Cichlid Fish Community Structure as an Index of Water Quality in Three Tropical Lagoon Ecosystems

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Abstract
The study evaluated the effect of water quality variables on the distribution of cichlid fish species in Badagry, Lagos and Lekki lagoons, southwest Nigeria. Generally, there was no significant variation in the mean surface water temperatures, salinity, hydrogen ion concentration, dissolved oxygen and transparency recorded in the range of 25.5–32.3 ºC, 0–24.5, 6.29–7.96, 3.9–11.8 mg/L and 0.0–61.0 cm, respectively. However, relatively higher mean values were recorded in the Lagos lagoon for salinity and turbidity during the dry and rainy seasons, respectively. From the results, it was observed that 2 of the 6 cichlids species recorded; *Tilapia guineensis and Hemichromis fasciatus*, were common to Badagry, Lagos and Lekki lagoons. Meanwhile *Sarotherodon melanotheron* was only recorded in Badagry and Lagos lagoons, *Tilapia mariae* and *Hemichromis bimaculatus* were recorded only in Badagry and Lekki lagoons while *Chromidotilapia guentheri* was recorded in Lekki lagoon. Although the distribution of cichlid species seems not to be significantly influenced by most of the examined water quality parameters, the result, however, indicates that transparency had minimal effect on species abundances in Badagry and Lekki lagoons whilst salinity was a major factor that influences cichlid species distribution pattern in the three Lagoons.

Keywords: Cichlids fish, Lagos lagoon complex, salinity, water quality indicators

Introduction

Cichlid fishes are among the most diverse animals in terms of the number of species and the diversity of their behaviour (Barlow, 2000). They belong to the family *Cichlidae* and order *Perciformes,* which are the largest order of fishes.

The family is one of the major groups of teleost fishes with about 105 genera and more than 1600 species (Kullander, 1998). They occur in Africa, parts of Asia, Central and South American tropical zones (Fryer and Iles, 1972). The family has also been introduced into a number of water bodies in different countries of the world and had been acknowledged to have both beneficial and, in some cases, major adverse ecological conditions. The adverse ecological concern as noted in a previous report stems from the fact that tilapias demonstrate characteristics shared by many successful invasive species (Canonico *et al*., 2005) in aquaculture.

Badagry, Lagos and Lekki lagoons are adjacent and interconnecting ecosystems in the Lagos lagoon complex. While the Lagos lagoon is under the tidal influence of the sea, the tidal effect on Badagry and Lekki Lagoons is either minimal or non-existent. However, the Badagry lagoon is open to the sea through the Cotonou lagoon, which is connected to the sea during the rainy season. As such, the Badagry lagoon remains brackish during the rainy season due to the inflow from the Cotonou lagoon. During a preliminary survey, some variations were observed in cichlids species present in these three lagoons hence the present study was aimed at investigating the factors responsible for the observed variations in the species composition.

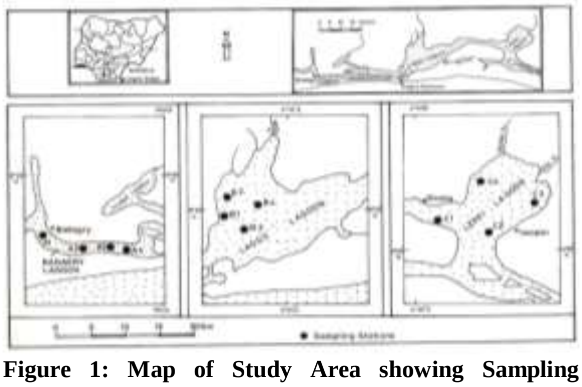

Figure 1: Map of Study Area showing Sampling Stations (Onyema, 2009)

Materials and Methods

Study Areas

Badagry Lagoon is located in Lagos State. It lies between longitude 3^o 00" E and 3^o 07" E and between latitude 6^o 24" N and 6^o 30" N (Figure 1). 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 the Niger delta with the depth of water ranging from 1–3 metres. The area is characterised by thick shrubs and small trees.

