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Effects of Available Diets with Different Protein to Energy Ratios on Growth, Nutrient Utilization and Body Composition of Juvenile Himalayan Golden Mahseer, *Tor putitora* (Hamilton)

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Abstract

To enhance the growth of Himalayan golden mahseer under culture systems, it becomes necessary to know about its feeding requirements. As a first step to improve rearing conditions and profitability of cultured Himalayan golden mahseer, a growth experiment was performed to study the nutritional utilization of three diets available in the country with different protein to energy ratios. Fish of 3.24±0.03 g body size were stocked in tanks with flow through water system keeping three replicates for each treatment. Feeding was done twice daily with the three available diets D1, D2 and D3 having protein to energy ratios of about 26 (D1), 23 (D2) and 19 (D3) mg of crude protein kJ^{-1} for a period of 90 days. The results showed that the net weight gain, percent weight gain, specific growth rate (SGR), protein efficiency ratio (PER), protein productive value (PPV) and energy retention were significantly ($P<0.05$) higher for diet D2 compared to diets D1 and D3. Yet there was no statistically significant ($P>0.05$) difference between the feed conversion ratio (FCR) and feed conversion efficiency (FCE) values for feed D1 and feed D2. On the other hand fish fed with diet D3 showed significantly ($P<0.05$) lower growth, feed efficiency, nutrient utilization and energy retention compared to the other diets. The percentage survival was independent of treatments. Whole body protein, fat and energy contents

were higher and moisture content was lower in fish fed with feed D2 than the fish fed with diets D1 and D3. However, there was insignificant ($P>0.05$) difference between the body protein, body fat and body energy contents of fish fed with the diets D1 and D2. Diet D3 exhibited the significantly ($P<0.05$) lowest body protein, fat and energy and significantly ($P<0.05$) highest body moisture content than diets D1 and D2. Ash content was almost similar for all the treatments. These results suggest that diet D2 appears to be more adequate for growth of Himalayan golden mahseer.

Introduction

Coldwater fisheries in the central Himalayan region of India are poorly developed and are mainly capture fisheries. The majority of the coldwater fishes are invariably slow growing and many of them are small sized which do not occur in great abundance. Himalayan golden mahseer and snow trout are the only two indigenous fish species that form mainstay fisheries of the region. But due to anthropogenic pressure, environmental degradation, indiscriminate fishing, slow growth rate and poor recruitment of these fish species in the natural water bodies had declined to an alarming level. To over come this alarming situation the researchers' attention was drawn towards aquaculture of the indigenous fish species of the region. Himalayan golden mahseer with its many qualities like sufficient high growth rate, acceptability to the consumers and availability of the technology for its breeding and larval rearing (Joshi 1988, Mohan et al. 1998) makes it a good species for aquaculture. Pilot pre grow out and grow out studies have been conducted in floating cages and earthen tanks (Anon 1998 and 2002) yielding encouraging results.

Adaptation of Himalayan golden mahseer to culture conditions requires information on its nutritional requirements as nutrition plays a pivotal role in aquaculture of any fish species. For proper growth fish requires diets that meet their nutrient and energy demands. However, cost of feed makes up a large percentage of the total expenses of an aquaculture system. It is therefore necessary to enhance the nutritional efficiency of the diets in order to improve the economic performance of the aquaculture system.

The nutritional requirements of Himalayan golden mahseer are not known, barring few preliminary works (Joshi et al. 1989, Sunder and Raina 1995, Sunder et al. 1995). The aim of the present study was to evaluate the growth of Himalayan golden mahseer using three available feeds in the country with different protein to energy ratios.

