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Growth Patterns, Diet Composition and Sex Ratios in Giant African Threadfin, *Polydactylus quadrifilis* from Ologe Lagoon, Lagos, Nigeria

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ABSTRACT

The growth patterns, diet composition, and sex ratio of Giant African threadfin, *Polydactylus quadrifilis* (Cuvier, 1829) was investigated in Ologe lagoon in Nigeria to provide necessary baseline data toward the development of fisheries in Lagos lagoon system. A total of 180 individuals were caught from Ologe lagoon with gill and cast nets between October 2007 and September 2008. The fish measured between 90 and 490 mm Total length and weighed 8.5-950 g Body weight, respectively. The length-weight relationships were Log W = -4.96 + 2.92 Log TL (n = 83, r = 0.96) for males and Log W = 3.44+2.27 Log TL (n = 41, r = 0.88) for females. The growth exponential was near isometric for males (b = 2.92) and allometric for females (b = 2.27). Condition factor (K) of the fish ranged from 5.2×10^{-4} to 1.3×10^{-3} g/mm^3 for males and 4.24×10^{-4} to 1.3×10^{-3} g/mm^3 for females. 53.33% of the stomachs had foods, while 46.67% were empty. The species has piscivorous habit and carnivorous in nature. The diets comprised eight food items that were grouped into three categories, and four classes of animal taxa. The most eaten group was crustaceans that constituted 51.48% of the total number of food encountered. The least eaten was nematode (round worm), which constituted 1.48% by number. There were more male than the female. The sex ratio was 1 male: 0.49 female, this was significant ($P \leq 0.05$) and a significant departure from the theoretical and expected 1 male: 1 female sex ratio. The differences probably might be more ecological than genetical in Ologe lagoon. © 2011 Friends Science Publishers

Key Words: Polynemidae; Hermaphrodite; Exponential; Protandrous

INTRODUCTION

A giant African threadfin, *Polydactylus quadrifilis* (Cuvier, 1829) is a member of the Family Polynemidae. Threadfins are of considerable importance in commercial fisheries in tropical and subtropical seas. The species inhabits inshore and offshore sandy bottoms up to a depth of 50 m and between 1 to 150 m in river mouths or brackish mangrove estuaries. According to Feltes (1991) and Motomura (2004a & b), the family comprises of approximately 40 species, which are found in coastal marine waters, estuaries or rivers in the tropic. The species is highly regarded for its delicacy and forms important commercial, recreational and subsistence fisheries. It is noted for its ability to tolerate a wide range of salinity levels (Froese & Pauly, 2000).

Polynemids which include the giant African threadfin (*P. quadrifilis*) attain at least 40 cm and can grow to 150–200 cm. They grow rapidly and reach maturity early in life (Dentzau & Chittenden Jr, 1990; Szyper *et al*., 1991). Sexual maturity in males occurs at 12 to 15 cm. They subsequently undergo sex reversal passing through a hermaphroditic stage, and become females between 18 and 24 cm (Motomura, 2002). Although the majority of threadfin species are apparently protandrous hermaphrodites, a few are gonochoristic (Dentzau & Chittenden Jr, 1990). Judging from the few species that have been studied, most exhibit protandry, their sex changing from male to female with fish growth. However, their spawning behavior has never been reported, their spawning grounds are also un-known, they probably occur in coastal waters and estuaries.

Diets consist of shrimps, smaller fish, crabs, polychaete worms, and other benthic invertebrates (Motomura, 2004a). Their filamentous pectoral rays are thought to serve as tactile structures, helping the fish to find prey within the sediments. They are presumed to be pelagic spawners.

