Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(4): 2184-2188

Received: 16-05-2020
Accepted: 20-06-2020

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Effect of feeding on growth performance, survival and production of carp in net partition system in canal of Sundarbans, India

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Abstract
A study was conducted to investigate the effect of different feeding percentage on the growth performance and survival of stocked fishes in net partition system at Bharua canal of Sundarbans. The fingerlings of *Labeo catla*, *Labeo rohita* and *Ctenopharyngodon idella* were stocked in three net screen partition systems @2 nos. m-2 at the stocking ratio of 50: 40: 10 and fed with three feeding rate (% body weight) 0% (T1), 2% (T2) and 4% (T3) twice a day (10.00 hrs. and 16.00 hrs.) for 180 days. The result showed that the fishes in fed group (T2 & T3) achieved significantly (p<0.05) higher growth than the non fed treatment (T1). The minimum feeding rate of 2% body weight appeared to be optimal to support the satisfactory growth with low FCR and high feeding efficiency for the culture of Indian major carps and exotic carp in canal system of Sundarbans.

Keywords: Carp culture, growth, survival, net partition system, canal, Indian Sundarbans

Introduction
India has vast inland water resources in terms of river, canal, reservoirs and wetlands. Canals are the most important source of irrigation which has tremendous potential for the fish production. Naturally, fish enter to these canals from the source waters (sluice gate) and some fish species may form natural populations in the canals. In various countries such as Egypt, Sudan and Thailand this canal resources are effectively utilized for fish production [1]. The canals are able to support various levels of fish production. Despite having the vast resources in India, the canals received little attention which might be boost in Inland fish production by judicious utilization. Fisheries from canals are poorly documented. Information on trophic status of canal habitat, biotic community structure and hydrological parameters are also lacking. Indian Sundarbans has wide network of canals which are being used for irrigation and flood control purpose but culture of fishes in canals are not documented.

Pen culture technology was developed by ICAR-CIFRI for inland water bodies such as floodplain wetlands and reservoirs to augment the fish production. Pen culture is an economically viable technology for in-situ raising of stocking material and table size production. Rearing of Indian major carps fry to fingerling stage in pen and subsequent release to the wetland have shown better survivability and growth [2-9]. Pen system mostly used in reservoir and wetlands for seed raising but there is no record for the utilization of pen technology for canal.

Polyculture of Indian major carps such as catla (*Labeo catla*), rohu (*Labeo rohita*) mrigal (*Cirrhinus mrigala*) and exotic carps such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) are commonly practiced in semi-intensive system in India. The combination of this species effectively utilized the natural food in the system due to their different feeding habits. Addition of supplementary feed may effectively increased the fish growth and production along with natural food [10, 11]. Due to lack of knowledge about optimum feeding rate, the fish farmer apply high amount of feed with higher feeding rate which results in over feeding and feed loss in the system and eventually cause lower economic return and ecological imbalance. Supplementary feed is expensive and contributes major share in production cost and fish farmers cannot afford that. The present study was conducted to evaluate the effect of different feeding rate on growth, survival and production of catla, rohu and grass carp in net partition system in Bharua canal,

Materials and Methods

Study area

The present study was conducted in Bharua canal, which is located in Shibpur, Fraserganj area of Sundarbans (21°36'39.3"N 88°15'21.6"E). The canal is tidal fed connected with river Hooghly, water in the canal is subjected to slightly saline due to intake of water from the estuarine zone of river Hooghly. The canal is about 1.7 km in length and width ranged from 35-60 m. The canal water depth remain 8-10 feet (maximum) during rainy season and 3-5 feet during the winter. On the bank of the canal, human settlement was there which utilized the canal water for irrigation of agricultural crops, livestock rearing and capture fishing activities round the year. The canal was moderately infested with aquatic macrophytes such as *Eicchornia crassipes* and *Nelumbo nucifera*. The ichthyo-faunal diversity of the canal mainly contributed by small indigenous fish (SIF'S) like *Puntius sophore*, *Puntius ticto*, *Amblypharngyodon mola*, *Rasbora daniconius* and *Salmostomo bacaila*, *Mystus gulio* etc. Seasonal fish diversity was observed highest during monsoon season.

