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Feed Intake Pattern and Growth Performance of Indian Major Carps, Common Carp and Freshwater Prawn in a Rice-fish Integration System

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Abstract

This study was carried out to evaluate feed intake pattern, growth and yield performance of fish and prawn under rice-fish integration system in rainfed medium land ecosystem. Omnivorous feeding behaviour was observed in the case of each species except *Catla catla*, while the degree of omnivorous feeding behaviour was high in the case of *Macrobrachium rosenbergii (giant freshwater prawn).* Comparative degree of satiation, indicated a distinct declining trend from fry/juvenile stage to advanced fingerling stage in the case of each species. Positive indices of electivity were observed for phytoplankton (0.02 - 0.31) in monsoon-winter, while it was negative for zooplankton (-0.14 to - 0.46) during the same period. Matrix of dietary overlap(s) established a stronger possibility of competition for food among bottom dwellers. Irrespective of stocking density, faster growth rate was recorded for *Catla catla* followed by *Cyprinus carpio, Cirrhinus mrigala, Labeo rohita* and *Macrobrachium rosenbergii*. However, an average productivity of 906.6 - 1282.3 kg•ha^{-1} of fish and prawn has been achieved, which was much higher than the earlier recorded productivity in a season under rice-fish integration system in India. Moreover, for short duration fry to advanced fingerling stage rearing under rice-fish culture system, a stocking density of 25000 ha^{-1} is recommended, beyond which biomass yield decreases and density-dependent growth takes place.

Introduction

Adoption and practice of rice-fish culture in India dates back almost 1500 years (Ali 1990). Out of 42 million ha of rice cultivated land in India, about 20 million ha is suitable for adoption of rice-fish integration system (Rao and Ramsingh 1998) and only 0.23 million ha is presently under rice-fish culture (Radhey Shyam 1998) where, a productivity of 200-800 kg•ha^{-1} of fish has been obtained (Mukhopadhyay et al. 1991). Unfortunately, the carrying capacity of these suitable lands has not been utilized to the fullest extent. If these lands were brought under integrated rice-fish system, it would help to compensate the economic losses in rice production brought about by natural calamities. Further, it will also enhance the use of land and water without bringing about environmental degradation (Mohanty et al. 2002). In addition to enhanced productivity, this system could further generate employment opportunity and increased income for farmers. However, despite great advances, several technical and production constraints are yet to be resolved such as yield gap between experimental and field models, inconvenience in pesticide application and development of suitable design. Although lot of research have been carried out on different aspects of rice-fish integration system (Likangmin 1988, Lightfoot et al. 1992 and Rao and RamSingh 1998), very little information is available on food preference and intake pattern of cultured species, soil and water chemistry in relation to yield, and management strategy to enhance unit yields. Keeping the above stated points in view, attempt has been made here to evaluate rice-fish integration system in rainfed medium land ecosystem with special reference to stocking density, food preference and intake pattern of cultured species, and soil and water chemistry in relation to yield.

Material and Methods

The present experiment was carried out at WTCER Research Farm, Deras, Bhubaneswar, India (Lat. 20°30′ N and Long. 87°48′10″ E) during 1999-2001 for three successive years. Plots of 30 x 10 m size were selected for the proposed study. Three different weir heights (10 cm, 12.5 cm and 15 cm) were chosen as treatments with three replications each. Each rice field was provided with a peripheral trench of 0.75 m wide and 0.5 m deep on three sides (Fig. 1). A slope of 0.5% was provided at the trench bottom towards downstream side. When water level recedes in the rice field, fish and prawns move to the peripheral trench and finally to the refuge through the regulated inlets. Refuges were constructed at the down stream end of each plot as per the size determined by Mishra et al. (1998). The area of the refuges was 45 m^2, 35 m^2 and 15 m^2 for 10, 12.5 and 15 cm weir heights plots, respectively. The depth of the ref-

