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Feed utilization and wastage in semi-intensive pond culture of mahseer, *Tor putitora* (Ham.)

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Abstract

Mahseer, *Tor putitora* with 12.75, 12.11, and 12.02g of initial weight were found to attain a net weight gain of 12.0 kg, 11.5 kg, and 11.4 kg respectively in pond-1 (commercial feed), pond-2 (farm-made feed), and pond-3 (farm-made feed), respectively against 78.2 kg, 70.3 kg, and 68.1 kg feed fed. Gross energy contents in fish were 1359.3 Kcal/kg, 1281.5 Kcal/kg and 1266.6 Kcal/kg, respectively in pond-1, pond-2, and pond-3 against 3630.4, 3876.9 and 3570.5 Kcal/kg energy in the feed fed. Only 9.4%, 10.5% and 13.7% of the protein, and 8.9%, 3.4% and 3.3% of the lipid fed to fish were converted into muscle respectively in pond-1, pond-2 and pond-3. It was observed that the higher the protein content in feed, the lower the rate of conversion in muscle; the same was also true for lipid. It is supposed that feed derived wastes contribute potentially to water quality deterioration and eutrophication. Lower feed conversion, higher nitrogenous and phosphatic concentrations and higher plankton biomass in the ponds are all supportive to this observation.

Key words: Feed utilization, Feed wastage, *Tor putitora*

Introduction

An effective feeding regime is one of the key factors affecting the goals of a fish production unit. Considerable research on fish nutrition have so far been done but information regarding the proportion of supplied feeds that is actually utilized and transformed into fish muscle, the proportion lost in one way or other is not adequate or complete. At the same time, production of wastes from feeds and the role of feed wastes on pond ecology and productivity are also important considerations.

An effective feeding regime must take into account the composition of feed, its digestibility, feeding rate and frequency, method of preparation and supplying all of which affect feed consumption and utilization (De Silva and Davy 1992, Chiu *et al.* 1987, Das and Ray 1989). Moreover, a fishery manager must be aware of the ecological implications related to feeding of aquatic animals. Even if feeds are appropriately formulated and fed, the amount of feeds that is actually utilized and retained in fish body is very low, not exceeding around 40% of the ingested feeds (Bergheim and Bratten 2000). The remaining portions are lost in the environment as waste, fish fecal matters, excretory products etc. and increasing feed losses are associated with higher FCR values (Das and Ray 1989) resulting not only in poor production but also ecological complications. Leaching of nutrients from feed contributes further to increase FCR values.

Waste management in aquaculture has been difficult for a number of reasons. Prediction of feed intake and optimum feeding level, collection of wastes and rapid dispersion of wastes into surrounding water are all complicated to a considerable extent. Therefore, feed waste contributes a relatively large proportion of total waste output in many aquaculture operations (Cho *et al.* 1994). In recent years, attentions have been paid to reduce feed losses and production of wastes from feeds. Improved diet quality and feeding regimes have contributed significantly in reducing feed losses and feed derived wastes. The present study was undertaken to observe the pattern of utilization of feeds supplied to aquaculture ponds of mahseer, *Tor putitora*.

Materials and methods

Formulation and preparation of feeds

Rice bran (33%), mustard oil cake (20%), soybean meal (15%), fishmeal (5%), blood meal (17%), wheat flour (6%), casein (2.5%), vitamin and mineral premix (0.25%) and common salt (1.25%) were used as ingredients for preparing feed 'B'. Feed 'C' was prepared with only the conventional ingredients such as rice bran (50%), mustard oil cake (20%), soybean meal (15%) and wheat flour (15%). All the feeds were supplied as pellets of 3-4 mm size. Among the three feeds, feed A was an commercial feed, purchased from SABINCO feed industry. The other two feeds (feed B and C) were prepared at the Laboratory. Feed 'C' was prepared completely from locally available ingredients. The feeds were different in proximate composition as well as in the total energy content.

