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Condition factor and gastrointestinal parasitic fauna of three fish species as stress indicators in lekki lagoon, Lagos, Nigeria.

Akinsanya Bamidele; Kuton Minasu Pentho , Saliu Joseph Kayode , Oyebola Lambe , and Ukwa Uche David
Department of Zoology, University of Lagos, Nigeria.

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ABSTRACT

Host condition factor and Gastrointestinal protozoa and helminth parasites in *Synodontis clarias, Synodontis filamentosus* and *Chrysichthys nigrodigitatus* in Lekki lagoon, Lagos, Nigeria were investigated from September, 2014 to February, 2015. Eighty specimens each of both *Synodontis clarias* and *Chrysichthys nigrodigitatus* and fifty of *Synodontis filamentosus* were examined from Lekki lagoon and dissected for parasitological investigation The. Condition factors of all individual fishes were determined. Median condition (K < 1.41 and K > 1.41) for *Synodontis clarias,* (K < 2.14 and K > 2.14) for *Synodontis filamentosus* and (K < 1.49 and K > 1.49) for *Chrysichthys nigrodigitatus* were used in grouping the individuals. Heterogeneous infection of intestinal protozoa in *C. nigrodigitatus* were greater among the low condition individuals; 0.18 compared to high condition individuals with 0.10. This also aplies to *S. clarias,* low condition individuals; 0.28, while high condition individuals had infection rate of 0.13. *S. filamentosus* showed a different trend, the rate of infection were greater among the high condition individuals; 0.15, compared to low condition of 0.10. The rate of infection of parasitic helminths in *C. nigrodigitatus, S. clarias* and *S. filamentosus* were higher among low condition individuals compared to high condition individuals. High condition individuals of the fish species harbor more parasites than low condition individuals. Infected individuals of low condition factor (K < 1.49) of *C. nigrodigitatus* had a greater histopathological alteration index (HAI, 12.0) compared to the high condition individuals (HAI, 6.0). These individuals had from mild to severe ulceration of the mucosa and congestion of the blood vessels. In infected individuals of low condition factor (K < 1.41), (K < 2.14) of *S. clarias* and *S . filamentosus*, there were mucosal edema and haemorrhage in their intestinal walls. They also had greater histopathological alteration index (HAI, 24.0), (HAI, 18.0) compared to the high condition individuals (HAI, 10.0) and (HAI, 4.0) respectively. These low condition infected individuals in the population are multi-stressed and have showed significant pathological responses in their tissues.

INTRODUCTION

Fish is an important dietary element and one of the few sources of animal protein available to many Nigerians and as a vector of some human disease pathogens. Fishing is carried on in Nigerian rivers, creeks, lagoons and in Lake Chad.

One of the scientific importance of identifying a fish properly is to tell to some reliable extent the health condition of the fish, and certain parasitic infections present with some symptoms that bear on the external treatment of the fish. The well-being of fish and their population in general can be determined by analyses of condition factor (Schmitt and Dethloff 2000).

Condition factor is a measure of energetics, nutritional status and viability of a host. Fishes are hosts to taxonomically diverse parasites, and infections can significantly affect fish behaviour, metabolism, body condition, fecundity or survival (Dobson *et al*., 2008; Lafferty, 2008; Sepp¨anen *et al*., 2009). The composition of the parasite fauna is a product of interactions of biotic and abiotic factors of the environment. For parasites to maintain their populations, all parasites need is to eventually reproduce and infect new hosts. Therefore, one factor that may be contributing to the lower rate of infection of intestinal parasites in the exposed water body could be a lower density of host populations. Host density is especially critical since the free-living transmission stage of some parasites is relatively short-lived (i.e. a matter of hours) (Mackenzie *et al*., 1995).

There are times when changes in the environment (natural or anthropogenic) can change the state of balance of the parasite between host and nature, thus resulting in disease. These changes can be environmental such as temperature, climate, or anthropogenic such as pollution and urbanization (Lafferty and Kuris 1999). When the dynamic equilibrium between host and parasite is lost, some changes can occur within the host. These changes can cause mechanical damage (fusion of gill lamellae, tissue replacement), physiological damage (cell proliferation, immunomodulation, altered growth, detrimental behavioral responses,) and/or reproductive damage (Buchman and Lindstrøm 2002, Knudsen *et al*. 2009, Al-Jahdali and Hassanine 2010). All fish species are vulnerable to various parasitic infections depending on the species and the type of stream inhabited (Edema, 2008). Microparasite such as Myxosporidea is a class of protozoa which parasitize invertebrates and lower vertebrates particularly fish, often fatal consequences for the host (Bassey, 2011). They are made from many cells during sporulation. Infections by *Myxobolus, Thelohanellus* and *Henneguya* occur in both East African and West African waters. They are apparently host specific and as widespread as their respective host. Infections of Cichlids from Africa as thus been reported. Endoparasitic infections normally give an indication of the quality of the water since this infections increase in more polluted waters (Poulin, 1992; Avenant – Oldewage 2001). The roles, functions, and life-styles of parasites help to characterize an ecosystem. Parasitism is increasingly recognized as playing an important role in structuring animal communities (Marcogliese, 2004).

