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Effect of Feeding Rates on Growth, Feed Utilisation and Nutrient Absorption of Murrel Fingerling, *Channa striata* (Bloch) and Determination of Protein and Energy Requirement for Maintenance and Maximum Growth

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Abstract

Two experimental diets, containing 35% crude protein (P35) and 1628.4 kJ digestible energy and 45% crude protein (P45) and 2088.8 kJ digestible energy with protein to energy (P/E) ratio of 21.5 mg protein kJ^{-1} in both diets, were fed at incremental rates (1.0, 1.5, 2.0, 2.5, 3.0, 4.0 and 5.0% of body weight day^{-1} ($Bw.d^{-1}$) to murrel (*Channa striata*) fingerlings for 8 weeks. A linear increase in growth rate of fingerlings was observed up to 10.5 g protein (kg $Bw.d)^{-1}$ and 488.51 kJ energy (kg $Bw.d)^{-1}$ in P35 diet (r^2=0.83) and 11.25 g protein (kg $Bw.d)^{-1}$ and 522.2 kJ energy (kg $Bw.d^{-1}$) in P 45 diet (r^2=0.89). Regressing growth rate obtained for both the diets to zero weight gain, resulted in a maintenance requirement of 0.3 g protein (kg $Bw.d)^{-1}$ and 16.6 kJ energy (kg $Bw.d^{-1}$). The net gain in body protein also increased linearly with increasing feeding rates up to 10.5 g protein (kg $Bw.d)^{-1}$ and 488.51 kJ energy (kg $Bw.d)^{-1}$ in P35 (r^2=0.74) and 11.25 g protein (kg $Bw.d^{-1}$) and 521.99 kJ energy (kg Bw. $d)^{-1}$ in P45 (r^2=0.4). Regression equations from the data obtained with the P35 diet predicted that 1.58 g protein (kg $Bw.d)^{-1}$ and 71.4 kJ energy (kg $Bw.d)^{-1}$ was required to maintain a constant amount of tissue protein in fingerlings. But with P45, the protein and energy intake levels have insignificant effects on carcass protein. The ration maximum (R_{max}) values for growth were calculated to be 13.4 to 14.7 g protein (kg $Bw.d)^{-1}$ and 666.6 kJ energy (kg Bw. $d)^{-1}$ in both diets which corresponded to growth maximum (G_{max}) of 1.18 to 1.28% wt d^{-1} for protein and 1.24 to 1.26% wt. d^{-1} for energy. The R_{max} value for body protein deposition was calculated to be 11.8 g protein (kg $Bw.d)^{-1}$ and 571.4 kJ energy (kg $Bw.d)^{-1}$ with a predicted protein maximum (P_{max}) of 1.62 to 1.72% with P35 diet. The effect of feeding rate on feed, protein and energy conversion efficiency and proximate composition were also examined.

Keywords: *Channa striata*; Feeding rate; Protein; Energy; Feed utilization

Introduction

Channa are highly priced fish all over India [1,2]. They are also prevalent in most southern and south-eastern Asian countries largely due to their good taste and fast growth as well as resistance to diseases, handling and tolerance to inferior water quality [3]. It is a popular farmed fish, preferred for its faster growth performance and delicate taste. This fish is of high nutritional value for human with a good essential amino acid and fatty acid profile [4]. Unfortunately, there are no commercially available feed formulated for this species and only little empirical information on its nutritional requirements has been reported so far [5].

Growth and survival of *Channa striata* fry [6-8] and fingerling [9,10] were observed using live feed. Raizada et al. [11] revealed that the protein requirement of *C. marulius* fry is around 540–600 g kg^{-1} and the fry could be reared to fingerling size on formulated diets. Studies were conducted on the dietary protein requirement of fry [12,13] and fingerling [14,15] of *C. striata* and showed that the juveniles require about 50% protein in their diet for maximum growth. Inadequate protein in feed results in growth reduction but when it is overloaded in a diet, the excess protein is converted to energy through direct oxidation of amino acids. This will lead to increased production cost and extra nitrogenous waste [16,17]. Thus optimum protein to energy (P/E) ratio in the diets is very important to maintain fish quality and to reduce the dietary cost [15].

