CHAPTER-FIVE
DISCUSSIONS
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The recycling of fresh poultry droppings in fish culture by installing cages over the pond (Sharma et al., 1985; Ranjan, 1989) have the advantage of releasing nutrients gradually as they slowly disintegrate and become available to the overlying water surface. The present condition of self fertility of the experimental pond is initiated by the raw poultry droppings from the cages which releases nutrients like nitrogen at the rate of 1.29% to 2.10%, phosphorus 0.42% to 0.61%, potassium 0.62% to 1.29%, calcium 3.87% to 6.30%, magnesium 0.96% to 2.74%, sodium 0.62% to 1.27%, fats 1.09% to 3.15% and crude protein 7.54% to 12.69%. Poultry droppings are rich in essential nutrients required for pond fertility (Ranjan, 1989), although fertilizing efficiency is more in chicken manure in combination with cattle manure which has been established in nursery ponds, (Banerjee et al., 1969). However, a new potentiality of rabbit excreta is well established by Kumar et al., (1992).

Schroeder (1978) has reported about the importance of organic manure as the sole nutrient in fish ponds (75% of the yields attained by using supplemental grain feeds and 60% of the yields attained by using protein enriched pellets.). Intensive use of manure in conventionally fed fish ponds doubled the fish yields with half the normal supplemental feed requirements.

On an average chicken manure on dry matter basis contains 3-4% N, (18 - 25% protein) which can be recycled by feeding to the birds upto the levels of 40% (Flegal and Zindel, 1971). It was estimated that 50 birds produce about 20,000 kg deep litter in one year. The built up deep litter contains 2.9% N, 2.0% P, whereas 1.0% N is obtained in fresh poultry droppings (Sharma and Das, 1988). Nitrogen in animal waste may be present in the form of NH\textsubscript{3}, NH\textsubscript{4}, NO\textsubscript{3} and NO\textsubscript{2}. Analysis of cage battery fresh poultry droppings reveals the presence of 1.6% N, 1.8% P\textsubscript{2}O\textsubscript{5} and 0.7% K\textsubscript{2}O (Coles, 1964). In the present observation, the dry matter of poultry manure contains 1.3% to 2.1% N as against 2.9% N in deep litter and 1.0% in fresh poultry droppings are obtained by Sharma and Das (1988) and 1.6% N in fresh poultry droppings by Coles (1964).
The daily addition of raw poultry manure in experimental pond at the rate of 12.0 kg to 20.6 kg enhance fertility of water to grow 2636.625 kg to 2775.795 kg of fish biomass which can be transformed into 5492.970 kg to 5782.900 kg per hectare per year without the supplementary nutrients and feeds. The similar experiments with occasional raking of bottom have maintained all the factors like alkalinity, nitrogen and phosphorus at the required concentrations and with the zooplankton concentration sufficiently rich resulting in the high rate of survival with encouraging fish growth (Moyle, 1946; Alikunhi et al., 1955). Poultry manure has the characteristics of releasing high soluble salts unlike other organic manures (Ray and David, 1969), although the nitrogen content in rabbit excreta has been estimated ten times higher than that of cow dung and even more than that of poultry litter (ICAR, 1971). Characteristically, poultry manure is a complete fertilizer with both organic and inorganic fertilizers (Banerjee et al., 1979; Sharma et al., 1979; Babu et al., 1993) due to which it reflects the very high growth of *Catla catla* in the present experiment.

The high potentiality of the poultry droppings can be fruitfully utilized as fertilizer and feed in aquaculture (Icchhponani and Lodhi., 1976). The application of 40 - 50 kg deep litter per day per hectare stated to be produced by 500 poultry birds can optimise the pond productivity for carp. culture (Sharma et al., 1985).

The present study reveals that 500 birds are adequate to produce 52.0 kg to 89.5 kg fresh poultry droppings per day which has been recycled in per hectare rate to obtain better growth in *Catla catla* at the rate of 1633.275 kg to 1742.400 kg (X, 1687.84 kg) in individual biomass per year and contribute 61.95% to 62.77% to the total annual yield (5492.97 - 5782.90 kg/ha) which is much higher than the conventionally fed pond culture in Assam.

In the integrated fish farming system the major inorganic nutrient components (NPK) and trace elements like Ca, Cu, Fe, Mg and Zn generally came from the feeds which are fed to the animals as recovered from the excreta (Taiganides, 1978). The amount of wastes excreted daily by an animal is directly proportional to its total live weight (TLW) (Taiganides, 1978) which is also evident in the present study. In comparison to the rate of production of hen excreta by 6.6 kg/day X TLW (Taiganides 1978), the production of poultry droppings at the rate of 17.12 kg/day has been obtained from the TLW of 300.42 kg in the present experiment. From the dry poultry droppings 1.64% N, 0.52% P and 0.89% K are obtained in the present observation against the findings of Taiganides(1978) proposing 1.5% N, 0.50% P and 0.44% K from the hen excreta being recovered.
Coprophagy character of fish in the integrated fish culture with livestock has been demonstrated by Le Mare, (1952) and Campose and Sampaio, (1976). It is observed by Sharma et al., (1988) that Mrigal, Common carp and to some extent Rohu feed on pig dung. In the present observation, however, all the three Indian Major Carp species cultured namely, *Catla catla, Labeo rohita* and *Cirrhitia mrigala* have been observed to feed on fresh poultry droppings. However, *Catla catla* feeds voraciously on the raw poultry droppings over the surface. Hence, poultry droppings serve as direct feed for *Catla* and also act as pond fertilizer for autotrophic and heterotrophic production of natural fish food organisms (Figure 19). In the present study the poultry droppings serve as a direct feed for *Catla catla* is well in conformity with that of earlier workers.