The Lagos lagoon is located between longitude 3° 23" E and 3° 34" E and latitude 6° 26" N and 6° 37" N. The lagoon is an open tidal estuary and it is fed in the north by Ogun River. It opens into the Atlantic Ocean via the Lagos harbour.

The Lekki lagoon is a large expanse of shallow freshwater and covers an area of nearly 247 km^2. It lies between longitude 3° 54" E and 4° 13" E and latitude 6º 25" N and 6º 35" N. The lagoon is fed by River Oni in the north-eastern part while Rivers Osun and Saga flow into its north-western parts. The three lagoons are economically important to the economies of Lagos State and Nigeria due to their strategic locations to the coast of Nigeria. They serve various purposes, which include transportation, fishing activities, recreation and research work.

Collection of Specimens

Specimens of cichlids species (*Tilapia guineensis, Tilapia mariae, Sarotherodon melanotheron, Hemichromis fasciatus, Hemichromis bimaculatus* and *Chromidotilapia guentheri*) were collected twice monthly from artisanal fishermen using a set net of 44 mm mesh size at the fish jetties in Badagry, Makoko and Epe for the samples from Badagry, Lagos and Lekki lagoons, respectively. The relative occurrence and abundance of each species in the total catch made by the local fishermen were observed and recorded after landing at the various jetties during the bimonthly sampling to estimate the distribution patterns. Specimens were collected from May 1999 to October 2000. The specimens were transported in an ice-chest with ice blocks between the point of collection and laboratory for further analysis.

Physicochemical Parameters

The physicochemical parameters of the surface water from each lagoon were determined twice monthly between 8:00–10:00 h. Air and surface water temperatures, salinity, pH, dissolved oxygen and transparency were measured *in-situ* (Boyd, 1979). The Beckman Induction Salinometer (Model R 55-3) was used to measure air and surface water temperatures. Salinity was determined with the aid of hand-held refractometer (Biomarine Aquafauna). The pH of water was obtained using the Oakton pH meter (Model 356 24-00). Dissolved oxygen was determined using Jenway DO meter (Model 9071). Water transparency was obtained using a 20 cm-diameter black and white-coloured Secchi disc.

Statistical Analyses

Shannon-Wiener Diversity Index (Hs) (Shannon and Wiener, 1963).

$$Hs = \Sigma P_i \ln P_i \quad (1)$$

where Hs = Shannon–Wiener diversity index, Σ = summation, *i* = ith species, ranging from 1 to *n*. P*i* = proportion that the ith species represent to the total number of individuals in the sampling space.

Menhinick Index (D) (Ogbeibu, 2005).

$$D = S/\sqrt{N} \quad (2)$$

where S = number of species in a population, N = total number of individuals in S species.

Margalef Index (d) (Margalef, 1951).

$$d = (S - 1)/\ln N \quad (3)$$

where d = Margalef richness index or species diversity index, S = total number of species in the population, N = total number of individuals in species.

Species' Equitability (j) (Ogbeibu, 2005).

Species' equitability or evenness was determined by equation (4):

$$j = Hs/ \ln S \quad (4)$$

where j = Equitability index, Hs = Shannon–Weiver diversity index, S = number of species in the population.

Simpson Dominance Index (C) (Ogbeibu, 2005).

$$C = \Sigma (n/N)2 \quad (5)$$

where n = the total number of organisms of a particular species, N = the total number of organisms of all species.

Results

Physicochemical Parameters of the Badagry, Lagos and Lekki Lagoons

The results of the physicochemical parameters and the monthly variations of Badagry, Lagos and Lekki lagoons are illustrated in Figures 2–7.

