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The Potential Suitability of Nocturnally Occurring Plankton Flora in Earthen Freshwater Nursery Ponds

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Abstract: Many microfloral factors of the fish nursery ecosystem act to the favour or detriment of fish larvae at night. In this experiment, 2 replicates each of three treatment freshwater ponds were tested with varying nutrient regimes to assess their impact on phytoplankton populations at night. The first treatment-A (200 m^2 surface area supplied 70 kg ha^{-1} $month^{-1}$ pig manure only), treatment-B (200 m^2 surface area supplied 70 kg ha^{-1} $month^{-1}$ pig manure, 50 kg ha^{-1} $month^{-1}$ N.P.K [15:15:15] and 30 kg ha^{-1} $month^{-1}$ Urea) and Treatment-C (1500 m^2 surface area supplied 1150 kg ha^{-1} $month^{-1}$ commercial grade 40% crude protein compounded feed). Water replenishment for Treatment A was daily tidal deluge from the New Calabar River while that for treatment B and C was from column well and occasional rains. For 6 months, 36 contrasting phytoplanktons were nocturnally encountered in the whole experiment. Economically important pond flora such as *Coelastrum microporum*, *Pediastrum tetras*, *Scenedesmus quadricauda* were obtained from all treatments while singular occurrences were *Coelastrum proboscigera*, *Closterium venus*, *Chlamydomonas olifanii*, *Merismopedia glauca*, *Cyclotella striata* and *Melosira italica* (treatment-A); *Closterium reticulum*, *Closterium macilentum*, *Pleodorina carlifornica*, *Scenedesmus acuminata*, *Treubaria triappendiculata*, *Aphanotheca clathrata*, *Gleocapsa limnetica*, *Microcystis pulverea* and *Spirulina gracile*, *Trachelomonas hispida*, *Cyclotella antiqua*, *Fragillaria intermedia*, *Melosira varians* and *Tribonema viride* (treatment-B); *Selenastrium bibriaianum*, *Volvox globator*, *Spirulina principes*, *Euglena wangi*, *Phacus longicauda*, *Phacus pleuronectes* and *Synedra ulna* (treatment C). These indicate their potential mono- and polyculture as well as the varying nutritional and ecological fortune derivable from these nutrients in practice.

Key words: Phytoplankton, nocturnal, suitability, algal feed, earthen freshwater, nursery ponds

INTRODUCTION

Various reasons have been advanced for the use of different fertilization regimes in earthen freshwater nursery ponds. While some of these reasons sound critical others range from the incidental to the consequential (Szumiec, 1985a). Evidence abounds that the ultimate effect of nursery pond fertilization is primary productivity, increase in dissolved oxygen and eventually attraction of live-feed organisms to the pond (Urbaniec, 1985a). Often than not however, eutrophication of the nursery pond space occur to the detriment of fish larva and the commercial venture of bearing them, especially at night.

Till date no exact model exists detailing a single pattern of the combination of environmental and pond management factors that leads to the desirable culture of algae in primary production that gives rise to the optimal culture of zooplankton live feed in earthen freshwater ponds (Szumiec, 1985b). The situation is further worsened by the scarcity of information on what is the long-term composition; relative abundance, trophic and ecological implication of the plankton flora generated by the various pond fertilization regimes in common use in Nigeria. Though it is common knowledge that some phytoplanktons, if even inadvertently, are included in the diet of freshwater fish larvae (Zagarese, 1988). This is notwithstanding the fact that autotrophs amongst them help to increase dissolved oxygen in the daytime (Urbaniec, 1985b) yet little is known about their suitability in the nursery pond at night.

This study examined the potential suitability of the phytoplankton compositions in the different nutrient regimes in popular use in Nigeria with a view to identifying which of these regimes is best suited to raising algal feed and what could encourage better larval fish health as a consequence of what happens to fish fry during night time after stocking in the day time.

