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The Influence of Size, Sex and Season on the Feeding Regime of *Synodontis membranaceus* (Osteichthyes: Mochokidae) in Jebba Lake, Nigeria

Olufemi D. Owolabi
Department of Zoology, University of Ilorin, P.M.B. 1515, Ilorin 240003, Nigeria

Abstract: The influence of size, sex and season on the feeding regime of *S. membranaceus* were examined over a period of 24 months in Jebba Lake, Nigeria using frequency of occurrence, numerical, gravimetric and index of Relative Importance (RI) methods. Dietary composition and feeding intensity were sex dependent. RI established that there was a progression from a detritivorous diet in fish below 20 cm Standard Length (SL), through a transitional planktivorous phase (20-27 cm, SL), to a predominantly molluscivorous/insectivorous diet in fish above 27 cm SL; thus indicating a switch from a relatively passive filter-feeding habit when young to an active predatory habit at adult stage. Food preference also varied with season hence intraspecific competitions were low. Abundant food and ability to evolve trophic strategies that ensure optimum foraging in spite of seasonal changes enable *S. membranaceus* to maintain its overwhelming prominence and wide distribution in Jebba Lake.

Key words: *S. membranaceus*, food, feeding strategies, Jebba Lake, Nigeria

INTRODUCTION

Synodontis membranaceus (Geoffroy Saint Hilarie) is ubiquitous throughout the local waters of Northern Nigeria and also common throughout the year (Reed *et al*., 1967) and perhaps more important in the commercial catch than any other species in the region. It is mostly sought after because of the excellent flavour of its flesh either fresh or dried. It is particularly suited to making into the popular Nigerian dish of peppered soup. *S. membranaceus* performs an important trophic role in their habitat (Reed *et al*., 1967) where they serve as food for other commercially important fishes and hence the need for their conservation. They are also important as aquarium exhibits (Otubusin, 1986; Teugels, 1996), as their habit of swimming up side down makes them beautiful and interesting to behold.

Quantitative and qualitative dietary compositions of tropical fish species have been reported to vary with size (Fagbenro *et al*., 1991; Ezenwaji, 1999), sex (Fryer and Iles, 1972; Jobling, 1981; Ezenwaji, 2002) and season (Tudorancea *et al*., 1988; Ugwumba and Adebisi, 1992; Odum and Anuta, 2001; Saliu, 2002). Equally important factors attributable to changes in the quantity and quality of fish diets include time of feeding, kinds of food available, types of digestive enzymes in gut, life history stage, morphological changes in feeding apparatus due to age and the locality in which the fishes are found (Imevbore and Bakare, 1970; Ikusemiju and Olaniyan, 1977; Fagade, 1978; Akinwumi, 2001; Ogbeibu and Ezeunara, 2005). Although, *S. membranaceus* has been reported to be omnivorous, subsisting on any readily available food items in Jebba lake (Owolabi, 2005), the influence of size, sex and season on the trophic strategies of the species has not been reported. Biological information to keep track of any ecological alterations as it affects the species in their environment is necessary for their management and conservation. Information on the size related changes in diets of fishes, in particular, might facilitate the understanding of appropriate dietary requirement of fishes, as they grow from larva, juvenile to adult in any culture system.

This study was intended to examine the feeding strategies of *S. membranaceus* in relation to their size, sex and seasonal changes in Jebba Lake, Nigeria.

MATERIALS AND METHODS

Jebba Lake (9° 10' to 9° 55' N and 4° 30' to 5° 00' E) was formed in August 1983 as an impoundment in the valley of River Niger. It extended from the dam-site at Jebba to southern tip of Kainji dam. The lake is therefore unique as the first and the only man-made lake in Nigeria that has a direct inflow from another man-made lake located upstream to it. It is bounded by Kwara State on the west and Niger State on the east. The lake has a surface area of 303×10^6 m^2, length of 100 km, maximum depth of 33.0 maximum width of 10.0 km and maximum volume of $1{,}000\times10^6$ m^3 (Adeniji, 1991). One sampling station each was selected from each of the three zones

(basins) i.e., Dam-site from the Southern basin (maximum depth: 23.0 m), Old Gbajibo from middle basin (maximum depth: 27.0 m) and Faku from the Northern basin (maximum depth: 33.0 m).