![Figure 19](image.png)

**Figure 19** A diagrammatic representation of poultry droppings recycling in fish cum poultry farming system.

**Ecological impact**

The tropical or subtropical climatic condition is dominated by high atmospheric temperature (16.7°C to 39.5°C) and profound rainfall. These two climatic parameters have great significance in the integrated livestock fish culture system. The water volume of the pond increases due to the downpour during monsoon which dilutes the poultry dropping inputs in the studied experimental pond and reduces the rapid microbial activities under the influence of high atmospheric monsoon temperature preventing organic pollution. The lower BOD ranges (14.2 mg/l to 35.0 mg/l) also show that there is no organic pollution. Due to
such dilution effect the poultry droppings load could be increased for greater growth of fishes under increased metabolic activities. During warmer period the growth increment of fish is higher due to increased metabolic activities.

Rainfall reduces the accumulation of Nitrogenous excretory products by dilution (Avinimelech, et. al., 1992) preventing organic pollution. In the present integrated system the BOD level remains far below the danger mark and low range of BOD is generally indicative of non polluted organic water. During rainy season due to less stagnation the DO value increases followed by decrease of \( \text{FCO}_2 \). The water disturbance caused by rainfall helps mixing of atmospheric air into the surface film of water which gradually dissolves with the lower column keeping water more aerated inspite of increased microbial activities associated with intake of raw poultry droppings and higher water temperature. However, DO depletion might occur due to increased water temperature which is evident in the present observation.

The physicochemical characteristics have profound impact over the aquaculture systems. In general, under Assam condition the fish ponds and natural lakes attain the highest turbidity during the monsoon due to incoming of the turbid rainwater / flood water from the catchment area (Bhuyan, 1970; Dey, 1981; Lahan, 1983; Kar, 1984 and Goswami, 1985). However, in the present study high turbidity is recorded during the winter months when the pond water volume is less due to rapid rate of evaporation. This may be stated that due to low water volume, constant input of raw poultry droppings and development of zooplanktonic swarm, caused by Crustacean plankton, the water becomes turbid during the winter period. However, transparency increases to its maximum level during May - June probably due to dilution effect caused by the downpour that enhances the water volume. Highly turbid waters are undesirable for fish ponds. Productive ponds are generally found to have slightly turbid water (Smith, 1934).

The degree and annual variation of water temperature in culturable pond, in general, is directly correlated with the air temperature and have a great bearing upon its productivity (Ganapati, 1959; Hussainy, 1967; Munawar, 1970). Of all the physical factors, temperature and light are essential for maintenance of the autotrophic component through photosynthetic activity which, in turn, is basic to productivity. In the present observation temperature variation is recorded between 19.3°C and 33.1°C in the experimental pond throughout the two years of investigation, which follows air temperature fairly closely. The seasonal temperature variation of water is noticed with the colder months with low temperature and the hotter months with the elevated water temperature.
The uptake of atmospheric heat caused by sunlight per unit area entering the pond water gets immediately circulated by the overlying effect of the wind (Reed and Olive, 1956; Sylvester, 1958;) and this helps the pond water to maintain an isothermal condition and resists it from extreme heating beyond the tolerance range of the organisms including the carp species. Such a situation was earlier studied in the shallow water bodies of Assam with special relevance to productivity (Dey, 1981; Lahan, 1983; Kar, 1984; Goswami, 1985). But in respect of livestock fish integrated system temperature plays an important role in the rate of mineralization of the livestock manure. The inorganic transformation of poultry manure both at high and low temperature levels is more rapid with 43.2% to 50.0% in 30 days under full aerobic condition and high temperature (Banerjee et al., 1979 and Garg et al., 1971) which is significant in relation to the prevailing high temperature profile sustaining for a prolong period of 8-9 months in context of the present study under Assam condition. It has however been found that the wide fluctuation in summer temperature does not have any pronounced adverse effect on the fish since the BOD level varies from 14.2 to 35.0 mg/l in the experimental pond. However, in the experimental pond, charged with poultry manure, induces the more significant effect to increase the rate of biochemical activity of the microbiota so that the release of nutrients by decomposition of settled organic matter is more at the higher temperature with consequent increase in nutrient status corroborating the findings of Banerjea (1967).

It is also common experience in the tropics that the growth rate of fish is much higher in summer than in winter. The temperature data of present experimental pond exhibit that the temperature remains below 25.0°C during November to March, between 25.0°C to 30.0°C in April, May, September and October and beyond 30.0°C during June to August. Thus, it is found that for about 7 months in the year the temperature remains between 25.0°C to 33.1°C in the experimental pond, and 25.0°C to 32.7°C in the control pond which may be responsible for the high productivity of the pond for the growth of *Catla catla*. With the decrease of water temperature the solubility of oxygen enhances and the dissolved oxygen depletion is attributed to its utilization during organic decomposition (Sreenivasan, 1966; Sahai and Sinha, 1969).

All the chemical constituents accounting for aquaculture, the hydrogen ion concentration has a distinct role in the fish productivity and life processes of organisms inhabiting in the pond water system. Both highly acidic and highly alkaline waters derived from different sources are unfavourable for fish production (Ohle, 1938) It has been observed that a weak alkaline reaction (pH 7.4 to 8.0) is most productive and that very acid waters are
distinctly undesirable. (Nees, 1946). The various sources inducing acidity or alkalinity in the open water system have little relevance with the pH encountered in the integrated systems. The more important influence of pH in the aquaculture system is that it affects metabolism and physiological processes of fish. Fish in general are intolerant of extremes of water pH, outside the range of pH 5.0-9.0, beyond which it affects excretion of CO₂ and ammonia and the ion exchange transfer at gill surface, reduces swimming performance at high pH and causes impairment of oxygen transport at low pH. Under the influence of livestock manure in the integrated systems, these extremes of pH must not be achieved. In the present experiment, with raw droppings of poultry excreta at the rate of 12.0 to 20.6 kg/day into the experimental pond does not create such condition of pH extremities, since the pH range remains at the best favourable range between 6.4 and 7.9 at zone A, and it is considered at the best for fish growth. Due to integration of livestock with fish, pH is least affected, rather it shows the optimal ranges for fair fish growth.