Proximate analysis of the prepared feeds and experimental fish

The experimental diets were analyzed for proximate composition using the methods described in AOAC (1980). Nitrogen Free Extract, which was considered as soluble carbohydrate, was determined by 'substracting method' according to Castell and Tiews (1980).

Pond preparation, stocking and management

The selected ponds were drained, renovated and cleaned of aquatic vegetation. Lime (limestone, $CaCO_3$) was then applied by spreading over the bottom at the rate of 250 kg/ha. The bottom was then ploughed and left to dry for about a week. Ponds were then filled with water at a depth of about 1.5 meter and a more or less same depth was maintained for the whole experimental period. Cowdung at the rate of 1000 kg/ha and urea and TSP both at the rate of 25 kg/ha were applied 1 week prior to stocking. Overwintering fingerlings were stocked in the experimental ponds at the density of 32 fish per decimal ($40m^2$).

Feeding

Feeds in the form of pellets (3-4 mm) were supplied on a tray once every day between 09.00 and 10.00 h at the rate of 6% of the body weight of the fish. The tray was cleaned every day before placing the feed on it and any uneaten feed was carefully observed and recorded. About 40% of the fishes were sampled fortnightly to adjust the feed requirement on the basis of the weight gained by the fish.

Water quality criteria

Important nutrients of water such as nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), ammonia nitrogen (NH_3-N) and phosphate phosphorus (PO_4-P) were monitored fortnightly between 09.00 and 10.00 hour on each sampling day. The concentrations of the nutrients were used as an index of eutrophication (Cho *et al.* 1994).

Water samples were filtered through glass fibre filter paper (Whatman GF/C) and treated for nutrient analyses. Clean white PVC plastic bottles of 250 ml were used to collect water samples for nutrient analyses. Standard methods and procedures were followed during sample collection and care was taken to avoid contamination. Nitrate nitrogen, nitrite nitrogen, and ammonia nitrogen were determined by a HACH water analysis kit (DR/2000, direct reading spectrophotometer). Phosphate phosphorus was measured by a spectrophotometer (Milton Roy Spectronic, model 1001 plus) following the method described by Stirling (1985).

Plankton study

Quantitative estimates of phytoplankton and zooplankton was taken fortnightly as an index of the extent of eutrophication resulting from waste feeds. Depth integrated samples of ten liters of water were passed through plankton net (mesh size 0.04 µm) to get a 50 ml sample. The sample was preserved immediately in small sealed plastic bottles with 5% buffered formalin. Plankton were enumerated following the simple method described by Vollenweider (1985) using a Sedgwick-Rafter cell (S-R cell). The slide was left for 15 minutes to allow the plankton to settle and then all plankton cells and colony forming units were counted using a binocular compound microscope (Swift M-4000) in 10 random fields from each sample. The plankton density (number of cells per litre of water sample) was estimated using the following formula:

$$N = (P \times C \times 1000) / L$$

Where,

N = the number of plankton cells or units per litre of original water
P = the number of plankton counted in10 fields
C = the volume of final concentrate of the sample in ml
L = the volume of water sample in litre

Estimation of growth and feed utilization parameters

The growth and feed utilization were calculated in terms of the feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), and the gross and net production of the fish per unit area. For calculation of FCR, the dry weight of the feed was obtained by using a correction for the analyzed moisture content of the diet. The FCR was calculated after Castell and Tiews (1980) as follows:

$$\text{FCR} = \frac{\text{Feed fed (dry weight)}}{\text{Live weight gain}}$$

For calculation of FCR, the dry weight of the feed was obtained by using a correction for the analyzed moisture content of the diet. However, for calculation of the FCR, the amount of feed supplied was taken into account rather than the actual amount of feed fed by the fish and the amount lost in the environment.

