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Research Article

Culturally important freshwater Lakes in the central Niger Delta, Nigeria: Fish assemblage and diversity assessment

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Abstract

Freshwater systems shelter a vast array of biodiversity and are considered as one of the world's richest habitats for fish species, molluscs and other aquatic animal species. However these systems are imperilled by reclamation, drainage and pollution, particularly in the coastal states of the Niger Delta region, Nigeria; where the influx of oil companies opportunists struggle for available resources. But, within several communities of the region, freshwater lakes exist that have restricted access. These lakes are harvested periodically, ranging from a minimum of once in two years to maximum of once in ten years, with strict observance of rules based on indigenous belief systems. Drawing from findings of an interdisciplinary research conducted within the Niger Delta floodplain, this paper examines the fish assemblage and diversity of four lakes in Bayelsa State. Two lakes were assessed from the southern fringes of the inland flood zone of Osiama (Lake Adigbe) and Sabagreia (Lake Efi) communities and two lakes from the marsh forest ecozone of Biseni (Lakes Esiribi and Obaa). Preliminary physico-chemical analyses of the four lakes show slight variation between lakes, with pH range of 4.95 – 6.87. In consonance with cultural fishing practices observed in these lakes, a combination of cast and drag net samples with different mesh sizes (35 – 130mm), were acquired. A total of thirty eight (38) species from seventeen (17) Families and seven (7) Orders were identified. In the four lakes studied, the genus *Citharinus citharus* showed overall dominance, followed by *Synodontis membranaceous*. Comparisons across lakes show similarity in the assemblage of fish species, with more diversity in the three lakes having secchi depths > 2 metres. The management of these lakes by indigenous systems is commendable going by its sustainability and the absence of resources needed for enforcing conventional methods. Hence, the management of these lakes and similar tagged lakes using cultural systems could ultimately be the key to sustainable management of aquatic resources within the region.

Keywords: Freshwater Lakes, Fish diversity, Bayelsa State

INTRODUCTION

Aside being home to a vast number of dependent species such as fishes and molluscs [Strayer, 2001; IUCN, 2004], freshwater habitats particularly lakes play an important role in the cultural life of certain people. Examples of culturally important lakes are found in ancient Japanese mythology [Kawanabe, 2003], the Asante people of Ghana [Appiah-Opoku and Hyma, 1999] and the Batongwe and Holoholo tribes of Tanzania [Finke, 2006].These tribes considered the

rivers and waterfalls as 'Sacred' abodes of guardian spirits and left certain areas completely untouched [Finke, 2006]. 'Sacredness' has implicit and explicit meanings within these communities and elsewhere [for instance; Castro, 1990; Dorm-Adzobu et al., 1991; Pei and Luo, 2000; Byers et al., 2001; Campbell, 2005]. In Lake Bosumti for example, sacredness means that no human waste is deposited in it, and in certain portions of the lake fishing is completely forbidden [Appiah-Opoku and Hyma, 1999].

Belief systems that preserve certain ecosystems as abode of guardian/ancestor spirits are common amongst indigenous groups in the Niger Delta. Entrenched within these belief systems are natural resources practices that appear to resonate with the concept of sustainable use of natural resources. But, the effectiveness of these practices needs testing, particularly in the face of the Delta's escalating human population. The Niger Delta as an ecological complex is a biodiversity hotspot [Hilton-Taylor, 2000; Myers et al., 2000]. However, the region is plagued by various socioeconomic challenges which have led to spurts of resource-based conflicts [Ibeanu, 2000; ARD Inc, 2002; Niger Delta Development Commission, 2006; Hamadina et al., 2007]. The Delta's increased urbanization, population pressure and vulnerability of floodplain areas to the effect of climate change underscores the importance of human systems which drive biodiversity management. It is in examining this interrelationship between humans and other biodiversity, that effective conservation planning can be formulated. Importantly, the Delta's exclusion from the nation's protected area network means biodiversity management and protection is done by indigenous institutions [Powell, 1997]. Consequently, in maintaining freshwater ecosystems important for fish breeding and their livelihood, indigenous communities within this region are inclined towards customary edicts, enforced by their institutions [Anwana et al., 2010]. Thus, assessing these practices in parallel with biodiversity conservation is important. More so, the pervasive destruction of vast ecosystems in the Delta, coupled with poor taxonomic survey and record of faunal composition puts biodiversity on a precipice. If biodiversity loss is to be tackled within this area, then it is crucial that the rich biodiversity of the region is systematically documented before it is lost forever. It is in consonance with this view that the study was designed. It studied the indigenous fish harvesting regimes of some culturally important lakes within the region with the objective of assessing their relevance to biodiversity conservation. In addition, preliminary assessment of the species richness of fish fauna within the study area was done.

