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Evaluation of three forms of feed on growth and survival of rohu *Labeo rohita* (Hamilton, 1822) juveniles reared in outdoor tanks

PRATAP CHANDRA DAS, GUNNUR MUDDALINGAIAH SIDDAIAH, PRABHATI KUMARI SAHOO, SNATASHREE MOHANTY, LINGARAJ MUDULI, BISHNU PRASAD DWARI, MITALI MADHUSMITA SAHOO[*] AND KRUTTIKA PANDIT[*]
ICAR-Central Institute of Freshwater Aquaculture, Kousalyaganga, Bhubaneswar - 751 002, Odisha, India
[*]College of Fisheries, Odisha University of Agriculture and Technology, Rangeilunda, Berhampur - 760 007, Odisha, India
e-mail: sddu@rediffmail.com

ABSTRACT

A feeding trial for 90 days duration was conducted to study the efficacy of three forms of feed (dough, sinking and floating feeds) on growth performance and survival of rohu *Labeo rohita* (Hammilton, 1822) juveniles. Four hundred and fifty fingerlings (average weight 8.7±0.7 g, average length 9.68±0.37 cm) were randomly distributed into nine large outdoor concrete tanks (50 m^2), grouped into three treatments with three replicates each. Three forms of diet designated as T_1 (dough feed), T_2 (sinking pellets) and T_3 (floating pellets), prepared from the same quantity of ingredients, were fed at 8% of biomass twice a day. The results revealed significantly higher weight gain, specific growth rate (SGR) and lower feed conversion ratio (FCR) in sinking pellet fed group ($p<0.05$). Further, the biomass yield was also higher in T_2 despite lower juvenile survival as compared to the other groups. However, there was no significant difference in growth performance of juveniles between T_1 and T_3 groups ($p>0.05$). Though rohu is known to feed from column to bottom zones, the present results revealed better efficacy of sinking pellet over dough or floating form to improve the growth performance of the species during juvenile rearing.

Keywords: Condition factor, Feed form, Growth, *Labeo rohita*, Water quality, Yield

Introduction

Feed is a vital farming input that accounts 40-60% of total production costs (De Silva and Hasan, 2007). The economic performance of a production system greatly depends on types of feed used. Generally, Indian major carps (IMCs) are grown under the provision of fertilisation and farm-made feeds comprising mostly oilcake and rice bran as the main ingredient sources (Ramakrishna *et al.,* 2012; Sarder, 2013). But in recent years, there has been paradigm shift in the farming practices, oriented towards intensification, due to competition for land and water resources. Such a move necessitates the adoption of nutritionally balanced feeds which is increasing the demand for both farm-made and commercially produced sinking feeds (De Silva and Hasan, 2007; Rana *et al.,* 2009). There has been shrinkage in use of traditional mash feed and fish farmers now a days are more inclined towards commercially available pellet feed realising the economic return. Further, farmers are influenced by commercial feed manufacturers to use the extruded floating feed without assessing the need and economics of their use. Though floating pellets are being widely used in culture of catfishes because of good palatability, digestibility and subsequent higher growth, the high market price of extruded floating pellets limits their use in the culture of carps in India.

Freshwater aquaculture in India witnessed an exceptional increase in production in the last few decades with quality production of the three IMCs such as catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*). Among these IMCs, rohu is the most pursued and intensively cultured species (Jhingran and Pullin, 1985) and contributes the most to aquaculture production. The fry stage of rohu predominantly filters plankton from the surface. But in the fingerling stage, it switches over to feeding at the water column and bottom, mainly on filamentous algae and decomposed vegetation (Chondar, 1999). Feed type, forms and diet shape profoundly influences feeding behaviour with respect to capture and rejection. The form of feed is also an important factor and should suit to the feeding behaviour for its greater acceptance. Though floating pellets outperform sinking and dough feed in several species in terms of growth performance, there is little information available with regard to the relative preference of rohu *L. rohita* to the different forms during its juvenile stage. The present attempt aimed to study this aspect where growth performance was assessed in rohu grown with the three different forms of feed, *i.e.* dough, sinking and floating pellet, during juvenile rearing.

Materials and methods

Experimental design

The study was carried out for 90 days in a set of nine large concrete tanks (10 m x 5 m x 1 m) in the carp culture unit of ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar, India. Each tank was stocked with 50 fingerlings of rohu (8.7±0.7 g; 9.68±0.37 cm) after due acclimatisation for a week. There were three treatments designated as T_1 (dough feed), T_2 (sinking feed) and T_3 (floating feed) in triplicates. Water level was maintained up to 75 cm throughout the experiment. Apart from the periodic water replenishment to maintain optimum water depth, water exchange up to 10-12% level was given in the tanks four times at 15 days intervals in the last two months (30th, 45th, 60th and 75th day) to provide suitable growing environment.