MATERIALS AND METHOD

Study Area

Lekki Lagoon supports a major fishery in Nigeria. The lagoon is located in Lagos State Nigeria and lies between longitudes 4 00’ and 4 15’E and between latitudes 6 25’ and 6 37’ N. It has a surface area of about 247km2 with a maximum depth of 6.4m; a greater part of the lagoon is shallow and less than 3.0m deep. The Lekki lagoon is part of an intricate system of waterways made up of lagoons and creeks that are found along the coast of south-western Nigeria from the Dahomey border to the Niger Delta stretching over a distance of about 200km. It is fed by the River Oshun and Saga discharging into north-western parts of the lagoon.

Lekki lagoon experiences both dry and rainy seasons typical of the southern part of Nigeria. The vegetation around the lagoon is characterized by shrub and *raphia* palms, *Raphia sudanica* and oil palms, *Elais* *guinensis*. Floating grass occur on the periphery of the lagoon while coconut palms *Cocos nucifera* are widespread in the surrounding villages. The rich fish fauna of the lagoon includes *Heterotis niloticus, Gymnarchus niloticus, Clarias gariepinus, Malapterurus electricus, Synodontis clarias, Chrysichthys nigrodigitatus, Parachanna obscura, Mormyrus rume, Calabaricus calamoichthys, Tilapia zillii, Tilapia galilaeus, Hemichromis fasciatus* and *Sarotherodon melanotheron*. Fig. 1 shows map of Lekki lagoon, Lagos, Nigeria

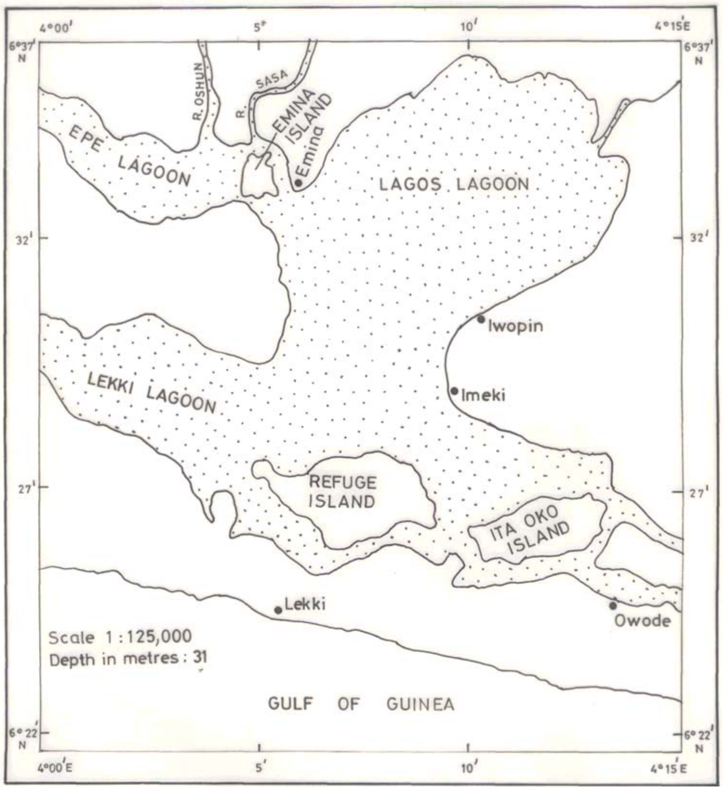

Fig. 1: Map of Lekki Lagoon, Lagos Nigeria

Field Sampling

Eighty individuals each of *Synodontis clarias*, and *Chrisichthys nigrodigitatus* and fifty individuals of *Synodontis filamentosus* (n =210*)* were obtained from fisherman at the lagoon and dissected for intestinal parasites. Sexes were identified and the sex ratio, parasite prevalence, load, intensity, and Fulton Condition Factor (K) were estimated using the formulae below;

Sex Ratio = No of Male individuals / No of Female individuals

Examination of intestines for Parasite Recovery

The intestines of the fish hosts collected from the lagoons was examined for the presence of parasites. The Fishes were examined for protozoan parasites using the techniques suggested by Markevich (1951). The fraction of the teased intestine were collected in EDTA bottles and preserved in Bouin's fluid for histopathological analysis. The intestines were also examined for helminth parasites. The recovered parasites were preserved in 70% alcohol. The recovered helminth parasites were sorted out into various groups using standard parasitological guidelines. They were counted and recorded. Samples of the parasites were transferred to vials thoroughly sealed and labelled appropriately for detailed identification. Prevalence, mean intensity and abundance was calculated using the formulae;

$$\text{Prevalence (\%)} = \frac{\text{Number of infected fish} \times 100}{\text{Total number of fish examined}}$$

$$\text{Percentage load} = \frac{\text{Number of collected parasites} \times 100}{\text{Number of fish examined}}$$

Condition Factor

The condition factor also known as the Ponderal index or the Fulton Coefficient of condition was computed using the formula described by Worthington and Ricardo (1936)

$$K=\frac{100W}{L^b} \quad \text{(Le Cren, 1951)}$$

b =Value obtained from the growth exponent in the length

W=Total weight of fish (g)

L= Standard length (cm)

K=Condition factor

Condition factor (K) was used as a base for grouping individuals into low condition status and high condition status (Carlander, 1969, Friedmann *et al*, 2002, Amber *et al*, 2007, Goede and Barton, 1990). Median Condition factor was calculated using Ranking cases; order of magnitude of condition factors of 80 individuals of *Synodontis clarias and Chrysichthys nigrodigitatus* in the sample 50^{th} percentile, median condition ($K < 1.14$ and $K > 1.14$) and ($K < 1.49$ and K > 1`.49) respectively and ($K < 2.14$ and $K > 2.14$) for *Synodontis filamentosus.* Individuals with Condition factor less than 1.14, 1.49 or 2.14 were grouped into low condition status while individuals with Condition factor greater than 1.14, 1.49 or 2.14 were grouped into high condition status.

