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Full Length Research Paper

Aspects of ecology and biology of the cichlid, *Tilapia mariae* from two adjacent low-brackish water lagoons in Nigeria

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Some aspects of the ecology and biology of the spotted tilapia, *Tilapia mariae* from Badagry and Ologe Lagoons in Nigeria were examined between August 2006 and May 2007. The species was captured throughout the sampling period and constituted about 34.55 and 38.42% of five cichlid species in the catch from Badagry and Ologe Lagoons respectively. Whereas, the total lengths of the specimens from Badagry Lagoon ranged from 8.2 to 17.1 cm (SL, 6.5 – 15.0 cm), specimens from Ologe Lagoon had a total length of 8.9 – 18.1 cm (SL, 6.9 – 13.5 cm). The total weight ranged from 15.50 to 86.50 g and 15.00 to 105.40 g for the specimens from Badagry and Ologe Lagoons respectively. Generally, the condition factors of *T. mariae* from Badagry Lagoon were higher than those from Ologe lagoon. The sex ratio of 1:0.66 and 1:0.70 were obtained in specimens from Badagry and Ologe Lagoons respectively. Four gonad maturation stages were recorded in Badagry Lagoon, while three were recorded in Ologe Lagoon. Plant materials, diatoms and green algae predominated the food items consumed by the species in Badagry Lagoon, while diatoms, cyanobacteria and green algae were the most abundant items consumed in Ologe Lagoon. Adequate management of the species will enhance fish production in the sub-region.

Key words: Brackish-water, Lagoon, *Tilapia mariae*, cichlid, food items

INTRODUCTION

Cichlids are one of the great economically viable fishes in tropical inland waters of Africa and they play significant roles in the ecology of African freshwater bodies (Ikomi and Jessa, 2003). Several literatures are available on Cichlid species and these include aspects of the ecology and biology (Fagade, 1982; Ikomi and Jessa, 2003) age, growth and mortality (Faunce et al., 2002), condition factor (Fagade, 1983b; Arawomo, 1982; Anene, 2005) among others. However, studies on the biology and ecology of *Tilapia mariae* from the Badagry and Ologe Lagoons are very scarce. This species has a wide distribution in the fresh and brackish water rivers of southern Nigeria (Fagade, 1971). Fagade and Olaniyan (1974) reported the occurrence of the species in the Lagos Lagoon when the water is either fresh or recording low Salinities (less than $1^{o}/_{oo}$) Ikomi and Jessa (2003) examined the biology of this species in Ethiope River, Nigeria.

There are still gaps in the current knowledge on the ecology and the biology of this species of high commercial importance in low brackish waters as Badagry and Ologe Lagoons. The present investigation examined the ecology and some aspects of the biology of the species in two low brackish water lagoons of south-west Nigeria, with a view to contributing to the knowledge of the species in the region.

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MATERIALS AND METHODS

Description of the study area

Badagry Lagoon (Figure 1), which is approximately 60 km long and 3 km wide, lies between longitude 3°0′ and 3°45′ E and latitude 6°25′ and 6°30′ N. It is part of a continuous system of lagoons and creeks lying along the coast of Nigeria from the border with the Republic of Benin to Niger Delta with depth of the water ranging from one meter to three meters (1 – 3 m). It is also characterized by freshwater and low brackish water situations for most of the year