Importance of giant African threadfin, *P. quadrifilis* in the fisheries of Lagos and its environs can not be underestimated; it is jointly harvested by the artisanal fishermen and industrial fleets because of commercial value (Fishstat Plus, 2000). In recent years, the annual yields from Nigerian water in particular have declined so markedly that

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the commercial fisheries for those stocks have virtually collapsed. Their decline is due to their susceptibility to fishing pressure, which is typically biased toward the larger individuals in a population. There is a need for proper management of Nigerian waters to conserve this commercially valued fish and prevent its fisheries from extinction. To begin with this, bioecological studies must be carried out on this fish. In Lagos lagoon system especially Ologe lagoon, there is dearth of information on the *P. quadrifilis*, especially on aspects of its biology. This study was conducted to provide information on its biology. The biological data from our study will provide information that will be useful to regulating agencies toward its management and conservation especially in Ologe lagoon, Lagos, Nigeria.

MATERIALS AND METHODS

Description of ologe lagoon: Ologe lagoon (Fig. 1) lies between 6º27'N 3º01'E and 6º30'N 3º07'E. It is a large expanse of water body located in Lagos, Nigeria. It drains rivers such as Owo and Ore. It is a major source of water to Badagry creek, which opens into the Atlantic Ocean via the Lagos Harbour.

Ologe is bounded in the north by Ijanikin town, in the west by Asepe-Mushin and Araromi-Ale, Gbanko town and Badagry creek in the south and east by Ikotun and Idoluwo villages. It is extensively polluted with different wastes substances from sites along its length (Chukwu & Nwankwo, 2004; Ogunwenmo & Kusemiju, 2004). The lagoon is surrounded by pharmaceutical, breweries, food processing, pulp and paper industries, which discharge their wastes into it. This untreated discharges coupled with domestic wastes constitute a high level of pollution in the water body. In spite of the high pollution level, it continues to be a source of fish supply and transportation for people. The common fish in this water include Tilapia such as *Tilapia zillii, T. mariae* and *Oreochromis niloticus*, catfishes are *C. nigrodigitatus*, *Clarias gariepinus,* and *C. anguillaris*; ten pounder, *Elops lacerta*; threadfin, *Polydactylus quadrifilis*; mullets e.g., *Mugil cephalus* and *Liza falcipinnis;* clupeids, *Ethmalosa fimbriata* and snakehead, *Parachanna obscura*. In this study the collection stations (marked or starred) were located in Oto-Awori, Obele, Gbanko and Ibiye fishing villages.

Collection of specimens: A total of 180 specimens of *P. quadrifilis* were collected monthly from collection stations between October 2007 and September 2008. Specimens were caught using cast net of 20 mm mesh size at depths of <5 m and gill net of 40 mm mesh size for collection of specimens at depths of 5-50 m. Services of motorized artisanal fishermen operating in the lagoon were employed for the collection.

Laboratory procedures: In the laboratory, biometric data on total length (TL) and body weight (BW) were recorded. TL was measured to the nearest 1mm and W to the nearest 0.01 g body weight. Growth studies were carried out from analysis of length frequency data following Pauly (1987) method. The specimens were categorized as juveniles, sub-adults and adults. The length-weight relationship (LWR) between fish total length (L) and body weight (W) was presented in a linear form by logarithms transformation as:

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

The parameters 'a' 'b' and |r| were estimated from the least square regression method.

The condition factor (K) was estimated to determine the state of well being of the fish from equation:

$$K = \frac{100 \times W}{L^3} \text{ (Le Cren, 1951)}$$

Where, W = body weight in g; L = total length in mm. K was calculated in relation to sex.

The stomach contents were analyzed to establish the diet composition of the fish by making incision from the anus through the throat to reveal the alimentary canal. The stomach contents were identified. The analysis of the items in the stomachs of the specimens was undertaken by numerical and frequency of occurrence methods. The numerical method took the number of food items into consideration. The value was expressed as a percentage of the total number of all food items consumed by the fish. The frequency of occurrence considered the number of times each food item occurred in the stomachs examined. The frequency of occurrence was calculated relative to the number of stomachs containing food items. The merits and demerits of these methods have been examined by Hyne (1950), Hyslop (1980) and Wootton (1990).