Histopathological Technique

Fish tissues were fixed in Bouins's fluid for six hours and transferred to 10% phosphate buffered formalin. The dehydration of the tissues took place in increasing concentrations of alcohol (70%, 95% and then twice in absolute alcohol at 30 minutes duration). Tissues were impregnated in molten paraffin wax three times and later embedded in molten paraffin wax and allowed to solidify. The blocked tissues were sectioned at 4 – 5 microns, floated into a pre-coated slides and dried. The sections were stained using Haematoxylin and eosin stains. The stained tissues were washed off in tap water and the over-stained ones destained in 1% acid alcohol. The tissues were mounted, using DPX mountant dried and examined under the microscope. Photomicrographs were taken in the pathology laboratory of the Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Ibadan.

Statistical Analysis

Analysis of variance (ANOVA) SSPS, IBM 20.0 Version was used to compare means of morphometrics values, weight and condition factor of the fish species of the lagoon ecosystem. Pearson Chi-Square, Correlation and Regression analysis were also used

RESULT

Prevalence of Intestinal Helminth Parasites of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Table 1 shows prevalence of intestinal helminthes of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos. The rate of infection among the fish species were; *Chrysichthys nigrodigitatus* 16.25%, *Synodontis filamentosus* (40.00%), and *Synodontis clarias* (30.00%). Within sexes, male individuals of *Synodontis clarias* and *Synodontis filamentosus* had greater prevalence; 32.20% and 40.91% compared to the females, 23.81% and 33.33% respectively. In *Chrysichthys nigrodigitatus,* female individuals had the higher prevalence; 23.07% compared to males, 16.25%.

Table 1: Prevalence of Intestinal Helminth Parasites of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

	Sex	Infected	Non-infected	Total (% Prevalence)
Synodontis clarias	Male	19	40	59 (32.20)
	Female	5	16	21 (23.81)
	Both	24	56	80 (30.00)
	Chi-Square = 0.198			
Synodontis filamentosus	Male	18	26	44 (40.91)
	Female	2	4	6 (33.33)
	Both	20	30	50 (40.00)
	Chi-Square = 0.199			
Chrysichthys nigrodigitatus	Male	10	57	67 (14.92)
	Female	3	10	13 (23.07)
	Both	13	67	80 (16.25)
	Chi-Square = 0.189			

Condition factor and morphometrics of *Chrisichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Table 2 shows the condition factor and morphometrics data of *Chrisichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos. In *Chrysichthys nigrodigitatus*, the low condition individuals had a mean±standard deviation condition factor of 1.33±0.16, p < 0.01, less weight; 87.64±63.98 (g), p < 0.01, but much greater size; 18.04±4.08 (cm), p < 0.01, compared to the high condition individuals; Condition factor, 1.82±0.24, p < 0.01, weight, 107.21±82.96 (g), length, 17.26±3.70 (cm). The weight of these individuals strongly correlates with their length, (R = 0.952, p < 0.01 0.947, p < 0.01). The trend of a low condition individuals having greater sizes than high condition individuals was the same in *Synodontis filamentosus and Synodontis clarias. Synodontis filamentosus*; low Condition individuals, 1.87±0.27, p < 0.01; weight, 67.69±10.14 (g), p < 0.01, length, 15.38±0.77 (cm), p < 0.01, (R = 0.421, p < 0.01), high condition individuals, 2.41±0.21, p < 0.01; weight, 82.44±14.22 (g), length, 15.04±0.90 (cm) , (R = 0.889, p < 0.01), *Synodontis clarias;* low Condition individuals, 1.60±0.23, p < 0.01; weight, 50.80±6.77 (g), p < 0.01, length, 14.73±0.95 (cm), p < 0.01, (R = 0.609, p < 0.01), high condition individuals, 2.28±0.30, p < 0.01; weight, 53.35±7.98 (g), length, 13.28±0.80 (cm) , (R = 0.735, p < 0.01),

Table 2: Condition factor and Morphometrics of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Fish Species	mK	Condition factor	Weight (g)	Length (cm)	R
C. nigrodigitatus	K < 1.49	1.33±0.16**	87.64±63.98**	18.04±4.08**	0.952**
	K > 1.49	1.82±0.24**	107.21±82.96**	17.26±3.70**	0.947**
S. clarias	K < 1.41	1.60±0.23**	50.80±6.77**	14.73±0.95**	0.609**
	K > 1.41	2.28±0.31**	53.35±7.98**	13.28±0.80**	0.735**
	K > 2.14	1.87±0.27**	67.69±10.14**	15.38±0.77**	0.421**
S. filamentosus	K < 2.14	2.41±0.21**	82.44±14.22**	15.04±0.90**	0.889**
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

R means correlation coeficient
mK means median condition

Prevalence of Parasitic infection based on Host Condition factor of *Chrysichthys nigrodigitatus, Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Table 3 shows the prevalence of parasitic infection based on host condition factor in Lekki lagoon. Protozoa infection in the gut includes; Myxosporidia and

