Utilization of Lipid as Dietary Energy Source for Fingerlings of *Channa striatus*

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ABSTRACT   An experiment was carried out to determine the dietary lipid requirement of the fingerlings of the striped murrel *Channa striatus*. Cod liver oil was used as a source of lipid and six crude lipid levels (7.54 – 22.3%) and energy levels (3.54 – 4.38 kcal/g) were selected. Each diet was given as 3% of total wet body weight in two equal rations to triplicate groups of 20 fingerlings with an average individual weight of 0.62 ± 0.22g in cement aquaria (capacity: 500 l) for 8 weeks. Growth rate was the highest in fingerlings fed at 13.54% lipid diet, where the conversion was the lowest (1.33) and the specific growth rate was the highest (2.15%/day). Dietary lipid produced a significant difference in the growth of *C. striatus*.

(*Channa striatus*, lipid, dietary requirement, growth rate)

INTRODUCTION

Lipids are important in the fish diets as a source of energy [1, 2, 3 and 4], essential fatty acids, sterols, phospholipids (as carriers of fat soluble vitamins A, D, E and K) and pigments in lipid transport. They provide flavors and textural properties to the fish feed [5]. Previous studies indicated that fish could use 20-30% of dry diet ingredients as fat, provided adequate amount of choline, methionine and tocopherol are present in the ration [1 and 6]. Moreover lipids have a distinct advantage of being almost completely digestible. In fish ration the natural lipid component is useful for diet formulation and is especially desirable in feeds of fry and fingerlings, which require high energy intake for rapid growth. The principal gross signs of essential fatty acids deficiency reported for various fishes are dermal signs (fin rot), a shock syndrome, myocarditis, reduced growth rate, reduced feed efficiency and increased mortality [7, 8 and 9]. The reduction of protein percentage in feed formulation and increase in dietary lipid level to compensate the protein for energy not only increase the fish growth but also reduce the feed cost from an economic point of view [10 and 11].

Hence the present study was carried out to determine the dietary lipid requirement of the fingerlings of the snakehead *Channa striatus*.

MATERIALS AND METHODS

The induced bred fingerlings of *C. striatus* were collected from CARE aquafarm and they were stocked in cement aquaria (3m x 1.5m x 1m) and acclimatized for one week. During the period of acclimatization they were exposed to 0.5% solution of potassium permanganate ($KMnO_4$) on every alternate day for a period of five minutes to prevent any infection prior to start the experiment and were fed *ad libitum* on finely chopped chicken intestine [12]. During the experimental period dissolved oxygen 5.8 ± 0.5 mgO_2 / l, water temperature 28 ± 1^{0}C, photoperiod 13 L/11D and pH 6.8 – 7.5 were recorded.

Feed ingredients and waste output can scientifically be estimated based on:
i.   Prediction of growth and nutrient and energy gains
ii.   Estimation of excretory and feed waste outputs
iii. Quantification of energy and nutrient needs
Six diets containing 7.54%, 9.54%, 13.54%, 19.80% and 22.30% lipids were prepared (Table

1) followed by Haniffa and Jesu [4]. The diets were formulated in such a way that they contain all predicted essential nutrients in equal quantity except the level of lipid. The dry ingredients of each diet were mixed in a mixer for about 10 minutes. Cod liver oil was gradually added to the mixture [3] and the ingredients were mixed for another five minutes. Subsequently a sufficient quantity of water was added to the dry mixture, blended for another five minutes and extruded through 1mm die. The freshly prepared extruded semi moist pellets were shade dried to maintain moist level below 15% before feeding the test fish. The stability of the semi moist diet was analyzed according to Farmin *et al.* [13].

After ensuring complete evacuation of their guts by starving them for 24 hours, the fingerlings were randomly selected with an average length and body weight of 4.07 ± 0.56cm and 0.62 ± 0.12gm respectively. Twenty fish were introduced into each aquaria (capacity 500 l) and triplicates were maintained for each diet. Since air breathing fishes like murrels do not readily accept pelleted feed [14] and hence *C. striatus* fingerlings were supplied with semi moist pellet (at 9 and 16 hours).

Whenever test fish died, they were recorded and replaced. Faeces were collected from the aquaria every morning prior to feeding [15]. The unfed was collected two hours after feeding with minimal disturbance to test fish and were dried at 60^0C in a hot air oven [15] and weighed for further calculations. The length and weight of the test fish were measured every fortnight. The scheme of energy budget followed in the present work is that of the IBP formula of Petrusewicz and Macfadyen [16][1] Specific growth rate is widely used to describe growth rate of fish. Fish growth rate expression: Specific growth rate (SGR), which is based on the natural logarithmic of body weight.