MATERIALS AND METHODS

Study area: The 82 hectare sized fish farm of the African Regional Aquaculture Centre (ARAC) at Aluu, Port

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Harcourt, Rivers State of Nigeria was the study area chosen for this experiment. Three types of freshwater earthen ponds in two replicates each were selected with treatments (A) and (B) being of 200 m^2 surface area while treatment (C) had a surface area 1500 m^2. Treatment A was linked to a tidal channel to the New Calabar River for regular water renewal and deluge apart from occasional rain. For the other two treatments (B and C), separate column well water replenishment were obtained.

Nutrient regime: Nutrient regime supply for treatment (A) was organic fertilizer: 900 kg ha^{-1} $month^{-1}$ of fresh pig manure only; treatment (B) was combined organic and inorganic fertilizers: 750 kg ha^{-1} $month^{-1}$ piggery manure, 300 kg ha^{-1} $month^{-1}$ N.P.K (15:15:15) with 50 kg ha^{-1} $month^{-1}$ Urea while the third treatment (C) was supplied 1150 kg ha^{-1} $month^{-1}$ (40% crude protein) of commercial compounded feed (ARAC grade catfish fry feed the Branblo).

Sample collection: A one-litre glass beaker was used to collect one liter of water from ten randomly chosen points from the pond periphery and towards the centre at a depth of not more than 30 cm from the pond surface. All samples collected were added up in a 15 l plastic bucket with care taken not to waddle in the pond to collect samples. The water was then strained through a twenty-five micrometer mesh-sized plankton concentration net with only a 100 mL of these samples fixed in four drops of four percent (4%) lugol's iodine solution.

Phytoplankton identification and enumeration: Sample preparation, examination and enumeration were as described by APHA (1985) and Pennak (1986) while phytoplankton identification followed the methods of Han (1981).

Ecological parameters: The phytoplankton species encountered in this study were itemized in a table while indicating their individual frequencies of occurrence and relative abundances as well as the aggregate spatial distribution of the taxa to which they collectively belong. The frequency of occurrence inversely measured the unique encounter of a given phytoplankton species across all the treatments, relative abundance measured comparatively the number of cells mL^{-1} of one phytoplankton species to the others; while spatial distribution comparatively measured the number of species of a given class of phytoplankton encountered across all treatments as an indication of their suitability in generating known live feeds.

The following methods were used to calculate the parameters:

- The frequency of occurrence for a given species = number of treatments in which the species occurred/total number of treatments.
- Relative abundance for a given species was as ranked below in the legend under Table 1 in the results.
- The spatial taxa distribution for a taxon (%) = total number of species of a taxon in a treatment/total number of species of that taxa in all three treatment × 100.

RESULTS

Phytoplankton species composition

Chlorophyta: The species composition for chlorophytes in the pig-manure only treatment was *Coelstrum microporum*, *Coelastrum proboscigera*, *Closterium venus*, *Pediastrum duodenarium*, *Pediastrum tetras*, *Chlamydomonas olifanii* and *Scenedesmus quadricauda* while those in the combined fertilization treatment were *C. microporum*, *Closterium reticulum*, *Closterium macilentum*, *P. tetras*, *Pleodorina carlifornica*, *Scenedesmus acuminata*, *Scenedesmus quadricauda* and *Treubaria triappendiculata*. Those species in the compounded feed treatment were *C. microporum*, *Pediastrum duodenarium*, *Pediastrum tetras*, *S. quadricauda*, *Selenastrum bibriaianum* and *Volvox globator* (Table 1).

Cyanophyta: There were fewer species of the cyanophytes in all the treatments compared to those of the chlorophytes. The species composition for the pig-manure treatment was *Gleocapsa minima* and *Merismopedia glauca*, while those in the combined fertilization treatment were *Aphanotheca clathrata*, *Gleocapsa limnetica*, *G. minima*, *Microcystis pulverea*, *Spirulina major* and *Spirulina gracile*. The only two species in the compounded feed treatment were *S. major* and *Spirulina principes* (Table 1).

Euglenophyta: The only Euglenophyta in the pig-manure treatment was *Trachelomonas similis* while those in the combined fertilization treatment were *T. similis* and *Trachelomonas hispida* and those in the compounded feed treatment were *Euglena wangi* and *Phacus longicauda* and *Phacus pleuronectes* (Table 1).