Coccidians. Heterogeneous infection of these protozoa in *C. nigrodigitatus* were greater among the low condition individuals; 0.18 compared to high condition individuals with 0.10. This is appliied to *S. clarias,* low condition individuals; 0.28, high condition individuals had infection rate of 0.13. *S. filamentosus* showed a different trend, the rate of infection were greater among the high condition individuals; 0.15, compared to low condition; 0.10. Crustacean copepods were not found in *C. nigrodigitatus* but were found in *S. clarias,* (low condition; 0.08, high condition; 0.05), *S. filamentosus, (*low condition; 0.10, high condition; 0.15) (Table 4). The rate of infection parasitic helminths in *C. nigrodigitatus* was higher among low condition individuals, 0.20, compared high condition individuals, 0.15. The same goes for *S. clarias* (low condition; 0.35, high condition; 0.10) and *S. filamentosus,* (low condition, 0.52, high condition, 0.26). High condition individuals of *C. nigrodigitatus* harbor more intestinal helminth parasites (0.35) than low condition individuals. The same goes for *S. clarias* (low condition; 0.15, high condition; 0.32) and *S. filamentosus,* (low condition, 0.10, high condition, 0.23).

Table 3: Prevalence of Parasitic infection based on Host Condition factor of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Fish Species	mK	Protozoa	Crustacean Copepod	Helminths	Helminth Intensity
	K < 1.49	0.18	0.00	0.20	0.20
C. nigrodigitatus	K > 1.49	0.10	0.00	0.15	0.35
S. clarias	K < 1.41	0.28	0.08	0.35	0.15
	K > 1.41	0.13	0.05	0.10	0.32
	K > 2.14	0. 10	0.10	0.52	0.10
S. filamentosus	K < 2.14	0.15	0.15	0.26	0.23

Parasitic fauna of the three fish species

Table 4: Protozoa and Helminth Parasites from the intestine of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

Parasites	Class	Parasite Species	Fish Host
Protozoa	Myxosporidia	*Myxobolus spp* Myxosporidial cysts	*C. nigrodigitatus* *S. clarias, S. filamentosus*
	Coccidia	Coccidia spores	*S. clarias* *S. filamentosus*
Helminths	Cestodes	*Wenyonia spp* *Wenyonia minuta* *Caryophyllaeus spp*	*S. clarias* *S. filamentosus*
		Stocksia spp	*S. filamentosus*
		Monobothriodes woodlandi *Breviscolex orientalis*	*S. clarias* *S. filamentosus*
	Trematodes	*Siphodera ghanensis*	*Chrysichthys nigrodigitatus*
	Nematodes	*Cucullanus spp* *Procamallanus* spp	*S.filamentosus*

Histopathological Alteration Index (HAI) showing degree of changes in the Intestines of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in Lekki lagoon, Lagos.

The microscopic study of the intestines of the recovered helminth parasites revealed different pathological effects. Plates 1 – 6 show the histopathological sections of the fish host intestines. Infected individuals of low condition factor (K < 1.49) of *Chrysichthys nigrodigitatus* had a greater histopathological alteration index (HAI, 12.0) compared to the high condition individuals (HAI, 6.0). (Table 5) These individuals had from mild to severe ulceration of the mucosa and congestion of the blood vessels. In infected individuals of low condition factor (K < 1.41), (K < 2.14) of *Synodontis clarias* and *Synodontis filamentotus*, there were mucosal edema and haemorrhage in their intestinal walls. They also had greater histopathological alteration index (HAI, 24.0), (HAI, 18.0) compared to the high condition individuals (HAI, 10.0) and (HAI, 4.0) respectively.

Table 5: Histopathological Alteration Index (HAI) showing degree of changes in the Intestines of *Chrysichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias* in the Lekki lagoon.

Fish Host	Number	Condition factor	Summation of HAI					
			1	2	3	4	5	ΣX
Chrysichthys nigrodigitatus	5	K < 1.49	0.0	4.0	4.0	2.0	2.0	12.0
		K > 1.49	0.0	2.0	2.0	0.0	2.0	6.0
Synodontis clarias	5	K < 1.41	2.0	6.0	4.0	6.0	6.0	24.0
		K < 1.41	2.0	0.0	2.0	2.0	4.0	10.0
Synodontis filamentosus	5	K < 2.14	6.0	2.0	4.0	2.0	4.0	18.0
		K < 2.14	2.0	0.0	0.0	2.0	0.0	4.0

DISCUSSION AND CONCLUSION

Most of the commonly encountered fish parasites are protozoans. With practice, these can be among the easiest to identify, and are usually among the easiest to control. Protozoans are single-celled organisms, many of which are free-living in the aquatic environment. Typically, no intermediate host is required for the parasite to reproduce (direct life cycle). Consequently, they can build up to very high numbers when fish are crowded causing weight loss, debilitation, and mortality. Four groups of protozoans were identified in this study: flagellates, myxosporidia, and coccidians. Among African fish, infection by Eimerine coccidia has so far been demonstrated in cichlid fish, in *Clarias gariepinus* and in eel (*Anguilla mossambica*) investigated. In this study, coccidia, as shown in plate 6, infect *Synodontis clarias* and *Synodontis filamentosus.* Individuals with low condition were found susceptible to the infection. Heterogeneous infection of these protozoa in *C. nigrodigitatus* was greater among the low condition individuals; 0.18 compared to high condition individuals with 0.10. This also implies to *S. clarias,* low condition individuals; 0.28, high condition individuals had infection rate of 0.13. The taxonomic relationships (at the generic and species levels) between parasites found in different hosts are still unresolved.

