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Enhancing Pond Productivity of Indian Butter Catfish (*Ompok bimaculatus*): Impact of Protein-Rich Feeds over Conventional Feed

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Abstract

Ompok bimaculatus (Pabda fish), is a sought-after fish in Eastern and North-eastern India, and is cultivated extensively in these regions by feeding traditional feeds intended for carps, which may not meet always the high protein requirements of this fish. A study was carried for over six months in earthen ponds to evaluate the impact of different diets on the growth of with a stocking density of 4000 fish per hectare. Three types of feed were tested: a conventional feed with 23.84% crude protein (CP), and two protein-rich feeds with 30.47% and 35.24% CP, respectively. The feeding rate varied from 2% to 4% of the fish biomass. Water quality and plankton were monitored monthly. The fish on the higher protein diets showed significantly better growth rates and weight gain compared to those on the conventional diet. Survival rates increased by 15%-15.2%, and total biomass improved by 126.3 to 132 kg/ha with the higher protein feeds. The feed conversion ratio was also better with high protein feeds. No significant differences in growth or survival were noted between the two higher protein feeds. The overall composition of the fish flesh determined by proximate analysis remained consistent across all diets. The study concludes that a minimum of 30% CP in feed is essential for the effective pond cultivation of Pabda fish, particularly in low-input systems.

Keywords: Indian butter catfish, pond farming, protein feed, energy feed, fish growth, survival

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Introduction

Ompok bimaculatus (Bloch, 1794) is a highly valued catfish belonging to the family Siluridae. Endemic to freshwater ecosystems in Southeast Asian countries, including India, it thrives at altitudes ranging from 100 to 2500 meters above mean sea level (MSL) (Sridhar et al., 1998). Commonly known as the 'Indian butter catfish' or 'Pabda', *O. bimaculatus* is greatly esteemed in Eastern and North-Eastern India for its unique taste, distinct flavor, texture, and tender bones. It typically sells for around Rs. 400-500/kg in Tripura and other Eastern states but can fetch up to Rs. 1000/kg during festivals, particularly in Tripura.

Beyond its culinary value, *O. bimaculatus* is also an ornamental fish, known in the international trade as the 'Two-spot glassy catfish.' Once abundant in Indian water bodies, especially in Eastern and North-Eastern regions, its natural populations have declined due to overfishing, habitat alteration, pollution, and other factors. This decline has led to *O. bimaculatus* being classified as an endangered species (Lakra et al., 2010).

To promote conservation efforts, it was declared the 'State fish' of Tripura in 2006. Furthermore, the National Bureau of Fish Genetic Resources (NBFGR) in Lucknow has identified it as a high-priority species for the diversification of Indian aquaculture (NBFGR, 2011).

While breeding and seed production protocols for *O. bimaculatus* are well-established, the availability of this species for consumption is less. This scarcity is partly due to a lack of standardized grow-out production techniques specific to this fish. Feed plays a critical role in grow-out production, but comprehensive knowledge on this aspect is lacking for *O. bimaculatus*. Although aquaculture of this species has gained traction recently, the optimum feeding requirements needed for optimal growth and production is lacking (Debnath et al., 2016).

In Tripura, *O. bimaculatus* is cultured with Indian major carps, a practice generally discouraged due to negative effects on growth and survival caused by *Cirrhinus mrigala* (Debnath et al., 2020). Additionally, *O. bimaculatus* is usually fed conventional carp feeds (RB: Rice Bran and MOC: Mustard Oil Cake), which are unsuitable for the dietary needs of a catfish species. Studies such as Deyoe & Tiemeier (1968) suggest that feeds containing 30% to 35% crude protein (CP) promote satisfactory growth and survival in many catfish species. However, specific information regarding *O. bimaculatus* dietary needs is currently unavailable.