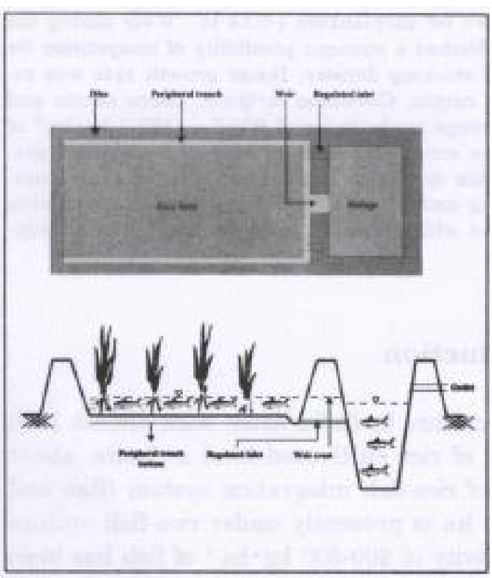

Fig. 1. Layout of rice-fish integration system in rainfed medium lands

uges was kept at 1.75 m. The excess rainwater spilling over the weir was harvested in the refuge. Two regulated inlets (pipes) were provided to each refuge at the bottom surface of the peripheral trench. These inlets remain closed most of the time. Only when the water level in the rice field recedes, they are opened to allow the fish and prawns to come to the refuge from the rice field. Further, each refuge was provided with an outlet (hume pipe fitted with fine meshed net) to dispose of the excess water above 1.75 m in the event of heavy down pour.

After two years of varietal trial of rice amongst *MW-10, Swarna* and *Lalat; Swarna* was selected as the best variety and was grown in each plot of the present study with a spacing of 20 x 10 cm (between rows and plants). Transplanting was usually carried out during 2nd week of July. The seed and fertilizer application rate for rice was 50 $kg \cdot ha^{-1}$ and 80:40:40 (N:P:K) ha^{-1} , respectively. 50% of N and full dose of P and K were given as basal dose at the time of transplanting. The rest of the Nitrogen was applied in two equal splits during tillering (20 days after transplanting) and panicle initiation (45 days after transplanting) stages. Crop growth and yield parameters of rice were recorded at regular intervals. No pesticide was used in the experimental plots to prevent fish mortality.

Refuge preparation with application of lime @ 2000 $kg \cdot ha^{-1}$, raw cow dung @ 5000 $kg \cdot ha^{-1}$ and fertilizers (Urea:SSP :: 1:1) @ 2 ppm was carried out prior to stocking. Seven days after refuge preparation, fry (0.82 - 0.97g) of *Catla catla, Labeo rohita, Cirrhinus mrigala, Cyprinus carpio* and post larvae (PL_{3-5}) of freshwater prawn *Macrobrachium rosenbergii* were stocked in the refuge during 4th week of July –1st week of August with a species composition of 30:30:15:15:10, respectively. Keeping the size of stocking material and duration of rearing (120 – 130 days) in view, stocking density of fry and prawn seed was kept at 15000, 25000 and 35000 ha^{-1} (refuge area only) during 1st, 2nd and 3rd year of experimental study, respectively and rearing was continued for 120 days. Supplemental feed (rice bran:groundnut oil cake :: 1:1) @ 10%, 8%, 6% and 4% of mean body weight (MBW) was given twice a day, during 1st, 2nd, 3rd and 4th month to harvesting, respectively. Periodic manuring @ 500 $kg \cdot ha^{-1}$ and liming @ 200 $kg \cdot ha^{-1}$ were carried out at every 15 days interval to maintain plankton population in the eco-system.