SGR = (ln FBW – ln IBW)/D
FBW = Final body weight
IBW = Initial body weight
D = Number of days

Food conservation ratio (FCR) (dry food intake / live weight gain), protein efficiency ratio (PER) (live weight gain / dry protein intake) and

average daily gain (ADG) (live weight gain / experimental duration) were calculated according to Petrusewicz and Macfadyen [16].

Gross energy values were calculated based on standard physiological values of 4.5 Kcal/g proteins [17], 3.49 Kcal/g carbohydrates [18] and 8.51 Kcal/g fats [19]. The protein, lipid and carbohydrate of the diets were calculated according to Haniffa and Jesu [4]. The data were subjected to one way ANOVA and the mean differences were analyzed by Tukey's multiple range tests [20].

RESULTS AND DISCUSSION

The proximate composition of the feed ingredients is reported in Table 1. All the six prepared diets were isoprotein in nature (49.32% - 49.94%). Lipid level varied between 7.54% and 22.30% and carbohydrate level ranged from 7.68% to 18.66% (Table 1). In the present study *C. striatus* readily accepted all the six diets and survival was the highest (97.5%) in D6 followed by D3 (95%), D2 (85%), D5 (65%), D1 (40%) and D4 (35%). Akand *et al.* [21] formulated eight isoprotein diets (34.8% - 3.53%) with variation in the lipid level from 2.8 to 14.9% for *H. fossilis* and reported 82% to 93% survival.

Feeding rate of *C. striatus* ranged between 14.5 mg/g/day in D1 and 25.2 mg/g/day in D4. Pandian [22] suggested that the dietary protein level might determine the feeding rate of herbivores but not carnivores [6 and 23]. Since the diets are isoprotein in the present study any conclusion could not be arrived between dietary protein level and the feeding rate. But it is possible to suggest that lipids contain more energy / unit weight than any other dietary component and they are used efficiently by fish as energy sources [4]. In the present investigation feeding rates were high (22.5 – 25.2 mg/g/day) for the lipids level between 13.5 – 19.8%. Test diet containing (D6) the highest lipid level of 22.3% produced not only a decrease in feeding rate (15.9 mg/g/day) but also conversion rate (3.5 mg/g/day) (Table 2) and the difference were statistically significant ($p < 0.001$).

According to Bogut and Opacak [24] the optimum growth was attained in *Oncorhynchus kistuch, O. keta, O. nerka, O. tshawytsch and O. mykiss* at 9.5% level of lipid. Lipid requirement of African fish species *viz., Clarias gairepinus,*

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[1] Consumption = Production + Respiration + Faeces + Urine

C. isheriensis, Heterobranchus longifilis, H. kidorsalis, Asian species *viz., C. batrachus, C. macrocephalus, C. fucus* and *Heteropneustes fossilis* and European specis *viz., Silunis glanis* ranged between 5%e and 10% [25]. However in *Dendex dendex* diets containing 17.3% lipid produced better growth [25]. De Silva and Anderson [26] recommended 10-20.5% lipid in fish diet for optimal growth without any excessive fatty carcass. However the optimum lipid requirements of Indian major carps and common carp were determined as 4-6% [27, 28].

From an initial body weight of 620mg, *C. striatus* fed on D3 (14% lipid level) reached 2.26g followed by 2.01g in D5 after eight weeks. Poor growth recorded in D1 and D2 could be due to low lipid level. The value obtained for average daily gain (ADG) was also very high (2.13mg/day) in D3 followed by 1.98 mg/day in D5 (Table 3). ADG was significantly different ($p<0.001$) with the dietary lipid level. The SGR increased from 1.185%/day to 2.15%/day with increase in dietary lipid level from 7.5 to 13.5% and thereafter decreased. Similar results are also available for *Cirrhinus mrigala* and *H. fossilis* (13% lipid level) [6] in the literature.

For instance SGR increased from 1.62%/day to 1.98%/day with the increase in lipid level from 3-10% and after that the SGR decreased in *H. fossilis* [29]. The highest SGR (2.15%/day) was observed in *C. striatus* fed diet, which contained 13.5% lipid and 3.88 Kcal/g of energy. Previous authors suggested that the high energy content in the diet could be the reason for the decreasing SGR and weight gain and also found an inverse relationship between dietary energy and growth [11, 30 and 31]. Diet 3 containing 13.5% dietary lipid level was significantly different ($p<0.001$) with the other treatments in terms of SGR.

