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Effects of Climatic Changes on Fish Diversity and Abundance and Prevalence of Fish Parasitic Infections in Southern Nigeria

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Abstract
An important component of the natural resources in Nigeria is fishery and aquaculture. These resources are vulnerable to climatic change with a consequential effect on the socio-economic life of the people. The major contributory factor to climate change in Nigeria is the release of harmful substances into water bodies and the atmosphere from oil and gas extracting sector, including gas flaring in the Niger Delta. Climate change especially due to global and ocean warming lead to sea level rise and floods. Associated with these effects of climate change are outbreak of food and water-borne infectious diseases and agents, emergence of new diseases, resurgence of old diseases and redistribution of vector borne diseases. Studies carried out at Ikpoba River, Benin City, Nigeria, showed a great reduction in the diversity of fish over the years (58 species in 1988, 39 in 2004 and 7 in 2012). A high prevalence of parasitic infections was observed in the studies (22.9% and 15.6%). Some of the parasites recorded in 2004 were absent in 2012. The observed reduction in fish diversity is associated with climate change causing alteration in fish metabolism and physiology with consequences for growth, fecundity, feeding, behaviour, distribution and migration. High prevalence of parasitic infections observed in the studies could be a consequence of increased transmission rates of parasites with increasing temperatures due to global warming. Reduction in fish species over the years was accompanied by reduction in parasite species. Effects of climate change working synergistically with effects from anthropogenic stressors such as contaminants from oil spills and effluents, undoubtedly, have adverse effect on fish population and their parasites.

Keywords: Climatic changes, Fish, Diversity, Prevalence, Parasitic infections

Introduction
Climate change has been recognized as the foremost environmental problem of the 21st century. Climate change is defined as variation in the earth's climate over time, ranging from decades to millions of years (1). It can be caused by both natural processes and anthropogenic activities. The natural processes include orbital forcing (variations in earth orbit around the sun), volcanic eruptions and atmospheric greenhouse gas concentrations. The sun is the primary source of energy on earth, though the sun's output is nearly constant, small changes over an extended period of time has been observed to lead to climate change. One of the most important gases emitted during volcanic eruptions is sulphur dioxide (SO2), which forms sulphur aerosol (SO4) in the atmosphere. Changes in atmosphere concentration of aerosol, greenhouse gas, land cover and solar radiation alter the energy balance of the climate system causing warming or cooling of the earth's atmosphere.
Greenhouse gases (GHGs) are gaseous constituents of the atmosphere that are responsible for the greenhouse effect leading to an increase in the amount of infrared or thermal radiation near the surface. Greenhouse gases can be generated naturally or anthropogenically. Natural greenhouse gases in the earth atmosphere include, water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and Ozone (O3). Human – made greenhouse gases in the atmosphere include halocarbons and other chlorine-bromine containing substances. Most CO2 emissions are from the burning of fossil fuels such as coal, oil and gas as well as deforestation which eliminates an important carbon sink of the terrestrial biosphere. Halocarbons such as CFCs (chlorofluorocarbons), produced from the chemical industry where they are used as coolants and in foam blowing, are the major cause of depletion of the ozone layer thereby causing global warming.
Climate change is likely to lead to some irreversible effects on the earth and the ecosystem as a whole. Generally approximately 20 – 30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5 – 2.50C. In fact extinctions of 40 – 70% of species assessed around the global is expected if global average temperature increase exceeds 3.50C. (1)
In view of the afore mentioned observations and the threats, the present study was undertaken to report on the effects of climate changes on fish diversity and abundance and prevalence of fish parasitic infections in Southern Nigeria.

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Materials and Methods

Fish samples were purchased monthly from fishermen who regularly fished at Ikpoba River (6°13'0" N and 5°46'0" E), Benin City, Nigeria. Fish were transported in plastic containers quickly to the laboratory. In the laboratory, the total and standard lengths of the fish were measured to the nearest centimetre and their wet weight taken to the nearest gram. The fins, eye sockets, mouth cavity and skin of fish were examined in situ for ectoparasites, and for pathological conditions such as lesion, scars, ulcers and cysts. Scrapings of the slime, from the skin and fins were smeared on a microscope slide and examined. The fins and gills were removed from the fish, placed in petri dishes containing 0.72% normal saline and examined under a dissecting microscope. The abdominal cavity of each fish was cut open and the coelomic cavity inspected for parasites. The viscera consisting of the gut, liver, caeca, heart, swim bladder, urinary bladder, gonads and kidneys were isolated and examined separately in petri dishes containing normal saline. The brain and muscle of the fish were also examined. Nematodes were fixed in hot 70% alcohol and preserved in the same medium. The cestodes, trematodes, leeches and acanthocephalans were flattened under a cover slip on microscope slides and fixed in 10% formol-saline, fixed specimens were preserved in 10% formol-saline. Permanent mounts were made in Canada balsam after the worms were stained in aceto-carmine, dehydrated and cleared in xylene. Nematodes were cleared in lactophenol before examination. Parasites were identified using guides provided by Yamaguti (2, 3, 4, 5).

