ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XXVIII, Fasc. 1 Szczecin 1998

Amlan Krishan *SAHA*, Arun Kumar *RAY*

Aquaculture

PERFORMANCE OF ROHU, *LABEO ROHITA* (HAMILTON), FINGERLINGS MAINTAINED ON ALTERNATE FEEDING OF PLANT AND ANIMAL PROTEIN BASED DIETS

EFEKTY ŻYWIENIA PALCZAKÓW *LABEO ROHITA* (HAMILTON) ALTERNATYWNĄ PASZĄ OPARTĄ O BIAŁKA ROŚLINNE I ZWIERZĘCE

Department of Zoology, Visva-Bharati University, West Bengal, India

To understand the applicability of mixed feeding schedule in the fingerlings of the Indian major carp—rohu, *Labeo rohita*, an 80-day feeding experiment was conducted in the laboratory involving alternate feeding of plant and animal protein based diets with low and high levels of proteins, respectively. Feeding one day with soaked *Leucaena* ('subabul'/'ipil-ipil') leaf meal based diet, followed by three days of animal protein (fish meal) based diet (feeding schedule 1S/3F) resulted in better performance of rohu in terms of live weight gain (%), SGR (%/day) and FCR as compared to those fed continuously with animal protein based diet (schedule F). Schedule 1S/3F also resulted in higher protein deposition in muscle and protein efficiency ratio. The results are expected to open up a new avenue to develop better feeding strategies with a view of reducing feed input cost by incorporating plant ingredients in the diets and by taking advantage of the existing natural variations in daily digestibility of protein.

INTRODUCTION

Aquatic animals are more sensitive to feed quality than terrestrial animals. This implies that closer attention must be given while formulating aquafeeds. At the same time the ingredients must also be cost-effective (Akiyama 1991). The increasing cost of the fish feed has focused research on reducing the cost of the most expensive item, the protein source (Wee and Wang 1987) through proper formulation adopting economic feeding strategies. FAO (Anonymous 1993) also recommended for utilising locally available in-

gredients, after processing them through simple and cheap methods to increase their nutritional value. The efficacy of various plants protein sources for partial or complete replacement of fish meal in aquafeeds has been investigated by a number of workers (Atack and Matty 1979; Viola et al. 1982; Tacon 1993; Ray and Das 1995). *Labeo rohita* is primarily a herbivorous to omnivorous species and prefers to feed on plant materials (Talwar and Jhingran 1991). But dietary formulations consisting solely of plant proteins in complete diets for tilapia have not yielded results comparable to those of fish meal (Jackson et al. 1982). However, due to comparative high values for apparent protein digestibility coefficient of plant feedstuffs (Wee 1991), it is perhaps necessary to reconsider the whole concept. On the other hand, Indian major carp need 30–40% protein content within diets (Shetty and Nandeesha 1988). But it was not known whether they require the same level of protein everyday in their diet or not. De Silva (1985) conclusively opined that feeding fish everyday with the same level of protein is not economical. Based on these facts we did this experiment to judge the applicability of mixed feeding schedule in rohu fingerling including the plant protein diet in the schedule, rather than including that through partial replacement of fish meal.

MATERIAL AND METHODS

Experimental diets and feeding schedules

Two diets were formulated for this experiment, viz., diet ED-I, consisting only of plant protein derived largely from 'subabul' (*Leucaena leucocephala*) leaf meal and diet ED-II, consisting fish meal as the source of animal protein. Diet ED-I had 30% leaf meal and diet ED-II had 30% fish meal (Tab. 1, 2). The 'subabul' leaf meal was used after soaking in water for 48 hours and them sundrying to eliminate mimosine—the toxic amino acid, according to Wee and Wang (1987).

Table 1

Experimental diets and feeding schedules

ED-I	Experimental Diet-I Diet with plant protein source—'subabul' leaf meal
ED-II	Experimental Diet-II Diet with animal protein (fish meal) source
Feeding schedules	
S	Group of fish fed continuously ED-I, throughout the experiment
F	Group of fish fed continuously ED-II, throughout the experiment
1S/3F	Group of fish fed one day ED-I, followed by three days with ED-II and repetition of the same schedule throughout the experiment
2S/3F	Group of fish fed two days ED-I, followed by three days with ED-II and repetition of the same schedule throughout the experiment

Table 2

Ingredient composition of the diet (% dry weight)

Ingredient composition (%)	Diets	
	ED-I	ED-II
Leaf meal	30.0	—
Fish meal	—	30.0
Mustard oilcake	39.0	39.0
Rice bran	25.0	25.0
Vit. min. mixture*	1.0	1.0
Binder**	5.0	5.0
Total	100.0	100.0

* Vitaminetes forte (Roche India Ltd., Mumbai).

