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Primary productivity and plankton production of poultry waste recycled fish ponds in mid hills

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ABSTRACT

An attempt has been made to assess the impact of poultry integration on primary productivity and plankton production in fish ponds of different farmers of the Champawat district of Uttarakhand state. Experiment was conducted for two integration level of poultry birds (10 and 20 chicks/100m^2) having fish stocking densities 3.0 fish/m^3 in triple replication. Due to the lower thermal regimes in hills, the Plankton volume and density was low, but comparatively zooplankton density was observed in higher side. A total of 17 genera of phytoplankton were recorded including 7 genera of chlorophyceae, most dominant group of algae. A total of 6 species of zooplankton were observed with abundance of rotifers in integrated ponds. The values of GPP were in lower side than that of in tropical condition. Recorded community respiration was 50.8-57.3% of GPP. Integrated pond could sustain higher phytoplankton density and primary production than the non-integrated pond. Hence the recycling of poultry waste is recommended in the mid hills because of its availability, low cost and its direct impact on biological productivity of fish ponds.

***Key words** : Poultry integration, Primary productivity, Plankton, Chlorophyceae, GPP, Recycling.*

Introduction

In integrated poultry-fish farming system, animal excreta are the major source of organic matter and nutrients in the fish ponds and affect the primary productivity and production of natural fish food organisms in the ponds. Nutrients from the chicken sub-system are recycled in the pond and this allows for intensification of production and income while reducing the impact, the disposal of the wastes would have had on the environment (Costa-Pierce, 2002). Direct use of livestock production wastes is one of the most widespread and conventionally recognized type of integrated fish farming and the practice increases the efficiency of both chicken farming and fish culture through the profitable utilization of animal and feed waste products (Little and Edwards, 2003; Nnaji *et al.*, 2009).

Primary production is the elaboration of organic matter from inorganic materials within a certain period of time by autotrophic organisms in the presence of radiant energy. Primary productivity has been used as a potential index for describing the functional aspects of many diverse ecosystems of the world (Wetzel, 1966). In fish ponds, the species richness, density, chlorophyll *a* concentration and primary production of phytoplankton are greatly affected by solar radiation (Efford, 1967), temperature (Rao *et al.*, 1982), pH (Rao *et al.*, 1982), free CO_2 (Mukherjee and Pankajakshi, 1995) and nutrient status of water bodies (Rao and Raju, 1989 and Ayyappan *et al.*, 1990, Kelvin and Musuka, 2012). Algal primary productivity is the driving force behind secondary productivity in aquaculture systems

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stocked with herbivorous fish. It is influenced by the availability of nutrients (Knud-Hansen, 1997) and among a large number of nutrients required to stimulate growth, low concentrations of nitrogen, phosphorus and occasionally carbon are commonly responsible for limiting algal growth (Lin *et al.*, 1997). The phytoplankton presents biological wealth of the water body and form the base of food chain in ponds (Pokorný *et al.*, 2005).

Zooplankton is a principal component of food for omnivorous fish that are usually farmed in extensive aquaculture (Brummett, Noble, 1995). Anyhow the knowledge of composition and abundance is important characteristic that should be taken in account in calculation regarding fertilizing, stocking density and in general pond management. Zooplankton are the grazers of phytoplankton therefore, their population depends on the availability of phytoplankton (Sivakami *et al.*, 1995). The diversity of zooplankton is generally higher in temperate waters as compared to subtropical and tropical waters (Singh *et al.*, 1990 and Rawat, 1991). Light, temperature, dissolved oxygen, nutrient and food are major factors affecting zooplankton abundance (Sivakami *et al.*, 1995).

Organic manures, being less expensive compared to chemical fertilizers, contain all the essential nutrient elements (Jana *et al.*, 2001) and are traditionally applied to fish ponds to release inorganic nutrients which stimulate the growth of plankton (Ansa & Jiya, 2002; Kadri & Emmnuel, 2003). The study of primary productivity in poultry waste recycled ponds focused to address issues about the effect of organic fertilization on water quality, pond productivity and growth of carp (Vromant *et al.*, 2002; Dhawan and Kaur, 2002), the water quality and fish production in ponds with organic fertilization and no fertilization (Nikolova *et al.*, 2008a, 2008b) and the effect of supplemental feeding on water quality and structure of phytoplankton in fertilized earthen ponds (Abdel-Tawwab *et al.*, 2007).

