Development and Testing of Demand Feeder for Carp Feeding in Outdoor Culture Systems

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ABSTRACT

The demand fish feeder, which was made-up of Fibre Reinforced Plastic (FRP) material was designed with an angle of repose 50^o and tested in outdoor conditions. It was fabricated with general-purpose tools at a cost of Rs. 3,100 (US $ 69) in 2007. It was maintenance free and easy to operate. It was tested in cisterns of 10m^3 capacity at the CIFA farm, Bhubaneswar for a period of 110 days to evaluate its efficiency against that of hand feeding the fish. Fish fed by the demand feeder gained an average of 12.61% more weight than hand-fed fish. During the experiment, the total of 25.86 and 30.58 kg of pelleted feed were used to produce 7.15 and 6.25 kg of fish in the demand and hand-fed cisterns, respectfully. The hopper can hold 10 kg of feed, which can be fed to 500 kg of fish in a day, if provided @ 2% of their body weight. The total cost saved from feed efficiency and man-hour labour reduction was calculated to be Rs 1012/- in this present study. Details of design and fabrication of the feeder are discussed in this paper.

Key words: FRP, Demand feeder, Carp, Feeding, Pond

1. INTRODUCTION

Aquaculture contributed 45 per cent of the country's total fish production of 6.98 million tonnes in 2006. Indian aquaculture has demonstrated a six and a half fold growth over the last two decades, and freshwater aquaculture was contributing over 95 per cent of the total aquaculture production. The three Indian major carp, namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) contribute the bulk of production of over 3.02 million tonnes (FAO, 2006); followed by silver carp, grass carp and common carp forming a second important group. Average national production from ponds has increased from 0.6

tonnes/ha/year in 1974 to 2.2 tonnes/ha/year at present, and several farmers are even demonstrating production levels as high as 8–12 tonnes/ha/year. The technologies of induced carp breeding, and polyculture in ponds and tanks are virtually revolutionizing the freshwater aquaculture sector and turning it into a fast growing industry. In addition, the sector has been witnessing increased interest in diversification with the inclusion of high-valued species, including medium and minor carp, catfish, murrels, etc. Per capita fish consumption in the country has reached to 8 kg per year as against the required level of 11 kg. The continuous supply of fish for consumption to the ever-increasing population can only be achieved through vertical and horizontal expansion of existing aquaculture practices in the country.

One of the major components of scientific fish culture is the providing of artificial feeds to the fish according to their requirement, which helps in reducing the feed loss and in maintaining a suitable culture environment. One of the most important challenges for engineers is the designing of proper feeding devices for fish farm use. Several authors have reported different types of automatic fish feeding devices (Baldwin 1983; Charlton and Bergot, 1986; Parker 1989; Mohapatra et al., 2003) and different kinds of demand feeders (Statler, 1982; Meriwether, 1986; Alexander et al., 1993; Alanara, 1996; Mohapatra et al., 2003; Rubio et al., 2004). Many of the existing feeders operate successfully with pelleted or powdered feed (Parker, 1989), but, these have not been tested for carp feeding in Indian conditions. In most of the automatic feeders, it is difficult to adjust the exact time and amount of feed to be delivered to fish, as well to document the real feed demands and appetite of the fish. Automatic feeding leads to over feeding, waste of food and pollution of pond water. From these points of view, the self–demand feeders appear to be preferable and fish themselves decide when and what amount of feed they consume. Because of some good qualities such as easy construction, low cost and low maintenance requirements, demand feeders will be more useful in the aquaculture sector.

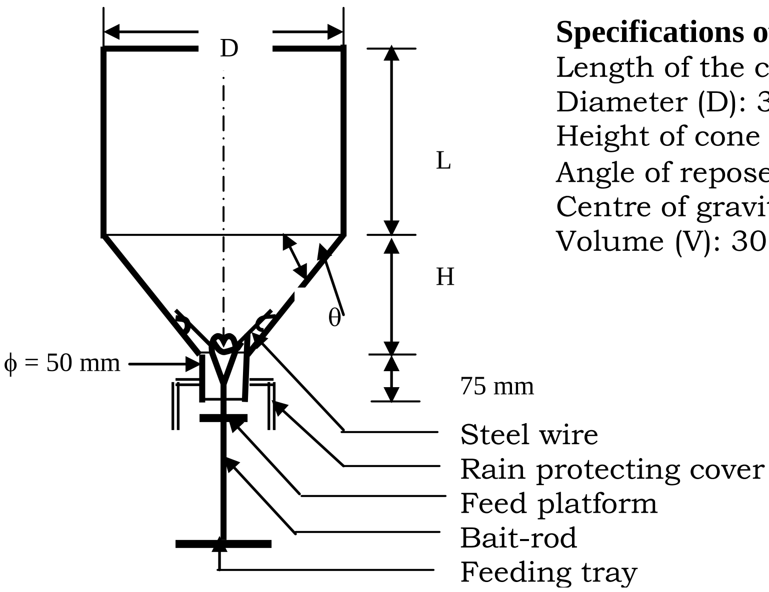
In the present study the objectives were:

- To design and fabricate a demand feeder suitable for delivering pelleted feed to Indian major carp in the aquaculture system,
- To test its efficiency and usefulness for delivering pelleted feed in field conditions, and

- To estimate the gain in fish production by use of this gadget over traditional methods of feeding.

2. MATERIALS AND METHODS

The demand feeder was designed with an angle of repose 50^{o} and fabricated with FRP material for pelleted feed for outdoor culture systems used to feed the fish. The angle of repose/ angle of inclination plays an important role in designing any feeding devices for aquaculture purposes. In demand feeding systems, feed drops by gravitational force, which is directly related to the angle of repose. Before designing the feed hopper, the angle of repose was calculated to be 41^{o} for pelleted feed with size specifications of (Specific weight: 0.49 g/cc; feed diameter: 2.5 ± 0.16 mm and avg. length 8.7 ±1.19 mm) at normal room temperature. In the present design, we have taken the angle of repose as 50^{o}, which was slightly higher than the actual required angle of repose (41^{o}) of that particular material for effective and free flow of feed material (Fig.1).



Specifications of feed hopper
Length of the cylinder (L): 285 mm
Diameter (D): 330 mm
Height of cone (H): 200 mm
Angle of repose/ inclination (θ): 50^{o}
Centre of gravity: 342.5 mm from base
Volume (V): 30 l

Fig.1. Schematic diagram of FRP demand feeder hopper

The main components of the feeder were a 30 L capacity feed hopper, an activating mechanism and a hopper holding stand (Fig. 2).

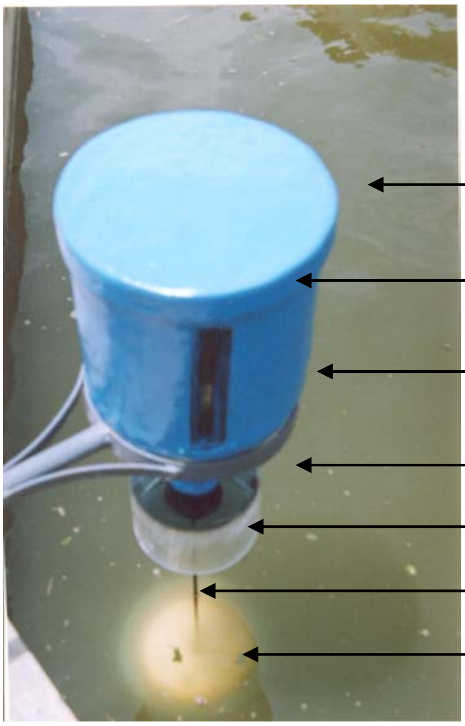


Fig.2. View of the demand feeder in the rearing tank

In 2007, the fabrication cost of a feeder was about Rs. 3,100 or US $ 69 (Table 1). The tools and construction skills required were available in the CIFA workshop. The FRP feed hopper was fabricated from a wooden mould by hand–lay-up process. A short threaded piece of Rigid PVC (SCH-80) of 50 mm diameter and 50 mm length was joined at the end of the conical bottom of the hopper. The joint was reinforced with glassfibre. A rain protecting cover of 200 mm diameter and 150 mm length was fabricated from acrylic (PMMA) tube, where one end was covered with a 5 mm thick acrylic sheet in a 50 mm diameter hole at the centre of the sheet. The rain protecting cover was fixed to the threaded portion of the conical bottom with two threaded PVC sockets (ϕ50×20 mm). For holding the bait-rod, two pieces of

MS angle-iron (L shaped with 5 mm diameter holes) were riveted to the body at a distance of 380 mm from the top of the hopper.