** Carboxymethylcellulose.

In the experiment, four different feeding schedules (Tab. 1) were tried viz., (i) feeding fish continuously with ED-I (S), (ii) feeding fish continuously with ED-II (F), (iii) feeding one day with ED-I, followed by three days with ED-II (1S/3F), (iv) feeding two days with ED-I, followed by three days with ED-II (2S/3F).

Experimental design

The experiment was conducted for eighty days, in recirculating glass aquaria (76 × 35 × 40 cm) each containing 75 dm^3 of water from a deep tubewell, with continuous aeration. *Labeo rohita* (Ham.) fingerlings were obtained from a local fish seed dealer and acclimated to the laboratory conditions for 15 days, prior to the commencement of the experiment, and fed with a 1:1 mixture of rice bran and mustard oilcake. Fish fingerlings (mean weight 7.51 ±0.55 g) were randomly distributed at the rate of 10 fish per aquarium with three replications for each feeding schedule. All fish were fed according to the respective schedule, twice a day at 9:00 hours and at 15:00 hours, feeding rate being 5% of the body weight per day. The rate was adjusted every 10 days after weighing each group of fish. Fish were exposed to their respective diets continuously for three hours during each ration, and then the uneaten feed were taken out and stored separately for calculating the feed conversion ratio. At the termination of the experiment, all the fish were weighed individually; lengths were measured and used for subsequent analyses. The ranges of water parameters were as follows: temperature: 27.0–31.5°C, pH: 7.38–7.86, dissolved oxygen content: 6.5–8.5 mg/ dm^3.

Chemical analyses

Feed ingredients, experimental diets and the fish muscle composition (initial and final) were analysed for proximate composition (%) following the procedures described by AOAC (Anonymous 1990). The water quality parameters were monitored following the methods outlined by APHA (Anonymous 1980).

Data collection and statistical analysis

The following indices were calculated:

$$\text{Average live weight gain} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Initial body weight}} \times 100\ (\%)$$

$$\text{Specific growth rate (SGR)} = \frac{\ln \text{final body weight} - \ln \text{initial body weight}}{\text{Days of trial}} \times 100 \text{ (\%/day)}$$

$$\text{Fed conversion ratio (FCR)} = \frac{\text{Dry weight of feed consumed}}{\text{Wet weight gain of fish}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Wet weight gain of fish}}{\text{Protein intake}}$$

$$\text{Apparent net protein utisation (ANPU)} = \frac{\text{Net increase in carcass protein}}{\text{Protein consumed}} \times 100 \text{ (\%)}$$

Analysis of variance (ANOVA) followed by Duncan's multiple range test (Duncan 1955) was employed to test the difference between means.

RESULTS

Table 3

Proximate composition (%) of the diets (on dry matter basis)

Proximate composition (%)	Diets	
	ED-I	ED-II
Dry matter	95.43	95.22
Protein	23.76	34.42
Lipid	6.42	6.78
Ash	11.62	12.51
Crude fibre	16.39	10.23
Nitrogen-free extract	37.24	30.87
Gross energy (kcal/g)	4.14	4.27

Diets

The proximate composition of the formulated diets is presented in Tab. 3, which showed higher level of protein (34.42%) in diet ED-II. The protein content of diet ED-I, containing plant protein source, was lower (23.76%). Dry matter, lipid, and ash contents varied within a close range (95.22–95.43%, 6.42–6.78% and 11.62–12.51% respectively) in the two experimental diets (Tab. 3). Both diets were almost isocaloric (4.14 kcal/g and 4.27 kcal/g in diets ED-I and ED-II respectively).