The optimum dietary protein to energy ratio has been determined for many cultivable fish species like Indian major carp [18], tilapia [19,20], African catfish [21], channel catfish [22]. Feed preparation and feed management strategies within semi-intensive fish farming systems in tropics is the important criteria [23]. So this study was conducted to work out the feeding ration for maintenance and maximum growth of *Channa striatus.*

Material and Methods

Experimental diets and design

Two experimental diets, formulated to have 35% (P35) and 45% (P45) crude protein at the gross energy levels of 1628.4 and 2088.8 kJ respectively (Table 1), were used for the experiment. Both diets had the same P/E ratio of 21.5 mg protein kJ^{-1}, which was previously found to be optimum for this fish [15]. The digestible energy values for these ingredients were not been determined for this fish species. So, standard mammalian physiological fuel values (17, 17 and 38 kJ g^{-1} for protein, carbohydrate and lipid, respectively) were utilized to calculate the energy content of these diets [24]. Energy values of diets were also determined by REICO plain bomb calorimeter.

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	Dietary Code	
	P35	P45
Ingredient (g kg^{-1})		
Casein (vit. free)	305	379
Gelatin	57	85
Dextrin	437	285
Vegetable oil	50	120
Cod Liver oil	40	100
Vitamin[1] and Mineral[2] mixture	20	20
Binder[3]	10	10
α-Cellulose	82	1
Nutrient content		
Crude protein (%)	35.0	45.0
Energy kJ 100 g^{-1} (calculated)	1640.9	2084.6
Energy kJ 100 g^{-1} (estimated)	1628.4	2088.8
Protein to energy (P/E) ratio mg protein kJ^{-1}	21.5	21.5

[1]To supply per 100 g diet: Vitamin A IP (as acetate) 10,000 IU; cholecalciferol (Vit. D_3) 1000 IU; thiamine mononitrate IP 10.0 mg; riboflavin IP 10 mg; pyridoxin hydrochloride 60 mg; cyanocobalamin IP 30.0 mcg; nicotinamide IP 200.0 mg; ascorbic acid 300 mg, tocopheryl acetate 50.0 mg; biotin USP 0.50 mg

[2]To supply per 100 g diet: Calcium phosphate IP 258.0 mg; magnesium oxide light IP 120.0 mg; dried ferrous sulphate IP 64.08 mg; manganese sulphate IP 4.06 mg; total phosphorous in the preparation 50.16 mg. Trace elements: Copper sulphate IP 6.78 mg; zinc sulphate IP 4.40 mg; sodium molybdate 0.50 mg; sodium borate IP 1.76 mg

[3]Carboxymethyl cellulose, sodium salt (high viscosity)

Table 1: Composition of the experimental diets.

The feed was prepared as done previously [15]. The dry ingredients were weighed individually and mixed well using an electric grinder. Vitamin and mineral premixes were mixed separately with cellulose prior to mixing with other ingredients. Oil was added to the dry ingredients and mixed again. Water was added and moist mixture was hand kneeded till dough was formed. It was then pelleted using a hand pelletizer. The pellets were oven-dried at 60°C. The dry pellets were crumbled to appropriate sizes before feeding to fish. The experiment was conducted in two phases. In phase 1 P35 and in phase 2 P45 diet was tested following the same experimental protocol and same size fingerlings. Prior to the start of the experiment, the hatchery-reared fingerling of *Channa striata*, of average weight 10.8 g ± 0.2 (10.5–11.6 g), were acclimatized for 2 weeks to the experimental diets and culture conditions. Twenty fish were stocked in each of the 24,110 L FRP tanks with re-circulating system to have a total fish biomass of 212 g (S.D. ± 0.5) in each tank to test each diet at each feeding level in triplicate. The flow rate was adjusted to 90 ml min^{-1}. Water temperature was maintained at 28 ± 2°C and fluorescent lighting provided a 12-h light cycle and all the tanks were continuously aerated throughout the experimental period. Dissolved oxygen and pH were monitored and found to vary between 6.3-7.2 mg l^{-1} and 7.3 to 7.7 respectively.

The diets (P35 & P45) were fed at 1.0, 1.5, 2.0, 2.5, 3.0, 4.0 and 5.0% of wet body weight per day, to random groups of fish in triplicate. The fish were fed twice a day, seven days a week for 8-weeks. Left over feed, if any, were siphoned out after 3-4 h of feeding and weighed after drying in an oven to determine the feed consumption. Three other groups of fish were not fed during the entire experimental period. All fish in each group were collectively weighed each week for feed adjustment and feeding was stopped 24 h prior to sample collection.