For this study, we define culturally important lakes as lakes within the confines of a community governed by reason of spiritual/customary edicts, enforced by indigenous institutions, based on the foundation of their historical world views. In the course of this study and addressed elsewhere [Anwana et al., 2010], it is noted that certain lakes have restricted access. Usually, restricted access lakes have open and closed seasons and strict customary regulations. In most of the communities within the study area, restricted access lakes fishing rights are limited to a particular family or only members of same patriarchal lineage. Typically these lakes have totemic faunal species which are protected by the indigenous institutions. The reverse is the open access lake, where several families and other communities are allowed to fish regularly.

MATERIALS AND METHODS

Study Area

The Niger Delta has three major divisions; the central, eastern and western areas [Oyebande et al., 2001]. The main ecological division is between the southern tidal freshwater or Marsh forest zone and the inland Flood forest zone of the eastern flanks [Powell, 1997]. The Marsh Forest zone in contrast has greater tidal influence with permanent swampy channels and it is characterized by extensive mangrove vegetation. Bayelsa State (4^{o} 15' N, 5^{o} 23' S; 5^{o} 22' W and 06^{o} 45' E) is considered as the central Niger Delta owing to its geographical position [Alagoa, 1999]. It receives flood water directly from the River Niger at its northern apex and has over 70% of its total area inundated with floodwater during the wet season [Oyegun, 1999].The State also comprises a vast majority of rivers directly discharging waters of the Niger into the Bight of Benin [Alagoa, 1999; UNDP, 2006]. Thus, Bayelsa State represents a characteristic sample of the flora and fauna within the Niger River basin. Annual rainfall patterns vary within the State from as high as four thousand (4,000) millimetres in Brass, to about three thousand (3,000) millimetres in Yenagoa [UNDP, 2006]. The area's low relief and high water table coupled with heavy rainfall, imply many riverine areas of the State are prone to flooding and erosion of its coastline [UNDP, 2006; Moffat and Linden, 1995].

Survey methods

Project communities and adjacent lakes were selected through a ranking exercise from an initial reconnaissance survey. Ranking was done using a scale of 1 to 5, where 1 was the lowest rank and 5 the highest. The following criteria were

used for selection:

- Comparative size of culturally important lake and accessibility of the site (sites which had strict cultural observance, limiting access only to the "initiated few" were avoided), also accessibility in terms of topography of lake terrain was a strong consideration for safety reasons;
- Representative community and lakes of different ecozone (i.e. marsh forest zone and inland flood forest zone);
- Presence or absence of endemic, vulnerable and threatened biodiversity (i.e. species of traditional, national and regional conservation interest) and
- Extractive, Government and interest within the community (for instance oil wells, tourism site).

Based on the selection criteria, three communities, Osiama town (Sagbama local government area), Sabagreia (Kolokuma/Opokuma local government area) and Biseni (Yenagoa local government area) were selected for in-depth studies. Preliminary assessment of the fish diversity and composition was done for four lakes of the three communities. Three restricted lakes were assessed from the three communities namely; Lake Adigbe (Osiama), Efi (Sabagreia) and Esiribi (Biseni), while one open access lake was examined from Biseni area Lake Obaa.

Sampling

Three sampling points each were geo located on the four lakes (termed stations 1, 2 and 3) using a hand-held Global Positioning System. At each sampling station water temperature, pH, turbidity and depth were taken.

Physico-chemical Assessment of Lake Systems

The pH measurements of each of the lakes were taken at each site at about 5cm below the water surface using a pocket pH meter (HANNA HI-98103). Similarly, water temperature was measured using a pocket thermometer (HI-98501). The lake transparency (which is an index of trophic level and water quality) was measured using the Secchi Disk (SD, diameter 30-cm) method [LaPerriere and Edmundson, 2000; Amarasinghe and Welcomme, 2002]. Depths of each lake type were determined using a 50m fishing line with a weight at its end and dropped until it touched the bottom of the lake.