Preparation of experimental feed

Iso-nitrogenous (CP 28%) feeds in three forms namely dough, sinking and floating pellets were prepared from locally available ingredients in the ICAR-CIFA feed mill and details are given in Table 1. The dried ingredients were milled into fine particles using the two stage grinder, weighed and mixed in the required proportion according to feed formulae. The mixture was then blended with sufficient water. Pellets were produced by extruding this dough through a pelletiser and subsequently dried for 24 h to minimise fungal attack.

Table 1. Composition of ingredients of the different forms of feed

Ingredients	Proportion in feed (g kg^{-1})
Maize	400
Soybean	340
Ground nut oil cake	50
Fishmeal	50
De-oiled rice bran	148
Vegetable oil	10
Vitamin-mineral mix	2

Composition of vitamin-mineral mix (value per kg):
Vit A - 7,00,000 IU; Vit D3 - 70,000 IU; Vit E - 250 mg; Cobalt - 150 mg; Copper - 1200 mg; Iodine - 325 mg; Iron - 1500 mg; Magnesium - 6000 mg; Potassium - 100 mg; Sodium - 5.9 mg; Manganese - 1500 mg; Sulphur - 0.72%, Zinc - 9600 mg; DL-methionine - 1000 mg.

Proximate composition of diet

Proximate composition of the diets was determined following the standard methods of AOAC (1995) and given in Table 2. The moisture content was determined by drying at 105^{o}C to a constant weight. Nitrogen content estimated by Kjeltec Auto distillation and crude protein (CP) by multiplying nitrogen percentage by 6.25. Ether extract (EE) was measured by Soxtec system using diethyl ether (boiling point, 40-60^{o}C) as a solvent. Ash content was determined by incinerating samples in a muffle furnace at 540^{o}C for 6 h. Nitrogen free extract (NFE) was calculated as total carbohydrate = 100 - (Moisture+CP+EE+Ash) and expressed as g kg^{-1}.

Supplementary feeding

The daily feed ration in the tanks was determined based on the level of acceptance of floating feed in T_3. Feeding in these tanks was provided as per demand for 2 h and total quantity consumed was determined. Based on the dry matter contents of the consumed floating feed, the quantity of dough and sinking feed in T_1 and T_2 were corrected as per their moisture contents and fed in the respective tanks. The daily ration was adjusted in the meals of next 3 to 4 days after each sampling and the same feed quantity was continued till next sampling. The calculated daily ration was provided in two meals at 9.30 and 16.30 hrs.

Sampling

Water sampling in the tanks was carried out between 08.00 and 09.00 hrs at 15 days intervals and analysed in the laboratory. The parameters studied included dissolved oxygen (DO) (Winkler, 1888), pH (Elico pH meter), total alkalinity and total hardness using standard procedures as per APHA (2005); while the nutrients such as total ammonium nitrogen (TAN), nitrite-N, nitrate-N and phosphate phosphorous were studied using a spectrophotometer (Varian 50 Bio UV-visible spectrophotometer). In addition, transparency level in each tank was recorded using Secchi disc, while volumetric analysis of plankton was done by filtering 50 l of tank water through a plankton net of 125 µm mesh size bolting silk followed by centrifugation.

Table 2. Chemical composition of different forms of feed

Proximate composition	Forms of feed		
	T_1 (Dough feed)	T_2 (Sinking feed)	T_3 (Floating feed)
Dry matter (%)	90	91.3	91.5
Crude protein (%)	28.18±1.2	28.2±0.82	27.92±0.46
Ether extract (%)	4.02±0.1	3.91±0.14	4.28±0.11
Ash (%)	9.8±0.04	7.76±0.1	8.29±0.08
NFE (%)	48±1.6	51.43±0.9	51.01±0.81

NFE: Nitrogen Free Extract

Growth study

A total number of 25 juveniles were randomly sampled from each tank at every 30 days intervals. The length and weight of each fish was recorded. Growth performance of fingerling was evaluated in terms of weight gain, survival, specific growth rate (SGR) and feed conversion ratio (FCR) as per the following formulae:

Weight gain = Mean final weight - Mean initial weight

SGR (%) = ($\log_e$ Average final weight - $\log_e$ Average initial weight/ Number of culture days) x 100

FCR = Total feed given (dry weight) (g) / Body weight gain (Wet weight) (g)

Condition factor (K) = (W / L^3) x 100

where, W = Final weight of fish (g), L = Final length of fish (cm)

Statistical analysis

Data was analysed by one-way analysis of variance (ANOVA) and the significant difference between the treatments was determined by Duncan's Multiple Range Test (DMRT) using SPSS (Version16). The level of significance employed was 0.05.