Results

The results of the studies carried out on Ikpoba River, Benin City, Nigeria, showed a great reduction in diversity of fish in this river over the years (Table 1).Table 2 shows members of cichlidae were more abundant in all the studies. Only three of the eight species of cichlids recorded in 2004 were recorded in 2012 with slightly different abundance except for H. bimaculatus. Majority of the non-cichlid species reported in 2004 in Ikpoba River were not recorded in 2012. The abundance of the recorded non-cichlid species in 2012 had increased except for Chrysichthys that showed a slight decrease. A high prevalence of parasitic infections have been observed in the studies and the same groups and species of parasites were isolated from the fish in the studies (Table 3). The report showed that for the cichlids (Table 4) reduction in fish species over the years also affected recorded parasite species. Some of the parasites recorded in 2004 were absent in 2012. The mean intensity of infection for majority of the parasites was below 1, except for Acanthogyrus tilapiae a common parasite in 75% of the cichlid fishes from the River, that had a mean intensity greater than 1 (Tilapia aurea had mean intensity of 7.00 , Table 4).

Table1: Fish Diversity in Ikpoba River

Study Site	Number Examined	Number of Families	Number of Species	Authors
Ikpoba River	-	-	58	Victor & Tetteh (1988)
Ikpoba River	594	19	39	Awharitoma & Okaka (2004)
Ikpoba River	137	05	7	Awharitoma & Ehigiator (2012)

Table2: Fish Abundance in Ikpoba River

Year	Fish Family	Fish Species	Abundance (%)
2004	Cichlidae	Chromidotilapia guentheri	23.2
	”	Hemichromis bimaculatus	20.5
	”	Hemichromis elongatus	23.9
	”	Pelvicachromis pulcher	0.7
	”	Tilapia aurea	0.7

”	Tilapia mariae	4.2
”	Oreochromis niloticus	1.4
”	Tilapia zilli	25.3
Anabantidae	Ctenopoma kingsleyae	1.6
Bagridae	Auchenoglanis biscutatus	7.5
Claroteidae	Chrysichthys sp	13.4
Channidae	Parachanna obscura	4.6
Characidae	Alestes baremose	2.3
”	Brycinus longipinnis	9.5
”	Micralestes acutidens	1.0
Claridae	Clarias gariepinus	1.3
Cyprinidae	Barbus callipferus	11.8
Cyprinodontidae	Epilatys bifasciatu	0.7
Gymnardiidae	Gymnarchus niloticus	0.3
Hepsetidae	Hepsetus odoe	2.6
Icthyboridae	Phagoborus ornatus	0.3
Malapteruridae	Malapterurus electricus	2.3
Mochokidae	Synodontis sp	2.9
Momyridae	Gnathonemus petersii	0.3
”	Gnathonemus tamandua	3.6
”	Hyperopisus bebe	2.6
”	Isichthys henryi	0.3
”	Marcusenius brachyistius	3.9
”	Mormyrops deliciosus	1.0
”	Mormyrops rume	0.7
”	Petrocephalus bane	0.3
”	Petrocephalus ansorgii	0.3
”	Petrocephalus simus	8.5
Notopteridae	Papyrocranus afer	2.6
	Xenomystus nigri	4.2
Nandidae	Polycentropsis abbreviate	3.3
Phractolaemidae	Phractolamus ansorgii	2.0
Polypteridae	Calamoicthys calabaricus	1.0

	Schibeidae	Schilbe intermedius	3.3
2012	Cichlidae	Chromidotilapia guentheri	26.3
	”	Hemichromis elongatus	21.2
	Bagridae	Auchenoglanis biscutatus	8.8
	Channidae	Parachanna obscura	10.2
	Claridae	Clarias gariepinus	13.9
	Claroteidae	Chrysichthys nigrodigitatus	10.9
	Mochokidae	Synodontis nigrila	8.8

Table3: Prevalence of Parasite Infection in Fish from Ikpoba River

Study Site	Prevalence (%)	Parasites Isolated
Ikpoba River	22.9	**Acanthocephala:** Acanthogyrus tilapiae, Rhadinorhyncus horridus
		Nematoda: Camallanus , Dichelyne Procamallanus laeviconchus, Echinocephalus sp Spirocamallanus spiralis
		Cestoda: Lytocestus sp, Wenyonia sp
		Trematoda: Clinostomium sp, Euclinostomium sp
		Crustacea: Lamproglena
Ikpoba River	15.6	**Acanthocephalan:** Acanthogyrus tilapiae
		Nematoda: Oxyurid nematode, Dichelyne sp
		Cestoda: Wenyonia virilise
		Trematoda: Clinostomium tilapiae