Plankton estimation, primary productivity, weekly observation on water quality and monthly observations on soil quality was recorded using standard methods (APHA 1989 and Biswas 1993). Field test instruments were also in use to analyze *in-situ* water pH (Checker-1, HANNA, USA), Soil pH (DM-13, Japan), and dissolved oxygen (YSI-55, USA). Crop performance, fish/prawn growth parameters, condition factor of fish and prawn, feed conversion ratio were measured/estimated. To estimate the food preference and feed intake pattern of cultured species, intestine index (I.I. = L_I / SL; where L_I =Length of intestine and SL= standard length of fish), gut content analysis, degree of satiation (Mohanty et al. 2000), indices of electivity of different food components (Ivlev 1961), frequency, abundance and matrix of dietary overlaps (Johnson, 1999) were carried out. Every year, during the experiments, 12 pieces of each species were sacrificed for this purpose.

Results

The recorded minimum and maximum values of various water and soil quality parameters during the experimental period were: water temperature 27.5 - 30.2^{0}C; water pH 6.9 - 8.8; dissolved oxygen 3.9 - 8.1ppm; total alkalinity 69 - 129 ppm; dissolved organic matter 0.6 - 4.7 ppm; nitrite –N 0.006 - 0.071 ppm; nitrate-N 0.06 - 0.52 ppm; ammonia 0.01 - 0.21 ppm; total suspended solid 89 - 319 ppm; phosphate-P 0.06 - 0.34 ppm; water depth 89 - 175 cm; soil pH 6.6 - 7.0; available-N in soil 7.9 - 10.7 mg 100^{-1}g; available P in soil 0.29 - 0.67 mg 100^{-1}g ; organic carbon in soil 0.16 - 0.53% and total plankton count 2.4 x 10^2 – 9.1 x 10^3 nos/l.

Phytoplankton and zooplankton was most preferred food item for *C. catla* and *L. rohita*, while mud and detritus was highly preferred by *C. mrigala, C. carpio* and *M. rosenbergii* in rice fish integration system (Table 1). However, quantity-wise most consumed food items were artificial supplemental feed of rice bran and groundnut oil cake. Among bottom dwellers (*C. mrigala, C. carpio* and *M. rosenbergii*), phytoplankton and benthos were preferred more by *M. rosenbergii* while zooplankton and detritus by *C. Carpio* and *C. mrigala* respectively. Omnivorous feeding behaviour was observed in case of each species except *Catla catla*, while the degree of omnivorous feeding behaviour was high in case of *M. rosenbergii* (Table 1). Comparative degree of satiation, indicated a distinct declining trend from fry/juvenile stage to advanced fingerling stage in case of each species (Table 2).

Table 1. Average % of analyzed species in which mentioned food component was found (frequency) and % of individual gut content volume (abundance) of cultured species

Food component	Frequency (%)					Abundance (%)				
	1	2	3	4	5	1	2	3	4	5
Phytoplankton	94.4	83.3	55.6	66.6	72.2	<11.2	<5.1	<2.3	<2.7	<4.3
Zooplankton	88.8	83.3	44.4	72.2	44.4	<5.9	<4.3	<1.4	<1.9	<1.6
Mud+Detritus	11.1	22.2	94.4	88.9	77.8	<5.6	<15.4	>29.1	>32.1	<21.0
Benthos	-	5.5	44.5	55.6	61.1	-	<1.0	<12.2	<12.2	<16.4
Artificial feed	72.2	77.8	83.3	88.8	77.8	>56.7	>49.3	>45.8	>46.1	>61.7

1 - *Catla catla*, 2 - *Labeo rohita*, 3 - *Cirrhinus mrigala*, 4 - *Cyprinus carpio*, 5 - *Macrobrachium rosenbergii*

Table 2. Estimated degree of satiation (F_i) of cultured fish and prawn species

Cultured species	F_i at fry/juvenile stage	F_i at advanced fingerling stage
Catla catla	6.3 ± 0.6	2.4 ± 0.3
Labeo rohita	6.1 ± 0.2	5.1 ± 0.3
Cirrhinus mrigala	5.9 ± 0.3	5.1 ± 0.6
Cyprinus carpio	7.2 ± 0.4	6.4 ± 0.4
Macrobrachium rosenbergii	5.9 ± 0.3	5.0 ± 0.1

Fi = w x 100/W; where, w- weight of gut content and W- weight of individual fish/prawn.