Akand *et al.* [21] reported FCR values ranging between 1.6 and 2.3 for *H. fossilis* and *Clarias batrachus.* FCR calculated in the present study ranged between 1.3 and 2.7 and FCR was better among the groups, where SGR and weight gain were also high (D3 and D5) and FCR was statistically significant ($p<0.001$) with the dietary level. PER values ranged between 1.14 and 1.31 among the test diets. Increasing dietary lipid level produced elevated values in PER and similar trend was also noticed by Page and Andrews [30] Daniels and Robinson [31]. Low PER values obtained in D1 and D2 could be due to inadequate dietary lipid as suggested by Daniels and Robinson [31] and Haniffa and Jesu [4]. In terms of PER there was no significant difference except in diet 5. Since Diet 3 produced the best results with regard to SGR, FCR and PER, it is possible to suggest that 14% lipid level is optimum for rearing fingerlings of *C. striatus.*

Table 1. Percentage and proximate composition of ingredients in the formulated diets

Ingredients (%)	1	2	3	4	5	6
Chicken intestine	70	70	70	70	70	70
Dextrin	14.5	12.5	10.5	10	8	4.5
Rice bran	10	10	8	6.5	5	5
Cod liver oil	0	1	3	5	9.5	12
Ground nut oil cake	0	1	3	3	3	3
Cellulose	1.5	1.5	1.5	1.5	1.5	1.5
Mineral mix[2]	2	2	2	2	2	2
Vitamin mix[3]	2	2	2	2	2	2
Nutrient contents						
Protein (%)	49.99	49.99	49.72	49.52	49.32	49.32
Carbohydrate (%)	18.66	16.66	14.27	13.47	11.18	7.68
Lipid (%)	7.54	9.54	13.54	15.38	19.80	22.30
Gross energy (Kcal/g)	3.54	3.64	3.87	4.00	4.29	4.38

[2] Trace mineral mix use providing the following concentration (ppm) Cu 10; Fe 100; Mn 50; Zn 50; Co 0.05; and I 0.1.
[3] Vitamin mixture providing the following concentration per kg diet. Vitamin A 5000 IU; Vitamin D 400 IU; Vitamin E 20mg; Thiamin mononitrate (B1) 4mg; Riboflavin (B2) 6mg; Nictotinamide 50mg; Pyridoxine 3mg; Calcium patothenate 10mg; Cyanocobalmia (B12) 2mg; Ascorbic acid (Vitamin C) 100mg; Biotin 0.1mg.

Table 2.   Energy budget of *C. striatus* fed on diets with different lipid levels (x̄ ± SD)

Diet	Consumption rate (mg/g/day)	Absorption rate (mg/g/day)	Absorption efficiency (%)	Conversion rate (mg/g/day)	Gross conversion efficiency (%)	Net. Conversion efficiency (%)	Metabolic rate (mg/g/day)
D1	14.46[a] ± 0.48	10.30[a] ± 1.02	71.15[a] ± 4.73	4.96[b] ± 1.30	32.3[c] ± 7.19	45.05[e] ± 8.13	5.6[a] ± 0.27
D2	17.65[b] ± 1.62	14.57[b] ± 1.72	82.4[c] ± 2.4	5.61[b] ± 0.82	32.0[c] ± 7.63	39.0[d] ± 10.32	8.99[b] ± 2.5
D3	22.5[c] ± 1.37	20.03[c] ± 1.37	88.79[d] ± 1.75	7.88[c] ± 1.09	34.95[d] ± 0.21	39.4[a] ± 0.98	12.14[c] ± 1.03
D4	25.21[d] ± 1.42	22.9[d] ± 1.55	90.80[e] ± 1.08	4.83[b] ± 1.09	19.3[a] ± 5.37	21.25[a] ± 6.15	17.75[d] ± 2.12
D5	24.45[d] ± 0.63	22.05[d] ± 0.77	90.3 [e] ± 0.55	5.56[b] ± 1.15	22.75[b] ± 5.44	25.2[b] ± 6.08	16.09[d] ± 1.27
D6	15.87[a] ± 0.82	13.07[b] ± 0.24	79.84[b] ± 1.04	3.52[a] ± 0.20	22.25[b] ± 2.47	28.25[c] ± 3.88	9.14[b] ± 1.02