Fish growth

The performance of the fish in terms of length and weight increments, average live weight gain (%), SGR (%/day), FCR, PER, ANPU (%) and survival rate maintained at different schedules, is depicted in Tab. 4. The final length (12.80 cm) and body weight (22.87 g), average live weight gain (205.1%), and SGR (1.39%/day)of the fish reared on schedule 1S/3F were significantly ($P < 0.05$) higher than those reared continuously on the fish meal based diet (schedule F). But the fish reared on other two feeding schedules, viz., S and 2S/3F, resulted in poor performances. The fish with schedule F attained the final

body weight 20.29 g and the average live weight gain and SGR were 169.6% and 1.23%/day respectively.

Table 4

The performance of *Labeo rohita* fingerlings maintained on different feeding schedules for 80 days

Parameters	Feeding schedules			
	S	F	1S/3F	2S/3F
Final body length (cm) *	11.35 ± 0.54 [a]	12.14 ± 0.43 [b]	12.80 ± 0.36 [c]	11.58 ± 0.55 [a]
Final body weight (g) **	15.71 ± 0.45 [a]	20.29 ± 0.38 [c]	22.87 ± 0.60 [d]	16.20 ± 0.45 [b]
Average live weight gain (%)	109.6 [a]	169.6 [c]	205.1 [d]	115.4 [b]
SGR (%/day)	0.92 [a]	1.23 [b]	1.39 [c]	0.95 [a]
PER	1.39 [a]	1.92 [c]	1.97 [c]	1.46 [b]
FCR	3.24 [c]	2.26 [b]	1.93 [a]	3.11 [c]
ANPU (%)	25.77 [a]	30.24 [c]	31.86 [c]	27.63 [b]
Survival rate (%)	85	100	100	90

* Initial body length = 9.22 ± 0.45 cm

** Initial body weight = 7.51 ± 0.55 g

Values having the same superscripts in the same row are not significantly different ($P < 0.05$).

Values in the parentheses indicate standard deviations.

The PER and ANPU (%) did not show any significant difference between the schedules F (1.92 and 30.24% respectively) and 1S/3F (1.97 and 31.86% respectively). The FCR was however, found to be better with schedule 1S/3F (1.93) than that with schedule F (2.26). On the other hand, the FCR was poor with schedule S and 2S/3F, being 3.24 and 3.11 respectively. These feeding schedules also resulted in lower PER (1.39 and 1.46) and ANPU (25.77 and 27.63%). Throughout the experimental period no mortality of fish was recorded with feeding schedules F and 1S/3F. The survival rate of fish, reared on other schedules, was also noted satisfactory, being 85% and 90% with schedules S and 2S/3F respectively (Tab. 4).

Fish muscle composition

The biochemical composition of skeletal muscle of the fish maintained on different feeding schedules is presented in Tab. 5. No significant difference in moisture (75.21 and 75.08%) and ash (1.24 and 1.28%) contents was noticed in fish reared on schedules F and 1S/3F, respectively. Whereas, levels of muscle moisture (77.18 and 76.85%) and ash (1.41 and 1.37%) were significantly ($P < 0.05$) higher in fish with other two (S and 2S/3F) treatments. Muscle protein (15.15 and 15.65%) and lipid contents (3.89 and 4.07%) also did not vary significantly among the fish reared on the former two schedules (F and 1S/3F respectively), while, protein (13.46 to 13.58%) and lipid (3.52 to 3.64%) contents in fish muscle remained significantly ($P < 0.05$) lower in other two schedules, S and 2S/3F (Tab. 5).

Table 5

Proximate muscle composition (% wet weight) of *Labeo rohita* fingerlings at the beginning and termination of 80-day feeding trial

Muscle composition	Initial value	Final values			
		S	F	1S/3F	2S/3F
Moisture	81.53 ± 0.32	77.18 ± 0.45 ^{b}	75.21 ± 0.56 ^{a}	75.08 ± 0.60 ^{a}	76.85 ± 0.42 ^{b}
Protein	11.51 ± 0.76	13.46 ± 0.55 ^{a}	15.18 ± 0.64 ^{b}	15.65 ± 0.58 ^{b}	13.58 ± 0.50 ^{a}
Lipid	2.37 ± 0.35	3.52 ± 0.26 ^{a}	3.89 ± 0.30 ^{bc}	4.07 ± 0.24 ^{c}	3.64 ± 0.31 ^{ab}
Ash	1.58 ± 0.26	1.41 ± 0.25 ^{c}	1.24 ± 0.18 ^{a}	1.28 ± 0.31 ^{ab}	1.37 ± 0.27 ^{bc}

Values having the same superscripts in the same row are not significantly different ($P < 0.05$).
Values in the parentheses indicate standard deviations.

