Diversity and Species Composition of Periphyton in a Tropical Earthern Pond in South Eastern Nigeria.

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Abstract: Studies were conducted on periphyton species diversity and composition in the University of Calabar Fish Farm, Nigeria between January and March, 2014 using samples obtained from bamboo substrates. Samples were taken 30.0cm below the top of the submerged region of the substrates 90 days after installation using known area of 5.0cm^2. Forty-one taxa of periphyton belonging to seven families namely: Bacillariophyceae, Chlorophyceae, Chrysophyceae, Cyanophyceae, Euglenophyceae, Protozoa and Rotifera. Bacillariophyceae had 7 taxa with 282 individuals (22.26%), while Chlorophyceae had 12 taxa, which contained 397 individuals forming 31.33% of the periphyton population. Others were Cyanophyceae with 9 taxa, 318 individuals (25.10%), Euglenophyceae had 5 taxa, 78 individuals (6.15%), Protozoa had 2 taxa, 62 individuals (4.89%) and Rotifera had 3 taxa, 49 individuals (3.88). Margalef's diversity index d, ranged between 0.24 and 1.84 with a mean of 0.92, while Shannon-wiener index ranged between 2.29 - 3.04, with a mean of 2.76. Results of the study are discussed in relation to periphyton-based aquaculture especially in Nile tilapia (Oreochromis niloticus) farming as the cichlid is known to feed on periphyton, both in the wild and under culture condition in fish pond.

Key words: Diversity, Species Composition, Periphyton, Tropical, Earthern Pond, *Oreochromis niloticus* Nigeria.

1. Introduction

Periphytons are complex of sessile aquatic biota with associated detritus, attached to submerged substrates. It includes phytoplankton, algae, zooplankton and other bottom organisms in combination with microbial bio-films. In aquaculture, the substrate can be anything ranging from coral reefs, stones, branches from any tree or shrub species, higher aquatic plants, bamboo, plastics, etc. (Azim *et. al.,* 2002), which have become embedded in a mucopolysaccharide matrix (Van Dam *et. al.,* 2002), providing a good source of food for both fin and shellfishes possessing planktivorous mode of nutrition (Azim *et al.,* 2001). Periphyton assemblages have been an important factor in the success of various traditional fishing systems and periphyton-based aquaculture has contributed to reduce the need for external production while improving nutrients utilization efficiency (Azim *et. al.*, 2001, 2002). Dempster *et. al.,* (1993, 1995) showed that tilapias graze more efficiently on periphyton substrate than on micro-particles in the water column.

In aquatic systems the food web is driven by energy and biomass fixed through primary production, which is transferred through successive trophic levels. Normally, pond management enhances phytoplankton production as the primary energy source. Moss, (1988) argued that macrophytes or periphyton are important, often the principal contributor to primary production. Farmers in Africa have traditional used tree branches and bamboo poles as fish aggregating devices. They also served to promote the growth of fishes by increasing natural food availability through the production of periphyton on these substrates. Through this simple method, productions of 4.20 t/ha have been reported (Welcome, 1972, Hem & Avit 1994).

In periphyton-based monoculture ponds, phytoplankton and bottom detritus remained under-utilized (Wahab *et al*., 1999). This indicates that stocking densities can be increased further. Besides periphyton, other natural foods like phytoplankton, zooplankton, suspended organic matter, and bottom detritus are also potential food sources for the fishes cultured.

Studies on periphyton around the world by other researchers include those of Diana *et. al.,* (1991, 1994), Konan-Brou *et. al.,* (1991), Dempster *et. al.,* (1993, 1995), Shanker *et. al*., (1998), Wahab *et. al* (1999), Huchette *et. al.,* (2000), Azim *et. al.,* (2001, 2002, 2004), Van Dam *et. al.,* (2002), Uddin *et al.,* (2003) and Kaggwa *et. al.,*(2006). None of the studies has however reported on the diversity and species composition of periphytton assemblages in tropical earthen ponds in the Nigerian environment which the present study is designed.