The intestine index values of all analyzed fish varied between 6.7 to 9.8 and no correlation was found with standard length. These relatively high values are typical to planktivorous, detritivorous or phytobenthophagous fishes. Positive indices of electivity were observed for phytoplankton in monsoon-winter, while it was negative for zooplankton during the same period (Figs. 2 and 3). Degree of food preference was much similar between *C.carpio* and *M.rosenbergii* (0.89), while, it was poorly overlapped between *C.catla* and *M.rosenbergii* (0.41).

Faster growth rate was recorded for *C. catla* followed by *C. carpio, C.mrigala, L. rohita* and *M. rosenbergii* during 120 days of culture at stocking density of 15000, 25000 and 35000 ha^{-1} (Tables 3, 4 and 5). Species-wise overall survival rate was high at stocking density of 15000 ha^{-1} which decreased with increase in stocking density (Tables 3, 4 and 5). *Catla catla* and *Labeo rohita* showed a distinct declining trend in survival rate with increase in stocking density from 15000 to 35000 ha^{-1} while, no such trend was marked in case of *C. mrigala, C. carpio* and *M. rosenbergii.* Condition factor (Ponderal index) of fish and prawn (Tables 3, 4 and 5) was less than 1.0 at the initial three weeks of rearing and improved thereafter with gradual improvement in water quality. Yield in terms of productivity ($kg \cdot ha^{-1}$ $4months^{-1}$) of fish and prawn was however, higher ($p<0.05$) in refuges with 10 cm weir height plots, irrespective of stocking density while, overall yield performance was good at stocking density of 25000 ha^{-1} (Table 6). An increase in stocking density from 25000 to 35000 ha^{-1} however, recorded a negligible maximum increase of 125.8 $kg \cdot ha^{-1}$ $4months^{-1}$ in fish/ prawn yield in refuges with 12.5 cm weir height plots while, total yield decreased by 4.5% in refuges with 15 cm weir height plots.

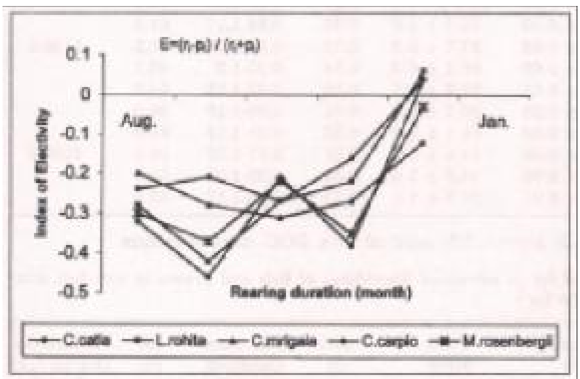

Fig. 2. Monthly indices of electivity for zooplankton of cultured fish and prawn in the rice field refuge

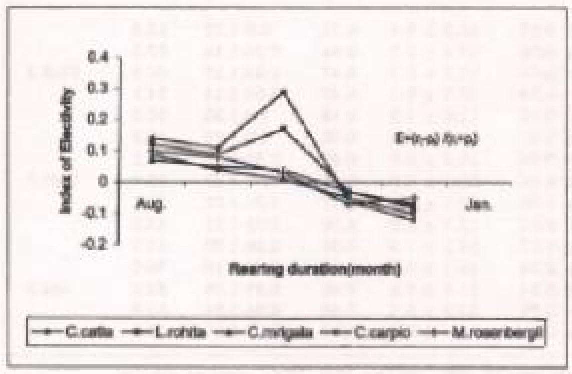

Fig. 3. Monthly indices of electivity for phytoplankton of cultured fish and prawn in the rice field refuge

