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Gastrointestinal Parasites of *Sarotherodon melanotheron*(Ruppel, 1852) Histopathological Alterations and Organochlorine Pesticides Pollution from Lagos, Lagoon, Nigeria.

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ABSTRACT

This study investigates the prevalence and intensity of intestinal parasites and determines the combined impact of organochlorine pesticides and parasites on the total health of the fish in Lagos lagoon. Twelve congeners of organochloride pesticides (OCPs) were analyzed in water, sediment, fish and parasites using mass chromatograph coupled with an electron detector. The prevalence of intestinal helminth infection in *Sarotheron melanotheron* was 20.83%. Twenty-five individuals were infected with parasitic cestode *Wenyonia sp* (20.83%, Chi-Square, $X^2 = 11.2$, p<0.05), out of which 18 (15.00%) were males and 7 (5.83%) were females. The intestinal parasites found in S.*melanotheron* were cestode; *Wenyonia sp*, protozoa; *Myxobolus sp.* Coccidian spores, *Myxosoma sp, and Hexamita sp.* Five congeners were detected in the water, sediment, fish and parasites. Some protozoa parasites of *Sarotherodon melanotheron* have shown qualities of bioindicators from the study. *Myxosoma* sp showed positive correlation (r = 0.315, p<0.05) with DDT and heptachlor (r = 0.301, p<0.05) but its correlation coefficient was not significant for endosulfan 1, aldrin and total OCPs. None of the intestinal helminth parasite infection correlates significantly with any of the OCPs congeners in the lagoon. Iddo station had the highest parasite prevalence and concentrations of DDT, Aldrin, Dieldrin, and Heptachlor in the water and sediment and the highest GAI, showing high frequencies of several inflammations, and tissue necrosis as a result of greater multi-stress pressure.

INTRODUCTION

Pollution may be defined as the discharge of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called pollutants. Water pollution is caused by a variety of human activities such as industrial, agricultural and domestic. Several literatures have reported contamination of water bodies through man activities along the coast of the Lagos Lagoon (Akpata and Ekundayo, 1978; Akpata et al, 1996; Don-Pedro et al, 2004; Akinsanya et al, 2015). Agricultural run-off laden with excess fertilizers and pesticides, industrial effluents with toxic substances and sewage water with human and animal wastes pollutes the water (Akinsanya et al, 2015). Pesticides like DDT and others used in agriculture may contaminate water bodies.

Aquatic organisms take up pesticides from water get into the food chain (aquatic in this case) and move up the food chain. Akinsanya et al, (2015) reported the distribution and bioaccumulation of organochlorine pesticide residues along the food chain. At the higher trophic level they get concentrated and may reach the upper end of the food chain. This is because pesticide misuse in various sectors of agriculture often has been associated with health problems and environmental contamination worldwide (Nayak *et al*., 1995). Misuse of highly toxic pesticides, coupled with a weak or a totally absent legislative framework in the use of pesticides, is one of the major reasons for the high incidence of pesticide poisoning in developing countries (Köhler *et al*., 2002). Low education levels of the rural population, lack of information and training on pesticide safety, poor spraying technology, and inadequate personal protection during pesticide use have been reported to play a major role in the intoxication scenario (MacFarlane *et al*., 2013).

Parasitism is a non-mutual symbiotic relationship between species, where one species, the parasite, benefits at the expense of the other, the host. Classic examples of parasitism include interactions between vertebrate hosts and tapeworms, flukes, the *Plasmodium* species, and fleas. Parasites reduce host biological fitness by general or specialized pathology, such as parasitic castration and impairment of secondary sex characteristics, to the modification of host behaviour. Parasites increase their own fitness by exploiting hosts for resources necessary for their survival, e.g. food, water, heat, habitat, and transmission.

Fish parasites are listed among species that have been identified as highly sensitive either because of their physiological response to aquatic contaminants or because of their ability to accumulate particular toxic agents (MacKenzie et al, 1995). In fact, certain intestinal parasites, particularly thorny-headed worms parasitizing fish, have been shown as organisms that accumulate organochlorine at concentrations that are many times higher than those recorded in the host tissues. The aim of this study is to investigate the prevalence and intensity of intestinal parasites and determine the combined impact of organochlorine pesticides and parasites on the total health of the fish.

MATERIALS AND METHODS
The Study Area:

The Lagos lagoon is more than 50 km long and 3-13 km wide, separated from the Atlantic Ocean by a long sand pit 2-5 km wide, which has swampy margins on the lagoon side. Its surface area is approximately 6,354.7 km². The lagoon is fairly shallow and is not plied by ocean-going ships but by smaller barges and boats.

The lagoon receives the discharge of the Ogun River and the Osun River. Lagos Lagoon empties into the Atlantic via Lagos Harbour, the main channel through the heart of the city, 0.5 km to 1 km wide and 10 km long. The principal ocean port of Lagos is located at Apapa in a broad western branch off the main channel of the harbour.