2. Methodology
2.1 Study Area

The study area was the University of Calabar Fish Farm. This area is geographically located on the

Western bank of the Great Kwa River between latitude $04^0 56.020$'N and longitude $008^0.20.450$'E in Cross River State, Nigeria (Asuquo *et al.*, 2009). The Fish farm since its establishment in 1987 had been on a continuous research to develop dexterity in the artificial production of quantitative and qualitative fresh water fish species. The major cultured species consist of *C. gariepinus* (African catfish), *Heterobranchus longftilis* (African mud fish) and *Oreochromis miloticus* (Nile tilapia). The area where the farm situates, offers the land with a potential for sound aquaculture development. Ecologically, it provides possible fresh water hydrological system of large flood plain, hence is a suitable ecological habitat for the culture and survival of potential freshwater species (Fig. 1).
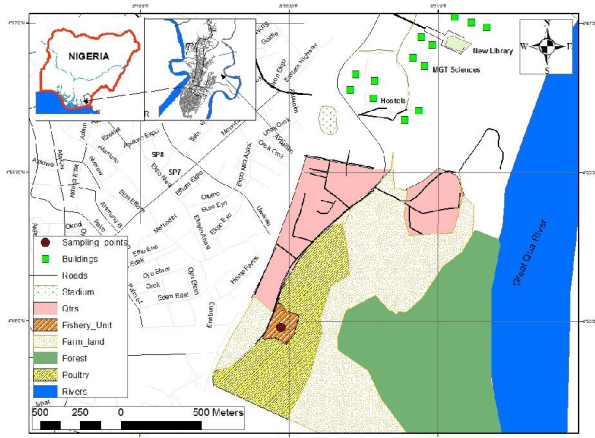

Fig 1: Map of the Study Area

2.2 Collection of Samples

Periphyton samples were collected from submerged substrates in March, 2014 from the earthen ponds of the University of Calabar Fish Farm, Nigeria. Samples were collected from randomly selected substrates 90 days after installation. The substrates which composed of bamboo sticks were removed from the water and scrapped as recommended by Kaggwa *et. al*, (2006) to obtain samples of known area ($5.0cm^2$). Samples were taken 30.0cm below the top of the submerged region of the substrates.

2.3 Preservation of Samples

Scrapped samples were suspended in 50mls of distilled water in 100mls capacity glass bottle. The use of distilled water instead of pond water excluded the influence of floating algal species in the samples. Two drops of Lugol's iodine solution was added to the samples, stored in an ice-chest and transported to Devine concept laboratory, Port Harcourt, for analysis.

2.4 Identification of Samples

In the laboratory, samples were concentrated to 10mls and sub-sampled into plankton sedimentation chambers for microscopy examination using Zeis inverted plankton microscope. Periphyton taxa were identified using identification schemes of Sharma (1986), Eaton *et. al.* (1995), and Sverdrup *et. al.* (2006).

2.5 Data Analysis

Data obtained from each periphyton group were empirically analyzed using the formula:

$\% R_a = {}^n/_N \times 100$ (Ali *et al.*, 2003).

Where: $\% R_a$ = relative abundance

n = number of individuals

N = total number of all individuals.

Margalef's diversity index d was used in determining the very current ecological status of the pond using the formular:

$$D = \frac{S-1}{\ln(N)}$$ (Margalef, 1978; Ogbeibu, 2006).

Where: ln = natural or Naperian logarithm ($\log_e$)

S = number of taxa in each periphyton family.

N = total abundance in each periphyton family.

Shannon-wiener index was used to determine the species density of the periphyton species using the formular:

$$H = \frac{N \log N - fi \log fi}{N}$$ (Ogbeibu, 2006).

Where: H = Shannon-wiener index

N = Numerical abundance of all periphyton assemblages/families

fi = number of each periphyton family.