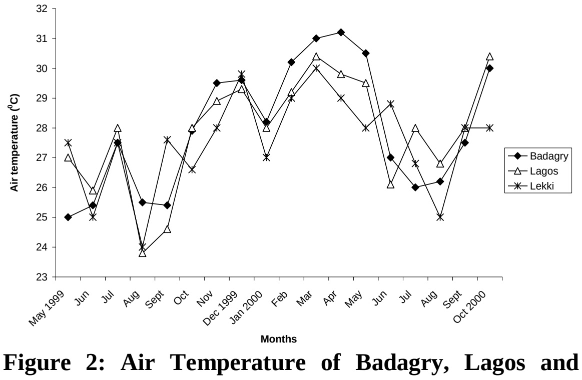

Figure 2: Air Temperature of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

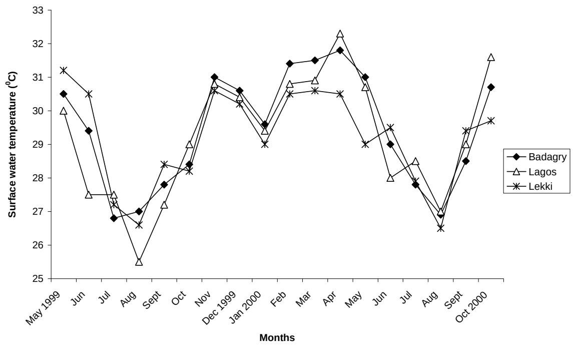

Figure 3: Surface Water Temperature of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

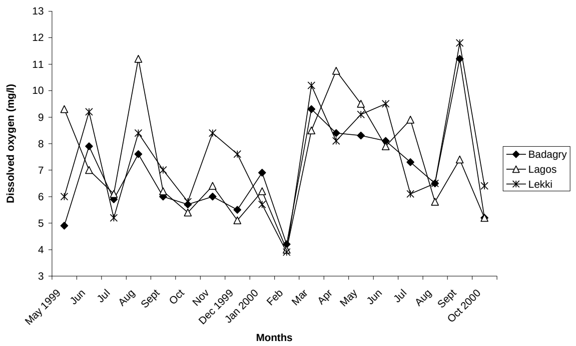

Figure 4: Dissoved Oxygen of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

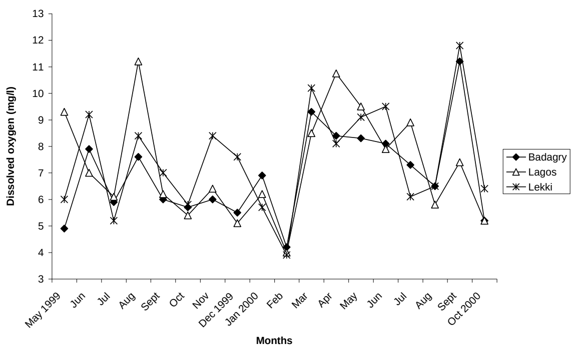

Figure 5: Salinity of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

Air temperature ranged from 25.0–31.2 ºC, 23.8–30.4 ºC and 23.0–30.0 ºC for Badagry, Lagos and Lekki lagoons, respectively, whereas the surface water temperatures recorded were between 26.8–31.8 ºC, 25.5–32.3 ºC and 26.5–31.2 ºC for Badagry, Lagos and Lekki lagoons, respectively. The salinity in the Lekki lagoon was very low (0–3.0%) whereas the salinity in Lagos (1.0–24.5%) and Badagry (0–10.0%) lagoons fluctuated between freshwater and brackish water conditions. Relatively higher salinity levels were recorded in the Lagos lagoon during the dry season while salinity in the Badagry lagoon was generally low except during the beginning of the rainy season due to its connection to the sea through Cotonou, Republic of Benin. The pH values were 6.43–7.81, 6.51–7.96 and 6.29–7.60 for Badagry, Lagos and Lekki lagoons, respectively.

The dissolved oxygen content was 4.2–11.2 mg/L (Badagry), 4.0–11.2 mg/L (Lagos) and 3.9–11.8 mg/L (Lekki), respectively, whereas the transparency of the water was 7.3–51.1 cm, 0–35.7 cm and 0–61 cm for Badagry, Lagos and Lekki, respectively. The Lekki and Badagry lagoons were less turbid while turbidity level of the Lagos lagoon was high especially during the rainy season (July–October).

