ANNEXURE-C

Summary of the findings

The study was undertaken to formulate low-cost fish feed using locally available agro-based wastes in the *Apatani* landscape of Arunachal Pradesh, North-east India. The study was done with the overall goal of improving fish production through supplementation of low-cost fish feed in the rice-fish system of the *Apatani* landscape. We studied the habitat condition, food availability, feeding, growth, and nutrient assimilation of the stocked fish in the rice-fish system of *Apatani* Plateau. The fish feed was formulated using locally available agro-based raw materials. This was followed by nutrient analyses and efficacy test of the formulated feed on growth performance of the stocked fish under laboratory condition.

The physicochemical properties of rice field water revealed the rice-fish system to be a shallow water system. Investigation of planktonic and rice stem periphytic communities present in the rice-fish system of the *Apatani* Plateau revealed that the phytoplankton and phyto-periphytic algae were more diverse communities than the zooplankton communities. Bacillariophyceae was the most dominant phytoplankton class in the rice field water as well as the most dominant phyto-periphyton class on the rice stem while Cladocera was the most dominant zooplankton group in the rice-fish system.

Gut content analyses revealed the stocked fish in the rice-fish system to be omnivorous in nature. Body nutrient content of the stocked fish revealed variations in the proximate and mineral nutrient compositions in the body of the stocked fish with respect to months. This indicates variations in the availability and type of food in the rice-fish system across different months leading to monthly variations in the body nutrient content of the stocked fish.

The fish-feed formulation was done using locally available raw materials in the *Apatani* Plateau. This was followed by the analyses of the proximate composition of the fish-feed formulation and an aquaculture

Tapati Das 23/12/19

Scanned by CamScanner

experiment to test the effectiveness of the prepared fish-feed on the overall growth and health performance of the stocked fish, *Cyprinus carpio*. Efficacy test was performed also to quantify the proportion of feed to be supplemented in the rice-fish system that would be appropriate for optimal growth of the stocked fish without disrupting the natural ecological balance within the rice-fish system.

Efficacy test performed with formulated feed under laboratory condition suggests that the stocked fish would grow much faster if the prepared fish-feed were supplemented into the rice-fish system of *Apatani* Plateau @ 3% of their initial body weight while stocking in the rice field. However, further studies following on-farm feeding trials would enhance a better understanding of the growth behavior of the fishes in this system.

Overall, the study highlights the possibility of increasing the production of fish in the rice-fish system of *Apatani* Plateau by exploiting the existing agro-based wastes in the study area as supplementary fish feed which would definitely result in more per capita fish-protein consumption and better economic returns to the local people of the *Apatani* landscape in sustainable and eco-friendly ways.

Tapati Das
23/12/19

Scanned by CamScanner

Final Technical Report

on

FORMULATION AND EVALUATION OF LOW COST FISH FEED FOR SUPPLEMENTATION IN THE RICE-FISH SYSTEM OF APATANI PLATEAU, ARUNACHAL PRADESH, INDIA

UGC Major Research Project, Sanction No. 40-143/2011 (SR)

SUBMITTED TO

UNIVERSITY GRANTS COMMISSION, NEW DELHI - 110002

PRINCIPAL INVESTIGATOR
Dr. Tapati Das,
Department of Ecology and Environmental Science,
Assam University,
Silchar-788011

CO-PRINCIPAL INVESTIGATOR
Prof. D.N. Das,
Department of Zoology,
Rajiv Gandhi University,
Doimukh -791112

PROJECT FELLOW
Ms. Bipasha Dev Gupta,
Department of Ecology and Environmental Science,
Assam University,
Silchar-788011

Tapati Das
23/12/19

ASSAM UNIVERSITY, SILCHAR
DECEMBER, 2014

Scanned by CamScanner

ACKNOWLEDGEMENTS

We are thankful to Dr. P. K. Samal, the then Scientist in-Charge (NE Unit), G. B. Pant Institute of Himalayan Environment and Development, Vivek Vihar, Itanagar, Arunachal Pradesh, for providing infrastructural facilities for nutrient analysis of fish samples and raw materials used for fish feed formulation.

We express our heartfelt gratitude and thanks to all the villagers of the study area for information sharing and their cooperation during the investigation.

We are thankful to all the persons who directly or indirectly helped us to carry out the project work.

We also acknowledge the University Grants Commission, New Delhi for the financial support in the form of a major research project to carry out the research work.

(TAPATI DAS)

(Dr. Tapati Das)
Principal Investigator,
UGC-MRP

Place: Silchar
Date: 31-12-2014

Tapati Das
23/12/19

Scanned by CamScanner

CONTENTS

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 1

GENERAL INTRODUCTION AND OBJECTIVES

Apatani Plateau of lower Subansiri district of Arunachal Pradesh (26° 55' to 28°21' N and 92° 40' to 94° 21' E) dominated by Apatani tribe are involved in Integrated Agriculture Aquaculture (IAA) in their wet rice fields since many years. The plateau is bowl-shaped surrounded by high hills and interspersed with paddy fields and bamboo–pine groves. Inhabitants of this valley are divided into a number of clans and each clan lives in a clearly defined part of the village. They worship the sun (Donyi) and the moon (Polo) and there are several fascinating myths attached to their deities and their origin which serves to reinforce their uniqueness as compared to the neighbouring communities. Almost all their festivals are connected to nature conservation and community welfare.

The Apatani tribe practice the culture of fish in rice fields merged with their traditional agronomic practices over the past 50 years. This IAA is free from the use of agrochemicals and additional input of supplementary feed for fish and is popularly known as 'aji ngui assonii' (Saikia and Das, 2004). They basically follow the traditional agronomic practices for rice even in rice-fish combination pertaining to field preparation and maintenance. Field preparation starts in April, occasionally continues up to late May, and rice seedlings are planted in May-June. The strains of common carp (*Cyprinus carpio*) are stocked at fry stage (3–5 cm), after just ten days of transplanting the rice and reared in the field for about 3 to 4 months. However, limited availability of natural feed and short duration of the rearing period do not allow the fish to gain much biomass (Halwart and Gupta, 2004). As a result, only 150 to 250 kg ha^{-1} of fish (*Cyprinus carpio*) per season are harvested from the system (Saikia and Das, 2004), which is much lower comparing to similar systems in China (Zhang, 1995; Halwart, 1998).

Tapati Das
23/12/19

Scanned by CamScanner

Administering supplementary feeding material to the fish in the paddy fields may increase the secondary productivity (Halwart and Gupta, 2004). Locally available ingredients such as agro-based by-products and other organic wastes may be used as feed input in the system, which may a promising solution from the perspective of the rural economy and sustainability.

The present research project had the following objectives:

1. To investigate the environmental quality and the availability of natural fish feed in rice environment.
2. To characterize the feeding habit of the stocked fish along with their food preferences.
3. To select available resources from the agro-based by-products of the Apatani plateau.
4. To determine the nutritional values of the local feed ingredients.
5. To formulate the suitable feed using composite mixture of local ingredients.
6. To conduct efficacy test for formulated feed under laboratory condition.
7. To prepare an extension manual on processing and formulation of the fish feed to promote rice-fish based farming systems of the area.

Tapati Das.
23/12/19

Scanned by CamScanner

Chapter 2

DESCRIPTION ON THE STUDY AREA AND LAYOUT OF THE STUDY

Location

The Apatani Plateau, bifurcated by the river Kele, is located in Lower Subansiri District, Ziro, Arunachal Pradesh. The plateau is bowl-shaped surrounded by high hills and interspersed with paddy fields and bamboo–pine groves. The valley lies at an altitude of 1524 m with temperatures on the cooler side and its population density is 554 person/km^2. The valley enjoys cool subtropical climate with 2,350 mm annual rainfall. Ziro is famous for paddy-cum-fish cultivation. It may be mentioned here that the agrarian hill tribe in this region has cultured fish in rice fields merged with their traditional agronomic practices over the past 50 years. Their practice, locally termed *aji ngui assonii*, is free from the use of agro-chemicals and additional input of supplementary feed for fish (Saikia and Das 2004). The Apatanis belong to the Tibeto-Mongolid stock (Haimendorf 1962). Literally the word Apatani is from 'Apa' means addressing someone out of affection and 'Tani' means the descendents of Abotani, who is considered as the forefather of the Apatani. Apatani people perform different ritual ceremonies like Myoko, Murung, and Dree of which Myoko is the most important festival. There are seven major villages namely Hong, Bulla, Hari, Hija, Bamin–michi, Mudang-Tage and Dutta (Dollo *et al.*, 2009). For the present study five stations from Apatani plateau were selected (Long. 27°33'-27°35'E and Lat. 093°49' to 093°50'N). These were Bamin-michi, Hari, Bulla, Hiza and Hong (Figure 2.1). The study was undertaken to formulate fish-feed using local resources for enhanced fish productivity in the rice-fish system of Apatani Plateau.

Tapati Das
23/12/19

Scanned by CamScanner

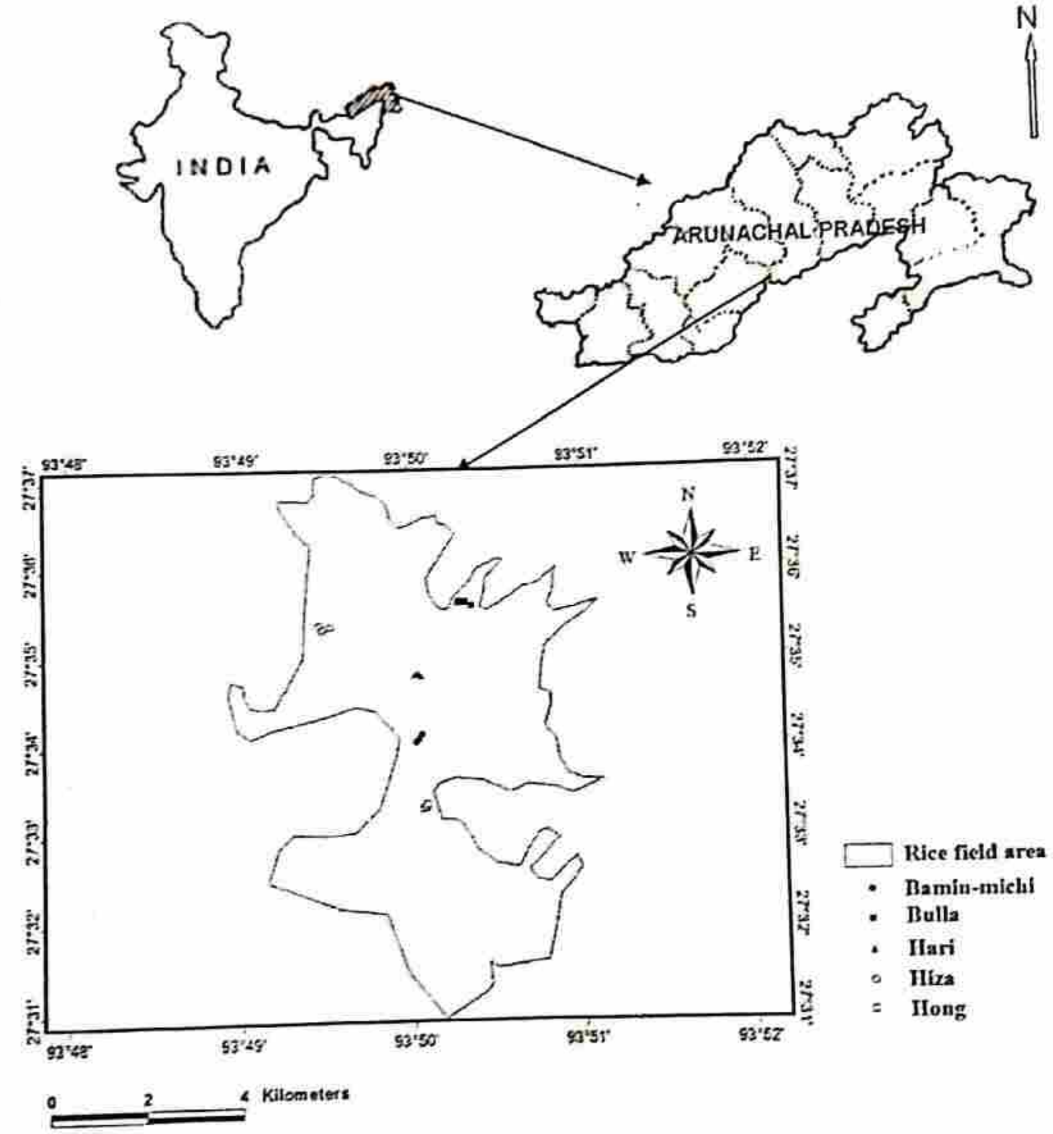


Figure 1. Map showing the sampling stations

Tapati Das
23/12/19

Scanned by CamScanner

Climate

Ziro experiences a temperate climate. Summers are cool, though the area witnesses extensive rainfall during the monsoons and winters are cold. The summer season starts in April till the end of June and the monsoons start in July and end in September. Winter sets in by November and lasts throughout February. The climate is largely influenced by the nature of terrain depending upon altitude and location of place. Annual rainfall in the south is heavier than that in the northern areas of the district. During the monsoon period more than 70 percent of the rain over the southern half occurs while in the northern portions it is about 60 percent. Variability of rain fall for the monsoon and the year, as a whole, are relatively small. Average annual rainfall of the district headquarters, Ziro recorded an average rainfall of 59.85 mm and the total rainfall was 718.2 mm during the year 2012. In the year 2013 the average rainfall was 60.28 mm and the total rainfall recorded was 723.4 mm. Relative humidity is always high throughout the year except in the winter months being slightly less humid.

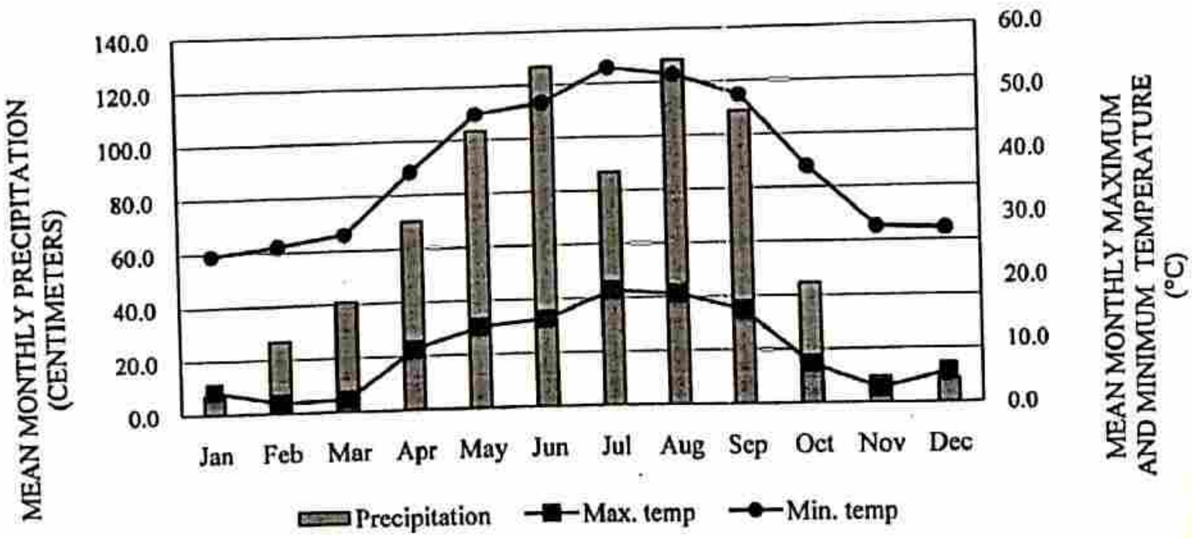
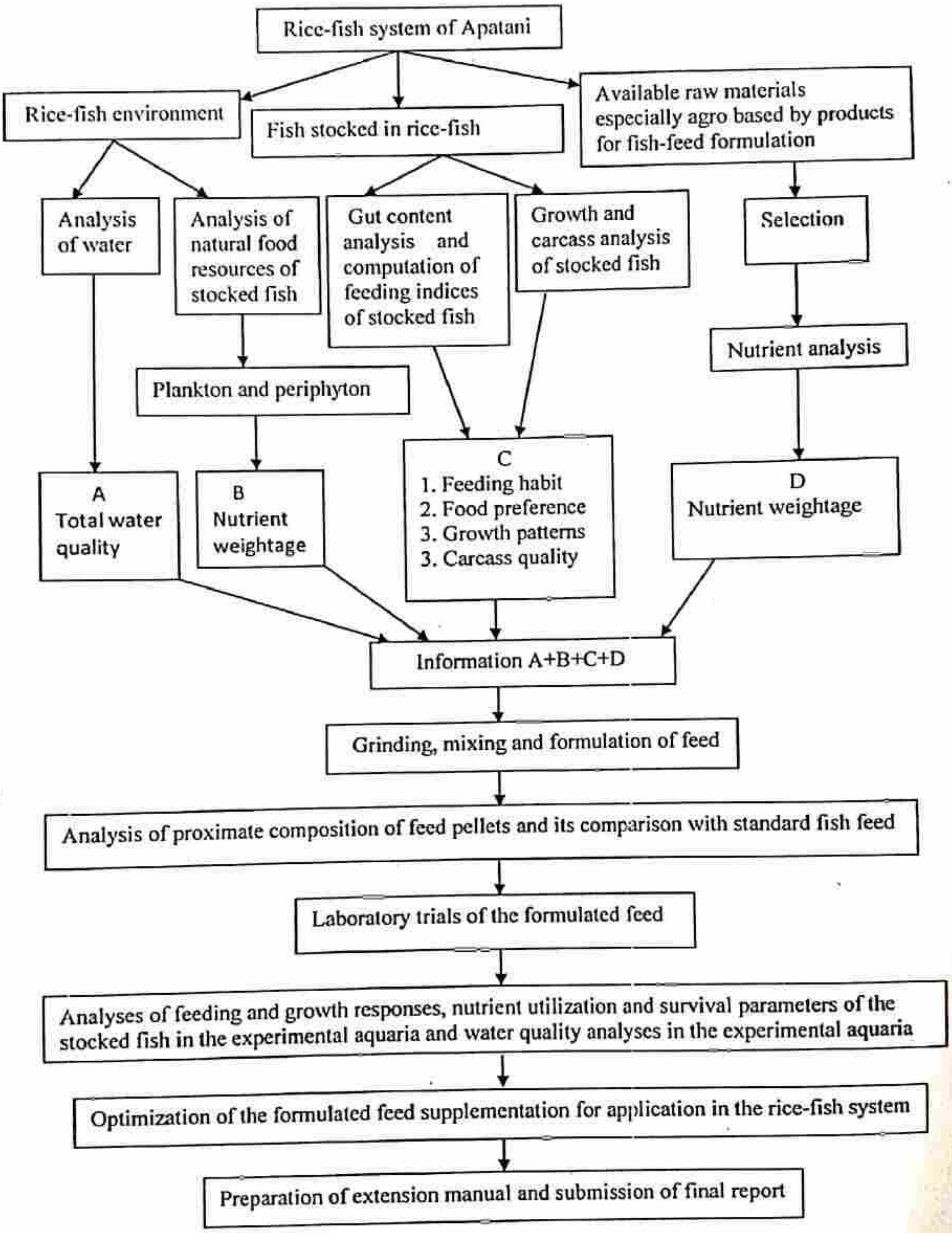


Figure 2. Climatogram of the study area depicting the average monthly precipitation, maximum and minimum temperatures for three years i.e. 2012, 2013 and 2014

Tapati Das.
23/12/19

Scanned by CamScanner

Layout of the study



Tapati Das
23/12/19

Scanned by CamScanner

Chapter 3

MATERIALS AND METHODS

Physico-chemical properties of the rice field water

In order to assess the natural habitat condition of the stocked fish in rice-fish system water samples of the rice-fish system during the fish stocking stage was collected at monthly intervals from the selected sampling stations. Physico-chemical parameters of the rice-field water were analysed following Michael, 1984; Eaton *et al*., 1995; Ramesh and Anbu, 1996; Gupta, 1999; Tripathi and Govil, 2001.

