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Comparative Effect of Different Stocking Densities of Heteroclarias on Plankton Abundance in Tarpaulin Tanks

Ofonime Edet Afia, Gift Samuel David*, and Imoh Bassey Effiong

Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, PMB 1017, Nigeria.

***Corresponding Author:** Gift Samuel David, Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, PMB 1017, Nigeria.*

ABSTRACT

The effect of different stocking densities of hybrid catfish (Heteroclarias) on plankton abundance in tarpaulin tanks was studied for a period of six (6) months (January – June 2016). The study employed Complete Randomized Design (CRD) experimental design. Five different stocking densities (treatments) were employed (T_1 = 100fish/m^2, T_2 = 75fish/m^2, T_3 = 38fish/m^2, T_4 = 18fish/m^2 and T_5 = 9fish/m$^{2)}$. These were replicated three times. Filtration technique was employed. Mesh size plankton net (25µm) was used to filter 10L depth integrated water samples. The water samples (net content) were emptied into a wide mouth plastic container and preserved in 5% formalin solution after proper labeling. The samples were then taken to the laboratory and were allowed to stand for at least 24hrs in the laboratory for the plankton to settle. The samples were pipetted (1ml sample) with sample pipette. The content was placed in a Sedgewick-Rafter plankton-counting chamber and examined under a magnification of 500× and 1000×. The plankton were identified, enumerated and total number of species were also recorded using keys and check lists. For phytoplankton, a total of eighty-three (83) species belonging to six (6) taxonomic groups were observed in the experimental tanks. Bacillariophyceae occurred highest and was represented by thirty-six (36) species. Chrysophyceae and xanthophyceae occurred least with one (1) species respectively. For zooplankton, a total of twenty (20) species belonging to four (4) taxa were identified during the study. Cladocera occurred highest with nine (9) species, while protozoa occurred least with two (2) species. T_5 (9fish/m^2) had the highest abundance of phytoplankton and zooplankton. T_1 (100fish/m$^{2)}$ had the least abundance of phytoplankton and T_2 (75fish/m^2) had the lowest abundance of zooplankton. Therefore, a stocking density of 9fish/m^{2}of heteroclarias is optimal and is recommended in order to maintain better plankton presence and good environmental condition.

Keywords: *Heteroclarias, hybrid catfish, phytoplankton, zooplankton, stocking density*

INTRODUCTION

Aquaculture is the rearing of fish and other aquatic organisms in man-made ponds, reservoirs, cages or other enclosures in lakes and coastal waters[1]. Aquaculture practices in Nigeria have increased drastically as seen in other parts of the world because of the increasing demand on fish protein. FAO[2] report shows that global total fisheries production (excluding aquatic plants) reached 167.2 million tonnes in 2014, with 93.4 (55.86%) million tonnes from capture and 73.8 (44.14%) million tonnes from aquaculture. Nigeria accounted for 0.42% of global aquaculture production in 2014 [2]. In Nigeria, getting fast growing fish seed have been a major problem to farmers targeting high yields. Hybrid catfish production has increased rapidly in the last few years and apparently market demand is still increasing. Among the culturable finfish in Nigeria, catfish is the most sought after fish species, very popular with fish farmers and consumers; it commands very good commercial value in Nigerian markets [3].

Heteroclarias is an inter-specific hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis* which transfer or combine desirable traits of the two species [4-5]. Hybridization is one of the genetic improvements in aquaculture industry which has been recognized as a tool for stock improvement and management purposes. Several studies have demonstrated that *Clarias gariepinus* × *Heterobranchus bidorsalis* hybrid exhibit superior growth, improved survival and general hardiness than true breed of either *Clarias gariepinus* or *Heterobranchus bidorsalis* [6-9]. These hybrids have been reported to show heterosis which makes it a very good aquacultural candidate [10-11]. The hybrid of *Heterobranchus bidorsalis* and *Clarias gariepinus* is a voracious omnivore, feeding on a wide range of food from live animal prey through aquatic plants to plankton organisms [9]. Heteroclariasfish culture in ponds started in Nigeria in 1973 and the fish combines the fast growth traits of *Heterobranchus* species and early maturing traits of *Clarias gariepinus* [12]. The technology was widely accepted as it gave 58% internal rate of return (IRR) on investment [12]. Fish culture with particular reference to *Heteroclarias* has become an important sector in terms of its potential for contributing to food and family income. It is very profitable as a result of their high resistance against diseases and environmental stress [13]. The blending of high survival rate and fast growth rate in the hybrid catfish (Heteroclarias) offers higher production prospects.