Myxosporidian cysts were diagnosed by microscopic examination of their contents for the presence of the typical spores. Such spores are characterised by the presence of the typical one to four polar capsules which contains a spiral filament. The life-cycle of most histozoic species of myxosporidia including all African species has not been determined experimentally because of the difficulties in establishing infection by feeding spores or infected tissues to susceptible fish. Spores are released from cyst before they can become infective, require prolonged ageing under specific conditions which for most species remain still undetermined. Myxosporidian cysts in the tissues do not provoke any inflammatory reaction or necrosis even when cysts cause pressure or considerably displace the host tissue. Some muscular atrophy, however, has been reported around sub-cutaneous nodules of Myxobolus in Cyprinids. Cysts in the gut may induce metaplastic proliferation of the infected host tissue and become infilterated by capillary network. In this study, there was detachment of villi from the mucosal basement and marked absence of globlet glands due to damage done to the mucosa and burst of the epithelial cells. Large cysts or large aggregates of small cysts may possibly cause some mechanical damage as seen in the study.

One conceptual definition of ecosystem health is the absence of disease, as disease is considered a stress on the environment (e.g contaminant), again conveying organismal properties on an ecosystem. To many parasites are organisms of no value to contemporary society that simply should be eradicated. In case of deterious diseases of humans and their biological resources, that will no doubt be desirable, but where does that leave the vast majority of parasites that occur in nature and the scientists who study them? Parasites are indeed important components of any ecosystem that not only play key roles in population dynamics and community structure, but that can provide important information on environmental stress, foodweb structure and function, and biodiversity (Marcoglise, 2003, 2004) that are relevant to societal needs. Indeed, in theory, the absence of disease under certain circumstances may reduce biodiversity and promote the expansion of introduced species (Lafferty, 2003).

Numerous studies have examined effects of anthropogenic-induced environmental perturbations on parasitic organisms at both population and community levels. The subject has been extensively and thoroughly reveiwed by Khan and Thulin (1991) and Mackenzie *et al*., (1995) among others. Types of stressors include domestic and industrial sewage, euthrophication, acidification, pulp mill effluents, pesticides, thermal stress, hydrological changes, urban development and ultra-violet light. In general, responses of fish hosts and communities vary depending on the type and intensity of the stressor, the parasite lifecycle and exposure time (Marcoglise, 2004), contrary to the organismal notion of ecosystem health meaning the absence of disease. Diversity of endoparasites may decrease because free-living stages may be directly affected or certain intermediate hosts may be reduced, thus hindering parasite tramission (Mackenzie, 1999). Concurrently, population of parasites species with direct life-cycles, usually protozoa and monogeneans, may increase, an effect usually attributed to compromised immune response by the host (Mackenzie *et al*., 1995; Mackenzie, 1999). Other parasite population may increase or decrease as a result of direct toxic effects on intermediate host populations (Poulin, 1992; Overstreet, 1997).

Exhaustive empirical surveys have shown that, almost without exception, intestinal helminth parasites are aggregated across their host populations, with most individuals harbouring low numbers of parasites, but few individuals playing host to many (Shaw and Dobson, 1995). Heterogeneities such as these are generated by variation between individuals in their exposure to parasitic infective stages and by differences in their susceptibility once an infective agent has been encountered. In the absence of any heterogeneities in exposure, even small differences in susceptibility between hosts can rapidly produce non-random, aggregated distributions of parasites (Lafferty, 1997). Sex and host condition factor have been found to be one of these varying factors. The well-being of fish and the population in general can be determined by the analyses of condition factor (Carlander, 1969). Condition factor is a measure of energetics, nutritional status and viability of a host. There was not much difference in the range of the weight and length of individuals of low and high condition factor of *Chrisichthys nigrodigitatus Synodontis filamentosus and Synodontis clarias*. But, each of these populations showed wide range variation in condition factor. This simply proves that condition factor is independent on size and weight and could only be used in comparing individuals of same species. In this study, High condition individuals of *C.nigrodigitatus* harbor more intestinal helminth parasites (0.35) than low condition individuals. The same goes for *S.clarias* (low condition; 0.15, high condition; 0.32) and *S.filamentosus,* (low condition, 0.10, high condition, 0.23).

Within populations, individuals differ in their ability to compete for limited resources (Begon *et al*,1990) and the resulting unequal division of nutrients lead to variation in growth rates, body size and nutritional condition (e.g. Rubenstein, 1981; Metcalfe, 1986; Westerberg *et al*., 2004). Unequal nutrient intake by competitors is also likely to have consequences for any parasites they may harbor, though it is difficult to predict the direction of such effects. Since condition factor (K) is a measure of nutritional status in fish, parasite load and intensity among low condition individuals were less than those of their high condition individuals. This shows that these individuals had low nutritional and energetic competence to harbor parasites. A relative number of these parasites might have been reduced by direct toxic effect of the stressed aquatic environment just as it might have had on the host. These parasites are completely dependent on host derived energy for growth and development (Bush *et al*., 2001), infecting better competitors might benefit parasites, particularly those with significant energetic requirements. Alternatively, if the best competitors are either in better nutritional condition as a result of their competitive superiority, or of intrinsically higher genetic quality, then they may be poor hosts for parasites if they have better immune systems or are able to limit the availability of nutrients to growing parasites. On the contrary, the rate of infection or prevalence is greater among the low condition individuals; this is due to the fact that stress could affect host immune competence. Studies have also indicated that intestinal parasites attach themselves to the host leading to mechanical damage, inflammation and necrosis and the blocking of the intestine (Scott and Grizzle, 1979, Boomker *et al*., 1980, Hoffman, 1980). Parasitism coupled with pollution could either increase or decrease the prevalence, intensity and load of the parasites and upset host/parasite equilibrium which could lead to diseased condition and mortality of the host. The low condition infected individuals in the population are multi-stressed and have showed significant pathological responses in their tissues. The importance of parasitological studies in the development of fisheries potential of freshwater habitat cannot be overemphasized. Fish parasitology is a tool in aquatic health studies and the basic understanding of the biology of the parasites is essential for instituting mechanisms of control.