Biological parameter of the rice field: plankton and rice-stem periphyton communities

For quantitative estimation of plankton and rice-stem periphyton Lackey's drop method (Lackey, 1938) was followed. Both the plankton and periphyton were sorted out and identified to the lowest possible taxonomic level using light microscope (Magnus MLXi binocular microscope). Identification of phytoplankton and periphyton was done at magnification 40X and that of zooplankton at 10X following Needham and Needham, 1962; Pentecost, 1984; Battish, 1992; Anand, 1989, 1998; Bilgrami and Saha, 2004; John *et al*., 2011 and APHA, 2012 etc.

Feeding habit and food preferences of stocked fish

To find out the feed preference of the stocked fish in the rice-fish system fish samples were collected from the rice fields of the study area during three hours of the day (i.e. 8am-9am, 11am-12pm, and 2-3pm) and were preserved in 10% formalin. Later on the samples were brought to the laboratory and their respective lengths and weights were noted down. Intact stomach was separated from the fish and weighed using an electronic balance (Shimadzu, Ax200,No D440420098). Afterwards, the stomach was dissected and its contents were preserved with 4ml 10% formalin in test tubes. Later on the weight of empty stomach was also noted. The gut contents were examined following Lackey's drop method (Lackey,

Tapati Das 23/12/19

Scanned by CamScanner

1938) using light microscope (Magnus MLXi binocular microscope). Identification of gut content of the fish was done following standard keys Ward and Whipple, 1959; Needham and Needham, 1972; Biswas, 1980; Ghosh and Sengupta, 1982; Michael, 1984; Vazirani, 1984; Gohan, 1988; Anand, 1989, 1998; Santhanam *et al.*, 1989; Battish, 1992; Santra, 1993 Calculation of different feeding indices were done following Levins,1968 and Hobson, 1974 as follows:

(1) Niche breath (Levins, 1968)

$B = 1/\sum (pj^2)$

Where,

B is Levin's diet/niche breadth,

pj is fraction of items in the diet that are of food category j.

B value ranges from 1.0, when the population under study uses one resource state exclusively and equal to R (i.e. the number of taxonomic identity or size category or anything categorizing resource or food) when the population uses all resource states.

(2) Ranking index (Hobson, 1974)

Ranking index of each prey item=

(Volumetric scale of prey item/ Volumetric scale of all prey items combined) x100

Growth of the stocked fish and its nutrient contents

In order to study the growth condition of the stocked fish in the rice field, fish samples were collected from the rice fields at monthly interval during the fish stocking stage (May to August) during 2014 by draining the water from the rice field through the outlet pipes. The fish samples were kept in ice box lined with ice cubes and brought to the laboratory. In the laboratory their respective length and weight were noted down in order to get information on their growth pattern. Total length of the fish samples was noted with the help of a measuring scale in centimetre. The weight of the fish was noted down using an

Tapati Das. 23/12/19

Scanned by CamScanner

electronic balance (Shimadzu, Ax200, No D440420098) after drying it with tissue paper. The growth pattern of the fish in terms of its body length and body weight was noted following Bhuiyan and Biswas, 1982.

Nutrient contents of the stocked fish

For determination of nutrient contents in the body of the stocked fish in the rice-fish system, fish samples were collected from the rice fields at monthly interval during the fish stocking stage (May to August) during 2014 by draining the water from the rice field through the outlet pipes. The fish samples were kept in ice box lined with ice cubes and brought to the laboratory. In the laboratory the fish samples were dried in an oven at 60°C for 24 hours after which these were transferred to desiccators and kept for another 24 hours. The samples were powdered with the help of mortar and pestle. Finally subsamples of the powdered form of the fish carcass after homogenization were used for determination of nutrient content of the fish samples. Determination of the body nutrient of the stocked fish in the rice-fish system comprised of proximate components like carbohydrate, protein, fat, and mineral components like sodium, potassium, calcium and phosphorous. Determination of carbohydrate was done by Anthrone method. Determination of protein was done by Kjeldahl method after acid hydrolysis (crude protein= total nitrogen x 6.25). Determination of fat (crude fat) was done by extracting it by petroleum ether in a Soxhlet apparatus. The macro elements like sodium (Na), potassium (K) and calcium (Ca) were determined by flame photometer method. Phosphorous (P) was determined by spectrophotometric method. Determination of all the above mentioned nutrients were done following standard references as per Raghuramulu *et al.* (1983), Okalebo *et al.* (1993), and Sadasivam and Manickam (1996).

Tapali Das
23/12/19

Scanned by CamScanner

Formulation of low-cost fish feed

A. *Selection of raw materials*

For formulating the fish-feed, raw materials which are commonly available in the Apatani Plateau were selected as the ingredients. These are: (1) the leftover of processed and fermented rice after preparation of the local rice beer, '*Apong*', (2) algae which remain as clump near the rhizosphere of the rice plant in the paddy field, and (3) garlic (*Allium sativum*) as antioxidant.

B. *Formulation of fish-feed*

The raw materials i.e. leftover of processed and fermented rice and algae were dried separately in an oven at 70°C for 48 hrs. Followed by this, each of the components were separately grinded to a powdered form in a grinder. The powdered ingredients were then mixed in the proportions – (100 gm leftover of processed and fermented rice) + (50 gm clumped algae from the rice field) + (1 gm garlic paste). Soft dough was prepared using water at normal room temperature. This was followed by pelleting the dough using a pellet machine. Finally, the pellets were kept for drying in oven at 60°C for 24 hours.

C. *Determination of proximate composition of the raw materials and the prepared fish-feed*

The nutritional value of the raw materials used for the fish-feed formulation and of the final product, were analyzed for their proximate composition following standard methods of Raghuramulu *et al.* (1983), Okalebo *et al.* (1993), and Sadasivam and Manickam (1996).

D. *Efficacy test of the fish-feed under laboratory condition*

Aquaculture experiment was performed to test the efficacy of the formulated fish-feed on fish growth. For this, fish fries were collected from the nearest fish farm, and were acclimatized for 48 hours in an aquarium. The feeding trial was conducted for four weeks (December, 2014) in four experimental aquariums (30 L capacity) @ 12 individuals per aquarium. The fishes were fed twice per day at 08:30 hr and 17:30 hr with three feeding treatments (i. e. supplementation of the prepared fish feed @ 3%, 5%, and 7% of the initial

Tapati Das
23/12/19

Scanned by CamScanner

body weight of the stocked fish in three different experimental aquaria) and one control (where no supplemental feed was given and it is presumed that the fish survived only on the available plankton in the experimental aquaria). At the end of each week the stocked fish (three replicates) in different experimental aquaria were tested for different growth parameters. The water in the experimental aquaria was changed once on the 15th day of the feeding trial. Growth response, feeding response and survival parameters of the stocked fish under different treatments were recorded following Fulton (1911), Bhuiyan and Biswas (1982), Faturoti and Akinbote (1986) and Lovell (1988).

Water quality parameters which are required for aquaculture experiments were also analyzed for two times- one set of analysis was done during the 14th day and the other on the 28th day of the experimental set up in different aquaria under different treatments following APHA (2012).

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 4

WATER QUALITY OF RICE-FISH SYSTEM OF APATANI PLATEAU

Introduction

Rice today is grown in 113 countries in the world in a wide range of ecological conditions and water regimes. The cultivation of most rice crops in irrigated, rain fed and deepwater systems offers a suitable environment for fish and other aquatic organisms. Over 90% of the world's rice, equivalent to approximately 134 million hectares, is grown under these flooded conditions providing not only home to a wide range of aquatic organisms, but also offering opportunities for their enhancement and culture (Halwart and Gupta, 2004).

Fish culture in waterlogged rice fields have been known to be practiced in Asia for 5000-6000 years. The earliest record of rice fish culture was originated from China 2000 years ago (Li, 1988). An early review on rice-fish culture showed that by the mid-1900s it was practiced in 28 countries on six continents, namely, Africa, Asia, Australia, Europe, North America and South America (F.A.O., 1957). Countries with a recorded history of rice-fish culture are India, Indonesia, Malayasia, Thailand, Japan, Madagascar, Italy and Russia (Halwart, 1994).

Rearing of fish along with paddy is an old practice in India (Alikunhi, 1955) Rice and fish are immensely important to the livelihoods of the rural poor in India as both a source of nutrition and as a source of income. Rice and fish are considered to be the main sources of food in this region. It has been estimated that rice constitutes as much as 60% of the daily food intake of the majority of Asians.

However, in this regard, mention must be made that the fish production in rice fish system of Apatani Plateau, in fact, is far below the carrying capacity of the field in comparison to similar systems elsewhere. And, in order to increase the fish productivity research is needed to understand the pattern of nutrient dynamics in relation to fish

Tapati Das. 23/12/19

Scanned by CamScanner

production in the rice- fish system and based on the information of the field condition, the water quality parameters were analysed.

Results and discussion

Table 4.1 shows the physico-chemical properties of water in the rice-fish system of Apatani Plateau. In Bamin-michi, high values of pH, DO and least value free CO_2 and PO_4-P gives a general indication about the presence of less organic matter content in that station. Greater value of NO_3-N in Bamin-michi was perhaps due the less water depth and subsequently less water volume in the station and hence the concentrations of nitrates particularly due to faecal matters of the stocked fish. Least value of total alkalinity in Bamin-michi indicates very low buffering capacity of the water there and hence more stressed condition for the stocked fish. Greater values of BOD and PO_4-P in Bulla indicates presence of phosphorous-rich organic matters in more quantities and more microbial activities that lead to the release of PO_4-P in greater amount at that station. Hiza had highest value of water and sediment temperatures. This might be due to less water depth at this station and also might be due to the reason that sampling in this station was done when the solar intensity was high that also lead to increase in air temperature thereby reflecting the close interaction of air, water and sediment temperatures in the aquatic system. Hiza also had greater value of total alkalinity thereby reflecting relatively more buffering capacity of the water in this station. Low values of pH, DO and greater value of free CO_2 in Hong reveals a relatively stressed condition in this station. This might be due to more density of planktonic organisms (Figure 4) and also the stocked fish. However, BOD was less in Hong. This was perhaps due to more water depth and hence more water volume that lead to the dilution of organic matters in the water and less water temperature that lead to less microbial activities in that station. Least value of NO_3-N in Hong was perhaps due to greater photosynthetic activity of the phytoplankton which had a highest density at that station.

Tapati Das
23/12/19

Scanned by CamScanner

Table 4.2 shows the Analysis of Variance for water properties in rice-fish system of Apatani Plateau. It showed that all the properties water in the rice-fish system varied significantly across stations, months and stations x months.

Table 4.3 shows the comparison of water properties in rice-fish system of Apatani Plateau with relevant standard of freshwater fisheries in warm water. It is observed that except for CO_2, all the parameters of the rice field water during the fish stocking stage were within the range for freshwater fishery.

Tapati Das.
23/12/15

Scanned by CamScanner

Table 4.1. Physico-chemical parameters of water in the rice fish system of Apatani Plateau

Stations	AT (°C)	WT (°C)	ST (°C)	WD (cm)	pH	TA (mgl^{-1})	DO (mgl^{-1})	BOD (mgl^{-1})	Free CO_2 (mgl^{-1})	Nitrate-N (mgl^{-1})	Phosphate-P (mgl^{-1})
Bamin-michi	24 ±1.30 (20-33)	26.08 ±0.85 (22-30)	25.7 8±0.7 (21-30)	10.19 ±0.83 (6.4-13.5)	7.38 ±0.12 (6.7-7.9)	20.45 ±1.45 (12.6-29.33)	8.71 ±0.7 (7.06-11.28)	3.41 ±0.48 (1.33-6.48)	11.63 ±1.21 (5.9-17.91)	5.66 ±1.09 (0.23-12.31)	0.04 ±0.01 (0.01-0.12)
Hari	24.08 ±1.08 (20-30)	26.45 ±1.03 (22-30)	25.42 ±0.72 (22-29)	12.6 ±0.83 (9.2-15.5)	7.22 ±0.15 (6.3-7.6)	24.47 ±2.31 (12.60-33.30)	7.85 ±0.33 (6.28-10.27)	2.19 ±0.39 (0.72-4.67)	12.77 ±1.10 (5.9-17.15)	5.03 ±1.00 (0.39-12.04)	0.06 ±0.01 (0.005-137)
Bulla	23.73 ±0.94 (19-32)	24.53 ±0.94 (20-29)	23.33 ±0.75 (19-28)	12.02 ±1.50 (6.2-20.6)	6.83 ±0.2 (5.02-7.5)	28.54 ±4.25 (13.2-34-66)	8.3 ±0.27 (6.48-10.54)	3.67 ±0.45 (0.94-4.91)	13.82 ±1.08 (4.59-19.2)	4.08 ±0.70 (0.52-9.04)	0.07 ±0.02 (0.01-0.29)
Hira	24.58 ±1.33 (20-33)	27.33 ±1.47 (21-35)	25.92 ±1.20 (20-32)	10.23 ±1.09 (5.0-15.0)	7.24 ±0.07 (6.7-7.5)	32.54 ±2.49 (20-44.66)	8.4 ±0.44 (6.34-11)	3.54 ±0.68 (0.72-8.44)	12.7 ±1.11 (6.59-18.57)	4.5 ±0.90 (0.34-8.21)	0.05 ±0.01 (0.004-0.114)
Hong	22.93 ±1.08 (19-32)	24.4 ±0.62 (20-28)	24.33 ±0.54 (22-29)	12.62 ±1.35 (6.0-21.7)	6.69 ±0.27 (4-7.7)	23.18 ±2.70 (12.6-35.33)	7.11 ±0.36 (5.12-9.04)	2.15 ±0.43 (0.24-7.01)	14.6 ±0.95 (7.98-19.9)	3.85 ±0.64 (0.11-7.07)	0.05 ±0.01 (0.003-0.075)

Mean ±SE; n=45; AT-Air temperature; WT-Water temperature; ST-Sediment temperature; WD-Water depth; TA-Total alkalinity; DO-Dissolved oxygen; BOD-Biological Oxygen Demand. Numbers in parenthesis designate range of mean values of the physico-chemical properties of water in different stations of the study area)

Tapati Das.
23/12/19

Scanned by CamScanner

Table 4.2 Analysis of Variance for water properties in rice-fish system of Apatani Plateau

Physico-chemical properties of water	ANOVA		
	One-way		Two-ways
	Stations F-ratio	Months F-ratio	Stations x Months F-ratio
Air temperature	69.12*	857.1*	68.1*
Water temperature	142.42*	2463.91*	296.54*
Sediment temperature	177*	2759.7*	326.9*
Water depth	17.6*	70.908*	6.264*
pH	66.12*	987.12*	85.12*
Total alkalinity	18.4*	82.511*	2.748*
Dissolved oxygen	22.434*	155.682*	41.447*
Biological oxygen demand	7.5854*	31.8813*	7.6206*
Free carbon dioxide	7.6157*	25.4957*	6.3431*
Nitrate-nitrogen	3.12*	200.408*	5.895*
Phosphate-phosphorous	3.656*	18.5942*	2.1407*

*$p<0.01$

For one-way ANOVA degree of freedom=4

For two-ways ANOVA degree of freedom=16

Tapali Das.
23/12/19

Scanned by CamScanner

Table 4.3. Comparison of water properties in rice-fish system of Apatani Plateau with relevant standard of freshwater fisheries in warm water

Parameters	Standards of water properties for freshwater fisheries in pond as per Das *et al.*, 2013	Standards of water properties for freshwater fisheries in pond as per Boyd, 1998	Range in water properties in rice-fish system of Apatani Plateau during fish stocking stage
Water temperature (°C)	25-32, *25-35	-	20-35
Water depth (cm)	>30; *5-25	-	2-21.7
pH	6.5-8.5	7-9	4-7.7
Total alkalinity (mg l^{-1})	50-300	-	12.6-77.33
DO (mg l^{-1})	5-10	5-15	5.12-11.28
BOD (mg l^{-1})	<10	-	0.24-8.44
Free CO_2 (mg l^{-1})	<3	1-10	4.59-19.9
Nitrate-N (mg l^{-1})	0.1-3	0.2-10	0.11-12.31
Phosphate-P (mg l^{-1})	0.05 to 2.0	0.005-0.2	0.003-0.137

*Standard of water temperature and water depth for fish culture in rice-fish system as per standard given by Tamilnadu Agricultural University, Coimbatore

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 5

NATURAL FISH FOOD IN RICE-FISH SYSTEM OF APATANI PLATEAU

Introduction

In rice rice-fish culture the presence and abundance of food organisms are very important factors. It harbours lots of phytoplankton and filamentous higher algae in its aquatic phase (Fernando, 1993). All these aquatic fauna and flora play important role on the overall ecology of rice field. Con The term "Plankton" refers to those minute aquatic forms which are non motile or insufficiently motile to overcome the transport by currents and living suspended in the open or pelagic water (Greek planktons, meaning wandering). They comprise of heterogeneous group of tiny plants and animals adapted to suspension in the sea and fresh water. Their intrinsic movements, if any, are so feeble that they remain essentially at mercy of every water current. The plankton belonging to plant origin are called phytoplankton (phyto =plant; plankton =floating) and those belonging to animal origin are called zooplankton (zoo = animal; plankton = floating) (Eaton *et al.*, 1985).

