

Indices from *Chrysichthys nigrodigitatus* (Lacépède, 1803), *Tilapia guineensis* (Bleeker, 1862), *Clarias gariepinus* (Burchell, 1822) and *Clarias anguillaris* (Linnaeus, 1758) as Bioindicators of Organic Pollution in Ogun River, Southwest Nigeria

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Abstract

The current health status of Ogun river Southwest Nigeria was investigated using body and derived indices from *Chrysichthys nigrodigitatus*, *Tilapia guineensis*, *Clarias gariepinus* and *Clarias anguillaris*. Quality of effluents from the two abattoir located at Isheri-Olofin and Lafenwa, and the adjacent receiving water of R. Ogun were evaluated. Physico-chemical parameters exceeded the NESREA (2011) national criteria for effluent and USEPA (2002) for aquatic life. NH₃-N and PO₄ indicated elevated levels of organic pollution but trace metal contents has direct implication for aquatic life. Reduction in growth indices of total length, standard length, total body weight and fecundity were observed in all the species compared with previous records. Derived indices of gonadosomatic index and Fulton's condition factor (K) exhibited similar pattern. Livensomatic index (LSI) were elevated indicative of disruption in body mechanism of the fish species arising from pollution. The remaining indices of gonadal index (GI), visceral somatic index (VSI) and percentage dress out (PDO) were significant and first reports any species from Ogun river.

Keywords: Stress; Fishes; Abattoir wastes; River health; Fecundity

Introduction

The use of finfishes as indicators of aquatic quality and health have been suggested because many observed physiological and anatomical changes, often manifest a form of stress compensating response [1]. These compensating responses classified from primary to tertiary responses; usually divert energy from critical processes .

Ogun River is one of the perennial rivers found in southwest Nigeria. It rises at approximately 8°41'N, 3°28'E with altitude of 380 m flowing for 320 km southwards into Lagos lagoon at approximately 6°35'N, 3°25'E. It has a total drainage area of about 21,800 km². Detailed information on hydrology had been provided by Sydenham [2,3]. The degradation the river health increased with the construction of abattoirs at Lafenwa and Isheri-Olofin along the river course with capacity to process 300-320 cows and 40-50 goats/rams daily. The offal and processing wastes are washed directly into river system daily.

Previous studies on the river were limited and scattered covering composition and zonation of resident fish species [2,4]; hydrology [2,5]; food and feeding [5]; reproduction [6]; faunal changes [7], bioaccumulation [8] and physico-chemistry [9,10]. Presented here is use of various indices from *Chrysichthys nigrodigitatus* (Lacépède, 1803), *Tilapia guineensis* (Bleeker, 1862), *Clarias gariepinus* (Burchell, 1822) and *Clarias anguillaris* (Linnaeus, 1758), four economically important fish species, as bioindicators of aquatic ecosystem health and the physico-chemistry of Ogun river and abattoir wastes from Lafenwa and Isheri-Olofin Southwest Nigeria.

The river rises in Oyo State near Shaki at coordinates 8°41'0"N 3°28'0"E and flows through Ogun State into Lagos State. The river is crossed by the Ikere Gorge Dam in the Iseyin local government area of Oyo State. The reservoir capacity is 690 million cubic metres (560,000 acre-ft).

Materials and Methods

Ch. nigrodigitatus, *T. guineensis*, *C. gariepinus* and *C. anguillaris* were collected between June and December 2004 directly from fisher