Table 3. Growth performance in rearing of fry to advanced fingerlings of fish and prawn in rice-fish integration system at stocking density of 15000 ha^{-1}

Treatment	Species reared	Initial MBW (g)	Final MBW (g)	ADG (g)	Min.-max. Condition factor (K_n)	SR (%)	Productivity ($Kg \cdot ha^{-1}$ 120 DOC^{-1})
10 cm weir	*C.catla*	0.84 ± 0.07	123.6 ± 4.8	1.02	0.91-1.27	78.9	
height plot	*L.rohita*	0.92 ± 0.03	88.4 ± 7.1	0.73	0.82-1.11	84.2	
with refuge	*C.mrigala*	0.97 ± 0.08	92.8 ± 6.8	0.76	0.96-1.38	70.0	1026.7
	C.carpio	0.88 ± 0.11	94.6 ± 4.3	0.78	0.96-1.18	60.0	
	M.rosenbergii	0.04 ± 0.01	24.8 ± 1.2	0.21	1.01-1.44	66.6	
12.5 cm weir	*C.catla*	0.84 ± 0.07	121.0 ± 8.2	1.0	0.9-1.31	73.3	
height plot	*L.rohita*	0.92 ± 0.03	79.2 ± 4.9	0.65	0.84-1.2	80.0	
with refuge	*C.mrigala*	0.97 ± 0.08	84.0 ± 6.3	0.69	0.92-1.17	87.7	962.8
	C.carpio	0.88 ± 0.11	87.1 ± 6.3	0.71	0.92-1.22	62.5	
	M.rosenbergii	0.04 ± 0.01	24.3 ± 0.8	0.2	0.99-1.38	77.8	
15 cm weir	*C.catla*	0.84 ± 0.07	113.8 ± 5.8	0.94	0.88-1.19	71.4	
height plot	*L.rohita*	0.92 ± 0.03	73.0 ± 5.2	0.6	0.97-1.14	71.4	
with refuge	*C.mrigala*	0.97 ± 0.08	78.5 ± 3.8	0.64	0.97-1.16	75.6	906.6
	C.carpio	0.88 ± 0.11	79.2 ± 4.4	0.65	0.91-1.23	50.0	
	M.rosenbergii	0.04 ± 0.01	24.3 ± 0.8	0.2	0.96-1.22	66.6	

MBW-mean body weight, ADG-average daily growth, SR- survival rate, DOC- days of culture

Table 4. Growth performance in rearing of fry to advanced fingerlings of fish and prawn in rice-fish integration system at stocking density of 25000 ha^{-1}

Treatment	Species reared	Initial MBW (g)	Final MBW (g)	ADG (g)	Min.-max. Condition factor (K_n)	SR (%)	Productivity ($Kg \cdot ha^{-1}$ 120 DOC^{-1})
10 cm weir	*C.catla*	0.82 ± 0.03	103.8 ± 4.1	0.85	0.99-1.24	58.8	
height plot	*L.rohita*	0.88 ± 0.03	76.9 ± 5.2	0.63	0.84-1.15	61.7	
with refuge	*C.mrigala*	0.92 ± 0.06	88.8 ± 6.8	0.73	0.96-1.21	58.8	1243.1
	C.carpio	0.88 ± 0.09	90.2 ± 4.3	0.74	0.94-1.16	58.8	
	M.rosenbergii	0.04 ± 0.01	24.1 ± 1.4	0.2	1.04-1.24	60.0	
12.5 cm weir	*C.catla*	0.82 ± 0.03	98.2 ± 6.1	0.81	0.93-1.22	57.6	
height plot	*L.rohita*	0.88 ± 0.03	76.2 ± 4.9	0.63	0.84-1.17	61.5	
with refuge	*C.mrigala*	0.92 ± 0.06	87.7 ± 6.3	0.72	0.97-1.27	61.5	1156.5
	C.carpio	0.88 ± 0.09	90.2 ± 6.8	0.74	0.93-1.2	46.1	
	M.rosenbergii	0.04 ± 0.01	22.8 ± 0.8	0.19	0.99-1.33	50.0	
15 cm weir	*C.catla*	0.82 ± 0.03	90.2 ± 5.3	0.74	0.98-1.19	50.0	
height plot	*L.rohita*	0.88 ± 0.03	68.1 ± 5.2	0.56	0.91-1.13	66.6	
with refuge	*C.mrigala*	0.92 ± 0.06	74.6 ± 3.2	0.61	0.97-1.26	50.0	1036.6
	C.carpio	0.88 ± 0.09	74.8 ± 5.0	0.62	0.95-1.21	50.0	
	M.rosenbergii	0.04 ± 0.01	20.3 ± 1.1	0.17	0.96-1.12	33.3	