Results

Water quality

The various water quality parameters recorded in the experimental tanks during the course of the study are presented in Figs. 1 and 2. There was a gradual increase in the pH of water in all treatments in contrast to the gradual decrease in dissolved oxygen (DO) level with progress of culture. Both alkalinity and hardness followed similar trend of initial reduction followed by increase from the day 45 onwards. However, no marked difference in these parameters was observed among the treatments at any point of sampling. Although the transparency level continuously decreased in all with progress of culture and indicated plankton build up, volumetric study of plankton showed fluctuation in density (0.1-0.7 ml l^{-1}) as depicted in Fig. 1. Nutrients such as TAN and nitrate showed slight reduction during the 1st month and thereafter stabilised, whereas, nitrite and phosphate levels had no marked change in the tanks (Fig. 2). Marked difference in the level of any of the parameter could not be observed among the treatments.

Growth performance

Marked differentiation in growth (both length and weight gain) was observed from the growth curves of the juveniles after 45 days of feeding with the different forms of feed (Fig. 3), where sinking pellet had an edge followed by those fed dough and floating form. Juveniles fed T_1 (dough) and floating pellets (T_3) showed higher survival (92.0-96.7%) compared to fish fed the sinking pellets (T_2) (73.3%). Juveniles in T_2 showed the highest weight gain, SGR and lowest FCR followed by dough (T_1) and floating pellets (T_3) (Table 2). But, no statistically significant difference in these attributes were seen between T_1 and T_3 ($p>0.05$). Despite significant lower survival in T_2, the yield (g m^{-3}) in all treatments were similar ($p>0.05$) irrespective of the forms of feed (Table 3). However, T_2 showed comparatively higher yield followed by T_3 and T_1. The condition factor (K) of fish ranged from 1.0 to 1.15 (Table 3) and there was no significant difference among the treatments.

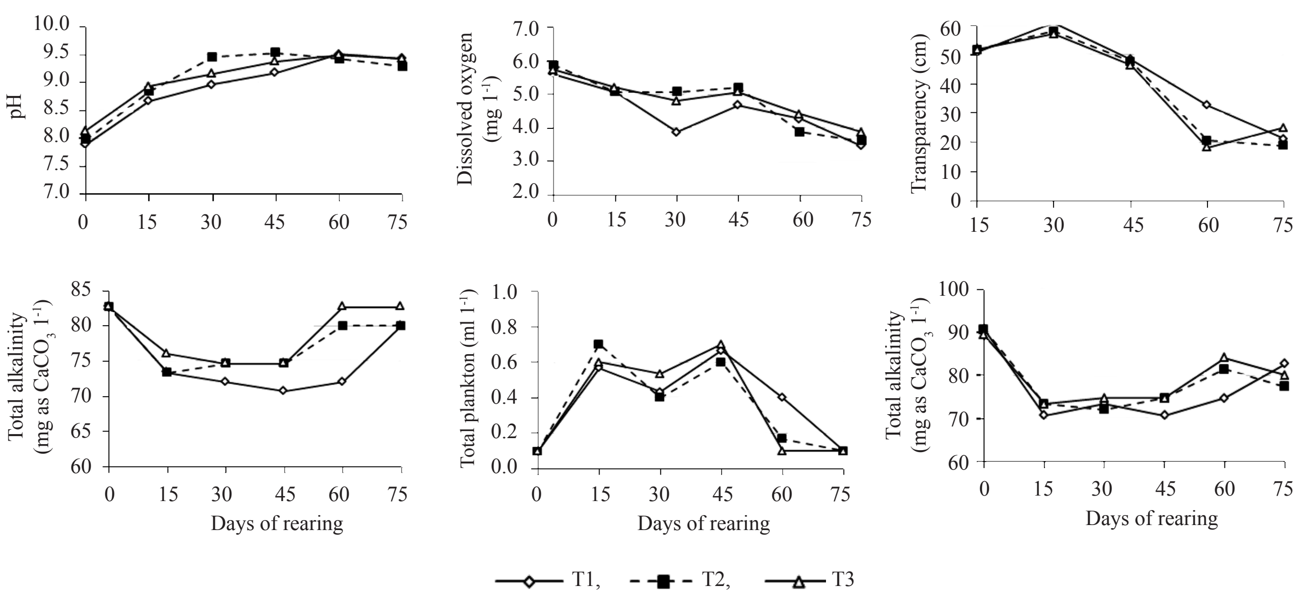

Fig. 1. Water quality parameters of the experimental tanks during evaluation of different forms of supplementary feeds (n=3). (T_1- Dough feed; T_2- Sinking pellet; T_3-Floating pellet)