Sample Collection:

Three sediment, water, fish samples and parasites were collected from each station to be representative of the frequently consumed type. The samples were identified, frozen and taken to Institute of Oceanography and Marine Research (NIOMR)- Physical and Chemical division, where they were individually weighed, measured, and stored in the cold room below 4°C prior to preparation and analysis.
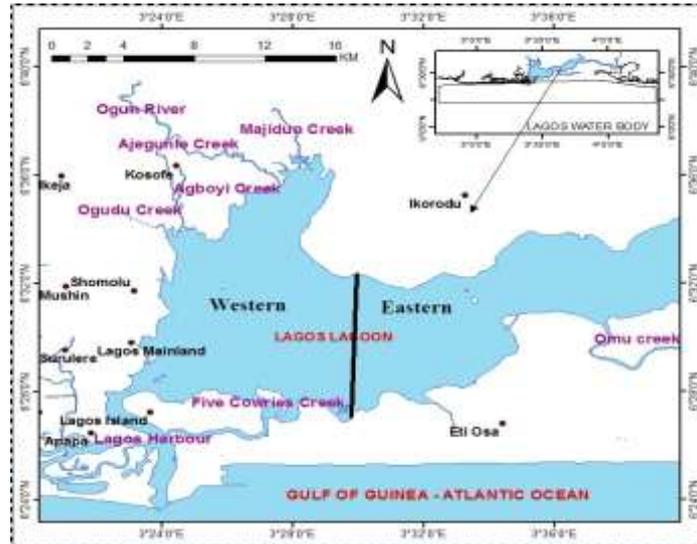
Fig. 1: Map of Lagos Lagoon showing the sampling sites.

Water Samples:

The surface water sample was collected with the use of a well cleaned and sterilized amber bottle. A Randomly taken sample was homogenized to form a composite sample (1L) for each of the 3 locations.

Sediment Samples:

The sediment sample was collected at same points as water sample from a 0.5–10m depth using a Van Veen Grab sampler operated from a boat, at each of the 3 locations. The sample was then wrapped up in aluminum foil and then put in a polyethylene bag. Samples were kept cool during transportation to the laboratory. At the laboratory, they were freeze-dried prior to sample preparation and analysis. Sediment samples were later thawed and air- through 2.0 mm stainless steel sieve. The less than 63 μm soil samples were prepared using the 63 μm stainless steel sieve prior to analysis.

Fish Samples:

One hundred and twenty specimens of *Sarotherodon melanotheron* were caught at random from the Lagos Lagoon. The fishes were then transported in a clean plastic bowl to the laboratory for analysis.

Water, Sediment and Fish Analysis for OCPs:

The methodology employed in this project was based on the United State – Environmental Protection Agency (US-EPA) method 8082A with slight modification. The methodology includes weighing or measurement of the sample, grinding of solid samples with mortal and pestles, extraction of OCPs component, extraction of OCPs residues, sample extract clean up by column chromatography, concentration of sample extracts, and separation and quantification of the OCPs residues by gas chromatograph equipped with 63Ni Electron Capture Detector (ECD).

For water samples, separating funnels were used for extraction. 200ml of water sample was measured into the separating funnel and 100 ml of dichloromethane was used as the organic solvent. Two batch extractions were carried out i.e. after the first extraction another 100ml of DCM was added. After about 15 minutes, the organic layer was collected over glass funnel, glass wool and Sodium Sulphate anhydrous. The two fractions were pooled together and concentrated using a rotary evaporator to approximately 5mL.

Fish samples (5g) were weighed into a mortal, grinded with Sodium

Sulphate anhydrous (previously baked at 160^oC for 24 hours). The thoroughly grinded sample with Sodium Sulphate anhydrous was cold extracted with 50 ml n-hexane/acetone (ratio 2:1) for 3 hours twice. The extract was concentrated to approximately 2mL with rotary vacuum evaporator.

Chromatographic Column Clean up:

The column chromatography was performed to remove interfering organic and polar species. Briefly, a Silica gel column (250 mm x 25 mm) was packed from the bottom up with glass wool, approximately 20g of activated silica gel and 5.0 g anhydrous sodium sulphate used to cap it. The column was pre-rinsed with 30 ml of n-hexane before the sample was loaded. The first fraction was eluted with 20 ml of pentane for removal of the aliphatic hydrocarbon and was discarded. The second fraction was eluted with 50 ml of n-hexane for OCPs. The eluted extract was concentrated using a Rotary Vacuum evaporator to 2-5 ml. 2 μl of cleaned extract was injected into a gas chromatograph equipped with an electron capture detector (GC-ECD) for quantification.

Determination of OCPs Concentration Using GC-ECD (Separation and Quantification of OCPs) :

This was carried out using a Gas Chromatograph (Hewlett Packard 5890 series II) equipped with a 63Ni Electron Capture Detector (ECD). A fused capillary column (Rtx 5) of 30 m x 0.25 mm id with 0.5 μm of stationary phase (5% diphenyl-95% dimethyl polysiloxane) was used for all the determinations. The column oven temperature was initially maintained at 180^oC for 1 min and programmed to increase at 10^oC min-1 to 225^oC then held for 10 mins, and ramped to 250^oC at 10^oC min-1 and held for 10 min. The injector and detector temperature were maintained at 250^oC and 325^oC respectively. Purified nitrogen gas (99.99% purity) was used as carrier gas with a flow rate of 1.0 ml/min.

Histopathology:

Some of the teased intestine sections were preserved in Bouin's fluid for histopathological studies; the tissues were later preserved in 10% phosphate buffer.

The tissues were cut and placed inside well labelled tissue embedding cassettes. They were then processed using an automatic tissue processor for 17-19 hours. The tissues were first fixed in 10% formal saline and were dehydrated in different ascending grades of dehydrating fluids (70% to absolute isopropyl alcohol) after which they were cleared in clearing agents (Xylene I and II) and impregnated in molten paraffin wax.

The tissues after being processed were embedded using an automatic embedding center and some sections of the tissue were cut using a microtome and placed in glass free slide which was then placed on a hot plate for 30 minutes in order for sections to adhere to the slides. The sections were later stained using the Haematoxylin and Eosin (H and E) staining method. The stained tissues were washed off in tap water, dehydrated using ascending grades of alcohol (70% alcohol- 95% alcohol- absolute alcohol) and cleared in xylene. The tissues were finally mounted using Di-n-butylphthalate in xylene (D.P.X) and dried. They were later examined under the microscope and their photomicrographs were taken.