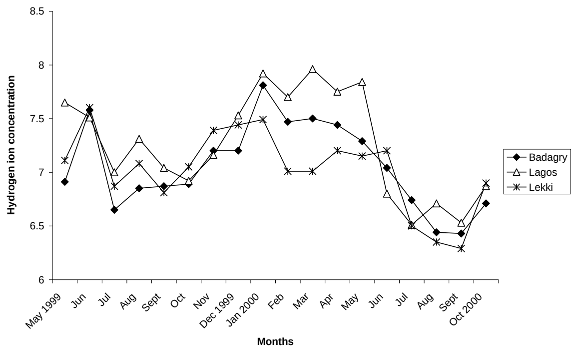

Figure 6: pH of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

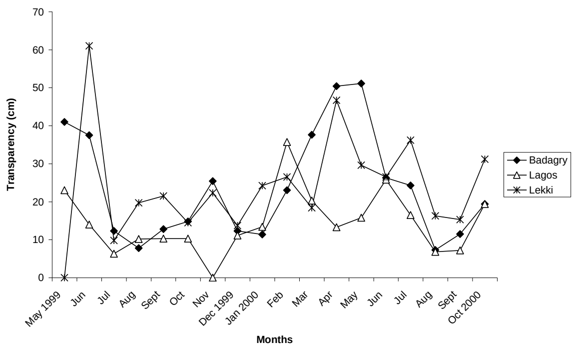

Figure 7: Transparency of Badagry, Lagos and Lekki lagoons (May 1999–October 2000)

The statistical evaluation of the results using the correlation matrix **(**Tables 1, 2 and 3) indicated a significant positive correlation between surface water temperature and pH (r^2 = 0.655), surface water temperature salinity and transparency (r^2 = 0.677) and between salinity and transparency (r^2 = 0.847) in the Badagry lagoon. In the same vein, there was a significant positive correlation (r^2 = 0.501) between the abundance of *Sarotherodon melanotheron* correlated with transparency in Badagry lagoon. Similarly, a significant positive correlation was observed between salinity and pH (r^2 = 0.852), surface water temperature and salinity (r^2 = 0.523) and between salinity and transparency (r^2 = 0.598) in the Lagos lagoon.

Table 1: Correlation Matrix of Physicochemical Parameters and Cichlid Abundance in the Badagry Lagoon

	Air Temp	Water Temp	DO	Salinity	pH	Transparency	*T. guineensis*	*H. fasciatus*	*S. melanotheron*	*T. mariae*
Air Temp	1									
Water Temp	.749**	1								
DO	0.06	-0.049	1							
Salinity	-0.08	0.333	0.215	1						
pH	0.437	.655**	-0.003	0.229	1					
Transparency	0.361	.677**	0.219	.847**	.483*	1				
T. guineensis	-0.12	0.042	-0.35	0.087	0.114	0.016	1			
H. fasciatus	-0.051	0.077	-0.222	-0.253	0.146	-0.172	-0.43	1		
S. melanotheron	0.23	0.348	.497*	0.446	0.208	.501*	-0.291	-0.379	1	
T. mariae	0.211	0.111	0.398	0.386	0.165	0.4	0.136	-0.388	0.156	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlation Matrix of Physicochemical Parameters and Cichlid Abundance in the Lagos Lagoon

	Air Temp	Water Temp	DO	Salinity	pH	Transparency	*T. guineensis*	*H. fasciatus*	*S. melanotheron*
Air Temp	1								
Water Temp	.890**	1							
DO	0.211	-0.078**	1						
Salinity	0.368	.523*	0.222	1					
pH	0.287	0.442	0.196	0.852*	1				
Transparency	0.236	0.395	-0.071	.598**	0.332	1			
T. guineensis	0.181	0.142	-0.081	0.209	0.04	-0.14	1		
H. fasciatus	-0.001	0.187	0.152	0.338	0.344	0.04	0.055	1	
S. melanotheron	-0.358	-0.516*	0.215	-0.306	-0.389	-0.197	-0.254	-0.282	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlation Matrix of Physicochemical Parameters and Cichlid Abundance in the Lekki Lagoon