folks after landing and transported live or dying to laboratory at Olabisi Onabanjo University, Ago-Iwoye. A total of 200 individuals were collected. Total Length (TL), Standard Length (SL), Total Body Weight (TBW) and Gutted Weight (GtW) were determined on each individual. Sexes were determined by combination of external features and dissection. Liver and gonads were separated and weighed. Ovaries were stored in Gilson's fluid for three weeks to liberate individual eggs for determination of absolute fecundity [11]. The following indices were calculated for each individual: (1) length-weight relationship as $W=aL^b$ (2) Gonadosomatic index (GSI)= $gw.tbw^{-1}.100$ (3) Gonadal Index (GI)= W^0/TL^b (4) Fulton's condition factor (K)= $100.tbw/TL^3$ (5) Livensomatic Index (LSI)= $lw/tbw.100$ (6) Visceral-Somatic-Index (VSI)= $(tbw-gtw)/tbw.100$ and (7) Percentage Dress Out (PDO)= $gtw/tbw.100$; where $tbw=W$ =total body weight, gw =gonad weight, gtw =gutted weight, lw =liver weight, $TL=L$ =total length, W^0 =ovary weight, b =slope of regression line of $\log_{10}tbw$ and $\log_{10}TL$ computed using the least square method, a =the intercept [9,12-17]. The relationship among sexes for all body indices was explored using heteroscedastic t-test. Temperature, pH, Total Dissolved Solids (TDS), conductivity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), nitrate-nitrogen NO₃-N, ammonia-nitrogen (NH₃-H), phosphate (PO₄³⁻), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg) and zinc (Zn) on momentary samples of abattoir effluent and Ogun river using combination of *in situ* and laboratory standard methods.

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Results

Summary of morphometrics, body and derived indices from collected *Ch. nigrodigitatus*, *T. guineensis*, *C. gariepinus* and *C. anguillaris* are presented on Tables 1-4. Lower mean TL=21.05±5.40 and GtW=85.68±86.41 were recorded in female *Ch. nigrodigitatus* (n=19) compared with lower SL, TBW, GdW and Lwt the males (n=31) (Table 1). Derived indices of GSI, K, GI, and VSI recorded higher values in *Ch. nigrodigitatus* females compared with LSI and PDO with higher respective values of 0.75 ± 0.53 and 102.02 ± 136.20 from the males. Mean SL, TBW, GdW, Lwt, GSI, K, GI and VSI values from females and TL, GtW and PDO from males were higher compared with total means. Reduced mean LSI was observed from the separate sexes compared with the pooled (0.95 ± 0.56) value. Mean values of TL, SL, TBW, GtW, GdW and Lwt were higher in *T. guineensis* females (n=32) (Table 2). Derived indices of K=4.88 ± 1.78 and VSI=119.91 ± 91.31 were higher in males (n=18) while GSI (1.45 ± 1.10), LSI (0.97 ± 0.47) and PDO (56.60 ± 23.76). *C. gariepinus* recorded higher mean values in females (n=15) for body measurement but higher values in males (n=35) for only LSI (0.74 ± 0.40) (Table 3). Contrary to observations in other fishes *C. anguillaris* recorded higher mean values in the males (n=25) for all body measurements except GdW which was higher in females (6.75 ± 13.21; n=25). All derived indices were higher in females except VSI which recorded a higher value of 20.01 ± 10.84 in males (Table 4).

Relationships between SL and derived indices (GSI, K and LSI) are

Parameter	Male	Female	Total
N	31	19	50
Total length (TL) (cm)	22.82 ± 4.86	21.05 ± 5.40	22.15 ± 5.09
Standard length (SL) (cm)	16.06 ± 3.70	16.17 ± 4.45	16.10 ± 3.96
Total body weight TBW) (g)	115.24 ± 46.89	121.04 ± 89.44	117.45 ± 65.52
Gutted weight (GtW) (g)	96.26 ± 46.28	85.68 ± 86.41	92.24 ± 63.89
Gonad weight (GdW) (g)	0.13 ± 0.10	1.90 ± 5.76	0.80 ± 3.69
Liver weight (Lwt) (g)	0.70 ± 0.66	0.86 ± 1.15	0.76 ± 0.86
Absolute fecundity		2267.47 ± 8853.54	
Gonadosomatic Index (GSI)	0.15 ± 0.17	1.00 ± 1.17	0.47 ± 1.17
Condition Factor (K)	1.01 ± 0.39	1.20 ± 0.53	1.11 ± 10.39
Liversomatic Index (LSI)	0.65 ± 0.53	0.59 ± 0.34	0.85 ± 0.56
Gonadal Index (GI)	4.37 ± 11.97	13.16 ± 21.94	7.71 ± 16.83
Visceral somatic Index (VSI)	35.45 ± 35.50	72.23 ± 51.31	49.04 ± 45.43
Percentage dress out (PDO) (%)	78.02 ± 17.08	65.59 ± 16.95	72.16 ± 18.48

Table 1: Body indices of *Ch. nigrodigitatus* from Ogun river.