Data Analysis:

The prevalence rate of parasitic helminths in fish species and protozoa were deduced by the formula:

$$\text{Parasite Prevalence} = \frac{\text{Number of infected individuals in the population}}{\text{Total No examined}} \times 100 \ \%$$

Analysis of variance (ANOVA), SPSS IBM, 20.0 was used to compare means of fish health parameters and the means of the pesticide congeners in

media (fish, water and sediment) of the lagoon ecosystem and Microsoft Excel, 2007, for graphs.

RESULTS

Morphometrics and Organosomatic indices of infected and Non-Infected *Sarotherodon melanotheron* in Lagos Lagoon:

The intestinal parasites found in *S. melanotheron* were a cestode *Wenyonia* sp.; protozoa; *Myxobolus* sp., *Myxosoma* sp., *Hexamita sp.* and Coccidian spores.(Table 1) The mean intensity of *Wenyonia* sp. was 0.29 with a standard deviation of 0.35 (p<0.01). Table 2 shows morphometrics and organosomatic indices of infected and non-infected individuals of *Sarotherodon melanotheron* in Lagos Lagoon.

The total length of infected *S.melanotheron* ranged from 10.11cm to 23.50cm with the mean±SD total length, 16.21±1.91, p<0.01, and mean±SD standard length, 15.00±2.61, p<0.01. The infected fish had greater weight, ranging from 15.00g to 160.00g with mean±SD, 62.50±30.50, p<0.01. The infected fish also had less liver weight with mean liver weight of 1.25±0.56, p<0.01, but greater egg weight of 2.45±1.90, p<0.01, hepatosomatic index, 2.16±1.97, p<0.01, and gonadosomatic index, 1.95±1.21, p<0.01.

Table 1: Prevalence of *Wenyonia* sp. infection in *Sarotherodon melanotheron* in Lagos Lagoon.

STATUS	MALE	FEMALE	TOTAL
Infected Individuals	18 (23.08%)	7 (16.67%)	25 (20.83%)
Non-Infected Individuals	60 (76.92%)	35 (83.33%)	95 (79.17%)
TOTAL	78 (65.00%)	42 (35.00%)	120 (100.00%)
Chi-Square X² (2) = 11.2, p<0.05.			

NA means Not Applicable, **Signifies p<0.01 and *Signifies p<0.05.

Table 1: Parasite Prevalence, Morphometrics and Organosoma-TIC Indices of infected and Non-Infected *Sarotherodon melanotheron* in Lagos Lagoon

PARAMETERS	NON-INFECTED FISH		INFECTED FISH	
	MEAN±SD	MIN – MAX	MEAN±SD	MIN – MAX
Total length (cm)	15.58±3.27**	9.50-22.00	16.21±1.91**	10.11-23.50
Standard length (cm)	14.17±3.09**	8.00-21.00	15.00±2.61**	9.51-20.00
Weight (g)	60.72±27.22**	12.00-150.00	62.50±30.50**	15.00-160.00
Stomach Content	0.46 ±0.27**	0.00-1.00	0.67±0.15**	0.00-1.00
Condition Factor	2.13±0.56**	0.27-3.00	2.25±0.30*	0.40-3.20
Egg Weight (g)	2.13±1.72**	0.60-8.90	2.45±1.90**	0.70-10.30
Liver Weight (g)	1.41±0.78*	0.20-4.40	1.25±0.56**	0.15-4.10
HSI	2.93±2.47**	0.30-14.67	2.16 ±1.97**	0.50-16.00
GSI	1.31±2.47**	0.00-13.25	1.95±1.21**	0.00-16.50
Parasite Intensity	NA	NA	0.29±0.35**	1.00-4.00

Mean Concentrations of Organochloride Congeners in Water, Sediment, Fish and The Parasites in Lagos Lagoon:

Out of the twelve congeners of organochloride pesticides (OCPs) analyzed in water, sediment, fish and parasites, five congeners were detected. Table 3-5 and figures 4-8 show the presence and concerntrations of OCPs in the three stations in the lagoon; Iddo,

High rise and Okobaba. At Iddo, the congeners detected in water and sediment media were; p,p'-DDT, endosulfan 1, heptachlor and aldrin, these were also detected in the high rise. The Okobaba had p,p'-DDT, endosulfan 1,dieldrin, heptachlor and aldrin in water, sediment, fish and parasites. Iddo station had the highest concentrations of DDT, Aldrin,

Dieldrin, and Heptachlor in the water and sediment.

The concentration of aldrin (Table 5) in water and sediment media in all the stations were bellow EPA limit, 1.3υl/l, Iddo (water, 0.059υl/l, sediment, 0.0121υl/l), High rise (water, 0.0005υl/l, sediment, 0.008υl/l), Okobaba (water, 0.006υl/l,, sediment, 0.0003υl/l). The sediment concentration of dieldrin in Iddo (0.056υl/l) exceeded EPA limit, (0.243υl/l). EPA limit for heptachlor is 0.053υl/l, all the stations were also below this limit, Iddo (water, 0.03υl/l, sediment, 0.04υl/l), High rise (water, 0.025υl/l, sediment, 0.026υl/l), Okobaba (water, 0.027υl/l, sediment, 0.024υl/l). All the stations exceeded EPA limit for endosulfan (0.034υl/l), Iddo (water, 0.04υl/l, sediment, 0.043υl/l), High rise (water, 0.000υl/l, sediment, 0.041υl/l), Okobaba (water, 0.041υl/l, sediment, 0.000υl/l).

Table 3: Mean concentrations of organochloride congeners in water, sediment, fish and the parasites in Lagos Lagoon.