	Air Temp	Water Temp	DO	Salinity	pH	Transparency	*T. guineensis*	*H. fasciatus*	*T. mariae*	*C. guentheri*
Air Temp	1									
Water Temp	.634**	1								
DO	0.115	0.208	1							
Salinity	-0.768	-0.476	-0.097	1						
pH	0.133	0.504*	-0.007	-0.227	1					
Transparency	-0.14	0.203	0.192	0.096	0.3	1				
T. guineensis	0.343	-0.186	-0.138	-0.444	-0.26	-0.188	1			
H. fasciatus	-0.209	-0.387	-0.185	0.393	-0.23	-0.251	-0.305	1		
T. mariae	-0.254	0.141	0.448	0.317	-0.113	-0.114	-.685**	0.065	1	
C. guentheri	-0.492*	0.03	0.106	.514*	0.37	0.441	-.693**	0.337	0.308	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

In the Lekki lagoon, a significant positive correlation was also observed between the surface water temperature and pH ($r^2 = 0.504$) as well as the salinity and abundance of the cichlid species *Chromidotilapia guentheri* ($r^2 = 0.514$).

Distribution and Abundance of Cichlids Species in Badagry, Lagos and Lekki Lagoons

The results of the investigation of the distribution and abundance of cichlids species in Badagry, Lagos and Lekki lagoons showed that more cichlid species were recorded in the Lekki lagoon when compared to the Badagry and Lagos lagoons. *T. guineensis*, was the most prevalent and dominant species in Lekki lagoon (Table 4**).** Other species recorded during the study period included: *S. melanotheron*, *H. fasciatus* and *T. mariae.* The cichlid species, *H. bimaculatus* was encountered once, however, the number of samples obtained (4 pieces) indicated that it was an incidental sample. In the Lagos lagoon, the results showed that the most significant and dominant cichlid species was *S. melanotheron* (Table 4). Other species recorded were *T. guineensis*, *H. fasciatus*, *C. guentheri* and *T. mariae. Hemichromis bimaculatus* was also recorded once during the period of sampling. However, the number of samples (12 pieces) obtained indicated that it was also an incidental sample.

Diversity Indices of Cichlids Species in Badagry, Lagos and Lekki Lagoons

The indices of species' richness (d), Shannon–Wiener (Hs), Evenness (j) and Similarity (S) are presented as community composition parameters in Table 5**.** The Margalef index ranged between 0.38–0.43 for *T. guineensis*. The Shannon–Wiener index was lowest for *C. guentheri* and *T. mariae***.** The species' equitability (j) ranged from 0 (in *C. guentheri*) and 0.45. The Menhinick index was highest (0.28) in *T. guineensis* and lowest (0.14) in *C. guentheri*. The Shannon–Wiener indices were high for the cichlids.

Table 4 Distribution: of Cichlids from Badagry, Lagos and Lekki Lagoons (May 1999–October 2000)

Month\ Lagoon	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**Total**
Tilapia guineensis																			
Badagry	62	47	35	67	52	64	30	52	37	83	43	47	49	35	47	44	40	32	**866**
Lagos	41	26	33	27	27	44	34	31	46	35	24	35	39	24	40	40	34	27	**607**
Lekki	48	34	59	46	85	86	70	66	60	58	77	70	78	59	72	73	53	67	**1161**
Hemichromis fasciatus																			
Badagry	16	34	15	16	22	19	60	31	31	13	11	15	12	20	25	25	16	25	**406**
Lagos	21	12	16	18	34	16	18	22	21	21	21	22	25	13	21	11	18	14	**344**
Lekki	14	17	33	14	12	12	11	12	11	14	13	10	11	12	12	17	16	10	**251**
Sarotherodon melanotheron																			
Badagry	38	28	22	19	27	26	19	17	33	19	62	39	31	41	32	25	33	35	**546**
Lagos	56	66	55	63	59	44	50	49	41	48	64	47	59	58	66	83	61	55	**1024**
Tilapia mariae																			
Badagry	-	-	-	12	-	-	-	-	-	-	5	5	15	5	-	-	-	-	**42**
Lekki	24	19	13	22	15	11	13	11	13	14	13	14	14	19	11	13	25	15	**279**
Chromidotilapia guentheri																			
Lekki	20	49	24	22	14	12	11	14	24	12	17	10	14	20	14	17	14	21	**329**

Discussion

The mean air temperatures recorded were 28.0 ± 2.12 ºC, 27.9 ± 1.88 ºC and 27.5 ± 1.63 ºC while the mean surface water temperatures were 29.4 ± 1.71 ºC, 29.2 ± 1.85 ºC and 29.2 ± 1.45 ºC for the Badagry, Lagos and Lekki lagoons, respectively, indicating a tropical warm climate. Similar results have been obtained from Epe, Lekki and Badagry lagoons (Olaniyan, 1969; Kusemiju, 1981; Ezenwa and Kusemiju, 1985).