Sample collection and analysis

At the end of the each phase of the experiment, 9 fish (3 from each tank) from each feeding trial were frozen for subsequent carcass analysis. Feed ingredients, experimental diets and fish carcasses were analyzed following AOAC [25]. Moisture was determined by oven drying at 100°C to constant weight [15]. Crude protein was determined indirectly from the analysis of total kJeldahl N_2 (crude protein=N_2 × 6.25) by kJeldahl method. Samples were extracted with petroleum ether for 8 h in Soxhlet extraction apparatus for crude fat determination. Ash content was determined from weighed samples in a porcelain crucible placed in a muffle furnace for 6 h at 550°C. Whole body energy content was calculated from proximate composition using 17 kJ g^{-1} for protein and 38 kJ g^{-1} for fat [26]. At the beginning of each phase of the experiment, the body composition of representative fish samples was determined as per the above method.

Statistical analysis

Specific growth rate (SGR-% wt day^{-1}) [27] and change in body protein of the fish were regressed (2nd order polynomial) against protein and energy intake using SPSS statistical package. The regression equations were used to calculate the maintenance requirement through quadratic analysis. The ration maximum (R_{max}) for protein and energy for growth and tissue protein deposition was calculated considering dy/dx=0. The corresponding growth maximum (G_{max}) and protein maximum (P_{max}) were predicted. The mean of feed efficiencies and body composition data were subjected to one-way analysis of variance (ANOVA) and Duncan's multiples range test [28] using SPSS computer package (ver. 10.0).

Results

Fingerlings fed at different levels of feeding showed an increase in growth rate up to 10.5 g protein (kg Bw.d) $^{-1}$ and 488.51 kJ energy (kg Bw.d)$^{-1}$ in P35 diet (Table 2) and 11.25 g protein (kg Bw.d)$^{-1}$ and 521.99 kJ energy (kg Bw.d)$^{-1}$ in P45 diet, of which the former produced fish better than the later. This indicated that feeding more than 10.5 g protein (kg Bw.d)$^{-1}$ and 488.51 kJ energy (kg Bw.d)$^{-1}$ suppress growth rate in this fish. The starved fish were found to lose weight continuously throughout the experimental period. The application of second order polynomial regression analysis to ration size on growth response suggested significant relationship between feeding levels (protein and energy) and specific growth rate in both P35 (r^2=0.83) (Figures 1A and 1B) and P 45 (r^2=0.89) (Figures 2A and 2B) diet. The growth rate of murrel fingerling (y) to increasing levels of protein and energy (x) in P35 was described by the equations:

$Y=-0.052+0.187x–0.007\ x^2$ for protein;

$Y=-0.054+0.004\ x–0.000003\ x^2$ for energy.

In P 45 such relationships were described by the equations:

$Y=-0.054+0.183\ x–0.0062\ x^2$ for protein;

$Y=-0.054+0.004x–0.000003\ x^2$ for energy.

Regressing protein and energy intake of both the diets back to zero weight gain resulted in maintenance requirements of 0.3 g protein (kg Bw.d)$^{-1}$ and 16.6 kJ energy (kg Bw.d)$^{-1}$, respectively. The ration maximum (R_{max}) value for growth were calculated to be 13.4-14.7 g protein (kg Bw.d)$^{-1}$ and 666.6 kJ energy (kg Bw.d) $^{-1}$ in both the diets which correspondent to the growth maximum (G_{max}) of 1.18 to 1.28% wt.d^{-1} for protein and 1.24 to 1.28% wt.d^{-1} for energy.

In P35 feed conversion efficiency increased significantly at a feeding level of 10.5 g protein (kg Bw.d)$^{-1}$ and 488.51 kJ energy (kg Bw.d)$^{-1}$. The efficiency then decreased at higher feeding levels. Protein efficiency ratio, with the same diet, progressively increased with the increase in feeding level up to 7.0 g protein (kg Bw.d) $^{-1}$ and 325.67 kJ energy (kg