The plankton can further be divided on the basis of their size viz., megaplankton- more than 8cm, macroplankton-size vary from 1mm to 1cm, mesoplankton- 0.5-1mm, microplankton- 0.06-0.5mm, nanoplankton- 0.005 to 0.06mm, and ultraceston -0.0005 to 0.005mm (Battish, 1992).

Planktons are of immense value as food for fishes and play an important role in the natural purification of polluted waters. However some plankton form a harmful bloom and they cause high mortality among the aquatic organism and pose a serious hazard in the water supply for domestic and industrial use. Plankton also play important role as bio indicator of water quality

Tapati Das 23/12/19

Scanned by CamScanner

Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and some fish and it can be an important sorer of contaminants. Periphyton is also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of times scales representing physiological to community-level changes.

Results and discussion

Table 5.1 shows the distribution of phytoplankton in the study area. It reveals the presence of 77 taxa of phytoplankton belonging to classes Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, and Zygnemophyceae out of which 45 taxa belonged to Bacillariophyceae, 13 taxa to Chlorophyceae, 12 taxa to Cyanophyceae, 5 taxa to Zygnemophyceae and 1 each to Dinophyceae and Euglenophyceae. In all the stations Bacillariophyceae followed by Chlorophyceae was the most dominant phytoplankton class (Figure 5.1). The dominance of Bacillariophyceae in the rice-fish system was due to more silica content in the sediment and water which is the major nutrient required by the diatoms (Lukaw *et al.*, 2012). The second dominant phytoplankton class was Chlorophyceae which was perhaps due to low temperature of the rice field water, moderate nutrients like NO_3-N and PO_4-P (Mustapha, 2010) accompanied by better substrates, the paddy plants. Among all the stations, Hiza and Hong had the highest phytoplankton density (Figure 5.4A). However, phytoplankton taxa were relatively rich in Hiza and poor in Hong (Table 5.1). Therefore, different reasons can be ascribed for the greater density of phytoplankton in two different stations of the rice field systems. In Hiza the greater phytoplankton density with more phytoplankton taxa might be due favourable environmental condition (particularly due to more alkalinity) for diverse taxa at that station. In Hong the greater phytoplankton density

Tapati Das
23/12/19

Scanned by CamScanner

with less phytoplankton taxa might be due favourable environmental condition for selected taxa at that station.

Table 5.2 represents the distribution of zooplankton in the rice -fish system of the study area. It shows the presence of a total of 15 taxa of zooplankton in the study area belonging to groups Cladocera, Rotifera, Decapoda, Copepoda, Calanoida and Diplostraca. A total of 8 taxa belonged to Cladocera, 2 each to Rotifera and Copepoda besides 1 each to Decapoda, Copepoda, Calanoida and Diplostraca. It was observed that in all the sampling stations Cladocera was dominant zooplankton group (Figure 5.2) thereby indicating the rice-fish system to be free from intense pollution which favoured their growth and reproduction (Ferdous and Muktadir, 2009). Besides, the abundance of Cladocera also indicates the presence of rich nutrients with weeds and shallow waters (Sharma *et al.*, 2012) in the rice-fish system. Zooplankton density as well as its taxonomic richness in the rice-fish system of Apatani Plateau was highest in Hari and lowest in Hiza (Figure5.4B and Table 5.2). This was perhaps due to greater variations in the water properties in both these station that favoured the growth of zooplankton community in one station (Hari) while in the other station (Hiza) the water properties were not that congenial for the growth of diverse zooplankton.

Table 5.3. shows the distribution of rice-stem periphyton in the rice-fish system of Apatani Plateau. It shows the presence of a total of 56 taxa of rice-stem periphyton in the study area belonging to classes Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae, Rhodophyceae, Xanthophyceae and Zygnemophyceae out of which 34 taxa belonged to Bacillariophyceae, 10 taxa to Chlorophyceae, 8 taxa to Cyanophyceae, and 1 each to Dinophyceae, Euglenophyceae, Rhodophyceae, Xanthophyceae and Zygnemophyceae. In all the stations Bacillariophyceae was the most dominant periphyton (Figure 5.3). Hari was found to have highest density of periphytic community which might be due maximum penetration of solar radiation into the system

Tapati Das.
23/12/19

Scanned by CamScanner

because of the shallowness of the system, which lead to periphytic growth. While the periphytic communities was lowest in Bamin-michi which may be due to deep water column which limits photosynthesis and retards periphytic growth (Figure 5.4C).

Tapati Das.
23/12/19

Scanned by CamScanner

Table 5.1. Distribution of phytoplankton in different stations of the rice-fish system of Apatani Plateau

Class	Taxa	Bamin-michi	Hari	Bulla	Hiza	Hong
Bacillariophyceae	*Achnanthes* sp1.	-	+	+	+	+
	Acnanthes sp2.	+	-	+	-	-
	Amphiplena pellucida	+	-	-	-	-
	Amphora	+	-	-	+	+
	Amphora ovalis	+	+	+	+	+
	Asterionella	-	-	-	+	-
	Cymbella sp1.	+	+	+	+	+
	Cymbella sp2.	-	+	-	-	-
	Diatoma sp1.	+	+	+	+	+
	Diatoma sp2.	-	-	+	+	+
	Diatoma vulgare	-	+	+	+	-
	Encyonema	+	+	+	+	+
	Epithemia	-	+	+	+	+
	Eunotia	+	+	+	+	+
	Fragellaria	-	+	+	+	-
	Frustulia	+	+	+	+	+
	Gomphonema	-	+	+	+	+
	Gomphonema angustrum	+	-	-	+	-
	Gyrosigma	-	+	-	-	-
	Gyrosigma valticum	-	-	-	+	-
	Himantidium	-	-	-	+	-
	Mastogloia	-	-	-	+	-
	Melosira	+	+	+	+	+
	Microcoleus vaginatus	+	+	-	+	-
	Pinnularia sp1.	+	+	+	+	+
	Pinnularia major	+	-	+	+	+
	Pinnularia sp2.	-	+	+	-	-
	Pleurosigma	-	-	-	+	-
	Navicula gracillis	-	+	+	+	+
	Navicula placenta	+	+	+	+	+
	Navicula rhynchocephala	+	+	+	+	+
	Navicula sp.	+	+	+	+	+
	Navicula viridis	+	+	+	+	+
	Nitzschia	+	-	+	+	-
	Nitzschia sigmoida	-	+	+	+	-
	Stauastrum	+	+	+	+	+
	Stauastrum magnum	-	-	-	-	+
	Stauroneis	+	-	+	+	+
	Stauastrum brachiatum	+	-	-	-	-
	Stauastrum magnum	-	-	-	-	-
	Surirella sp1.	+	+	+	+	+
	Surirella sp2.	+	+	+	+	+
	Synedra	+	+	+	+	+
	Synedra fumosa	-	-	+	+	+
	Synedra ulna	+	+	+	+	+
	Tabellaria	+	-	+	-	-
	Tabellaria flocculosa	-	-	-	-	+
	Rholophalodia gibba	+	+	+	+	+
Chlorophyceae	*Ankistrodesmus*	-	+	+	-	-
	Closterium	+	+	+	+	+
	Closterium striolatum	-	-	-	+	-
	Cosmarium	+	+	+	+	+
	Desmidium	-	+	-	+	+
	Docidium	+	+	+	-	+
	Euastrum	+	+	-	+	-

Tapali Das 23/12/19

Scanned by CamScanner

	Euastrum crassum	+	+	-	-	-
	Gonatozygon	+	+	+	+	+
	Scenedesmus	-	+	-	-	-
	Spirogyra sp1.	+	+	+	+	+
	Spirogyra sp2.	-	+	-	-	-
	Ulothrix	+	-	-	-	+
	Zygonema	+	+	-	-	-
Cyanophyceae	*Anabaena*	+	+	+	+	+
	Aphanizomenon	+	+	+	+	+
	Nostoc	-	-	+	+	-
	Oscilatoria sp.	-	+	+	+	-
	Phormidium	+	+	-	+	-
	Phormidium autumnale	-	-	-	+	-
	Pseudoanabaena	+	+	-	-	-
	Spirulina	-	+	+	-	-
Dinophyceae	*Massartia*	-	+	-	-	-
Zygnemophyceae	*Micrasterias* sp1.	+	+	-	-	-
	Micrasterias sp2.	-	+	-	-	+
	Micrasterias radiosa	-	+	-	+	-
	Miscrasterias foliacea	-	-	-	+	-
Euglenophyceae	*Euglena*	+	+	+	+	-
Total taxa	77	43	52	45	54	39

'+' indicates presence and '-' indicates absence of the taxa concerned

Tapati Das
23/12/19

Scanned by CamScanner

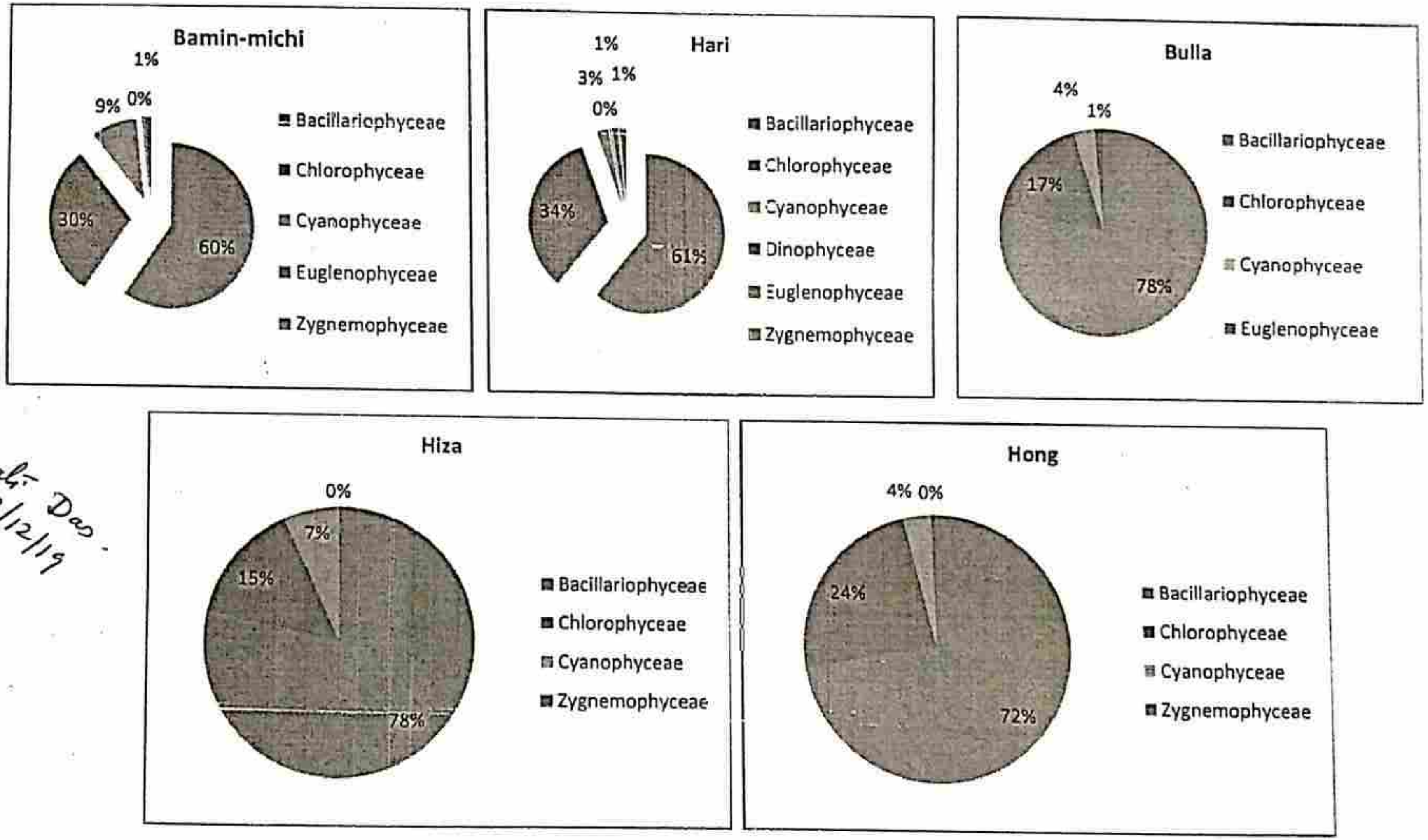
Table 5.2. Distribution of zooplankton in different stations of the rice-fish system of Apatani Plateau

Groups	Taxa	Bamin-michi	Hari	Bulla	Hiza	Hong
Cladocera	*Alona*	-	-	+	-	-
	Bosmina	+	+	+	+	+
	Chydorus	+	-	-	-	-
	Daphnia	-	+	-	+	+
	Leydigiopsis	-	-	+	-	-
	Moina	+	-	-	-	-
	Pleuroxus	-	-	+	-	-
Copepoda	*Cyclops*	-	+	-	-	-
	Canthocamptus	+	-	-	-	-
Calanoida	*Diaptomus*	+	-	-	-	-
Decapoda	*Alonella*	-	+	+	+	+
	Palemonetes	-	-	+	-	-
Diplostraca	*Sida crystallina*	-	+	-	-	-
Rotifera	*Asplanchna*	-	+	-	-	-
	Brachionus	-	+	-	-	-
Total taxa	15	5	7	6	3	3

'+' indicates presence and '-' indicates absence of the taxa concerned

Tapati Das
23/12/19

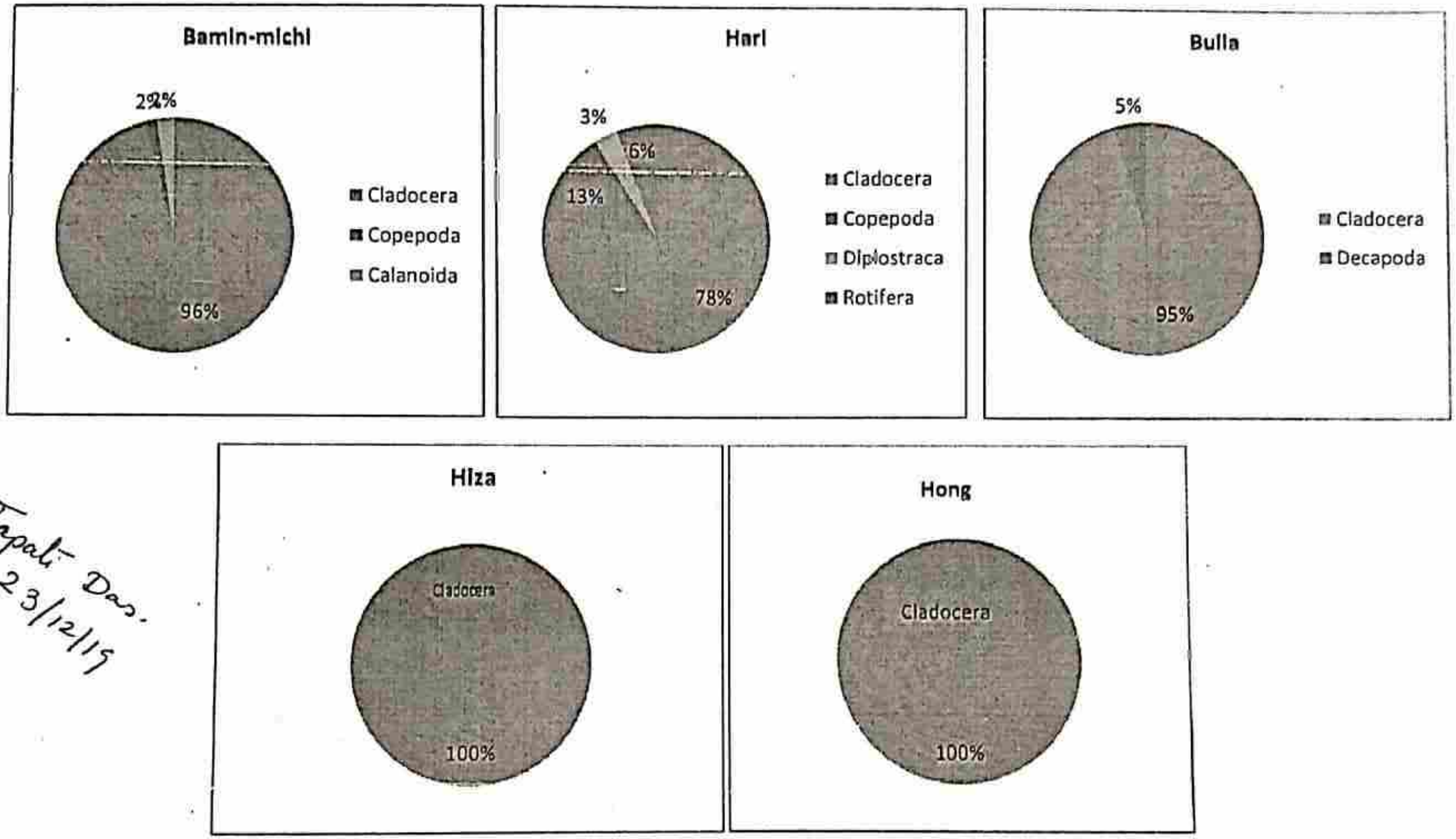
Scanned by CamScanner



Tapali Das
23/12/19

Figure 5.1. Class representation of phytoplankton in different stations of the rice-fish system of Apatani Plateau

Scanned by CamScanner



Tapati Das.
23/12/19

Figure 5.2. Order representation of zooplankton in different stations of the rice-fish system of Apatani Plateau

Scanned by CamScanner

Table 5.3. Distribution of rice-stem periphyton in different stations of the rice-fish system of Apatani Plateau

