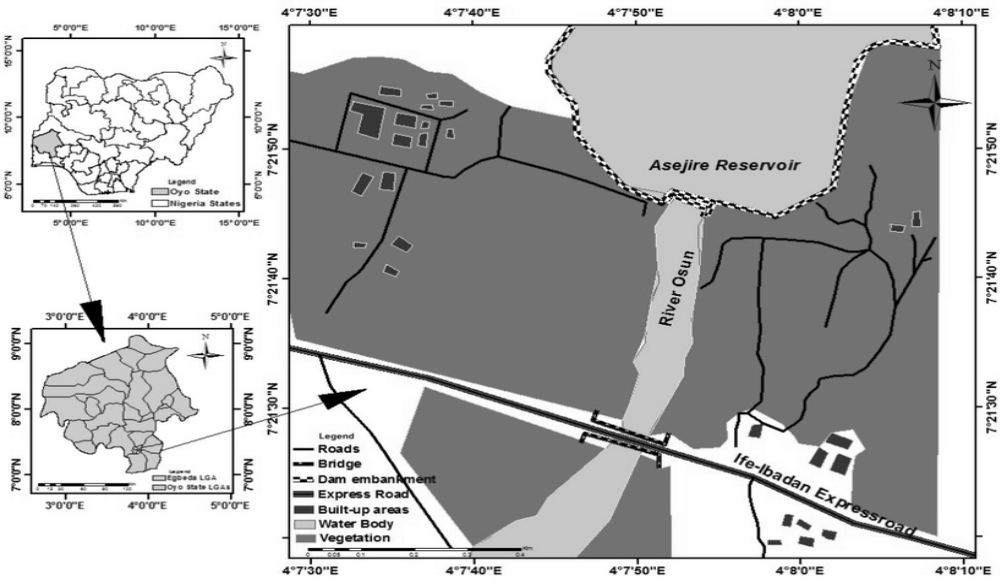

Fig. 1. A map of Asejire Lake, Oyo State, Nigeria

Morphometric and laboratory analysis

In the laboratory, samples were measured for a standard length to the nearest 0.1 cm on a wooden measuring board (60.0 cm). Body weight was recorded with a precision balance (OHAUS Model CT 6000) to the nearest 0.1 g. The samples examined were divided into small-sized group (9.0 to 15.2cm) and large-sized group (15.3 to 29.7cm) to establish variation in food items. Sexes were determined based on the possession of a genital papilla by the male, and binocular dissecting microscope was used for some small specimens.

Length-weight relationship (LWR) and condition factor

The parameters for the LWR models were estimated by linear regression on log-transformed data, using the statistical package for social sciences. The LWR model is a function of length (L), $\mathbf{W= aL^b}$; which was transformed to logarithmic modification according to the following equation: **Log W = a ± b log L.** Fulton's condition factor (K) was calculated based on **LeCren (1951)** using the equation of $K = 100W/L^3$. Where, K = condition factor; W = weight of fish (g) and L = Length of fish (cm). The correlation coefficient (R^2) was estimated to determine the degree of relationship between the length and weight of the samples.

Stomach content analysis

The fish was dissected and the gut was taken out for dietary analysis. The food composition in each gut was determined using a points and occurrence method as described by **Hyslop (1980)**. Each category of food was sorted out and points were awarded for each food item. Thus, the total points allotted in a food category in all samples were summed and expressed as the percentage of the total points. Combining percentage of occurrence and points, the index of preponderance (I) was calculated following **Natarajan and Jhingran (1961)**.

$$\mathbf{I} = \frac{ViOi}{\sum ViOi} x\,100$$

Where:I is the index of preponderance of the food item, V_i is the percentage of volume index of the item, and O_i is the percentage of occurrence index of the item.

Trophic niche breadth

Diet breadth (Bi), which is a measure of the food spectrum, is determined following **Hulbert (1978)** formula: $\mathbf{Bi} = \frac{1}{\sum Pi\ 2}$

Where, **Bi** is the trophic niche breadth and $\mathbf{P_i}$ is the numeric proportion of food item i in the diet.

Statistical analysis

Data obtained were analyzed using descriptive statistics, chi-square and multiple linear regressions in statistical package for social sciences (SPSS for Windows version 20).