3. Results and Discussion

The periphyton species composition during the period of investigation is presented in Table 1. Forty-one periphyton taxa belonging to seven families were recorded. These included Bacillariophyceae with 7 taxa and 282 individuals which represented 22.26% of the periphyton population. Chlorophyceae had twelve taxa with 397 individuals (31.33%), Chrysophyceae contained 81 individuals (6.39%), Cyanophyceae contained nine taxa and 318 individuals (25.10%), Euglenophyceae had five taxa with 78 individuals (6.15%), Protozoa had two taxa and 62 individuals (4.89%) and Rotifera had three taxa and 41 individuals which represent (3.35%) of the peripyton population encountered during the study (Table 2, Fig 2, Fig 3). The artificial substrates were colonized by both sessile zooplankton and algae which provide concentrated food item on which fish can graze more efficiently than filter feeding on planktonic foods alone.

Margalef's diversity index d, ranged between 0.24 and 1.84 with a mean of 0.92, while Shannon-wiener index ranged between 2.29 - 3.04, with a mean of 2.76 indicating that the periphyton were densely distributed at the 30cm depth (Fig 4).

Table 1: Periphyton Families / Taxa Encountered during the Study

Family	S/N	Species	Numerical Abundance (n)	Relative Abundance (%n)
Bacillariophyceae	1	*Melosira* sp	22	7.80
	2	*Cylotella* sp	41	14.54
	3	*Pinullaria* sp	16	5.67
	4	*Synedra ulna*	36	12.77
	5	*Synedra cyclopum*	45	15.96
	6	*Suriella spiralis*	58	20.57
	7	*Asterionella gracilluna*	64	22.70
		Number of taxa (S)	**7**	
		Total abundance (N)	**282**	**100**
Chlorophyceae	1	*Cladophora* sp	26	6.55
	2	*Oocystis* sp	40	10.08
	3	*Ulva* sp	13	3.27
	4	*Gonium* sp	24	6.04
	5	*Zygnema* sp	53	13.35
	6	*Scenesmus* sp	18	4.53
	7	*Anacystis* sp	16	4.03
	8	*Closterium fragilla*	12	3.02
	9	*Chlorogonium* sp	38	9.57
	10	*Spirogyra* sp	64	16.12
	11	*Ulothrix* sp	56	14.11
	12	*Akinsotrudesmus fulcatus*	37	9.32
		Number of taxa (S)	**12**	
		Total abundance (N)	**397**	**100.0**
Chrysophyceae	1	*Dinobryon* sp	36	44.44
	2	*Tribonema* sp	21	25.93
	3	*Mallomonas* sp	24	29.63
		Number of taxa (S)	**3**	
		Total abundance (N)	**81**	**100.0**
Cyanophyceae	1	*Anabaena* sp	24	7.55
	2	*Nostoc* sp	36	11.32
	3	*Oscillatoria lascustria* sp	54	16.98
	4	*Oscillatoria* sp	56	17.61
	5	*Asterococcus superbus*	32	10.06
	6	*Spirulina* sp	20	6.29
	7	*Asterococcus* sp	36	11.32
	8	*Microcystis* sp	44	13.84
	9	*Cyclindrospermum* sp	16	5.03
		Number of taxa (S)	**9**	
		Total abundance (N)	**318**	**100.0**
Euglenophyceae	1	*Euglene rubra*	16	20.51
	2	*Euglena* sp	12	15.38
	3	*Euglenaacus* sp	22	28.21
	4	*Calcium* sp	8	10.26
	5	*Cyrptoglena* sp	20	25.64
		Number of taxa (S)	**5**	
		Total abundance (N)	**78**	**100.0**
Protozoa	1	*Colpoda* sp	38	61.29
	2	*Paramecium caudatum*	24	38.71
		Number of taxa (S)	**2**	
		Total abundance (N)	**62**	**100.0**
Rotifera	1	*Brachionus* sp	14	28.57
	2	*Keretella* sp	19	38.78
	3	*Nothoica* sp	16	32.65
		Number of taxa (S)	**3**	
		Total abundance (N)	**49**	**100.0**

Table 2: Summary of the Distribution of the Major Periphyton Families in the University of Calabar Fish Farm, Nigeria during the Study Period.