Fig 1: (A) Net partition system structure in Bharau canal, Sundarban and (B) google map showing experimental site

Experimental fish, acclimatization of fish and stocking

Healthy fingerlings of Indian major carps i.e. *L. catla*, *L. rohita* and exotic carp *C. idella* with average weight of 5.84±0.10g, 5.65±0.48g and 6.49±0.26g were obtained from fish seed supplier, Naihati, North 24 Parganas, Kolkata, West Bengal. Before stocking, fish were acclimatized in hapa for one week. Fish were stocked in net partition system @ 2 nos./m2 with the stocking ratio of 50: 40: 10 respectively.

Net partition system construction, experimental design and feeding rate

Three net partition systems were constructed in the selected canal with dimension of 50m × 45m (L × B) each; covering a total culture area of 2,250 m2. Net partition system is a kind of pen structure constructed from locally available HDPE net screen (8 mm mesh size), bamboo poles, and foot rope (12 mm diameter). The bamboo poles were fixed by driving them into the mud upto 1 foot deep at the distance of 1.5 m intervals. The lower portion of net screen was fixed in bottom mud with the help of wooden hooks attached to foot rope to prevent the escape of stocked fishes. The net screen then tied to the bamboo pole at three joints and made erected structure. The structure of net partition system constructed in the Bharua canal and experimental site are showed in figure 1. Three feeding rate (% body weight) were set as, 0% in partition-I (T1), 2% in partition-II (T2) and 4% in partition-III (T3). The fishes were fed with a commercial diet containing 28% crude protein and 5% crude lipid twice a day (10.00 hrs. and 16.00 hrs.). Feeding trial period was lasted for 180 days.

Environmental parameters

The environmental parameters were analysed by collecting water and soil samples from all net partitions system at monthly interval. Some of the water quality parameters were analysed on site such as water temperature was analysed by degree centigrade thermometer (range -10 to 50 °C), pH was measured by digital pH meter (HANA instrument), specific conductivity was measured with Digital conductivity meter (Multiline P4-82362) and transparency measured by using Secchi disc. Salinity, dissolved oxygen (DO), total alkalinity (TA) and total hardness (TH) was analysed by titrimetric method described in APHA [12]. The water samples collected from subsurface (0.5 m) depth were immediately transferred in to pre-rinsed polyethylene bottles (1.0L) and brought to the laboratory in cold condition for analysis of nutrients viz., nitrate (Nitr.), total nitrogen (TN), phosphate (Phos.), total phosphorous (TP), silicate (Sili.), Ca++ and Mg++ by following recommendations and methods described in APHA [12]. The sediment samples were collected from the depth of 30 cm and brought to the laboratory in cool condition. Collected samples dried in hot air oven, powdered and then sieved for further chemical analysis. Particle size was analysed by hydrometer method. Sediment pH was measured electrometrically with glass electrode pH meter in water using sediment/water ratio of 1:10. Specific conductivity calculated by conductivity meter. Organic carbon in the sample was determined by wet oxidation method of Walkley and Black [13]. Available nitrogen in the sample was determined by alkaline potassium permanganate method [14]. The available phosphorous in the sample was determined by Brays II method [15]. The free calcium carbonate was determined volumetrically with HCL soluble CaCO3 method. The Chlorophyll content was measured by spectrophotometric method given in APHA [12].

Sampling and data collection

Before stocking in culture system, 30 numbers of each species were randomly selected and individual weight (g) was recorded using digital weighing machine. Thereafter, growth performance data of stocked fishes was recorded at monthly interval. About 30 numbers of fishes of each species randomly selected from each partition system. The growth data was recorded by taking individual fish weight as before. The feed ration was calculated and adjusted on monthly interval as per the average growth of the fishes. After 180 days of culture period, all the fishes were harvested from three net partition systems and counted and weighted individually to determine the growth performance, survival and yield. The growth parameters such as weight gain (WG), Relative growth rate (RGR %), specific growth rates (SGR %), feed conversion ratio (FCR), feed efficiency ratio (FER), survival rate (SR %) were calculated by using the following formula.

$$WG\ (g) = Wf - Wi$$
$$RGR\ (\%) = (Wf - Wi)/Wi \times 100$$
$$SGR\ (\%/day) = (\ln Wf - \ln Wi)/t \times 100$$