The gonads were examined microscopically and by naked eye for sex determination. The gonads that were not discernible to be differentiated as males or females were classified as immature. The ratios of the numbers of males to females were subjected to Chi-square (X^2) test:

$$X^2 = \sum_{i=1}^{} \frac{(O-E)^2}{E}$$

Where, O = number observed and E = number expected.

RESULTS

Length frequency distributions: Histograms of the length frequency distribution of *P. quadrifilis* in Ologe lagoon are presented in Fig. 2. The fish TL varied between 90 and 327 mm. Unimodal class distribution was observed. The highest size cohort was 220 mm TL.

The summary of size distribution patterns of *P. quadrifilis* is given in Table I. In the study three (3) size groups were encountered, juveniles were those that measured between 90 and 180, sub-adults ranged from 181 to 280 and adults varied between 281 and 500 mm TL. They constituted 38.3%, 55.0%, and 6.7% of the fish population, respectively.

Table I: Size distribution patterns in *P. quadrifilis* from Ologe lagoon

Year	Months	Sample size	Juveniles 90-180 mm TL	Sub-adults 181-280 mm TL	Adults 281-500mm TL
2007	October	19	3	13	3
2007	November	0	0	0	0
2008	December	0	0	0	0
2008	January	0	0	0	0
2008	February	25	4	20	1
2008	March	45	9	36	0
2008	April	35	27	8	0
2008	May	8	7	1	0
2008	June	5	3	2	0
2008	July	28	16	7	5
2008	August	8	0	6	2
2008	September	7	0	6	1
	Total	180	69(38.33%)	99(55%)	12(6.67%)

Table II: Sex distribution patterns in *P. quadrifilis* from Ologe lagoon

Year	Months	Sample size	Number of immature	Number of males	Number of females
2007	October	19	2	11	6
2007	November	0	0	0	0
2008	December	0	0	0	0
2008	January	0	0	0	0
2008	February	25	8	8	9
2008	March	45	8	27	10
2008	April	35	20	8	7
2008	May	8	6	0	2
2008	June	5	0	4	1
2008	July	28	12	12	4
2008	August	8	0	6	2
2008	September	7	0	6	1
	Total	180	56(31.11%)	83 (46.11%)	41(27.78%)

Table III: Condition factor (K) in *P. quadrifilis* from Ologe lagoon

Sex	Sample size	Total length (mm)		Range of K		
		min	max	min	max	Mean ±SD
Immature	56	90	210	4.4×10^{-4}	1.86×10^{-2}	8.38×10^{-4}
Males	83	160	490	5.2×10^{-4}	1.3×10^{-3}	7.34×10^{-4}
Females	41	155	327	4.2×10^{-4}	1.3×10^{-3}	7.52×10^{-4}

Sex distribution patterns of *P. quadrifilis* in Ologe lagoon (Table II) showed that the specimens were classified as immature, males and females consisting of 31.1%, 46.1% and 22.7% of the catch and measuring 90-209, 165-490 and 155-327 mm TL, respectively.

Length-weight relationships (LWR): The TL measurements varied between 90 and 209 mm (143.68±30.03 mm TL) and weighed 6-68 g (25.62±13.36) g BW, respectively for unsex fish. The log transformation of the LWR is expressed in Fig. 3 as:

Log W=-3.69+2.35 Log L (n=56, r= 0.89)

The TL of males ranged from 165 to 490 (227.17±55.1) mm for fish that measured between 29 and 950 (101.18±111.11) g BW, respectively. The log transformation of the LWR is represented as:

Log W=-4.96+2.92 Log L (n=83, r= 0.96) (Fig. 4).

In females the TL measurements were between 155 and 327 (220.78±36.51) mm and 33.5-299.8 (83.01±40.17) g BW. The LWR is given as:

Log W=-3.44+2.27 Log L (n=41, r= 0.88) (Fig. 5).