A number of investigations have been carried out on the biological productivity of integrated fish ponds of fresh warm water condition, but the coldwater pond ecosystem is different due to the microclimatic conditions of hills and the findings of biological productivity in this temperate condition are scanty.

Materials and methods

Study area and experiment design

The experiment was carried out for a period of 12 months in different locations of District Champawat in Uttarakhand state (80° 10' E longitude, 29° 60' N Latitude and an altitude of 1750 msaL) at farmers fields. The experiment was designed for two level of poultry integration (10 and 20 nos. /100 m^2). The experiment was performed in triplicates. The ponds having an area of 100 m^2 and 1.0 m water depth with perennial source of water from spring were selected for the present study. Fish seed (2-3 cm size) was stocked in recommended ratio 40:30:30 (silver carp: grass carp: common carp) and fish density of 3.0 fish/m^3 in all ponds. The control ponds C1-C3 were without integration, while T1-T3 were integrated with 10 chicks/100m^2 and R1-R3 were integrated with 20 chicks /100m^2. The poultry cages were fabricated with locally available bamboo or wooden splits and constructed on the dyke of the fish ponds with the proper facility of the waste drainage directly into the pond water.

Sampling and analysis

The primary production in pond water was measured by "light and dark bottle method" (Gaarder and Gran, 1927). The productivity was calculated in

Table 1. Biotic parameters and gross primary productivity (GPP) of integrated and non- integrated fish ponds at Champawat district

Parameters	Non-integrated	Integrated(10 nos.)	Integrated(20 nos.)
Plankton vol. (ml/50L)	0.2-1.6	0.52-2.6	0.4-3.2
Phytoplankton density(nos./L)	200-1678	581-2654	400-3283
Zooplankton density(nos./L)	106-289	139-432	132-442
Macro- invertibrates (nos./m^2)	75-763	88-875	92-1023
GPP (gC/m^3/6hrs)	0.111-.569	0.111-.627	0.110-.679
NPP(gC/m^3/6hrs)	0.124-0.140	0.143-0.156	0.154-0.166
CR(gC/m^3/6hrs)	0.234-0.265	0.268-0.308	0.301-0.326

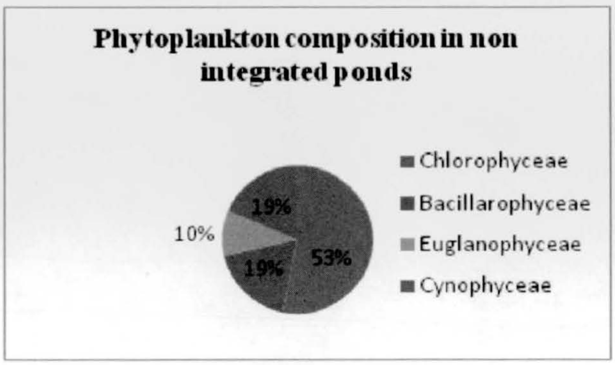
terms of carbon by multiplying gross oxygen production with a factor 0.375 (Westlake, 1963; Sreenivasan, 1964). For qualitative analysis, the plankton samples were collected filtering pond water through silk cloth and identified according to Ward and Whipple (1959), Tonapi (1980). For the quantitative study of plankton, 50 litre of pond water was filtered with the plankton net and the numerical enumeration was carried out in a "sedgewick-rafter cell" adopting the procedure outlined by Welch (1948). Samples for macrobenthic faunal analysis were collected from different units with the help of a hand dredge (25 cm^2) and identified according to the procedure described by Pennak (1978) and Tonapi (1980).