Taxa	Bamin-michi	Hari	Bulla	Hiza	Hong
Achnanthes	+	+	+	+	+
Amphora ovalis	+	+	+	+	+
Amphidium	-	-	+	-	-
Asterionella	+	-	+	-	-
Cymbella	+	+	+	+	+
Cyclotella	-	-	-	+	-
Diatoma	-	-	+	+	+
Encyonema	-	-	+	+	+
Epithemia	+	+	+	+	+
Eunotia	+	+	+	-	+
Flagelleria	-	-	+	-	-
Frustulia	+	+	+	+	+
Gomphonema	+	+	+	+	+
Himantidium	-	-	-	+	+
Melosira	+	+	+	+	+
Navicul placenta	+	+	+	+	+
Navicula gracillis	-	+	+	-	-
Navicula radiosa	-	-	+	-	-
Navicula rhynchocephala	+	+	+	+	+
Navicula sp.	+	+	+	+	+
Navicula viridis	+	+	+	+	+
Nitzschia sigmoida	-	-	-	-	+
Oocystis	-	+	-	-	-
Pinnularia	+	+	+	+	+
Pinnularia major	+	+	+	+	+
Rophalodia gibba	+	+	+	-	+
Stauroneis	+	+	+	+	+
Staustrum	-	+	-	+	+
Surirella	-	-	+	+	+
Surirella elegans	+	+	+	+	+
Synedra	+	-	-	+	+
Synedra fumosa	+	+	-	+	+
Synura	-	+	-	-	-
Tabellaria	-	+	+	+	-
Closterium	-	+	+	+	+
Cosmarium	-	+	-	-	-
Docidium	-	+	+	-	+
Desmidium	+	+	-	+	-
Gonatozygon	-	+	-	-	+
Netrium	-	-	+	-	-
Scenedesmus	+	+	+	-	-
Spirogyra	-	+	-	-	-
Ulothrix	-	-	+	+	+
Zygonema		+	-		-
Anabaena	-	-	-	+	+
Aphanizemenon	+	+	+	-	-
Cylindospermum	-	+	+	-	-
Merismopedia	-	+	-	-	-
Microcoleus vaginatus	+	+	-	-	-
Oscillatoria	+	-	-	-	-
Phormidium	+	+	+	-	+
Spirulinu	-	-	-	+	+
Xanthidium antilopaeum	-	+	-	-	-
Ceratum	-	+	+	-	-
Phacus	+	+	+	+	+

Tapati Das.
23/12/19

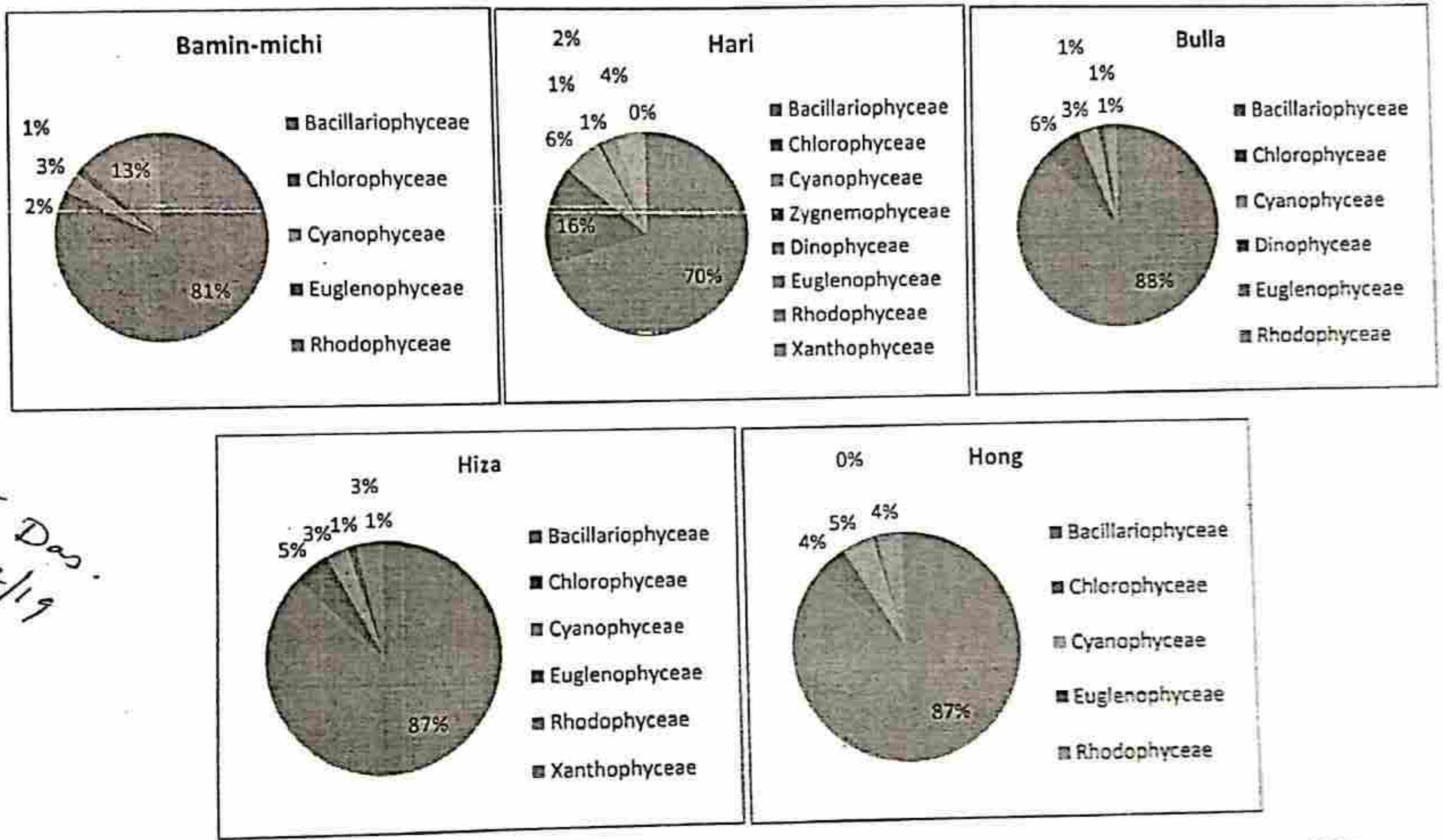
Scanned by CamScanner

Batrachospermum	+	+	+	+	+
Vaucheria	-	+	-	+	-
56	**28**	**40**	**36**	**31**	**32**

'+' indicates presence and '-' indicates absence of the taxa concerned

Tapati Das
23/12/19

Scanned by CamScanner



Tapati Das.
23/12/19

Figure 5.3. Class representation of rice-stem periphyton in different stations of the rice-fish system of Apatani Plateau

Scanned by CamScanner

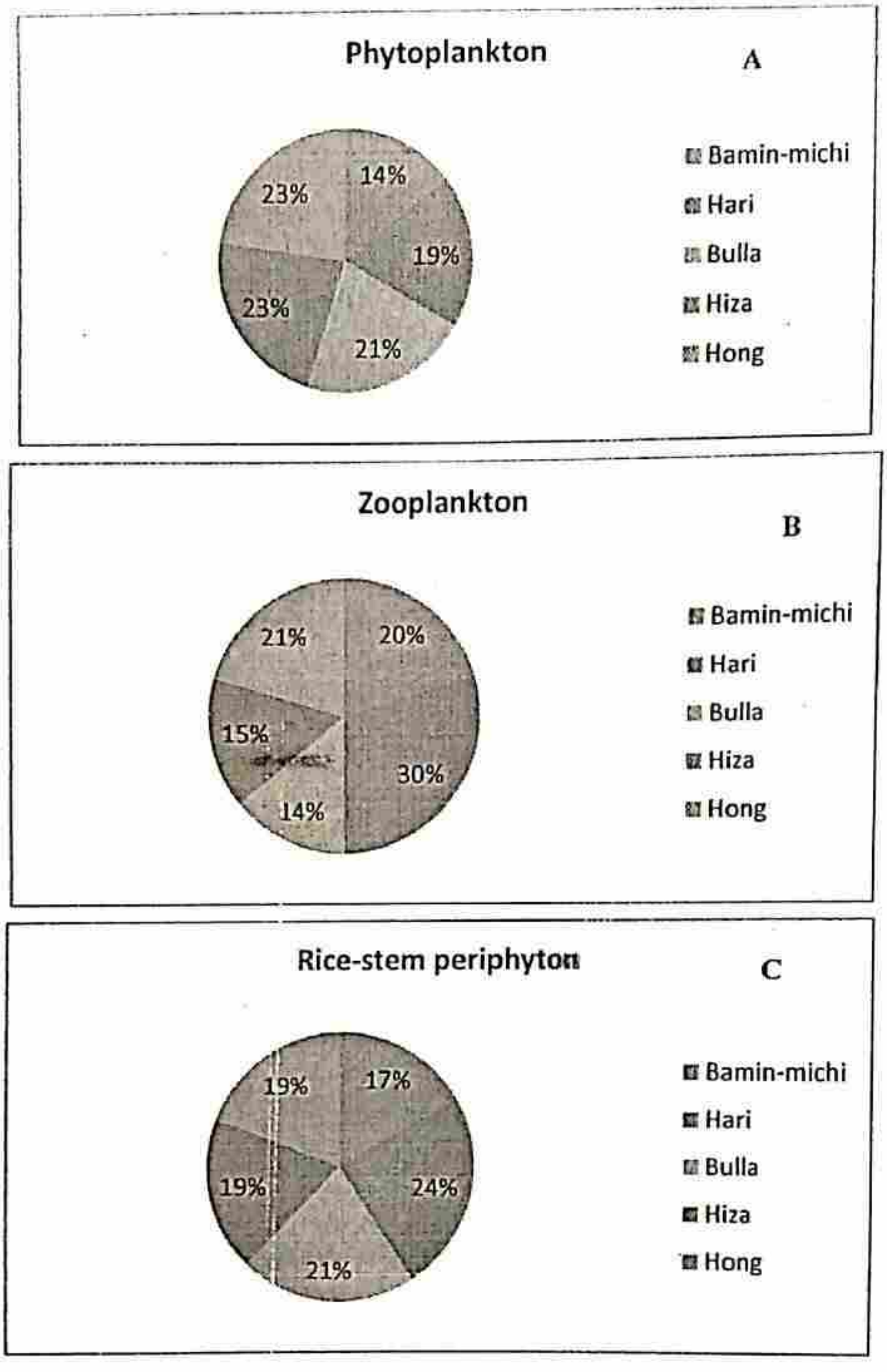


Figure 5.4. **Total** abundance of phytoplankton (A) **and** zooplankton (B) and rice-stem periphyton **(C) in different** stations of the rice-fish **system of Apatani** Plateau

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 6

FEEDING HABIT AND FOOD PREFERENCES OF STOCKED FISH IN RICE-FISH SYSTEM OF APATANI PLATEAU

Introduction

Apatani tribe dwelling in Apatani Plateau, located in lower Subansiri district of Arunachal Pradesh, North East India, are involved in Integrated Agriculture Aquaculture in their wet rice fields since 50 years. This Integrated Agriculture Aquaculture is free from the use of agrochemicals and additional input of supplementary feed for fish and this unique practice is popularly termed as 'aji gnui assonii' (Saikia and Das, 2004). The cropping pattern of the area includes mono-cropping of wet rice once in a year accompanied by stocking the fish species, *Cyprinus carpio*. Being a simple production method, both fish and rice grow synergistically in rice fish system and harness the environmental resources only. About 1.5 to 2.5 t/ha of rice and 150 to 250 kg/ha of fish per season are harvested from such system (Saikia and Das, 2004). In this regard, mention must be made that the fish production in rice fish system of Apatani Plateau, in fact, is far below the carrying capacity of the field in comparison to similar systems elsewhere like China. And, in order to increase the fish productivity research is needed to get complete information on the food, feeding behaviour and growth parameters of the stocked fish in such systems. Based on the information of the field condition, appropriate management techniques can be adopted which will result in rapid growth and greater production of the stocked fish in the concurrent rice-fish culture.

Till now there is no detailed information on the food and feeding habit of fish stocked in this unique rice-fish system of Apatani Plateau located in the Indian Eastern Himalayan region of North East India.

With the above background information the present chapter tries to answer some question like:

Tapati Das
23/12/19

Scanned by CamScanner

(i) What is the food preference of the stocked fish in the rice fish system?

(ii) What is the feeding behaviour of the stocked fish?

Results and discussion

After constant observation, *Cyprinus carpio* was found to consumed on plankton, periphyton, detritus, and some miscellaneous. The Phytoplankton/phyto-periphyton communities belong to classes Bacillariophyceae, Chlorophyceae, Cyanophyceae Euglenophyceae, Zygenemophyceae, Rhodophyceae, and zooplanktons belonging to groups Protozoa, Cladocera and Copepoda. Gut content analyses of the stocked fish comprised a total of 27 taxa belong to Bacillariophyceae,14 to Chlorophyceae, 5 to Cyanophyceae, 3 Euglenophyceae,1each to Zygenemophyceae, Rhodophyceae and Protozoa,7 Cladocera and 4 Copepoda .(Table6.1)

Niche breadth (Figure 6.1 A) was observed to be maximum during evening and morning hours of the day which reflected that the fish prefer to feed during these hours. Wider niche breadth reflects the fish to be an opportunistic feeder, while the narrow niche breadth reflects an increased specialization of the fish and this might be due to increased size and competitive ability of the species (Haroon & Pittman, 1998). When the niche breadth was considered month-wise, it was observed to be highest during May and lowest during the months June and July (Figure 6.1 B). The reason for highest niche breath during May might be due to maximum availability of food resource and also indicated good food preference and feeding activity by the young fish stocked in the rice-fish system, which feeds on the available food resource, which subsequently declines in the succeeding month. due to less availability of resource.

Ranking index of different food items is presented in Table 6.3. Amongst the phytoplankton/phyto-periphyton communities, Bacillariophyceae occupied the 1st rank followed by Chlorophyceae, Cyanophyceae, Rhodophyceae, Euglenophyceae, and

Tapati Das
23/12/19

Scanned by CamScanner

Zygnemophyceae. Among zooplankton, Cladocera ranked 1st position followed by Copepoda and protozoa. Amongst the phytoplankton/phyto-periphyton class Bacillariophyceae, the preferred taxa found in the gut of the fish were *Melosira>Pinnularia>Navicula>Navicula placenta>Cymbella.* The preferred taxa for the class Chlorophyceae was ***Docidium*** *>Staurastrum.* The preferred food item of fish belonging to Cyanophyceae were *Phormidium> Anabaena>Nostoc* For the Class Rhodophyceae, the preferred food taxa of fish was *Batrachospermum*. For the class Euglenophyceae was *Euglena>Phacus>* ***Trachelomonas*** and the taxa preferred by the fish belonging to Zygnemophyceae was *Miscrasterias.* Amongst the zooplankton group, the preferred taxa of fish belonging to Cladocera was *Bosmina>Alona> Macrothrix>* ***Chydororus***. For Copepoda the preferred taxa was ***Cyclops*** > *Mesocyclops>Diaptomus.* The preferred food belonging to group Protozoa was ***Centropyxis***. The species which were ranked first, indicating to be the most preferred item for the fish.

Tapali Das.
23/12/19

Scanned by CamScanner

Table 6.1. Gut content (Number of individuals per gut) of *Cyprinus carpio* stocked in different stations of the rice-fish system in Apatani Plateau

Phytoplankton and /or phyto-periphyton class/ Zooplankton group	Taxa	Station 1	Station 2	Station 3	Pooled mean
Phytoplankton					
Bacillariophyceae	*Achnanthes*	58±56 (0-112)	51±72 (0-133)	75±33 (50-112)	62±12 (51-75)
	Amphora	6.94±12.03 (0-21)	-	7±12 (0-21)	5±4 (0-7)
	Amphora ovalis	8±14 (0-25)	-	25±27.32 (0-54)	11±13 (0-25)
	Cyclotella	89±81 (21-179)	58±74 (0-142)	67±47 (13-100)	71±16 (58-89)
	Cymbella	54±44 (25-104)	104±38 (63-138)	78±39 (46-121)	79±25 (54-104)
	Diatoma	8±140 (0-25)	4±7 (0-13)	13±22 (0-38)	8±4 (4-13)
	Diatoma vulgare	-	-	4±7 (0-13)	1±2 (0-4)
	Encyonema	47±41 (0-75)	18±4 (13-21)	7±12 (0-21)	24±21 (7-47)
	Eunotia	28±32 (0-66)	56±64 (0-125)	61±88 (0-163)	48±18 (28-61)
	Flagellaria	-	4±7 (0-13)	36±63 (0-108)	13±20 (0-36)
	Frustulia	13±13 (0-25)	8±7 (0-13)	4±7 (0-13)	8±4 (4-13)
	Gomphonema	8±7 (0-13)	8+14 (0-25)	13±22 (0-38)	10±2 (8-13)
	Melosira	499±152 (371-667)	106±119 (0-233)	976±411 (550-1371)	527±436 (106-976)
	Navicula	104±29 (88-138)	183±73 (129-267)	81±24 (54-100)	123±54 (81-183)
	Navicula placenta	86.±63 (25-150)	110±73 (54-192)	169±69 (104-242)	122±43 (86-169)
	Navicula rhyncocephala	49±43 (0-83)	4±7 (0-13)	-	18±27 (0-49)
	Nitzschia	-	13±13 (0-25)	8±7.22 (0-13)	7±6 (0-13)
	Pinnularia	208±99 (104-300)	825±207 (625-1037)	883±1118 (225-2175)	639±374 (208-883)
	Pinnularia major	-	-	4.17±7.22 (0-13)	1±2 (0-4)
	Rophalodia gibba	4±7 (0-13)	-	29±40 (0-75)	11±16 (0-29)
	Stauroneis	26±27 (0-54)	-	57±31 (25-87)	28±29 (0-57)
	Surirella	63±58 (21-129)	67±116 (0-200)	13±13 (0-25)	47±30 (13-67)
	Synedra	25+13 (13-38)	4±7 (0-13)	13±13 (0-25)	14±11 (4-25)
	Synedra ulna	8±14 (0-25)	4±7 (0-13)	31±43 (0-79)	14±14 (4-31)