MBW-mean body weight, ADG-average daily growth, SR- survival rate, DOC- days of culture

Table 5 . Growth performance in rearing of fry to advanced fingerlings of fish and prawn in rice-fish integration system at stocking density of 35000 ha^{-1}

Treatment	Species reared	Initial MBW (g)	Final MBW (g)	ADG (g)	Min.-max. Condition factor (K_n)	SR (%)	Productivity ($Kg \cdot ha^{-1}$ 120 DOC^{-1})
10 cm weir	*C.catla*	0.91 ± 0.07	86.3 ± 8.4	0.71	0.9-1.22	52.0	
height plot	*L.rohita*	0.9 ± 0.08	54.4 ± 5.3	0.44	0.84-1.14	62.5	
with refuge	*C.mrigala*	0.95 ± 0.04	57.1 ± 6.7	0.47	0.93-1.28	66.6	1245.3
	C.carpio	0.87 ± 0.09	57.7 ± 9.3	0.47	0.96-1.14	54.1	
	M.rosenbergii	0.04 ± 0.01	21.6 ± 1.2	0.18	1.0-1.25	50.0	
12.5 cm weir	*C.catla*	0.91 ± 0.07	90.8 ± 8.8	0.75	0.9-1.19	55.5	
height plot	*L.rohita*	0.9 ± 0.08	55.5 ± 5.9	0.45	0.88-1.2	61.1	
with refuge	*C.mrigala*	0.95 ± 0.04	56.4 ± 6.9	0.46	0.9-1.22	66.6	1282.3
	C.carpio	0.87 ± 0.09	58.1 ± 6.3	0.47	0.94-1.22	61.1	
	M.rosenbergii	0.04 ± 0.01	22.4 ± 0.9	0.18	0.95-1.31	40.0	
15 cm weir	*C.catla*	0.91 ± 0.07	84.2 ± 7.8	0.69	0.88-1.29	43.7	
height plot	*L.rohita*	0.9 ± 0.08	46.7 ± 5.9	0.38	0.98-1.16	50.0	
with refuge	*C.mrigala*	0.95 ± 0.04	51.7 ± 8.8	0.42	0.97-1.26	62.5	984.6
	C.carpio	0.87 ± 0.09	53.3 ± 5.4	0.43	0.94-1.24	50.0	
	M.rosenbergii	0.04 ± 0.01	21.3 ± 0.6	0.17	0.96-1.27	40.0	

MBW-mean body weight, ADG-average daily growth, SR- survival rate, DOC- days of culture.