Where, Wi and Wf are initial and final weights (g), respectively, and t is the time of the experiment (days).
FCR = Total feed given/ weight gain of fish
FER = Weight gain of fish/ total feed given
Survival Rate (%) = (Total number of fish harvested /Total number of fish stocked) x 100 Gross yield = Avg. final weight x total no. of survivors

Statistical analysis
Parameters in this study were analyzed using SPSS (version 24). Data are shown as means ± standard error. One-way analysis of variance (ANOVA), followed by Duncan's multiple range test was carried out. Differences were considered statistically significant at $P<0.05$.

Result and Discussion
Environmental parameters
The water quality parameters in the partition system were within the range for carp culture. The variations in physicochemical parameters of Bharua canal in different partitions are given in table 1 Water temperature ranged from 25.3 – 29.4 ^{0}C. Salinity variation was wide in Bharua canal which was ranges from 0.37 – 3.54 ppt and highest salinity was recorded during pre- monsoon season. The pH of surface water ranged from 7.27 – 8.5. Overall, the pH of the canal was alkaline. D.O. ranged from 4.4 – 6.5 ppm and favorable for good production of fish. Total alkalinity ranged from 64 – 140 ppm. So overall, the canal had a very good "buffering" capacity. Nutrient concentrations were also in favorable range in all the partitions throughout the seasons. Total Chlorophyll concentration was ranged between 0.383 – 5.211 mg/m3 with higher concentration was recorded during post monsoon season. Chlorophyll concentrations showed no significant difference among the treatments. All the water quality parameters recorded during the study period were within the acceptable range as recommended for fish culture [16].

Table 1: Physico-chemical parameters of Bharua canal

Parameters	Partition I	Partition II	Partition III
Water temperature (℃)	28.38 ± 0.46	27.15 ± 0.63	27.13 ± 0.67
Transparency (cm)	29.13 ± 7.36	26.33 ± 5.24	27.90 ± 5.44
Specific conductivity (m S/cm)	3.41 ± 1.43	4.70 ± 1.28	4.65 ± 1.24
pH	7.54 ± 0.15	7.75 ± 0.14	7.75 ± 0.13
DO (ppm)	5.65 ± 0.45	5.48 ± 0.34	5.63 ± 0.27
Total Alkalinity (ppm)	104.50 ± 14.79	91.00 ± 14.27	111.25 ± 16.63
Salinity (ppt)	1.77 ± 0.80	2.45 ± 0.71	2.60 ± 0.74
Total hardness (ppm)	430.50 ± 169.63	282.25 ± 135.01	295.50 ± 131.54
Total N (ppm)	0.17 ± 0.11	0.22 ± 0.16	0.29 ± 0.15
Nitrate (ppm)	0.009 ± 0.003	0.011 ± 0.005	0.010 ± 0.003
Total phosphate (ppm)	1.40 ± 0.67	1.57 ± 0.92	2.15 ± 0.55
Phosphate - P (ppm)	0.08 ± 0.02	0.10 ± 0.02	0.09 ± 0.03
Silicate (ppm)	4.99 ± 0.97	5.84 ± 0.70	6.20 ± 0.48
Sulphate (ppm)	35.76 ± 34.02	37.519 ± 35.83	75.37 ± 42.52
Ca+	30.80 ± 12.07	21.33 ± 8.95	21.81 ± 10.78
Mg++	88.29 ± 31.99	60.33 ± 26.00	62.97 ± 23.56
Chlorophyll a	1.35 ± 0.46	1.37 ± 0.47	1.63 ± 0.69
Chlorophyll b	0.976 ± 0.22	1.51 ± 0.40	1.45 ± 0.36
Chlorophyll c	1.08 ± 0.07	1.88 ± 0.33	2.11 ± 0.49
Total Chlorophyll	2.70 ± 1.02	3.33 ± 1.60	3.58 ± 1.48

The values are means ± standard errors

Canal sediment size fraction showed that major percentage of the sediment is contributed by silt (43.50 ± 1.76%) followed by sand (42.50 ± 0.87%) and clay (14.00 ± 2.61%). Organic carbon content in soil was low to medium (1.58 ± 0.07%); which means there is a less organic matter accumulation at the bottom. The soil pH of the canal was 7.08 ± 0.025. In this canal, an accumulation of available nitrogen and phosphorus were found in good quantity, especially available phosphorus (Table 2).