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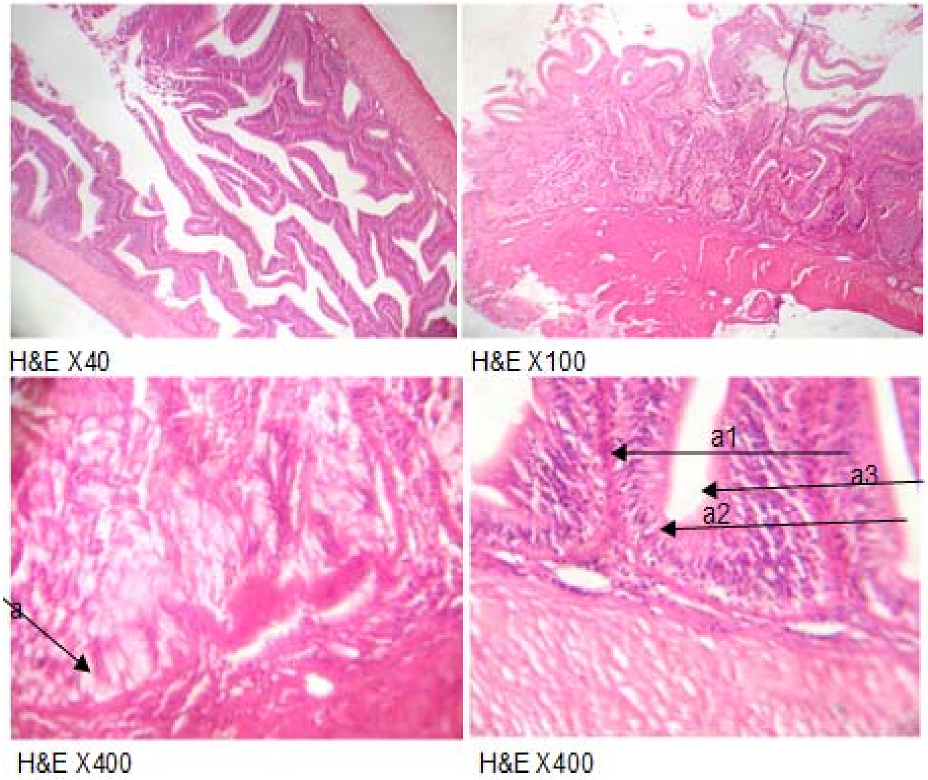

Plate 1: Photomicrographs show slight erosion (**a**) of the mucosa. blood capilliary (**a1**), epithelium (**a2**), intestinal crypt (**a3**) scored (HAI) of 2.