Tapati Das
23/12/19

Scanned by CamScanner

	Synedra fumosa	14±12 (0-21)	38±33 (13-75)	36±21 (13-50)	29±13 (14-38)
	Tabellaria	38±22 (13-50)	105±84 (13-175)	33±38 (0-75)	59±40 (33-105)
	Striatella	-	-	21±36 (0-63)	7±12 (0-21)
Chlorophyceae	*Ankistrodesmus*	4±7 (0-13)	4±7 (0-13)	-	3±2 (0-4)
	Aphanizomenon	21±36 (1-50)	-	-	7±12 (0-21)
	Closterium	21±19 (0-38)	4±7 (0-13)	25±25 (0-50)	17±11 (4-25)
	Cosmarium	33±30 (0-58)	42±42 (0-83)	22±28 (0-54)	32±10 (22-42)
	Desmidium	7±12 (0-21)	-	-	2±4 (0-7)
	Docidium	58±80 (0-150)	4.±7 (0-13)	17±19 (0-38)	26±28 (4-58)
	Gonatozygon	-	-	4.17±7.22 (0-13)	1±2 (0-4)
	Hydrodictyon	-	13±13 (0-25)	-	4±7 (0-13)
	Oocystis	4±7 (0-13)	4 ±7 (0-13)	-	3±2 (0-4)
	Scenedesmus	19±19 (0-38)	-	12.50±0 (13-13)	11±10 (0-19)
	Spirogyra	25±18 (13-38)	7±12 (0-21)	46±14 (38-63)	26±19 (7-46)
	Staurastrum	96±35 (71-121)	64±29 (33-92)	17±29 (0-50)	59±40 (17-96)
	Staurastrum bengalense	-	-	7±12 (0-21)	2±4 (0-7)
	Ulothrix	-	-	8±14 (0-25)	3±5 (0-8)
Cyanophyceae	*Anabaena*	21±7 (13-25)	25±25 0	42±38 (0-75)	29±11 (21-42)
	Microcystis	-	-	4±7 (0-13)	1±2 (0-4)
	Nostoc	21±0 (21-21)	26±24 (13-54)	4±7 (0-13)	17±12 (4-26)
	Oscilatoria	-	-	17±19 (0-38)	6±10 (0-17)
	Phormidium	79±56 (25-138)	29±19 (13-50)	96±81 (13-175)	68±35 (29-96)
Euglenophyceae	*Euglena*	-	4±7 (0-13)	13±13 (0-25)	6±6 (0-13)
	Phacus	-	-	8±14 (0-25)	3±5 (0-8)
	Trachelomonas	-	-	21±7 (13-25)	7±12 (0-21)
Zygnemophyceae	*Miscrasterias*	4±7 0	-	-	1±3 (0-4)
Rhodophyceae	*Batrachospermum*	26±15 (13-42)	24±23 (0-46)	100±109 (25-225)	50±43 (24-100)
Zooplankton					
Protozoa	*Centropyxis*	-	-	4±7 (0-13)	1±2 (0-4)
Cladocera	*Alona*	83.±113	-	-	28±48

Tapoli Das.
23/12/19

Scanned by CamScanner

		0			(0-83)
	Biapertura affinis (Leydig)	4±7 0	-	-	1±2 (0-4)
	Bosmina	144±94 (71-250)	56±19 (38-75)	19±17 (0-33)	73±64 (19-144)
	Chydororus	17±19 (0-38)	13±13 (0-25)	-	10±9 (0-17)
	Daphnia	8±14 (0-25)	-	-	3±5 (0-8)
	Macrothrix	21±19 (0-38)	-	22±19 (0-33)	14±12 (0-22)
	Pleuroxus	28±24 (0-46)	-	-	9±16 (0-28)
Copepoda	*Cyclops*	21±7 (13-25)	4±7 (0-13)	9±16 (0-28)	11±9 (4-21)
	Diaptomus	-	-	8±14 (0-25)	3±5 (0-8)
	Leptodiaptomus	8±7 (0-13)	-	-	3±5 (0-8)
	Mesocyclops	7±12 (0-21)	-	13±13 (0-25)	7±6 (0-13)
Miscellaneous					
		4±7 (0-13)	-	-	1±2 (0-4)
		4±7 (0-13)	-	-	1±2 (0-4)

'-' indicates absence of the taxa concerned; mean±SD; n=36

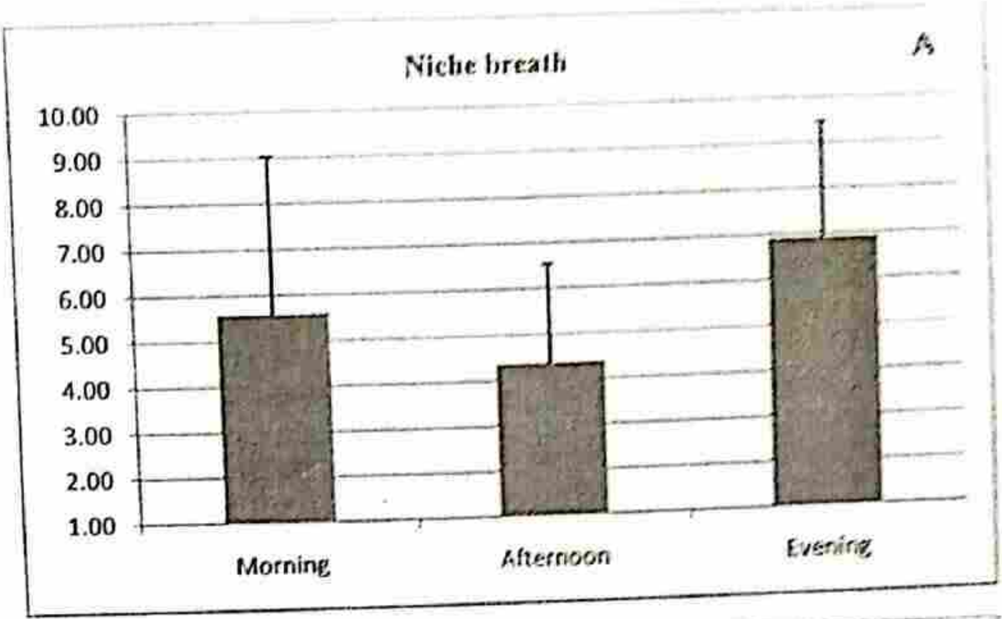
Table 6.2. Diurnal and monthly variations in niche breadth of *Cyprinus carpio* stocked in different stations of the rice-fish system in Apatani Plateau

Niche breadth					Pooled mean
	Months	**Hours of day**			
		Morning	**Afternoon**	**Evening**	
Station 1	May	5.35	6.21	9.19	6.92±2.01
	June	11	5.56	9.15	8.57±2.76
	July	8.66	4.25	6.50	6.47±2.21
	August	9.82	2.88	10.71	7.80±4.29
Station 2	May	10.29	3.28	6.70	6.75±3.50
	June	2.78	1.36	2.27	2.14±0.72
	July	1.84	7.54	9.91	6.43±4.15
	August	2.92	6.76	6.25	5.31±2.08
Station 3	May	2.65	6.40	6.57	5.21±2.22
	June	3.44	4.78	7.35	5.19±1.99
	July	2.61	1.54	4.38	2.84±1.43
	August	5.68	1.86	3.84	3.79±1.91
Mean±SD and range		5.59±3.44 (1.84-11)	4.37±2.17 (1.36-7.54)	6.90±2.56 (2.27-10.71)	

mean±SD; n=36; Number within parenthesis represent range of the respective mean value

Tapoti Das
23/12/19

Scanned by CamScanner



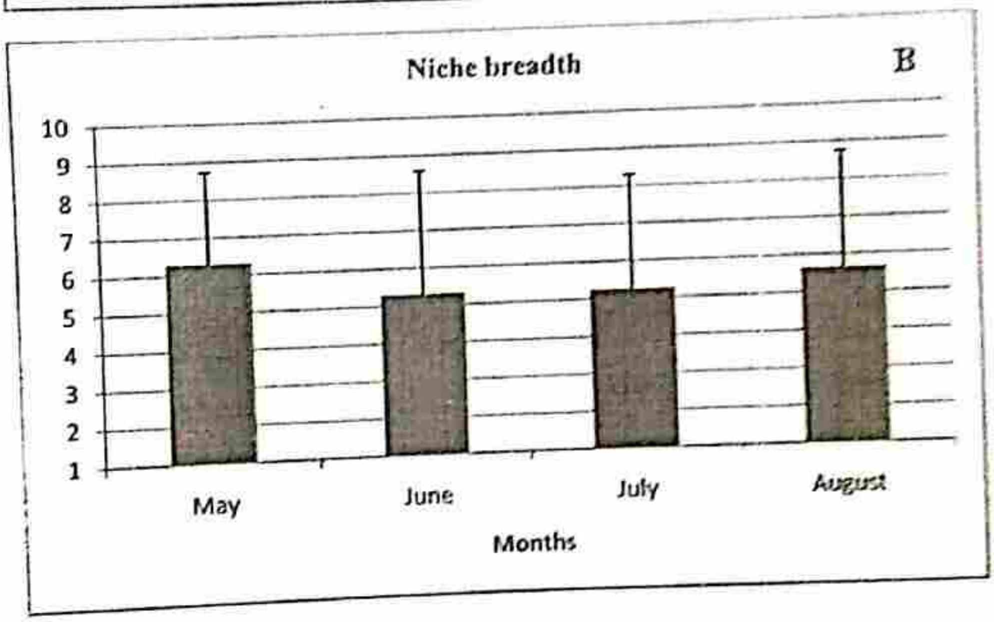


Figure 6.1. Diurnal (A) and monthly (B) variations in niche breadth of the stocked fish in the rice-fish system of Apatani Plateau

Tapati Das.
23/12/19

Scanned by CamScanner

Table 6. 3. Variations in ranking index of food items of *Cyprinus carpio* stocked in different stations of the rice-fish system in Apatani Plateau

Phytoplankton/ Phyto-periphyton class And zooplankton groups	Taxa	Station 1	Station 2	Station 3	Pooled mean
Bacillariophyceae	*Achnanthes*	4±9 (0-33)	2±4 (0-9)	-	2±2 (0-4)
	Amphora	1±3 (0-11)	-	0.18±0.61 (0-2)	0.4±1 (0-1)
	Amphora ovalis	0.15±1 (0-2)	-	1±2 (0-6)	0.31±0.42 (0-1)
	Cyclotella	6±10 (0-30)	6±15 (0-53)	3±4 (0-11)	5±2 (3-6)
	Cymbella	3±5 (0-11)	6±6 (0-15)	2±2 (0-6)	4±2 (2-6)
	Diatoma	0.31±1.07 (0-4)	0.38±1 (0-5)	0.27±1 (0-3)	0.32±0.06 (0.3-0.4)
	Diatoma vulgare	-	-	0.09±0.31 (0-1)	0.03±0.05 (0-0.1)
	Encyonema	4±7 (0-22)	1±2 (0-4)	0.35±1 (0-4)	2±2 (0.4-4)
	Eunotia	3±9 (0-33)	2±7 (0-23)	2±4 (0-13)	2±1 (2-3)
	Flagellaria	-	0.42±1 (0-5)	1±2 (0-8)	0.41±0.40 (0-1)
	Frustulia	1±2.75 (0-8)	1±3 (0-8)	0.13±0.44 (0-2)	1±1 (0.13-1)
	Gomphonema	1±2 (0-6)	1±2 (0-5)	0.16±1 (0-2)	1±0.34 (0.16-0.8)
	Melosira	21±13 (6-46)	11±17 (0-57)	35±22 (3-66)	23±12 (11-35.)
	Navicula	7±10 (0-33)	11±9 (0-27)	2±3 (0-8)	7±4 (2-11)
	Navicula placenta	7±13 (0-44)	4±7 (0-23)	4±5 (0-17)	5±2 (4-7)
	Navicula rhyncocephala	4±13 (0-44)	-	-	1±2 (0-4)
	Nitzschia	-	1±2 (0-6)	0.14±0.4 (0-1)	0.3±0.4 (0-1)
	Pinnularia	15±16 (0-56)	23±33 (0-87)	15±25 (0-80)	18±5 (15-23)
	Pinnularia major	-	-	0.1±0.3 (0-1)	0.03±0.1 (0-0.1)
	Rophalodia gibba	0.11±0.4 (0-1)	-	0.40±1 (0-4)	0.17±0.21 (0-0.4)
	Stauroneis	3±6 (0-22)	-	2±3 (0-9)	1±1 (0-2)
	Striatella	-	-	1±3 (0-9)	0.3±0.4 (0-1)
	Surirella	4±6 (0-18)	2±6 (0-21)	1±1 (0-4)	2±2 (1-4)
	Sydera	1±2 (0-6)	1±2 (0-7)	0.33±1 (0-3)	1±1 (0.33-1)
	Sydera ulna	0.4±1 (0-3)	1±2 (0-7)	1±2 (0-4)	1±0.20 (0.4-1)
	Synedra fumosa	1±3.15	4±7	1±1	2±2

Topali Das
23/12/19

Scanned by CamScanner

		(0-11)	(0-21)	(0-7)	(1-4)
	Tabellaria	3±5 (0-17)	2±5 (0-18)	1±2 (0-6)	2±1 (1-3)
Chlorophyceae	*Akistodesmus*	1±2 (0-6)	0.42±1 (0-5)	-	0.30±0.3 (0-1)
	Aphanizomenon	1±3 (0-11)	-	-	0.30±1 (0-1)
	Closterium	1±2 (0-6)	0.29±1 (0-4)	0.10±0.36 (0-1)	1±1 (0.1-1)
	Cosmarium	3±6 (0-22)	1±3 (0-9)	0.28±1 (0-2)	1±1 (0.3-3)
	Desmidium	1±3 (0-11)	-	-	0.30±1 (0-1)
	Docidium	5±8 (0-25)	0.29±1 (0-4)	3±6 (0-14)	3±2 (0.3-5)
	Gonatozygon	-	-	0.1±0.31 (0-1)	0.03±0.05 (0-0.1)
	Hydrodictyon	-	1±3 (0-8)	-	0.42±1 (0-1)
	Microcystis	-	-	0.13±0.44 (0-2)	0.04±0.08 (0-0.13)
	Oocystis	0.25±1 (0-3)	0.1±0.30 (0-1)	-	0.11±0.13 (0-0.25)
	Scenedesmus	1±1 (0-4)	-	0.4±1 (0-3)	0.33±0.31 (0-1)
	Spirogyra	1±4 (0-12)	0.23±1 (0-3)	1±1.94 (0-5)	1±1 (0.23-1)
	Staurastrum	5±7 (0-18)	4±4 (0-15)	1±2 (0-5)	3±2 (1-5)
	Staurastrum bengalense	-	-	0.18+1 (0-2)	0.06+0.10 (0-0.18)
Cyanophyceae	*Anabaena*	2.43±4.15	2.56±7.14	0.95±1.71	1.98±0.89 (0.95-2.56)
	Nostoc	1.10±3.15	2.31±3.49	0.05±0.18	1.15±1.13 (0.05-2.31)
	Oscilatoria	-	-	0.57±1.13	0.19±0.33 (0-0.57)
	Phormidium	5±5 (0-13)	1±3 (0-9)	3±5 (0-18)	3±2.04 (1-5)
Zygnemophyceae	*Miscrasterias*	1±1 (0-6)	-	-	0.17±0.30 (0-0.52)
Rhodophyceae	*Batrachospermum*	2±3 (0-8)	1±2 (0-7)	5±8 (0-23)	3±2 (1-5)
Euglenophyceae	*Euglena*	-	0.1±0.30 (0-1)	0.4±1 (0-3)	0.16±0.20 (0-0.4)
	Phacus	-	-	0.10±0.36 (0-1)	0.03±0.1 (0-0.1)
	Trachelomonas	-	-	1±1 (0-3)	0.21±0.4 (0-1)
Protozoa	*Centropyxis*	-	-	0.1±0.31 (0-1.08)	0.03±0.1 (0-0.1)
Cladocera	*Alona*	10±12 (0-31)	-	-	3.35±6 (0-10)
	Biapertura affinis	1±3 (0-10)	-	-	0.28±1 (0-1)
	Bosmina	41±58	49±55	13±31	34±19

Tapati Das
23/12/17

Scanned by CamScanner

		(0-200)	(0-150)	(0-100)	(13-49)
	Chydororus	3±5 (0-11)	4±14 (0-50)	-	2.33±2.13 (0-4)
	Daphnia	2±5 (0-17)	-	-	1±1 (0-2)
	Macrothrix	3±7 (0-20)	-	7±15 (0-50)	3±3 (0-7)
	Pleuroxus	6±13 (0-33)	-	-	2±4 (0-6)
Copepoda	*Cyclops*	7±19 (0-67)	8±29 (0-100)	0.03±0.10 (0-0.33)	5±4 (0.03-8)
	Diaptomus	1	1	8±29 (0-100)	3±5 (0-8)
	Leptodiaptomus	2.78±9.62	-	-	0.93±1.61, (0-2.78)
	Mesocyclops	-	-	21±40 (0-100)	7±12 (0-21)
Miscellaneous		2±5 (0-17)	-	-	1±1 (0-2)

mean±SD; n=36; Number within parenthesis represent range of the respective mean value

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 7

GROWTH OF THE STOCKED FISH AND ITS NUTRIENT CONTENTS

Introduction

Knowledge of nutrient composition of any food item is an important aspect in understanding the links between food production, access and nutrient intake and in devising policies and programmes such as development of improved production technologies (Thilsted and Wahab, 2014a) to ensure that the food production fulfils the nutrient requirement of the population and to enhance their health and socio-economic condition. Fish has an important role in food security and poverty alleviation in both rural and urban areas. Analyses of proximate composition of a fish species helps to assess its nutritional and edible value (Prapasri, 1999; Hei and Sarojnalini, 2012). The nutrient analysis of reared fish can give an assessment of its food composition, its physiological condition and can serve as guide for any future feed formulations for fish in captivity (Dempson *et al.*, 2004).

In the present study attempt has been made to determine the month-wise variations in the growth of *C. carpio* stocked in the rice-fish system. Attempt has also been made to determine the month-wise variations in body nutrient contents of *C. carpio* stocked in the rice-fish system of Apatani Plateau.