In the utilization of piggery waste for integrating fish culture the pH range has been monitored between 6.6 and 9.0 (Woynarovich, 1980) 7.7 to 7.9 (Sharma and Das, 1988), 7.5 - 7.9 (Sharma et al., 1988). In fish-cum-duck it ranges from 7.0 to 7.8 (Sharma and Das, 1988) and in fish cum poultry pH ranges between 7.2 - 7.7 (Sharma and Das, 1988). Schroeder (1980) has obtained pH range from 8.3 to 8.9 in livestock manure.

The pH maintains its range between 6.4 to 7.9 in the first year of experiment after liming was done at the rate of 300 kg/ha in the experimental pond. However, the pH range remains between 6.7 to 7.7 in the second year of experiment without liming but the water was charged with raw poultry droppings at the rate of 12.0 kg to 20.6 kg/0.48ha/day. Besides, zone B experiences with slightly higher pH range and zone C produces higher pH range (7.2 - 8.6 in 1991-92 and 7.1 - 8.8 in 1992-93) after liming at the rate of 300kg/ha in both the years. The present observation advocates the necessity of liming in view of the tendency of pH decrease under the influence of poultry droppings. The control pond exhibits the moderate alkaline range in both the years in contrast to the low pH record of Assam waters (Banerjea, 1967; Dey, 1981; Lahan, 1983; Kar, 1984 and Goswami, 1985).

Dissolved oxygen level exhibits no adverse implications on the fishes in the poultry dropping charged A zone as it maintains the productive range of above 5.0 mg/l throughout the years (Figure 5). However, compared to the B zone of the experimental pond and C zone (control pond), the A zone which receives raw faecal droppings directly from the poultry cages is experienced with lower DO level due to increased microbial activities during
the time of organic decomposition.

The direct feeding of *Catla catla* on the raw poultry droppings minimised the accumulation of organic matter which lessens the microbial activities and in turn keeps the DO level above 5.0 mg/l. However, there has been observed a significantly high and productive DO range 6.5-9.8 mg/l in the B zone of the experimental pond (Figure 5) which probably helps to overcome any stress in the A zone due to reshuffling of water between A and B zones by wind effect (Reed and Olive, 1956; Sylvester, 1958).

In the present observation, on the monitoring of early morning DO level in the three zones (Figure 9), it has been noticed that there is incidence of DO depletion at faster rate at zone A than at zone B and C. DO in water decreases in the morning when accumulation of organic load is more in the fish pond. However, morning DO as observed at zone A has never come down to the critical level.

The high production of free carbon dioxide is an index of organic pollution but in the present experiment the free carbon dioxide level in the poultry litter-charged zone (A-zone) of the experimental pond is fairly within the productive range and shows no indication of organic pollution. This probably happens due to scavanging of raw poultry droppings by *Catla catla* as a direct feed and its less accumulation in water column. It is, however, noticed that FCO₂ value is still higher at A-zone than the B and C zones. In addition to that, there is utilization of FCO₂ in the autotrophic production. Inspite of 12.0 to 20.6 kg of raw poultry droppings and community respiration in the heterotrophic level constituted by high abundance of zooplankton and respiration of fish stock, the FCO₂ level in the experimental pond is fairly of the productive ranges throughout the period of investigation except in April 1991-92 and June to July 1992-93. Fairly oxygenated water mixing from the B zone minimizes the FCO₂ production in the poultry litter-loaded A zone with no adverse effect of FCO₂ on the cultured fishes in livestock-fish integration system. Since fishes are known to avoid CO₂ concentration as low as 5.0 mg/l the present trend of FCO₂ level has no serious implication on the population of *Catla catla* tested with the poultry droppings in the present integrated system. The lethal effects of CO₂ normally occured at levels greater than 15.0 mg/l and the sublethal effects at 12.0 mg/l are not recorded with the present experiments.

However, while monitoring the early morning FCO₂ in the zone A there has been a noticeable elevation of the FCO₂ amount than at the other two zones (Figure 9), which is also found below the sublethal level of FCO₂, as is observed with other water bodies of
FCO$_2$ concentration is inversely proportional to DO concentration due to its utilization in photosynthesis at the autotrophic level and utilization of oxygen in respiration resulting in release of CO$_2$ in the process.

Total alkalinity (TA) primarily determines the magnitude of diel fluctuation of pH of water which, when it is low (<15.0 mg/l), has low buffering capacity. In the present observation, the total alkalinity and total hardness are recorded to be in a very productive range. These two parameters are normally similar in magnitude because of the parallel action of calcium and magnesium ions which is also evident in the present experiment. The balance state of these two parameters indicates favourable productive state under the influence of poultry litter.

In the present study, the range of variation is recorded in between 50.0 mg/l and 120.0 mg/l except 30.0 mg/l (Aug) in 1991-92 in the experimental pond. These observations corroborate with the findings of Moyle (1946) and have been found to be very productive (Banerjea, 1967).

Under the influence of raw droppings of poultry faeces chloride (Cl) stands within the range of 16.6 to 48.4 mg/l in A zone and 12.5 to 35.5 mg/l in the B zone showing variation of its content between the poultry dropping concentrated zone and the dilution zone of the same experimental pond. It is significantly observed that the Chloride content in the experimental pond water maintains a lower profile during the winter months and it elevates with the advent of the hotter months showing direct correlation with the water depth temperature and faecal matter which contradicts the general norm of Chloride fluctuation inversely with water depth in the ponds not charged with the livestock manure (Saha et al., 1971).