Results and Discussions

Total plankton volume was recorded as 0.2-1.6 ml/50L, 0.52-2.6 ml/50L and 0.4-3.2 ml/50L in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively. Due to the lower thermal regimes in hills, the Plankton volume in the present study is in lower side as observed (0.6-4.2 ml/50 L) by Pandey and Malik (2005) in tropical conditions. Plankton volume was low during the winter season.

Total phytoplankton density varied from 200-1678 nos./L., 581-2654 nos./L and 400-3283 nos./ L in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively. These values are in lower side as observed by Sharma (1980) in integrated fish ponds under tropical conditions. It may be because of temperature as primary production of phytoplankton is greatly affected by temperature (Rao *et al.*, 1982). Higher density in poultry waste recycled ponds may be due to the increase in the concentration of essential nutrients which enhances the phytoplankton productivity (Rao and Raju, 1989; Ayyappan *et al.*, 1990). Highest density was observed in the month of May-June with appearance of algal bloom and minimum during December and January in all ponds, might be due to the high rate of mineralization in summer.

A total 14 genera of phytoplankton were recorded in non-integrated ponds including 6 genera of chlorophyceae, 3 genera of bacillariophyceae, 3 genera of cynophyceae, 1 genera of euglenophyceae and one genera of dinophyceae. Kunjwal *et al.* (2010) observed 15 species of phytoplankton with dominance of the members of chlorophyceae and bacillariophyceae in temperate fish ponds at Nainital. In integrated ponds, a total of 17 genera of phytoplankton were recorded including 7 genera of chlorophyceae, 4 genera of bacillariophyceae, 3 genera of cynophyceae, 2 genera of euglenophyceae and one genera of dinophyceae. Maximum numbers was observed for green algae (51.5-54% in non-integrated and 50.5-60.8% in integrated ponds) followed by diatoms (17.0-20.5% in non-integrated and 20.7-31.5% in integrated ponds). Padmavathi and Prasad (2009) and Ponce-Palafox JT *et al.* (2010) also found the major groups of phytoplankton in carp ponds as those reported in this study. Singh and Kumari (1994) also reported Chlorophyceae as largest group of phytoplankton in integrated fish pond. Total zooplankton density varied from 106-289 nos./L., 139-432 nos./L and 132-442 nos./ L in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively. The above findings reflect the higher productive nature of the chicken waste recycled ponds in terms of greater abundance (no. /L) of total plankton compared to the control treatment as also evidenced by Jha *et al.* (2008) and Kumar *et al.* (2012). Highest density was



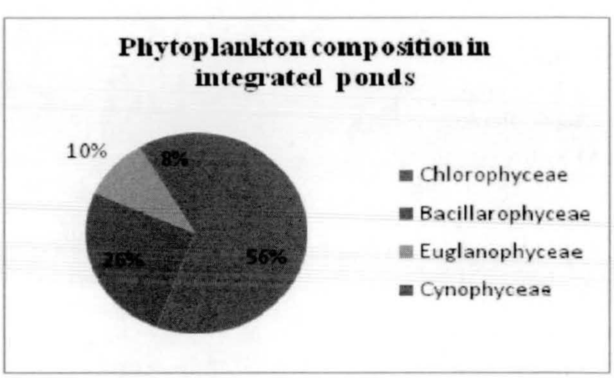


Fig. 1. Phytoplankton composition in integrated and non integrated fish ponds

observed in the month of November. A total of 7 species of zooplankton were observed with abundance of rotifers in non-integrated ponds, whereas while only 6 species were seen in the integrated ponds. Rotifers were more dominant (54- 61.5% in non-integrated ponds and 46.5-51.55% in integrated ponds) in total composition of zooplankton population of control pond. Though, the total counts of zooplankton (106-442 nos. /l) indicates good productivity in integrated ponds as it was reported in the range of 27-558 no/l by Singh and Sharma (1998) in tropical condition and it supports the opinions of Fernando(1980), Dumont and Tundisi (1984) and Vijverberg *et al.* (1987) that the zooplankton remain higher in temperate regions compared to the tropical climate. Further, relatively low species richness of zooplankton in the integrated ponds may be due to higher concentrations of the nutrients in these ponds which tend to reduce the species richness.