Plankton is the collective name for certain organisms (mostly microscopic) that drift in the oceans, lakes, rivers and other bodies of water. Plankton have a tremendous importance in the web of life on earth[14]. They are primarily divided into broad (functional groups) or tropic levels which phytoplankton photosynthesize to convert sunlight into chemical energy for life; zooplankton which feed on the phytoplankton or other zooplankton and bacterioplankton, mainly decompose the remains of other organisms[14]. Phytoplankton are grouped into cyanobacteria (blue-green algae), diatoms, Chlorophyceae, dinoflagellate and seaweeds etc. Zooplankton are also grouped into copepods, protozoa, krill, jelly fish and larva etc.In any aquatic ecosystem, plankton are an integral part and play a basic role in the food web [15]. These populations form the basic link in the food chain of all aquatic animals [16]. Algal as well as plankton are one of the most helpful indicators of water quality due to their rapid response to environmental changes related to larger animals and plants. Therefore, a true knowledge of abundance of phytoplankton and its quality in time and space in relation to environmental condition has become a prerequisite for higher fish production.

Fish stocking density is the most sensitive factor determining the productivity of a culture system as it affects growth rate, size variation and mortality [17]. The full utilization of space for maximum fish production through intensive culture can improve the profitability of the fish farm. Fish intensification by increasing stocking density is also found suitable to overcome the problem of land shortage [18]. Fish density may be an important determinant of growth or survival through competition for prey resources [19]. Stocking density is one of the main factors determining the growth [20-21] and the final biomass harvested [22]. Environmental variables, farming conditions and food availability are other factors that can affect fish growth[1]. In terms of the fish production in aquaria, stocking density which is related to the volume of water or surface area per fish is an important factor. Increase in stocking density results in increasing stress, which leads to higher energy requirements, causing a reduction in growth rate and food utilization[1]. Contrarily, in case of low stocking densities fish may not form shoals/group together and feel comfortable. Consequently, identifying the optimum stocking density for a species is a critical factor not only for designing an efficient culture system, but for optimumhusbandry practices[1].

Studies on stocking density and its effect on growth performance of cultured species are limitless. In addition, studies [23-25] on the influence of stocking density on growth performance of heteroclarias (hybrid catfish) abound. Several authors [21, 26-32] have also investigated relationship between fish species and plankton abundance. However, there is limited information on the effect of stocking density of heteroclarias on plankton abundance in a culture medium.

The objective of this paper is to examine the effect of different stocking densities of heteroclarias(hybrid catfish) on plankton abundance in tarpaulin tanks.

Materials And Methods

Study Area

The experiment was carried out at the Fish Hatchery complex of Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Akwa Ibom State, Nigeria. The area lies between latitudes 4°52' S and 4°51' N and longitudes 7°54' W and 8°03' E. The experiment was conducted for a period of six months (January to June 2016) using fifteen tarpaulin tanks of 1 M^3 volume.

Experimental Design And Procedures

The study employed Complete Randomized Design (CRD) experimental design. Fifteen tarpaulin tanks measuring 1×1×1 m^3 were used. Each was designed with an outlet for easy drainage. Five different stocking densities (treatments) were employed (T_1 = 100fish/m^2, T_2 = 75fish/m^2, T_3 = 38fish/m^2, T_4 = 18fish/m^2 and T_5 = 9fish/$m^{2)}$. These were replicated three times. The fingerlings of *Heterobranchus longifilis* × *Clarias gariepinus* (hybrid catfish) used was obtained from abreeding exercise using two broodstock females and two broodstock males according to method of Ngugi et al. [33]. The selection of brood fish was based onexternal morphology and eggs characteristics.The initial weight of the fingerlings (2.06 ± 0.48 g) was taken before stocking them in the various tanks whichwere randomly positioned.The fish was fed three times daily using commercial feed at 3% body weight.The feed was adjusted monthly with increase in body weight. Water exchange was carried out monthly after plankton sampling.