Parameter	Male	Female	Total
n	18	32	50
Total length (TL) (cm)	13.57 ± 3.71	14.26 ± 2.76	14.01 ± 3.12
Standard length (SL) (cm)	10.58 ± 2.79	11.09 ± 2.06	10.91 ± 2.33
Total body weight TBW) (g)	94.42 ± 52.73	98.27 ± 40.66	96.89 ± 44.88
Gutted weight (GtW) (g)	58.11 ± 54.38	69.58 ± 49.09	65.45 ± 50.81
Gonad weight (GdW) (g)	0.15 ± 0.16	1.29 ± 1.31	0.88 ± 1.18
Liver weight (Lwt) (g)	0.15 ± 0.16	1.07 ± 1.15	0.99 ± 1.25
Absolute fecundity		2734.90 ± 6280.19	
Gonadosomatic Index (GSI)	0.15 ± 0.09	1.25 ± 1.10	0.85 ± 1.02
Condition Factor (K)	4.78 ± 1.78	3.63 ± 1.35	3.83 ± 1.53
Liversomatic Index (LSI)	0.66 ± 0.59	0.98 ± 0.47	0.86 ± 0.54
Gonadal Index (GI)	0.03 ± 0.19	0.27 ± 0.26	0.19 ± 0.24
Visceral somatic Index (VSI)	119.81 ± 91.21	68.06 ± 52.81	86.57 ± 72.62
Percentage dress out (PDO) (%)	54.60 ± 23.76	63.89 ± 17.46	60.54 ± 20.50

Table 2: Body indices of *T. guineensis* from Ogun river.

Parameter	Male	Female	Total
n	35	15	50
Total length (TL) (cm)	23.79 ± 3.70	27.11 ± 5.79	24.78 ± 4.63
Standard length (SL) (cm)	21.38 ± 3.15	23.70 ± 4.88	22.08 ± 3.85
Total body weight TBW) (g)	117.58 ± 68.01	228.02 ± 134.73	150.71 ± 104.92
Gutted weight (GtW) (g)	67.40 ± 43.78	179.37 ± 130.97	100.99 ± 94.43
Gonad weight (GdW) (g)	0.25 ± 0.29	1.52 ± 1.19	0.63 ± 0.90
Liver weight (Lwt) (g)	0.76 ± 0.39	1.17 ± 0.43	0.88 ± 0.44
Absolute fecundity		4230.21 ± 7230.12	
Gonadosomatic Index (GSI)	0.19 ± 0.14	0.75 ± 0.50	0.36 ± 0.39
Condition Factor (K)	0.86 ± 0.25	1.05 ± 0.73	0.91 ± 0.26
Liversomatic Index (LSI)	0.74 ± 0.40	0.63 ± 0.28	0.71 ± 0.37
Gonadal Index (GI)	0.002 ± 0.004	0.005 ± 0.00	0.001 ± 0.00
Visceral somatic Index (VSI)	89.68 ± 91.09	46.34 ± 36.32	76.68 ± 80.85
Percentage dress out (PDO) (%)	58.07 ± 13.57	71.88 ± 15.57	62.21 ± 15.43

Table 3: Body indices of *C. gariepinus* from Ogun river.

Parameter	Male	Female	Total
n	25	25	50
Total length (TL) (cm)	30.69 ± 5.56	29.35 ± 4.44	30.05 ± 5.05
Standard length (SL) (cm)	26.75 ± 4.71	25.36 ± 3.68	26.08 ± 4.26
Total body weight TBW) (g)	196.26 ± 89.44	197.07 ± 86.09	196.81 ± 89.56
Gutted weight (GtW) (g)	160.94 ± 79.29	158.18 ± 80.19	159.61 ± 78.10
Gonad weight (GdW) (g)	5.081 ± 2.65	6.75 ± 13.21	5.88 ± 12.82
Liver weight (Lwt) (g)	1.48 ± 1.59	1.45 ± 0.82	1.46 ± 1.27
Absolute fecundity		7878.10 ± 10719.78	
Gonadosomatic Index (GSI)	2.39 ± 5.51	2.53 ± 4.12	2.64 ± 4.84
Condition Factor (K)	0.65 ± 0.15	0.71 ± 0.18	0.68 ± 0.17
Liversomatic Index (LSI)	0.78 ± 0.57	0.83 ± 0.55	0.78 ± 0.56
Gonadal Index (GI)	1.72 ± 4.26	2.25 ± 4.32	1.97 ± 4.25
Visceral somatic Index (VSI)	19.01 ± 10.84	17.09 ± 28.95	18.09 ± 21.31
Percentage dress out (PDO) (%)	80.68 ± 10.84	82.90 ± 28.95	81.90 ± 21.31