Classes of OCPs	Congener	Iddo Station		High Rise Station		Okobaba Station		Fish	Para-SIte
		Water	Sediment	Water	Sediment	Water	Sediment		
Lindane	α- BHC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	β- BHC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	¥- BHC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	d- BHC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DDT	P,P'-DDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	P,P'-DDT	5.761	1.31	0.411	0.793	0.614	0.021	0.756	0.383
Cyclodiene	Endosulfan 1	0.040	0.043	0.00	0.041	0.039	0.00	0.005	0.001
	Aldrin	0.059	0.012	0.001	0.008	0.006	0.001	0.003	0.001
	Dieldrin	0.00	0.056	0.00	0.00	0.00	0.00	0.002	0.001
	Endrin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Heptachlor	0.03	0.04	0.025	0.026	0.027	0.024	0.016	0.001
	Heptachlor Epoxide	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

KEY: x – Absent, V – present

Table 4: Mean Concentrations of Organochlorine Pesticides in Water, Sediment, Fish and Parasites in the Lagos Lagoon.

| Classes of OCPs	Congener	Iddo Station		High Rise Station		Okobaba Station		Fish	Para-Site
		Water	Sediment	Water	Sediment	Water	Sediment		
Lindane	α- BHC	x	x	x	x	x	x	x	x
	β- BHC	x	x	x	x	x	x	x	x
	¥- BHC	x	x	x	x	x	x	x	x
	d- BHC	x	x	x	x	x	x	x	x
DDT	P,P'-DDE	x	x	x	x	x	x	x	x
	P,P'-DDT	V	V	V	V	V	V	V	V
Cyclodiene	Endosulfan 1	V	V	V	V	V	V	V	V
	Aldrin	V	V	V	V	V	V	V	V
	Dieldrin	x	x	x	x	x	V	V	V
	Endrin	x	x	x	x	x	x	x	x
	Heptachlor	V	V	V	V	V	V	V	V
	Heptachlor Epoxide	X	X	x	x	x	x	x	X
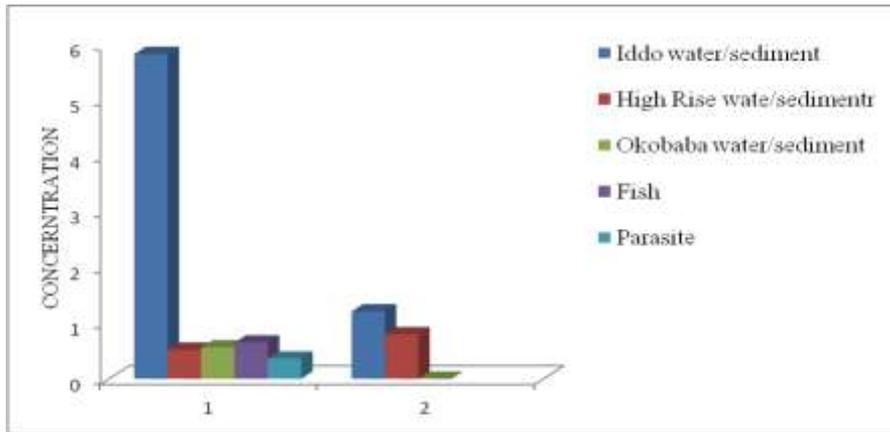
Fig. 4: The mean concentrations of ddt in the various compartments (Water, Sediment and Biota) in the Lagoon. 1 – Water medium, 2 – Sediment medium. The Concentration values are in the factor of 10^{-2} ppm
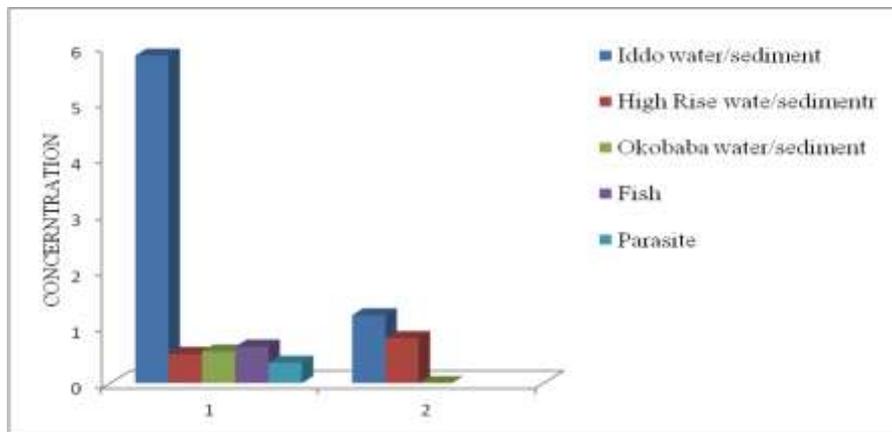

Fig. 5: shows the mean concentrations of endosulfan 1 in the various compartments (water, sediment and biota) in the lagoon 1 – water medium, 2 – sediment medium. the concentration values are in the factor of 10^{-2}ppm
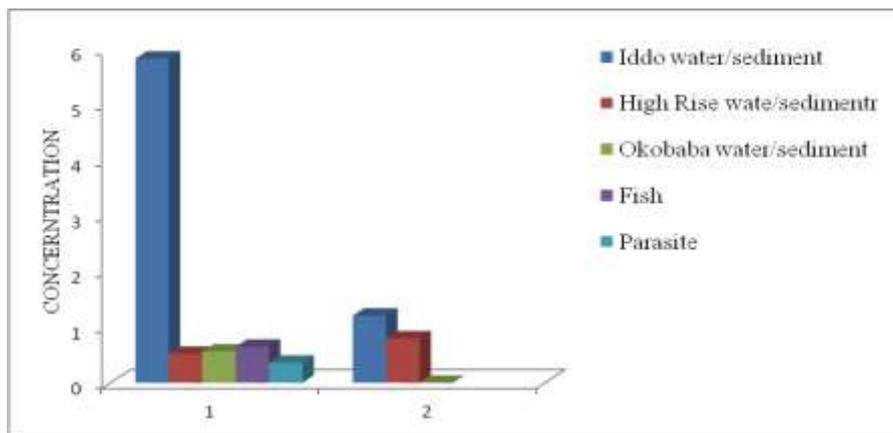