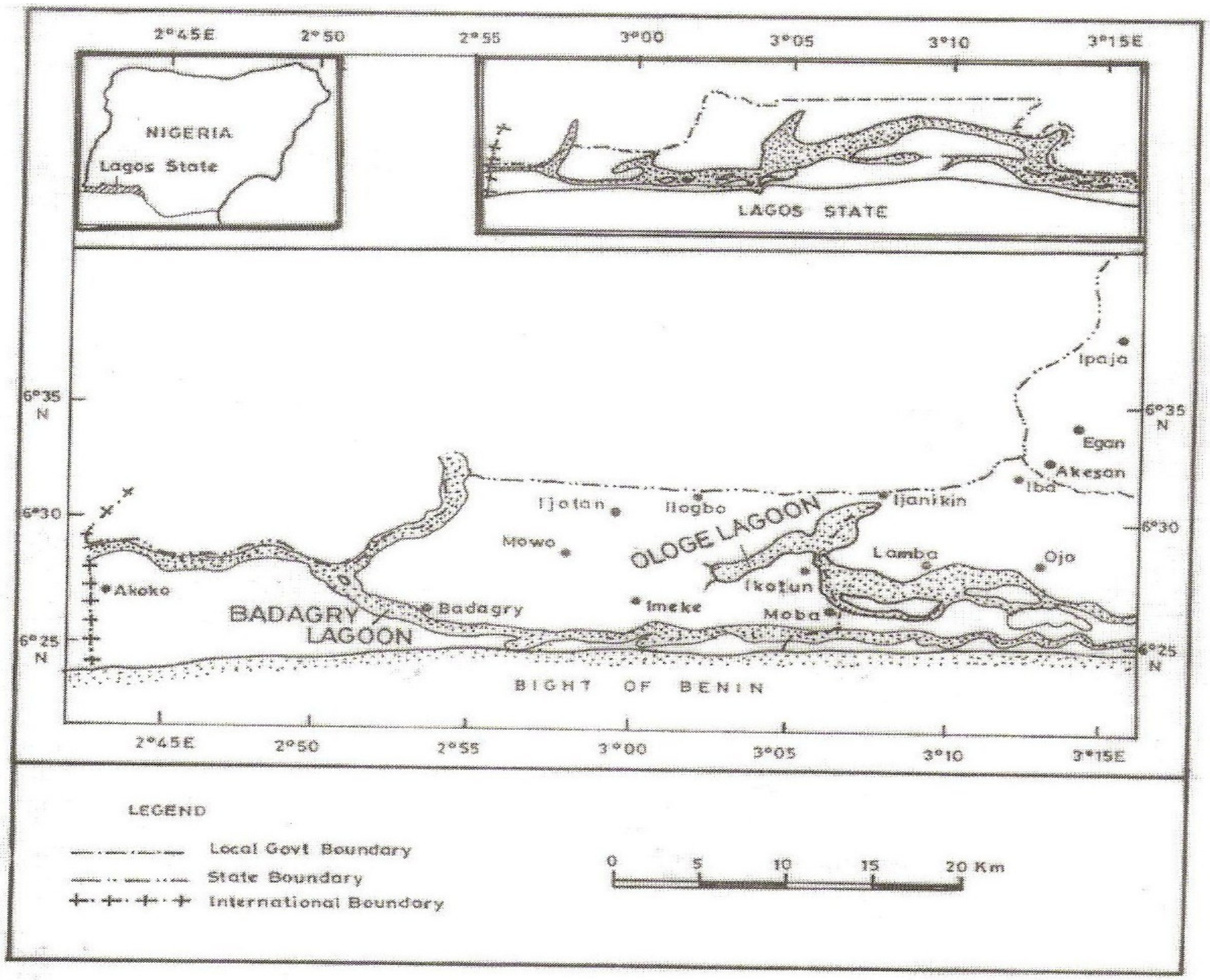


Figure 1. The Badagry and Ologe Lagoons in south-western Nigeria.

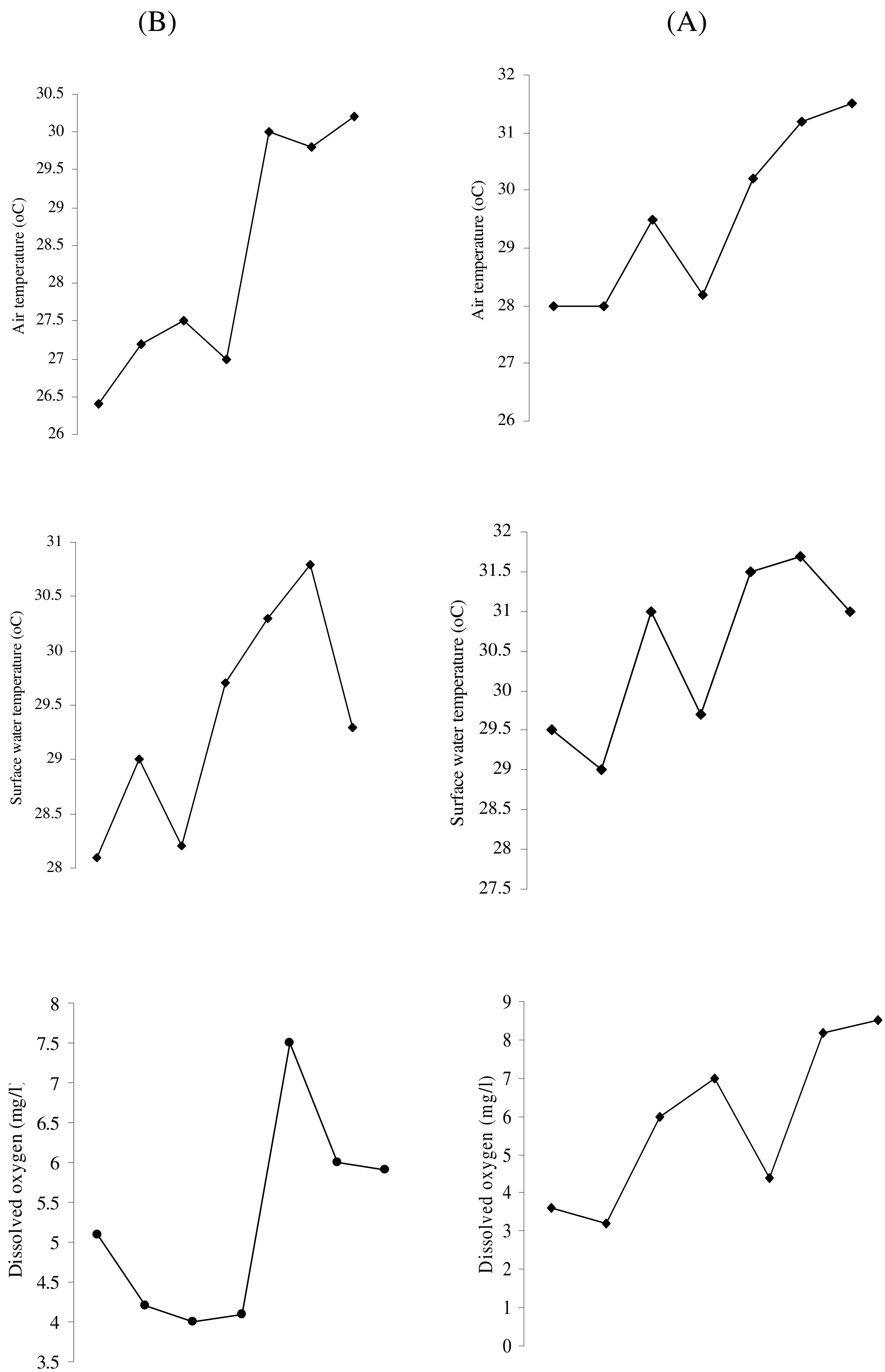
(Ezenwa and Kusemiju, 1985). It is influenced by tides and floods from Lagos Lagoon and Cotonou harbour through Lake Nokue and Lake Porto-Novo. River Yewa is the major river emptying into the lagoon and has rivers Isalu and Ijomo as tributaries. Creeks connected to the lagoon include Bawa and Doforo. There are few Islands: Toto and Egborovi Islands and many fishing villages such as Topo, Gbaji, Iyatin, Pako and Ibakwe Kekere scattered around the lagoon. The area is characterized by thick shrubs and trees such as Raphia palms (*Raphia sudanica*); Oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera*) are the dominant flora in the area (FAO, 1969).