The growth exponential values of b=2.35, 2.93 and 2.27 were allometric for immature, males and females. The regression coefficient (r) values 0.89, 0.96 and 0.88, respectively. There was increase in L with a corresponding increase in W. the growth exponential 'b' and 'r' were better in males than both immature or females.

Condition factor (K): The condition factors of the specimens are presented in Table III. The values varied with sex. In immature fish it was $4.37x10^{-4}$-$1.86x10^{-3}$ ($8.38x10^{-4}\pm2.92x10^{-4}$) g/mm^3, between $5.2x10^{-4}$ and $1.3x10^{-3}$ ($7.34x10^{-4}\pm1.35x10^{-4}$) g/mm^3 in males and from $4.2x10^{-4}$-$1.3x10^{-3}$ ($7.52x10^{-4}\pm1.97x10^{-4}$) g/mm^3 in females. Immature exhibited better K than both male and female.

Diet composition: Summary of the stomach contents in *P. quadrifilis* from Ologe lagoon is presented in Table IV. Of the 180 stomachs examined in this study, food items were encountered in 96 (53.33%) stomachs, while 84 (46.67%) were empty. The diets comprised eight (8) types of food from five (5) classes in three (3) categories. The invertebrates comprised three classes of animals viz: Crustacea, nematoda, chaetognatha. Crustaceans represented by copepod (*Calanus finmarchicus*), swimming crab (*Callinectes sp.*) and pink shrimp (*Penaeus notialis*) constituted 34.72, 9.64 and 7.12% by number and occurred in 57.29, 35.42 and 29.17% of the stomachs, respectively. Round worm, the only representative of Class Nematoda contributed 1.48% by number and 1.04% by occurrence. An arrow worm (*Sagitta sagitta*) of the class Chaetognatha constituted 15.13 and 61.46% by number and occurrence, respectively.

The phylum vertebrata was represented only by bony fish (Pisce), *Ilisha africana* and *E. fimbriata* were clupeids (Family: Cluipeidae) that formed part of the diet of this fish. They constituted 6.68 and 5.94 by number and occurred in 46.88 and 41.67% of the stomachs, respectively. The only detritus in the diets of *P. quadrifilis* in Ologe lagoon was sand grains, which respectively contributed 19.29% by number, occurring in 26.04% of the stomachs containing foods.

Sex ratios: Summary of the monthly sex ratios in *P. quadrifils* is presented in Table V. The immature gonads constituted 56 (31.11%). 83 (46.11%) of the specimens were males and 41 (22.78%) females, giving an overall ratio of 1male: 0.49 female. A Chi-square test revealed significant ($P\leq0.05$) departure from the theoretical 1 male: 1 female ratio ($X^2>X^2_{1,\ 0.05}=3.84$). The sex ratio was in favor of males. The monthly sex ratios of this species in Ologe lagoon showed more males than females except for February and April when 1 male: 1 female ratio was obtained. The highest ratio of 7 males to 0 female was recorded in September.

Table IV: Diet composition in 96 stomachs of *P. quadrifilis* from Ologe lagoon

Category	Classes	Food items	Numerical method		Occurrence method	
			Number	%	Number	%
Invertebrates	Crustacea	Copepod:*Calanus finmarchicus*	234	34.72	55	57.29
		Swimming crab :*Callinectes*	65	9.64	34	35.42
		Pink shrimp: *Penaeus notialis*	48	7.12	28	29.17
	Nematoda	Round worm	10	1.48	10	1.04
	Chaetognatha	Arrow worm**:** *Sagitta sagitta*	102	15.13	59	61.46
Vertebrates	Pisce: Bony fish	Clupeids: *Ilisha africana*	45	6.68	45	46.88
		Ethmalosa fimbriata	40	5.94	40	41.67
Detritus	Detrita	Inorganic matter :sand grains	130	19.29	25	26.04
			674*		#	