Table 4: Mean Intensities of Infection of Cichlid fish species in Ikpoba River

2004			2012		
Fish species	**Parasites isolated**	**Mean Intensity of infection**	**Fish species**	**Parasites isolated**	**Mean Intensity of infection**
FAMILY CICHLIDAE			FAMILY CICHLIDAE		
Chromidotilapia guentheri	Acanthogyrus tilapiae	0.79	Chromidotilapia guentheri	Acanthogyrus tilapiae	2.30
	Camallanus sp	0.03		Clinostomium tilapiae	0.30
	Hirudinea	0.03		Dichelyne sp	4.00
Hemichromis bimaculatus	Acanthogyrus tilapiae	1.63			
Hemichromis elongatus	Acanthogyrus tilapiae	1.25	Hemichromis elongatus	Acanthogyrus tilapiae	4.40
	Rhadinorhynchus horridus	0.15		Clinostomium tilapiae	2.00
	Spirocamallanus spiralis	0.20			
	Wenyonia sp	1.00			
	Clinostomum sp	0.40			
Pelvicachromis pulcher					
Tilapia aurea	Acanthogyrus tilapiae	7.00			
Tilapia mariae	Acanthogyrus tilapiae	0.89			
	Camallanus sp	0.11			
	Cucullanus sp	0.11			
	Lamproglena sp	0.22			
Oreochromis niloticus	Procamallanus laeviconchus	2.00			
Tilapia zilli	Acanthogyrus tilapiae	0.38			
	Procamallanus laeviconchus	0.15			
	Cucullanus sp	0.08			
	Wenyonia sp	0.05			

Discussion

In the present study, there was a reduction in fish diversity in Ikpoba River over the years but abundance of fish was not noticeably affected. Reduction in fish diversity observed in the studies is not surprising as it had been projected by IPCC (1) that approximately 40 – 70% of species of organisms so far assessed were likely to be at increased risk of extinction if global average temperature increase exceeded 3.50C. Increased global temperature leads to changes in spatial distribution of fishes due to migration of fishes from one region to another in search of suitable conditions. Brander (9) reported a rapid pole ward shifts in distribution of fish and plankton in North East Atlantic where there was rapid temperature change. Mass mortalities of many aquatic species including fish have been attributed to climate change (10, 11). Changes in species composition and abundance and subsequently biodiversity has been associated with climate change that caused alien fish species to expand into regions where previously they could not survive and reproduce (12). Other climatic change effects on fisheries include, reduced body size of fish and declining fisheries catches due to declining primary production among other factors (13). Studies by Marcogliese (14) reported that relatively small temperature changes alter fish metabolism and physiology with consequences for growth, fecundity, feeding behaviour, distribution, migration and abundance.

The synergistic negative effects of climate change, pollutants from effluents and oil spills and over fishing could be considerable on fish abundance and diversity. On the effect of pollutants from effluents, a study by Oronsaye and Obasohan (15) on Ogba River, in Benin City, Nigeria recorded the stations closest to the point where the drainage channel opened onto the river were completely devoid of fish. The absence of fish in this station could be attributed to the effect of the large influx of drainage effluents which must have completely obliterated conditions favourable for fish habitation.

On the effects of climate change on the parasites and infectious diseases of fish, the results obtained in our studies from Ikpoba River can be explained using information from investigations by previous researchers. According to Gale et al. (16) climate change could have important effects on parasitism and disease in both freshwater and marine ecosystems with consequences for human health and socio-economics. These researchers opined that the distribution of parasites and other, pathogens will be directly affected by global warming and indirectly through effects on host range and abundance. It was deduced that generally transmission rates of parasites and other pathogens will increase with increasing temperature, (hence relatively high prevalence of infection observed in the present study) and virulence of some pathogens including parasites may increase with global warming. For example, the nematode parasite Anguillicola crassus was found to cause in the fish Anguilla anguilla, altered physiological response and lowered thermal tolerance at high environmental temperature and lowered tissue oxygen tension. Similarly, the nematode parasite, Spinitectus gracilis and the trematode, Acanthostomum sp caused in the fish, Gymnocephalus cernuus, reduced survival at lowered tissue oxygen tension.

In aquaculture systems, climate change was found to affect productivity and increase vulnerability of cultured fish to diseases (17). Effects of increased temperature on parasites include rapid growth and earlier onset of maturation, increased parasite mortality, increased number of generations per year, increased rates of parasitism and disease, earlier and prolonged transmission and the possibility of continuous, year round transmission.

In conclusion, the effects of climate change on fish and parasites work synergistically with effects from anthropogenic stressors such as contaminants to increase negative effects on fish organisms and populations, with the effects cascading through food webs with consequences for entire ecosystems.

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