Total macro invertebrates density varied from 75-763 nos. /m^2., 88-875 nos./m^2 and 92-1023 nos./ m^2 in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively.

The values of GPP in non- integrated and integrated ponds with 10 chicks and 20 chicks ranging between 0.111-.569 gC/m^3/6hrs (1268 mg C/m^3/day), 0.111-.627 gC/m^3/6hrs (1360 mg C/m^3/day) and 0.110-.679 gC/m^3/6hrs (1448 mg C/m^3/day), respectively. These values are in lower side to the values of GPP recorded by other workers in fertilized ponds (Rao and Raju, 1989; Ayyappan *et al.*, 1990) in tropical conditions. This might be due to the

Table 2. Species composition and distribution pattern of plankton in non-integrated ponds

Months/Species	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Phytoplankton												
(A) Chlorophyceae												
Pediastrum *spp.*	+	++	+					+	++		+	++
Volvox sp.		++	+		+		+		+	++		++
Scenedesmus spp.	+	+					+		+	++	+	+
Chlorella spp.	+	++		+		+			++	+	++	+
Spirogyra sp.		+	++	+					+	++	+	+
Oedogonium sp.		+	+	+					+			
(B) Bacillariophyceae												
Navicula *spp.*	++	++	+					+	+	+	+	
Nitzschia spp.		+		+							+	
Pinnularia sp.		+	+						+	+	+	
(C) Cynophyceae												
Microcistis sp.		+	+	+	+			+			+	
Anabaena sp.	+	+	+	+		+				+		+
Nostoc sp.		+	+	+				+				
(D) Euglenophyceae												
Euglena sp.	+	+	+	+	+	+					+	+
(E) Dinophyceae												
Peridinium spp.				+	+			+	+	+	+	
Zooplankton												
(A) Rotifera												
Brachionus spp.	+	+	+		+	+		+	+		+	+
Keratella spp.		+	+			+	+					
(B) Cladocera												
Daphnia spp.	+	+	+	+	+	+	+		+	+	+	
Moina sp.	+	+	+	+	+	+	+		+	+	+	
Bosmina sp.		+	+			+						
(C) Copepoda												
Cyclops spp.		+	+	+		+	+	+				
Diaptomus sp.		+	+			+			+			

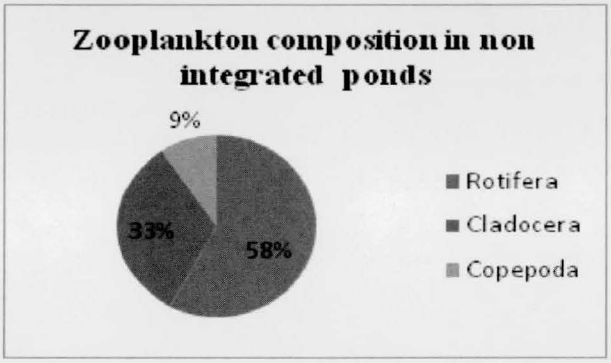
low thermal range of the pond water and low light intensity in the hills. Wetzel (1966) has observed that high rate of primary production was almost always associated with an increased availability of solar radiation. GPP increased rapidly from the beginning of the experiment reaching peak values in the months of September- October in both types of ponds. From March onwards again, the values of GPP started increasing attaining second peak in the month of April- May. Intensity of the second peak was higher than the first peak in all ponds. The higher values in integrated ponds support the findings of Mitra *et al.* (1987); Ovie and Adenji (1991) and Singh and Sharma (1999) that application of organic manures and fertilizers in fish ponds increases the level of primary production. The mean values of NPP were obtain as 0.140±0.12gC/m^3/6hrs, 0.156±0.14 gC/m^3/6hrs and 0.166±0.13gC/m^3/6hrs in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively. It was minimum (0.085 gC/m^3/hrs, 0.086 gC/m^3/hrs, and 0.081 gC/m^3/hrs) in beginning and maximum (0.265 gC/m^3/hrs, 0.308 gC/m^3/hrs and 0.326 gC/m^3/hrs) in the end of the experiment during the month of April in all ponds. These values are non-significantly different. The data of seasonal variation of NPP revealed that period of the higher GPP values (April-May and September-October) coincided