Ologe Lagoon (Figure 1) is a part of the continuous system of lagoons and creeks linked with the Lagos Lagoon. It is close to the Badagry Lagoon and lies between Latitude 6°27′ and 6°30′ N and Longitude 3°02′ and 3°07′ E. Rivers Imede, Owo, Oponu and Ilo are major rivers emptying into Ologe Lagoon. Its main outlet empties into Elete creek through which it connects with other creeks and lagoons such as the Iyagbe Lagoon, Badagry and Lagos Lagoons. Its shallow parts are characterized by blooms of aquatic macrophytes e.g. *Eichhornia crassipes*. A number of Industries from Agbara Industrial Estate discharge their wastewater into the lagoon. Inspite of the level of pollution, the lagoon fisheries is a source of livelihood in the state (FAO, 1969).

Collection of specimens and field studies

The 147 *T. mariae* specimens used for this study were purchased from local fisher-folks on landing at Badagry and Ologe fisheries jetties from August 2006 – May 2007. The specimens were sub-samples of a survey of the fishes of both lagoons during the sampling period. The specimens were fished with cast nets in the lagoons. The specimens were preserved in an ice-chest containing ice cubes in the field and later transferred into a deep freezer (temperature -20°C) in the laboratory after sorting and identification prior to further examination.

Water samples were collected from the lagoons for analysis of physico-chemical parameters. The atmospheric and surface water temperatures were measured using a simple mercury thermometer. The salinity was determined using a Refractometer (BIOMARINE,