Table 6. Effect of stocking density on fish yield at different weir height plot-cum-refuge under rice-fish integration system

Stocking density (nos ha^{-1})	Yield ($kg \cdot ha^{-1}$)		
	10.0 cm	12.5 cm	15.0 cm
15000	1026.7[b]	962.8[c]	906.6[c]
25000	1243.1[a]	1156.5[b]	1030.6[a]
35000	1245.3[a]	1282.3[a]	984.6[b]

Values are means of three replications. Means having different superscript(s) in a column by DMRT differed significantly ($p<0.05$)

Discussion

Water quality, changes in response to daily and seasonal climatic rhythms, while fish/prawn can adapt to this natural fluctuations to a certain level and fails thereafter due to stress. In this experiment, various hydrobiological parameters did not show any distinct trend between the treatments except in the cases of total suspended solid, dissolved oxygen and total alkalinity. The dissolved oxygen content showed a decreasing trend with the advancement of rearing period, attributed to gradual increase in biomass, resulting in higher oxygen consumption. Increased level of water and concentration of total suspended solid was observed in refuge with 10 cm weir height plots, followed by 12.5 and 15 cm weir height plots, probably due to more volume of runoff from the rice field along with sediment and other nutrients. Turbidity caused by suspended soil particles has usually no direct effect on fish (Pillay 1992) but as it restricts light penetration, photosynthesis and natural food availability becomes limited (Mohanty 1996). Poor growth performance of cultured species takes place at pH < 6.5 (Mount 1973) while, higher values of total alkalinity (>90ppm) indicates a better productive ecosystem (Banerjea 1967) and increased plankton density reflects higher nutrient status of the water body. The availability of CO_2 for phytoplankton growth is related to total alkalinity, while water having 20-150 ppm total alkalinity produce suitable quantity of CO_2 to permit plankton production (Boyd and Pillai 1985). However, the recorded minimum and maximum range of total alkalinity during the experimental period was 69 and 129 ppm respectively, which was maintained due to periodic liming. Decreased level of transparency, increased level of ammonia and total suspended solids were probably due to entry of runoff water from the rice field along with sediment and other nutrients, periodic manuring, decomposition of weeds, metabolic deposition and organic load (Mohanty 1999). Average primary production in the first month of rearing ranged between 93 – 117 mgC m^{-3} h^{-1}, which improved further (514.5 $\pm$ 89.4 mgC m^{-3} h^{-1}) with the advancement of rearing period. Low primary production in the initial phase of rearing was probably due to fixation of nutrient ions by suspended soil/clay particles as well as rich organic matter. In general, water reaction process is low during monsoon (July – August) due to dilution of alkaline substances or dissolution of atmospheric CO_2 (Mohanty et al. 2002).

Comparative degree of satiation, indicated a distinct declining trend from fry/juvenile stage to advanced fingerling stage in case of each species, probably due to relatively low nutritional value of the ingested matter (mud and debris) and comparatively less preferance to artificial feed at the initial stage of rearing that lend support to the findings of Spataru (1976). Negative indices of electivity for zooplankton (-0.14 to - 0.46) in case of all species was recorded during monsoon-winter (August - November) and improved thereafter. This was probably due to rich detrital food web in the initial phase of rearing where raw cattle dung was applied @ 5000 kg•ha^{-1} for refuge preparation prior to stocking. However, positive indices of electivity for zooplankton were observed during December, only in case of *C. catla, L. rohita* and *C. carpio*. Similarly, positive indices of electivity (0.02 - 0.31) for phytoplankton was observed in case of all species during August - October (monsoon) while it was negative thereafter probably due to increased density of zooplankton. Matrix of dietary overlap(s) of cultured species under rice-fish integration system (Table 7) revels that, degree of food preference was more similar between *C. carpio* and *M. rosenbergii* (0.89), while, it was poorly overlapped between *C. catla* and *M. rosenbergii* (0.41). This high similarity index between bottom dwellers established a stronger possibility of competition for food among each other.

