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Indices from *Chrysicthys nigrodigitatus* (Lac é p è de, 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 *Chrysicthys 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 PO43 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 Fultons' condition factor (K) exhibited similar pattern. Liversomatic 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 km^2. 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], bioaccumuluation [8] and physico-chemistry [9,10]. Presented here is use of various indices from *Chrysicthys 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 $(GI)=W^O/TL^b$ (4) Fulton's condition factor $(K)=100\ tbw/TL^3$ (5) Liversomatic 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^O=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 NO_3-N, ammonia–nitrogen (NH_3-H), phosphate (PO_4^{3-}), 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 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).

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.

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) male

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

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

T. guineensis

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

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

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

C. gariepinus

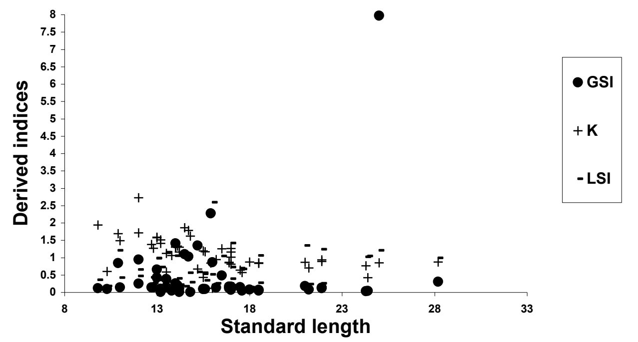

Figure 1: Relationship between standard length and derived indices of *Ch.nigrodigitatus*.

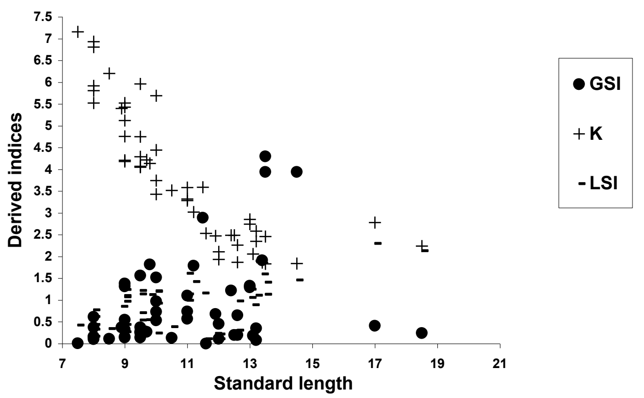

Figure 2: Relationship between standard length and derived indices from *T. gueneensis*.

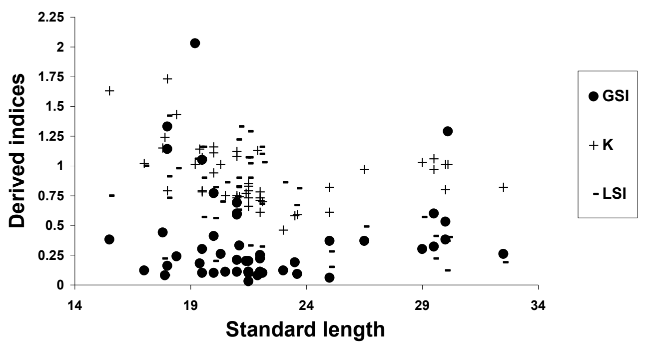

Figure 3: Relationship between standard length and derived indices from *C. gariepinus*.

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

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

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

C. anguillaris

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

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

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

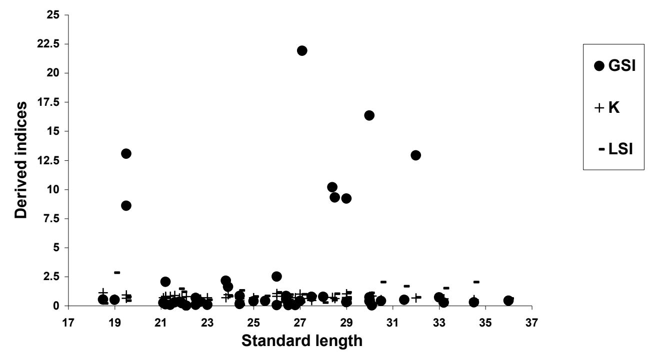

Figure 4: Relationship between standard length and derived indices from *C. anguillaris.*

Parameters	*Ch. nigrodigitatus*	*T. guineensis*	*C. gariepinus*	*C. anguillaris*
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.