(B)
(A)
Air temperature (oC)
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26.5
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Air temperature (oC)
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Surface water temperature (oC)
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Dissolved oxygen (mg/l)
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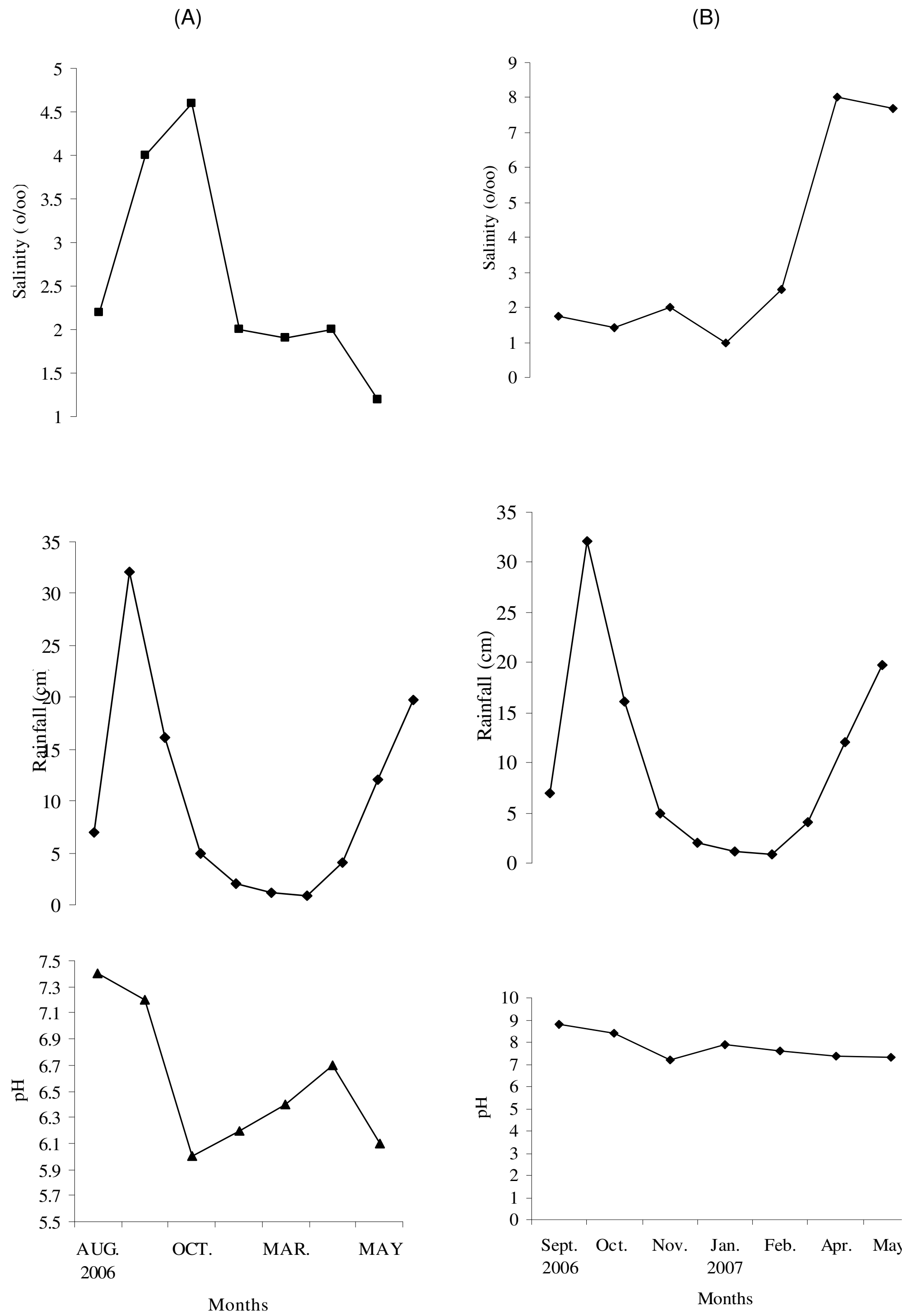

Figure 2. Variations in the physical and chemical parameters of Badagry (A) and Ologe (B) Lagoons during the sampling period (August 2006 – May 2007).

Aqua Fauna Model). Dissolved oxygen (DO) of the water samples was determined using a Jenway DO Meter (Model 4310). The pH values were determined using a Jenway pH meter Hanna (HI 991301) Model. Data on rainfall for the study period were obtained from the Federal Department of Meteorological Services, Lagos, Nigeria.-

Laboratory procedures

The preserved specimens were thawed and wiped dry before laboratory analysis. The standard and total lengths (in centimeters) were measured on a measuring board while the weights (in grammes) were determined using a sensitive 'Sartorious' electric balance (Model 1106). Each stomach content was emptied into a Petri dish and examined under a binocular microscope. The food habits were studied using the numerical and occurrence methods (Hyslop, 1980). The gonad of each fish was examined to ascertain the sex and the gonadal stage, which were then recorded.

Statistical analysis

The length-weight relationship was expressed by the equation:

Log weight = Log a + bLog total length

Where a and b are regression constants.

The condition factor was calculated using the formula:

$$K = \frac{100W}{L^3}$$

Where, K = condition factor, L = standard length (cm) and W = weight (g).

Statistical evaluations of the variations observed in the species from the two environments were also assessed using the SPSS (1999) window version 10.0.

RESULTS

Physical features of the lagoons

The surface water temperature was high and ranged from 29.5 – 31.7°C and 28.1 – 30.8°C for Badagry and Ologe Lagoons respectively, while the air temperature ranged from 28.7 – 30.7°C and 26.4 – 30.2°C respectively (Figure 2). The salinity ranged from 1.0 – 8.0$^{o}/_{oo}$ and 1.2 – 4.6 $^{o}/_{o}$ for Badagry and Ologe Lagoons respectively rainfall ranged from 0.90 – 32.10 cm for both lagoons; pH ranged from 7.2 – 8.8 and 6.0 – 7.4 respectively, while DO ranged from 3.2 – 8.5 mg/l and 4.0 – 7.5 mg/l respectively. The salinity increased slightly during the rainy season from August to October when there was a slight increase in temperature. There was a sharp increase in salinity from February to May which coincides with the dry season when there was very low rainfall and surface water temperature was relatively high in Badagry Lagoon, while there was a fluctuation in the decreased salinity from January to May in Ologe Lagoon. The water was relatively neutral and slightly alkaline in the Badagry Lagoon, while the pH of Ologe Lagoon was relatively neutral during the rainy season and slightly acidic during the dry season, while the dissolved oxygen was relatively high.