Fig. 6: Shows the mean concentrations of aldrin in the various compartments (water, sediment and biota) in the lagoon. 1 – water medium, 2 – sediment medium. The concentration values are in the factor of 10^{-2}ppm
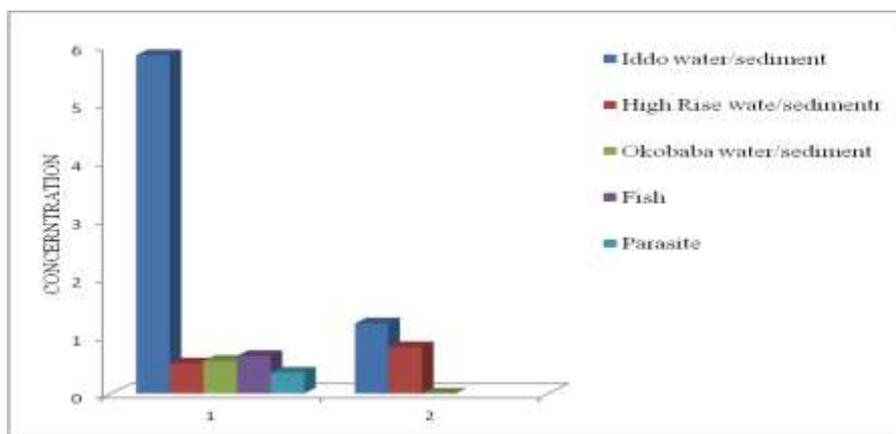
Fig. 7: Shows the mean concentrations of dieldrin in the various compartments (water, sediment and biota) in the lagoon. 1 – water medium, 2 – sediment medium. The concentration values are in the factor of 10^{-2}ppm
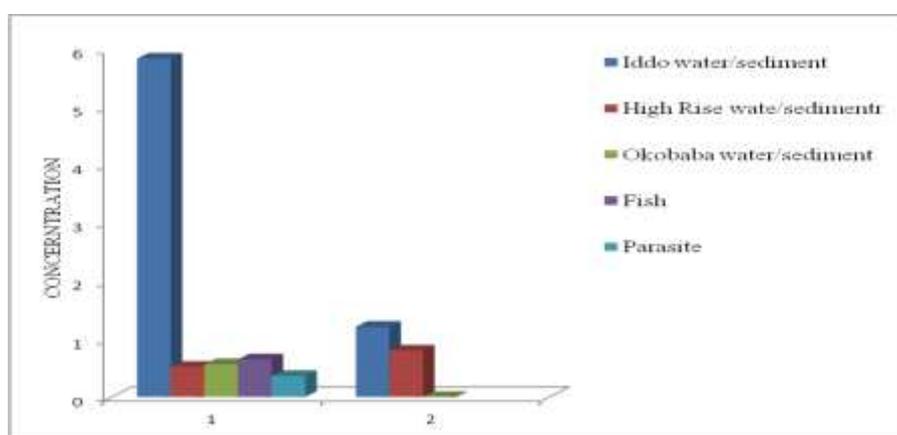

Fig. 8: Shows the mean concentrations of heptachlor in the various compartments (water, sediment and biota) in the lagoon. 1 – water medium, 2 – sediment medium. The concentration values are in the factor of 10^{-2}ppm

Parasite Prevalence, Intensity, and Mean Gut Pathological Alteration Index (GAI) in *Sarotherodon melanotheron* in Lagos Lagoon:

Table 5 shows the parasite prevalence and intensity in *Sarotherodon melanotheron* in Lagos lagoon. Coccidian spores were present in High rise with prevalence and intensity of 2.5% and 0.15 respectively but were absent in Okobaba and Iddo stations. *Myxosoma* sp. was the most widely spread infection in the fish, found in all stations with prevalence and intensity as; Okobaba, 5%, 0.05, Iddo, 10%, 0.25 and

High rise, 5%, 0.10 while *Hexamitasp was* found predominantly in Iddo station only with prevalence of 15% and intensity of 0.10. *Entameoba* sp. was only found in Okobaba station (2.5%, 0.05) likewise, *Myxobolussp* and *Hexamitasp* were only found in Iddo station. The mean gut pathological alterations (GAI) in the various stations estimated as follows; Okobaba GAI, 2.0, High rise GAI, 2.5, and Iddo GAI, 4.0. Iddo station had the highest GAI, showing high frequencies of several inflammations, and tissue necrosis as a result of greater multi-stress pressure.