Table 2: Sediment quality of Bharua canal

Parameters	Bharua canal
Sand (%)	42.50 ± 0.87
Silt (%)	43.50 ± 1.76
Clay (%)	14.00 ± 2.61
pH	7.08 ± 0.025
Specific conductivity (ms/cm)	7.35 ± 0.29
Available nitrogen (mg/100g)	18.62 ± 0.74
Available P2O5 (mg/100g)	3.23 ± 0.47
Organic carbon (%)	1.58 ± 0.07
Free CaCO3 (%)	1.44 ± 0.16

The values are means ± standard errors

Effect of feeding rate on growth parameters and yield
Detail growth performances of stocked fishes in terms of final weight, weight gain, relative growth rate (RGR %), Specific growth rate (SGR), Survival and production are given in Table 1 The mean final weight of stocked fishes significantly varied among different treatments. The study showed that the fishes in fed group (T2 & T3) achieved significantly ($p<0.05$) higher growth than the non fed treatment (T1). It indicates the tested feeding rates influenced the growth and production of stocked fishes. Supplementary feed and feeding rate are the most important factors which influence the fish performance and promote growth and production [10, 11]. In present study, *L. catla* and *L. rohita* (except *C. idella*) achieved significantly higher growth performance in terms of mean final weight, mean weight gain, relative growth rate and specific growth rate in fed group with 4% body weight (T3) than other treatments, whereas lower growth observed in non feeding group (T1).
In present study the stocked fishes such as *L. catla* and *L. rohita* showed similar growth pattern in response to the increasing feeding rates as mean weight gain was increased with increasing feeding rate in fed groups (Fig. 1). Among all

the species included in the study the *L. catla* performed well in all treatments with significantly (p<0.05) highest mean weight gain reported in T3 (402.72 ± 11.58) whereas, lowest value recorded in T1 (210.60 ± 9.56). *L. rohita* ranked second in performance with significantly highest mean weight gain observed in T3 (282.29 ± 8.87) followed by T2 (209.67 ± 7.89) and lowest value in T1 (173.43 ± 8.04) respectively. The highest mean weight gain for *C. idella* was recorded in T2 (204.18 ± 10.73) however no significant difference observed in T1 and T3. It was observed that the mean weight gain was not influenced by feeding rate in *C. idella*. In present study the specific growth rate (SGR %) for *C. catla, L. rohita* and *C. idella* was ranged from 2.02 ± 0.03 to 2.36 ± 0.02; 1.88 ± 0.04 to 2.25 ± 0.09 and 1.75 ± 0.06 to 1.96 ± 0.06 respectively. In *L. catla* significantly higher SGR recorded in T3 followed by T2 and lowest value in T1. In *L. rohita* highest SGR recorded in T3 than the non significant T1 & T2. *C. idella* showed no significant difference for SGR among the treatments. The result showed that the specific growth rate was increased with increasing feeding rate percentage for L. catla was ranged from 72.35 to 74.81%, L. rohita was 75.32 to 79.34% and *C. idella* was 76.67 to 81.5% respectively. Among all the stocked species, survival of *L. catla* was comparatively low than the other two species. The result showed that different feeding rate has no clear effect on survival percentage of stocked fishes. Some workers reported the similar observation with the polyculture of Nile tilapia, common carp and silver carp with different feeding rates [11]. In present study, the value of feed conversion ratio (FCR) was 2.16 for 2% BW and 4.2 for 4% BW feeding rate. The value of Feed efficiency ratio (FER) at 2% and 4% BW feeding rate was 0.45 and 0.23 respectively. The feed conversion is directly proportional to the amount of feed used [18]. The FCR increases with increased in feeding rate and the feeding efficiency decreases [11]. The higher FCR value in 4% BW feeding rate indicated overfeeding with low feeding efficiency ratio whereas the fishes fed at 2% feeding rate showed optimum feeding level with higher FER value. In present study the highest production (kg/ha) was achieved in T3 (4% feeding rate) followed by T2 (2% feeding rate) and lowest yield obtained in T1 (0% feeding rate) (Table 3). The result suggests that the total yield (kg/ha) was increased in fed group fishes (T2 & T3) than the non fed group (T1). The supplementary feed has effectively contributed in the production of fishes as it caused increased in the yield by 39.68% and 69.63% in the treatments where the fishes were fed at 2% and 4% feeding rate respectively. The study suggested that the fishes reared with 2% feeding rate attended satisfactory growth with low FCR and high feeding efficiency compared to 4% feeding rate. In the present study it was observed that fish fed at 2% BW feeding rate consumed 59.95% less feed than the fish fed at 4% feeding rate. In fish culture practice, the feeding rate which gives maximum production does not always economical as the fish feed contributes upto 60% of total production cost. Therefore, the study suggested that the culture of Indian major carp and exotic carp in polyculture with 2% feeding rate in canal system may be a cost effective and beneficial to the fish farmers. Adoption of net partition system can provides an alternate livelihood to the fishermen community as the IMC has great demand in local markets in addition to the native fishes of the canal.