Growth pattern

Length-frequency distribution

The total lengths of *T. mariae* from the Badagry and Ologe Lagoons ranged from 8.2 to 17.1 cm (standard length, 6.5 – 15.0 cm) and 8.9 to 18.1 cm (standard length, 6.9 – 13.5 cm) respectively. The length-frequency distribution of *T. mariae* from the two lagoons is shown in Figure 3. One age group was recorded for Badagry Lagoon, while two age groups were recorded in Ologe Lagoon.

A t-test on the mean size of the cichlid from the two lagoons showed that the mean size of *T. mariae* from both lagoons had no significant difference ($P > 0.05$). Badagry Lagoon specimen had a mean size of 12.64 ± 2.03, while Ologe lagoon specimen had a mean value of 13.16 ± 1.86.

Length-weight relationship

The weights of *T. mariae* from Badagry Lagoon ranged from 15.50 to 86.50 g (mean: 44.65 ± 18.36), while those from Ologe Lagoon weighed between 15.00 to 105.40 g (mean: 49.90 ± 19.17). The log length–log weight relationship for this species from the two lagoons is shown in Figure 4.

The length–weight relationship reflected a common general increase in weight with increasing length. The least squares common fit of the transformed data gave the following linear equations for the two lagoons:

Badagry Lagoon
Log weight = -0.8088 + 2.209 log length
(n = 70, r = 0.7372)

Ologe Lagoon
Log weight = -1.4391 + 2. 757 log length
(n = 77, r = 0.9502)

The value of b for this species in both lagoons was less than 3 thus indicating a negative allometric growth.

Condition factor (K)

Values of condition factor (K) for immature, males, females and combined sexes of *T. mariae* from the two lagoons are presented in Table 1. The K-values of imamture specimens were highest (2.78 and 2.07) in Badagry and Ologe Lagoons respectively, except for the female specimens in Ologe Lagoon which had a slightly higher K-value (2.08) than the immature specimens. Condition factor of males (2.76) in Badagry Lagoon was higher than females (2.11), while the females had a higher condition values than males (2.01) in Ologe Lagoon. Generally, the K-values of *T. mariae* from Badagry Lagoon were higher than those from Ologe Lagoon.

Sex ratio

In Badagry Lagoon, a total of 63 specimens were sexed (38 males and 25 females) with a sex ratio of 1: 0.66. In Ologe Lagoon, a total of 75 specimens were sexed (44 males and 31 females) with a sex ratio of 1: 0.70. The males were more than the females as different from the