DISCUSSION

Feed input in the single largest operational cost in majority of aquacultural practices (De Silva 1985). Fish nutrition investigations are mainly directed towards reducing feed cost through substitution of the expensive dietary components, specially the protein sources (Cruz and Laudencia 1977; Jackson et al. 1982; Viola and Arieli 1983). The significant findings of De Silva and Perera (1983, 1984) on the existence of rhythmicity in the digestibility of protein in cichlids have opened up new ways of reducing feed cost. De Silva (1985) conclusively proved the existence of daily variations in dry matter and protein digestibility and opined that feeding fish everyday with the same level of protein is not economical. Based on this theory, this experiment was conducted to test the applicability of mixed feeding schedules in *Labeo rohita* fingerlings with alternate feeding of plant and animal protein based low and high protein diets.

Diet composition

In the present study, diet ED-I contained no fish meal, while diet ED-II was largely based on fish meal protein. Soaked *Leucaena* leaf meal was used at 30% incorporation level in ED-I as the plant protein source. *Leucaena leucocephala* ('subabul'/'ipil-ipil') leaf meal has been widely investigated as a possible protein source in the diets for *Oreochromis mosambicus* (cf. Camacho and Dureza 1977), *O. niloticus* (cf. Pantastico and Baldia 1980; Wee and Wang 1987), *Cyprinus carpio* (cf. Ghatnekar et al. 1983) and *Labeo rohita* (cf. Hasan et al. 1994).

Relatively good growth was obtained by Wee and Wang (1987) and Hasan et al. (1994) with 'subabul' leaf meal involving water soaking treatment (to remove mimosine) as compared to sundried and commercially processed meals. In the present investigation, 'subabul' leaf meal was used after soaking in water 48 hours to reduce the mimosine con-

tent. The plant protein diet was low in overall crude protein content (23.76%) than the fish meal based diet (34.42%).

Fish growth

Feeding fish continuously with fish meal diet (schedule F) or one day with 'subabul' leaf meal diet followed by three days of fish meal diet (schedule 1S/3F) proved equally effective and better than rearing fish on schedules S and 2S/3F. In fact, schedule 1S/3F induced better growth of fish than schedule F, in terms of average live weight gain (205.1 and 169.6% respectively) and SGR (1.39 and 1.23%/day respectively). Although no marked variation was noted with regard to PER and ANPU between these two treatments, FCR was found better with schedule 1S/3F than schedule F. However no mortality was recorded in any of these two groups of fish. I contrast, fish reared on the schedules S and 2S/3F resulted in relatively poor growth and PER and higher FCR.

Labeo rohita fingerlings are known to grow well with about 35% protein diet (Saha 1996). Pandian (1989) revealed that the dietary protein requirement of various herbivorous/omnivorous fishes is in the range of 25–30%. However, the fish meal based control diet ED-II, in the experiment has almost 35% protein which proved to be optimum requirement for rohu fingerlings. Since the growth attained in treatment 1S/3F was superior to the respective control treatment, fed on 35% protein diet continuously (schedule F), it appears that this species does not require the same dietary protein input every day. Conducting experiments on mixed feeding schedules, similar types of growth response have also been reported in common carp (Srikanth et al. 1988; Nandeesha et al. 1993). Existence of rhythmicity in digestibility of protein has been reported in *Etroplus suratensis* (De Silva and Perera 1983) and *Oreochromis niloticus* (De Silva and Perera 1984). De Silva and Perera (1983, 1984) were, however, unable to trace a well defined rhythm in cichlids, and hence, De Silva (1985) adopted randomly determined feeding schedules to confirm its existence. His study showed that mixed feeding in Nile tilapia with low and high protein diets resulted in higher growth and better returns. Although Nandeesha et al. (1993) opined that daily variation in digestibility of dry matter and protein was more pronounced in rohu as compared to catla, the variation in the two species also did not appear to follow a well defined pattern, similar to the observations made in cichlids (De Silva and Perera 1983, 1984) and common carp (Srikanth et al. 1988). The results of the present investigation indicate the possible existence of such a rhythmicity in *Labeo rohita* fingerlings. Alternate administration of high and low protein diet influences the growth performances of fish independently of the mean dietary protein input, which is due to rhythm in certain basic metabolic activities (De Silva 1985).