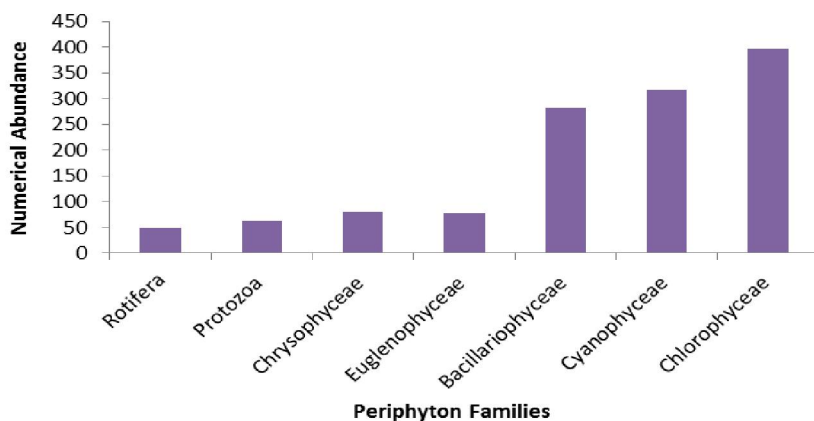| S/N	Periphyton Families	Numerical Abundance (n)	Number of taxa (S)	(%n)	D	H
1	Rotifera	49	3	3.88	0.51	3.04
2	Protozoa	62	2	4.89	0.24	3.02
3	Chrysophyceae	81	3	6.39	0.46	2.98
4	Euglenophyceae	78	5	6.15	0.92	2.99
5	Bacillariophyceae	282	7	22.26	1.06	2.56
6	Cyanophyceae	318	9	25.10	1.39	2.47
7	Chlorophyceae	397	12	31.33	1.84	2.29
	Total abundance (N)	**1,267**	**41**	**100.0**	**Σd=6.42**	**ΣH=19.35**

Fig. 2: Variation in Numerical Abundance of the Major Periphyton Families in the University of Calabar Fish Pond Nigeria, during the Study Period.
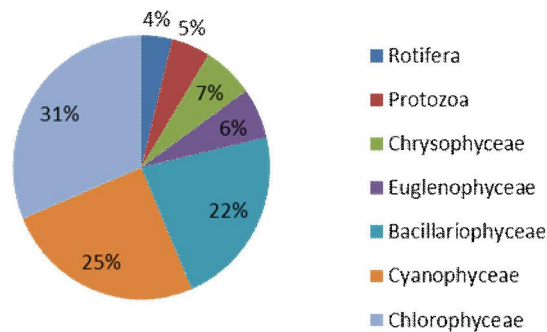

Fig 3: Relative abundance of the Major Periphyton Families in the University of Calabar Fish Pond Nigeria, during the Study Period.
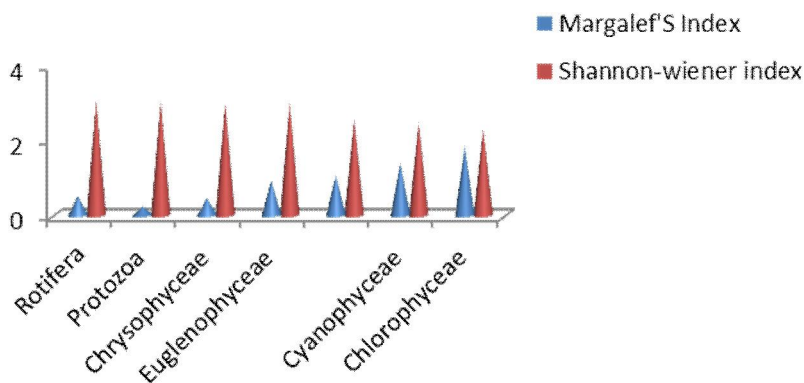

Fig 4: Margalef and Shannon-wiener indices of the Major Periphyton Families in the University of Calabar, Fish Pond Nigeria, during the Study Period.