Materials and Methods

Himalayan golden mahseer juveniles were collected from river Kosi and transported live to the experimental site and were acclimatized to the experimental conditions and test diets. After recording their initial length and body weight, the fish were randomly distributed (50 fish/tank) in the nine experimental tanks (size: 100x100x45.0cm; water depth: 30cm) having flow through water system, keeping three replicates for each treatment. Each group (three replicates/diet) was fed one of the three types of feeds viz., D1 (high protein to energy ratio), D2 (medium protein to energy ratio) and D3 (low protein to energy ratio), obtained from the National Research Centre on Coldwater Fisheries, Himachal Pradesh State Fisheries Department and Central Institute of Freshwater Aquaculture, respectively for a period of 90 days. The nutrient compositions of all the three diets are shown in table 1. Dry matter, crude protein, crude fat, crude fiber and ash were analysed as per AOAC (1995) methods. Gross energy content was calculated by applying standard conversion factors for fat (39.54 kJg^{-1}), protein (20.08 kJg^{-1}) and carbohydrates (17.15 kJg^{-1}) as recommended by Brett and Groves (1979). Feeding was done at a rate of 5% of body weight per day divided into two equal installments. Growth in terms of total length and body weight and survival was monitored at regular fortnightly intervals and based on the growth and survival of fish, the quantity of feed was adjusted throughout the experimental period. Uneaten feed, if any, was siphoned out after one hour of feeding, dried and weighed. On conclusion of the trials the final total length and body weight attained by the fish were recorded separately for all the replicates of each treatment. Growth performance and feed efficiency were determined by evaluating a number of growth and nutrient utilization indexes, including net weight gain, percentage weight gain, specific growth rate (SGR), feed conversion ratio (FCR), feed conversion efficiency (FCE) and protein efficiency ratio (PER), protein productive value (PPV) and energy retention. At the beginning and at the end of the experimental period body composition was determined in five fish per tank in terms of moisture, protein, fat and ash contents (AOAC 1995) and energy content was calculated with the standard conversion factors for protein, lipid and carbohydrates as given by Brett and Groves (1979).

Table 1. Proximate composition of the diets (% dry matter)

	D1	D2	D3
Crude protein	51.65	47.47	30.00
Crude lipid	14.80	17.89	9.00
Crude ash	8.00	8.40	15.47
Crude fiber	4.50	1.37	10.00
NFE [a]	21.05	24.87	35.53
Gross energy (kJ g^{-1})	19.83	20.87	15.68
P/E (mg protein kJ^{-1})	26.05	22.75	19.13

[a] Nitrogen-free extract.

Water quality parameters were monitored at regular weekly intervals as per standard methods (APHA 1985) and while temperature being a crucial factor was monitored twice daily, in morning and evening throughout the experimental period that averaged as 10-20°C water temperature, 7.4-7.8 mgl^{-1} dissolved oxygen, 1.2-1.6 mgl^{-1} free carbon dioxide, 7.0-7.2 pH, 70-72 mgl^{-1} total alkalinity and 0.30-1.0 l min^{-1} flow rate.

The data obtained was analysed statistically by one-way analysis of variance (ANOVA) and a multiple range test at 5% level of significance (Snedecore and Cochran 1968).

Results

Growth performance, feed efficiency and survival data for fish fed with feeds D1, D2 and D3 are shown in table 2. Mortality rate was least in feed D2 followed by feed D1 and feed D3. But statistically there was no significant ($P>0.05$) difference among the survival rates of the treatments. Net weight gain, percent weight gain, SGR, PER, PPV and energy retention were significantly ($P<0.05$) higher in fish fed with feed D2 compared to fish fed with feed D1 and feed D3. But there was no significant ($P>0.05$) difference in the FCR and FCE values for fish fed with diets D1 and D2. However, the growth, feed efficiency, PER, PPV and energy retention for fish fed with feed D3 were significantly lower ($P<0.05$) than that for feeds D2 and D1.

Table 2. Growth response of Himalayan golden mahseer fed the diets with different P/E ratios.