The two elements together form the most abundant ions in fresh waters. Ohle (1938), classified the lakes as ‘poor’, ‘medium’ and ‘rich’ depending upon their calcium content in mg/l being less than 10, between 10 - 25 and more than 25 respectively. In the present observation calcium ranges from 20.0 mg/l to 81.0 mg/l in the experimental pond and 25.0 mg/l to 70.0 mg/l in the control pond. Magnesium is absolutely essential for chlorophyll-bearing algae and plants. In the present observation Magnesium ranges from 15.0 mg/l to 44.0 mg/l in the experimental pond and 20.0 mg/l to 39.0 mg/l in the control pond.

The element of phosphorous is recognised to be the most critical single factor in the maintenance of pond fertility. Dissolved phosphorous occurs in water in very low
concentrations. The value, < 0.05 may be considered undesirable for a productive fish pond. In the range 0.05 to 0.20 ppm medium to high production is expected and highly productive fish ponds generally have a phosphate concentration greater than 0.2 ppm (Moyle, 1946). Moyle also has expressed the dissolved phosphate as ppm of P. In the present studies the phosphate ranges from 1.0 mg/l to 3.6 mg/l in the experimental pond and 1.2 mg/l to 3.2 mg/l in the control pond.

As a constituent of protein, nitrogen occupies a highly important place in aquatic ecosystem. Chu (1943) concluded from the results of laboratory experiments that nitrogen and phosphorus naturally occur in quantities far below the upper limit for optimal growth of plankton and often do not reach lower optimal concentrations, the optimal limit of nitrogen being given by him as 0.3 to 1.3. These, however, may not be applicable to natural conditions. Dissolved nitrogen below 0.1 ppm does not indicate a productive condition. While in the range 0.1 - 0.2 ppm an average production is expected, above 0.2 ppm (0.2 - 0.5) may be considered favourable for fish production. In the present observation the dissolved nitrogen is recorded from 0.11 mg/l to 0.66 mg/l in the experimental pond and 0.15 mg/l to 0.55 mg/l in the control pond.

The BOD ranges (7.10 to 17.10 mg/l) indicate an organic load in the experimental pond during the period of investigation, indeed, no adverse effect of poultry droppings is noticed as such. However, there is slight depletion of dissolved oxygen (DO) and an increase of free carbon dioxide (FCO₂) noticed in the experimental pond during very early morning time. The water parameter reading also does not produce any stress on the life of *Catla catla* even in the first year of experiment inspite of restricting this fish species to a minimized water area in the A zone. High BOD level (47.0 mg/l) is also reported in fish-poultry integration in tanks without any noticeable adverse effect on fishes (Banerjee et al., 1979).

**Heleoplankton diversity**

Heleoplankton development in the integrated poultry-fish culture is of special significance. Sharma and Das (1988) have studied the plankton volume in the poultry fish pond and observed the range between 0.5 and 2.0 ml/50 l. Among phytoplankton they have recorded Diatomaceae, Chlorophyceae and Myxophyceae, while Rotifers, Cladocerans, Copepods and nauplii are recorded among zooplankton. Rotifers and Diatoms are found to be predominant. Hopkins and Cruz (1978) have obtained the most common and dominant phytoplankton in chicken - fish ponds are *Pediastrum, Cosmarium, Closterium, Scenedesmus, Coelastrum* and *Chlorella* (Chlorophyta); *Microcystis, Lyngbya, Oscillatoria* and *Merismopedia* (Cyanophyta); *Euglena*, *Phacus* and *Trachelomonas* (Chrysophyta) and...
The most common and dominant zooplankton genera are *Brachionus*, *Trichocerca*, *Asplancha*, *Filinia* (Rotifera); *Moina* and *Diaphanosoma* (Cladocera); *Cyclops*, unidentified copepodites, nauplii (Copepoda) and harpacticoids.

In the present observation the plankton volume ranges from 1.4 ml to 5.8 ml/100 ml with the maximum at zone A in the experimental pond whereas it ranges from 1.2 to 2.2 ml/100 l at zone C in the control pond (Table 12). The most common and dominant phytoplankton genera encountered are *Microcystis* (Myxophyceae); *Phacus*, *Euglena* (Euglenineae); *Eudorina*, *Pandorina*, *Volvox*, *Pediastrum*, *Closterium*, *Cosmarium*, *Sphaerocystis*, *Staurastrum*, *Euastrum*, *Sirogonium* and *Spirogyra* (Chlorophyceae); *Peridinium* and *Ceratium* (Dinophyceae); *Asterionella*, *Diatoma*, *Synechocystis*, *Fucus*, *Navicula* and *Pinnularia* (Bacillariophyceae). Among zooplankton most dominant and common genera are recorded as *Arcella*, *Difflugia*, *Nebela*, *Centropyxis* (Protozoa); *Brachionus*, *Keratella*, *Asplancha*, *Filinia* and *Polyarthra* (Rotifera); *Daphnia*, *Moina*, *Diaphanosoma*, *Bosmina*, *Alona* (Cladocera); *Cyclops*, *Neodiaptomus* (Copepoda). *Philodina* has not been recorded in the present observation as is in conformity with the record of Hopkins and Cruz (1978). Among zooplankton *Diaphanosoma* shows the highest occurrence frequency.