Therefore, this study aims to investigate the growth and production effects of feeding *O. bimaculatus* with 30% CP and 35% CP feeds, compared to conventional feeds. The findings will improve our understanding of the impact of different protein feeds, enabling the adoption of appropriate feeding strategies for the successful grow-out production of *O. bimaculatus.*

Materials and Methods

The study was conducted in earthen ponds at Tripura, NE India, involving nine naturally stabilized earthen ponds of uniform shape (rectangular), size (0.03 ha), depth (1.5m), basin conformation, contour, and bottom type, with proper inlet and outlet facilities. The ponds were thoroughly cleaned before initiating the experiment. Subsequently, basal fertilization was carried out by applying lime at a rate of 250 kg/ha, raw cattle manure (RCM) at a rate of 3000 kg/ha, and single superphosphate (SSP) at a rate of 30 kg/ha. Once the water turned green to light green (approximately a week later), *O. bimaculatus* fingerlings (procured from the Govt. Farm) were stocked at a density of 4000/ha (average size: 1.6g). Feeding was initiated 24 hours after stocking the fingerlings.

The feeds were prepared on the farm by procuring ingredients from local markets. The Pearson square method was followed for feed preparation, and the compositions of the feeds are presented in Table 1. Feed 1 was prepared using RB and MOC in a 1:1 ratio (conventional feed). Feeds containing 30% CP (feed 2) and 35% CP (feed 3) were prepared using RB, MOC, and fish meal as basal ingredients. After preparation, the proximate compositions of the feeds were analyzed for CP, crude lipid (CL), crude fiber (CF), ash, nitrogen-free extract (NFE), and energy, following the methods of the Association of Official Analytical Chemists (AOAC) (AOAC, 1984). The CP content was estimated to be 23.84% in Feed 1, 30.47% in Feed 2, and 35.24% in Feed 3 (Table 2).

The feeds were applied in semi-solid dough form, and the broadcasting method was employed for feed application. The feeding rate was set at 4% of the fish body weight (BW) during the initial 2 months of culture (June-July), 3% of BW during the following 2 months (August-September), and 2% of BW during the last 2 months of culture (October-November). The feeding rate was adjusted monthly based on the fish body weight, assuming a 90% survival rate from the second month of culture.

Intermittent fertilization was carried out at 15-day intervals using RCM at a rate of 500 kg/ha, urea at a rate of 10 kg/ha, and SSP at a rate of 15 kg/ha to maintain pond fertility. Additionally, intermittent liming was performed at a rate of 100 kg/ha every 2 months.

Water quality parameters were monitored monthly between 8:00-9:00 AM by sampling water from 10 cm below the water surface. Temperature (°C) was determined using a thermometer, dissolved oxygen (DO) was measured using Winkler's method, pH was measured using a digital pH meter (Merck), transparency was assessed using a Secchi disc, and total alkalinity (TA) was determined following the Standard Methods (APHA, 1998). The levels of ammonia and phosphate were estimated using kits from Merck®. Soil samples were analyzed at the beginning and end of the culture period for pH, available nitrogen (N), available phosphorus (P), and organic carbon (OC) using standard protocols. Plankton samples were collected bi-monthly by filtering 50 litres of water through a bolting silk net (No. 25, mesh 34 μ) from different locations in each pond. The collected samples were qualitatively and quantitatively analyzed following the method outlined by Jhingran et al. (1969).

After 6 months, all fish were harvested through repeated netting, and the survival rate was calculated. Approximately 10% of the fish were individually measured for total length and wet weight, and their average daily gain (ADG), specific growth rate

(SGR), food conversion ratio (FCR), and total fish production were estimated.

The fish growth and production attributes studied in this experiment are as follows:

- SGR (%/day) = [ln(final weight) - ln(initial weight)] / days of experiment x 100.
- FCR = Fish biomass / total feed given.
- ADG (g/fish) = (Final weight - Initial weight) / days of culture.
- Fish production = Final weight x number of fish survived.

Three fish were sacrificed from each treatment, and their flesh samples were collected for the analysis of moisture, CP (crude protein), CL (crude lipid), ash, and NFE (nitrogen-free extract) following the AOAC (AOAC, 1984) methods.