Fish species richness and composition

The fishery of the lakes surveyed was determined by assessing the relative abundance of the fish species from each study community's lake (i.e. restricted access) in comparison to that of an open access lake. The four lakes were sampled within three days of the stipulated fishing season, between July 2006 and March 2007. Fish sampling was done in lakes Adigbe in May 2006 and in Lake Efi, July 2006. Lakes Obaa and Esiribi were sampled in March 2006 and 2007 respectively. Catches made by local fishermen were examined for species diversity and relative abundance adapting the method employed by [Koranteng et al., 2000] who enumerated the number of fishes caught by fishermen during the day at 3-hour intervals from 06:00 - 18:00 GMT. Local fish traps and netting were used for sampling as suggested by netting of various mesh sizes (Table 1) were set by fishermen overnight; hence most of our sampling was done at dawn from 06:00 – 11: 35 GMT.

Table 1. Types of nets used and their mesh sizes

Lake	Cast net 1 **35 mm**	Cast net 2 **50.8**	Cast net 3 **110**	Drag net 1 **115**	Drag net 2 **127**	Drag net 3 **130**
Adigbe	√	√	√	√	√	√
Efi	√	√	√	√	√	√
Esiribi	√		√	√	√	√
Obaa	√	√	√	√		

Samples of catch were identified to species level using identification keys [Lévêque et al., 1992)]. Fish diversity for each lake type; restricted-access and open-access, was computed using Simpson's index of diversity [Simpson, 1949; Bakus, 1990], expressed as:

$D = 1/C,$

Where $C = \sum \frac{N_i (N_i - 1)}{N_t (N_t - 1)},$

But usually:

$C \sim \sum (N_i/N_t)^2$

N_i being the number of individuals of the ith species and N_t is the total number of individuals in the sample. Diversity index (D) can be expressed in the form 1-C [Southwood, 1978]. Comparisons were made using two other biodiversity indices, The Shannon-Wiener function (H) and the Berger-Parker dominance index. The Shannon-Wiener function for each lake assessed was calculated using the formula:

$H = -\sum Pi \log_e Pi,$

Where Pi = the proportion of individuals in the ith species [Southwood and Henderson , 2000].The Berger-Parker dominance index, expresses the proportion of the total catch, N_T that is due to the dominant species, $N_{max,}$ and is calculated using the formula [Southwood and Henderson , 2000]:

$d = N_{max}/N_T$

RESULTS

Physicochemical parameters in the three project communities measured over an annual cycle are summarised in Table 2. Results show a variation across spatial location. Lake Adigbe had a near neutral pH of 7.23. Both Esiribi and Obaa were similar with pH values of about 6.

Table 2. Average readings of physico-chemical parameters in the different Lakes

Lake	Parameters				
	Temperature (°C)	pH	Turbidity (metres)	Depth (metres)	Altitude (metres)
Adigbe	32.07	7.23	0.40	2.29	5.89
Efi	30.01	6.09	0.51	3.20	6.01
Esiribi	34.03	6.87	0.7	1.99	6.61
Obaa	28.2	6.16	0.8	1.32	5.18

Faunal Composition

The Order Characiformes had numerical dominance, comprising 50.69% of the individuals and 7.89% of species (Table 3). However, Siluriformes dominated in terms of number of species (34.21%).

Table 3. Fish species of the four lakes in the Niger Delta

Order	Family	Species	Lakes				
			Adigbe	Efi	Esiribi	Obaa	Number
CHARACIFORMES	CITHARINIDAE	*Citharinus citharus*	242	383	56	-	681
		Distichodus rostratus	2	2	1	-	5
	HEPSETIDAE	*Hepsetus odoe*	1	-	2	-	3
CYPRINIFORMES	ALESTIDAE	*Alestes baremoze*	5	1	-	-	6
		Alestes macrolepidotus	-	5	2	-	7
		Brycinus macrolepidotus	3	-	-	-	3
		Brycinus nurse	41	-	-	-	41
		Hydrocynus forskalii	-	4	1	-	5
	CYPRINIDAE	*Cyprinus* sp.	2	-	-	-	2
		Labeo coubie	1	1	-	-	2
		Labeo senegalensis	-	1	-	-	1
		Labeo sp.	-	-	12	-	12
ELOPIFORMES (tarpons)	ELOPIDAE	*Elops lacerta*	2	-	-	-	2
OSTEOGLOSSIFORMES	OSTEOGLOSSIDAE	*Heterotis niloticus*	-	3	1	-	4
	GYMNARCHIDAE	*Gymnarchus niloticus*	1	4	2	-	7
	MORMYRIDAE	*Hyperopisus bebe*	1	-	-	-	1
		Mormyrus spp.	-	-	12	-	12
	NOTOPTERIDAE	*Papyrocranus afer*	1	-	4	-	5
PERCIFORMES	CENTROPOMIDAE	*Lates niloticus*	-	1	15	-	16