Fish muscle composition

Protein and fat deposition i fish muscle was recorded significantly higher in the fish reared on schedules F and 1S/3F than those with schedules S and 2S/3F. The protein and fat deposition in fish muscle clearly correlates the growth pattern of fish raised on different feeding schedules. In tilapia (De Silva 1985), common carp (Nandeesha et al. 1993), similar variations in muscle protein have also been reported when reared on such different feeding schedules. However, the moisture and ash contents in fish muscle followed an inverse relationship with muscle protein contents has also been reported in catla (Nandeesha et al. 1993) and common carp (Nandeesha 1989).

Based on the economics of production, it was observed that treatment 1S/3F resulted in saving 7.74% protein input and 17.96% production cost. Although treatment 2S/3F showed 28.75% reduction in feed input cost, saving 26.38% protein input as compared to feeding fish continuously with fish meal based diet (schedule F), the performance of fish reared on this schedule was not satisfactory. However, schedule 1S/3F could able to save protein input as well as the production cost effectively, without compromising the growth of *L. rohita* fingerlings. Feeding fish continuously with high protein diet proved uneconomical and also did not promote growth proportionate to protein input. Hence, adoption of this feeding schedule in carp culture will be no doubt worthy.

The result of the present study indicate that intensified research using a number of feeding schedules could lead to cost effective feeding schedules. This area of research being relatively new, sincere efforts may contribute to effective utilisation of other sources of low quality proteins. Dietary formulations consisting solely of plant proteins have not yielded comparable results to those of fish meal (Mazid et al. 1979; Jackson et al. 1982; Jauncey and Ross 1982; Ofojewku and Ejike 1984). Moreover, replacement of fish meal with plant proteins, derived from *Leucaena* leaf meal, in the diets of *O. niloticus* (cf. Wee and Wang 1978), female brood *O. niloticus* (cf. Santiago et al. 1988) and *L. rohita* (cf. Hasan et al. 1990) also failed to yield comparable growth of fish than the respective controls. However, based on the results of the present investigation, it appears that *Leucaena* leaf meal can be effectively utilised in the carp diet, principally based on the natural variation in digestibility pattern rather than using it for partial substitution of fish meal. The results are expected to open up a new avenue to develop better feeding strategies for *Labeo rohita* fingerlings with a view to reduce feed input cost by taking advantage of the existing natural variations in daily digestibilities of protein.

ACKNOWLEDGEMENTS

The authors are grateful to CSIR, New Delhi and UGC (DSA Programme in the Department of Zoology, Visva-Bharati) for financial supports to carry on the research works.

REFERENCES

Anonymous, 1980: Standard methods for the examination of water and waste water. 15th edn. American Public Health Association, American Water Works Association and Water Pollution Control Federation, Washington DC.

Anonymous, 1990: Official methods of Analysis of AOAC. Vol. 1, 15th edn. [Helrich K. (ed.)]. Association of Analytical Chemists, Inc., Arlington, VA.

Anonymous, 1993: Recommendations in the Proceedings of the FAO/AADCP Regional Consultation on Farm-Made Aquafeeds (14–18 December, 1992, Bangkok, Thailand). In: Farm-made Aquafeds [New M.B., A.G.J. Tacon, I. Csavas (eds.)], RAPA Publication 1993/18, AADCP/PROC/5, Publ. FAO Regional Office for Asia and the Pacific.

Akiyama D.M., 1991: The use of soy products and other plant protein supplements in aquaculture feeds. In: Proceedings of the Aquaculture Feed Processing and Nutrition Workshop held in Thailand and Indonesia [Akiyama D.M., R.K.H. Tan (eds.)]. American Soybean Association, Singapore: 199–206.

Atack T.H., A.J. Matty, 1979: The evaluation of some single cell protein in the diets of rainbow trout. II. The determination of net protein utilization, biological value and true digestibility. In: Finfish Nutrition and Fish Feed Technology [Halver J.E., K. Tiews (eds.)]. Heeneman, Berlin, vol. II: 261–273.