The data were analyzed using SPSS (version 21.0) and expressed as Mean ± S.D. One-way ANOVA was performed to assess the differences between the treatment means. To determine specific group differences, Duncan's multiple range test (DMRT) was conducted at a 5% level of significance ($p \leq 0.05$).

Table 1. The composition of the feeds

Ingredients	Feed-1	Feed-2	Feed-3
RB	50	32	24
MOC	50	28	36
FM	-	30	30
WF	-	9	9
VMP*	-	1	1
Total	100	100	100

*Each 5 kilograms contained Vitamin A-100,00,000 IU, Vitamin D_3-20,50,000 IU, Vitamin B_2-2.6g, Vitamin E- 1750 IU, Vitamin K- 2g, Calcium pantothenate- 5g, Vitamin B_{12}-15mg, Choline chloride-12% (w/w), Calcium- 1,700g, Manganese-55g, Iodine-2g, Zinc-30g, Iron-15g, Copper-4g and Cobalt-0.9g

Results and Discussion

The present study provides insights into the effects of feeding protein-rich feeds compared to conventional RB+ MOC feed on the growth, survival, and production performance of *O. bimaculatus* over 6 months under earthen pond conditions in Tripura.

Table 2. The proximate compositions of the feeds

Components (%)	Feeds		
	1	2	3
Moisture	12.04±1.06	10.12±0.97	10.07±0.60
CP	23.84±0.57	30.47±0.54	35.24±0.17
CL	6.01±0.44	6.53±0.22	6.44±0.21
CF	9.52±0.24	8.36±0.37	8.83±0.35
Ash	18.81±0.70	13.23±0.95	13.20±0.36
NFE	34.75±1.35	31.26±1.06	26.13±0.70
Energy (kcal/g)	2.46±0.17	3.34±0.21	3.40±0.20

The feed intake by fish and the assimilation of feed nutrients into their bodies are heavily influenced by water quality parameters, fish size, stocking density, and soil quality, among others. In this study, the water quality attributes such as mean water temperature ranged from 28.25 to 28.45°C, transparency from 45.82 to 46.13 cm, dissolved oxygen (DO) from 5.10 to 5.12 mg/l, pH from 7.45 to 7.5, total alkalinity (TA) from 65.20 to 65.21 mg/l, ammonia-nitrogen from 0.45 to 0.46 mg/l, and phosphate-phosphorus from 0.22 to 0.23 mg/l (Table 4) with no significant differences among the treatments. The phytoplankton density ranged from 7.65 to 7.83 × 10^3 cells/l, and the zooplankton density ranged from 2.39 to 2.44 × 10^3 individuals/l (Table 4), with no significant differences between the treatments. Furthermore, no differences were observed in the plankton diversity among the ponds supplied with different feeds. Overall, the phytoplankton diversity was represented by five families (Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, and Dinophyceae), while the zooplankton diversity was represented by three families (rotifers, copepods, and cladocerans). Within these groups, Chlorophyceae included *Carteria, Platymonas, Chlamydomonas, Chlorogonium, Pyramimonas, Gonium, Pandorina, Eudorina, Volvox, Physocystium, Pleudorina,* and *Phacotus*. Bacillariophyceae included *Cyclotella, Surirella, Melosira, Synura*, and Dinobryon. Cyanophyceae (Myxophyceae) included Microcystis, Anabaena, Oscillatoria, Spirulina, Arthrospira, and Raphidiopsis. Euglenophyceae included Euglena and Trachelomonas. Dinophyceae included Peridinum and Ceratium. Rotifers were represented by *Brachionus, Asplanchna, Polyarthra*, and *Keratella*. Copepods included Cyclops, Mesocyclops, and Diaptomus. Cladocerans included *Moina, Daphnia, Bosmina, Ceriodaphnia, Dipahanosoma,* and others.

The soil pH before *Ompok* seed stocking ranged from 6.7 to 6.73, organic carbon (OC) from 0.42 to 0.52%, available nitrogen (N) from 1.75 to 1.81 mg%, and available phosphorus (P) from 0.85 to 0.92 mg%, with no significant differences between the treatments (Table 5). Based on these observations of water quality parameters, soil quality, and plankton parameters, similarly the morphological conditions of the pond were also the same, and same was the case with the fingerlings that were the same cohort. The stocking density and feeding rate also had no effect on the observed differences in growth attributes of *O. bimaculatus* under different treatments. Instead, the variations in growth attributes were due to the qualities of the feeds provided to the fish.