Bi-monthly collection of 1,208 fish specimens was carried out for 24 months (April 2002-March 2004) using gill nets of various mesh sizes ranging from 5.08 to 10.16 cm. Fishes caught were identified using the meristic features provided by Willoughby (1974) and were put in ice chest to reduce post humous digestion. In the Laboratory, the total and standard lengths and weight of each specimen were measured following the procedure of King (1996) after blotting out excess water on the fish. Each specimen was slit open and its degree of stomach fullness rated as 0 (empty; ES), 1 (quarter-full; QFS), 2 (half-full; HFS), 3 (three quarter-full; TQF) or 4 (full stomach; FS). The contents of the stomachs were emptied into separate petri dishes and identified to the lowest taxonomic level according to the method of Ward and Whipple (1950). The contents were analyzed instantly, but when this was not possible, the contents were preserved in 4% formaldehyde. Frequency of occurrence, numerical and gravimetric methods (Ricker, 1968; George and Hadley, 1979) were employed in the analysis of the gut contents. To reduce bias, dietary importance of food items was determined using the Relative Importance (RI) index (George and Hadley, 1979; Hyslop, 1980). Food items with RI > 5.0 were considered major or important food items. Each specimen was grouped into different size categories based on the analysis of growth rings on the opercula bones (Owolabi, 2005). Feeding intensity and food composition data were analyzed using student's t-test.

RESULTS

There was a significantly higher FS ($t = 7.62$, $p<0.001$) in males and higher ES ($t = -7.19$) in females (Table 1) than in their opposite sexes. There was no significant difference in QFS and TQS ($p>0.001$) between sexes. Table 2 shows that the qualitatative compositions of food in both sexes were similar. The RI of dietary compositions of males was significantly higher in plant parts, seeds and coleopteran larvae and lower in detritus, *Aspatharia* species, gastropod and insect appendages than females (t-test, $p<0.05$) in each case. Variations in the RI of other food items were not different ($p>0.05$) between sexes. Changes in stomach fullness condition with size (Table 3) shows that FS and TQS were both highest and QFS lowest in the size group 28-35 cm SL, while 20-27 cm SL group had the lowest incidence of ES. All the size categories examined fed on all the food items except *Aspatharia*, gastropod and copepod (Table 4). The obtained RI values established detritus as the most important food item for fish below 20 cm SL with a value of 26.88, while copepod, adult *Povilla adusta* and gastropod were the most prominent food items in fish between 20-27 cm SL, 28-35 cm SL and 36-43 cm SL with corresponding RI values of 22.61, 21.44 and 20.06, respectively. RI values of detritus and *Spirogyra* decreased with increase in length, while RI values of

Table 1: Sexual variation in stomach fullness condition of *S. membranaceus* from Jebba Lake, Nigeria

	Mean stomach fullness proportion (%)±SD		
Stomach fullness condition	Sex		
	Male (n = 601)	Female (n = 607)	P*
ES	27.62±05.18	32.95±08.32	<0.001
QFS	16.31±04.17	17.13±04.64	<0.001
HFS	14.48±04.63	17.63±04.83	<0.001
TQS	15.47±05.44	13.01±05.13	ns
FS	26.12±07.65	19.28±06.88	<0.001

P* Significant level for t-test between sexes; ns: Non significant; ES: Empty Stomach; QFS: Quarter Full Stomach; HFS: Half Full Stomach; TQS: Three Quarter Full Stomach; FS: Full Stomach

Table 2: Sexual variation in RI of dietary composition of *S. membranaceus* from Jebba Lake, Nigeria