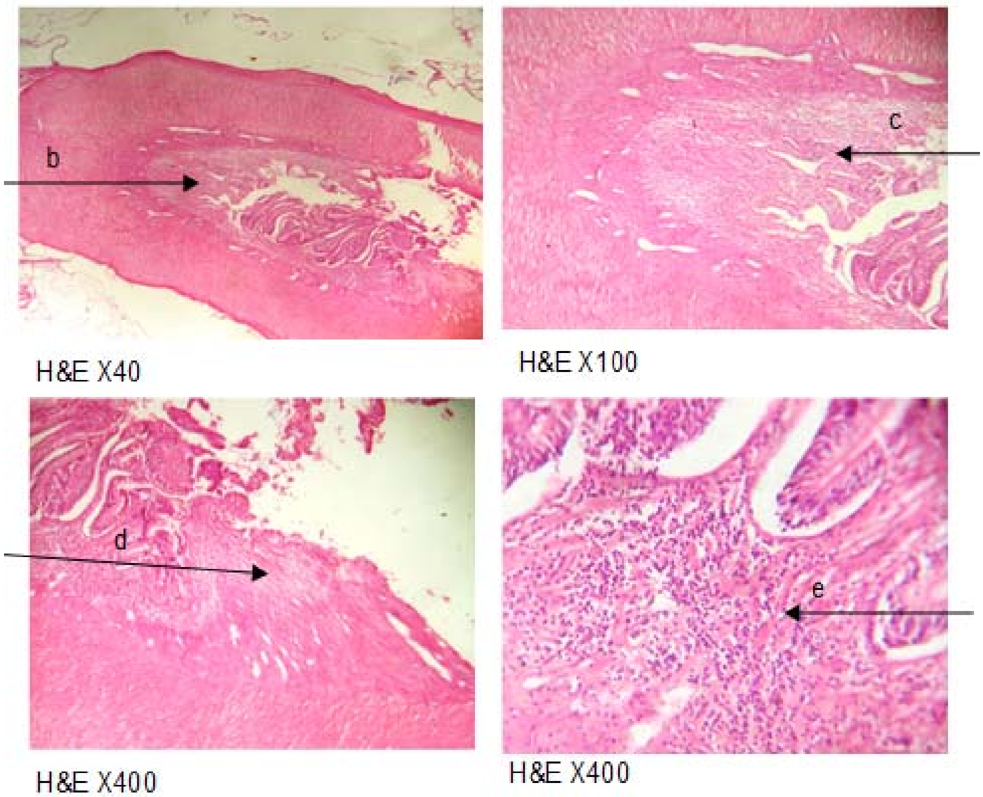

Plate 2: Photomicrographs show severe ulceration of mucosa (**b, c, d**) and inflammatory cells (**e**) There is marked absence of globlet glands due to damage done to the mucosa and burst of the epithelial cells. scored (HAI) of 6 or 8.

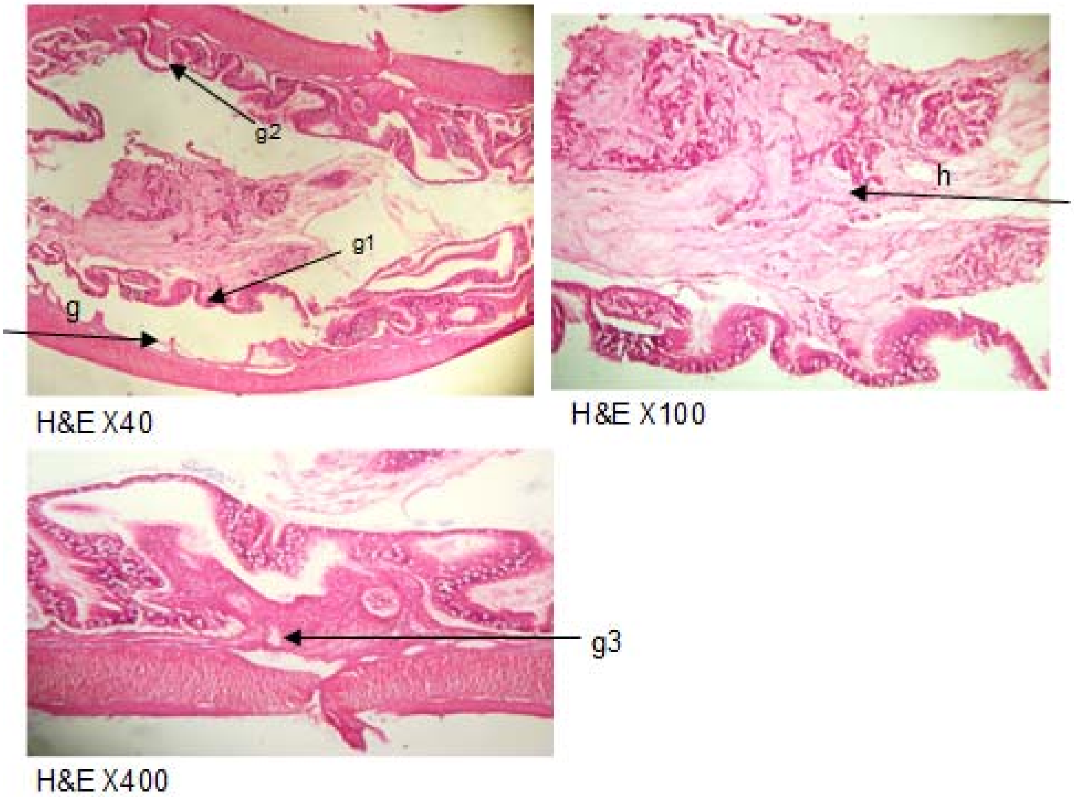

Plate 3: Photomicrographs show marked ulceration (**g, g3**) of the mucosa, detachment of villi from the mucosal basement (**g1**), undetached villi (**g2**) and presence of debris (**h**). scored (HAI) of 4 or 6.