Table 4: Body indices of *C. anguillaris* from Ogun river.

presented as Figures 1-4. Derived indices of GSI, K and LSI exhibited comparable direct, but moderate relationships with standard length (Figures 1 and 3) in *Ch. nigrodigitatus* and *C. gariepinus*. Strong direct relationships between SL with GSI and LSI in *T. guineensis* were depicted while K exhibited strong inverse relationship (Figure 2). The relationships between SL and derived indices were moderately direct for *C. gariepinus* (Figure 3). *C. anguillaris* exhibited irregular relationships (Figure 4).

Significant difference between sexes was observed only for GI in *C. gariepinus* (Table 5). Regression equations for males, females and the pooled sexes of all the species are presented below:

Ch. nigrodigitatus

$$W = -0.2554 L^{1.6788} (r^2 = 0.3445) \text{ male}$$

$$W = -0.5869 L^{1.9784} (r^2 = 0.6504) \text{ female}$$

$$W = -0.3076 L^{1.7354} (r^2 = 0.4322) \text{ pooled}$$

T. guineensis

$$W = 0.4679 L^{1.3138} (r^2 = 0.7997) \text{ male}$$

$$W = 0.5765 L^{1.2153} (r^2 = 0.6306) \text{ female}$$

$$W = 0.5238 L^{1.2621} (r^2 = 0.7140) \text{ pooled}$$

C. gariepinus

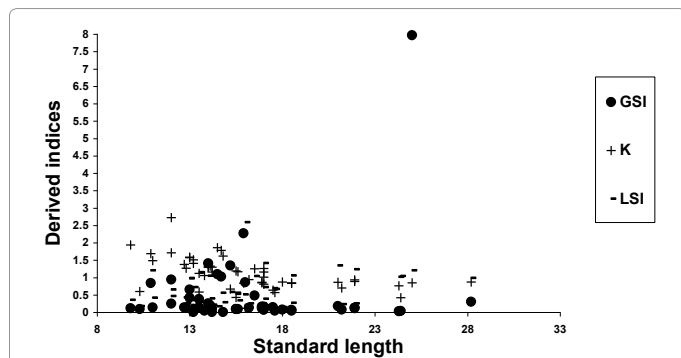


Figure 1: Relationship between standard length and derived indices of *Ch. nigrodigitatus*.

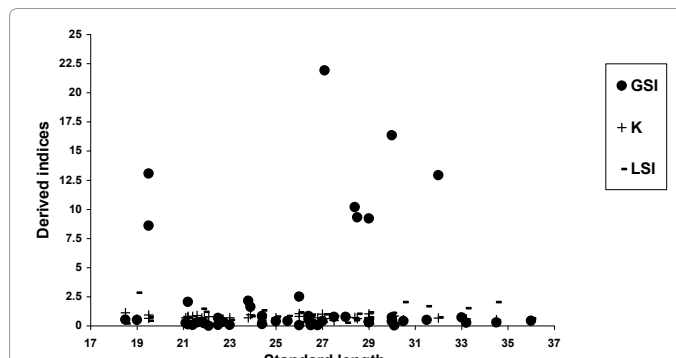


Figure 4: Relationship between standard length and derived indices from *C. anguillaris*.

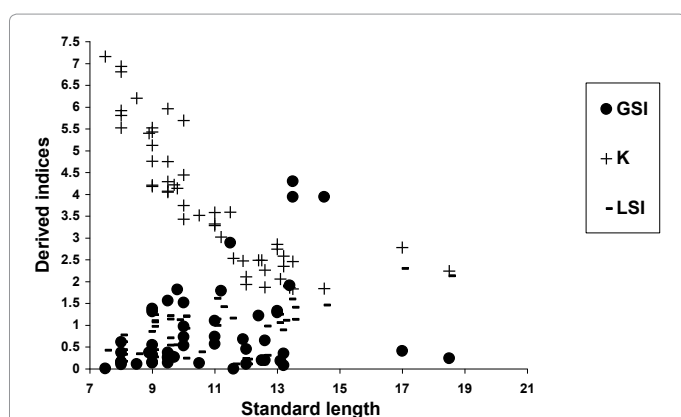


Figure 2: Relationship between standard length and derived indices from *T. guineensis*.