The SGR is the instantaneous change in weight of fish calculated as the percentage increase in body weight per day over any given time interval. The SGR was calculated after Brown (1957) as follows:

$$\text{SGR (\% day)} = \frac{\text{Log } W_2 - \text{Log } W_1}{T_2 - T_1} \times 100$$

Where,
W_1 = The initial live body weight (g) at time T_1 (day)
W_2 = The final live body weight (g) at time T_2 (day)

The protein efficiency ratio (PER) was calculated according to Steffens (1989) and Wu and Dong (2002) as follows:

$$\text{Protein efficiency ratio (PER)} = 100 \text{ x } (W2 - W1)/Dp$$

Where,
W2 and W1 = final and initial wet weight (g) of the fish.
Dp = dry protein intake (g).

The gross energy content of the diet and fish muscle was calculated according to Hossain *et al.* (2001) using a Bomb Calorie meter. The gross and net yield of fish for each treatment was determined by multiplying the average weight of fish by the total number and was expressed as production in kg/ha.

Estimation of waste discharge

The estimation of the waste discharge was done by using the simple equations given by Einen *et al.* (1995) as follows:

$$\text{Waste discharged} = \text{nutrient fed} - \text{nutrient gain} \qquad (1)$$

Where,

nutrient fed = ration fed (g) × nutrient in feed (g g^{-1} diet) (2)
nutrient gain = growth (g) × nutrient in fish (g g^{-1} diet) (3)

Results

The formulation of the experimental feeds and their proximate composition are shown in Table 1 and Table 2 respectively. Feed B was highest in crude protein content followed by feed A. The highest protein content (28.3%) in feed B was attributed to the protein sources used particularly fishmeal and casein.

Table 1. Formulation of the supplementary feeds (feed 'B' and feed 'C')

Ingredients	Composition (%)	
	Feed 'A'	Feed 'B'
Blood meal	17	-
Mustard oil cake	20	20
Rice bran	33	50
Fish meal	5	-
Soybean meal	15	15
Wheat flour ('atta')	6	15
Casein	2.5	-
Salt (common salt)	1.25	-
Premix (Embavit fish premix)	0.25	-

Table 2. Biochemical composition of the supplied feeds and experimental fish

Pond No.	Composition (%)											
	Moisture		Crude protein		Crude lipid		Ash		Crude fibre		NFE*	
	Feed	Fish	Feed	Fish	Feed	Fish	Feed	Fish	Feed	Fish	Feed	Fish
1	11.83	76.18	27.71	17.87	6.85	3.01	16.08	1.69	12.24	0.66	37.12	0.59
2	7.40	76.59	28.30	18.26	12.03	2.44	15.42	1.43	16.46	0.61	27.79	0.67
3	10.52	78.49	21.32	15.90	13.13	3.07	11.79	1.23	15.74	0.68	32.62	0.63

Water quality and plankton

Mean values of nitrate, nitrite, ammonia nitrogen and phosphate phosphorus and the total plankton counts are shown in Table 3. Total number of phytoplankton varied between 1,254 x 10^3 and 2,255 x 10^3 (mean = 1,916 ± 220 x10^3) in pond 1, 1,372 x 10^3 and 2,239 x 10^3 (mean =1,805 ± 192 x10^3) in pond 2 and 1,247 x 10^3 and 2,444 x 10^3 (mean = 1,945 ± 231 x 10^3) in pond 3. Total number of zooplankton varied between 24 x 10^3 and 42 x 10^3 (mean = 34 ± 4 x 10^3) in pond 1, 23 x 10^3 and 31 x 10^3 (mean = 29 ± 2 x 10^3) in pond 2 and 27 x 10^3 and 38 x 10^3 (mean = 31 ± 2 x 10^3) in pond 3.