Bacillariophyta: There were only three bacillariophyte species in the pig-manure treatment and those were

Table 1: The phytoplankton species composition, relative abundance and frequency of occurrence in nocturnal pond water sample collections from the three treatments

	Treatments			
Taxa species composition	Pig-manure only	Combined fertilization	Compounded feed (40% C.P)	Frequency of occurrence (%)
Chlorophyta				
Coelastum microporum	xxx	xxx	xx	100
Coelastrum proboscigera	x^{r}	a	a	33.3
Coelastrum reticulum	a	xxx^{r}	a	33.3
Closterium venus	x^{r}	a	a	33.3
Closterium macilentum	a	xx^{r}	a	33.3
Pediastrum duodenarium	xx	a	x	66.7
Pediastrum tetras	xx	xx	xx	100
Pleodorina carlifornica	a	x^{r}	a	33.3
Chlamydomonas olifanii	xx^{r}	a	a	33.3
Scenedesmus acuminata	a	xxx^{r}	a	33.3
Scenedesmus quadricauda	xxxx	xxx	xx	100
Selenastrum bibriaianum	a	a	x^{r}	33.3
Treubaria triappendiculata	a	x^{r}	A	33.3
Volvox globator	a	a	x^{r}	33.3
Total number of species	7	8	6	
Cyanophyta				
Aphanotheca clathrata	a	x^{r}	a	33.3
Gleocapsa limnetica	a	xxxx^{r}	a	33.3
Gleocapsa minima	xx	xx	a	66.7
Merismopedia glauca	xx^{r}	a	a	33.3
Microcystis pulverea	a	xxx^{r}	a	66.7
Spirulina major	a	xx	x	33.3
Spirulina principes	a	a	x^{r}	33.3
Spirulina gracile	a	xx^{r}	a	
Total number of species	2	6	2	
Euglenophyta				
Euglena wangi	a	a	xx^{r}	33.3
Phacus longicauda	a	a	xx^{r}	33.3
Phacus pleuronectes	a	a	x^{r}	33.3
Trachelomonas similes	xx	x	a	66.7
Trachelomonas hispida	a	xxx^{r}	a	33.3
Total number of species	1	2	3	
Bacillariophyta				
Coscinodiscus lacustris	a	xxx	xx	66.7
Cyclotella antiqua	a	xx^{r}	a	33.3
Cyclotella striata	xx^{r}	a	a	33.3
Fragillaria intermedia	a	x^{r}	a	33.3
Melosira italica	x^{r}	a	a	33.3
Melosira varians	a	xx^{r}	a	33.3
Nitzschia paradoxa	xx	a	xx	66.7
Synedra ulna	a	a	xx^{r}	33.3
Total number of species	3	4	3	
Xanthophyta				
Tribonema viride	a	x^{r}	a	33.3
Total number of species	0	1	0	

*Phytoplankton enumeration and relative abundance rankings: x = 1-15 cells mL^{-1} (sparsely abundant), xx = 16-63 cells mL^{-1} (fairly abundant), xxx = 64-225 cells mL^{-1} (very abundant), xxxx = 256-1024 cells mL^{-1} (most abundant), a = Species absent not encountered in entire enumeration, ^{r} = Rare species occurrence and only encounter in the entire enumeration

Coscinodiscus striata, *Melosira varians* and *Nitzschia paradoxa*, while those in the combined fertilization were *Coscinodiscus lacustris*, *Cyclotella antiqua*, *Fragillaria intermedia* and *Melosira varians*. There were three species in the compounded feed treatment and these were *C. lacustris*, *N. paradoxa* and *Synedra ulna* (Table 1).

Xanthophyta: The only xanthophyte species encountered in the whole experiment was *Tribonema viride* and it was found in the combined fertilization treatment (Table 1 and Fig. 1).

Relative abundance of species: There was equal relative abundance of *C. microporum* in the pig-manure and combined fertilization treatments (very abundant) while *Scenedesmus quadricauda* had the highest relative abundance (most abundant) in the pig-manure treatment than in the other 2 treatments. However, amongst the chlorophytes *Pediastrum tetras* had same relative abundance across the three treatments being fairly abundant (Table 1).