Sampling

Qualitative estimates of plankton in the experiment tanks were taken monthly. Plankton samples were collected by filtering 10L of depth integrated water samples through a fine-meshed plankton net (35 µm) to obtain a 50ml samples. The water samples (net content)were emptied into a wide mouth plastic container and were preserved immediately with 5% buffer formalin in plastic bottle to preserve the organisms after proper labelling. The samples were then taken to the laboratory and were allowed to stand for at least 24hrs in the laboratory for the plankton to settle. The samples were pipetted (1ml sample) with sample pipette. The content was placed in a Sedgewick-Rafter plankton-counting chamber and examined under a magnification of 500× and 1000×. The plankton were identified, enumerated and total number of species were also recorded using keys and check lists [34-38]. The total number of species encountered per ml for each sample was determined by simple summation after counting and thensorted into each taxonomic group for phytoplankton and zooplankton respectively.

Water Quality Analysis

Water quality parameters of the ponds were monitored monthly throughout the six months. Temperature (°C) was measured with a Celsius thermometer, dissolved oxygen was measured with a DO meter(Hanna product model HI9146) and pH was measured with a direct reading digital pH meter.

Statistical Analysis

Water quality parameters were subjected to one-way analysis of variance (ANOVA) to test for significant difference at 0.05 level. Results with $P \leq 0.05$ were considered significantly different[39]. The statistical analysis was done using IBM SPSS Inc. (Windows version 20.0).

Results

Plankton Structure

Diversity and abundance

The species diversity and relative abundance of both phytoplankton and zooplankton species observed during the study period is presented in Table 1 and Figs. 1 and 2. For phytoplankton, a total of 83 species belonging to six families were identified during the study. Bacillariophyceae was the most dominant group with 36 species. This was followed by chlorophyceae with (22) species, cyanophyceae with (14) species, dinophyceae with (9) species. Xanthophyceae and chrysophyceae had (1) species each. For zooplankton, a total of 20 species belonging to four (4) families were identified during the study. Copepoda recorded the most abundant population among zooplankton with nine (9) species, followed by rotifera (6) species.Cladocera had three (3) species and protozoa with two (2) species.

Bacillariophyceae constituted 43% (highest), while chrysophyceae and xanthophyceae constituted 1% (lowest) respectively of identified phytoplankton. Copepoda constituted 45% (highest), while protozoa made up 10% (lowest) of identified zooplankton.

Table1. *Diversity and relative abundance of plankton species in the experimental tanks*

Phytoplankton	No. of species identified	Relative abundance (%)	Zooplankton	No. of species identified	Relative abundance (%)
Bacillariophyceae	36	43	Protozoa	2	10
Chlorophyceae	22	27	Rotifera	6	30
Cyanophyceae	14	17	Cladocera	3	15
Dinophyceae	9	11	Copepoda	9	45
Chrysophyceae	1	1			
Xanthphyceae	1	1			
Total	**83**	**100**		**20**	**100**