Similar alphabet did not significantly differ at *p<0.001* level

Table 3.   Survival and growth response of *C. striatus* fed on diets with different lipid levels (x̄ ± SD)

Diet	Initial weight (g)	Final weight (g)	FCR	PER	ADG (mg/day)	SGR (%/day)	Survival (%)
D1	0.62[a] ± 0.12	1.78[a] ± 0.21	2.65[a] ± 0.21	1.14[a] ± 0.01	1.22[a] ± 0.11	1.18[a] ± 0.15	40[a] ± 4.24
D2	0.62[a] ± 0.12	1.82[a] ± 0.23	2.56[c] ± 0.12	1.17[a] ± 0.02	1.47[b] ± 0.15	1.22[a] ± 0.18	85[c] ± 0
D3	0.62[a] ± 0.12	2.26[c] ± 0.15	1.33[a] ± 0.09	1.21[a] ± 0.28	2.13[d] ± 0.14	2.15[c] ± 0.11	95[d] ± 4.07
D4	0.62[a] ± 0.12	21.99[b] ± 0.13	1.66[b] ± 0.04	1.23[a] ± 0.26	1.79[c] ± 0.12	1.33[b] ± 0.21	35[a] ± 3.52
D5	0.62[a] ± 0.12	2.01[c] ± 0.11	1.52[c] ± 0.09	1.31[b] ± 0.09	1.98[c] ± 0.2	1.49[b] ± 0.15	65[b] ± 3.52
D6	0.62[a] ± 0.12	1.89[a] ± 0.11	2.37[c] ± 0.11	1.22[a] ± 0.14	1.55[b] ± 0.14	1.28[b] ± 0.16	97.5[d] ± 3.53

Similar alphabet did not significantly differ at *p<0.001* level

REFERENCES

1. Lee, D.J. and Sinnhuber, R.O. (1972). Lipid requirements p: 145-180. In J.E. Halver (ed). *Fish Nutrition*. Acedemic Pres. Inc. New York. NY.
2. Watanabe, T. (1982). Lipid nutrition in fish. *Comp. Biochem. Physiol* **73**, 3-15 pp.
3. Sargent, J.R., Henderson, T. and Techer, D.R. (1989). The lipids in fish nutrition. J.E. Halver (ed) Academic Press, Inc. New York, 153-218 pp.
4. Haniffa, M.A. and Jesu, A. (1999). Dietary lipid requirement in the fingerlings of *Channa striatus* (Bloch). *In Nat. Sym. On Sustainable Development of Fisheries Towards 2020 AD – Opportunities & Challenges*. Univ. of Science and Technology, Cochin Abst. No: ADS 29
5. Paulraj, R. (1993). Hand book in aquafarming and auaculture feed. Published by MPEDA, Cochin INDAQUA, 93 pp.
6. Marimuthu, K. and Sukumaran, N. (2001). Effect of dietary lipid levels on growth and survival of fingerlings of *Cirrhinus mrigala. Fish. Technol.* **38**(1), 48- 50 pp.
7. Castell, J.D., Sinnhuber, R.O., Wales, J.H and Lee, D.J (1972). Essential fatty acids in the diet of rainbow trout (*Salmo gairdneri*) growth, feed conversion and some gross deficiency symptoms. *J. Nutr.* **102**, 77 – 86.
8. Takeuchi, T and Watanabe, T. (1977). Requirement of essential fatty acids for carp fingerling. *Bull. Jpn. Soc. Sci. Fish*, **43**, 541 – 551 pp.
9. Sastoh, S., Poe, W.E. and Wilson, R.P (1989). Effect of dietary n-3 fatty acids on

weight gain and liver polar lipid fatty acid composition of fingerling channel catfish. *J. Nutr,* **119**, 23 – 28 pp.

10. Phillip, A.M., Livingstone, D.L. and Postan, H.A. (1969). The effect of changes in protein quality, calorie sources and calorie levels up to the growth and chemical composition of book mount. *Fish. Bull.* **29**, 6-14 pp.

11. Sethuramalingam, T.A. (2001). Interaction of dietary protein and lipid levels on growth and carcass composition in *Cirrhinus mrigala* fry. *J. Natcon* **13**(1), 15-23 pp.

12. Josemon, P.K., Haniffa, M.A., Sethuramalingam, T.A. and Arulselvan, V. (1994). Chicken intestine as a supplementary protein source for potential murrel culture. *In Proceedings of the National Symposium on Aquaculture for 2000 AD,* 263-267 pp.