RESULTS

1. *Growth pattern and condition factor*

The sample size and sex distribution of *S. mystus* examined are shown in Table (1). A total of 105 fish samples composed of 47 (44.76%) males and 58 (52.24%) females were collected during the study period. The sex ratio (male: female) for sampled population in

Asejire Lake was 1.0 ♂: 1.23♀, which did not show departure from the expected 1:1 rate (χ^2 = 3.65; p>0.05).

The specimens weighed between 17.60 g and 275.20 g, with an average of 86.00±14.30 g. While the standard length ranged between 9.40 cm and 29.70 cm, with an average of 19.30±3.50 cm. The equation of length-weight relationship, as obtained, was: Log W = - 1.74 + 2.87 Log SL (Fig. 2). The regression analysis revealed a high significant difference (*p<0.05*) with coefficient of determination (R^2) of 0.85. However, the mean condition factor was 1.32±0.26.

Table 1: Length-weight distribution and condition factor of *S. mystus*, captured from Asejire Lake, Oyo State, Nigeria.

Parameters	Mean±SD	Range	p-value	R^2	Condition factor (K)
Standard length (cm)	19.30±3.50	9.40 – 29.70	<0.05	0.8	1.32±0.26
Body weight (g)	86.40±14.30	17.60 – 275.20		5	

Where SD is standard deviation and R^2 is correlation coefficient.

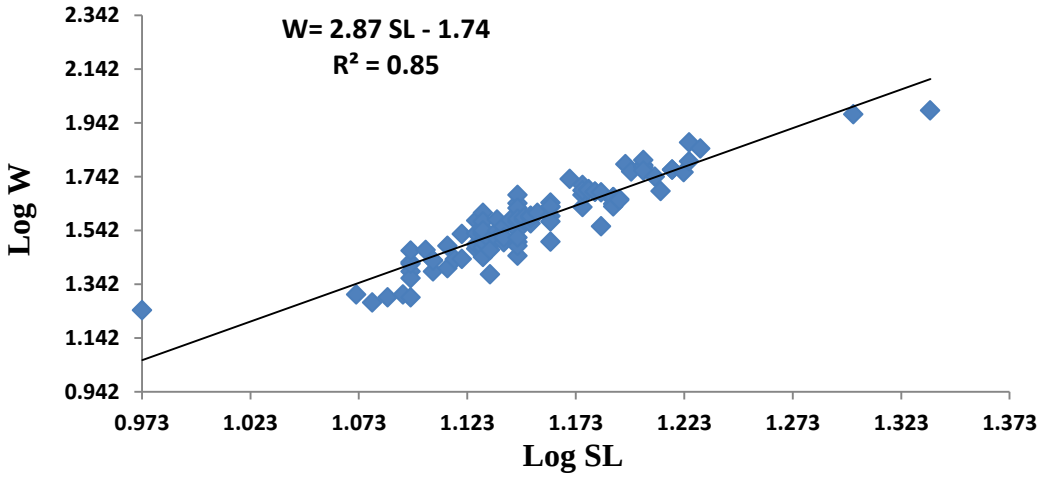

Fig. 2: Length-weight relationship of *Schilbe mystus* in Asejire Lake, Oyo State, Nigeria.

2. *Food items in relation to size, season and sex*

Major food items of *S. mystus* in relation to size, season and sex are presented in Table (2). The predominant food items in both small-sized (9.0 to 15.2cm) and large-sized (15.3 to 29.7cm) groups are insects, crustaceans, plankton and macrophytes. Small-sized group however, had high occurrence of insect (55.2%) and crustacean (26.0%); while plankton (26.0%) and macrophyte (13.1%) were more pronounced in large-sized group. Seasonally, the most common food items identified during dry season were plankton (55.0%), macrophyte (4.0%) and Charcoal (1.5%). Whereas in wet season, crustacean (28.0), insects (58%) and mollusc (1.0%) were frequent. As shown in Table (2), the occurrence of crustacean (22.0 %), insect (58.2 %), mollusc (1.8 %), macrophyte (5.4 %) and charcoal (1.8

%) were significantly ($p<0.05$) higher in male while only plankton (62.0 %) predominated in female. There was a significant difference among the occurrences of each food item in different sizes, seasons and sexes.