Table 3. Species composition and distribution pattern of plankton in integrated ponds

Months/Species	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Phytoplankton												
(A) Chlorophyceae												
Pediastrum spp.	+	++	+			+			+	++	++	+
Chlamydmonas sp.	++	++	+					+	+	+	+	+
Volvox sp.		+	+				+		++	+		++
Scenedesmus spp.	+							+		+	+	
Chlorella spp.	++			+		+			+	++	++	+
Spirogyra sp.		+	+	+					+		+	+
Oedogonium sp.		+	+	+								
(B) Bacillariophyceae												
Navicula spp.	++	+	+	+				+	+	+	+	
Nitzschia spp.					+	+			+		+	
Fragilaria spp.			+					+	+	+		+
Pinnularia sp.		+							+	+	+	
(C) Cynophyceae												
Microcistis sp.		+	+	+	+			+			+	
Anabaena sp.	+	+	+	+		+				+		+
Nostoc sp.		+	+	+				+				
(D) Euglenophyceae												
Euglena sp.	+	+	+	+	+	+					+	+
Phacus sp.		+	+			+		+				
(E) Dinophyceae												
Peridinium spp.				+	+			+	+	+	+	
Zooplankton												
(A) Rotifera												
Brachionus spp.	+	+	+		+	+		+	+		+	+
Keratella spp.		+	+			+	+					
(B) Cladocera												
Daphnia spp.	+	+	+	+	+	+	+		+	+	+	
Moina sp.	+	+	+	+	+	+	+		+	+	+	
Bosmina sp.		+	+			+						
(C) Copepoda												
Cyclops spp.		+	+	+		+	+	+				

with the highest NPP value in both types of ponds. The values were relatively low during winter months in both types of ponds, due to the slow activities of the photosynthesis. The mean values of community respiration in the experimental pond found 55.5%, 50.8%, and 57.3% of GPP in non- integrated and integrated ponds with 10 chicks and 20 chicks, respectively. The values of CR in non- integrated and integrated ponds with 10 chicks and 20 chicks ranging between 0.025-0.319 gC/m^3/6hrs, 0.028-.325gC/m^3/6hsr and 0.032-.367g C/m^3/6hrs, respectively. Higher values of community respiration could be due to the higher standing biomass of plankton and bacteria in these ponds, which increases the rate of respiration than the production. Ayyappan *et al.* (1990) recorded community respiration values of 47-124% of GPP in earthen fish ponds. In ANOVA analysis, variation in all observed parameters was found significant between integrated and non-integrated ponds at 0.01 & 0.05 levels, which reflect the direct impact of poultry waste recycling on biological productivity of fish ponds.

The study reveals that higher amount of poultry excreta supplied in fish pond could sustain higher phytoplankton density and primary production, which enables the fish production in mid altitudinal area of hill. Increase in fish production in fertilized ponds was attributed to the increments in primary productivity (Diana *et al.*, 1991; Ahmad *et al.*, 2001; Abdel-Tawwab *et al.*, 2002a; 2002 b). Therefore poultry fish integration farming system is recommended in the hill area because of its availability, low cost and direct impact on biological productivity of fish ponds.



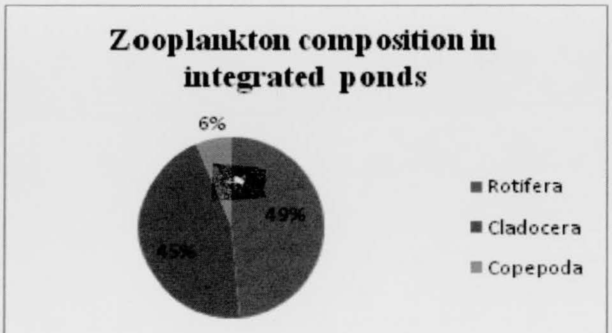


Fig. 2. Zooplankton composition in integrated and non integrated fish ponds

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