13. Farman, A., Lauterio, T. and Ibe, V. (1982). Improvement of the stability of commercial feed pellets for the giant shrimp *Macrobrachium rosenbergii. Aquaculture* **27**, 29-41 pp.

14. De Silva, S.S., Gunesekara, R.M. and Attapattu, D. (1989). Dietary protein requirement of young tilapia and evaluation of least cost dietary protein levels. *Aquaculture* **80**, 271-282 pp.

15. Haniffa, M.A. and Arulselvan, S. (1990). Studies on food utilization of *Oreochromis mossambicus* fed on formulated diets. *In National Seminor on Aquaculture Development in India-Problems and Prospects* No. 27-29. Kerala Univ. Trivandrum.

16. Petrusewicz, K. and Macfadyen, A. (1970). Productivity of terrestrial animals, IBP Hand book no. 13 Black well. Scientific publications, Oxford.

17. Smith, B.W. and Lovell, R.J. (1973). Determination of apparent protein digestibility in feeds for channel catfish. *Trans. Amer. Fish. Soc.* **102,** 831-835 pp.

18. Chiou, J.Y. and Ogino, C. (1975). Digestibility of starch in carp. *Bull. Japan Soc. Fish* **41**, 465-466 pp.

19. Austerng, E. (1978). Digestibility determination in fish using chromic oxide marking and analysis of content from different segments of the gastro intestinal tract. *Aquaculture* **13**, 265-272 pp.

20. Zar, J.H. (1984). Biostatistical analysis, 2nd Edition, Prentice – Hall Englewood Chaffs, New Delhi pp. 84 -170 pp.

21. Akand, A.M., Mia, M.I. and Haque, M.M. (1989). Effect of dietary protein level on growth, food conversion and body composition of 'shingi' (*Heteropneustes fossilis*). *Aquaculture* **77**, 175-180 pp.

22. Pandian, T.J. (1987). Fish energetics. In T.J. Pandian and Vernberg (eds.), *Animal Energetics,* Academic press, New York

23. Jobling, M. (1981). The influence of feeding on the metabolic rate of fishes a short review. *J. Fish Biol.* **18**, 85 400 pp.

24. Bogut, I. and Opacak, A. (1996). The needs and importance of fatty acids in the nutrition of fishes. *Ribarstov.* **101**(54), 75-91 pp.

25. Kalogeropouls, N., Alexis, M.N. and Henderson, R.J. (1992). Effects of dietary soybean and cod liver oil levels on growth and body composition of gilthead bream (*Sparus aurata*). *Aquaculture* **104**, 293-309.

26. De Silva, S.S. and Anderson, A.T. (1995). Fish nutrition in aquaculture, printed in Great Brittan, 1-180 pp.

27. Singh, B.N. (1990). Fish nutrition – nutritional requirements, digestibility and feed formulation. Abstract, P.8. *In Symposition on Modern Trend in Fish Biology Research.* 17-20 January 1990 at Bhagalpur.

28. Singh, B.N. (1991). Digestibility of lipid in different feeds by mrigal (*Cirrhinus mrigala*) (Ham) and grass carp (*Cternopharyngodon idella*) (Val) P. 83-86. In S.S. Desilva (ed) *Fish Nutrition Research in Asia. Proceedings of the Fourth Asian Fish Nutrition Workshop.* Asian Fish. Soc. Spell.Pub. **5**, 205 pp. Asian Fisheries Society, Manilla, Phillipines.

29. Akand, A.M., Hasan, M.R. and Habib, M.A.B. (1991). Utilization of carbohydrate and lipid as dietary energy source by stining catfish *Heteropneustes fossilis* (Bloch) P. 93-100. In S.S. Desilva (ed) *Fish Nutrition Research in Asia. Proceedings of the Fourth Asian Fish Nutrition Workshop.* Asian Fish. Soc. Spell. Pub. 5, 205p. Asian Fisheries Society, Manila, Philippines.

30. Page, J.W. and Andrews, J.W. (1973). Interaction of dietary levels of protein energy on channel catfish (*Ictalurus punctatus*) *J. Nutr.* **103**, 139-149 pp.

31. Daniels, W.H and Robinson, E.H. (1986). Protein energy requirements of juvenile red drum (*Sciaenops ocellatus*). *Aquaculture* **53**, 243-252 pp.