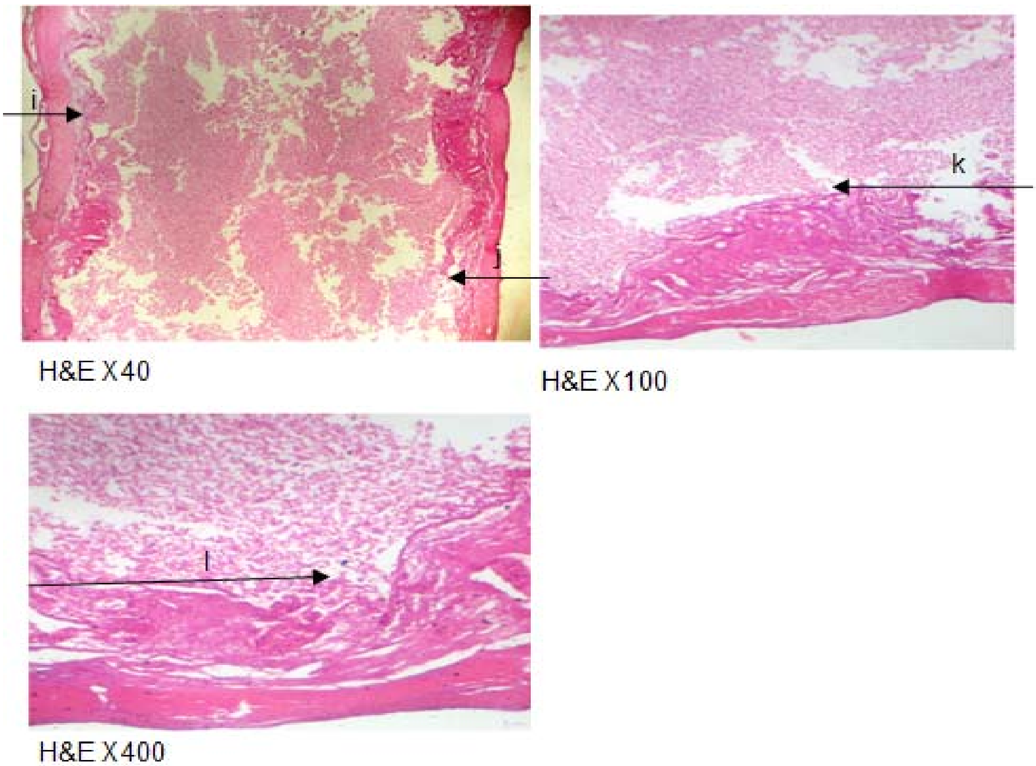

Plate 4: Photomicrographs show severe ulceration (**i, j & k**) of the mucosa and presence of debris scored (HAI) of 6.

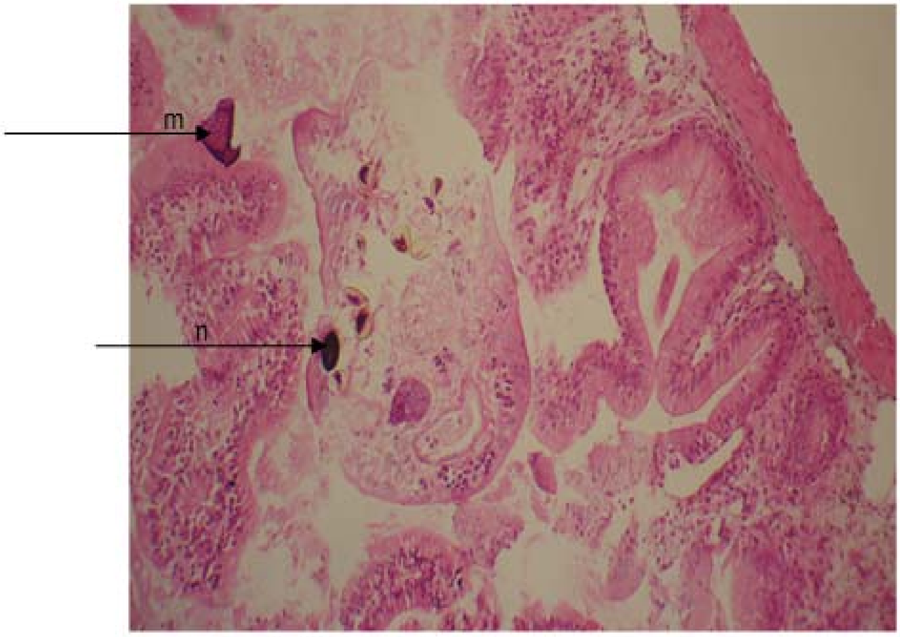

Plate 5: Photomicrographs show severe ulceration of the mucosa, presence of parasite ovum (**n**) and haemorrhage (**m**) scored (HAI) of 6.

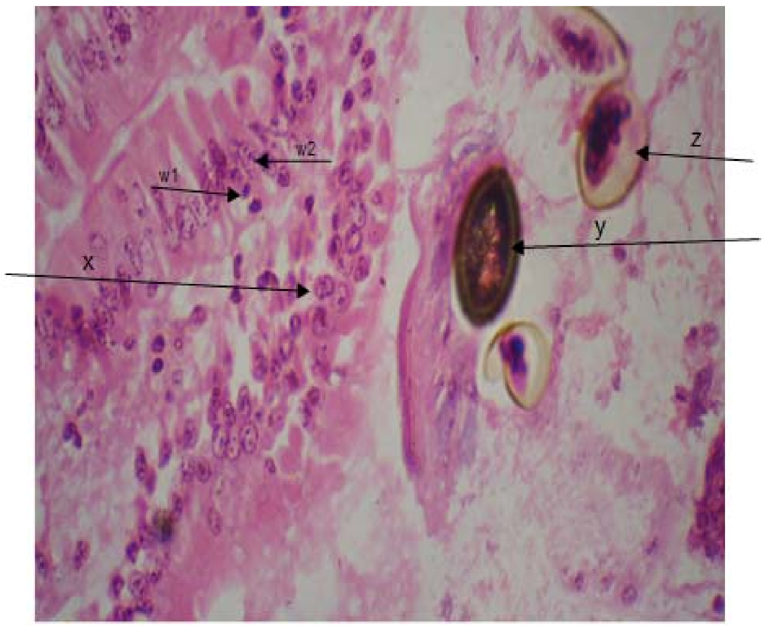

Plate 6: Photomicrographs show severe ulceration of the mucosa, epithelial cell (**w1**), globlet cell (**w2**) and presence of **x** -coccidia spores (*Emeria sp*) Coccidiosis, **y** and **z** – parasite ova scored (HAI) of 6 or 8.