Camacho A., L.D. Dureza, 1977: Feeding trials using treated and untreated ipil-ipil (*Leucaena leucocephala*) leaf meal in pelletized feed for tilapia. Inland Fish Proj. Techn. Rept., 11–12: 87–89.

Cruz E.M., L.L. Ladencia, 1977: Protein requirements of *Tilapia mosambica* fingerlings. Kalikasan Philipp. J. Biol., **6**: 177–182.

De Silva S.S., 1985: Performance of *Oreochromis niloticus* (L.) fry maintained on mixed feeding schedule of different protein content. Aquaculture and Fisheries Management, **16**: 331–340.

De Silva S.S., W.M.K. Perera, 1983: Digestibility of an aquatic macrophyte by the cichlid *Etroplus suratensis* (Bloch.) with observations on the relative merits of three indigenous components as markers and daily changes in protein digestibility. J. Fish Biol., **23**: 675–684.

De Silva S.S., W.M.K. Perera, 1984: Digestibility in *Saratherodon niloticus* fry effect of dietary protein level and salinity with further observations on variability in daily digestibility. Aquaculture, **38**: 293–306.

Duncan D.B., 1955: Multiple range and multiple F-tests. Biometrics, **11**: 1–42.

Ghatnekar S.D., D.G. Auti, V.S. Kamat, 1983: Feeding *Leucaena* to Mozambique tilapia and Indian tilapia and Indian major carps. Proceedings of a workshop on *Leucaena* research in the Asian Pacific region. IRDC–221e: 61–63.

Hasan M.R., Moniruzzaman, A.M. Omar Farooque, 1990: Evaluation of *Leucaena* and water hyacinth leaf meal as dietary protein sources of the fry of Indian major carp, *Labeo rohita* (Hamilton). In: Proceedings of the Second Asian Fisheries Forum [Hirano R., I. Hanya (eds.)]. The Asian Fisheries Society, Manila, Philippines: 275–278.

Hasan M.R., P.K. Roy, A.M. Akand, 1994: Evaluation of *Leucaena* leaf meal as dietary protein source of Indian major carp, *Labeo rohita* fingerlings. In: Fish Nutrition Research in Asia [De Silva S.S. (ed.)]. Asian Fish. Soc. Spec. Publ., **9**: 69–76.

Jackson A.J., B.S. Capper A.J. Matty, 1982: Evaluation of some plant proteins in complete diets for the tilapia. Aquaculture, **27**: 97–109.

Jauncey K., B. Ross, 1982: A guide to tilapia feeds and feeding. Institute of Aquaculture, University of Stirling, Stirling, U.K.

Mazid M.A., Y. Tanaka, T. Katayama, M.A. Rhaman, M. Simpson, C.O. Chichester, 1979: Growth response of *Tilapia zilli* fingerlings fed isocaloric diets with variable protein levels. Aquaculture, **18**: 115–122.

Nandeesha M.C., 1989: Formulation and evaluation of artificial diets for carps. Ph.D. Thesis. Visva-Bharati University, India.

Nandeesha M.C., S.S. De Silva, D. Krishnamurthy, 1993: Evaluation of mixed feeding schedules in two Indian major carps, catla (*Catla catla*) and rohu (*Labeo rohita*). In: Fish Nutrition in Practice [Kaushik S.J., P. Loquet (eds.)], INRA, Paris: 753–765.

Ofojewku P.C., C. Ejike., 1984: growth response and feed utilization in the tropical cichlid *Oreochromis niloticus* (L.) fed on cotton seed based artificial diets. Aquaculture, **42**: 27–36.

Pandian T.J., 1989: Protein requirements of fish and prawns cultured in Asia. In: Fish Nutrition Research in Asia, Proceedings of the Third Asian Fish Nutrition Network Meeting [De Silva S.S. (ed.)]. Asian Fish. Soc. Spec. Publ., **4**: 11–22.

Pantastico J.B., J.P. Baldia, 1980: Ipil-ipil leaf meal as supplement feeds for *Tilapia nilotica*. Fish Res. J. Philipp., 5: 63–68.