Bottom feeders (*C. carpio* and *C. mrigala*) performed better growth rate against that of *L. rohita* probably due to the fact that being surface and column dweller, *L. rohita* is more sensitive to oxygen depletion, while being bottom dwellers *C. carpio* and *C. mrigala* are more tolerant to fluctuation of oxygen concentration (Vijayan and Verghese 1986). Among bottom feeders, growth performance of *C. Carpio* appeared to be much better than *C. mrigala* probably due to their superior feed utilizing capability (Sinha 1998). Moreover, faster growth rate of *Catla catla* and bottom dwellers were attributed to effective utilization of ecological niches and rich detrital food web that was maintained through periodic manuring, liming and fertilization, which agrees to the findings of Mohanty (1995). Observations on feed conversion ratio (FCR) also supports the conclusion of effective utilization of ecological niches, as minimum and maximum FCR was 0.96 - 1.23, 0.94 - 1.13 and 0.9 - 0.97 at stocking density of 35000, 25000 and 15000 ha^{-1} respectively. FCR increased with increase in stocking density, probably due to inadequate availability of natural food, higher degree of metabolic deposition / organic load (Mohanty, 1999), low dissolved oxygen concentration and increased level of ammonia towards latter stage of rearing attributed by gradual increase in biomass. Comparative daily growth performance was satisfactory as periodic organic manuring and inorganic fertilization was a regular practice that improved primary productivity (514.5 $\pm$ 81.4 mgC m^{-3} h^{-1}) which enhanced the growth rate. Similar observation was also made by Noriega-Curtis (1979). Comparative growth performance (Tables 3, 4 and 5) of all species in terms of average daily growth rate decreased with increase in stocking density from 15000 to 35000 fry ha^{-1}, probably due to mutual competition for food and space that cause physiological stress and relatively degraded water quality due to increased density and biomass (Trzebiatowski, et al. 1981 and Mohanty 1999). Sinha and Ramachandran

Table 7. Matrix of dietary overlap(s) of fry to advanced fingerling stage of fish and prawn

Species	*C. catla*	*L. rohita*	*C. mrigala*	*C. carpio*	*M. rosenbergii*
Catla catla	-	0.71	0.53	0.52	0.41
Labeo rohita	-	-	0.55	0.52	0.45
Cirrhinus mrigala	-	-	-	0.86	0.84
Cyprinus carpio	-	-	-	-	0.89
Macrobrachium rosenbergii	-	-	-	-	-

(1985) also reported that, under crowded condition at higher stocking density, fish suffers stress due to aggressive feeding interaction, eats less and grows slowly.

Catla catla and *Labeo rohita* showed a distinct declining trend in survival rate with increase in stocking density from 15000 to 35000 ha^{-1} while, no such trend was marked in case of *C. mrigala, C. carpio* and *M. rosenbergii*. This was probably due to mutual competition for food among these three bottom dweller species at the lower level of food web. Growth, survival rate and yield performance of cultured species improved with decrease in weir height of rice field, due to increased spill out water supply to refuge with increased quantity of nutrients (Mishra et al. 1997), increased natural food availability and less fluctuation of physico-chemical parameters (Mohanty et al. 2001).

It was observed that, even with supplemental feeding, with increase in stocking density, density-dependent growth takes place while, biomass yield increase up to an optimum and then decrease, which lends support to the findings of Sinha and Ramachandran (1985). In fact, by increasing the stocking density beyond the optimum rate, the total demand for oxygen increases with drastic fluctuation of other physico-chemical parameters with no substantial increase in yield. Roy et al. (1990) reported that, in traditional deepwater rice-fish system in India, yield of fish in a season range between 50-200 $kg \cdot ha^{-1}$, while application of cowdung enhance the productivity of fish to 0.67 t ha^{-1}. However, in the present study, an average productivity of 906.6 - 1282.3 $kg \cdot ha^{-1}$ of fish and prawn has been achieved with application of cowdung @ 5000 $kg \cdot ha^{-1}$, which was much higher than the earlier recorded productivity in a season under rice-fish culture system in India.

This study will have a useful role in small-scale or commercial rice-fish culture and would help the aquaculturists in understanding the feeding habit of fish (fry to fingerling stage) and prawn (post-larvae to sub-adult stage) and thereby deciding the stocking density for optimum utilization of different food niches to get better output in terms of growth and yield.

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