Table 3. Range and mean (±SD) values of water quality criteria and plankton counts

Pond No.	Nitrate (mg/l)	Nitrite (mg/l)	Ammonia (mg/l)	Phosphate (mg/l)	Plankton (No. of cells/l)
1	0.95-1.85 (1.48±0.46)	0.01-0.03 (0.025±0.01)	0.1-1.48 (0.53±0.50)	0.47-2.22 (1.22±0.56)	1254×10^3-2255×10^3 ($1916 \pm 221 \times 10^3$)
2	1.05-1.70 (1.41±0.29)	0.016-0.038 (0.025±0.01)	0.11-1.33 (0.45±0.46)	0.40-2.66 (1.31±0.65)	1372×10^3-2239×10^3 ($1805 \pm 192 \times 10^3$)
3	1.0-1.57 (1.26±0.2)	0.008-0.022 (0.019±0.01)	0.12-1.23 (0.64±0.48)	0.05-2.75 (1.37±0.73)	1247×10^3-2444×10^3 ($1945 \pm 231 \times 10^3$)

Growth and feed utilization

Results of different growth parameters of fish in different treatments at the end of the experiment are shown in Tables 4. The net increase by length and weight recorded were 8.3 cm and 76.7 g in pond 1, 8.1 cm and 68.3 g in pond 2, and 8.6 cm and 69.6 g in pond 3 respectively. The trend of fortnightly average increase in length and weight showed that the growth rate was more or less rapid at the beginning and then slowed down towards the end of the experiment in all the treatments. The FCR, SGR and PER values were respectively 5.26, 0.56 and 0.55 in pond 1; 5.28, 0.75 and 0.58 in pond 2; and 5.43, 0.55 and 0.79 in pond 3.

Table 4. Growth and feed utilization parameters

Feed fed	Production (kg/ha)		Mean length gain (cm)	Mean wt. gain (g)	FCR	SGR (% day)	PER
	Gross	Net					
Feed A	599.25	497.25	8.31	76.69	5.26	0.5647	0.553
Feed B	638.78	541.90	8.11	68.31	5.28	0.7527	0.578
Feed C	567.40	471.24	8.61	69.62	5.43	0.554	0.786

Table 5 shows the mass balance of the amount of different ingredients of feed fed and the amount converted to respected ingredients of fish muscle. Comparative energy contents between feeds and fish muscles are also shown. Only 15.35%, 16.36%, and 16.74% of the supplied feeds were converted into harvestable components respectively in pond-1, pond-2, and pond-3. Muscle protein of 2.04 kg, 2.09 kg and 1.99 kg were obtained against 21.7 kg, 19.9 kg and 14.5 kg protein supplied, which, in case of lipid were 0.48, 0.29 and 0.31 kg against 5.4, 8.5 and 8.9 kg supplied to the fish which means that only 9.4%, 10.5%, and 13.7% of the protein and 8.9%, 3.4%, and 3.3% of the lipid fed to fish were converted into muscle respectively in pond-1, pond-2, and pond-3. Calculated gross energy contents in fish were 1359.3 Kcal/kg, 1281.5 Kcal/kg and 1266.6 Kcal/kg by supplying respectively 3730.4 Kcal/kg, 3876.9 Kcal/kg, and 3770.5 Kcal/kg. These values, in addition to those obtained in FCR, PER and SGR clearly indicate very poor feed utilization and conversion.

Table 5. Estimated mass balance of the amount of feed fed and the amount fish produced

Feed fed	Feed A	Feed B	Feed C
Total feed fed (kg)	78.2	70.3	68.1
Crude protein fed (kg)	21.7	19.9	14.5
Crude fat fed (kg)	5.4	8.5	8.9
Crude ash feed fed (kg)	12.6	10.9	11.7
Crude fibre fed (kg)	9.6	11.6	10.7
NFE fed (kg)	29.0	19.6	22.2
Gross energy (Kcal/kg) in feed	3730.4	3876.9	3770.5
Feed retained in fish body			
Total net biomass (kg)	12.0	11.5	11.40
Protein gain (kg)	2.04	2.09	1.99
Lipid gain (kg)	0.48	0.29	0.31
Ash gain (kg)	0.19	0.12	0.15
Crude fibre gain (kg)	0.09	0.08	0.08
NFE gain (kg)	0.08	0.07	0.07
Gross energy (Kcal/kg) in fish	1359.3	1281.5	1266.6