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 (NO_3-N), ammonia-nitrogen (NH_3-N) and phosphate (PO_4^{3-}) differ greatly between the two locations. NO_3-N and NH_3-N was higher at Isheri-Olofin, but PO_4^{3-} 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 ($\mu S^{-1} cm^{-1}$)	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 (NO_3-N) (mg/l)	0.018	133.1	0.015	94.7	40	9.1	1	1
Ammonia-Nitrogen (NH_3-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. *USEPA designated priority pollutant; #NESREA 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-temoral 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 Oluajo [36] on *Ch. nigrodigitatus* (TL=21.75 ± 7.55 and TBW=85.5 ± 69.5) and *C. gariepinus* (TL=15.5 ± 8.5 and TBW=143.0 ± 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 ± 2.22-18.6 ± 1.89 and 13.2 ± 3.73-14.9 ± 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 ± 9.85 -14.79 ± 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 ± 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 Wandeerlar-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 diversed 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 ± 0.003) and *C. gariepinus* (b=2.880 ± 0.15) populations from Epe lagoon were apparently allomeric 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. NH_3-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 (NH_3-N=62-159; PO_4^{3-}=142-180). The presence of NH_3-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.

References

1. Bonga WSE (1999) The stress response in fish. Physiol Rev 77: 591-625.
2. Sydenham DHJ (1977) The qualitative composition and longitudinal zonation of fish fauna of the River Ogun, Western Nigeria. Revue de Zoologie Africaine 91: 974-997.
3. Adebisi AA (1981) The physico-chemical hydrology of a tropical seasonal river-upper Ogun river. Hydrobiologia 79: 157-165.
4. Hugueny B (1989) West African rivers as biogeographic islands: species richness of fish communities. Oecologia 79: 236-243.
5. Adebisi AA (1981) Analysis of stomach content of pscivorous fishes of the upper Ogun River in Nigeria. Hydrobiologia 79: 167-177.
6. Adebisi AA (1987) The relationship between fecundities, gonadsomatic indices and egg size of some fishes of Ogun river, Nigeria. Archiv für Hydrobiologie 111: 151-156.
7. Adebisi AA (1988) Changes in structural components of fish community of seasonal river. Archiv für Hydrobiologie 113: 457-463.
8. Adeniyi AA, Yusuf KA, Okedeyi OO (2008) Assessment of the exposure of two fish species to metals pollution in the Ogun river catchments, Ketu, Lagos, Nigeria. Environmental Monitoring and Assessment 137: 451-458.
9. Jaji MO, Bamgbose O, Odukoya OO, Arowolo TA (2007) Water quality assessment of Ogun River, South West Nigeria. Environmental Monitoring and Assessment 133: 473-482.
10. Asonye CC, Okolie NP, Okenwa EE, Iwuanyawu UG (2007) Some physicochemical characteristics and heavy metal profiles of Nigerian rivers, streams and waterways. African Journal of Biotechnology 6: 617-624.
11. Bagenal TB, Tesch FW (1978) Age and growth. In ed. Bagenal TB, In Methods for assessment of Fish production in freshwaters. Blackwell Science Publications Ltd. Oxford: 101-136.
12. Le Cren ED (1951) The length-weight relationship and seasonal cycle in gonad weight and condition in the perch, (Perca fluviatilis). Journal Animal Ecology 20: 201-219.