Results and discussion

Growth parameters of *Cyprinus carpio* stocked in the rice-fish system

Monthly variations in body length and body weight of *Cyprinus carpio* stocked in the rice-fish system of Apatani Plateau are shown in Figure 7.1. The figure showed that both the body length (Figure 7.1.A) and body weight (Figure 7.1.B) of the stocked fish increased consistently from May to August. Highest values for body length and body weight of the stocked fish in the rice-fish system during August indicates the stocked fish attained maximum maturity during August.

Topali Das.
23/12/19

Scanned by CamScanner

Nutrient contents of *Cyprinus carpio* stocked in the rice-fish system

Month-wise variations in body nutrient contents (%) of *Cyprinus carpio* stocked in the rice-fish system of the study area during the study period are shown in the Figure 7.2.

Carbohydrate content in the body of the stocked fish was highest in the month of May and dropped down in June and again increased in July which again dropped during August (Figure 7.2.A). This is due to the fact that due to sufficient food material in the rice field during May the stocked fish did not have to invest much energy for feeding which lead to greater reserves of energy in the form of carbohydrate in their body in the month of May. However during June and August the carbohydrate content dropped down which indicates investment of more energy for survival and gathering food from the rice field during those months.

Protein content in the body of the stocked *Cyprinus carpio* was lowest in May and highest in August (Figure 7.2.B). This implies that there was scarcity of protein-rich food items in the rice field during May. However during August there was an increase in protein-rich food item in the rice field may be in the form of detrital matters which deposited in greater amount in the rice field during August.

Fat content in the body of the stocked fish in the rice field was lowest in May and highest in July (Figure 7.2.C). This is due to the fact that with maturity of the stocked fish there is greater deposition of fat in its body.

Month-wise variations in sodium content of the stocked fish in the rice fish system showed the lowest value in May and the highest value in July and August (Figure 7.2.D). This indicates greater concentration of Na in the rice field water in the successive months of fish stocking from which the stocked fish assimilate this mineral nutrient

Month-wise variations in potassium content of the stocked fish in the rice fish system showed its lowest value in May and the highest value in June (Figure 7.2.E). This indicates

Tapati Das
23/12/19

Scanned by CamScanner

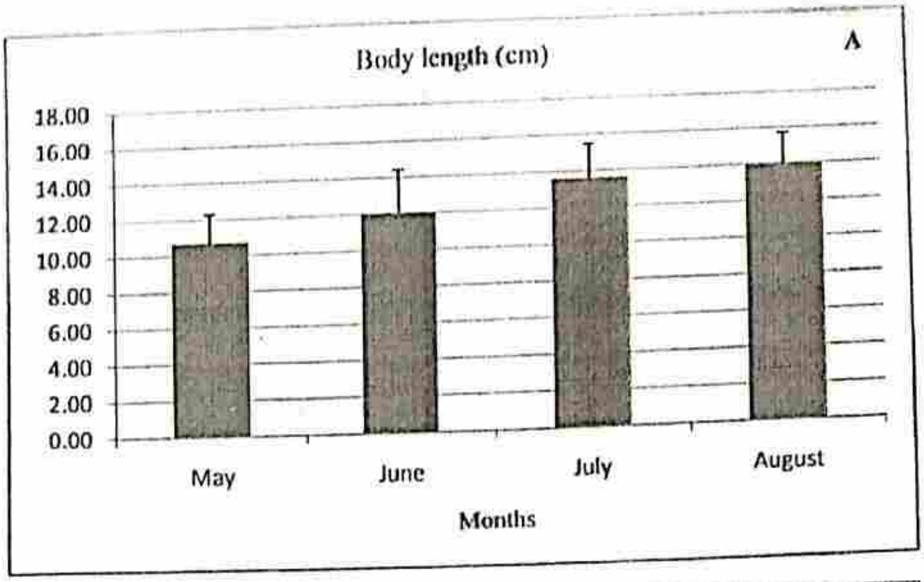
lower concentration of K in the rice field water during May and its greater value in June, July and August which entered in the rice field with the runoff water.

Month-wise variations in calcium content of the stocked fish in the rice-fish system showed that the value was same all throughout the months (Figure 7.2.F).

Month-wise variations in phosphorous content of the stocked fish in the rice fish system showed the highest value in August and the lowest value in July (Figure 7.2.G). This indicates greater concentration of P in the rice field water in June due to the effect of entry of silt-rich runoff water because of intense rainfall during June.

Tapati Das.
23/12/19

Scanned by CamScanner



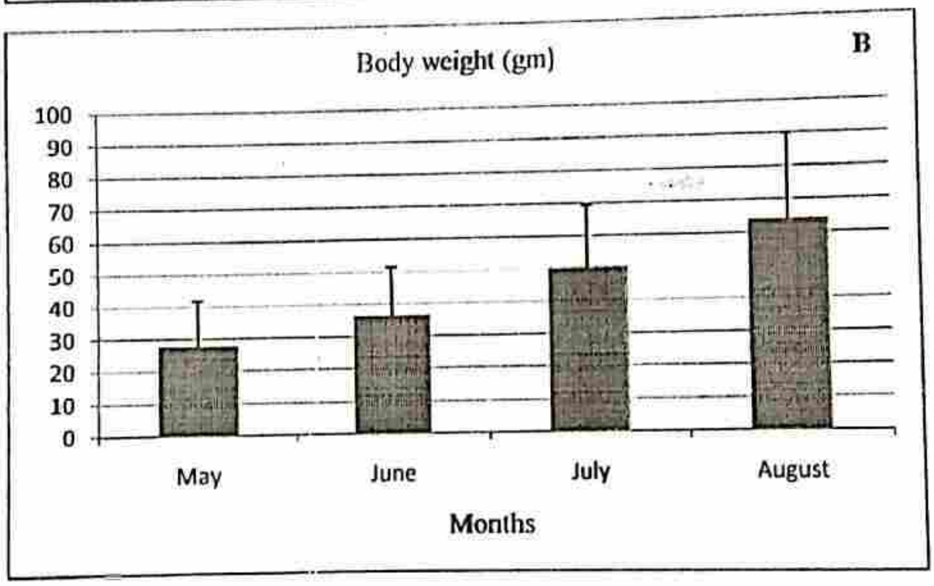
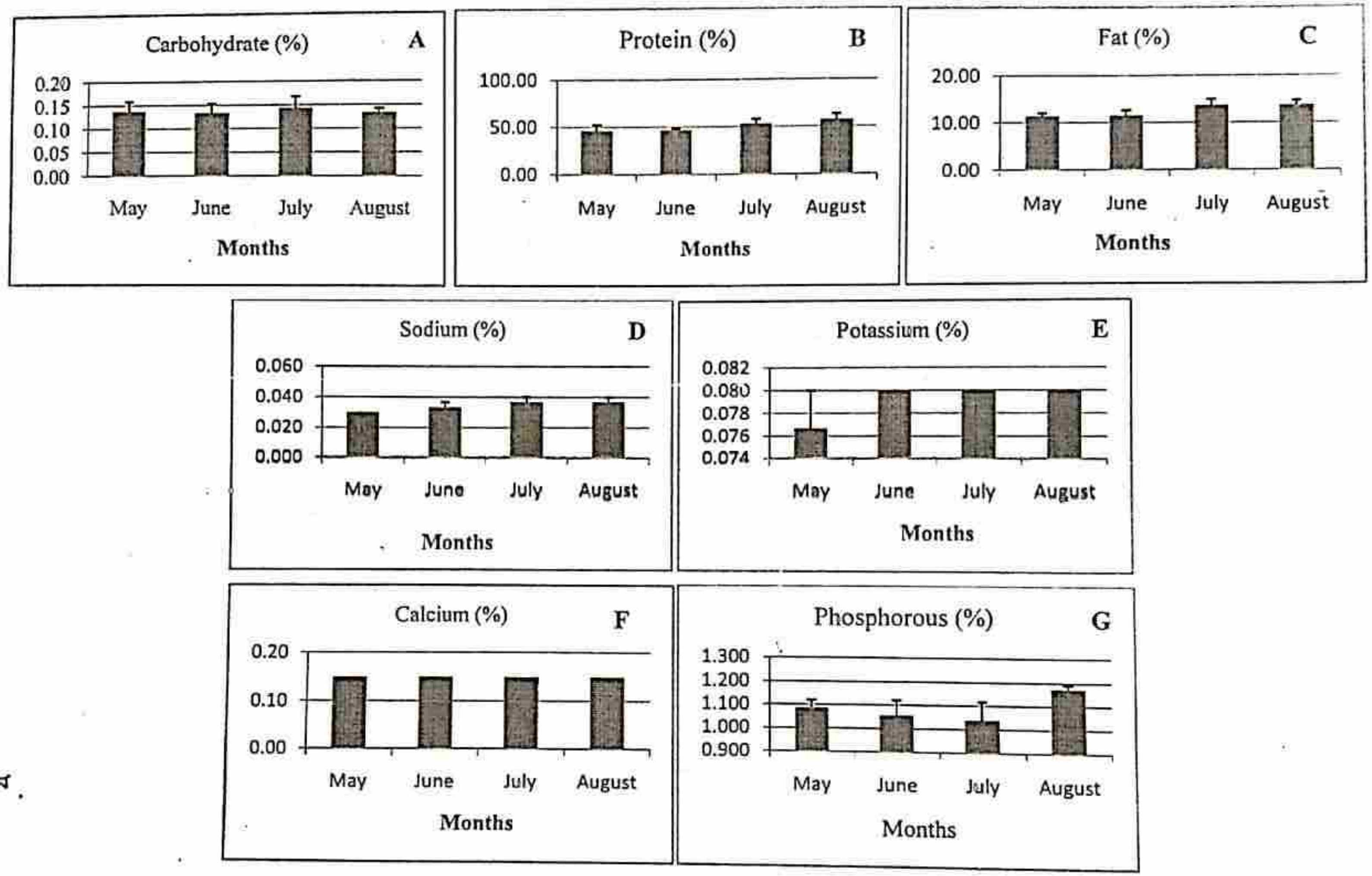


Figure 7.1. Monthly variations in body length and body weight of *Cyprinus carpio* stocked in the rice-fish system of Apatani Plateau.

Tapati Das.
23/12/19

Scanned by CamScanner



Tapati Das.
23/12/19

Figure 7.2. Month-wise variations in body nutrient contents (%) of *Cyprinus carpio* stocked in the rice-fish system of the study area during the study period

Scanned by CamScanner

Chapter 8

FORMULATION OF LOW-COST FISH FEED USING LOCAL INGREDIENTS AND ITS EFFICACY TEST ON GROWTH PERFORMANCE OF *Cyprinus carpio*

Introduction

Fish is an important source of food and income in the developing countries. Fish requires high quality nutritionally balanced diet for growth and attainment of market size within the shortest possible time. Therefore, local production of fish-feed is very crucial to the development and sustainability of aquaculture. Paddy-cum-fish culture is practiced in many parts of the world e.g. China, Egypt, India, Indonesia, Thailand, Vietnam, Philippines, Bangladesh, Malaysia etc (Fernando, 1993; Halwart and Gupta, 2004). In India, the agrarian *Apatani* hill tribe in the lower Subansiri district of Arunachal Pradesh also traditionally practice integrated agriculture aquaculture in the wet rice fields, which is the only prevalent system amongst the Indian tribal farmers. Energy subsidies in the form of agro-chemicals or feed are not administered in the agro-ecosystem during the culture period, which makes it very unique in the context of production. The fishes are cultured along with the rice plant in the paddy fields. The fishes depend on the natural feed such as plankton, benthic algae, and other feeding materials available in the rice fields. However, limited availability of natural feed and short duration of the rearing period do not allow the fish to gain much biomass (Halwart and Gupta, 2004). As a result, only 150 to 250 kg ha^{-1} of fish (*Cyprinus carpio*) per season are harvested from the system (Saikia and Das, 2004), which is much lower comparing to similar systems in China (Zhang, 1995; Halwart, 1998).

Administering supplementary feeding material to the fish in the paddy fields may increase the secondary productivity (Halwart and Gupta, 2004). Locally available ingredients such as agro-based by-products and other organic wastes may be used as feed input in the

Tapati Das
23/12/19

Scanned by CamScanner

system, which may be a promising solution from the perspective of the rural economy and sustainability.

In the present study, fish-feed formulation was done using locally available raw materials in the Apatani Plateau. This was followed by the analyses of the proximate composition of the fish-feed formulation and an aquaculture experiment to test the effectiveness of the prepared fish-feed on the overall growth and health performance of the stocked fish, *Cyprinus carpio*. Efficacy test was performed also to quantify the proportion of feed to be supplemented in the rice-fish system that would be appropriate for optimal growth without disrupting the natural ecological balance within the rice-fish system.

Results and discussion

The formulated feed contains higher dietary protein (22.92%) and less carbohydrate (2.39%) and lipids (3.35%) (Table 8.1). Higher dietary protein has often been associated with better growth rate in many fish species (Mohapatra and Patra, 2014). Although not essential, carbohydrates are included in aquaculture diets for their binding activity during feed manufacturing (Hassan, 2015). A recent trend in fish feeds is to use higher level of lipids/fats in the diet (Hassan, 2015). Vitamins are organic compounds which are not synthesized by fish, and must be supplied in the diet. Amongst all the vitamins, vitamin C is probably the most important, because it is a powerful antioxidant and helps in maintaining the immune system in fish (Hassan, 2015). In the prepared fish feed, vitamin C was also available in trace (0.04%). However, if we compare the proximate composition of the prepared fish-feed with the general fish-feed standard (as per Hassan, 2015), we can see that the quantity of lipid is relatively less, and that of phosphorous is more. So, care has to be taken regarding too much input of P into the culture system if the feed is supplemented in greater quantity.

Efficacy test revealed hundred percent survival of the fries in the different aquaria with various treatments (Table 8.2). Body weight, body length, standard length and body

Tapi Das
23/02/17

Scanned by CamScanner

depth of the fries showed better performance in treatment 2 (i.e., when the fish were fed with the prepared feed @ 5% of their initial body weight) where the feed conversion ratio was lowest. Weight gain was highest in Treatment 3 (i.e., when the fish were fed with the prepared feed @ 7% of their initial body weight) where the feed conversion was highest. However, specific growth rate and condition factor showed significantly greater value in treatment 1 (i.e., when the fish were fed with the prepared feed @ 3% of their initial body weight) where the feed conversion ratio was slightly greater than the lowest value (in treatment 2).

Different feeding treatments in the experimental aquaria showed that body length and body depth increased with increase in the supplementary feed till treatment 2. However, further increase in the supplementary feed decreased both the body length and body depth (Figure 8.1.A and 8.1.B). SGR showed better performance when the feed supplementation was less (Figure 8.1.C). Condition factor slightly declined when the fish were not given any feed or when the feed supplementation was greater (Figure 8.1.D). All these therefore show that fish can grow in a better way when they are provided with optimum quantity of feed.

Therefore, considering all the parameters of growth, feeding and survival conditions, it may be concluded that the fries of *Cyprinus carpio* would grow in a better and healthier way if they are fed with the prepared feed @ 3% of initial their body weight while stocking in aquaculture system.

Water quality was monitored before and after supplementation of the prepared fish-feed for four weeks in the experimental aquaria, and it varied between different treatments (Table 8.3). However, when compared with the relevant standard required for fresh- and warm water fishery (Boyd, 1998 and Das *et al*., 2013; Table 8.3), the water quality in all the aquaria were within the standards except the water temperature. This was due to the seasonal effect, as the experiment was conducted during the month of December, 2014.

Tapati Das.
23/12/19

Scanned by CamScanner

Table 8.1. Proximate composition (%) of raw materials used as fish-feed ingredients and the formulated fish-feed using these ingredients, and comparison of the proximate composition of the fish feed with standard fish-feed

Parameters	Raw materials		Fish –feed formulated using these raw materials	Proximate composition of standard fish-feed as per Hassan, 2015
	Leftover of processed and fermented rice after preparation of local rice beer, '*Apong*'	Algae which remained clumped in water of the rice-fish system of Apatani Plateau		
Carbohydrate	0.001	0.017	2. 39	Not very essential but may contain 15-20%
Protein	30.3	3.25	22.92	18-50%
Fat	0.1	0.01	3.35	10-25%
Calcium	0.01	0.06	1.15	Trace amount
Phosphorus	3.9	3.40	7.36	< 1.5%
Sodium	0.03	0.10	0.30	Trace amount
Potassium	0.3	0.63	1.27	Trace amount
Vitamin C	0.06	0.05	0.04	Trace amount

Tapati Das.
23/12/19

Scanned by CamScanner

Table 8.2. Feeding response, growth response, nutrient utilization and survival parameters of *Cyprinus carpio* fry fed with varying quantities of the prepared fish-feed in experimental aquaria

Parameters		Control	Treatment1 (feeding @ 3% of the initial body weight of the stocked fish)	Treatment2 (feeding @ 5% of the initial body weight of the stocked fish)	Treatment3 (feeding @ 7% of the initial body weight of the stocked fish)	F-ratio
Feeding response		-	Excellent	Good	Good	-
Growth response	Body weight (gm)	4.96 ±0.25	5.68 ±0.08	5.78 ±0.07	5.16 ±0.33	2.13
	Body length (cm)	7.11 ±0.20	7.33 ±0.11	7.66 ±0.10	7.28 ±0.15	7.64**
	Standard length (cm)	5.83 ±0.10	6.01 ±0.03	6.33 ±0.06	5.76 ±0.13	1.96
	Body depth (cm)	2.06 ±0.05	2.08 ±0.03	2.14 ±0.05	2.07 ±0.03	6.74**
	Specific growth rate (% day^{-1})	2.07 ±0.77	3.18 ±1.34	1.54 ±0.37	4.11 ±0.24	3.619*
Nutrient utilization	Feed conversion ratio for 1 gm increase in body weight	-	0.26 ±0.02	0.19 ±0.05	0.69 ±0.25	3.39
	Feed conversion ratio for 1 kg increase in body weight	-	260.60 ±72.54	187.20 ±49.00	687.44 ±242.04	3.39
Survival parameters	Survival rate	100%	100%	100%	100%	-
	Condition factor	1.39 ±0.08	1.45 ±0.07	1.32 ±0.05	1.34 ±0.03	6.69**