Table 2: Variation in % number of food items ingested by *Schilbe mystus* in Asejire Lake with respect to size, season and sex

Food items	Size		Season		Sex	
	Small	Large	Dry	Wet	Female	Male
Crustaceans	26.0	14.0	8.2	28.0	15.1	22.0
Insects	55.2	43.0	31.4	58.0	22.0	58.2
Planktons	18.2	26.0	55.0	15.1	62.0	12.3
Molluscs	1.0	0.0	0.0	1.0	0.1	1.8
Macrophytes	0.0	13.1	4.8	0.0	2.0	5.4
Charcoal	0.5	2.1	1.5	0.0	0.0	1.8
Unidentified material	0.0	0.8	0.1	0.0	0.0	0.1

3. *General diet composition of S. mystus*

Major food items and index of preponderance of *S. mystus* is presented in Table (3). The food items, discerned from the guts of *S. mystus*, were identified and broadly categorized into crustaceans, insects (Ephemeroptera nymphs, Megaloptera larvae, Hemiptera, Plecoptera, Coleoptera and Odonata), plankton, molluscs, macrophyte, charcoal and unidentified materials. Insects were the most predominant food items accounting for 84.41 % of the total food items. This was followed by crustaceans (12.59 %) and planktons (2.97 %). Additionally, the index of preponderance indicated that green charcoal (0.001) and unidentified materials (0.001 %) were the least food items encountered. The niche breadth (Bi) value of *S. mystus*, as analyzed in the study, is presented in Table (4). Niche breadth value was 2.15, indicating the presence of broader niches within the area.

Table 3: Diet composition and preponderance index of major food items in the stomach of *S. mystus* from Asejire Lake

Food items	Index of Occurrence (O_i) ($n_i \times 100 / \sum n_i$)	Index of Volume (V_i) ($v_i \times 100 / \sum v_i$)	O_iV_i	Index of preponderance (I_i)
Crustaceans	15	35	525	12.59
Insects	64	55	3520	84.41
Plankton	20	6.2	124	2.97
Mollusc	0.5	1.4	0.7	0.02
Macrophyte	0.2	1.5	0.30	0.04
Charcoal	0.1	0.60	0.06	0.001
Unidentified materials	0.2	0.30	0.06	0.001
Total	100	100	4170.12	

Table 4: Niche breadth of *S. mystus* in Asejire Lake

Food items	Numeric proportion (p_i)	p_i^2	Bi
Crustaceans	0.14	0.0196	
Insects	0.64	0.4096	
Plankton	0.19	0.0361	
Mollusc	0.007	0.000049	
Macrophyte	0.02	0.0004	
Charcoal	0.003	0.000009	
Unidentified materials	0.003	0.000009	
Total		0.4658	2.15

DISCUSSION

Size structure, growth and condition factor of *S. mystus*

The size distribution (9.40 – 29.70 cm) of *S. mystus*, obtained in this study, was comparatively wider than 8.0–21.0 cm and 7.8–21.5 cm reported by **Ayoade (2007)** in Oyan and Asejire reservoirs, respectively. In addition, **Kareem *et al.* (2015)** reported a wider distribution of 8.30–31.50 cm in Erelu Lake, Nigeria. **Kudale-Jadhav and Rathod (2014)** asserted that sex ratio of species offers information on sexual viability, segregation and aggregation of sexes according to their feeding, breeding or migratory behavior. The sex ratio in this study showed preponderance of female over male, but did not show any departure from the expected 1:1 rate. In contrast, **Komolafe and Arawomo (2011)** and **Kareem *et al.* (2015)** reported significant female dominant population of *S. mystus* in Erinle Lake and Erelu Reservoir, respectively. The non-significance of the sex-ratio in this study might be sequel to low sample number.