13. Bagenal TB, Braum E (1978) Eggs and early history. In: Ricker WE (ed.) Methods for assessment of Fish production in freshwaters. International Biological Program Handbook. Blackwell Science Publications Ltd. Oxford: 165-201.
14. Hoque MT, Yusoff FM, Law AT, Syed MA (1995) Effect of hydrogen sulphide on liver somatic index and Fulton's condition factor in Mystus nemurus. Journal of Fish Biology 52: 23-30.
15. Schulz UH, Junior MH (2001) Astyanax fasciatus as bioindicator of water pollution of Rio Dos Sinos, RS, Brazil. Brazilian Journal of Biology 61: 615-622.
16. Alberto A, Camargo AFM, Verani JR, Costa OFT, Fernandes MN (2005) Health variables and gill morphology in the tropical fish Astyanax fasciatus from sewage-contaminated river. Ecotoxicology and Environmental Safety 61: 247-255.
17. Torre DLFR, Ferrari L, Saliban A (2005) Biomarkers of a native fish species (Cnesterodon decemmaculatus) application to the water toxicity assessment of a peri-urban polluted river of Argentina. Chemosphere 59: 577-583.
18. Freidrich G, Chapman D, Bein A (1992) The use of biological material. In: Chapman D (ed.) Water Quality Assessments: A guide to the use of biota, sediments and water in environmental monitoring. Pub.: Chapman and Hall for UNESCO, WHO and UNEP: 171-237.
19. Graham JH, Freeman DC, Emleen, JM (1993) Developmental stability: A sensitive indicator of populations under stress. In: Environmental Toxicology and Risk Assessment: 136-158.
20. CY, Sowunmi AA (2000) Algal Biomonitoring: a case study of River Owo and Ologe lagoon, Agbara South-west Nigeria. Journal of Science Engineering and Technology 7: 2404-2422.
21. Ayoade AA, Sowunmi AA, Nwachukwu HI (2004) Gill asymmetry in Labeo ogunensis from Ogun river Southwest Nigeria. Revista de Biologia Tropical 52: 171-175.
22. Jeje CY, Winful AN, Sowunmi AA (2003) Nutrient characteristic of cowdung and composite of chicken manure of brewers' wastes. Asian Journal Microbiology, Biotechnology and Environmental Sciences 5: 151-156.
23. Anene A (2005) Condition factor of four cichlids species of a man-made lake in Imo state, Southeastern, Nigeria. Turkish Journal Fisheries Aquatic Sciences 5: 43-47.
24. Ikusemiju K (1975) A comparative racial study of the catfish, Chrysicthys nigrodigitatus (LACÉPÈDE) from Lagos and Lekki Lagoons Nigeria. Bulletin de L'linstitut Français d' Africaine Noire 37A: 887-898.
25. Fagade SO, Adebisi AA (1979) On the fecundity of chrysichthys nigrodigitatus (Lacépède) of the Asejire dam, Oyo State, Nigeria. Nigerian Journal Natural Sciences 1: 127-131.
26. Fagade SO (1978) On the biology of tilapia guineensis (Dumeril) from the lekki lagoon, Lagos state, Nigeria. Nigerian Journal Science 12: 73-83.
27. Obiekezie AI, Enyeheni UK (1988) Henneguya chrysicthyi sp. nov. (Protozoa: Myxozoa) from the gills of esturine catfish Chrysichthys nigrodigitatus (Lacépède) (Pisces: Bagridae) in Nigeria. Revue de Zoologie Africaine 102: 33-42.
28. King RP (1996) Length-Weight relationship of Nigerian Coastal water fishes. NAGA, The ICLARM Quarterly 19: 53-58.
29. Ekanem SB (2000) Some reproductive aspects of Chrysichthys nigrodigitatus (Lacépède) from Cross River, Nigeria. NAGA, The ICLARM Quarterly 23: 24-28.
30. Fapohunda OO, Godstates R (2007) Biometry and composition of fish species in owena reservoir, Ondo State, Nigeria. Journal of Central European Agriculture 8: 99-104.
31. King RP (1997) Length-Fecundity relationship of Nigerian fish population. NAGA, The ICLARM Quarterly 20: 29-33.
32. Tsadu SM, Adebisi AA (1997) Comparison of condition indices of pond raised and wild populations of African catfish, Clarias gariepinus (Burchell, 1822) (Pisces-Clariidae) in Plateau and Niger states, Nigeria. Journal of Aquatic Sciences 12: 49-58.
33. Eyo JE (2002) Conspecific discrimination in ratio morphometric character among members of the Pisces Genus: Clarias Scopoli. The Zoologist 2: 23-34.
34. Sowunmi AA (2003) Heamatology of the African catfish Clarias gariepinus (Burchell, 1822) from Eleiyele reservoir Ibadan, Southwest Nigeria. The Zoologist 2: 85-91.