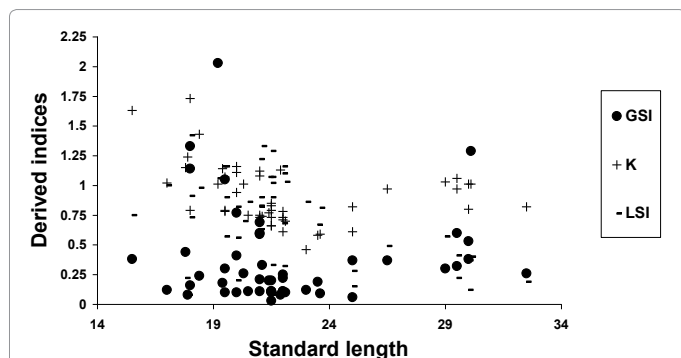


Figure 3: Relationship between standard length and derived indices from *C. gariepinus*.

$$W = -0.5934 L^{1.9168} (r^2 = 0.5893) \text{ male}$$

$$W = -1.5593 L^{2.7001} (r^2 = 0.8986) \text{ female}$$

$$W = 2.700 L^{-0.4012} (r^2 = 0.0178) \text{ pooled}$$

C. anguillaris

$$W = -1.2463 L^{2.3592} (r^2 = 0.8079) \text{ male}$$

$$W = -1.8028 L^{2.7578} (r^2 = 0.7447) \text{ female}$$

$$W = -1.4306 L^{2.4931} (r^2 = 0.7676) \text{ pooled}$$

The values of exponent b from *C. anguillaris* in all cases ranged between 2.3592-2.7578, with the females (b=2.7578) closest to 3, the

Parameters	<i>Ch. nigrodigitatus</i>	<i>T. guineensis</i>	<i>C. gariepinus</i>	<i>C. anguillaris</i>
Total length (TL)	1.1664	-0.6886	-2.0497	0.9398
Standard length (SL)	-0.0938	0.6699	-1.741	1.1708
Total body weight (TBW)	-0.2614	-0.2685	-3.0143	0.1986
Gutted weight (GtW)	-0.7707	-0.7409	-3.2342	0.2264
Gonad weight (GdW)	-1.3356	-4.798	-4.0386	-0.4554
Liver weight (Lwt)	-0.5703	-0.6164	-3.1128	0.0887
Gonadosomatic Index (GSI)	-2.045	-5.5876	-4.1733	-0.1025
Condition Factor (K)	-1.8228	1.1392	-2.5426	-1.2878
Liversomatic Index (LSI)	0.4708	-1.9875	1.0541	-0.6675
Gonadal Index (GI)	-1.6051	-5.1989	2.7583	-0.4321
Visceral somatic Index (VSI)	-0.0399	0.6431	-3.2342	0.3057
Percentage dress out (PDO)	-0.071	-1.6537	-2.9835	-0.3057

Table 5: Comparison of body and derived indices between sexes $t_{0.05} = 2.021$ $t_{0.01} = 2.704$.

ideal b value. The values from females *C. gariepinus* (b=2.7001) also close to the ideal value; but the b values for males and pooled varying significantly. b values for *Ch. nigrodigitatus* (1.6788-1.9784) and *T. guineensis* (1.2153-1.3138) the ideal value.