Due to different environmental and behavioural factors of biotic communities, plankton diversity indices respond differently (Bechtel and Copeland 1970; Pielou, 1966). Odum (1971) has defined the species diversity as the ratio between the number of species and importance values (number and biomass) of individuals. Sugunan (1991) has studied the changes in the phytoplankton species diversity indices in the river Krishna and Nagarjunasagar. The study of macrobenthic community in Kanti ox-bow lake. Thorough species diversity index is done by Singh (1988). Acharjee et al. (1995) have studied the phytoplankton species diversity indices in Dighali beel. They have obtained the overall diversity index ($H$) as 1.79497, and inverse relationship between diversity index and phytoplankton abundance. The overall evenness index ($J$) is found to be 0.8969. According to them low values of $J$ coincided with the high abundance of phytoplankton and inverse correlation is observed between $J$ and phytoplankton population. The concentration of dominance ($C$) has been found to be 0.3173. Inverse correlation between evenness index and concentration of dominance ($r = -0.9307$) and direct correlation between diversity index and concentration of
dominance (r = 0.9306) are observed.

In the present communication both phytoplankton and zooplankton species diversity indices (\(H\)) have been studied at three different zones in two years experimental period (Table 15). The overall (\(H\)) is found to be 1.4570 and 1.3902 at zone A in the experimental pond in 1991-92 and 1992-93 respectively. At zone B it is found to be 1.6597 and 1.6528 in 1991-92 and 1992-93, whereas at zone C 1.0594 and 1.2772 respectively have been observed during preceding and following year. It is observed that species diversity (\(H\)) is directly related to evenness index (\(J\)) which is in conformity with the findings of Acharjee et al., (1995) and inversely related to index of dominance (\(C\)) which is not in conformity.

In the present observation the zooplankton precedes the phytoplankton except in the control pond or at zone C where phytoplankton is more, which is unlike the findings of Menon (1945) and Nath (1966). Plankton are more plentiful over the surface column in the A zone than in the B and C zones as a result the surface feeder *Catla catla* feeds very well below the poultry house of the pond. The present observation highly emphasizes that *Catla catla* population confines itself in the A zone for getting its preferred feed. *Catla catla* does not cross the specific feeding niche due to availability of its preferred feed. Fish may cross specific feeding niches when it is faced with a shortage of their preferred feeds (Summerfelt et al., 1970; Terrell and Fox, 1974). This situation has not been observed in the integrated system.

In the present study of the integrated system it is revealed that the *Catla* stock as a whole congregate in the zone A due to high abundance of their feed. The fishes immediately encircle the area below the poultry house to feed intensively as soon as the continuous droppings of the poultry faecal matter reach the water surface in the morning and evening in the poultry feeding hours.

Two basic feeds namely poultry droppings and zooplankton in various proportions in fingerling to adult stages are identified in the gut content of *Catla catla*. However, phytoplankton are identified as their secondary feed. The basic feed which the fish usually consume comprises the major part of the gut content along with some phytoplankton as secondary feed. These secondary feeds occur frequently in the food pipe in smaller quantity (Nikol’sky, 1963) which have been demonstrated by the *Catla* stock in the present integrated farm. Intensive filtering of water is noticed with the adult stock which clearly indicates high abundance of food stock in the zone.

The analyses of the food pipe of *Catla catla* in the present context reveal that the
food of the fishes are composed of a highly macerated mass which contains a high proportion of semi-digested matter and poultry faecal detritus (Rege, 1958; Tampi, 1958; Basheeruddin and Nayar, 1961; Sivaprakasam, 1967; Bhatnagar and Karamchandani, 1970; Pathak, 1975), the presence of which is due to regular feeding on fresh poultry droppings. This type of detrital feed occurs in the gut frequently throughout the investigation period and in high proportion at the adult stage. Sivaprakasam (1967) has observed a high incidence of semi-digested pulpy matter classified as a distinct food which resembles the semidigested poultry faecal matter in the gut content of *Catla catla*. In the present experiment it has been observed that the healthy development of the zooplankton compartment and the growth of *Catla catla* go parallelly.

Although according to Bhatnagar and Karamchandani (1970) the animal matter is an accidental feed in *Catla catla*, the feeding of *Catla* in zone A of the experimental pond clearly demonstrates that *Catla* stock feeds primarily on zooplankton which comprises very healthy population of Crustacean and Rotifer besides the enormous production of nauplii. The raw faecal matter supplements the zooplanktonic feeding. That *Catla catla*, in its adult stage, feeds on zooplankton has already been established. The fry and fingerlings of the IMC species are in general zooplankton feeders (Alikunhi, 1952; Mitra and Mahapatra 1956 and Kamal, 1964). The rapid growth increment of *Catla catla* from the fingerling to the juvenile stage may, therefore, probably be attributed to their intensive feeding on healthy zooplankton like Copepod, Cladocerans and Rotifers.

For determining the food habits, the relative length of gut (RLG) may be considered as an important index (Sarbahi, 1939; Alikunhi and Nagaraja rao, 1951; Das and Moitra, 1956; Saxena and Chitray, 1964). The length of the gut varies not only with the food habits but also in relation to the size and age of the fish (Sinha, 1972; Singh and Moitra, 1976). Low and high RLG value are recorded for the carnivores and herbivores respectively with an intermediate value found for the omnivores.

The same species of fish have different RLG values according to different authors. As for example Sarbahi (1939) found the RLG in *L. rohita* as 14.0 whereas Alikunhi and Nagaraja Rao (1951) give the ratio as 12.0 only. Das and Moitra (1956) and Saxena and Chitray (1964) obtained a value of 2.0. Similarly, the values for *Ompok bimaculatus* and *Bagarius bagarius* were noted as 1.1 and 1.0 by Das and Moitra (1956), while they were found to be 1.0 and 0.60 by Saxena and Chitray (1964). These variations have been explained by different authors as due to variations in food and feeding in different waters in different
regions of the country. The RLG values differed even in the same waters in their different life history stages from fingerlings to adults. This is because of the changes in food and feeding in the same waters at the different stages of life history of the same fish. For example, the fingerlings feed mainly on plankton, while at a later stage the young adult of herbivores take to more and more of plant feeding and carnivores to animal feeding.