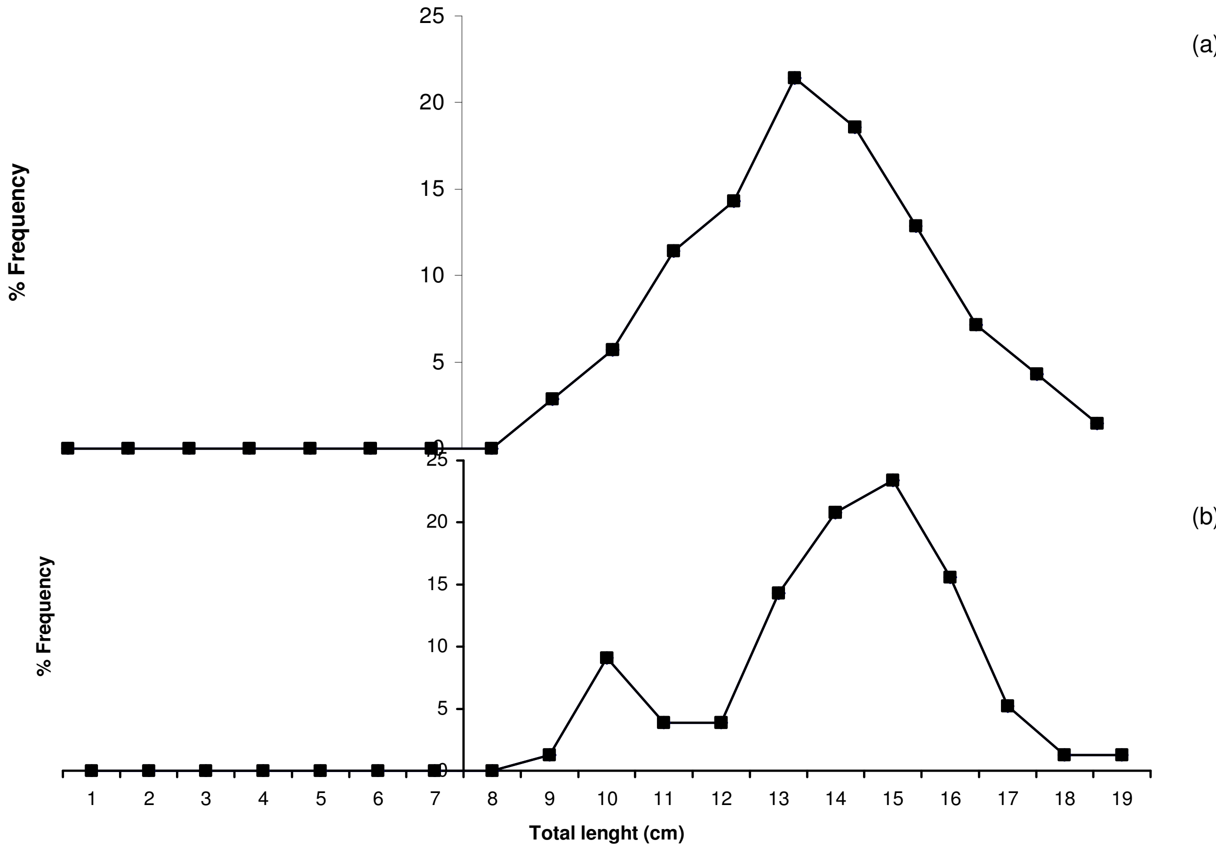

Figure 3. Length frequency distribution of *T. mariae* from Badagry (a) and Ologe (b) Lagoons.

expected 1:1 ratio. However, in Badagry Lagoon, females of *T. mariae* were more abundant in the collection during the months of September and May, while the females predominated the collection only in April in the Ologe Lagoon. All samples collected from Badagry Lagoon during the months of October and April were all males, while this was the same in Ologe Lagoon in March. The monthly sex ratio showed that the males were more than the females during the dry season, while the females were more abundant in some months during the rainy season in Badagry Lagoon. Females were only more abundant than the males in a month during the dry season (April) in Ologe Lagoon.

Gonad maturation stages

There were 4 gonad maturation stages observed in Badagry Lagoon specimens of *T. mariae*, while 3 stages were observed in Ologe Lagoon during the study period. The stages were: Stage I (Immature), Stage II (developing), Stage III (ripening) and Stage IV (ripe). The variation in the gonad stages of development are presented in Table 2.

Food and feeding habits

The stomach contents of 70 specimens of *T. mariae* from Badagry Lagoon (8.2 – 17.1 cm TL) and 77 specimens from Ologe Lagoon (8.9 – 18.1 cm TL) were examined. The summary of the food items observed are presented in Tables 3 and 4.

Summary of the food items

In Badagry Lagoon specimens, the most abundant food item in the stomachs examined were plant materials accounting for 42.81% by number and 17.61% by occurrence. Sand grains were the most abundant item by occurrence only, accounting for 18.66% and was closely followed by unidentified food masses which accounted for 17.96%. The second most important food items were the diatoms which accounted for 23.25% by number and 25.71% by occurrence. The most important diatom was *Melosira* sp. (8.63%). The least consumed food items were insect parts accounting for 5.41% by number and 4.93% by occurrence.

In Ologe Lagoon specimens, diatoms constituted the most important food items which accounted for 27.25% by number and 26.72% by occurrence. The most important diatom was *Navicula* sp. which accounted for 10.84 and 7.92% by number and occurrence respectively. The second most abundant food item was the cyanobacteria, *Oscillatoria* sp. Which accounted for 21.33 and 8.63% by

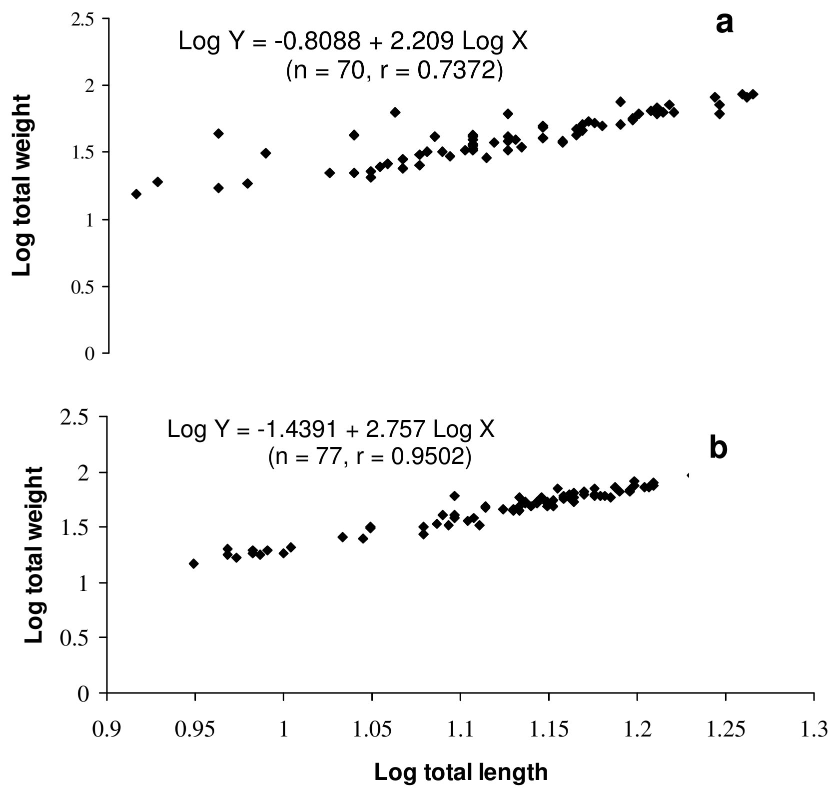

Figure 4. Log total length / Log total weight relationship of *T. mariae* from Badagry (a) and Ologe (b) Lagoons.