	RI values		
	Sex		
Food items	Male (n = 601)	Female (n = 607)	P*
Plant parts	26.24	20.81	<0.001
Spirogyra	18.09	17.74	ns
Seeds	23.75	15.07	<0.001
Insect appendages	21.25	26.08	<0.001
Aspatharia species	12.57	16.32	<0.001
Gastropoda	13.89	16.86	<0.001
Povilla adusta (adult)	25.63	24.13	ns
Dragon fly (adult)	02.42	02.42	ns
P. adusta (larvae)	02.19	02.16	ns
Chironomid larvae	01.59	02.24	ns
Coleoptera larvae	24.52	21.78	<0.001
Copepod	16.97	17.64	ns
Daphnia	02.20	02.19	ns
Water mite	01.89	01.88	ns
Fish scales	00.78	01.03	ns
Detritus	28.84	34.26	<0.001

RI: Relative Importance Index; P*: Significant level for t-test between sexes; ns: non-significant

Table 3: Size variation in stomach fullness condition of *S. membranaceus* from Jebba Lake, Nigeria

	Mean stomach fullness proportion (%)			
Stomach fullness condition	Size groups (SL, cm)			
	12-19	20-27	28-35	36-43
ES	71.82	57.84	60.29	73.57
QFS	57.40	44.44	13.71	23.38
HFS	34.83	40.19	20.42	14.75
TQS	20.20	27.70	34.23	19.76
FS	15.76	29.84	71.35	68.55

ES: Empty Stomach; QFS: Quarter Full Stomach; HFS: Half full Stomach; TQS: Three Quarter Full Stomach; FS: Full Stomach

Aspatharia increased with increase in size. Similarly, RI values of plant parts, seeds and coleopteran larvae increased with length except a decline in the length group 36-43 cm SL. The Table further shows that there was a progression from detritivorous diets in fish below 20 cm SL through a transitional planktivorous diets in fish between 20-27 cm SL to a predominantly insectivorous/molluscivorous diets in fish above 27 cm SL.

Table 5 shows that there was a significant rainy (wet) season increase in ES ($t = 5.01$, $p<0.001$), QFS ($t = 4.04$, $p<0.001$), TQS ($t = -5.67$, $p<0.001$) and FS ($t = -4.24$, $p<0.001$). *S. membranaceus* fed on different food items during both seasons (Table 6). RI established that detritus, *P. adusta*, coleopteran larvae, copepods, seeds and plant parts were extensively consumed during the rains (April- October). More gastropods, *Spirogyra* and *Aspatharia* were, however, consumed during the dry months (November-March). Insect appendages showed no general variation with seasons as their RI values did not show much difference. In wet season, obtained RI values indicated that detritus were the most important food items in fish below 20 cm SL while fish between 20-27 cm SL showed preference for a mixed zooplankton (copepods) and detritus diets (Table 7). In fish above 27 cm SL, insects (adult *P. adusta*) contributed significantly to the diets. During the dry season, detritus,

Table 4: Relative Importance Index of major food items in the stomach of various size groups of *S. membranaceus* from Jebba Lake, Nigeria

	Relative importance index values			
	Size group (SL, cm)			
Food items*	12-19	20-27	28-35	36-43
Detritus	26.88	16.35	10.87	09.00
Aspatharia sp.	00.00	01.86	09.51	16.52
Plant parts	08.19	10.13	15.57	13.16
Seeds	05.82	09.97	11.80	11.23
Spirogyra	15.21	10.64	08.46	01.52
Gastropoda	00.00	00.00	10.69	20.06
Insect appendages	10.98	08.00	14.75	13.60
Copepod	09.94	22.61	00.00	02.06
Povilla adusta	12.26	06.17	21.44	09.89
Coleoptera larvae	10.72	14.27	18.35	02.96

* Arranged in order of importance

Table 5: Seasonal variation in stomach fullness condition of *S.membranaceus* from Jebba Lake, Nigeria