	D1	D2	D3
Initial weight (g)	3.25 ± 0.06	3.18 ± 0.06	3.30 ± 0.04
Final weight (g)	5.28 ± 0.03 ^{a}	5.26 ± 0.07 ^{b}	4.35 ± 0.03 ^{c}
Net weight gain (g)	2.03 ± 0.03 ^{a}	2.44 ± 0.01 ^{b}	1.05 ± 0.02 ^{c}
Percent weight gain (%)	62.46 ± 1.91 ^{a}	76.87 ± 1.05 ^{b}	31.84 ± 0.97 ^{c}
SGR (% day^{-1})	0.54 ± 0.02 ^{a}	0.63 ± 0.01 ^{b}	0.31 ± 0.01 ^{c}
FCR	2.35 ± 0.10 ^{a}	2.20 ± 0.05 ^{a}	3.27 ± 0.13 ^{c}
FCE (%)	44.46 ± 0.57 ^{a}	45.43 ± 0.98 ^{a}	30.67 ± 1.19 ^{c}
PER	0.57 ± 0.04 ^{a}	0.81 ± 0.03 ^{b}	0.35 ± 0.02 ^{c}
PPV (%)	24.64 ± 0.77 ^{a}	32.18 ± 0.59 ^{b}	20.87 ± 0.27 ^{c}
ER (%)	23.22 ± 0.43 ^{a}	26.46 ± 0.73 ^{b}	13.36 ± 0.19 ^{c}
Survival (%)	97.33 ± 1.33 ^{a}	98.67 ± 1.33 ^{a}	96.00 ± 2.31 ^{a}

Data represent the mean ± S.E.M. of three replicates. Values on the same line with different superscripts are significantly different ($P<0.05$). SGR: Specific Growth Rate = (In Final weight – In Initial weight)/days X 100. FCR: Feed Conversion Ratio = Feed intake/ Weight gain. FCE: Feed Conversion Efficiency = (Weight gain/ Feed intake) X 100. PER: Protein Efficiency Ratio = Weight gain/ Protein intake. PPV: Protein Productive Value = (Protein retained/ Protein ingested) X 100. ER: Energy Retention = (Energy retained/ Energy intake) X 100.

The effects of different protein to energy ratio on Himalayan golden mahseer body composition are presented in table 3. The body composition showed that protein and fat deposition increased with increasing dietary energy content and were inversely related to the body moisture level. Diet D2 led to higher body protein, body fat and body energy and lower body moisture percentage than the diets D1 and D3. However, there was insignificant (P>0.05) difference between body composition and energy contents of the fish fed with the feeds D1 and D2. Whereas diet D3 exhibited significantly (P<0.05) lowest body protein, body fat and body energy and highest body moisture content than diets D1 and D2. Body ash content was not affected by the treatments.

Table 3. Body composition of Himalayan golden mahseer fed diets with different P/E ratios (% wet weight)

	D1	D2	D3
Moisture	73.26 ± 0.44 [a]	72.52 ± 0.52 [a]	76.71 ± 0.47 [b]
Crude protein	16.64 ± 0.41 [a]	17.31 ± 0.46 [a]	14.43 ± 0.46 [b]
Crude lipid	6.80 ± 0.36 [a]	7.05 ± 0.53 [a]	4.99 ± 0.44 [b]
Crude ash	3.34 ± 0.55 [a]	3.11 ± 0.59 [a]	3.84 ± 0.37 [a]
Gross energy (kJ g^{-1})	6.03 ± 0.22 [a]	6.27 ± 0.30 [a]	4.84 ± 0.28 [b]

Data represent the mean ± S.E.M. of three replicates. Values on the same line with different superscripts are significantly different (P<0.05).

Discussion

The growth performance of Himalayan golden mahseer was significantly affected by dietary P/E ratio. Himalayan golden mahseer grew best when fed the diet D2 containing about 48% protein, 18% fat and 21kJg^{-1} gross energy with P/E of 23mg protein kJ^{-1}. The experiment yielded acceptable growth results with feed D2, having higher energy content than feed D1 and D3, appearing to be more adequate for juveniles of Himalayan golden mahseer. The Himalayan golden mahseer juveniles have been reported in the literature to be carnivorous in feeding habit (Nautiyal 1994), suggesting higher protein and fat requirement during early stages of growth.

Like any other animal, fish eat to meet their energy demands, thus the level of feed intake was inversely related to feeds energy content. Feed conversion ratios (FCR) and feed conversion efficiency (FCE) of feed D2 was better than that for feeds D1 and D3. Although there was no statistically significant (P<0.05) difference between the FCR and FCE of feeds D1 and D2. Nevertheless FCR and FCE of feed D3 were significantly (P<0.05) poor as compared to that of feeds D1 and D2. The values of FCR and FCE obtained in the current study are comparable to those reported for Himalayan golden mahseer in earlier studies (Anon 2003).