Mean ±SE; n=16; **p<0.01; * p<0.05

Tapati Das
23/12/19

Scanned by CamScanner

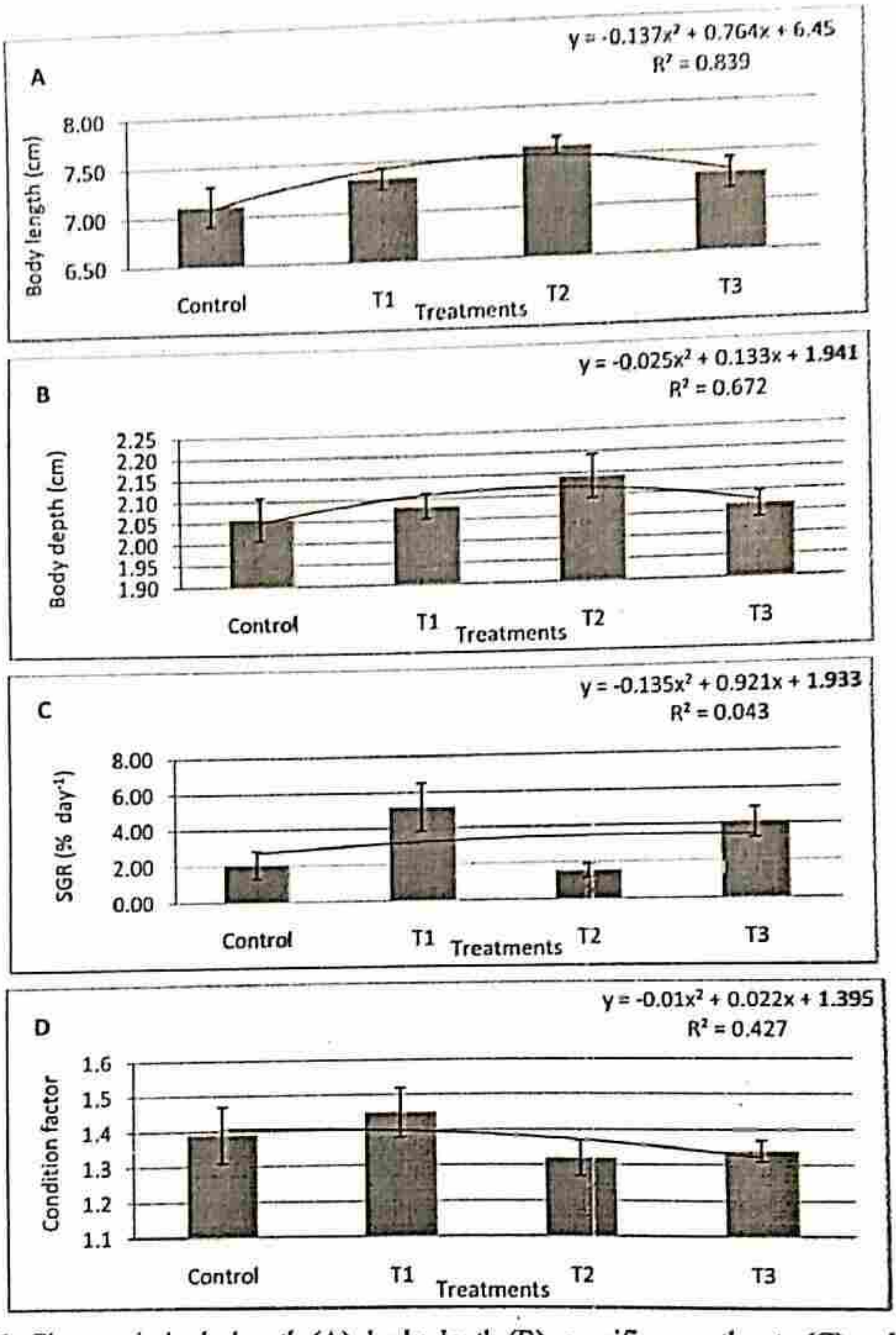


Figure 8.1. Changes in body length (A), body depth (B), specific growth rate (C) and condition factor (D) of *Cyprinus carpio* after four weeks of feeding with the prepared fish-feed under different feeding treatments in experimental aquaria

Tapati Das
23/12/19

Scanned by CamScanner

Table 8.3. Water quality parameters before and after supplementing the prepared fish-feed for four weeks in the experimental aquaria and comparison with water standard for freshwater fisheries

Parameters	Quality of water which was used for the experiment before stocking the fish and giving different treatments	*Water quality in experimental aquaria after four weeks of supplementation of the prepared fish-feed				Standards of water properties for warm freshwater fisheries in pond as per	
		Control	Treatment 1	Treatment 2	Treatment 3	Boyd, 1998	Das *et al.*, 2013
Water temperature (°C)	20	17±1.0	19±1.0	18.5±0.5	15.50±0.5	-	25.0-32.0
pH	6.5	7.33±0.08	7.44±0.17	8.02±0.37	7.84±0.07	7.0-9.0	6.5-8.5
Dissolved oxygen (mgl^{-1})	6.12	9.97±1.11	9.39±0.20	8.68±0.98	9.49±1.25	5.0-15.0	5.0-10.0
Biological oxygen demand ($mg\ l^{-1}$)	0.88	6.49±3.78	6.08±2.50	4.09±1.52	4.80±0.61	-	<10.0
Free carbon dioxide ($mg\ l^{-1}$)	10.09	9.99±1.33	7.99±1.33	8.65±1.33	8.99±0.33	1.0-10.0	<3.0
Nitrate-N ($mg\ l^{-1}$)	0.2	2.81±1.97	4.22±1.63	2.45±0.74	4.43±2.78	0.2-10.0	0.1-3.0
Phosphate-P ($mg\ l^{-1}$)	0.29	0.15±0	0.09±0.05	0.18±0.03	0.19±0.06	0.005-0.2	0.05 – 2.0

*Mean ±SE; n=2

Tapati Das
23/12/19

Scanned by CamScanner

Chapter 9

GENERAL DISCUSSION AND CONCLUSION

The present study was undertaken to formulate low-cost fish feed using locally available agro-based wastes. The study was done in context of increasing fish production through supplementation of low cost fish feed in the rice-fish system of Apatani landscape in Arunachal Pradesh, North-east India.

In the present study attempt was made to know the habitat condition, food availability, feeding, and growth and nutrient assimilation of the stocked fish in the rice-fish system of Apatani Plateau. Fish feed formulation was prepared using locally available agro-based raw materials in different proportions. This was followed by nutrient analyses of the feed formulation and an efficacy test of the formulated feed on growth performance of the stocked fish under laboratory condition.

In order to know the habitat condition and food availability of the stocked fish, a total of five stations (villages) were selected. For gut content analysis and analyses of different feeding activities of the stocked fish besides analysis of its growth performances and nutrient assimilation from its habitat, a total of 3 stations (villages) were selected. In the entire field study sampling was done at monthly interval during the fish stocking stage. For detailed analysis of the feeding activities of the stocked fish sampling was done 3 times a day covering morning, noon and evening hours.

The physico-chemical properties of water of rice fish systems (Tables 4.1 and 4.2) showed significant variations with respect to stations, months and stations x months. These significant variations indicate the system to be highly dynamic in nature both, spatially and temporally. Physico-chemical properties showed that the pH of rice field water in the rice-fish system of Apatani Plateau slightly fluctuated from slightly acidic to slightly alkaline range (4-7.7). Besides, it may be mentioned here that the value of water depth in the rice-fish

Topal Das
23/12/19

Scanned by CamScanner

system ranged from (2 to 21.7 cm) indicating it to be a shallow system. When the physico-chemical properties of rice field water in the rice-fish system was compared with the standard water properties for fresh water fishery (Table 4.3), it was observed that the value for CO_2 was high during some months of fish stocking period which reveals that the stocked fish can survive under the unfavourable condition which might be partially due to the hardy nature of *Cyprinus carpio* (Singh *et al.*, 2015) and/or partially due to presence of refuge trenches in the rice-fields that facilitate the movement of the stocked fish from adverse circumstance in the rice field.

Investigation of planktonic (Tables 5.1 to 5.2) and rice stem periphytic communities (Table 5.3) present in the rice-fish system of the Apatani Plateau revealed that the phytoplankton and phyto-periphytic algae were more diverse communities than the zooplankton communities. Bacillariophyceae was the most dominant phytoplankton and rice-stem phyto-periphyton class in the rice-fish system (Figures 5.1 and 5.3). Cladocera was the most dominant zooplankton group in the rice-fish system (Figure 5.2).

Gut content analyses (Table 6.1) revealed that the stocked fish in the rice-fish system consumed plankton, periphyton, and some miscellaneous items including detritus. The phytoplankton/periphyton communities present in the gut belonged to classes Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, Zygnemophyceae, and Rhodophyceae. The zooplankton communities present in the gut belonged to the groups Protozoa, Cladocera, and Copepoda. Gut content analyses of the stocked fish comprised a total of 27 taxa belonging to Bacillariophyceae, 14 to Chlorophyceae, 5 to Cyanophyceae, 3 to Euglenophyceae, 1 each to Zygnemophyceae, Rhodophyceae and Protozoa, 7 to Cladocera and 4 to Copepoda. The gut content study revealed a close relationship of food intake/preference with the available food items in the rice-fish system. The gut content analysis of the stocked fish revealed it to be omnivorous in nature.

Tapati Das
23/12/19

Scanned by CamScanner

The niche breadth of the stocked fish was maximum during evening and morning hours of the day (Figure 6.1.A) which reflected that the fish prefer to feed on different items during morning and evening hours of the day. While during afternoon the decrease in niche breadth is perhaps due to extreme environmental condition due to intense sunlight and increased water temperature which inhibit the stocked fish for free movement in the rice field and most of them take refuge in the refuge trenches of the rice field. When the niche breadth was considered month-wise, it was observed to be highest during May and lowest during the months June and July (Figure 6.1.B). The reason for highest niche breath during May might be due to maximum availability of food resource with the onset of fingerling stocking. This indicates greater food preference and feeding activity by the young fish stocked in the rice-fish system, which feeds on the available food resource, which subsequently declines in the succeeding month due to less availability of the food resource. The wider niche breadth during May also reflects the stocked fish to be opportunistic feeder.

The ranking index of the food items of the stocked fish (Table 6.3) showed that amongst phytoplankton/phyto-periphyton classes available in the rice field, the fish fed more on Bacillariophyceae followed by Chlorophyceae, Cyanophyceae, Rhodophyceae, Euglenophyceae and Zygnemophyceae. Amongst the phytoplankton/phyto-periphyton belonging to class Bacillariophyceae, the preferred taxa found in the gut of the fish were *Melosira* > *Pinnularia* > *Navicula* > *Navicula placenta* > *Cymbella.* The preferred food item of fish belonging to Chlorophyceae were *Docidium* > *Staurastrum* > *Spirogyra*. The preferred food item of fish belonging to Cyanophyceae were *Phormidium*> *Anabaena* >*Nostoc*. For the Class Rhodophyceae, the preferred food taxon of fish was *Batrachospermum*. For the class Euglenophyceae the preferred food item was *Euglena* > *Phacus* > *Trachelomonas* and the taxa preferred by the fish belonging to Zygnemophyceae was *Miscrasterias*. Amongst zooplankton/zoo-periphyton groups available in the rice field the fish fed more on Cladocera

Tapati Das
23/12/19

Scanned by CamScanner

followed by Copepoda. The preferred taxa of fish belonging to Cladocera was *Bosmina* > *Alona* > *Macrothrix* > *Chydororus*. Under the group, Copepoda the preferred taxa was *Cyclops* > *Mesocyclops* > *Diaptomus*. The preferred food belonging to group Protozoa was *Centropyxis*. The preferred food items of the stocked *C. carpio* was more for phytoplankton/phyto-periphyton communities belonging to class Bacillariophyceae and zooplankton communities belonging to group Cladocera.

When the growth parameters of the fish were observed, it was found that both the body weight and body length of the stocked fish increased consistently from May to August (Figure 7.1). Highest values for body weight and total length of the stocked fish in the rice-fish system during August indicate the stocked fish attained maximum maturity during August.

Body nutrient content of the stocked fish revealed variations in the proximate and mineral nutrient compositions in the body of the stocked fish with respect to months (Figure 7.2). This indicates variations in the availability and type of food across different months leading to monthly variations in the body nutrient content of the stocked fish.

Earlier study by Saikia and Das (2004) revealed that the production rate of *C. carpio* in the rice-fish system of Apatani Plateau is far below the carrying capacity of the field in comparison to similar systems elsewhere. This therefore, indicated the necessity of supplementary feed for the stocked fish to increase their production within a short period of time. In this regard, the fish feed formulation was performed using locally available resources in order to reduce the cost of feed production on one hand and to increase the fish production within limited time on the other.

Nutrient content analyses of the formulated fish feed showed it to be comparable with the standard fish feed material (Table 8.1). Efficacy test was performed with formulated feed under laboratory condition (Table 8.2 and Figure 8.1). The study suggests that, the stocked

Tapati Das
23/12/19

Scanned by CamScanner

fish would grow much faster if the prepared fish-feed is supplemented into the rice-fish system of Apatani Plateau @ 3% of their initial body weight while stocking in the rice field. However, further studies following on-farm feeding trials would enhance our understanding on the growth behaviour of the fishes in this system.

Overall, the study highlights the possibility of increasing the production of fish in the rice-fish system of Apatani Plateau by exploiting the existing agro-based wastes which would definitely result in more per capita fish-protein consumption and better economic returns to the local people of the Apatani landscape in sustainable and eco-friendly ways.

Tapali Das
23/12/19

Scanned by CamScanner

REFERENCES

Alikunhi, K.H. (1955). Rice field fish culture outside Indonesia. Lecture presented at third international inland Fisheries Training Centre, Bogor, Indonesia, FAO, Rome. (Mimeo).

Anand, N. (1989). *Handbook of Blue-Green Algae (of Rice Fields of South India)*. Bishen Singh Mahendra Pal Singh, Dehradun. p-79.

Anand, N. (1998). *Indian Freshwater Microalgae*. Bishen Singh Mahendra Pal Singh, Dehradun. p-93.

APHA (2012). *Standard Methods for Examination of Water and Wastewater*. 22nd Edition. American Public Health Association: New York. p-1496.

Blanc, M.P., Banarescu, J., Gaudet, L.and Hureu, J.C. (1971). European Inland Water Fish. Acassava peel. Nig. J. Appl. Fish. *Hydrobiol*. 1: 47-50.

Biswas, K. (1980). *Common Fresh and Brackish Water Algal Flora of India and Burma*. International Book Distributor, Dehradun. p-105.

Bhuiyan, A.S. and Biswas, B. (1982). Studies on the morphometry of Puntius chola (Hamilton-Buchanan) (Cyprinidae: Cypriniformes).*Univ. J. Zool.* Rajshahi Univ. 1:29-34.

Battish, S. K. (1992). *Freshwater zooplankton of India*. Mohan Primlani, New Delhi.p-233.

Boyd C.E. (1998). *Research and Water quality for pond aquaculture Development Series No. 43*. International Center for Aquaculture and Aquatic Environments, Alabama Agricultural Experiment Station, Auburn University, Alabama. p[1-482]

Bilgrami, K.S. and Saha, L.C. (2004). *A Text Book of Algae*. CBS Publishers and Distributors, New Delhi. p- 263.

Bhuiyan, A.S., Afroz, S. and Zaman, T. (2006). Food and feeding habit of the juvenile and adult snakehead, Channa punctatus (Bloch). *Journal of Life and Earth Science*. 1(2): 53-54.

Begum, M., Alam, M.J., Islam, M.A. and Pal, H.K. (2008). On the food and feeding habit of an estuarine catfish Mystus gulio (Hamilton) in the south-west coast of Bangladesh *University Journal of Zoology*, Rajshahi University. 27: 91-94.

Dempson, I.B., Schwarz, C.J., Shears, M. & Furey, G., (2004). Comparative proximate body composition of Atlantic salmon with emphasis on parr from fluvial and lacustrine habitats. *J. Fish Biol*.64: 1257-1271.

Dollo, M., Samal, P. K., Sundriya, R.C. and Kumar, K. (2009). Environmentally Sustainable Traditional Natural Resource Management and Conservation in Ziro Valley, Arunachal Himalaya, India. *Journal of American Science* .5(5):41-52.

Tapati Das
23/12/19

Scanned by CamScanner

Eaton, S.B. and Konner, M. (1985). Palaeolithic nutrition. A consideration of its nature and current implications. *N. Engl. J. Med.* 312: 283-289.

Eaton, A.D., Clesceri, L.S. and Greenberg, A.E. (1995). "Standard method for the examination of water and waste water (19th Edition)". American Public Health Association, New York. pp.4500.

F.A.O. (1957). "A preliminary review and annotated bibliography from Section II and III of Proc". *Indo-Pacif. Fish*.pp.193-206.

Faturoti, E.O. and Akinbote, O.A. (1986). Growth response and nutrient utilization in *Oreochromis niloticus* fed varying levels of dietary.

Fernando, C.H. (1993). Rice field ecology and fish culture—an overview. *Hydrobiologia*. 259:91–113.

Ferdous, Z. and Muktadir, A.K.M. (2009). A Review: Potentiality of Zooplankton as Bio indicator. *Applied Sciences*. 6(10):1815-1819.

Fulton T.W. (1911). *The Sovereignty of the Sea*. Blackwood, Edinburgh and London. p-480.

Ghosh, A. K. and Sengupta, T. (1982). *Handbook on insect collection, preservation and study*. Director, Zoological survey of India, Government of India. p-64.

Gahan, C. J. (1988). *The fauna of British India including Ceylon and Burma. Coleoptera (Cerambycidae)*. Volume I. Today and Tomorrow Publishers. p- 322.

Geldiay R, Balık S., 1996: *Freshwater Fishes in Turkey, (in Turkish)*. Ege Üniv. Su Urunleri Fakultesi Yayınlari No: 16, Izmir. p- 532.

Gupta, P. K. (1999). *Soil, plant, water and fertilizer analysis. Agrobios (India), Jodhpur, India*. p-438.

Haimendorf, CVF. (1962).The Apatanis and their neighbours, Oxford University Press, London.

Hobson, E.S. (1974). Feeding relationships of teleostan fishes on coral reefs in Kona, Hawaii. *Fish Bulletin*. 72: 915-1031.

Howes, G. J. (1991). "Systematics and biogeography: an overview. In Cyprinid Fishes. Systematics", Biology and Exploitation (Winfield, I.J. & Nelson, J. S., eds), London: Chapman & Hal. pp. 1–33.