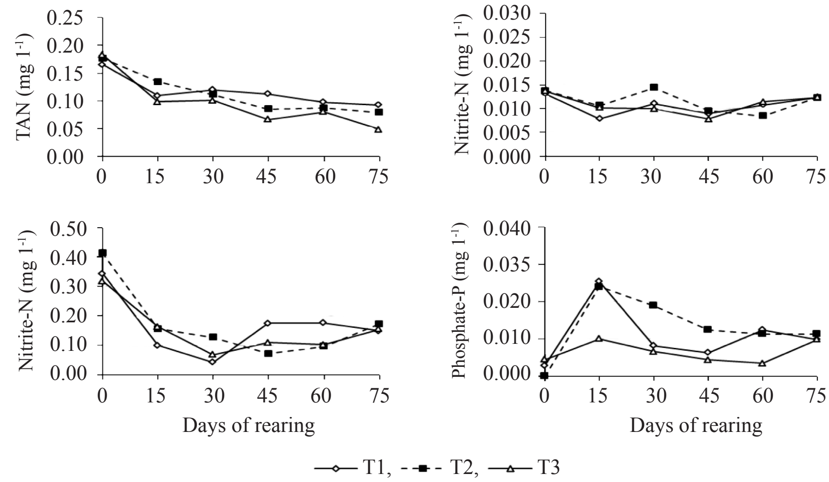

Fig. 2. Different nutrients in water of the experimental tanks during evaluation of different forms of supplementary feeds (n=3). (T_1- Dough feed; T_2- Sinking pellet; T_3-Floating pellet)

Table 3. Growth and yield attributes of *L. rohita* juveniles fed different forms of feed during experimental rearing in concrete tanks

Attributes	T_1 (Dough feed)	T_2 (Sinking feed)	T_3 (Floating feed)
Mean initial weight (g)	8.7	8.7	8.7
Mean final weight (g)	58.85±0.9^{b}	81.08±2.62^{a}	57.53±2.57^{b}
Weight gain (g)	50.15±0.91^{b}	72.38±2.62^{a}	48.83±2.57^{b}
Feed intake (g)	58.96	58.54	54.48
FCR	1.17±0.02^{a}	0.81±0.03^{b}	1.12±0.06^{a}
SGR (%)	2.12±0.02^{b}	2.48±0.04^{a}	2.09±0.05^{b}
Condition factor (K)	1.15±0.04^{a}	1.14±0.01^{a}	1.00±0.15^{a}
Survival (%)	92.0±6.0^{a}	73.3±7.6^{b}	96.7±1.2^{a}
Gross yield (kg tank^{-1})	2.70±0.22^{a}	2.97±0.37^{a}	2.78±0.23^{a}
Yield (g m^{-3} water)	47.11±3.83^{a}	51.75±6.46^{a}	48.38±4.15^{a}

Data expressed as: Mean±SE of 3 concrete tanks (n=3). Values within the same row with different superscripts signify statistical differences ($p<0.05$). FCR: Feed conversion ratio; SGR: Specific growth rate

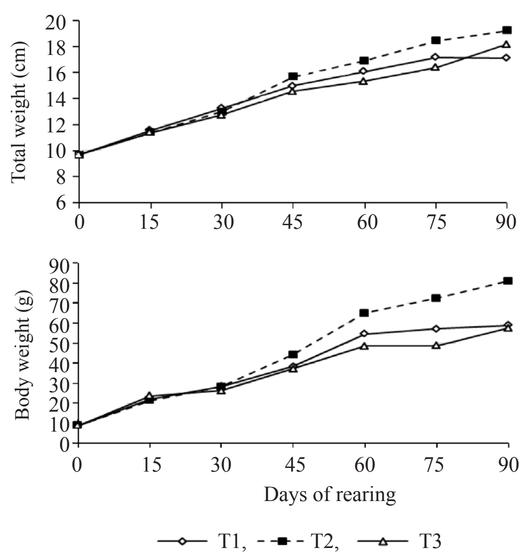

Fig. 3. Growth pattern of *L. rohita* juveniles fed different forms of feed during experimental rearing in concrete tanks. (T_1- Dough feed; T_2- Sinking pellet; T_3-Floating pellet)