The variations in temperature, in this study, were negligible in comparison to the previous studies. Higher temperatures were recorded in the dry season between December and May. This might be due to low rainfall and high evaporation during the dry season. In spite of its importance, the air and water temperatures did not have significant effects on the distribution of the cichlids since they are all warm-water fish species. According to Fitzsimmons, (2000), they are not found at high elevations and generally require water warmer than 20 ^{o}C.

The pH values were 6.43–7.81, 6.51–7.96 and 6.29–7.60 for Badagry, Lagos and Lekki lagoons, respectively. The pH varied between 6.3 and 8.0. According to Boyd (1979), the most desirable pH range for fish production is 6.5–8.5; pH levels outside this range may be toxic. The range of pH obtained during the period of study indicated that the hydrogen ion concentrations were adequate for fish survival and may not be a factor in the distribution of the fish species in the three lagoons.

The mean dissolved oxygen (DO) content was 6.94 ± 1.75 mg/L**,** 7.27 ± 2.04 mg/L and 7.49 ± 2.00 mg/L for Badagry, Lagos and Lekki lagoons, respectively. As noted in a previous report (Moller and Scholz 2007), fish species often segregate along a DO gradient, based on internal tolerances. In addition, Boyd (1979) reported a cessation in the feeding ability of the fishes when DO remains lower than 3–4 mg/L for a prolonged period. In the present study, the mean dissolved oxygen content of the 3 lagoons was an indication that the oxygen contents of the lagoons were high enough to support aquatic life.

The salinity regimes in the 3 lagoons varied widely with the Badagry, Lagos and Lekki lagoons having mean salinity values of 3.17 ± 2.99%, 9.75 ± 9.42% and 1.08 ± 1.19%, respectively. The Badagry lagoon fluctuated between fresh and low brackish conditions. The salinity of Lekki lagoon was very low hence, it maintained a freshwater condition throughout the study period except in the rainy season (July to September) when the salinity fluctuated 1–3%. The highest salinity reported for the Lekki lagoon by Kusemiju (1981) was 0.3% compared to the 3.0% recorded in this study; suggesting the potential intrusion of some new salt-water into the lagoon. In addition, this might be an indication that the linkage of Epe lagoon to Lagos lagoon was beginning to impact on the salinity of latter. The results also showed that salinity was a strong influence in the distribution of the cichlid species recorded in the 3 lagoons.

Although the Badagry, Lagos and Lekki lagoons are major Lagoon systems along the West African coast, they are interconnected with varied salinity regimes. The occurrence of *T. guineensis* and *H. fasciatus* in the 3 lagoons is an indication that the two species are truly euryhaline species with ability to withstand varied salinity fluctuations. This observation is similar to the findings of Philippart and Ruwet (1982), who reported that *T. guineensis* is a euryhaline species found along the West Coast of Africa from Senegal to Angola. *T. mariae* occurred throughout the sampling period in the Lekki lagoon but only recorded in the Badagry lagoon when the lagoon exhibited freshwater condition. On the contrary, the species was completely absent in the Lagos lagoon where the brackish water condition was most prevalent; suggesting that the species is limited by salinity in its distribution to the lagoons. According to Schwanck (1987), *T. mariae* inhabits freshwater over their native and non-native range. *S. melanotheron* occurred in the Badagry and Lagos lagoons, which were low brackish and brackish, respectively, but was absent in the freshwater Lekki lagoon. *S. melanotheron* was the major cichlid species in the Lagos lagoon, indicating that it is a stenohaline species tolerating small variations in salinity.