Continuation of table 3

	CHANNIDAE	*Parachanna obscurus*	-	-	2	-	6
	CICHLIDAE	*Hemichromis fasciatus*	1	-	-	-	1
		Tilapia niloticus	3	1	15	2	21
		Tilapia zilli	-	-	3	16	19
SILURIFORMES (catfish)	CLARIDAE	*Heterobranchusbidorsalis*	-	-	1	-	1
	BAGRIDAE	*Auchenoglanis occidentalis*	-	-	2	-	2
		Auchenoglanis sp.	-	1	-	-	1
		Bagrus bayad	-	3	5	-	8
		Chrysichthys auratus	-	-	9	-	9
		Chrysichthys nigrodigitatus	33	3	-	-	36
	MOCHOKIDAE	*Hemisynodontismembranaceous*	75	276	-	-	351
		Synodontis clarias	-	-	4	-	4
		Synodontis membranaceous	-	-	63	-	63
		Synodontis nigrita	-	-	1	-	1
		Synodontis schall	-	-	16	-	16
		Synodontis sp.	-	-	-	1	1
	SCHILBEIDAE	*Schilbe mystus*	2	-	1	-	3
TETRAODONTIFORMES	TETRAODONTIDAE	*Tetraodon lineatus*	-	-	1	-	1
			416	**689**	**231**	**19**	**1355**

In the Lake Esiribi(1- *D* = 0.84864) there were two hundred and thirty one (231) fish of twenty four (24) species from sixteen (16) families; while Lake Adigbe with a Simpson's diversity index of 0.61418 had four hundred and sixteen (416) fishes of seventeen (17) species from twelve (12) families (Table 4).

Table 4. Fish diversity indices in different lakes

Diversity Index	**Lakes sampled**			
	Adigbe	**Efi**	**Esiribi**	**Obaa**
Shannon-Weiner Function (*H*)	1.36732	0.93330	2.32199	0.53666
Simpson Diversity (1-*D*)	0.61418	0.53111	0.84864	0.29240
Berger-Parker Dominance (*d*)	0.58173	0.55588	0.27273	0.84211

The fish species recorded in the highest numbers from Lake Esiribi was *Synodontis membranaceous* (Family: Mochokidae), while the most numerous fish in Lakes Adigbe and Efi was *Citharinus citharus* (Family: Citharinidae). Of the three species identified in Obaa lake, *Tilapia zilli* was the dominant species. From the diversity index analysis, the three restricted access lakes (Efi, Esiribi and Adigbe) had a more diverse number of fish species than the open access lake. The four dominant families of fish species within the three lakes are; Mochokidae, Citharinidae, Cichlidae and Channidae. The Mochokidae family from the survey was the most diverse, having six (6) representative species. This was followed by the Alestidae and Bagridae groups, with records of five (5) species each (Figure 1).