G. limnetica was most abundant in the combined fertilization treatments, *G. minima* was fairly abundant in

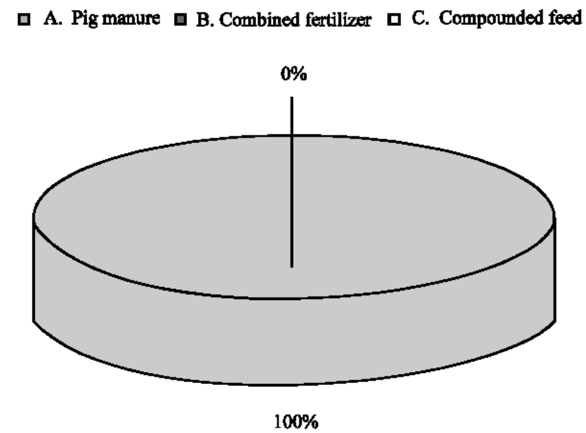

Fig. 1: Spatial distribution of Xanthophyte species in the three treatments

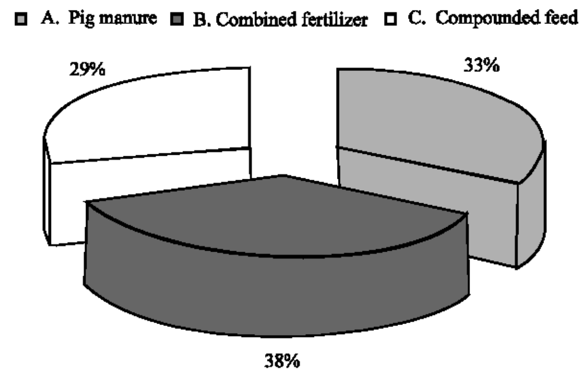

Fig. 2: Spatial distribution of Chlorophyte species in the three treatments

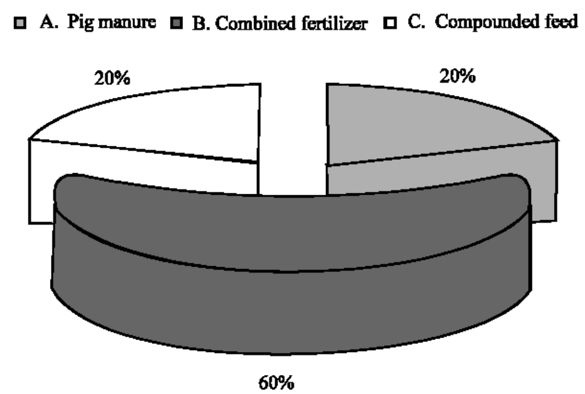

Fig. 3: Spatial distribution of Cyanophyte species in the three treatments

the pig-manure and combined fertilization treatments. *Microcystis pulverea* was very abundant in the combined fertilization treatment while *E. wangi* and *Phacus longicauda* were fairly abundant in the compounded feed treatment.

Coscinodiscus lacustris was very abundant in the combined fertilization treatment while *Cyclotella antiqua* and *M. varians* were fairly abundant in the combined fertilization treatment just as *C. striata* was fairly abundant in the pig-manure treatment. *N. paradoxa* and *S. ulna* were fairly abundant in the compounded feed treatment. *T. viride* was fairly abundant and occurred only in the combined fertilization treatment.

Frequency of occurrence

Chlorophyta: The chlorophyte species that occurred singularly in a given treatment with a 0.33 frequency of occurrence were *Coelastrum proboscigera*, *Closterium venus* and *Chlamydomonas olifanii* (pig-manure only treatment); *Coelastrum reticulum*, *Closterium macilentum*, *Pleodorina carlifornica*, *Scenedesmus acuminata* and *Treubaria triappendiculata* (combined fertilization treatment); *Selenastrum bibriaianum* and *V. globator* (compounded feed treatment) (Table 1).