Growth performance of fish with feed D2 surpassed the growth performance of fish fed with feeds D1 and D3, albeit a lower intake of feed D2 was required, this may probably be due to the fact that feed D2 was manufactured with better high quality ingredients. One has to balance, however, the advantage of using feed D2, as less feed was required to yield a greater amount of fish. From these results it can be concluded that feed D2 was a more profitable feed for juveniles of Himalayan golden mahseer.

The PER, PPV and energy retention values for fish fed with the feed D2 were significantly ($P<0.05$) higher compared to that of feeds D1 and D3, regardless of the fact that feed D1 had higher protein content, whereas feed D2 had higher fat percentage. This could be attributed to the reason that, the protein sources used to manufacture feed D2 may be of high quality than those of feeds D1 and D3. Moreover, the low fat content of feed D3 may force the fish to use some of the protein as an energy source, thereby reducing protein synthesis and causing growth retardation. Further, feed D3 had higher fiber content than the other diets, and it is well established that high fiber levels may interfere with the digestion of other nutrients, thus reducing diets digestibility (Alexis 1997). Thus, it is conceivable that juveniles of Himalayan golden mahseer require more energy (either protein or fat) than can be provided by feed D3. An inadequate dietary P/E ratio, feed D3, resulted in lower growth as well as lower protein and energy utilization as reported in other studies (Webster et al. 1995, Shiau and Lan 1996, Samantaray and Mohanty 1997). The growth rate of Himalayan golden mahseer fed diet D3 with lower lipid level (9%) was lower compared to fish fed diets D1 and D2 with higher lipid levels (about 15% and 18%, respectively). Higher dietary lipid level improved SGR, PER, PPV and energy retention, suggesting an obvious protein sparing effect of lipid. This effect has previously been observed in other species (De Silva et al. 1991, Vergara et al. 1996, Company et al. 1999, Nankervis et al. 2000, Morais et al. 2001).

The optimal P/E ratio (22.75 mg protein kJ^{-1}) in the present study is within the range reported for other fish species. The optimal P/E ratio has been reported to be 21.1-35.2 mg protein kJ^{-1} for channel catfish (Garling and Wilson 1976, Reis et al. 1989), 23.7-26.6 mg protein kJ^{-1} for sunshine bass (Webster et al. 1995, Keembiyehetty and Wilson 1998) and 27.5-29.5 mg protein kJ^{-1} for mutton snapper (Watanabe et al. 2001). To a certain extent optimal P/E ratio varies by the difference in dietary ingredients, fish species and even for the same species in different studies. The different design of dietary nutrient level affects the estimation of nutrient requirement (Mercer 1982). To achieve better growth, the dietary ingredients should be readily digestible and provide sufficient essential amino acids. However, different ingredients differ in their amino acid composition and availability (NRC 1993). Therefore, the optimal P/E ratio varied for the same physiological fuel values (Catacutan and Coloso 1995, Tibaldi et al. 1996), which probably affects the accuracy of optimal dietary P/E ratio.

Fish fed with feeds D1 and D2 had higher percentage of body protein and body fat than fish fed feed D3. This higher percentage could be attributed to the larger size attained by the fish, as it has been previously described for other species

(Shearer 1994). The data on body composition in this study showed that body lipid content was higher in fish fed with feed D2 with higher lipid content, similar to the previously reported studies (El-Sayed and Teshima 1992, Catacutan and Coloso 1995, Keembiyehetty and Wilson 1998). Body moisture was inversely related to body lipid as seen in other fish species (Zeitler et al. 1984, Parazo 1990).

It can be concluded that juvenile Himalayan golden mahseer can make good use of dry feeds currently available in the country, yielding entirely acceptable growth performance and feed efficiency. It would appear that better growth rates could be obtained at protein to energy ratio of about 22.75 – 26.05 mg protein kJ^{-1}.

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