Table 1. Condition factor of *T. mariae* from Badagry and Ologe Lagoons.

Lagoon	Immature				Males				Females				Combined-sexes			
	No. of samples	Mean total length (cm)	Mean weight (g)	Condition factor (K)	No. of samples	Mean total length (cm)	Mean weight (g)	Condition factor (K)	No. of samples	Mean total length (cm)	Mean weight (g)	Condition factor (K)	No. of samples	Mean total length (cm)	Mean weight (g)	Condition factor (K)
Badagry	7	11.0	37.06	2.78	38	11.5	41.98	2.76	25	13.4	50.82	2.11	63	12.5	46.40	2.40
Ologe	2	12.8	43.40	2.07	44	13.4	48.42	2.01	31	13.6	52.44	2.08	75	13.5	50.43	2.05

number and occurrence respectively. Green algae accounted for 18.00 and 18.56% by number and occurrence respectively, while plant materials accounted for 18.42 and 9.10% by number and occurrence respectively.

DISCUSSION

From the data of the physical and chemical factors operating in the lagoons (Figure 2), temperature was probably not responsible for the seasonal distribution of this fish fauna as there was only a slight variation from the wet to the dry season. The high air and water temperatures recorded during the study are typical of the area (Emmanuel and Onyema, 2007). Dissolved oxygen concentration ranged between 4.4 - 8.5 mg/l in Badagry Lagoon, with lower values recorded in the rainy season, while higher values were recorded in the dry season when the surface water temperature was slightly warmer. Badagry Lagoon had a higher DO range than Ologe Lagoon probably as a result of a condition encouraging higher oxygen dissolution in surface waters of Badagry Lagoon than in the latter. Whereas pH was alkaline throughout the study period in the Badagry Lagoon, the Ologe Lagoon was acidic at sometime. The values of pH recorded in both lagoons ranged within tolerant point for most fish species and this agreed with the report by Emmanuel and Onyema (2007). The salinity values in the Badagry Lagoon were higher than that in Ologe Lagoon. Cichlids have long been known to be euryhaline, or tolerant of a wide range in salinity (Oldfield, 2004) and some tilapias grow better in brackish water than freshwater (Martinez-Palacios, 1990). This supported the existence of *T. mariae* in both lagoons. The rainfall volumes were higher in the rainy season than the dry season; this agreed with the works of Emmanuel and Onyema (2007). Thus, the rainfall pattern of a tropical south-west area like Lagos has probably not changed remarkably.

The spotted tilapia, *T. mariae* was the second most abundant species of 37 fishes caught in Badagry Lagoon (7.17%) and most abundant in Ologe Lagoon (10.1%) of 25 fishes reported by Soyinka and Kassem (2008). Ikomi and Jessa (2003) reported that this fish flourished in the Ethiope River, Nigeria and was clearly the ecologically dominant cichlid in the river. This species possess a broad salinity tolerance (Schwanck, 1987) and this was reflected in its dominance in the low brackish Udiodong and King (2000) and Ikomi and Jessa (2003). Fryer and Iles (1972) observed male growth superiority over the of salinity fluctuation in under study. Ikomi and Jessa (2003) further reported that juveniles of the species prefer shallow, calm waters close to the littoral zones for nursery, feeding and refuge from predators. This may have been reflected in its species lagoonsdominance in Ologe Lagoon that suited these characteristics. Females among the cichlids. However, in this study, the females were slightly larger than the males. This difference could be as a result of environmental condition.

The largest size of *T. mariae* collected in Badagry (15.0 cm SL) and Ologe (13.5 cm SL) lagoons were smaller than those reported by Olaosebikan and Raji (1998), these lagoons as differing from the entirely freshwaters where their investigation was conducted. Also, the lagoon specimens of *T. mariae* were juveniles and young adults and so the males could still out-grow the females at a latter stage.

From the length-frequency curve, the specimens from Badagry were of one age group, while that from Ologe were of two age groups (with the size range 12.0 – 17.1 cm TL more abundant). The length exponent of the length/weight relationship was less than 3 in both lagoons, indicating that the fish exhibited a negative allometric growth pattern in the lagoons. Ikomi and Jessa (2003) reported an isometric growth for the same species in Ethiope River.