Table 5: Parasite Prevalence, Intensity, and Mean Gut Pathological Alteration Index (GAI) in *Sarotherodon melanotheron* in Lagos lagoon

Parasite	Species	Total ocps and parasite prevalence/intensity		
		Okobaba	High Rise	Iddo
Protozoa	Coccidian Spores	NF	2.5%, 0.15	NF
	Myxosoma sp.	5%, 0.05	10%, 0.15	20%, 0.15
	Myxobolus sp.	NF	NF	10%, 0.25
	Hexamita sp.	NF	NF	15%, 0.10
	Entameoba sp.	2.5%, 0.05	NF	NF
Cestoda	*Wenyonia sp.*	NF	10%, 0.5	25%, 0.15
Mean Gut Pathological Alteration (GAI) Index		1.0	2.5	3.75

NF = non found

Parasite Prevalence, Water Organochloride Concentrations and Pearson Correlation Coefficient (r) in Lagos Lagoon;

Pearson correlation was used to show the relationship between OCPs concentration in the water medium with parasite prevalence in the various stations in the lagoon. Table 6 shows the correlation coefficient (r) of the various OCPs congeners (p,p' DDT, endosulfan 1, aldrin, heptachlor, total OCP) with parasite prevalence in the lagoon. *Myxosoma* sp showed positive correlation (r = 0.315, p<0.05) with DDT and heptachlor (r = 0.301, p<0.05) but its correlation coefficient was not significant for endosulfan 1, aldrin and total OCPs. None of the intestinal helminth parasite infection correlates significantly with any of the OCPs congeners in the lagoon.

Table 6: Parasite prevalence, water organochloride concentrations and pearson correlation coefficient (r) in Lagos Lagoon

Parasite	Species	Prevalence/correlation coefficient (R)				
		P,p"-ddt	Endosulfan	Aldrin	Heptachlor	Total ocp
Protozoa	Coccidian Spores	0.010	0.116	0.104	0.059	0.150
	Myxosoma sp	0.351*	0.115	0.011	0.301*	0.021
	Myxobolus sp	0.110	0.018	0.121	0.112	0.114
	Entameoba sp	0.073	0.095	0.143	0.012	0.118
	Hexamita sp	0.009	0.098	0.149	0.124	0.092
Cestoda	*Wenyonia* sp	0.112	0.092	0.141	0.129	0.014

**Signifies p<0.001 and *Signifies p<0.005.

Histopathological Alteration in *Sarotherodon melanotheron* in the Lagoon:

Figures 9 shows the histopathological alterations in the intestines of *Sarotherodon melanotheron* in the lagoon. Each alteration was scored and graded based on the degree of alteration according to Adams *et al.,* (1993). Normal epithelial mucosa, submucosa, muscularis and serosa and well preserved intestinal villi got a GAI score of 0 to 1 scale. Presence of debris in the lumen got a GAI Score of 2. Presences of trophozoites or any parasites in the lumen of the intestine and moderate degeneration of the epithelial layer of the mucosa with stunting of the villi got a GAI Score of 3. Severe degeneration of the epithelial layer of the mucosa with severe stunting of the villi got a GAI Score of 4. Necrosis of the villi and other areas along the intestinal lumen got a GAI Score of 5.
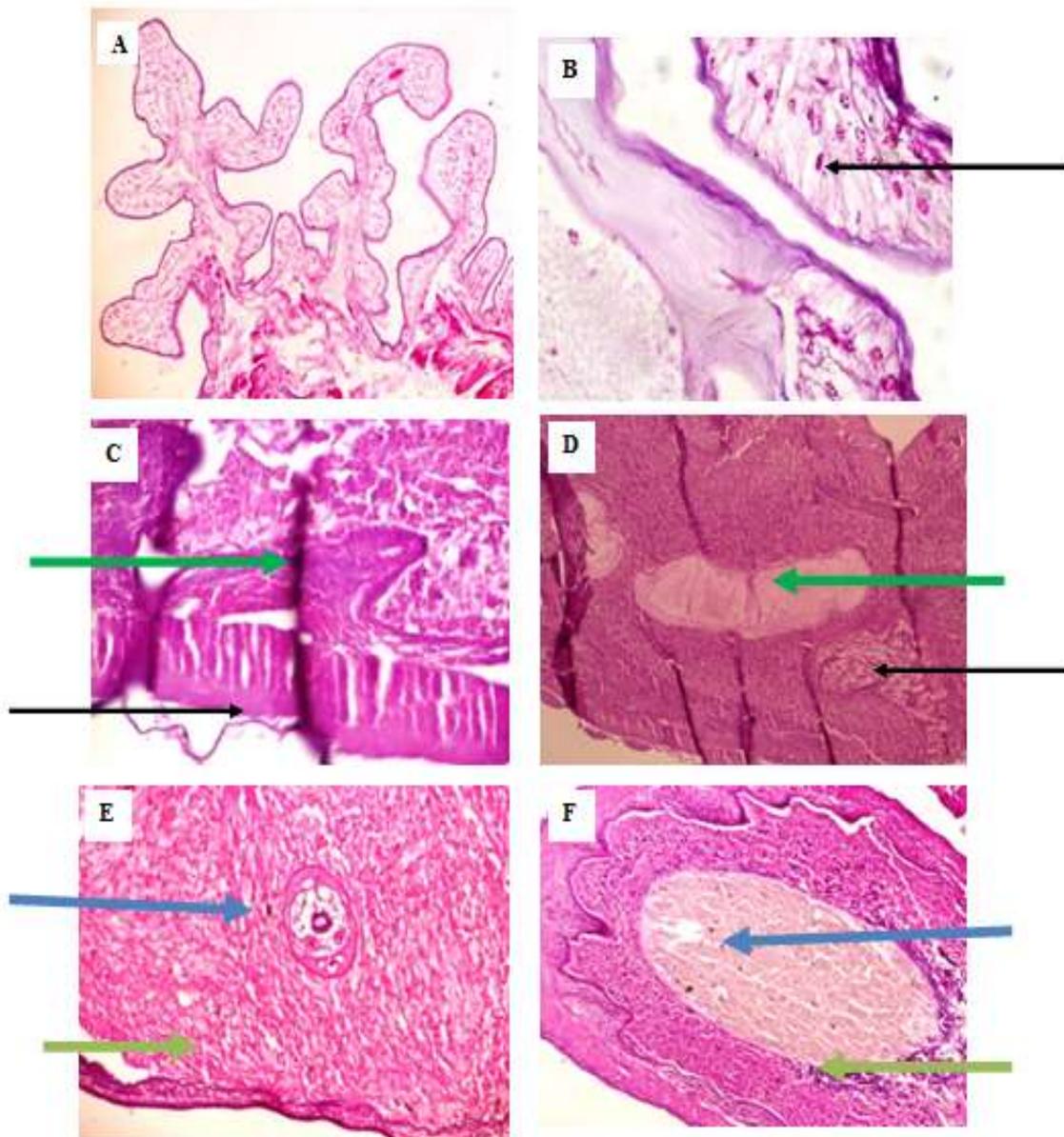
Plate A: Normal epithelial mucosa, submucosa, muscularis and serosa. The intestinal villi are well preserved. GAI score of 0 to 1 scale.