35. Sowunmi AA (2005) Incidence of gill asymmetry in Oreochromis niloticus (L.) Clarias gariepinus (Burchell, 1822) from Asejire reservoir, Southwest Nigeria. West African Journal Applied Ecology 7: 135-140.
36. Fafioye OO, Oluajo OO (2005) Length-weight relationships of five fish species in Epe lagoon, Nigeria. African Journal of Biotechnology 4: 749-751.
37. Lambert Y, Dutil JD (1997) Can simple condition indices be used to monitor and quantify seasonal changes in the energy reserves of Atlantic cod (Gadus morhua). Canadian Journal of Aquatic Sciences 54: 104-112.
38. Oost VR, Beyer J, Vermeulen NPE (2003) Fish bioaccumulation and biomarkers in environmental risk assessment: a review. Environmental Toxicology and Pharmacology 13: 57-149.
39. Htun-Han M (1978) The reproductive biology of the dab Limanda limanda (L.) in the North Sea: goandosomatic index, hepatosomatic index and condition factor. Journal of Fish Biology 13: 369-378.
40. Hussain MG, Rao GPS, Humayun NM, Randall CF, Penman DJ, et al. (1995) Comparative performance of growth, biochemical composition and endocrine profile in diploids and triploids tilapia Oreochromis niloticus L. Aquacutlture 138: 87-97.
41. Dutil JD, Castonguay M, Gilbert D, Gascon D (1999) Growth, condition and environmental relationships in Atlantic cod (Gadus morhua) in the northern Gulf of St. Lawrence and implications for management strategies in the Northwest Atlantic. Canadian Jornal of Aquatic Sciences 56: 1818-1831.
42. Ekwu AO (2006) Impact of oil spill on the fecundity and goandosomatic index of icthyo faunal species in the Cross river coastal waters. Pollution Research 25: 213-216.
43. Ofori-Danson PK, de Graaf GJ, Vanderpruye CJ (2002) Population parameters estimates for Chrysichthys auratus and C. nigrodigitatus (Pisces: Claroteidae) in Lake Volta, Ghana. Fisheries Research 54: 267-277.
44. Jons GD, Miranda LE (1997) Ovarian weight as an index of fecundity, maturity and spawning periodicity. Journal of Fish Biology 50: 150-156.
45. Nwadiaro CS (1987) Fecundity of cichlid fishes of the Sombreiro river in the lower Niger Delta. Revue de Zoologie Africaine 101: 433-437.
46. Buchtová H, Svobodová Z, Flajšhans M, Vorlová L (2003) Analysis of growth, weight and relevant indices of diploid and triploid population of tench Tinca tinca (Linnaeus 1758). Aquaculture Research 34: 719-726.
47. Odukoya OO (2000) Pollution trends in ogun river, abeokuta, nigeria. Nigerian Journal Science 34: 183-186.
48. United States Environmental Protection Agency (USEPA) (2002) National Recommended Water Quality Criteria.
49. National Environmental Standards and Regulations Enforcement Agency (NESREA) (2011).
50. Saad MAH, Amuzu AT, Biney C, Calamari DI, Imevbore AM, et al (1994) Domestic and Industrial organic loads. In Review of pollution in the African aquatic environment. CIFA Technical Paper 25, 23-31.5.
51. Boyd CE (1979) Water quality in warm water pond. Auburn University, Agricultural Experimental Stations: 353.
52. Alabaster JS, Lloyd RS (1982) Water quality criteria for freshwater fish. Butterworth Scientific, London 1-382.
53. Beaumont MW, Butler PJ, Taylor EW (1995) Plasma ammonia concentration in brown trout in soft acidic water and its relationship to decreased swimming performance. The Journal Experimental Biology 198: 2213-2220.
54. Pearl HW, Tucker CS (1995) Ecology of blue-green algae in aquaculture ponds. Journal of the World Aquaculture Society 26: 109-131.
55. Sowunmi AA, Jeje CY (2004) Response of food organisms to inorganic nitrogen availability. Global Journal Pure and Applied Sciences 10: 243-248.
56. Arimoro FO, Ikomi RB, Iwegbue CMA (2007) Ecology and abundance of oligochaetes as indicators of organic pollution in an urban stream in Southern Nigeria. Pakistani Journal Biological Sciences 10: 446-453.
57. Kelly MG, Ali AD (1993) The effect of organic pollution on algal communities in a tropical pond. Tropical Freshwater Biology 3: 353-370.
58. APHA (1996) Standard methods for the examination of wastes and wastewater. American Public Health Association, Washington DC.
59. Awa J, Anyanwu P, Ezenwa B (1988) Incidence of parasitic infection of pond