Summary of physico-chemistry of abattoir wastes and river Ogun at Lafenwa and Isheri-Olofin respectively is presented on Table 6. Temperature of 31°C and 29.5°C and pH of 6.8 and 7.8 were recorded at the respective locations. Isheri-Olofin recorded higher Total Dissolved Solids (TDS) (1700 mg/l) and conductivity (220 mg/l) compared with Lafenwa (600 mg/l and 147.5 mg/l). DO concentration from water (7.20 and 3.14 mg/l) compared with higher BOD values from the wastes (15.6 and 13.92 mg/l). Nutrient parameters of nitrate-nitrogen (NO₃-N), ammonia-nitrogen (NH₃-N) and phosphate (PO₄³⁻) differ greatly between the two locations. NO₃-N and NH₃-N was higher at Isheri-Olofin, but PO₄³⁻ concentration was higher (22.23 mg/l) at Lafenwa. Concentrations of trace metals were elevated at Isheri-Olofin. Zinc (Zn) had the highest concentration of 18.25 mg/l and mercury (Hg) the least of 0.089 mg/l. Concentrations of Manganese (Mn) recorded the least 0.074 mg/l and Iron (Fe) the highest of 0.195 mg/l at Lafenwa. Copper (Cu), Lead (Pb) and Mercury (Hg) were not detected in the effluent from Lafenwa.

Discussion

The presence of unwanted materials in aquatic environment has been known to cause subtle or robust damages to aquatic life forms

Parameters	Abattoir waste		Ogun river		NESREA -2011 effluent limits	NESREA -2011 Fis heries limits	USEPA (2002)	
	Lafenwa	Isheri-Olofin	Lafenwa	Isheri-Olofin			¹ CMC	² CCC
Tempearture (°C)	31	na	27.5	30	n.s	n.s	35	35
pH	6.8	7.8	6.9	6.2	6.5-8.5	6.5-8.5	6.5-9	6.5-9
Total Dissolved Solids (TDS) (mg/l)	600	1700	250	126	2000	Ns	250	250
Conductivity ($\mu\text{S}^{-1}\text{cm}^{-1}$)	147.5	220	85.4	280	n.s	ns	ns	ns
Dissolved oxygen (DO)(mg/l)	2.44	2.08	7.2	3.14	4		3	3
Biochemical Oxygen Demand (BOD)(mg/l)	15.6	13.92	4.66	7.52	6	3	ns	ns
Nitrate-Nitrogen ($\text{NO}_3\text{-N}$) (mg/l)	0.018	133.1	0.015	94.7	40	9.1	1	1
Ammonia-Nitrogen ($\text{NH}_3\text{-N}$)(mg/l)	25.28	59.92	22.5	27.78	2	0.05	0.85	11.5
Phosphate (mg/l)	22.23	6.88	4.45	3.98	3.5	3.5	0.0001	0.0001
Copper (Cu)(mg/l)*	ND	1.08	ND	0.16	0.01	0.001	0.013	0.009
Iron (Fe)(mg/l)	0.195	2.83	0.451	0.25	0.5	0.05	1	1
Lead(Pb)(mg/l)*	ND	0.81	ND	0.079	0.1	0.01	0.065	0.0025
Manganese (Mn)(mg/l)	0.074	0.81	0.112	0.27	5	ns	0.1	0.1
Mercury (Hg) (mg/l)*	ND	0.089	ND	0.004	0.0005	0.001	0.0014	0.0007
Zinc (Zn)(mg/l)*	0.169	18.25	0.32	10.2	0.2	0.01	0.12	0.12

ND: Not Detected, na: Not Available, ns: Not Specified. ¹USEPA designated priority pollutant; ²NESREA designated hazardous substance. 1: Criterion continuous concentration (CCC): to protect against chronic effects. 2: Criterion maximum concentration (CMC): to protect against acute and lethal effects.

Table 6: Physical and chemical quality of abattoir wastes and Ogun river.

effects of which can be used to detect spatio-temporal changes and distribution of the pollutants [18-22]. This is because the ultimate effect is biotic integration into body mechanisms.

Fish growth is considered a good indicator of fish and aquatic health because it manifests the influence of biotic and abiotic variables from the inhabited environment [14,23]. Bonga stated that growth rates reflect food availability, appetite and consumption, intestinal uptake and metabolic rates, all of which can be influenced by stressors [1].

Fish species from our study were apparently affected by the prevailing water condition as shown by reduction in growth indices (TL, SL and TBW) compared with reports on *Ch. nigrodigitatus* [24-30]; *T. guineensis* [26,31]; *C. gariepinus* [32-36] and *C. anguillaris* [37]. Adebisi in his studies recorded a range 10.40 -58.20 cm in TL for fishes from Ogun river, although none of the species in our own study was included, this differ from a range of 10.00-41.00 in our study [6]. Further supporting our submission of steady reduction in sizes of fishes resident in Ogun river.