	Mean stomach fullness proportion (%)±SD		
	Season		
Stomach fullness condition	Rainy (April-Oct) n = 808	Dry (Nov-March) n = 400	P*
ES	33.16±10.79	22.73±05.93	<0.001
QFS	19.57±06.42	11.22±04.12	<0.001
HFS	13.58±04.29	21.38±03.59	<0.001
TQS	12.42±04.73	17.99±03.15	<0.001
FS	21.28±09.77	26.67±04.00	<0.001

P*: Significant level for t-test between seasons; ns: non significant; ES: Empty Stomach; QFS: Quarter Full Stomach; HFS: Half Full Stomach; TQS: Three Quarter Full Stomach; FS: Full Stomach

Table 6: Seasonal variation in relative importance index of the major food items in the stomach of *S. membranaceus* from Jebba Lake, Nigeria

	Relative importance index values	
	Season	
Food items	Rainy (April-Oct) n = 808	Dry (Nov-March) n = 400
Detritus	35.60	27.50
Aspatharia sp.	07.86	20.03
Plant parts	27.68	19.87
Seeds	20.84	17.98
Spirogyra	13.74	22.09
Gastropoda	06.16	23.59
Insect appendages	24.25	23.08
Copepod	19.07	15.54
Povilla adusta	29.57	20.19
Coleoptera larvae	27.38	18.92

Table 7: Seasonal variation in the relative importance index of the major food items in the stomach of various size groups of *S. membranaceus* from Jebba Lake, Nigeria

	Relative importance index values							
	Rainy season (April-October)				Dry season (Nov-March)			
	Size groups (SL, cm)							
Food items	12-19	20-27	28-35	36-43	12-19	20-27	28-35	36-43
Detritus	15.30	10.34	05.91	04.03	11.50	06.01	04.96	04.97
Aspatharia sp.	00.00	00.00	03.32	04.54	00.00	01.86	06.19	11.98
Plant parts	03.92	06.71	09.74	05.31	04.27	03.42	05.83	07.85
Seeds	02.79	04.81	06.32	06.92	03.03	05.16	05.48	04.31
Spirogyra	04.43	04.02	05.29	00.00	10.78	06.62	03.17	01.52
Gastropoda	00.00	00.00	02.05	04.11	00.00	00.00	09.64	13.95
Insect appendages	06.49	04.71	06.00	07.05	04.49	03.29	08.75	06.55
Copepoda	06.68	10.33	00.00	02.06	03.26	12.28	00.00	00.00
Povilla adusta	08.26	02.90	13.09	05.32	04.00	03.27	08.35	04.57
Coloeptera larvae	06.62	09.34	10.29	01.13	04.10	04.93	08.06	01.83

zooplankton (copepods) and molluscs (gastropods and *Aspatharia*) were found to be the most prominent and important diets for fish below 20 cm SL, between 20-27 cm SL and above 27 cm SL, respectively (Table 7).

DISCUSSION

The variation in feeding intensity and dietary composition with sex may be due to the larger sizes attained by the females, thus enabling them to utilize relatively larger and nutritionally profitable food items such as *Aspatharia* and gastropod at the expense of the males. The lowest incidence of ES and QFS noted among the size groups 20-27 and 28-35 cm SL, respectively and the highest incidence of FS, TQS and HFS that fall between 20-35 cm SL indicate more intense feeding at this size group than others. The diversity in prey preference of the fish in all the size categories could be due to partitioning of food resource in a bid to avoiding intraspecific competition. This plasticity in diet composition of *S. membranaceus* in Jebba Lake reflects the availability of preferred prey organisms within a particular niche. The same reason could also be advanced for the progressive decline or increase in relative importance of the food items, as the fish grew older (Table 4). The establishment of detritus as the main food items in the juveniles (12-19 cm SL) suggested a filter-feeding habit. The ventral location of the mouth encourages a detritivorous mode of feeding. However, the inclusion of varied and large size food items in larger specimens indicated a switch from a filter feeding to increase reliance or active predation on appropriately sized prey that are probably selected individually. This may have been informed by the development of strong pharyngeal teeth and jaws. The diversity thus observed in the dominant food items as well as the mode of feeding agreed with Nikolskii (1969), Ayinla (1988), Fagbenro *et al.* (1991) and Fagbenro (1992).