Protein g (kg Bw.d)$^{-1}$	Energy kJ (kg Bw.d)$^{-1}$	Final average weight (g)	Feed conversion[2] efficiency	Protein conversion[3] efficiency	Energy conversion[4] efficiency
0	0	5.9^{f} ± 0.1	0	0	0
3.50	162.84	14.8^{e} ± 0.8	0.57^{b} ± 0.01	23.47^{c} ± 1.4	32.22^{a} ± 1.2
5.25	244.46	16.5^{d} ± 0.6	0.57^{b} ± 0.1	28.04^{ab} ± 0.8	18.41^{b} ± 0.9
7.0	325.67	18.2^{c} ± 1.1	0.49^{c} ± 0.01	30.31^{a} ± 2.1	11.53^{c} ± 0.7
8.75	407.09	19.8^{bc} ± 0.9	0.45^{c} ± 0.01	29.76^{a} ± 1.6	10.86^{c} ± 0.4
10.50	488.51	23.5^{a} ± 1.4	0.64^{a} ± 0.01	27.73^{b} ± 1.3	8.61^{d} ± 0.3
14.00	651.34	20.2^{b} ± 1.8	0.35^{d} ± 0.01	12.78^{d} ± 0.9	8.59^{d} ± 0.6
17.50	814.18	20.1^{b} ± 1.6	0.29^{e} ± 0.01	12.09^{d} ± 0.6	8.26^{d} ± 0.4

Mean values with same superscript within the column are not different significantly ($p<0.05$)
[1]Mean of three replicate groups ± SE
[2]Wet weight gain/dry weight fed
[3]Final body protein-initial body protein × 100/total protein fed
[4]Final body energy-initial body energy × 100/total energy fed

Table 2: Final average weight and feed efficiencies of murrel fingerling fed different levels of the diet containing 35% crude protein and 1628.4 kJ 100^{-1} g energy (P35)[1].

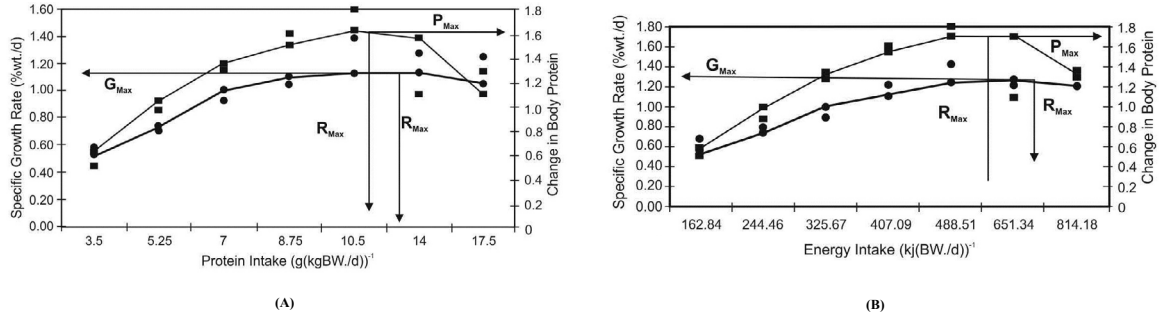

Figure 1: Effect of increasing level of protein and energy intake on growth (●) and body protein (□) of fingerling fed with P35 diet.

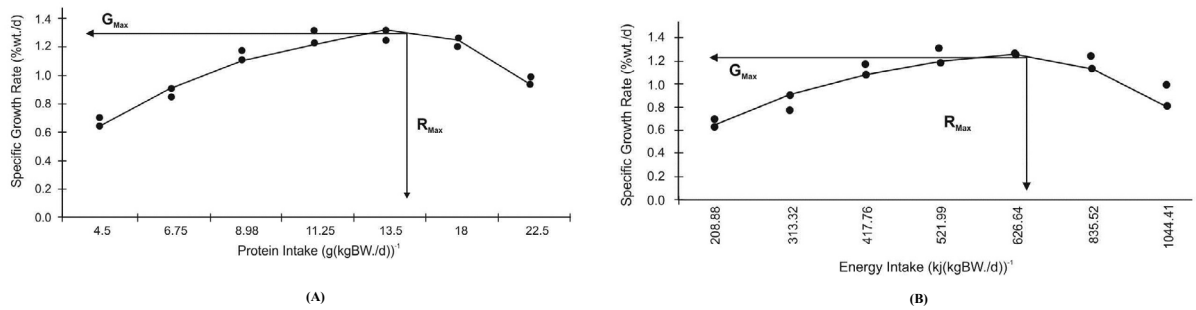

Figure 2: Effect of increasing level of protein and energy intake on growth (●) of fingerling fed with P45 diet.