raised Tilapia species and some cultivable fish species from three ecological areas of Lagos State. Nigerian Inst. for Oceanography and Marine Research: 1-24.

60. Cole MB, Arnold DE, Watten BJ, Krise WF (2001) Heamatological and physiological responses of brook charr, to untreated and limestone-neutralized acid mine drainage. Journal Fish Biology 59: 79-91.
61. Curvin-Aralar MLA, Aralar EV (1993) Effects of long-term exposure to a mixture of Cadmium,Zinc and inorganic Mercury on two strains of Tilapia niloticus. Bulletin of Environmental Contamination and Toxicology 50: 891-897.
62. Landis WG, Hughes JS, Lewis MA eds. ASTM STP 1179, American Society for Testing and Materials, Philadelphia, pp: 136-157.
63. Haylor GS (1993) Aspects of the biology and culture of the African catfish, Clarias gariepinus (Burchell, 1822) with particular reference to developing African countries. Recent Advances Aquaculture 4: 235-289.
64. Hovatter PS, Ross RH (1995) A comparative analysis of the toxicity of Boron compound to freshwater and saltwater species. In: Hughes JS, Biddinger GR, Mones E (eds) Environmental Toxicology and Risk Assessment, American Society for Testing and Materials, Philadelphia 3: 288-301.
65. King RP (1998) Weight-Fecundity relationship of Nigerian Coastal water fishes. NAGA, The ICLARM Quarterly 21: 33-36.
66. Kotze P, du Perez HH, van Vuren JHJ (1999) Bioaccumulation of Copper and Zinc in Oreochromis mossambicus and Clarias gariepinus, from the Olifants River, Mpumalanga, South Africa. Water South Africa 25: 99-110.
67. Lambert Y, Dutil JD (1997) Condition and energy reserves of Atlantic cod (Gadus morhua) during the collapse of the northern Gulf of St. Lawrence stock. Canadian Journal of Aquatic Sciences 54: 2388-2400.
68. National Environmental (Surface and GroundWater Quality Control) Regulations. S.I. 22.
69. Wepener V, Vuren JHJ, Du Preez HH (1992) Uptake and distribution of a copper iron and zinc mixture in gill, liver and plama of freshwater teleost, Tilapia sparrmani. Water South Africa 27: 99-108.
70. World Health Organization WHO (1993) Guidelines for Drinking water quality. International reference point for standard setting and Drinking water safety. Geneva.
71. Abrahim AT (2007) Distribution patterns of some heavy metals and pollution induced changes in some organs of three Nile fish species from Assiut, Egypt. Assiut Univ Egypt.
72. Anwar SM, El Shafy AA, El Serafy SSM, Ibrahim II, Ali EA (2001) Accumulation of trace elements in fish at lake quaroun as a biomarker of environmental pollution. J Egypt Ger Soc Comp Physiol Zool 36: 46-65.
73. Mekkawy IAA, Mahmoud UM, Ibrahim ATA (2008) Heavy metal distribution and their corresponding damage effect in some organs of Bagrus bajad (Forsskal, 1775) from three localities at Assiut. Egypt J Egypt Ger Soc Zool 54: 119-137.