*Sum of all food items encountered in 96 stomachs

96 stomachs contained food items

DISCUSSION

In this study the size of *P. quadrifilis* varied between 90 and 490 (199.572±56.862) mm TL and weighed 6-950 g W, respectively. The length frequency distribution showed the availability of the juveniles, sub-adults and adults in Ologe lagoon. Sub-adults were the most abundant consisting 55% of the total catch, the juveniles and adults were 38.3% and 6.7% of the population, respectively. Large population of juvenile is an indication that the lagoon is a breeding or spawning ground for reproduction, while little number of adults is an indication that their down stream migration to Lagos coast (Atlantic Ocean) via Badagry creek. Fishing pressure exerted by the local artisanal fishermen target against adult population may lead to their few number, many juveniles might escape the fishing gear. Variations in size also cut across the immature, males and females. These variations were 90-209, 165-490 and 155-327 mm TL for immature fish, males and females, respectively. Males grow bigger than the females, but latter mature faster than former. High percentage (31.1%) of immature population suggests its surplus in the spawning ground, female may probably leave the spawning ground more quickly to facilitate more rapid recovery of gonads, which may result in increase in the population of the immature.

In Ologe lagoon the growth exponential values of b of *P. quadrifilis* were 2.34, 2.92 and 2.28 for immature, males and females, respectively. The parameter "b" has a very significant biological meaning. It indicates the rate of weight gain in relation to growth in length. "b" equals to 3, means the isometric growth. "b" value greater than 3, signifies a positive allometric growth meaning the weight of the fish is too much for its length. A value of "b" lesser than 3 indicates a negative allometric growth, the fish becomes lighter for its length as it grows. The b values of length-weight relations are known to vary with age, maturity and sex (Dulcic & Kraljevic, 1996); geographic location, environmental condition, season, stomach fullness, disease and parasite loads (Le Cren, 1951; Ricker, 1975; Bagenal & Tesch, 1978; Erkoyuncu, 1995). The correlation values of r=0.89 (immature), 0.96 (males) and 0.88 (females) were indication of a strong relationship between total length and body weight measurements of the fish. There was an increase in body weight with corresponding increase in total length.

Table V: Summary of the monthly sex ratios of *P. quadrifilis* in Ologe lagoon

Year	Months	Sample size	Number of males	Number of females	Sex ratio
2007	October	19	11	6	1:0.55*
2007	November	0	0	0	0
2007	December	0	0	0	0
2008	January	0	0	0	0
2008	February	25	8	9	1:1.13
2008	March	45	27	10	1:0.37*
2008	April	35	8	7	1:0.88
2008	May	8	0	2	0
2008	June	5	4	1	1:0.25*
2008	July	28	12	4	1:0.33*
2008	August	8	6	2	1:0.33*
2008	September	7	6	1	1:0.17*
	Total	180	83	41	1:0.49

*Significance at P<0.05

Low condition factor (K) exhibited by both sex in June could indicate a period of spawning when accumulated fat was being used up for reproduction (Braga & Gennari-Filho, 1990), while higher values of K as it was observed in March, April and August 2008 probably when feeding activity would have resumed and gradual increase in accumulated fat, could suggest a preparation for a new reproductive period. Variation in values of K according to King (1995) may be indicative of food abundance, adaptation to environment and gonadal development of fish.

The diet composition of *P. quadrifilis* in Ologe lagoon comprised invertebrate such as copepods, crabs and shrimp. There presence was attestation to its carnivorous tendency, while occurrence of bony fish of the clupeids was an indication of its piscivorous habit with preference for clupeids such as ilisha (*I. africana*) and bonga (*E. fimbriata*). Clupeids are a group of marine fish with occasional incursions into brackish water of Ologe lagoon via Badagry creek. Presence of sand grains (19.29% by number & 26.04% by occurrence) in the fish stomachs did not indicate its preference over other foods in terms of the nutritional value. Sand grain does not have nutritional value or more important nutritionally than the other food items.