Bw.d)$^{-1}$ and then it decreased significantly from lower to higher feeding levels. Similarly in P45 the feed conversion efficiency remained almost same up to a feeding level of 11.25 g protein (kg Bw.d)$^{-1}$ and 521.99 kJ energy (kg Bw.d)$^{-1}$ after which it decreased significantly except that at 8.98 g protein and 417.76 kJ energy (kg Bw.d)$^{-1}$. However, the protein and energy efficiency decreased progressively to give lowest value at highest feeding levels.

Except moisture, the carcass composition was affected by the varying feeding rates in both the diets (Tables 3-5). When the body protein content increased linearly up to a feeding level of 10.5 g protein (kg Bw.d)$^{-1}$ and 488.51 kJ energy (kg Bw.d)$^{-1}$ in P35 and 11.25 g protein (kg Bw.d)$^{-1}$ and 521.99 kJ energy (kg Bw.d)$^{-1}$ in P45, the crude fat content was found to be affected reversibly in both the diets. The second order regression analysis to the present data of protein and energy intake on the changes of the carcass protein level suggests significant (r^2=0.74) relationship in P35 (Figures 1A and 1B) but insignificant (r^2=0.4) in P45. The change in body protein content (y) to increasing levels of protein and energy intake (x) in P35 was described by the equations:

$Y=-0.529+0.363\ x-0.0154\ x^2$ for protein;

$Y=-0.053+0.008\ x-0.000007\ x^2$ for energy.

In P45 the said equations were described by:

$Y=0.2479+0.1638\ x-0.00687\ x^2$ for protein;

$Y=0.2475+0.00353\ x-0.000003\ x^2$ for energy.

The equations obtained from P 35 were thus, used to predict the amount of dietary protein and energy required to maintain a constant amount of body protein as in P45 the protein and energy intake levels have insignificant effect on carcass protein level. The maintenance requirements were worked out to be 1.58 g protein (kg Bw.d)$^{-1}$ and 71.4 kJ energy (kg Bw.d)$^{-1}$. The R_{max} value for body protein deposition

Protein g (kg Bw.d)$^{-1}$	Energy kJ (kg Bw.d)$^{-1}$	Moisture [%]	Protein[2] [%]	Fat[2] [%]	Ash[2] [%]
0	0	78.6^{a} ± 1.4	13.4^{bc} ± 0.4	1.08^{d} ± 0.06	5.8^{a} ± 1.3
3.50	162.84	72.21^{b} ± 1.4	17.9^{b} ± 0.8	3.60^{a} ± 0.03	3.6^{d} ± 0.5
5.25	244.46	72.6^{b} ± 1.9	18.2^{ab} ± 0.6	3.3^{ab} ± 0.02	3.9^{d} ± 0.8
7.0	325.67	71.7^{b} ± 1.7	18.5^{ab} ± 0.3	3.0^{a} ± 0.04	4.8^{b} ± 0.6
8.75	407.09	72.4^{b} ± 1.8	18.7^{ab} ± 0.9	2.98^{b} ± 0.02	4.9^{b} ± 0.8
10.50	488.51	71.7^{b} ± 1.9	19.0^{a} ± 0.9	2.86^{b} ± 0.02	5.1^{a} ± 0.9
14	651.34	72.5^{b} ± 1.6	18.6^{ab} ± 0.6	3.4^{ab} ± 0.08	4.6^{b} ± 0.8
17.50	814.18	72.8^{b} ± 1.9	18.8^{a} ± 0.8	3.5^{a} ± 0.05	4.8^{b} ± 0.7
Initial		73.0^{b} ± 1.8	17.5^{b} ± 0.2	1.95^{c} ± 0.04	4.2^{c} ± 0.3

Mean values with same superscript within the column are not different significantly ($p<0.05$)
[1]Means of three replicate groups ± SEM
[2]Expressed on wet weight basis

Table 3: Carcass composition of murrel fingerling fed different levels of the diet containing 35% crude protein and 1628.4 kJ 100^{-1} g energy (P35)[1].