In the present IMC species *Catla catla*, the RLG values show a gradual increase from tender fingerlings to adult stage which corroborates the above findings. The nature and the composition of food for particular species may be determined according to the structure and adaptation of feeding mechanism. In *Catla catla* the gill rakers form a broad sieve-like structure across the gill slits for filtering the water in order to retain the food particles in the bucco-pharynx (Plate 2). They also serve to prevent the food elements from escaping out through the respiratory current of water. There is a peculiarity in the mouth of *Catla catla* having a large gap of the oral aperture which restricts the size of the food eaten (Hartman, 1958) as in the carnivorous fishes.

To determine feeding intensity, the gastro-somatic-index (GSI) is observed. GSI changes in relation to variation of food supply (Nikol’sky, 1963). Fluctuations of GSI depends on the size of the fishes which exhibit better condition in the smaller body sizes and with growth the values of GSI decrease. The intensity of feeding shows a downward trend with the approach of the maturation phase and ingestion improves only when the spawning is over.

**Autotrophic productivity**

The autotrophic compartment has immense role to play in the grazing food chain while the present integrated system the importance of detritus is considered more important. The primary producer level of the studied ponds is weakly constituted by phytoplanktonic component only in the total absence of macrovegetation. While comparing the three zones, A and B in the experimental pond and C in the control pond in respect of primary productivity, it has been found that there has been obtained a negligible difference. In general, under the influence of tropical and subtropical climates in the presence of adequate nutrients, the primary production reaches a maximum of about 10 g C/m²/d observed in algae production ponds (Tamiya, 1957; Anon., 1977). The situation observed under the present study of primary productivity is different due to very poor densities of phytoplankton and introduction of poultry droppings (in A and B zone) which may cause poor primary productivity in the system. In general organic waste such as animal manure when suitably introduced to a fish
pond, is decomposed by bacteria to release their nutrients to be utilized by algae in photosynthesis provided that the other requirements for the process are fulfilled. However, the present pond receives raw fecal droppings of poultry birds of which 54.65% to 93.44% is directly consumed by *Catla catla*. It naturally varies from the decomposed organic manure applied to the pond, which can readily strengthen the phytoplanktonic compartment for higher primary productivity ranges, (Sharma and Olah, 1986). In the present integrated system under the influence of raw poultry droppings, very large heterotrophic (zooplanktonic) compartment is produced with poor growth of the phytoplanktonic compartment resulting in 1.6 to 2.0 g C/m²/d gross primary productivity with an average of 1.75 g C/m²/d gross primary production which is far below the primary production ranges (2 to 5, X, 4 g C/m²/d) obtained from manured ponds without supplemental feeding (Schroeder, 1978). The present observation on the average monthly primary productivity (Table 16) clearly indicates a weak autotrophic compartment to justify the healthy growth of fish productivity with *Catla catla* as a relevance of detritus based food chain. Banerjee et al., (1979) has also observed poor primary productivity level with poultry droppings which maintain the ranges between 300 mg C/m³/hr and 380 mg C/m³/hr. Poor primary production with wide seasonal fluctuation range (1.3 to 8.5 g C/m²/d) also is reported from other subtropical fish ponds (Hepher, 1962). However, very rich primary productivity is achieved in the ponds charged with pig dung in Indian climate which ranges from 6.5 to 14.1 g C/m²/d establishing high photosynthetic activity resulting from the application of raw and fresh pig manure to the ponds (Sharma and Olah, 1986) in contrast to the present low photosynthetic activity obtained from the studied pond charged with raw poultry droppings falling from the poultry cages throughout the day and night hours.

**Growth dynamics of *Catla catla***

The growth dynamics of *Catla catla* resulting high fish yield have direct relationship with the enrichment of productivity in ponds through the recycling of poultry droppings. In the present study, about 6284.160 kg of fresh poultry droppings have been recycled in the 0.48 ha pond (13,092.00 kg or 13.09 tonne ha⁻¹ yr⁻¹) in the first year and 6224.160 kg (12,967.0 kg or 12.97 tonne ha⁻¹ yr⁻¹) in the second year. Since one poultry voids X, 26.06 kg fresh excreta/year, 240 birds would be sufficient to fertilize 0.48 ha of water. The yield of the experimental species *Catla catla* has achieved 1633.28 and 1742.4 kg in the first and second year respectively showing two years average as 3516.3 kg ha⁻¹ yr⁻¹ against the total yield of 5637.94 kg ha⁻¹ yr⁻¹ (Table 17). Ponds receiving 0.5 t to 1.0 t per hectare animal wastes
produce 1500 kg to 8000 kg per hectare per year fish yield (Allen and Hepher, 1976; FAO, 1977b; Moav et al., 1977; Rappaport and Sarig, 1978). Sharma and Das, (1988) have obtained 4665.5 kg ha\(^{-1}\) yr\(^{-1}\) fish yield from fish poultry farming system in Indian water condition while Bhagawati et al., (1992) have obtained 3988.8 kg to 4728.0 kg ha\(^{-1}\) yr\(^{-1}\) in Assam water condition. However, the yield which goes up to 7300.0 kg ha\(^{-1}\) yr\(^{-1}\) from the pig-fish experiment without the use of any supplementary feeds or inorganic fertilizers (Sharma et al., 1979) is higher than the present yield, but compared to the average yields of 3543.0 kg ha\(^{-1}\) yr\(^{-1}\) achieved through polyculture with intensive feeding and fertilization in the Eastern region of India (Anon. 1977); 4290.0 kg ha\(^{-1}\) yr\(^{-1}\) from Krishna nagar, West Bengal (Sharma et al., 1978), 4250.0 kg ha\(^{-1}\) yr\(^{-1}\) from district Nadia, West Bengal (Murshed et al., 1977) and 3232.0 kg ha\(^{-1}\) 6mo\(^{-1}\) at Kalyani, West Bengal (Sinha et al., 1973), the present yield achieved through poultry integration is still higher in the production rate.