Although the level of water toxins was not assessed in this study, based on the water, soil, and plankton parameters, it can be assumed that the culture water was free from water toxins or similar substances. Excessive feeding and fertilization can sometimes lead to the formation of algal blooms, scums, or eutrophication in water. However, no such issues were observed in any of the treatment ponds, indicating that the feeding and fertilization schedule followed in the experiment was appropriate, and any potential negative effects were likely mitigated over the course of the 6-month fish culture period (Debnath et al., 2020).

All water and soil quality parameters exhibited a similar pattern of change across the ponds, which can be attributed to the fact that the ponds used in this study had almost uniform shape, size, depth, and basin conformation (Murty et al., 1978). The concentration of water and soil nutrients was found to increase at the end of the culture period, which

Table 3. The mean values of water quality parameters under different feeding treatments

Parameters	Feed-1	Feed-2	Feed-3
Temperature (°C)	28.25±0.05[a]	28.45±0.04[a]	28.45±0.03[a]
Transparency (cm)	45.82±0.15[a]	46.13±0.22[a]	46.04±0.26[a]
Dissolved oxygen (mg/l)	5.12±0.002[a]	5.10±0.003[a]	5.11±0.002[a]
pH	7.45±0.02[a]	7.50±0.005[a]	7.46±0.002[a]
Total alkalinity (mg/l)	65.22±0.01[a]	65.32±0.04[a]	65.20±0.07[a]
Ammonia-nitrogen (mg/l)	0.45±0.005[a]	0.45±0.002[a]	0.46±0.006[a]
Phosphate-phosphorus (mg/l)	0.22±0.001[a]	0.23±0.002[a]	0.22±0.001[a]

Figures in the same row having the same superscripts are not significantly different ($p \geq 0.05$)

Table 4. The mean values of plankton density under different feeding treatments

Plankton groups	Feed-1	Feed-2	Feed-3
Phytoplankton ($\times 10^3$ cells/l)			
Chlorophyceae	5.50±0.04[a]	5.48±0.05[a]	5.45±0.08[a]
Cyanophyceae	1.65±0.03[a]	1.56±0.05[a]	1.58±0.16[a]
Bacillariophyceae	0.56±0.04[a]	0.48±0.11[a]	0.54±0.02[a]
Euglenophyceae	0.12±0.011[a]	0.13±0.015[a]	0.14±0.008[a]
Total	7.83±2.44[a]	7.65±2.45[a]	7.71±2.42[a]
Zooplankton (x10^3 individuals/l)			
Rotifer	1.88±0.05[a]	1.92±0.02[a]	1.85±0.09[a]
Crustacea	0.54±0.35[a]	0.52±0.45[a]	0.54±0.41[a]
Total	2.42±0.94[a]	2.44±0.98[a]	2.39±0.92[a]

Figures in the same row having the same superscripts indicate no significant difference ($p \geq 0.05$)

could be attributed to the gradual deposition of fish metabolites, spillage of feeds or fertilizers, and the death of plankton or fish (Jena et al., 2002).

Table 6 presents a comparison of parameters used to discuss the efficiency of the three different feeds: conventional feed, feed containing 30% CP, and feed containing 35% CP. The average initial weight of the fish in all three feed groups was the same, approximately 1.60 g. However, the average final weight of the fish differed significantly among the three feeds. Fish fed with feed containing 35% CP had the highest average final weight of 84.10g, followed by feed containing 30% CP with an average final weight of 82g. Fish fed with conventional feed had the lowest final weight of 54.8g. The final fish weight was 49.6% higher with the use of Feed-2 and 53.4% higher with the use of Feed-3 compared to Feed-1. This clearly indicates an improvement in feed quality, particularly in terms of protein content, resulting in increased fish growth.