Protein g (kg Bw.d)$^{-1}$	Energy kJ (kg Bw.d)$^{-1}$	Final average weight (g)	Feed conversion[2] efficiency	Protein conversion[3] efficiency	Energy conversion[4] efficiency
0	0	6.1^{e} ± 0.1	0	0	0
4.5	208.88	15.6^{d} ± 1.1	0.67^{a} ± 0.01	25.5^{a} ± 1.6	34.69^{a} ± 1.8
6.75	313.32	17.4^{c} ± 0.9	0.64^{a} ± 0.01	26.64^{a} ± 1.4	16.32^{b} ± 0.9
8.98	417.76	19.8^{b} ± 1.0	0.56^{b} ± 0.01	23.51^{b} ± 1.2	7.18^{c} ± 0.6
11.25	521.99	22.2^{a} ± 1.4	0.66^{a} ± 0.02	23.05^{b} ± 0.9	7.04^{c} ± 0.6
13.5	626.64	20.7^{ab} ± 0.8	0.50^{c} ± 0.01	8.43^{c} ± 0.3	5.30^{d} ± 0.6
18.0	835.52	20.5^{ab} ± 0.6	0.37^{d} ± 0.1	9.03^{c} ± 0.6	5.04^{d} ± 0.4
22.5	1044.41	19.4^{b} ± 0.9	0.27^{e} ± 0.01	3.62^{d} ± 0.1	3.37^{e} ± 0.2

Mean values with same superscript within the column are not different significantly ($p<0.05$)
[1]Mean of three replicate groups ± SE
[2]Wet weight gain/dry weight fed
[3]Final body protein-initial body protein × 100/total protein fed
[4]Final body energy-initial body energy × 100/total energy fed

Table 4: Final average weight and feed efficiencies of murrel fingerling fed different levels of the diet containing 45% crude protein and 2088.8 kJ 100 g^{-1} energy (P45)[1].

Protein g (kg Bw.d)$^{-1}$	Energy kJ(kg Bw.d)$^{-1}$	Moisture [%]	Protein[2] [%]	Fat[2] [%]	Ash[2] [%]
0	0	79.8^{a} ± 1.8	12.9^{c} ± 0.4	1.06^{f} ± 0.03	6.1^{a} ± 1.2
4.50	208.88	72.4^{b} ± 1.9	18.2^{bc} ± 0.6	2.81^{a} ± 0.08	4.6^{c} ± 0.8
6.75	313.32	72.6^{b} ± 1.8	18.6^{b} ± 0.5	2.29^{b} ± 0.08	5.3^{b} ± 0.6
8.98	417.76	72.9^{b} ± 1.1	18.8^{ab} ± 0.8	1.86^{e} ± 0.06	5.4^{b} ± 0.7
11.25	521.99	72.1^{b} ± 1.3	19.1^{a} ± 0.6	1.84^{e} ± 0.05	5.0^{bc} ± 0.8
13.50	626.64	72.0^{b} ± 1.6	18.2^{b} ± 0.9	2.18^{c} ± 0.08	4.8^{c} ± 0.9
18.00	835.52	72.2^{b} ± 1.9	18.5^{b} ± 0.4	2.20^{c} ± 0.07	5.1^{bc} ± 0.06
22.50	1044.41	72.2^{b} ± 1.4	18.0^{b} ± 0.3	2.23^{c} ± 0.09	5.3^{b} ± 1.1
Initial	-	73.0^{b} ± 1.8	17.5^{d} ± 0.2	1.95^{d} ± 0.04	4.2^{c} ± 0.3

Mean values with same superscript within the column are not different significantly ($p<0.05$)
[1]Means of three replicate groups ± SEM
[2]Expressed on wet weight basis

Table 5: Carcass composition of murrel fingerling fed different levels of the diet containing 45% crude protein and 2088.8 kJ 100 g^{-1} energy (P45)[1].

was calculated to be 11.8 g protein (kg Bw.d)$^{-1}$ and 571.4 kJ energy (kg Bw.d)$^{-1}$ with a predicted protein maximum (P_{max}) of 1.62 to 1.72% wt in P35 diet.

Discussion

The protein and energy intake at different feeding levels were found to affect the growth rate (Tables 2 and 4) and body protein content (Tables 3 and 5) with both the diets. In the present study on murrel fingerlings, the protein and energy requirements for maximum growth was determined to be 10.5 g protein (kg Bw. d)$^{-1}$ and 488.51 kJ energy (kg Bw.d)$^{-1}$. A lipid/protein ratio of 65/450 g kg^{-1} is considered adequate for good growth performance and survival of *Channa striatus* fry [2]. The percentage of protein required in the diet for maximum growth varies with feeding rate, digestibility, body size, culture conditions, water temperature etc. [29]. The higher protein and energy requirements observed for murrel fingerlings can be attributed to these factors [15]. Dayal et al. [30] have reported the influence of different sources of dietary lipid on the growth, feed efficiency and survival of snakehead *C. striatus* grow-out.