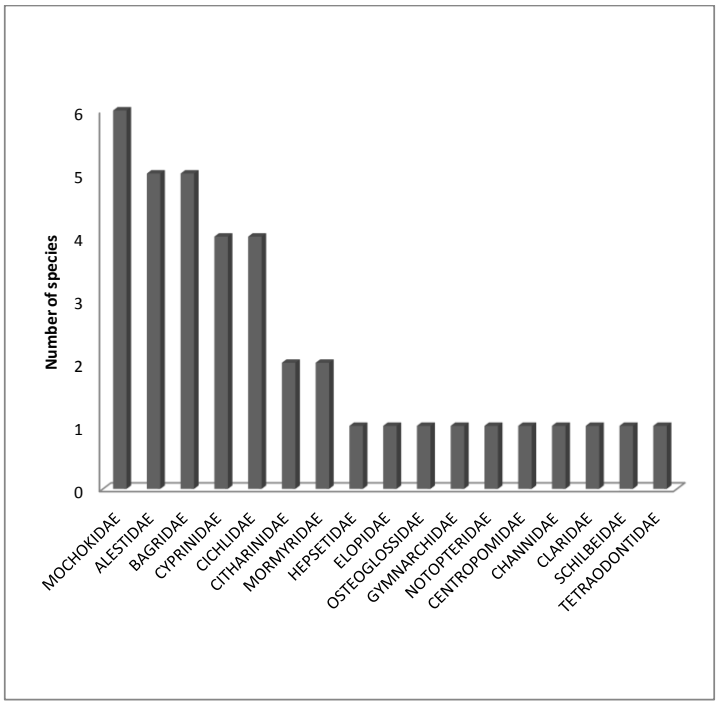

Figure 1. Number of species recorded in each family

DISCUSSIONS

Overall physico-chemical readings show that Adigbe, Efi and Esiribi have some similar characteristics. This perhaps accounts for the high diversity noted in these lakes in comparison to Lake Obaa. Also, the variation might be due to several factors such as; the nature of habitat, geographical location, size, and physical character of each lake's primary water body [Decher, 1997; Amarasinghe and Welcomme, 2002; Triantis et al., 2006]. The near neutral pH lakes were expected to yield greater fish species diversity than the acidic lakes, which are known to increase toxicity detrimental to fish survival [Dillon et al., 1987]. Usually, floodplains and delta lakes are strongly influenced by their associated rivers [Nevers and Whitman, 2004]. Esiribi and Obaa for instance, receive flood water directly from the River Niger, while Adigbe is fed by the Osiama creek (a tributary of the Niger River). Hence, it is expected that these lakes bear similarity to their associated rivers. The findings of fish assemblage obtained from this study are similar to the baseline data obtained from the upper Niger River [Ita, 1993; Ita, 1994]. Lakes Adigbe and Efi were found to be deeper than Lake Esiribi, and so would be expected to have a more diverse fish fauna than that of Lake Esiribi, as depth correlates positively with fish diversity [Barbour and Brown, 1974; Jeppesen et al., 2000]. However, results from this study deviated from the findings of [Barbour and Brown , 1974] and [Jeppesen et al., 2000] with rather higher species richness in Esiribi. This deviation is in line with the suggestion of [Dobson, 1992], who found that species richness was higher in areas rich in lakes as is the case in Biseni than in those with very few lakes. Additionally, fish diversity and other aquatic resources should be greater in lakes with rich macrophyte population [Olson et al., 1994]. This is perhaps one of the factors responsible for the diverse fish species recorded in three out of the four lakes. The three lakes with higher fish species diversity and abundance are the restricted access lakes. This restriction is enforced by traditional beliefs. It is therefore likely that the indigenous conservation systems are advantageous for ecosystem management.

However, the invasion by non-native species such as water hyacinth (*Eichhornia crassipes*) appears to limit optimum fish growth and yields. The invasion by *Eichhornia crassipes* in these lakes was mentioned as a primary problem of the waterways in Osiama and Biseni [Anwana, 2008]. In Lake Esiribi, for instance, water hyacinth has almost completely colonised the waterways, masking the growth of other macrophytes. In Lake Obaa, the submergent *Ceratophyllum* sp. was very visible, whereas it was scarce in Lake Esiribi. A similar observation was made in Lake Chivero, Zimbabwe, where due to the presence of water hyacinth, submergents were absent [Brendonck et al., 2003]. Until this study there was little published information available on fish species composition of the Niger Delta ecoregion and there remains a paucity of data on other groups. Wildlife surveys in the delta were not conducted until the late 1980s [Powell, 1997]. Therefore, it is difficult to compare results obtained from this survey with previous findings from the area. However, there

exist some similarity in the species richness observed elsewhere close to the study area [Ita , 1993]. A more recent source for comparison is the survey conducted by [Ezealor et al., 2004], who recorded one hundred and thirteen (113) fish species from sixty five (65) genera and thirty (30) families in Lake Esiribi. Various factors might account for the difference in results, including mesh size used and time of sampling. Their report did not give details of the fish sampling technique used and so caution is needed in the comparison of the two results. However their observation that the two most diverse families were the Alesteidae and the Cichlidae agrees with findings of this research.

Fish species from the three lakes have high economic value within the region and attract retailers from several communities within and outside the State. Moreso, fish provide an estimated 40% of the total animal protein consumed in the nation. However, in coastal states they probably account for about 80% of the animal protein consumed by the people [NEST, 1991]. Hence, it is important that the sustainability of the biodiversity management regime found within these communities is encouraged. Fishing as observed in restricted access lakes is limited to a calendar cycle. In Biseni for instance, Lake Adigbe is fished once in a two year - cycle. This practice allows for regeneration of most of the fishes found in the lake. Given that the minimum doubling time of the populations of most of the fishes found within these lakes is between 1.4 to 4.4 years, it appears that these indigenous communities, through experiential knowledge, have fixed the times of fishing for maximum yields. In addition, restricted access lakes could act as possible sanctuaries and spawning sites, feeding the fish diversity of the adjourning rivers. With the population growth of the area and attendant problems of resource use, the inclusion of these culturally important lakes in regional planning becomes imperative. Conservation programmes within the region should incorporate indigenous natural resources management systems for longer-term sustainability. The indigenous management system observed in the study communities should serve as models of community-based conservation programmes.

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