According to **Kareem *et al.* (2015)**, the condition factor is an index reflecting interactions between biotic and abiotic factor in the physiological condition of fishes. However, a condition factor that is greater than 1 indicates a generally good condition of the fish, whereas values less than 1, denotes a reverse condition **(LeCren, 1951)**. The condition factor of *S. mystus*, in this study, is comparable to the observation of **Kareem *et al.* (2015)** who reported a similar mean condition factor of 1.071±0.256 for *S. mystus* from Erelu Lake. On the contrary, **Uneke (2016)** recorded a lesser condition factor (0.681) for *S. mystus* from Cross River basin, Nigeria. The regression coefficient (b) value for *S. mystus* was 2.87, with a determination coefficient (R^2) value of 0.85. This result suggests that the species shows negative allometry growth; an indication that the fish becomes lighter with an increase in length. However, the correlation coefficients showed strong correlation between the standard length and the body weight of *S. mystus* from Asejire Lake. This result is in consonance with the observations of **Kareem *et al.* (2015)** and **Abdul *et al.* (2016)** in Erelu Lake and coastal estuary, Ogun Waterside, Oyo, respectively. Contrarily, **Ayoade (2011)** detected a positive allometry growth (3.348 and 3.2402) in Oyan Lake and Asejire Lake, respectively.

Diets and feeding habits of *S. mystus*

Accurate description of the diets and feeding habits of fish species from the wild provided clear understanding of their dietary requirements, which is useful for formulation of artificial diets under culture **(Malami *et al*., 2004)**. The results of the current study showed variations in diet of *S. mystus* with size, season and sex in Asejire Lake. Similar observations have been reported for *S. mystus* in Oyan and Asejire reservoirs by **Ayoade *et al*. (2008)**. The results indicated that the species is a europhagous feeder, able to change their diets according to the availability of different food items as observed by **Lowe-McConnell (1977)** and **Omondi and Ogari (1994)**. This variation might also be attributed to ontogenetic transformation and life history patterns of the species **(Vassilopoulou, 2006)**. In this study, seven broad categories of food items (crustaceans, insects, planktons, molluscs, macrophytes, charcoal and unidentified materials) were encountered in *S. mystus* gut. However, the most balanced feeding regime consisted of insects, crustaceans and planktons. This mixed diet composition revealed that the fish is an omnivore. According to **Menon and Chacko (1956),** fishes fed on filamentous algae, molluscs, worms, and they concluded that fishes whose guts contain sand grains in fair proportions are benthic feeders. Thus, *S. mystus* can be classified as benthic omnivore. This corroborates the earlier findings of **Omondi and Ogari (1994)** on *S. mystus* in River Nyando, Kenya. The present findings agree with the work conducted by **Ayoade *et al*. (2008)** who reported that insects, plankton and crustacean were the most sorted food item of the species in Oyan and Asejire Lakes, respectively. Furthermore, **Omondi and Ogari (1994)** found *S. mystus* from River Nyando, Kenya to be predominantly omnivorous, feeding mainly on chironomids and plant materials. A similar trend was reported by **Uneke (2016)**, who investigated the food, feeding habits and condition factor of the *S. mystus* from Cross River, Nigeria. The previous author found algae and zooplanktons as major food items of the species. These observations suggest that the availability of food in the habitat is the main factor that determines the feeding habits of *S. mystus*, and that such species have no food specificity.

Sequel to the presumption, niche breadth values are considered a measure of trophic specialization **(Hurlbert, 1978)**. *S. mystus* can be considered as specialist. This implies that it consumes a wide range of food items or prey in the Lake. The high niche breadth may be attributed to the reduced competition due to the slightly more diversified nature of the species. A similar increased niche breadth (1.0 to 2.38) in fishes of lake habitats have been documented in the study of **Oueda *et al*. (2008)**. According to **Abdul *et al*. (2016),** high niche breadth enables fishes to switch from one category of food to another in response to fluctuation in their abundance. Moreover, **Offem *et al*. (2008)** attributed the ability of the species to utilize many varieties of food effectively to being a trophic generalist.

CONCLUSION

Schilbe mystus exhibited negative allometry growth with good condition of well-being in Asejire Lake. Dietary analysis revealed that *S. mystus* is a specialist benthic omnivore feeding mainly on insects, crustaceans and planktons. The high niche breadth indicates a trophic generalist. Therefore, this research provides key information necessary for formulating artificial diet for *S. mystus* under culture environment.

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