In the present achievement of raising fish yield through poultry droppings a little difference is showing with the control pond which is managed with supplementary feeding and fertilization, but within the integrated system three species combination does not show much variation in the growth and total yield of *Catla catla* when compared to system of restriction of *L. rohita* and *C. mrigala* from mixing with *C. catla* as seen in the first year of investigation. Since significant variations of fingerling sizes are not very marked its influence on the growth rate of *Catla catla* could not be concluded although stocking of larger size fingerlings gives better growth under poultry fish integration system (Hopkins and Cruz, 1978).

In addition to, the proteinous zooplanktonic feed the undissolved detrital organic and inorganic particles originating from the leftover poultry droppings which are consumed by *Catla catla* as soon as these fall on the superlying water have also shown high nutrient value (Iccchliponani et al., 1976; Schroeder, 1978; Flegal and Zindel, 1971) as explicitly noticed in the present experiment (Table 5 and 6).

The interrelationship between the growth of *Catla catla* in relation to some chemical parameters of poultry droppings has observed during the period of investigation. The highly significant positive correlation relationship with the *Catla* growth (Table 20) shown by calcium \(r = 0.7244\), potash \(r = 0.7198\) and phosphate \(r = 0.8997\) is the indicative of the fact that these inorganic substances help in the growth dynamics of the fishes. Significantly very high positive relationship obtained in between *Catla* growth and poultry droppings \(r = 0.8799\) released into the pond justifies the self maintenance of the pond and substituting the
supplementary feed by poultry droppings it directly helps in fish growth.

By using t-test (table 20) the significant relationship has observed between *Catla* growth and calcium (t = 3.32), potash (t = 3.28), phosphate (t = 6.52) and poultry droppings, (t = 5.86) at 5% level at 10° freedom.

The growth dynamics of *Catla catla* is subjected to several biological activities of the pond which take place in response to the application of poultry droppings into it. This results in a natural food web of detritus origin. The recorded mineral composition (NPK) of poultry manure are 1.29 to 2.10% Nitrogen, 0.42 to 0.61% Phosphorus and 0.62 to 1.29% Potassium in the experimental pond (Table 7) as against 1.6% Nitrogen 0.7% Phosphorus and 0.7% Potassium (FAO, 1977a,b). These activities have proved a rich mineralisation for initiating the growth of *Catla catla*. These mineral fractions are directly responsible for autotrophic development for photosynthesis or heterotrophic growth of bacteria. Bacteria digests dead plankton or the organic fraction of poultry manure, liberates bound minerals and produces carbon-dioxide, both of which become available for further photosynthetic production (Kajak and Hill bricht - Ilkowska, 1972; Anderson and Mac Fayden, 1976). The faecal detritus originating from the added poultry droppings, the part thereof slowly undergoes sedimentation at the pond bottom which appears to have supplied a substrate for colonization of microorganisms that are essential for driving the food chain. The microorganisms are mostly eaten by zooplankters like cyclopoid and planktonic copepods. (*Neodiaptomus*, *Cyclops*, *Mesocyclops* and their nauplii), Cladocerans (*Moina*, *Diaphanosoma*, *Daphnia*), Rotifers (*Brachionus*, *Keratella*, *Filinia*, *Asplanchna*) and Protozoans (*Difflugia*, *Nebela*, *Centropyxis*). The healthy development of the zooplankton dominated by calanoid copepoda and cladoceran in the present experimental integrated pond, particularly at zone A (Table 9), forms a very sound trophic compartment for the zooplanktophagus IMC species *Catla catla*. The detritus which passes through the fish gut and voids at the water column are recolonized by microorganisms that are again eaten by zooplankton and then by fish. The microbial community in the detritus provides essential nutritional requirements of fish feeding on it (Fish, 1955; Newell, 1970; Hargrave, 1976).

A coarse matrix of organic matter surrounded by dense population of Protozoa actively grazing on what appears to be a bacterial layer coating or focussed on the matrix is evident from the microscopic examination of detritus collected from the present pond. The small particles of waste which are coated with bacteria are ingested by the zooplankton and by the fish directly (Schroeder, 1980). Aerobic digestion of organic matter by bacteria also
fixes 20 to 50% of the available carbon as bacteria cells, while the left out portion is used for metabolic energy. In the present experimental pond, the crude, inedible poultry droppings are converted into high quality fish feed by aerobic microbial activity. Evidently, the microbial activity in the pond ecosystem leads to natural fish feed production which in turn enhances the fish yields (Doetsch and Cook, 1973). With the development of the very healthy zooplanktonic component as well as the healthy growth of *Catla catla*, the detritus-bacteria-protzoan-intermingled food web plays the major role in the integrated system.

Under a condition of low fish density, the concept of specific trophic niches for different fish type is probably valid (Schroeder, 1980). Consequently, the growth rate of *Catla catla* remains high at high densities (ICLARM), since the demand for food in a given niche may exceed its supply. This forces the fish to exploit additional trophic niches, the reason here is more extrinsic than intrinsic, unlike the findings of May (1976). Concomitantly, the strong feeding interaction of the other two IMC species namely *L. rohita* and *C. mrigala* with *Catla catla* which feed on the faeces of the latter consuming partly digested plankton and detritus has an advantage of the dynamic nature of the food web (Yashouv, 1971). The growth of the other two IMC species cultured in the same pond after being isolated from *Catla catla* is also satisfactory and helps in removal of the organic waste load in the basin.