The switch from filter feeding to a predatory habit with increasing fish size is a common phenomenon in catfishes (Lowe-McConnell, 1975; Welcomme, 1985) and same phenomenon observed in *S. membranaceus* is not strange. Also, the progression from detritivorous diets through a transitional planktivorous phase to active predation on relatively bigger-sized prey with increasing fish size agrees with the observations of Ikusemiju and Olaniyan (1977), Willoughby (1979), Ochieng (1982) and Fagbenro (1992) that catfishes show a high degree of plasticity in their diets utilizing different food items as they grow. Preference for molluscs at adult stage could possibly be due to their small size, cylindrical shape and their high population in the reservoir. Being predominantly molluscivorous as adults suggests that *S. membranaceus* may provide a suitable non-chemical tool in the control of water molluscs and thus reducing molluscs transmitted diseases such as schistosomiasis. The significant rainy season increase in ES and QFS and a significant dry season increase in HFS, TQS and FS show that *S. membranaceus* fed less actively in the wet season than in the dry season. Owolabi (2005) reported that *S. membranaceus* bred in the wet season (April-October) in Jebba Lake. Therefore, the higher feeding activity in the dry season may be aimed at building up more fat stores in preparation for breeding in the wet season. The apparent changes in the relative importance index of food items with season suggests that the feeding habits of the fish changed at different times of the year depending on whatever food is available. Detritus, *P. adusta*, coleopteran larvae, copepods, seeds and plant parts were mostly consumed when gastropod; *Spirogyra* and *Aspatharia* were seemingly of less significance in the diets of the species (Table 6).

The transition from insectivorous diets in the rainy season to benthophagous diet in the dry season (Table 7) in specimen above 27 cm SL is an indication of food selectivity depending on the relative abundance of available food as well as the size spectrum. The size, which consumes more of particular major dietary items, augmented its food with less of other items as supplements. The consumption of food materials rich in supply at a particular season and supplementing such when in short supply along with size variation point towards means of avoiding or reducing possible competition within the species in the lake system. Changes in fish diet associated with size and in relation to seasonal availability have been reported by Arawomo (1976), Ugwumba and Adebisi (1992), Odum and Anuta (2001) and Saliu (2002). The increase in the quantitative composition of insects and their parts during the rainy season is attributed to the life history patterns of the insects and probably to the foraging efficiency of *S. membranaceus*. Detrital particles together with allochtonous food such as plant seeds washed by flood from the surrounding vegetation into the lake might have been responsible for the high incidence of each of these diets during the rainy season. The prominence of seeds in the rainy season raises the matter of their dispersal by *S. membranaceus*. Dispersal of seeds has been suggested for a number of fish species (Gottsberger, 1978; Goulding, 1980; Souza-Stevaux *et al.*, 1994; Ezenwaji, 2002). The more dependence of *S. membranaceus* on detrital materials in the rainy season than dry season

disagrees with the observation of Welcomme (1985) and Ezenwaji (2002). The mixed diet in the intermediate size (20-27 cm SL) emphasizes the importance of supplementary diet at ensuring optimal growth of the fish during artificial culture.

The feeding strategies of *S. membranaceus* permit the exploitation of all the food niches in the lake, i.e., the bottom, mid water and water-air interface. Although, the species subsists on any available dietary items in the lake, but seems to have propensity to feeding on molluscs when adult stage is attained. The wide distribution of the fish in the lake is therefore, consequent upon the rich variety and high quality food available to it and its ability to switch to available food items despite seasonal changes.

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