Table 1: List of materials required for fabrication of one FRP demand fish feeder
(Cost during April 2007)

Sl. No.	Description	Qty	Unit Cost (Rs.)	Total cost (Rs.)
1	FRP feed hopper (30 l)	01	1250	1250
2	FRP hopper lid	01	475	475
3	Acrylic pipe: ϕ200 × 150 mm length	01	250	250
4	Acrylic sheet: ϕ200× 5 mm thick	01	75	75
5	Steel wire (Clutch wire)	01	11	11
6	Jam nut	01	4	4
7	RPVC Socket: ϕ50 × 15 mm	02	6	12
8	RPVC Nipple: ϕ50 × 75 mm	01	9	9
9	Bait rod: ϕ3 mm	01 m	40	40
10	Nut & Bolt: M 6 × 100	01	25	25
11	Nut & Bolt: M 6 × 50	01	20	20
12	Feed disc: ϕ100 × 5 mm thick	01	8	8
13	MS pipe: ϕ 25 mm (M)	01m	120	120
14	MS pipe: ϕ 32 mm (M)	01 m	155	155
15	MS flat	01m	45	45
16	Cement concrete	0.2 m^3	1800	360
17	Miscellaneous (Paints, GI wire, PP ropes, etc.)	L.S	-	241
	Total	-	-	3100

(Rs 3,100 or US $ 69 based on Indian rupee in 2007)

Steel clutch wire along with the bait rod was fixed between the two clamps and at the other end of the wire, a draw nut was fitted to adjust the length of wire. The bait rod (ϕ 5 × 600 mm) was cut at a distance of 400 mm from the bottom, and a threaded bolt of M 6 × 100 mm was welded to it to hold the feed platform. At the other end (bottom) of the bait-rod, another bolt of M 6 × 50 mm was welded to hold the pendulum/ tray. The feeder was placed on the top of a cantilever MS pipe (ϕ25 mm) ring with the activating mechanism extending into the water (Fig. 2) projected towards the cistern. The length of activating rod in the water was kept at 450-600 mm. Feed dropped by gravity on to the adjustable acrylic feed platform (ϕ 80 × 5 mm) positioned below the hopper and above the water level on a free-swinging activator rod. When fish activated the rod, feed pellets were retained on the feed platform and slowly dropped on the water surface. The gap (distance) between the feed platform and the end of the hopper cone was adjusted as per the size of the pelleted feed.

The feeder was placed over a cantilever stand fixed at the corner of the cemented cistern of capacity $10 m^3$ for feeding the Indian major carp, *Labeo rohita* reared in it. The demand feeding experiment was conducted in triplicate. At the same time three similar cisterns were used as controls, where the fish were hand-fed in the experiment and control, the fish stocking density was 6 fish/m^3. The average initial stocking size of rohu was 31 g. The duration of the experiment was from 29^{th} April to 17^{th} August 2007. Normal fish rearing practices were followed and the fish were fed daily with pelleted feed (crude protein 26.6%, ether extract 7.8%, crude fibre 6.2% and ash 10.5%) @ 2-3% of their body weight. Every day 10-15% of water was replaced in the cisterns from a near-by canal. The water quality parameters such as dissolved oxygen, carbon dioxide, total alkalinity, pH, ammonia, nitrite, nitrate and phosphate were analyzed every fortnight by standard laboratory procedures (APHA 1998). Growth of fish was estimated by sampling fish from each cistern every fortnight. Based on the growth of fish, the feed quantity was determined and supplied to the rearing cisterns through feeders or by conventional means. The feed conversion ratio (FCR) was calculated using Eq. (1).

$$FCR = \frac{Feed\ consumed\ by\ fish\ in\ gram}{Weight\ gain\ by\ fish\ in\ gram} \qquad \ldots(1)$$

In the hand fed method, the feed was provided to fish once daily in the morning. In the case of demand feeding, the feeders were loaded once in a week with a predetermined quantity of feed for continuous delivery to the fish.

3. RESULTS AND DISCUSSION

In 110 days of rearing, rohu grew to150 g (net growth 119 g) and 135 g (net growth 104 g) in demand and hand-fed cisterns, respectively. The growth rates of fish were 12.61% higher in the demand feeding cisterns with feeders than for the control. The efficiency of demand feeding as based on the FCR is the major factor, which was found significantly (at the 5%

level) superior than the control. Feed conversion ratios differed among the cisterns, but the average FCR was found superior in the demand-fed system (Table 2).