Discussion

Use of inputs in the form of feed and fertilisers in concrete tank system leads to gradual build-up of organic matter and its decomposition further causes reduction of pH and increase in alkalinity and hardness (Avnimelech, 1999; Das *et al.,* 2005). In the present study, while the alkalinity and hardness levels in the tanks followed suit, pH increased during the 1st month and further stabilised between 9.0-9.5. Greater photosynthetic activity during the initial month, as indicated from the observed rise in plankton density (Fig. 1) and triggered by pre-stocking fertilisation, helped in a higher DO regime (4.0-6.0 mg l^{-1}) in tanks. Respiratory demand was also low during this phase because of low biomass. Consequently, such higher DO might have supported faster mineralisation and nutrient recycling (Das *et al.,* 2005), leading to increase and further maintenance of water pH at higher level. Whereas, in the 2nd phase, continued mineralisation of accumulated waste led to reduction of DO level in water (Avnimelech and Ritvo, 2003; Hargreaves and Tucker, 2004). An increased accumulation of organic matter and further mineralisation was expected to increase the nutrient levels in the tanks. In contrast, there was reduction in these parameters in the 1st month indicating good nutrient recycling and utilisation process, as also implicated from marked increase in plankton density during this period. The subsequent narrow range of fluctuation in water quality parameters in all treatments may be attributed to the routine water exchange followed in the tanks apart from the efficient nutrient recycling process. Notably, the total ammonia nitrogen (TAN) and nitrite-N values were comparatively low in floating form and high in dough fed group, obviously due to the high water stability and slow nutrient leaching from the former.

The process used to produce fish feed pellets may have direct impact on physicochemical properties, which can affect pellet durability, water stability and water quality (Hilton *et al.,* 1981; Misra *et al.,* 2002). In the present study, the water quality parameters that prevailed in the tanks, irrespective of the forms of feed, were within the tolerance levels of the carps as reported in other studies (Jhingran, 1991; Aravindakshan *et al.,* 1997; Jena *et al.,* 1998; Jena *et al.,* 2007; Pawar *et al.,* 2009). This suggested that with the water quality management and water exchange protocol followed in the present study, the three forms of feed did not have any significant influence on the water quality.

Limbu (2015) reported comparatively better growth performance of *Clarias garipeneus* fed floating feed than sinking form, but there was no significant difference. Yaqoob (2010) found better performance of carps (catla, rohu, mrigal and silver carp) grown in polyculture system using floating pellet than sinking pellet except grass carp which performed better on sinking feed. In contrast, the present study revealed higher weight gain and SGR in rohu juveniles fed sinking pellet than the group that received floating and dough forms. Such higher weight gain with sinking diet might be attributed to better feed acceptance as sinking form suits to the column-bottom feeding habit of rohu (Chondar 1999), thereby facilitating easy access to feed and less energy spent on feeding. The energy which otherwise would have required to capture floating feed, perhaps got diverted for tissue growth resulting in such higher growth of juveniles. Moreover, low survival in T_2 group attributed less competition for space which might have resulted in sufficient feed availability for individual and consequently higher growth.

Condition factor is a physiological indicator of overall health and wellbeing of an animal. In the present study, the K value varied between 1.0 and 1.15 which indicated a good rearing environment in all tanks. Mahmood *et al.* (2019) observed condition factors of pond reared rohu in the range between 0.96 and 1.89. In captivity, yield is determined by growth rate of the cultured fish (Mridh, 2014), survival rate (Al-Hafedh, 2004), ability to utilise nutrients (Aderolu, 2010) and the state of water quality parameters in the culture system (Ibrahim, 2010). Variation in these parameters significantly affects fish yield production from an aquaculture system (Cao Quoc, 2012). In this study, harvested length and weight were similar in dough and floating forms and both were significantly lower than that in T_2. As a result, the biomass yield and water productivity in T_2 were higher than the other two treatments despite significantly lower survival in the former. The results while suggested that use of dough or floating feed favoured survival of the juveniles, the sinking form of feed helped in improved growth and yield at this stage of life which is attributed to easy access to feed. Improved growth in T_2 also might have resulted from the presence of lesser individuals in the treatment due to lower survival. Nevertheless, yield is the ultimate outcome of fish production and it was higher in T_2, based on which it can be concluded that provision of sinking pellet is the better form of supplementary feed for rearing juveniles of rohu, *L. rohita* compared to the floating and dough forms.

Results of the present study indicate the existence of species and life stage specific preferences on feed form (sinking *vs* floating *vs* dough). Despite lower survival, sinking pellet fed group performed well with respect to condition factor, yield and growth. However, impact of the different forms of feed on nutrient budget especially on nitrogen and phosphorous cycle needs to be studied on long term basis.

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