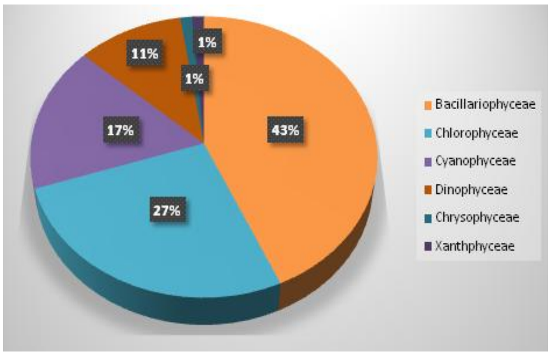

Fig1. *Relative abundance of phytoplankton taxa during the study*

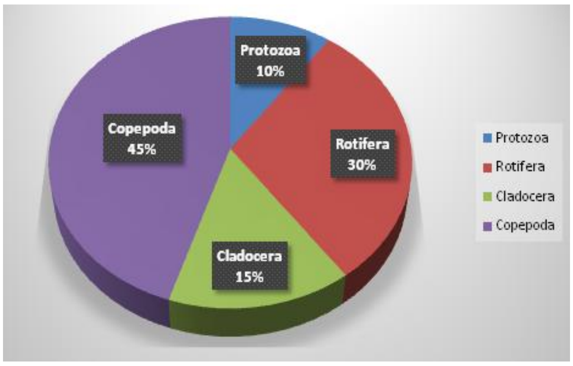

Fig2. *Relative abundance of zooplankton taxa during the study*

Spatial distribution

The spatial distribution of plankton species observed during the study period is given in Table 2 and Figs. 3 and 4. Among the phytoplankton groups, bacillariophyceae was the most dominant in all the treatments. Bacillariophyceae occurred 26 times (highest) in T_5 and 14 times (lowest) in T_2. Chlorophyceae was identified 11 times (highest) in T_5 and 4 times (lowest) in T_1 and T_3 respectively. Cyanophyceae occurred 11 times (highest) in T_4 and 5 times (lowest) in T_5. Dinophyceae was highest (5) in T_2 and T_4 respectively and lowest (1) in T_2. Chrysophyceae was highest (1) in T_1 and T_5 and lowest (0) in T_2,T_3 and T_4. Xanthophyceae was highest (1) in T_3 and T_5 and lowest (0) in T_1, T_2 and T_4.In the zooplankton groups, copepoda occurred 5 times (highest) in T_5 and 0 times (lowest) in T_4. Rotifera occurred 4 times (highest) T_5 and 0 (lowest) times in T_2 and T_3. Cladocera occurred 3 times (highest) in T_4 and 0 times (lowest) in T_1, T_2 and T_3. Protozoa was identified once in T_1 and T_3 and none in T_3, T_4 and T_5.

In all, the trend in total number of phytoplankton species were observed as follows:T_5 (48) >T_3 (45) >T_4 (44) >T_1 (44) >T_2. In zooplankton species, the trend was as follows: T_5(10) >T_1 (8) >T_4 (4) >T_3 (3) >T_2 (2).

Table2. *Spatial distribution of plankton during the study (number of species per ml)*

Phytoplankton	**Trmt 1**	**Trmt 2**	**Trmt 3**	**Trmt 4**	**Trmt 5**
Bacillariophyceae	24	14	28	19	26
Chlorophyceae	4	5	4	9	11
Cyanophyceae	9	7	8	11	5
Dinophyceae	5	1	4	5	4
Chrysophyceae	1	0	0	0	1
Xanthphyceae	0	0	1	0	1
Total	43	27	45	44	48
Zooplankton					
Copepoda	4	2	2	0	5
Rotifera	3	0	0	1	4
Cladocera	0	0	0	3	1
Protozoa	1	0	1	0	0
total	8	2	3	4	10

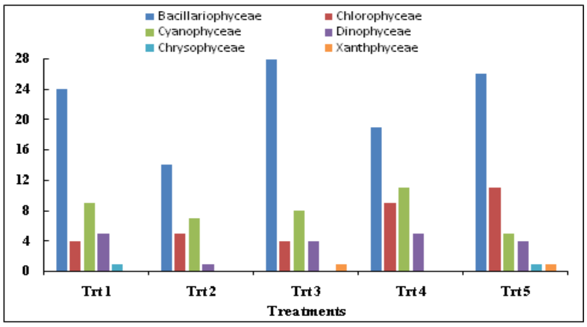

Fig3. *Spatial distribution of phytoplankton communities during the study*

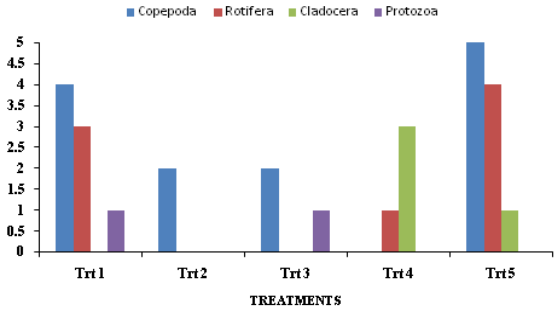

Fig4. *Spatial distribution of Phytoplankton communities during the study*

Water Quality Andplankton Monitoring

Table 3 shows the mean, minimum and maximum values of water quality parameters observed during the study. Temperature was significantly ($p<0.05$) higher in (T_5) than those in (T_1, T_2, T_3, and T_4) which showed no significant difference ($p>0.05$) among them.