The SGR varied significantly among the three feeds. Fish fed with feed containing 35% CP showed the highest SGR of 2.20% per day, followed by feed containing 30% CP with 2.18% per day. The conventional feed had the lowest SGR of 1.96% per day. Similarly, the ADG differed significantly among the three feeds. Fish fed with feed containing 35% CP had the highest ADG of 0.45 g/day, followed by feed containing 30% CP with 0.44 g/day. The conventional feed had the lowest ADG of 0.30 g/day. The higher growth and weight gain in *O. bimaculatus* with the use of feed containing 30% CP and 35% CP are again attributed to their higher protein and energy content.

Table 5. The mean values of soil quality parameters of the ponds under different feeding treatments

Parameters		Feed-1	Feed-2	Feed-3
Soil pH				
	Before	6.73 ± 0.11^a	6.70 ± 0.15^a	6.72 ± 0.12^a
	After	7.13 ± 0.05^a	7.15 ± 0.05^a	7.08 ± 0.13^a
Organic carbon (%)				
	Before	0.42 ± 0.15^a	0.52 ± 0.12^a	0.52 ± 0.12^a
	After	1.32 ± 0.12^a	1.34 ± 0.08^a	1.33 ± 0.12^a
Available N (mg/100g)				
	Before	1.75 ± 0.08^a	1.76 ± 0.07^a	1.81 ± 0.06^a
	After	32.50 ± 5.15^a	33.30 ± 4.54^a	38.22 ± 1.22^a
Available P (mg/100g)				
	Before	0.86 ± 0.05^a	0.92 ± 0.05^a	0.85 ± 0.05^a
	After	4.23 ± 2.25^a	5.01 ± 2.11^a	5.13 ± 2.14^a

Figures in the same row having the same superscripts are not significantly different ($p\geq0.05$)

Table 6. The growth and production parameters of *Ompok bimaculatus* under different feeding treatments

Parameters	Conventional feed	Feed containing 30% CP	Feed containing 35% CP
Initial weight (g)	1.60 ± 0.01	1.60 ± 0.01	1.60 ± 0.01
Final weight (g)	54.8 ± 3.06^a	82.00 ± 2.00^b	84.10 ± 2.50^b
SGR (%/day)	1.96 ± 0.45^a	2.18 ± 0.24^b	2.20 ± 0.21^b
ADG (g)	0.30 ± 0.03^a	0.44 ± 0.02^b	0.45 ± 0.03^b
FCR	2.22 ± 0.43^a	1.75 ± 0.40^b	1.86 ± 0.52^b
Survival (%)	70.2 ± 3.14^a	85.4 ± 0.90^b	85.2 ± 1.65^b
Production (kg/ha)	153.8 ± 10.02^a	280.1 ± 8.62^b	286.6 ± 4.91^b

Figures in the same row having the same superscripts are not significantly different ($p\geq0.05$)

The FCR varied significantly among the three feeds. Fish fed with feed containing 30% CP and feed containing 35% CP showed lower FCR values compared to those fed with the conventional feed, indicating better feed conversion efficiency. Feed containing 30% CP had the lowest FCR of 1.75, followed by feed containing 35% CP with 1.86. The conventional feed had the highest FCR of 2.22. This indicates that nutrients from the conventional feed were less assimilated, while nutrients from the other two feeds were better assimilated in the body of *O. bimaculatus*.

The survival rate differed significantly among the three feeds. Fish fed with feed containing 30% CP and feed containing 35% CP had higher survival rates compared to those fed with the conventional feed. Feed containing 30% CP and feed containing 35% CP both had similar survival rates, with values of 85.4% and 85.2%, respectively. The conventional feed had a lower survival rate of 70.2%. In the present study, although the production of phytoplankton was highest in ponds where fish received feed containing 30% CP, the survival rate was lowest (70.2%) in those ponds. This indicates that planktonic production alone is not adequate to ensure the survival of *O. bimaculatus* during grow-out production.