Table 2. Weight gain of *Labeo rohita* and feed conversion ratios in demand-fed and hand-fed (control) control cisterns

Treatment	Initial weight (g)	Total weight gain (g)	Feed conversion ratio (FCR)
Hand fed	31 ± 1.19	135 ± 1.79g	4.90 ± 0.1
Demand fed	31 ± 1.11	150 ± 1.07g	3.62 ± 0.02

The observation showed that in hand-fed cisterns more feed was required (4.9 kg) than the demand-fed cistern (3.62 kg) to produce one kilogram of fish. During 110 days of experiment, the totals of 25.86 and 30.58 kg pelleted feed were used to produce 7.15 and 6.25 kg of fish in demand- and hand-fed cisterns respectfully. The cost was calculated approximately Rs 11/= per kg of feed in 2007. By using demand feeding, 4.72 kg feed worth of Rs 51.90 (say Rs 52/=) was saved during the experiment. The feeders were loaded with feed once in a week. During 110 days of experiment, 94 days did not require the feeders to be loaded. Considering a saving of half an hour every day for feed loading, the total number of man-hours saved was 47. The cost saved from man-hours calculated @ Rs 20/- per hour was Rs 960/-. Total cost saving from feed and labor was Rs 1012/-. It is known that the FRP products exposed to outdoor conditions can last up to ten years (Mohapatra et al., 2004). Thus, the depreciation value of the feeder for four months was calculated to be Rs 103/- only, which was less than the cost saved from feed and labor during the experiment. It justified the fact that the use of a demand feeder in a rearing system is beneficial and economical to the users.

The hopper of the presently designed feeder can hold 10 kg of feed, and if fed @ 2% of the body weight of fish per day, it can be used for feeding 500 kg of fish in the rearing system. In the hand-fed system, if 10 kg feed is to be used for fish, it will be difficult to know the quantity of feed that has gone to waste in the rearing medium. In the demand feeder system once 10 kg feed is loaded for feeding the fish, at the end of the day, the rest of the feed will remain in the feed hopper and can be used the next day. This will avoid organic pollution in the rearing system caused by the delivering of excess feed into the water. This can also provide an indication to the culturist regarding the feed demand of fish. The present study indicated that the demand feeders will increase feed consumption in fish by making it available to them continuously.

The water quality did not differ significantly between the demand- and hand-fed rearing cisterns (Table 3). This might have been due to the daily replacement of 10-15% of the water in the cisterns with freshwater drawn from a near by canal. The specifications of water quality standards for the protection of cyprinid fish are: DO (100% of samples ≥5.0 mg/l); pH (6.0-9.0); nitrites (≤0.03 mg/l NO_2) and non-ionized ammonia (≤1.0 mg/l NH_3) (EEC, 1978). In the present study none of the water quality parameters exceeded these limits.

Table 3. Water quality parameters in demand and hand-fed rearing cisterns during experimentation

Water parameter	Source water (canal)	Demand-fed cistern	Hand-fed cistern (control)
D.O. (mg/l)	4.4±0.5	3.8±0.8	3.6±0.6
pH	7.4±0.2	7.1±0.3	6.9±0.5
Free CO_2 (mg/l)	8.0±1.5	10.0±2.0	12.0±2.2
Total alkalinity (mg/l)	140±5.5	136±8.0	130±14.0
P_2O_5 (mg/l)	0.05±0.01	1.09±0.4	1.32±0.8
NH_4-N (mg/l)	0.06±0.02	0.21±0.06	0.33±0.06
NO_3-N (mg/l)	0.02±0.05	0.15±0.06	0.19±0.04
NO_2-N (mg/l)	Trace	0.003±0.001	0.005±0.001

4. SUMMERY AND CONCLUSION

The demand feeder designed was found suitable for feed delivery to Indian major carp in outdoor culture systems. The feed conversion ratio (FCR) was superior in the demand-fed system. Its use can save substantially on the cost of feed and of man-hours used for feeding. The feeder designed can hold 10 kg feed, which can be fed to 500 kg fish if fed @ 2% of their body weight per day.

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