Results of the study showed that the species of periphyton encountered in the University of Calabar Fish Ponds are common to tropical earthen pond systems. Uddin *et. al.,* (2003) recorded Cyanophyceae, Dinophyceae, Crustaceae and Rotifera among the periphyton families in the pond during their studies on effects of periphyton substrates and addition of fresh water prawn *Macrobrachium rosenbergii* in Bangladesh. In the present study however, the periphyton families such as Crustaceae and Dinophyceae were not encountered. The differences observed here might have been related to addition of cow dung as manure to the pond water by Uddin *et al* (2003), while in the present study, chicken droppings were used. Different species of phytoplankton and attached algae are known to respond differently to certain manures and fertilizers than others causing them to become dominant (Ekpenyong, 2006; Ekpenyong & Adenyi, 1996), while some become abundant (Edward, 1993; Edward *et. al.*, 1994; Huchette *et.al.*, 2000; Job *et al.,* 2011).

The distribution pattern of the periphyton families took the pattern: Chlorophyceae > Cyanophyceae > Bacilloriophyceae> Chrysophyceae > Euglenophyceae > Protozoa > Rotifera. A result which agrees with those of (Uddin *et. al.,* 2003, Milstein *et. al.,* 2003, 2005, 2008).

The colonization of the substrate by both algae and sessile zooplankton as observed in this study was also reported by Dempster *et. al.,*(1993), and took the distribution pattern reported here. Periphyton is known to play a vital role in providing food for fish and other fauna in natural and controlled environment (Suat & Alev, 2005). Jones *et. al.*, (1997) reported of a wide range of fish and benthic invertebrates including snails, chiromids, mayflies, oligochaetes and several groups of crustaceans that includes periphyton in their diet (Suat & Alev, 2005). There is a common assumption that the phytoplankton community is the most important in terms of energy fixation and fueling of aquatic food web. Research has however shown that macrophyton and periphyton are significant and often the dominant contributor to primary production.

Considering the periphyton species composition in the ponds under study, one could in ecological point of view, maintain that fish species such as *Oreochromis niloticus* which is a planktivorous species can do well in fish yield to compensate for the high cost of feed usually encountered by local fish farmers. Similar observations were made in Israel (Milstein *et al.*, 2003, 2005), and in Bangladesh (Azim *et al.,* 2001, 2002, 2004). Again in Israel, species such as Tilapia, Mullet, Grass carp, Hybrid carp, Red drum, and Common carp have been commercially raised using periphyton (Milstein *et al.*, 2003).

Generally, in conventional fish ponds, the dominant autotrophic organisms are the planktonic algae (Milstein *et. al.*, 2005). The activity of planktonic algae occurs in the upper water layers while heterotrophic activity takes place mainly in the pond bottom (Milstein *et al.,* 2003, 2005). In periphyton-based aquaculture ponds as further reported by Milstein (2005), the addition of rigid surfaces into the oxygenated water column allows the development of attached autotrophic and heterotrophic populations, besides phytoplankton and bottom micro-organisms.

The use of bamboo as rigid surface in the present study gave similar result recorded by Milstein *et al.,* (2005) in Israel who reported the presence of Cyanophyceae, Chlorophyceae, Protozoa, Bacillariophyceae and Rotifera. They also reported Chlorophyceae as the dominant periphyton group in their ponds. The dominance of Chlorophyceae among the peripyton was also reported by Uddin *et. al.,* (2003) which agrees favourably with the present study.

4. Conclusions

Studies were conducted on diversity and species composition of periphyton in the University of Calabar Fish Farm, Nigeria using samples obtained from bamboo substrates. The success of periphyton–based aquaculture is depended on the premise that planktivorous fish species are able to graze on the highly nutritious attached autotrophic and heterotrophic populations, besides phytoplankton and bottom micro-organisms in the aquatic system. It was shown that by enhancing periphyton growth the fish production in earthern pond systems increased substantially, without a need for more fertilizers or feeds. This makes the technique interesting for resource poor farmers, if cheap substrates can be found and labor demand becomes not excessive.

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