Cyanophyta: *Merismopedia glauca* occurred only in the pig-manure treatment while the singular occurrences in the combined fertilization treatment were *A. clathrata*, *G. limnetica*, *Microcystis pulverea* and *Spirulina gracile* while *S. principes* occurred only in the compounded feed treatment (Table 1).

Euglenophyta: *Trachelomonas hispida* occurred only in the combined fertilization treatment while *E. wangi*, *Phacus longicauda* and *P. pleuronectes* occurred only in the compounded feed treatment (Table 1).

Bacillariophyta: *Cyclotella striata* and *Melosira italica* were recovered from only the pig-manure treatment while *C. antiqua*, *F. intermedia* and *M. varians* were recovered from only the combined fertilization treatment. The only occurrence of *Synedra ulna* was in the compounded feed treatment (Table 1).

Spatial taxa distribution: The temporal taxa distribution is a measure of the fraction of the number of species of a taxon across the treatments in percentages. This shows a comparative species yield for each of the treatments.

For example, Fig. 2 showed that the combined fertilizer treatment had the highest number of chlorophyte species followed by the pig-manure and the compounded feed treatment. For the cyanophytes, the combined fertilizers treatment also had the highest species count, however, there were equal number between those of the pig-manure and combined fertilizers (Fig. 3).

The euglenophyte species in the compounded feed treatment was the highest with pig manure coming next (Fig. 4). The combined fertilizer treatment had the

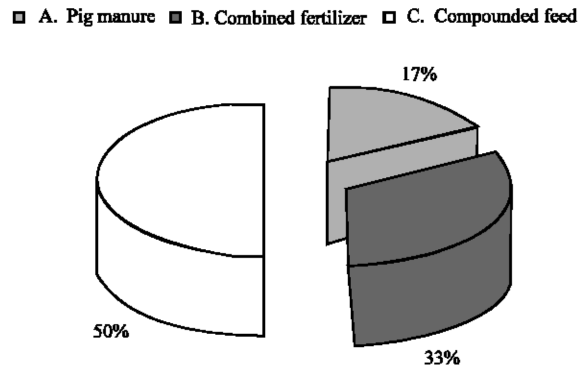

Fig. 4: Spatial distribution of Euglenophyte species in the 3 treatments

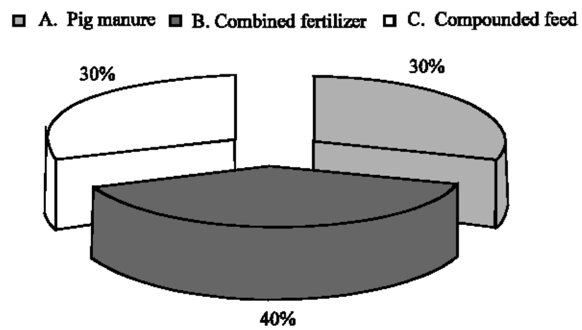

Fig. 5: Spatial distribution of Bacillariophyte species in the 3 treatments

highest bacillariophyte species count while the other two treatments had equal numbers of bacillariophyte species (Fig. 5).

DISCUSSION

The response of algae to sunlight and darkness with regards to photosynthesis and respiration follows a universal pattern. Congruence is struck between these patterns and those of organisms that graze on them. In the normal course of pond fertilization and mineralization in the daytime, proper exposure of the pond surface to solar radiation ensures photosynthesis of most or all the available phytoplankton leading to an increase in dissolved oxygen. This continues to be the situation until eutrophication results into massive shading of the pond leading to zonation and microvegetational succession amongst the various classes of plankton flora. The ultimate return of metabolic waste and organic decay to the water column conserves all chemical inputs to the biocoenosis (Goldman, 1979). Though the temperature condition of all the experimental ponds followed a similar trend (Akinwale and Ansa, 2005) yet the variation in nutrient supply showed a marked effect on the phytoplankton communities encountered in each case. Accordingly, a good working knowledge of the diurnally and nocturnally dominant plankton flora in earthen freshwater ponds would lead to a more productive harvest of pond water for the best quality algal feed for fish larvae or live feed nutrition in aquaculture. For this reason if the temperature, pond size and structure and nutrient supply profile remain similar, it would be possible to diagnose the occurrence and relative abundance of these species with a view to improving their sub-culture. In the current study, more chlorophyte species occurred than were encountered in the diurnal experiment by Akinwale and Ansa (2005) with even, 8 and 13 species encountered in the pig manure, combined fertilization and compounded feed treatments respectively in the nocturnal experiment as compared to 5, 6 and 12 species in the diurnal experiment. This runs against the expectation that photosynthesis in the daytime should have compelled more chlorophyll-bearing organisms to dominate the pelagic environment diurnally.