The condition factor value for males in Badagry Lagoon was higher than the females but vice-versa in Ologe Lagoon. Immature specimens had the highest condition factor values. Ikomi and Jessa (2003) highlighted that the fish were in peak condition at the beginning of the rainy season and at the peak of the flood period. Most mature specimens were laden with ripe gonads during these periods. The periods with low condition factor values may be associated with lean resource abundance and spawning activities. The authors also observed that the decreease in K-values with increasing size class indicates unfavourable environmental conditions for the group. Alternatively, improved K-values with increasing size indicate better adaptation to the prevailing environmental condition.

From the observation on the sex ratio and gonad maturation stages, no female with ripe gonad was collected in both lagoons during the investigation. It does appear that this species of cichlids may not spawn freely in lagoons but in freshwaters. *T. mariae* is a substratum spawner and spawns throughout the year (Fagade, 1983a; Ikomi and Jessa, 2003). This strategy may ensure the survival of the species, which is currently under heavy exploitation. Anene and Okorie (2008) reported that the overall male : female ratio of *T. mariae* of Umuoseriche Lake was in favour of the female, an observation which was consistent with that made for the same species of fish in a tropical rain forest stream (King, 1994). However, in the present investigation, the sex ratio favoured the males. This could have resulted from the environmental conditions of the lagoons as differing from the freshwaters where they reported their works.

From the summary of the food items consumed by *T. mariae* in both lagoons, it is probably evident that this species is predominantly herbivorous in feeding habit. Generally, the importance of plant material (algae, diatoms and macrophyte fragments) in the diet of *T. mariae* in both lagoons was clearly demonstrated. This agreed with the works of Fagade (1971) and Ikomi and Jessa (20 03) on many other tilapia species. Sand grains, unidentified food masses, detrital materials, were also found in the gut

Table 2. Percentage variation in the state of gonad development of *T. mariae* from the two lagoons.

Lagoon	Stages (%)							
	Immature	Males			Females			No. examined
	I	II	III	IV	II	III	IV	
Badagry	10.0	47.1	5.7	1.4	34.3	1.4	-	70
Ologe	2.6	57.1	-	-	36.4	3.9	-	77

Table 3. Summary of the stomach contents of *T. mariae* from Badagry Lagoon (September 2006 – May 2007).

Food items	Numerical method		Occurrence method	
	No.	%	No.	%
Higher plants				
Plant parts	372	42.81	50	17.61
Green algae				
Microcystis sp.	109	12.54	43	15.14
Scenedesmus sp.	92	10.59	22	7.75
Diatoms				
Melosira sp.	75	8.63	25	8.80
Cyclotella sp.	43	4.95	19	6.69
Navicula sp.	70	8.06	17	5.99
Synedra ulna	14	1.61	12	4.23
Pisces				
Fish eggs	19	2.19	15	5.28
Fish bones	3	0.35	9	3.17
Fish scales	25	2.88	5	1.76
Arthropoda				
Insect parts	47	5.41	14	4.93
Sand grains	-	-	53	18.66
Unidentified food mass	-	-	51	17.96
Total	869		284	

of this species, indicating a degree of deposit feeding habit. This was observed in some other cichlids (Oso et al., 2006). According to Welcomme (1985), detritus forms a major source of energy for fishes; allochthonous invertebrates (mainly insects that fell on the river surface from overhanging vegetation formed the major source of animal protein for *T. mariae* and this indicated a degree of surface feeding (Ikomi and Jessa, 2003; Fagade and Olaniyan, 1978). This was supported by the present investigation. No zooplankton was observed in the gut of *T. mariae* from these lagoons. This agreed with the works of Ikomi and Jessa (2003) in Ethiope River who did not report the presence of zooplankton in the diet of *T. mariae*, unlike other tilapine species such as *T. guineensis* and *S. melanotheron* (Fagade, 1971). It is not conclusive that *T. mariae* does not feed on zooplankton and further investigation needed to be carried out.

Conclusively, if the young of *T. mariae* in the lagoons could be properly managed and conserved to the reproductive stage, this resource would enhance fish production in the lagoons. Furthermore, the fish, as a result of its omnivorous feeding habit is a potential candidate for aquaculture.

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Table 4. Summary of the stomach contents of *T. mariae* from Ologe Lagoon (August 2006 – May 2007).

Food items	Numerical method		Occurrence method	
	No.	%	No.	%
Higher plants				
Plant parts	265	18.42	77	9.10
Green algae				
Microcystis sp.	85	5.91	46	5.44
Scenedesmus sp.	105	7.30	59	6.97
Pediastrum sp.	74	5.14	52	6.15
Diatoms				
Navicula sp.	156	10.84	67	7.92
Synedra ulna	43	2.99	38	4.49
Melosira sp.	47	3.27	29	3.43
Nitzschia sp.	68	4.73	51	6.03
Coscinodiscus sp.	45	3.13	24	2.84
Cymbella sp.	33	2.29	17	2.01
Cyanobacteria				
Oscillatoria sp.	307	21.33	73	8.63
Pisces				
Fish eggs	15	1.04	11	1.30
Fish scale	27	1.88	24	2.84

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