While it is important not to overlook gear selectivity as suggested by Fagade [26]. The possibility of gear selectivity as size factor simultaneously for species in this study is severely limited. Disturbance in body mechanisms possibly due to chronic organic pollution appeared a more viable determining factor.

Although, Fafioye and Olujajo [36] on *Ch. nigrodigitatus* (TL=21.75 \pm 7.55 and TBW=85.5 \pm 69.5) and *C. gariepinus* (TL=15.5 \pm 8.5 and TBW=143.0 \pm 132.0) from Epe lagoon and on *C. anguillaris* (TL=26.0 and SL=23.0) from Owena reservoir respectively reported values lower than our own observations reasons were not clearly stated for size observations.

Liver as a growth indicator is sensitive to food intake in fishes under variety of environment, especially stressed conditions and pollution impacts [14,37,38]. Differences in liver weight among sexes, as observed in this study, had been previously suggested [39-41] as indicative of allocation of resources to gonad development in females.

Comparable information on sex-related liver weight on *Ch. nigrodigitatus*, *T. guineensis* and *C. anguillaris* agreed largely with the conclusions of Htun-Han [39], Hussain et al. [40], Lambert and Dutil [41] and van der Oost et al. [38] on changes in liver weight due to environmental stress.

Reduction in reproductive potential was apparent in *Ch. nigrodigitatus*, *T. guineensis* and *C. gariepinus* compared values reported by Fagade [25,26,29,30,42]. Similar conclusions were difficult to draw for and *C. anguillaris* due lack of previous reports. However, when compared with post-oil spill reports of Ekwu [42], probability of reduction in reproductive potential is high because the values were not so incongruous. Effects of oil pollution are severe, immediate and obvious, unlike subtle and cumulative nature of organic pollution.

The use of GSI as index of the relationship between ovary weight and fecundity has been demonstrated [43]. The reported mean GSI for all species were very low compared with those from previous studies. Fagade and Adebisi [25] reported a range of 5-50 for *Ch. nigrodigitatus*; and Ekwu [42] 15.28 \pm 2.22-18.6 \pm 1.89 and 13.2 \pm 3.73-14.9 \pm 2.75 from pollution episode from Cross river for same species. Ofori-Danson [44] calculated a maximum GSI of 6.5 for *Ch. nigrodigitatus* from Volta lake in Ghana.

Tsadu and Adebisi [32] reported 0.225-0.594 and 4.732-11.511 respectively for male and female *C. gariepinus*. This was lower than 12.28 \pm 9.85 -14.79 \pm 2.75 later reported [42]. *T. guineensis* and *C. anguillaris* were not reported with GSI values from available literature. However with mean GSI of 0.85 \pm 1.02, *T. guineensis*, recorded significantly lower values compared with cichlids from Ogun river [6], Sombreiro river [45] and Cross river [42].

GSI reported for *C. anguillaris* was low compared values reported by Ekwu [42] for *C. gariepinus*, a comparable fish species. In contrast to observations on cichlids having reduced GSI due frequency of spawning, as reported by Adebisi [6] and Ekwu [42], only *C. anguillaris* had higher GSI compared with *T. guineensis*.

Information on gonad weights in males from earlier reproductive studies involving species used in this study was not available.

Generally males recorded lower gonadal weights compared with females, similar to observations of Hussain et al. [40], Tsadu and Adebisi [32] and Buchtová et al. [46].

Reduced fecundity is regarded as robust indicator of toxicity, because agents of pollution interact with endocrine control mechanisms of reproduction [1,38].

T. guineensis recorded the highest K value in our study, comparable

only to the minimum ($K=3.77-5.30$) reported by Fagade [26] for the species. Present conditions [14,37], past condition [37] nutritional status [37] and environmental stress [14,42,43] have been clearly linked to low or reduced K . This shows that fishes from our study were not in the desirable condition.

C. gariepinus was the only species with previous reports of LSI which Tsadu and Adebisi [32] as a measure of food availability. LSI of *C. gariepinus* from our study were clearly elevated. The sensitivity of liver to environmental changes [37,44-62] and pollution [14,38] greatly influence Lwt and LSI.