The fish biomass production per hectare differed significantly among the three feeds. Fish fed with feed containing 30% CP and feed containing 35% CP resulted in higher production compared to those fed with the conventional feed. Feed containing 35% CP had the highest production per hectare of 286.6 kg, followed by feed containing 30% CP with a production of 280.1 kg. The conventional feed had the lowest production per hectare of 153.8 kg. The fish production was 126.3 kg/ha higher with feed containing 30% CP and 132.8 kg/ha higher with feed containing 35% CP compared to the conventional feed, which is obviously due to the higher individual weight increment in fish.

In this study, interestingly, the additional 5% CP in feed containing 35% CP, compared to feed containing 30% CP, failed to cause a significant increase in fish biomass production. The reason could be an improper protein-energy ratio and deamination and wastage of unassimilated nitrogen through the faeces of the fish (Kumar et al., 2011).

In summary, the results indicate that feeds containing higher levels of crude protein (30% CP and 35% CP) resulted in improved growth performance, higher feed efficiency, increased survival rates, and greater production per hectare compared to the conventional feed. Patra (1994) also reported significant improvement in the growth and survival of Climbing Perch (*Anabas testudineus*) with improved feed quality, particularly in terms of CP content. Besides the low protein content in the conventional feed, other factors that contributed to its lower productivity for *O. bimaculatus* were the low energy content (as shown in Table 2) and the absence of a vitamin-mineral mixture in the feed (as indicated in Table 1).

Table 7. Proximate composition of *Ompok bimaculatus* under different feeding treatments

Components (%)	Feed-1	Feed-2	Feed-3
Moisture	67.3±1.25[a]	66.66±0.75[a]	66.8±0.70[a]
CP	15.03±0.20[a]	15.96±0.97[a]	15.56±0.32[a]
CL	4.40±0.21[a]	4.43±0.20[a]	4.47±0.22[a]
Ash	4.40±0.20[a]	4.31±0.16[a]	4.24±0.12[a]
NFE	11.82±0.61[a]	10.98±0.46[a]	11.76±0.65[a]

The proximate compositions of *O. bimaculatus* are presented in Table 7. The average CP content varied from 15.03% to 15.96%, CL from 4.40% to 4.47%, ash from 4.24% to 4.40%, NFE from 10.98% to 11.82%, and moisture from 66.6% to 67.3% (Table 7), which were almost comparable to the earlier findings of Debnath & Sahoo (2013). Feeding fish with protein-rich feeds resulted in improvements in proximate compositions; however, it remained statistically the same ($p \leq 0.05$) when compared with the conventional feed. This indicates that the proximate composition of *O. bimaculatus* remains unaffected by feeds containing CP in the range of 23.84% to 35.24%. Paul et al. (2012) also reported that dietary CP levels in the feed at 28% to 38% had no positive effect on the improvement in the proximate composition of *O. pabda* fry.

Conclusion

From the present study, it can be concluded that the quality of feeds, particularly in terms of crude protein, plays a crucial role in the grow-out production of *O. bimaculatus*. Quality feeding leads to improved production of *O. bimaculatus*. Based on the current study, it can be stated that feeds containing 30% to 35% crude protein result in increased growth of *O. bimaculatus* by 49.6% to 53.4%, survival by 15% to 15.2%, and production by 126.3 kg/ha to 132.8 kg/ha. Furthermore, since there is no significant difference in growth and production between 30% CP feed and 35% CP feed, maintaining the CP content at 30% can help minimize costs.

However, it's crucial to recognize the limitations of this study. The feeds used were not isocaloric, and the conventional feed lacked a vitamin-mineral premix. These factors introduce uncertainties into the results because the observed differences in growth and production performance among the treatments could be attributed not just to the varying protein levels but also to the differences in energy content and the presence or absence of essential vitamins and minerals. This study was conducted at the field level, focusing on farm trials where farmers typically don't make detailed changes to feed composition. In a typical field setting, only the protein content is adjusted, which in our study yielded promising results for this fish species. However, further studies are recommended to develop strategies that can enhance protein assimilation in the fish and improve overall biomass production across different pond culture systems in various agro-ecological settings

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