Table 3: Growth performance of stocked fishes in Net Partition system in canal

Parameters	Species	Partition – I (0% feeding)	Partition-II (2% feeding)	Partition-III (4% feeding)
Initial weight (g)	*L. catla*	5.72 ± 0.04	5.90 ± 0.31	5.90 ± 0.31
	L. rohita	6.13 ± 0.30	5.65 ± 0.45	5.17 ± 0.88
	C. idella	6.79 ± 0.36	6.27 ± 0.62	6.43 ± 1.21
Final weight (g)	*L. catla*	216.32 ± 9.56^{a}	317.74 ± 10.62^{b}	408.65 ± 11.83^{c}
	L. rohita	179.56 ± 7.93^{a}	215.33 ± 8.34^{b}	287.46 ± 9.44^{c}
	C. idella	157.33 ± 9.25^{a}	210.45 ± 10.60^{b}	175.36 ± 10.40^{a}
Weight gain (g)	*L. catla*	210.60 ± 9.56^{a}	311.84 ± 10.52^{b}	402.72 ± 11.58^{c}
	L. rohita	173.43 ± 8.04^{a}	209.67 ± 7.89^{b}	282.29 ± 8.87^{c}
	C. idella	150.55 ± 9.60^{a}	204.18 ± 10.73^{b}	168.93 ± 10.06^{a}
Relative growth rate (RGR %)	*L. catla*	3682.30 ± 171.36^{a}	5306.62 ± 266.69^{b}	6845.52 ± 229.64^{c}
	L. rohita	2845.76 ± 229.51^{a}	3733.38 ± 154.69^{ab}	5810.26 ± 1046.90^{b}
	C. idella	2243.90 ± 245.87^{c}	3324.88 ± 374.90^{c}	2835.40 ± 610.73^{c}
Specific growth rate (SGR)	*L. catla*	2.02 ± 0.03^{a}	2.22 ± 0.03^{b}	2.36 ± 0.02^{c}
	L. rohita	1.88 ± 0.04^{a}	2.03 ± 0.02^{a}	2.25 ± 0.09^{b}
	C. idella	1.75 ± 0.06^{a}	1.96 ± 0.06^{a}	1.86 ± 0.11^{a}
Survival %	*L. catla*	72.35	74.81	72.81
	L. rohita	75.32	78.24	79.34
	C. idella	79.71	76.67	81.5
FCR		-	2.16	4.2
Yield (kg/ha)	*L. catla*	1565.08	2377.01	2805.81
	L. rohita	1081.96	1347.79	1824.57
	C. idella	250.82	322.70	285.84
Total yield (Kg/ha)		2898	4048	4916

Acknowledgements

The study was financially supported by Indian Council of Agricultural Research (ICAR). The authors are thankful to the Director, ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India for guidance and support to conduct this study under the project. Exploration of Canal Resources of Punjab and Sundarbans (West Bengal) for Fisheries Development (REF/17-20/08). Contribution of field and technical staffs associated with project for analysis of physico-chemical parameters is duly acknowledged.

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