Table 5: Diversity Indices of Cichlid Fish Species in Badagry, Lagos and Lekki Lagoons (May 1999–October 2000)

Month\ Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
(a) *Tilapia guineensis*																		
S	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
N	151	107	127	140	164	194	134	149	143	176	144	152	166	118	159	157	127	126
Log S	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Log N	2.18	2.03	2.10	2.15	2.21	2.29	2.13	2.17	2.16	2.25	2.16	2.18	2.22	2.07	2.20	2.20	2.10	2.10
Hs	0.47	0.46	0.46	0.45	0.44	0.46	0.44	0.46	0.47	0.45	0.43	0.46	2.22	2.07	2.20	2.19	2.10	2.10
D	0.24	0.29	0.27	0.25	0.23	0.22	0.26	0.25	0.25	0.23	0.25	0.24	0.23	0.28	0.24	0.24	0.27	0.27
d	0.40	0.43	0.41	0.40	0.39	0.38	0.41	0.40	0.40	0.39	0.40	0.40	0.39	0.42	0.39	0.40	0.41	0.41
j	0.99	0.97	0.97	0.94	0.91	0.97	0.93	0.96	0.98	0.95	0.91	0.96	4.65	4.34	4.61	4.60	4.40	4.40
C	0.34	0.35	0.36	0.37	0.40	0.36	0.39	0.36	0.35	0.37	0.40	0.36	0.00	0.00	0.00	0.00	0.00	0.00
(b) *Hemichromis fasciatus*																		
S	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
N	51	63	64	48	68	47	89	65	63	48	45	47	48	45	58	53	50	49
Log S	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Log N	1.71	1.80	1.81	1.68	1.83	1.67	1.95	1.81	1.80	1.68	1.65	1.67	1.68	1.65	1.76	1.72	1.70	1.69
Hs	0.47	0.44	0.45	0.47	0.44	0.47	0.37	0.45	0.44	0.47	0.46	0.46	1.68	1.65	1.76	1.72	1.69	1.68
D	0.42	0.38	0.38	0.43	0.36	0.44	0.32	0.37	0.38	0.43	0.45	0.44	0.43	0.45	0.39	0.41	0.42	0.43
d	0.51	0.48	0.48	0.52	0.47	0.52	0.45	0.48	0.48	0.52	0.53	0.52	0.52	0.53	0.49	0.50	0.51	0.51
j	0.99	0.91	0.94	1.00	0.93	0.98	0.77	0.94	0.93	0.98	0.96	0.95	3.52	3.45	3.68	3.60	3.55	3.53
C	0.34	0.40	0.38	0.34	0.39	0.34	0.51	0.38	0.38	0.35	0.36	0.37	0.00	0.00	0.00	0.00	0.00	0.00

S: Total species diversity, **N**: Total abundance**, Log S**: Log of Species diversity, **Log N**: Log of abundance, **Hs**: Shannon–Wiener Index,
D: Menhinick Index, **d**: Margalef Index, **j**: Equitability Index, **C**: Simpson's Dominance Index