Fig. 1: (A) Map of Badagry Creek and Lagoon Complex-inset: Ologe Lagoon; (B) Map of Ologe Lagoon showing the fish collection sites (marked with stars)

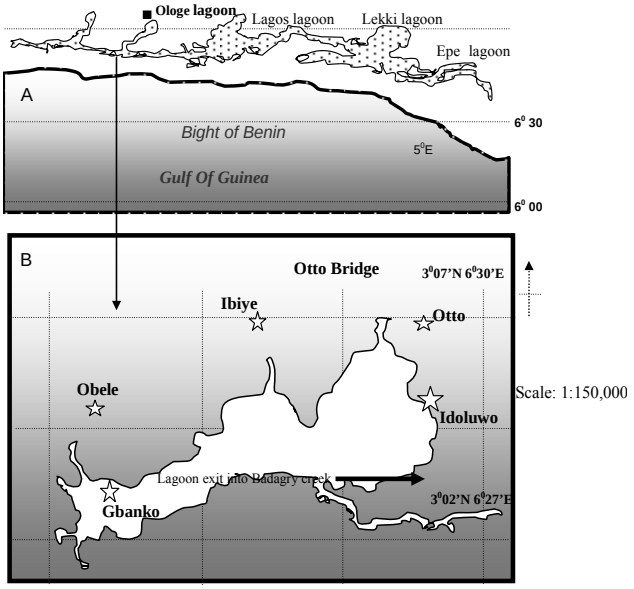


Fig. 2: Histograms of Length frequency distribution in *P. quadrifilis* from Ologe lagoon

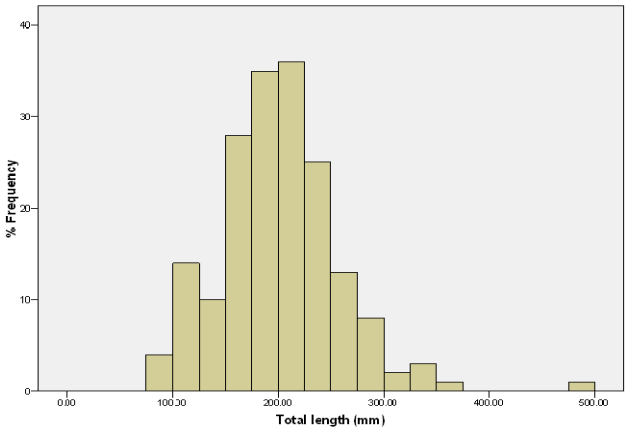


Fig. 3: Log total length-Log body weight relationship in immature *P. quadrifilis* from Ologe lagoon

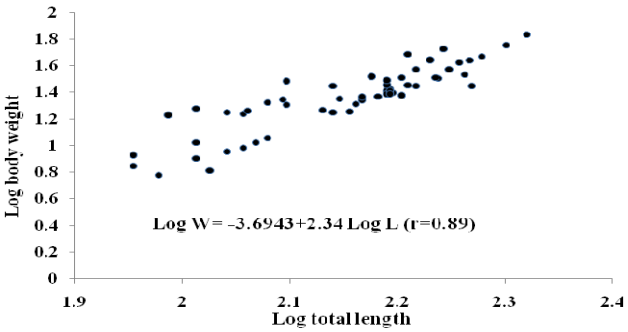


Fig. 4: Log total length-Log body weight relationship in male *P. quadrifilis* from Ologe lagoon