Plate B: Focal area of necrosis (arrow) of the villi. The intestinal villi are well preserved. GAI score of 5.0.

Plate C: Moderate degeneration of the epithelial layer of the mucosa with stunting (thin arrow) of the villi (GAI Score of 3).

Plate D: Presence of cellular debris (green arrow) in the lumen (GAI Score of 2). normal villi structure (thin arrow) (GAI Score of 0) and presence of cellular derris (green arrow) in the lumen (GAI Score of 2).

The surface epithelial were moderately preserved (GAI Score of 1).

Plate E: There were presences of trophozoites in the lumen of the intestine (blue arrow) (GAI Score of 3).

Plate F: Presence of debris (green arrow) in the lumen (GAI Score of 2).

DISCUSSION

In this study, the prevalence of intestinal helminth infection in *Sarotheron melanotheron* was 20.83%. Twenty-five individuals were infected with parasitic cestode *Wenyonia sp* (20.83%, Chi-Square, $X^2 = 11.2$, $p<0.05$), out of which 18 (15.00%) were males and 7 (5.83%) were females. The higher prevalence of intestinal helminth parasites in the present study could be ascribed to different factors which include absence of proper waste disposal and management system in which waste is dumped along the coastal areas of the lagoon; traditional ways of fishing which damaged the phytoplankton or zooplankton of the lagoon (feed/weed) that enhanced competition for feed; the use of small sized fish nets which trapped the fingerlings and juveniles; environmental pollutions and other stressors caused from the surrounding anthropogenic activities along the shores (Amadi et al, 1991; Amaeze, 2009).

However, the overall prevalence of intestinal parasites in the present study was lower when compared to the findings of Olofintoye (1996), who reported 60.23% prevalence of intestinal parasite in Tilapia. This suggests that the distribution of parasites can be varied from one habitat to the other due to host parasite relationship, abiotic factors like dissolved oxygen, temperature and pH. Holden and Reed (1972) reported a slight difference from what was observed, as compared to the above mentioned researcher's findings. There was a higher prevalence in smallest sized and juvenile fishes in this study. This may be due to the random selection of the specimens and to probable high level of immunity built up in the older and bigger fish specimens as explained by Akinsanya *et al.* (2008). The distribution of the parasites in the gut of the fishes could be due to the physiochemical factors operating in the gut, such as nutritional level, pH, osmotic tension and oxygen tension (Allumma and Idowu, 2011).

In fish, the factor of condition (K) reflects, through its variations, information on the physiological state of the fish in relation to its welfare. From a nutritional point of view, there is the accumulation of fat and gonad development (Le Cren, 1951). From a reproductive point of view, the highest K values are reached in some species (Angelescu *et al.*, 1958). K also gives information when comparing two populations living in certain feeding, density, climate and other conditions; when determining the period of gonadal maturation and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Bagenal and Tesch, 1978). There was a significant difference ($P<0.05$) in the mean condition factor of both infected and non-infected specimen of *S. melanotheron*.

The total length of infected *S. melanotheron* ranged 10.11cm to 23.50cm with mean±SD total length, 16.21±1.91, $p<0.01$, and mean±SD standard length, 15.00±2.61, $p<0.01$. The infected fish had greater weight; weight ranged 15.00g to 160.00g with mean±SD 62.50±30.50, $p<0.01$. The infected fish also had less liver weight; liver weight, 1.25±0.56, $p<0.01$, but greater egg weight, 2.45±1.90, $p<0.01$, hepatosomatic index, 2.16±1.97, $p<0.01$, and gonadosomatic index, 1.95±1.21, $p<0.01$, $p<0.01$.

Biotic and abiotic environmental conditions have the significant influence on condition factor and can be used to assess the status (that is, the ability of the water body to sustain life) of the aquatic ecosystem in which fish live (Ukwa, 2012). The low mean condition factors observed in the non-infected specimens might be as a result of pollution in the environment and/or the absence of helminth parasites residing in the host.

The high mean condition factors in the infected fish specimen indicate parasitism between parasites and host and it also indicates that the fish has a strong immune system. Parasites depend on host-derived energy for growth and development. Each organism has a limited amount of energy which is allocated to different fundamental functions (i.e. maintenance including immune defense, reproduction and growth) in accordance with current needs. The activation of the immune system is energetically costly (Dezfuli, 2003). Therefore, trade-offs are expected to occur as hosts infected by parasites should invest energy into immune responses, at the expense of other physiological tasks (Dezfuli, 2003). However, optimum host defense is governed by a parasite-mediated allocation trade-off between growth and immune function (Marcogliese and Cone, 1997). Owing to the fact that they depend on host-derived energy for growth and development, parasites are potentially affected by the host's ability to acquire nutrients under competitive foraging scenarios.