Month\ Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
(c) *Sarotherodon melanotheron*																		
S	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
N	94	94	77	82	86	70	69	66	74	67	126	86	90	99	98	108	94	90
Log S	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Log N	1.97	1.97	1.89	1.91	1.93	1.85	1.84	1.82	1.87	1.83	2.10	1.93	1.95	2.00	1.99	2.03	1.97	1.95
Hs	0.29	0.26	0.26	0.24	0.27	0.29	0.26	0.25	0.30	0.26	0.30	0.30	1.95	1.99	1.99	2.03	1.97	1.95
D	0.21	0.21	0.23	0.22	0.22	0.24	0.24	0.25	0.23	0.24	0.18	0.22	0.21	0.20	0.20	0.19	0.21	0.21
d	0.22	0.22	0.23	0.23	0.22	0.24	0.24	0.24	0.23	0.24	0.21	0.22	0.22	0.22	0.22	0.21	0.22	0.22
j	0.97	0.88	0.86	0.78	0.90	0.95	0.85	0.82	0.99	0.86	1.00	0.99	6.49	6.61	6.59	6.74	6.53	6.47
C	0.52	0.58	0.59	0.64	0.57	0.53	0.60	0.62	0.51	0.59	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00
(d) *Chromidotilapia guentheri*																		
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	20	49	24	22	14	12	11	14	24	12	17	10	14	20	14	17	14	21
Log S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Log N	1.30	1.69	1.38	1.34	1.15	1.08	1.04	1.15	1.38	1.08	1.23	1.00	1.15	1.30	1.15	1.23	1.15	1.32
Hs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	1.25	1.07	1.17	1.07	1.27
D	0.22	0.14	0.20	0.21	0.27	0.29	0.30	0.27	0.20	0.29	0.24	0.32	0.27	0.22	0.27	0.24	0.27	0.22
d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
j	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
(e) *Tilapia mariae*																		
S	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**
N	24	19	13	34	15	11	13	11	13	14	18	19	29	24	11	13	25	15
Log S	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30	0.30	0.30	0.00	0.00	0.00	0.00
Log N	1.38	1.28	1.11	1.53	1.18	1.04	1.11	1.04	1.11	1.15	1.26	1.28	1.46	1.38	1.04	1.11	1.40	1.18
Hs	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.25	1.46	1.34	0.95	1.04	1.38	1.11
D	0.20	0.23	0.28	0.34	0.26	0.30	0.28	0.30	0.28	0.27	0.47	0.46	0.37	0.41	0.30	0.28	0.20	0.26
d	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.34	0.30	0.31	0.00	0.00	0.00	0.00
j	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.83	4.86	4.45	0.00	0.00	0.00	0.00
C	1.00	1.00	1.00	0.54	1.00	1.00	1.00	1.00	1.00	1.00	0.60	0.61	0.00	0.00	0.00	0.00	0.00	0.00

S: Total species diversity, **N**: Total abundance**, Log S**: Log of Species diversity, **Log N**: Log of abundance, **Hs**: Shannon–Wiener Index, **D**: Menhinick Index, **d**: Margalef Index, **j**: Equitability Index, **C**: Simpson's Dominance Index

In the study by Jennings and Williams (1992), it was shown that *S. melanotheron* was most abundant in coastal lagoons and estuarine waters with muddy substrates and submerged vegetations. They reported that the species could spawn at salinities of up to 35% and survive brief exposures to hypersaline waters, under experimental conditions. Shafland (1996) reported that *S. melanotheron* was abundant in the mangrove areas and ventures into freshwater and salt waters over their native and non-native range.

Water transparency was higher in the Badagry and Lekki lagoons, with a mean of 23.68 ± 14.26 cm and 24.08 ± 13.93 cm, respectively, compared with low water transparency values of 14.41 ± 8.29 cm in the Lagos lagoon. The lower transparency in the Lagos lagoon could be attributed to shipping activities and industrial wastes discharge. The influx of flood from the rivers and run-offs into the Lagos lagoon may have made light penetration less effective during the rainy season. Transparency may be a factor in the distribution of the cichlids in the 3 lagoons. Cichlids are plankton feeders and require fairly transparent waters to feed and escape from predators. If water transparency is low, their ability to sieve planktons may be hampered and affect their rates of growth. In the present study, *S. melanotheron* was the dominant cichlid species in Lagos lagoon where the level of transparency of the water was low as compared to the Badagry and Lekki lagoons with higher levels of transparency of the water that had *T. guineensis* as the dominant cichlid species. The Lekki lagoon with the highest level of transparency had the lowest level of *H. fasciatus*, which is a predatory and piscivorous species. Fagade and Olaniyan (1973) reported that *H. fasciatus* fed on other fishes in the Lagos lagoon but Akintunde and Imevbore (1979) found small fishes in the stomach of the species from Lake Kainji.

Conclusion

This investigation gives valuable information on the habitat conditions and cichlid fish community in South-western Nigeria. Although species richness and diversity indices were low for almost all the recorded structure of the 3 interconnecting lagoon cichlid fish species, the present findings show that the cichlid community was dominated by *T. guineensis* and *S. melanotheron*, which constitute an important economic resource. Knowledge-based sustainable and successful exploitations of these lagoons require an integrated and holistic management scheme from continuous research and environment-monitoring.

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