The feed efficiency of both diets was poor. Better feed efficiencies were observed at the feeding levels that gave maximum growth in both the diets. Poor feed conversion ratios were reported earlier for fingerlings [15] fry [12,13] of *Channa striata*, while studying their optimum dietary protein requirements for maximum growth. Since murrels are slow bottom feeders, the fingerlings took long time to consume the whole ration and the nutrient leaching thus caused has

not been recorded in this study. This may be the cause of poor feed efficiency.

The better utilization of diet is reflected not only in specific growth rate but also in protein and energy efficiency values. In general the feed efficiency was found to be better with 45% crude protein diet than that of 35% crude protein diet in murrels. Significant improvement was noticed in weight gain and SGR in *Channa argus* at both 45 and 48% dietary protein levels as dietary lipid level increased from 9 to 12%, which is suggested to be due to protein-sparing effect [31]. Another species of the same genus, spotted snakehead (*Channa punctatus*) also had the highest weight gain with dietary protein of 45% [32]. This may be caused mainly by deficiency in dietary amino acids as a result of inadequate dietary protein. In the present study, the energy efficiency was found to be higher at lower feeding rates and decreased gradually with the increase in feeding levels in both the diets. Similarly the protein efficiency increased at lower feeding rates in both the diets but decreased at higher feeding levels. In P35, it increased up to 7.0 g protein (kg Bw.d)$^{-1}$ and 325.67 kJ energy (kg Bw.d)$^{-1}$ and in P45, it increased up to 6.75 g protein (kg Bw.d) $^{-1}$ 313.32 kJ energy (kg Bw.d)$^{-1}$. Similar trend was reported earlier for channel catfish by Gatlin et al. [22].

The minimum protein required to maintain the body weight and tissue protein, determined in the present study for murrel fingerlings, was 0.3 g and 1.58 g protein (kg Bw.d)$^{-1}$, respectively. Similarly, the energy requirement of murrel fingerling to maintain constant body weight and tissue protein was recorded to be 16.6 kJ and 71.4 kJ (kg Bw.d)$^{-1}$, respectively. The protein and energy maintenance requirements determined for channel catfish, ranged from 1.00 to 1.32 g protein (kg Bw.d)$^{-1}$ and 15.06 to 17.33 kcal energy (kg Bw.d)$^{-1}$, respectively [22], which were lower than that recorded for murrel fingerlings except the protein requirement to maintain body weight. However, rainbow trout have a protein requirement of 1.6 g protein (kg Bw.d)$^{-1}$ for maximum growth [29,33], which is on an average similar to that of murrels. However, energy requirements reported for rainbow trout was lower (15 kcal) than that of murrel [34].

It was interesting to note that a lower protein (1.23 g protein (kg Bw.d)$^{-1}$) with higher energy (54.28 kJ energy (kg Bw.d)$^{-1}$) of P45 was equivalent to higher protein (1.88 g protein (kg Bw.d) $^{-1}$ with lower energy 51.43 kJ energy (kg Bw.d)$^{-1}$ of P35 to maintain constant body protein content. This establishes the protein sparing action of lipid as was suggested by Sagada et al. [31]. The lipid from unsaturated origins could be effectively utilized by striped murrel fingerling with a better resultant growth [35].

Effect of varying levels of feeding on the proximate composition was mainly observed in crude protein and fat content of carcass. With the increase in dietary protein and energy levels up to maximum growth, in both the diets, the crude protein content increased with a decrease in lipid content. Similar trends were reported earlier for the murrel fingerling while studying their protein requirement for maximum growth [15] and fry of *Channa straiata* [12,13]. Highest whole-body protein found in *Channa argus* fed the highest protein diet [31] was comparable with reports by Chen et al. [36] and Wang et al. [37] on other fishes.

The 2nd order polynomial regression analysis has frequently been used not only for estimating protein and nutrient requirements of fish but also in estimating maximum and/or optimum ration level [35]. The R_{max} determined in the present study for murrel fingerling ranged from 11.8 to 14.7 g protein (kg Bw.d)$^{-1}$ and 571.4-666.6 kJ (kg Bw.d)$^{-1}$ depending on whether body protein content or growth rate were the determining criteria. From the R_{max} the corresponding G_{max} and P_{max} were predicted. No report is available in this regard for any fish species .

Hence, it is clear from the present study that a proper feeding level is to be maintained to provide required ration for maximum growth and to reduce feed loss.

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