Toxicants had also been reported to cause both increase and decrease in liver depending on the type of pollutant [14,38]. The mean LSI (< 1) for all species reported was much lower compared with 1.75 [40]; 1.1 ± 0.1 [14] and 1.4 ± 0.3 [17] as their least values. Fishes from our study were clearly experiencing some pathology.

The remaining derived indices of GI, VSI and PDO have not been reported for the species under study or used as indicator of aquatic health.

GI combines information on fecundity and length weight relationship, signifying the magnitude of alteration in resource allocation in fish, due to integration of pollutants. This was however extended in this study to include both sexes. The influence of sex is shown by difference of the GI value from gonad weight (Tables 2-5). Schulz and Martins-Junior [15] reported GI values for *Astyanax fasciatus* only females. Variations in GI in our observations probably reflected the toxic effects of pollutants on fecundity as suggested by Wandearlar-Bonga [1].

The extent of lipid storage in the viscera of individual fish is described by VSI and PDO. The high values of PDO of above 50% in all cases indicated some consistency in energy allocation, with highest allocation by *Ch. nigrodigitatus* and least by *T. guineensis*.

The Length-Weight Relationship (LWR) reported clearly defined the diversified body configuration associated with fish species from Nigerian waters in agreement with King [28], Fafioye and Oluajo [36]. *C. anguillaris* for both sexes and pooled and, *C. gariepinus* females clearly approximated allometric growth. However, *Ch. nigrodigitatus* and *T. guineensis* in all cases have the tendency to become thinner with size. This was also the case with *C. gariepinus* males and pooled [12]. Tsadu and Adebisi [32] reported similar sexual differences growth configuration in *C. gariepinus*. In contrast *Ch. nigrodigitatus* ($b=3.042 \pm 0.003$) and *C. gariepinus* ($b=2.880 \pm 0.15$) populations from Epe lagoon were apparently allometric in their growth configurations.

The observed reduction in size as with other body indices can be associated with immediate environment. It is therefore possible that reallocation of metabolic resources away from growth towards activities requiring intensification to restore homeostasis [1]. This continuous reallocation towards homeostatic balance, under prevailing conditions, could be responsible for the observed variability in relationships between length and derived indices.

The prevailing conditions in Ogun river has changed over time, as evident by differences of physico-chemical parameters compared with Adebisi [6], Odukoya [47], Asonye [10] and Jaji et al. [9]. The limited abiotic measurements previously reported on Ogun river were within allowable Nigerian limits with some exceptions from Asonye et al. [10]. Our study departed significantly, because more parameters were evaluated most of which exceeded USEPA [48] and NESREA [49] limits. $\text{NH}_3\text{-N}$ and PO_4^{3-} , two of parameters for detecting organic

pollution [50] were above allowable limits in both wastes and aquatic life for all locations. This was similar to observations of Osibanjo and Adie on Bodija abattoir Ibadan, Southwest Nigeria ($\text{NH}_3\text{-N}=62-159$; $\text{PO}_4^{3-}=142-180$). The presence of $\text{NH}_3\text{-N}$ at elevated concentration may reduce growth, fecundity and survival of fishes [51-53], although toxicity is influenced by actions of pH and presence of certain heavy metals [51,53].

The effects of excessive PO_4^{3-} on fish species are indirect, either via enhanced production of blue-green algae which is of low nutritive value to most fishes [51,54] or plankton die-offs after a bloom [51]; Pearl and Tucker, associated with peak-fall cycle of nutrients [21,51,54]. The effect is reduced DO from high BOD requirement of decomposition with many physiological implications for fish species [51,52]. Similar observations were reported from Orogodo river, South-south Nigeria, due to inputs of abattoir wastes [56], while elevated conductivity in Delimmi river Jos Nigeria, was traced to organic pollution [57-73].

Conclusion

Indices from finfishes as environmental sentinel is a robust and premium tool with an advantage of being inexpensive. The results from this study indicated that Ogun river is under stress from organic loading associated with the abattoirs from Lafenwa and Isheri-Olofin. *Ch. nigrodigitatus*, *T. guineensis*, *C. gariepinus* and *C. anguillaris* manifested this aquatic stress differently for comparable parameters. However the paucity of information on this aspect of the species created some difficulties in establishing benchmarks. Further evaluations of the species used in our study, and other abundant but less economically important species as observed in the use of fishes as bioindicators in other part of the world is highly desirable.

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