Although parasites might be expected to grow faster in hosts that are better at acquiring nutrients from natural ecosystems, it is also possible that the most competitive hosts are better at countering infections, if they have an improved immune response or are able to limit the availability of nutrients to parasites. This might explain the low mean condition factor found in some non-infected and infected fish specimen in this study. It is possible that under competitive foraging situations, infections have opposite effects on the nutrient intake of the best and worst competitors; previously poor competitors may become more competitive, but the best competitors may fail to maintain dominant feeding positions because of the debilitating effects of infection. The combined effects of increased motivation and reduced ability associated with infection may therefore have the effect of standardising the competitive ability of previously good and poor competitors. The factors controlling the growth of helminth parasites in their hosts are of current interest. . Marcogliese and Cone (1997) suggest that the size attained by larval cestodes may reflect either host-imposed resource constraints on growth, or arise as a result of evolved life history strategies.

Organochlorine pesticides (OCPs) are synthetic organochlorines which are lipophilic and hydrophobic. Their lipophilicity, hydrophobicity, stability to photooxidation, low vapour pressure, and low chemical and biological degradation rates have led to their accumulation in biological tissues and the subsequent magnification of concentrations in organisms, progressing through the food chain (Helberg *et al.*, 2005). In this study, twelve congeners of organochloride pesticides (OCPs) analyzed in water, sediment, fish and parasites, out of which five congeners were detected. At Iddo station, the congeners detected in water and sediment media were; p,p'-DDT, endosulfan 1, heptachlor and aldrin; these were also detected in the high rise station. The Okobaba had p,p'-DDT, endosulfan 1,dieldrin, heptachlor and aldrin in water, sediment, fish and parasites. Iddo station had the highest concentrations of DDT, Aldrin, Dieldrin, and Heptachlor in the water and sediment.

Organochlorines are persistent organic pollutants (POPs) and have caused worldwide concern as toxic environmental contaminants (Covacia *et al*., 2005). They can be recycled through food chains and produce a significant magnification of the original concentration at the end of the chain (Doong *et al.*, 2002). They are resistant to natural breakdown processes, extremely stable, persistent, highly toxic and bioaccumulation in the fatty tissues

of animals and humans (Forget *et al.*, 2001).

Bioindicators are species that reflect environmental impact because they respond to habitat alterations with changes in physiology or chemical composition. The intestinal parasites found in *S. melanotheron* were cestode *Wenyonia* sp.; and protozoa *Myxobolus sp.*, Coccidian spores, *Myxosoma* sp*., and Hexamita* sp*.* Some protozoan parasites of *S. melanotheron* have shown qualities of bioindicators from this study.

Coccidian spores were present in High rise with prevalence and intensity of 2.5% and 0.15, respectively, but were absent in Okobaba and Iddo stations. *Myxosoma* sp. was the most widely spread infection in the fish, found in all stations with prevalence and intensity as; Okobaba, 5%, 0.05 Iddo, 10%, 0.25 and High rise, 5%, 0.10 while *Hexamita* sp. *was* found predominantly in Iddo station only with prevalence of 15% and intensity of 0.10. *Entameoba* sp. was only found in Okobaba station (2.5%, 0.05) likewise, *Myxobolus* sp. and *Hexamita* sp. were only found in Iddo station.

Iddo station had the highest parasite prevalence and concentrations of DDT, Aldrin, Dieldrin, and Heptachlor in the water and sediment. Several examples show the usefulness of parasite prevalence and intensity as a bioindicator of the impact and recovery of habitats (Valtonen, 1997). During a Finnish lake survey, parasite abundance in lakes that were highly polluted with pulp and paper effluents (PPE) was lower than in lakes with lower PPE levels (Valtonen, 1997). After environmental conditions in the lakes improved, parasites returned to levels similar to those in less polluted lakes. New found land study, by contrast, showed that the numbers of *Cryptocotyle lingua* metacercariae infecting winter flounders were increased in the most polluted localities versus control sites (Khan, 2004). Therefore,

different types and degrees of environmental impacts can produce different physiological or numerical responses of both hosts and parasites, this can be identified in three studies (Marcogliese *et al*., 1998; Akinsanya et al, 2008; Saliu et al, 2014) that included both fieldwork and laboratory bioassays.

Parasites, contaminants and other environmental factors have caused changes in the fish's mechanism and compromised its immune system leading disease state and varying degree of pathological alterations. In this study, the mean gut pathological alterations (GAI) in the various stations estimated as follows; Okobaba GAI, 2.0, High rise GAI, 2.5, and Iddo GAI, 4.0. Iddo station had the highest GAI, showing high frequencies of several inflammations, and tissue necrosis as a result of greater multi-stress pressure.

Bioindicators are species that reflect environmental impact because they respond to habitat alterations with changes in physiology or chemical composition. The intestinal parasites found in S.*melanotheron* was cestode; *Wenyoniasp*, protozoa;*Myxobolus sp.* Coccidian spores, *Myxosomasp,* and *Hexamita sp.* Some protozoa parasites of *Sarotherodonmelanotheron* have shown qualities of bioindicators from the study. *Myxosoma*sp showed positive correlation (r = 0.315, p<0.05) with DDT and heptachlor (r = 0.301, p<0.05) but its correlation coefficient was not significant for endosulfan 1, aldrin and total OCPs. None of the intestinal helminth parasite infection correlates significantly with any of the OCPs congeners in the lagoon. Iddo station had the highest parasite prevalence and concentrations of DDT, Aldrin, Dieldrin, and Heptachlor in the water and sediment. It also had the highest GAI, showing high frequencies of several inflammations, and tissue necrosis as a result of greater multi-stress pressure. I hereby recommend for the design of future studies to evaluate the

anthropogenic impact on host–parasite interactions and increase the efficiency of environmental monitoring programs.

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