In the present observation, the development of the trophic system at zone A and zone B clearly demonstrates that the zone A receives 12.0 kg to 20.6 kg/day ($\bar{X}$, 17.12 kg) raw droppings of which 54.65% to 93.44% is eaten up directly and the rest has slowly sedimented to the bottom. Generally, the extreme cycles are formed in pond due to high loading of manure or other nutrient rich organic matter which is not evident in the studied pond since stocked with surface feeder IMC species *Catla catla* that feeds voraciously on both detritus (raw poultry droppings) and very healthy zooplankton. Ponds receiving high loadings of manure or other nutrient rich organic matter donot have the extreme cycles when stocked with a proper polyculture of fish (Schroeder 1975a; Allen and Carpenter 1977; Buck et al. 1978)

**Acceleration of growth**

The growth and survival of *Catla catla* are excellent ranging from 90.0% to 94.5% in the both experimental periods as there is no incidence of disease and very low mortality is caused by accidental and experimental reason in both the years. In the present observation, the rapid growth of *Catla catla* is recorded with the average monthly increment rate from 115.4 g to 116.7 g (Table 17). This is attributable to the enormous production of zooplankton
mainly dominated by cladoceran, callanoid copepods and cyclopoid species and to the direct consumption of the poultry droppings by the fishes. The contribution of *Catla catla* to the total yield is found 61.9 to 62.8% when stocked at the rate of 40% in the two year experimental periods. The growth increment of *Catla catla* from its fingerling size to the juvenile stage is very rapid due to rapid feeding on zooplankton biomass mainly contributed by the crustacean zooplankton (Panov et al., 1969). Two cladoceran species namely *Diaphanosoma* spp. and *Moina brachiata* besides a number of callanoid copepods species represented by *Neodiaptomus diaphorus, N. handelti, N. Schmackeri, Allodiaptomus raoi, Hehodiaptomus vidius* and *Spicodiaptomus chelaepus* and two cyclopoid species namely *Mesocyclops leuckerti* and *M. hyalinus* are enormously produced under the influence of poultry droppings at zone A (Table 14). Increase of zooplankton due to the effect of organic manure including poultry litter has already been established in the pond water system. (Woynarovieh, 1980; Panov et al., 1969 and Ray and David, 1969). *Catla catla* being the zooplanktophagous species takes full advantage of zooplankton availability (Sharma and Das, 1988) in the studied integrated system.

**Feeding influence**

Direct feeding on raw poultry dropping has been observed in the present experiment and a composition of gut content in *Catla catla* has also documented its feed quality in the present system of integrated farming. The examination of gill rakers indicates accumulation of large number of crustacean zooplankton in the gill filaments along with the faecal particle of poultry droppings. This type of food and feeding behaviour of *Catla catla* as observed in the present experiment has highly justified its high growth increment during the experiment. It has been noticed that there is a little difference in the growth increment of *Catla catla* between the experimental and the control pond. Since in the experimental pond no supplementary feeding and no fertilizers are added, the qualifying growth rate of *Catla catla* in this pond justifies an economically viable system of the integrated farming under the influence of poultry droppings. It shows from the experiment that poultry droppings substitute the supplementary feeding of *Catla catla* and do help self maintenance of the habitat by the production of biological feed contributed by zooplankton and detrital feed by raw poultry faeces.

The present study reveals that the water charged with 7.54 to 12.69% of Crude protein, 1.09 to 3.15% of Fats and 1.29 to 2.10% of Nitrogen, 3.87 to 6.30% Calcium, 0.96 to 2.74% Magnesium, 0.62 to 1.29% Potassium and 0.62 to 1.27% Sodium, do help the
growth increment of *Catla catla* at the rate of 6000/ha stocking density with 40% stocking ratio under the integrated poultry cum fish culture system. The release of protein and nutrients to water for raising fish growth has been estimated by Icchhponani and Lodhi, (1976); Schroeder,(1978); Flegal and Zindel,(1971).

**Positive allometric status**

The length-weight relationship in fishes is the basis for calculation of unknown weights from known lengths or unknown lengths from known weights. Since, the fish passes through several stages, the simple cube law (Le Cren, 1951) does not hold throughout the life span and equilibrium constant shows certain variability around 3, although the general principle is that the weight increases as the cube of length (Laglar 1952, Rounsfell and Everheart 1953).

The length-weight relationship and relative condition factor of *L. rohita, C. catla, C. mrigala* and *L. calbasu* from the river Brahmaputra have been studied by Choudhury et al., (1982) who have observed the correlation coefficient ‘r’ of *Catla catla* as 0.98. Applying t-test they have observed that the exponential value of *Catla catla* is not significantly different from 3 at 5% level, thereby indicating that weight increases at rate almost equal to the cube of length. In the present observation, the correlation coefficient ‘r’ of *Catla catla* is found to be 0.98 and 0.99 in 1991 - 92 and 1992 - 93 respectively in the experimental pond and are almost identical in the control pond. The exponential values are tested against 3 and found to be significant.

The value of ‘n’ in the equation \( W = aL^n \) (Le Cren, 1951) generally is nearer 3 (Allen, 1938) or between 2.5 and 4.0 (Hile, 1936; Martin, 1949) Jayabalan (1980) has reported the value as 2.5939 and 3.1629 in *Gazza minuta* and 3.0315 and 3.2291 in *L. splendens*. In the present observation the value of ‘n’ is found between 3.0802 and 3.4461 in the two years study period and results are in conformity with the above workers.

The relative condition factor ‘kn’ gives an indication of fatness, general well being or gonad development and suitability of environments (Le Cren, 1951). Choudhury et al. (1982) have studied that the value of relative condition factor ‘kn’ becomes high due to the presence of mature gonad and low due to the spawning. They have found the value to be highest in the younger size. In the present observation the ‘kn’ value ranges from 0.77 to 1.61. (Table 26). That the juvenile fishes are found to have higher relative condition in the present observation is in conformity with the earlier workers (Le Cren, 1951; Choudhury et al., 1982; Fawzy et al., 1987).