Discussion

It is evident that the performance of the fish in all ponds was very poor in terms of growth and feed utilization. Two major factors are supposed to be responsible; one, a major portion of the supplied feeds might not be taken by fish and, therefore, lost to the environment and the other, the digestibility of the feeds were poor which resulted in poor feed utilization even though the feeds were eaten. Asgard *et al.* (1998) reported that losses of feeds to the environment depend upon a number of factors such as feed formulation (balance of nutrients between that supplied and that required), nutrient digestibility, feed supplying methods including the ration size associated with feed intake and loss etc. In order to maximize feed utilization, fish should be fed by methods that allow feeding to satiation, but do not waste feed.

Considering the above-mentioned factors, there were many possibilities for a major part of the feeds supplied in the present experiment to be lost in the environment. The results of the nutrient analyses of water as well as that of plankton study also give logical support to this point (Palmer 1980). Very high concentration of nitrogenous (particularly ammonia nitrogen) and phosphatic nutrients in water in the present study are most likely to come from decomposition of uneaten feeds (Kissil and Lupatsch 1992, Ackefors and Enell 1994, Axler *et al.* 1996). Part of this may also be contributed by undigested feeds, fecal wastes and excretion products (Bergheim and Braaten 2000). Very high loading of wastes resulted from feed loss was also reported by NCC (1990).

The lower growth rates might also be associated with lower appetite and inefficient food utilization. The causes might be, among others, higher ration size, poor digestibility and wastage of feed. Andrews and Stickney (1972), Reddy and Katro (1979), and Das and Ray (1989) observed increasing trends of FCR values with increasing ration size. Ghosh *et al.* (1984) obtained FCR values 1.5, 2.92, and 4.29 by feeding common carp with supplementary feeds at the rate of 2%, 4% and 6% of body weight. De Silva and Davy (1992) stated that digestibility of fish plays an important role in lowering the FCR value by efficient utilization of food which, in turn, depends on daily feeding rate, its frequency and the type of food used (Chiu *et al.* 1987).

The ultimate source of wastes in any fish culture unit is feeds and feeding. Therefore, control and reduction of fish culture wastes can best be achieved through an effective nutritional approach focussing on feeds and feeding. Such a nutritional approach should include four main points; these are careful selection of ingredients based upon digestibility, balanced feed formulation to ensure maximum feed utilization, avoidance of excess nutrients, and an effective and strict feeding regime (Cho 1992 and Cho *et al.* 1994).

A further more critical analysis and discussion may be done from the waste production point of view according to Boyd (1999). From the FCR (the amount of feed in kg which results in the production of 1 kg of fish) values shown in Table 4, it may be concluded that 4.26, 4.28, and 4.43 kg of waste is generated in the production of 1 kg of fish each in treatment 1, 2, and treatment 3 respectively. But a more careful analysis of the relationship between feed input, fish production and waste generation reveals a very high loading of wastes in aquaculture ponds. For example, feed 'A' contained 88.7% dry matter and 11.83% water. Fish in treatment 1, on the other hand, contained 13.82% dry matter and 76.18% water. Thus in the production of 1 kg of fish with 5.26 kg of feed (FCR of 5.26), 4.64 kg dry matter in feed yields only 0.14 kg dry matter in fish. Therefore, in the production of 1 kg fish dry matter the dry feeds required is as high as 33.14 kg. Thus the dry matter conversion ratio is only 33.14 (33.14 kg dry feed, 1 kg dry fish). Therefore, the ratio of fish to wastes of 1:4.26 based on the usual method of estimating feed conversion ratio is an apparent ratio. But the true ratio based of dry matter conversion is 1: 32.14 in treatment 1 with feed 'A'. Similarly, in treatment 2 and treatment 3, the dry matter conversion ratios were 36.46 and 22.59 and the ratios of fish to wastes were 1: 35.46 and 1: 21.59 with feed 'B' and feed 'C' respectively.

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