The mean pH value showed no significant ($p>0.05$) differences among the observed treatments. However, numerically T_4 was highest and T_3 lowest. Mean dissolved oxygen (DO) level was significantly higher ($p<0.05$) in T_5than T_2 and T_3 ($p>0.05$) and T_1 andT_4 ($p>0.05$).

Table3. *Physico-chemical properties observed during the study*

Parameters	Treatment 1 Mean ± SD (Min – Max)	Treatment 2 Mean ± SD (Min – Max)	Treatment 3 Mean ± SD (Min – Max)	Treatment 4 Mean ± SD (Min – Max)	Treatment 5 Mean ± SD (Min – Max)
Temperature (°C)	$25.70±2.52^a$ (23.00-29.80)	$25.79±2.50^a$ (23.00-23.30)	$25.89±2.68^a$ (23.50-23.30)	$25.74±2.64^a$ (22.80-29-70)	$26.17±2.13^b$ (23.10-29.60)
pH	$7.48±0.96^a$ (6.23-8.88)	$7.62±0.88^a$ (6.06-8.81)	$7.29±0.72^a$ (6.21-8.66)	$7.49±1.64^a$ (2.27-8.98)	$7.34±0.99^a$ (6.03-8.78)
DO (mg/l)	$4.84±0.49^b$ (3.67- 5.81)	$4.33±0.39^{ab}$ (3.81-4.82)	$4.25±0.63^{ab}$ (3.29- 4.76)	$4.66±.86^b$ (3.77-5.43)	$5.54±1.78^a$ (4.61-5.71)

Discussion

Environmental parameters exert a significant influence on the maintenance of a healthy aquatic environment and production of natural food organisms[40]. Feed efficiency, feed consumption and growth of fish are normally influenced by a few environmental factors[41]. The range of temperature (25.70 – 26.17 °C) in the experimental ponds is within the acceptable range for aquaculture [42, 21, 31] and raising of fingerlings of heteroclarias agree well with earlier findings [43, 23, 25].

The dissolved oxygen level was low in ponds stocked with a higher density of fish compared to ponds with low stocking density, that might be due to the higher consumption rate of oxygen by the higher density of fish and other aquatic organisms[30]. Fluctuations in dissolved oxygen concentrations might be attributed to the photosynthetic activity, alteration of cloudy and sunny weather of the monsoon and variation in the rate of oxygen consumption by fish and other aquatic organisms [44]. However, the dissolved oxygen (DO) level was within the acceptable range for fish culture[42, 21, 45]. The pH values agree well with the findings of [42, 46, 21] and are within the range of good water quality for rearing of fry/fingerlings in nursery ponds[46, 45, 47].

Plankton abundance was highest in T_5 and this might be due to lesser stocking densities thanin T_1 – T_4. The higher abundance of plankton in T_5might be due to the lower density of fish than those in other treatments[31]. It seems likely that in the ponds where stocking density was high, consumption of plankton by the fishes was also high. Generally, higher plankton number in water normally indicates higher productivity of the pond[31]. It was found in all the ponds that phytoplankton abundance was consistently higher than zooplankton.Similar results were also reported in various carp and barb nursery ponds [48-50, 46], Mahseerfry [21]. This might be due to excess fertilization, uneaten feed, high rate of supplementary feeding[51-52]and decreased grazing pressure on phytoplankton due to the bottom dwelling and carnivorous nature of heteroclarias[53, 21].

Conclusion

A total of 103 species belonging to ten (10) plankton groups were identified of which 83 genera of phytoplankton belonging to bacillariophyceae (37), chlorophyceae (22), cyanophyceae (14), dinophyceae (9), xanthophyceae (1) and chrysophyceae (1) and a total of 20 genera of zooplankton belonging to rotifera (6), copepod (9), cladocera (3) and protozoa (2). Among the phytoplankton groups, bacillariophyceae was the dominant group in all treatments, while copepoda was the prevailing group among the zooplankton groups.

In the present study, a significantly higher total weight of table size fishwere produced in tanks stocked with 9 fish/m^2 than those from the ponds stocked with 18, 38, 75 and 100fish/m^2 respectively.However, availability of plankton varied among the ponds, being more abundant in ponds stocked at lower densities.The study therefore concludes a stocking density of 9fish/$m^2$of heteroclarias as optimal and suggested in order to maintain better plankton presence and good environmental condition.

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