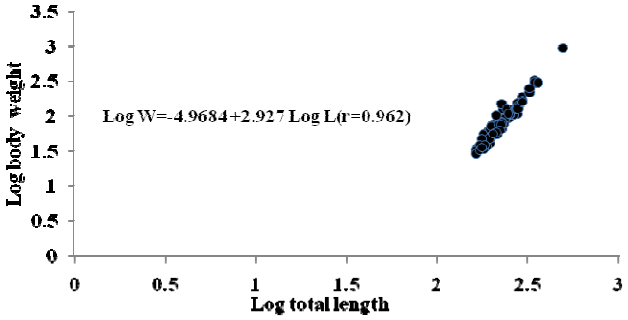
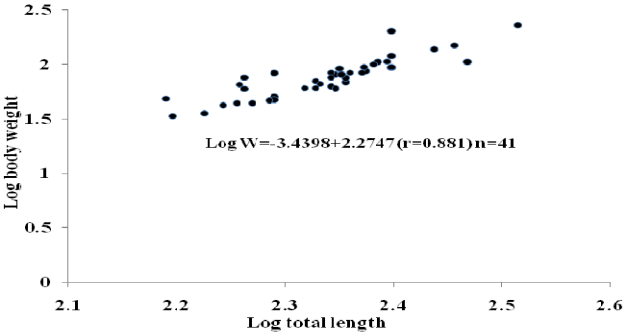


Fig. 5: Log total length-Log body weight relationship in female *P. quadrifilis* from Ologe lagoon



The grains probably might have found their way into the stomachs of fish via the ingestion of crabs and shrimps, which are sometimes benthic. We could not deduce based on our methodology, the importance of sand grains in digestion process of this fish.

In this study, we observed that *P. quadrifilis* possessed simple stomachs, un-like cryptobentic fishes (like mudskipper, *Periophthalmus papilio* & frill fin goby, *Bathygobius soporator*) and mullets with sand filled gizzards as parts of their stomachs (Lawson, 2004; Lawson & Jimoh, 2010; Lawson *et al.,* 2010; Lawson & Thomas, 2010).

The population *P. quadrifilis* in Ologe lagoon showed there were 46.1% males and 22.7% females. A sex ratio of 1 male to 0.49 female in this species was highly significant ($P<0.05$) and a departure from the expected and theoretical 1 male: 1 female. Sex ratios in favour of males during the spawning period were reported in *E. lacerta* (Ugwumba, 1984; Lawson & Aguda, 2010) and *C. walkeri* (Kusemiju, 1976) in some West African lagoons. The reasons probably may be ecological or genetical factors or both. Females were suspected to leave the spawning grounds more rapidly than the male counterparts (Ozcan & Balik, 2009). Males according to Nikolsky (1963) usually predominate in the young fish, because they mature earlier but live less long. Secondly, sex reversal, where some females reversed or change to male was suspected to have occurred at a stage in the life history of this fish (protandrous hermaphroditism). Sex ratio where large number of males is available to very few females may not be too well for reproduction of this

species especially in Ologe lagoon, this probably might have accounted for its not all year presence in this creek.

Sex ratios in favor of females were documented in *E. fimbriata* (Fagade & Olaniyan, 1972; Blay & Eyeson, 1982) and *M. cephalus* (Lawson, 1991; Lawson & Jimoh, 2010). However, sex ratio of 1 male: 1 female was reported by (Fagade, 1969; Lawson, 1998) on Tilapia and mudskipper, *P. papilio*, respectively in some Nigerian waters.

Sex ratio could be influenced by the availability of food (Nikolsky, 1969). Nikolsky (1963) reported that when food is abundant, females predominate, with the situation inverting in regions, where food is limited. Feeding activity, in this case, would be influencing metabolism through hormonal activity, resulting in changes in production of individuals of a given sex. Females requiring better environmental conditions than males and suffering in their development when environmental conditions deteriorate had been reported.

In this study information is therefore provided on growth patterns, diet composition and sex ratios in giant African threadfin, *P. quadifilis*. The baseline data contribution from this study will assist in the management and conservation of fish and fisheries of Ologe lagoon, Lagos, Nigeria.

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