The spatial distribution indicated that the combined fertilization treatment produced more number of chlorophyte species than in the other 2 treatments. This could have been because the immediate availability of inorganic nitrates and phosphate in the pond encouraged the growth of chlorophyte species in concordance with previous studies by Mur (1977) and Becker (1986) until such a time when most of the pond surface would have been overtaken by these algae. At this point of threshold nutrient exploitation and diminishing recycle of accessory factors of pond life, cyanophytes considerably succeed chlorophytes in dominating the plankton flora immediately the latter begins its decline. On the other hand, the pig-manure treatment which was also better endowed than the third treatment in readily dissolving and putrefying nutrients also aroused the growth of more chlorophyte species than in the compounded feed treatment as shown in Fig. 1. These events are in agreement with the results of studies by Becker (1986) and Pullin (1987) that showed chlorophyte species as belonging to the r group of algae that bloom upon pulsed increase in high quality manure in contradistinction with the k group of algae such as the cyanophyte species that bloom and burst the response to low quality of manure.

However, since the algal feed in contemporary use are mainly chlorophytes such as *Platymonas suecica*, *Chlorella* sp., for feeding *Brachionus plicatilis*

(Gatesooupe and Robin, 1981) *Scenedesmus costa-granulata* used for feeding *Brachionus rubens* (Schluter and Groeneweg, 1981), *Dunaliella tertiolecta, Platymonas* sp., *Monochrysis lutheri, Isochrysis galbana* used in mariculture (Spectorova *et al.*, 1981), *Scenedesmus obliquus* (Becker, 1984), *Chlorella fusca* (Issa *et al.*, 1994) and *Chlorella virginica* as algal feed for the rotifer and live feed, *Brachionus,* (Duray *et al.*, 1997) it would be necessary to examine possible candidates in this experiment. Other examples are the cyanophyte species *Spirulina* sp., (Gatesoupe and Robin, 1981; Becker, 1984).

Coelastrum microporum, Pediastrum tetras, Scenedesmus acuminata, S. quadricauda, Selenastrum bibriaiamum, Chlamydomonas olifanii, belong to the non-flagellate, unicellular and free-living green-algae Order Chlorococcales to which all the chlorophyte algal feed above belong. The attributes that make them suitable as algal feed are rapid growth rate, high protein and vitamin content, lack of a thick cell wall, being amenable to simple filtration because they are free floating or flagellated and would therefore not sink to the bottom of culture tank (Spectorova *et al.*, 1981; Becker, 1986).

However, a closer look at these plankton show that only *Scenedesmus acuminata, S. quadricauda, C. olifanii,* (chlorophytes) and *Spirulina major* and *S. principes* (cyanophytes) can be recommended as candidate algal feed. This is because *Coelastrum. microporum* is too mucilaginous and may impede digestibility, *P. tetras* possess calcareous spicules that may make mastication by foraging organism of the next trophic level difficult while *Selenastrum bibriaianum* is equally too sickle-shaped and unwieldy to ingest. The spine on *Scenedesmus* sp. easily detach and are biodegradable. Coleman and Edwards (1987) also found *Microcytis* sp., to be more easily digestible to Tilapia than the chlorophytes.

CONCLUSION

In regard of the above research findings it is recommended that earthen freshwater nursery ponds for raising finfish and shell fish larvae or those for the extensive culture of algal feed as live food organisms be fertilized with both organic and inorganic fertilizers. This is because of the relatively higher abundance of the candidate chlorophyte and cyanophyte phytoplankton available as food for fish in ponds fertilized with both forms of fertilizers.

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