Ray A.K., I. Das, 1995: Evaluation of dried aquatic weed, *Pistia stratiotes* meal as a feedstuff in pelleted feed for rohu, *Labeo rohita* fingerlings. J. Appl. Aquacult., **5** (4): 35–44.

Saha A.K., 1996: Evaluation of nutritional potentiality of some artificial diets for *Labeo rohita* (Ham.) fingerlings. Ph.D. Thesis. Visva-Bharati University, India.

Santiago C.B., M.B. Aldaba, M.A. Laron, 1988: Reproductive performance and growth of Nile tilapia *Oreochromis niloticus* broodstock fed diets containing *Leucaena leucocephala* leaf meal. Aquaculture, **70**: 53–61.

Shetty H.P.C, M.C. Nandeesha., 1988: An overview of carp nutrition research in India. In: Finfish Nutrition Research in Asia, Prodeedings of the Second Asian Fish Nutrition Network Meeting [De Silva S.S. (ed.)]. Heenemann Asia, Singapore: 96–116.

Srikanth G.K., M.C. Nandeesha, P. Keshavanath, T.J. Varghese, H.P.C. Shetty, N. Basavaraja, 1988: On the applicability of a mixed feeding schedule for common carp, *Cyprinus carpio* var. *communis*. Aquaculture Research in Asia. Pudoc, Wageningen, Netherlands: 254–260.

Tacon A.G.J., 1993: Feed ingredients for warmwater fish: Fish meal and other processed feedstuffs. FAO Fisheries Circular No. 856, FAO, Rome.

Talwar P.K., A.G. Jhingran, 1991: Inland Fishes of India and Adjacent Countries, Vol. I. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Viola S., Y. Arieli, 1983: Nutrition studies with a high protein pellet for carp and *Sarotherodon* spp. (Tilapia). Bamidgeh, **34**: 39–46.

Viola S., S. Mlokady, U. Rappaport, Y. Arieli, 1982: Partial or complete replacement of fish meal by soybean meal in feeds for intensive culture of carps. Aquaculture, **26**: 223–226.

Wee K.L., 1991: Use of non-conventional feedstuffs of plant origin as feeds—is it practical and economically feasible? In: Fish Nutrition Research in Asia, Proceedings of the Fourth Asian Fish Nutrition Workshop [De Silva S.S. (ed.)]. Asian Fish. Soc. Spec. Publ., **5**: 13–32.

Wee K.L., S.S. Wang, 1987: Nutritive value of *Leucaena* leaf meal in pelleted feed for Nile tilapia. Aquaculture, **62**: 97–108.

Amlan Krishan SAHA, Arun Kumar RAY

EFEKTY ŻYWIENIA PALCZAKÓW *LABEO ROHITA* (HAMILTON) ALTERNATYWNĄ PASZĄ OPARTĄ O BIAŁKA ROŚLINNE I ZWIERZĘCE

STRESZCZENIE

W celu zbadania możliwości zastosowania w praktyce mieszanego sposobu żywienia palczaków *Labeo rohita* – najważniejszego indyjskiego karpia – przeprowadzono 80-dniowy eksperyment laboratoryjny testując alternatywne żywienie ryb z zastosowaniem diet opartych o białka roślinne i zwierzęce, odpowiednio z niską i wysoką zawartością tych białek. Ryby żywione jeden dzień mączką z namoczonych liści *Leucaena* i trzy następne dni białkiem zwierzęcym (mączka rybna) – dieta 1S/3F – wykazywały lepsze przyrosty żywej masy (%), lepsze SGR (%/dobę) i FCR niż ryby karmione wyłącznie paszą opartą na białku zwierzęcym (dieta F). Żywienie 1S/3F powodowało również większe odkładanie białka w mięśniach i wyższy współczynnik ich wykorzystania. Oczekuje się, że niniejsze badania otworzą nowe możliwości w zakresie strategii żywienia, zmniejszając koszt pasz poprzez włączanie składników roślinnych do diety oraz poprzez wykorzystanie naturalnych różnic w dziennej zdolności trawienia białek.

Received: 8 September 1997

Author's address:

Professor Arun Kumar Ray
Fisheries Laboratory,
Department of Zoology,
Visva-Bharati University
Santiniketan–731235, West Bengal, India

e-mail: arunray@vbharat.ernet.in