Halwart, M. (1994). The ecology of fish in rice fields. *Annals of Tropical Research*. 10: 1-16.

Halwart, M. (1998). "Trends in rice-fish farming". FAN, the FAO Aquaculture Newsletter. pp.18.

Tapali Das
23/12/19

Scanned by CamScanner

Haroon, A. K. Y. and Pittman, K. A. (1998). Diel feeding pattern ration of two sizes of tilapia, Oreochromis species in pond and paddy fields. *Asian Fisheries of Science*. 10:281-301.

Halwart, M. and Gupta, M.V. (eds.) (2004). "Culture of fish in rice fields. FAO and the World Fish Center". pp.83.

Hassan M.A. (2015). Innovation in feeds and feeding practices. http://msam.nic.in.

Hei, A. and Sarojnalini, C. (2012). Proximate composition, macro and micro mineral elements of some smoke-dried hill stream fishes from Manipur, India. *Nature and Science*.10 (1): 59-65

John, D. M., Whitton, B. A. and Brook, A. J. (2011). *The Freshwater Algal Flora of British Isles*. Cambridge University Press, Cambridge. p - 878.

Lackey, J. B. (1938). The flora and fauna of surface waters polluted by acid mine drainage. *Public health reports*. 53: 1499-1507.

Li, K. (1988). Rice-fish culture in China, a review. *Aquaculture*. 71(3): 173-186.

Lovell T. (1988). *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York. p-(1-260).

Levins, R. (1968). Evolution in Changing Environments; Some Theoretical Explorations. Princeton University Press, Princeton. p-120.

Lukaw, Y.S., Ladu, J.L.C. and Kenyi, D.D. (2012) Seasonal Influence of Physicochemical Variables on Phytoplankton Abundance in Jebel Aulia Reservoir in Khartoum, Sudan. *Nature and Science*. 10 (11), 168-175.

Michael, P. (1984). Ecological *Methods for Field and Laboratory Investigations*. Tata McGraw-Hill Publishing Company Limited, New Delhi.p (403-407).

Mustapha, K.M. (2010).Seasonal influence of limnological variables in plankton dynamics of small, Shallow, tropical Africa reservoir. *Asian J Exp. Biol. Sci*. 1 (1):60-79.

Mohapatra S.B. and Patra A.K. (2014). Growth response of common carp (*Cyprinus carpio*) to different feed ingredients incorporates diets. *Advances in Applied Science Research*. 5(1): 169-173.

Needham, P.K. and Needham,P.K. (1962). *A guide to the study of fresh water biology*. Holden–day, Inc. San Fransisco, p-108.

Needham, James G., and Needham, Paul R. (1972). *A Guide to the Study of Freshwater Biology*. 5th Edition. Holden-Day Inc. San Francisco, Callifornia. p-108.

Okalebo, J.R., Gathua, K.W. and Woomer, P.L. (1993). *Laboratory Methods of Soil and Plant Analysis: A working manual*. TSBF-UNESCO, Nairobi, EPZ Publishers, Nairobi, Kenya. p-88.

Tapati Das
23/12/19

Scanned by CamScanner

Pentecost, A. (1984). *Introduction to Freshwater Algae*. Richmond Publishing Corporation. England. p-247.

Prapasri,P.,Kunchit,J.,Eakkarach,K.,Kriengkrai,V.,Yupapom,N.,Bhattacharjee,L.(1999).Proximate Composition of Raw and Cooked Thai Freshwater and Marine Fish. *Journal of food composition and analysis*.12: 9-16.

Raghuramulu, N., Nair, K. Madhavan and Kalyanasundaram, S. (1983). *A Manual of Laboratory Techniques*. National Institute of Nutrition, Indian Council of Medical Research, Jamai-Osmania, Hyderabad, India. p-559.

Ramesh, R. and Anbu, M. (1996). *Chemical methods for environmental analysis – water and sediment*. Macmillan India Limited. p- 260.

Santhanam, R., Velayutham. and Jegatheesan, G. (1989). *A Manual of Freshwater Ecology (An Aspect of Fishery Environment)*. Daya Publishing House, Delhi. p-134.

Santra, S.C. (1993). *Biology of Rice-Fields Blue-Green Algae*. Daya Publishing House, Delhi. p -184.

Sadasivam, S. and Manickam, A. (1996). *Biochemical Methods*. 2nd Edition. New Age International Private Limited, New Delhi. p-256.

Saikia, S. K. and Das, D. N. (2004). '*Aji gnui assonii*' – a practice of organic hill farming among the Apatani tribe of Eastern Himalaya. *Int. J. Sustain. Dev. World Ecol.* **11**: 211-217.

Sharma, V., Verma, B. K., Sharma, R., Sharma, M. S. and Gaur, K. S. (2012). A report on the freshwater Cladocera (Crustacea: Branchiopoda) of south Rajasthan (India). International *Journal of Environmental Sciences*. 3(1): 275-296.

Tripathi, B. D. and Govil, S.R. (2001). *Water pollution (an experimental approach)*. S. K. Jain for CBS Publishers and Distributors, New Delhi, India. p -132.

Thilsted, S.H., and Wahab, M.A., (2014a). Nourishing Bangladesh with Micronutrient-Rich Small Fish. Policy Brief: AAS-2014-08.Available at: http://www.worldfishcenter.

Vazirani, T. G. (1984). *Fauna of Coleoptera, Family- Gyrinidae and Haliplidae*. Zoological Survey of India Publication. p -138.

Ward, J. V. and Whipple, G. C. (1959). "Fresh water Biology". 2nd Edition. Wiley, New York. p-1248.

Zhang, R. (1995). "Scientific and technological development of rice-fish culture in China", In K.T. MacKay (ed.) *Rice-fish culture in China. International Development Research Centre (IDRC)*, Ottawa, Canada. pp. 23-30.

Tapati Das.
23/12/19

Scanned by CamScanner

Photographs

Tapati Das
23/12/19

Scanned by CamScanner

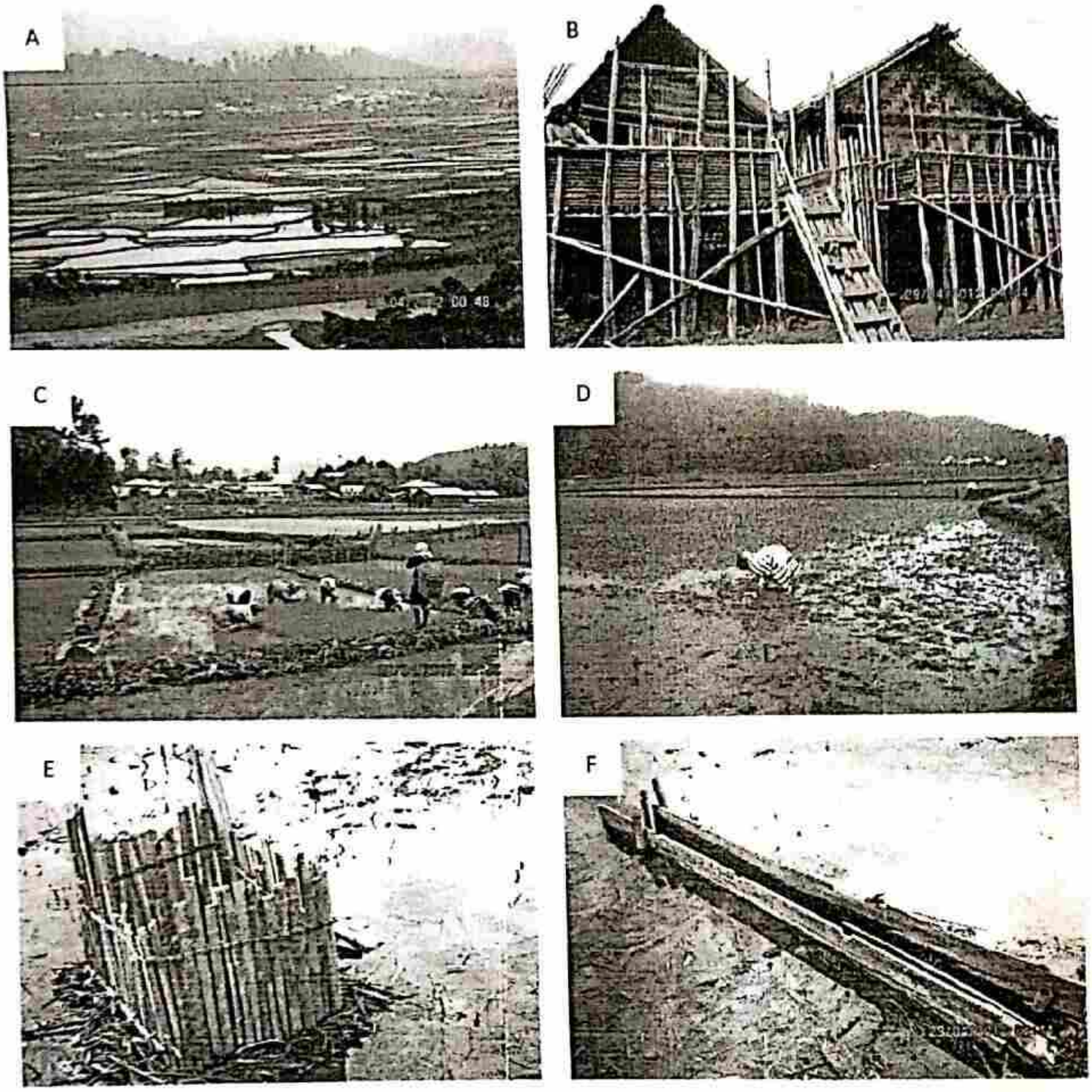


Plate 1. (A) Apatani agricultural fields with human settlements in the background, (B) A typical Apatani house in Ziro, (C) Collecting paddy plants from the nursery for transplantation, (D) Planting paddy plants in the prepared plot, (E) Agricultural plots marked after transplantation and introduction of fingerling of common carp, (F) Wooden channels made to maintain flow of water and for fish movement between different plots.

Tapati Das.
23/12/19

Scanned by CamScanner

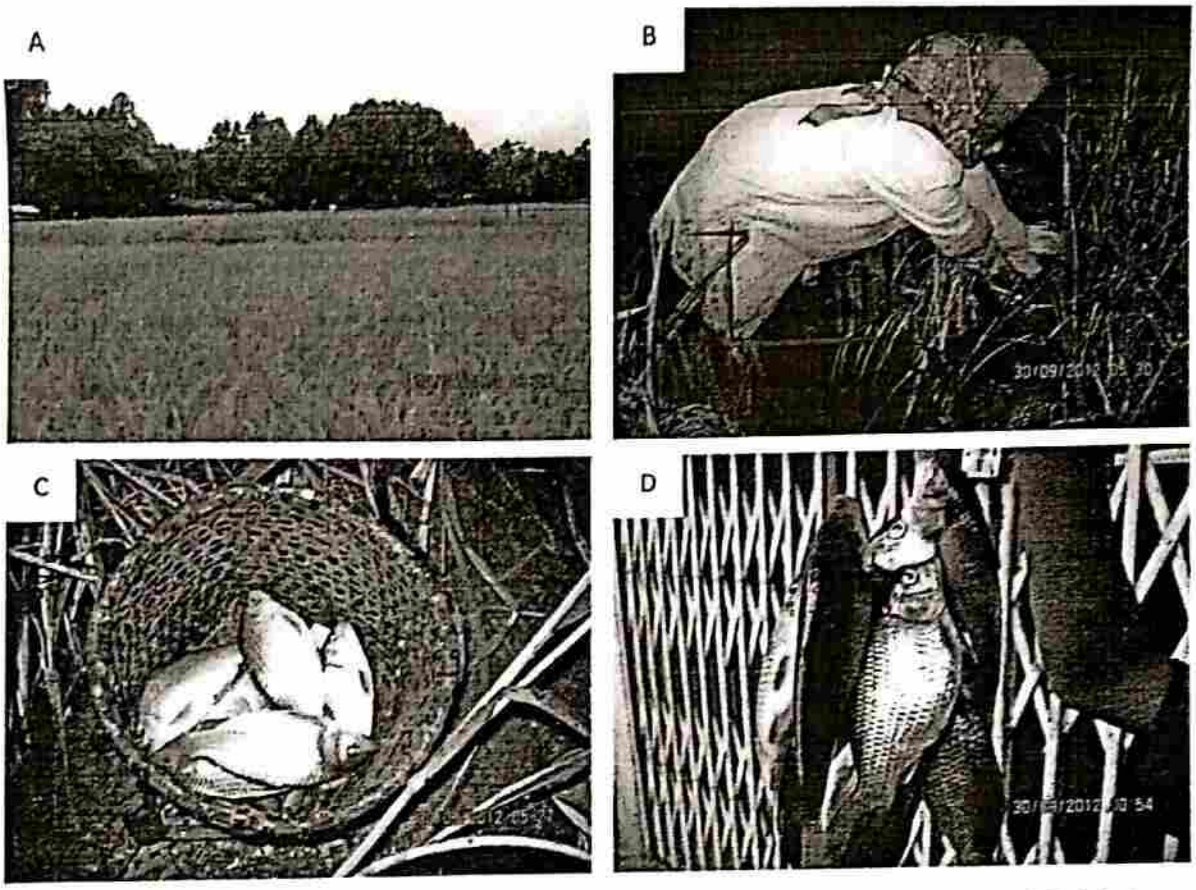


Plate 2. (A) Matured rice plant during the month of September, (B) Harvesting of fish being done before paddy harvest, (C) Harvested fishes in traditional basket, (D) Harvested fish brought to the market for sale.

Tapati Das.
23/12/19

Scanned by CamScanner

Raw materials locally available in the *Apatani* Plateau for preparation of low-cost fish-feed

Plate 3. Leftover of processed and fermented rice after preparation of the traditional rice beer, '*Apong*'

Plate 4. Filamentous algae clumped near the rhizosphere of the rice plant in the rice-fish system

Tapati Das
23/12/19

Scanned by CamScanner

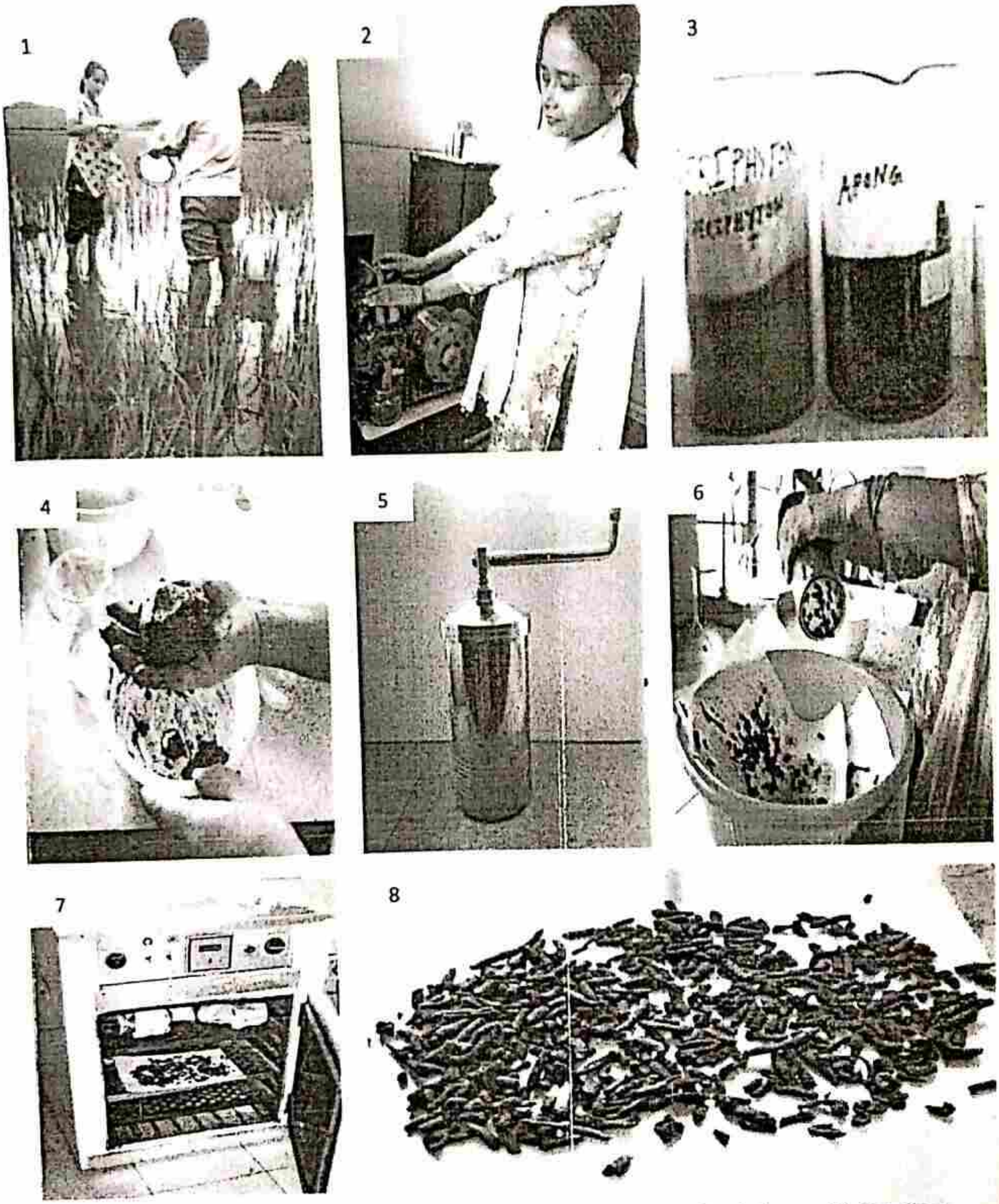


Plate 5. Steps involved in formulation of fish feed. (1) Collection of periphyton, (2) Grinding of raw materials, (3) Raw materials in powdered form, (4) Doughing the raw materials, (5) Put the dough in a palletizer, (6) Fish-feed pelleting, (7) Oven drying of the fish-feed, (8) Fish-feed ready to be supplemented in the rice-fish system

Tapati Das
23/12/19

Scanned by CamScanner

Plate 6. Conducting meeting and discussion with the villagers related to fish feed formulation and its application in the rice-fish system

Tapati Das,
23/12/19

Scanned by CamScanner