



(RESEARCH ARTICLE)



## Growth, survival and proximate composition analysis of Pengba, *Osteobrama belangeri* (Valenciennes, 1844), cultured with Indian major carps in natural ponds of Purulia, West Bengal

Shampa Mandal \*, Moumita Mahato, Labanya Sarkar, Arindam Mondal and Ashim Kumar Nath

Department of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal, India, 723104

International Journal of Science and Research Archive, 2025, 15(02), 279-288

Publication history: Received on 17 March 2025; revised on 26 April 2025; accepted on 29 April 2025

Article DOI: <https://doi.org/10.30574/ijrsra.2025.15.2.1201>

### Abstract

With aim to diversify the polyculture system target has been determined to incorporate another important candidate species into the carp culture system in Purulia district of West Bengal. *Osteobrama belangeri* (Valenciennes, 1844), generally named as 'Pengba' in Manipur, India is incorporated along with other Indian major carps viz, rohu, catla and mrigal in Bhangra village under Purulia II block in Purulia. This polyculture has been continued for 12 months. Pengba showed survival rate of 73% with a weight gain percentage of 6519.33 and specific growth rate of 1.16%, which is higher than rohu (1.08%) and lower than catla (1.36%) and mrigal (1.26%). It attains the maximum size of 200 g during this culture period and this size is marketable. Though its growth rate is less than catla and mrigal in this region but due to its glossy silvery appearance and good nutrient value (moisture – 77.33%, crude protein – 20.87%, crude lipid – 0.65%, ash – 0.72%, NFE – 0.07%), it may create a demand among the fish farmers and customers. This research work summarizes the growth, survival, proximate composition and future prospects of Pengba in this region.

**Keywords:** Pengba; Purulia; Polyculture; Weight Gain Percentage; Specific Growth Rate; Proximate Composition

### 1. Introduction:

Diversification of species has been a key strategy intended to boost fish production in freshwater ponds. Species diversification promotes enhancement of yield by utilizing the micro niches of pond ecosystem effectively. By producing a variety of fish it not only increases the consumer demand but also helps in conserving potential candidate species through culture propagation [1, 2, 3, 4]. In different regions attempts have been made to incorporate lesser known but promising species into the cultivation system which has expanded the species diversity and encouraged their conservation through propagation of culture [5, 6, 7, 8, 9]. In Indian system of major carp polyculture, the inter-cropping of minor carps has shown 28% increase in fish yield [10]. Among different cyprinid species with culture potential, *Osteobrama belangeri* (Valenciennes, 1844), known as Pengba is a medium sized carp that holds a significant importance, particularly in Manipur, a state of India [11, 12, 13]. This fish has been listed in the 91 endangered fish species of India as its wild population have decreased notably [14]. In Manipur Pengba has a high demand due to its significance in the cultural and social aspects of Manipuri life. The price of this fish vary with season and generally price ranges from Rs.400-800 per kg in the market of Manipur [15]. Its herbivorous nature makes it suitable for culture in pond and it replaces the grass carp in composite fish culture [12]. This fish shows herbi - omnivorous feeding patterns because it feeds different types of food items in different phases of its life. In juvenile stage it favours zooplankton and various insects and worms and in grown up stage it prefers plant based foods with aquatic macro vegetation contributing 40-60% of the gut content [15]. Pengba attained higher growth when it cultured with catla than that with rohu. So it is better compatible with catla than rohu. Pengba shows better growth and survival as well as greater length and weight increase in 10% addition of the IMC density (6500 fingerlings per ha) than 20% incorporation level [16].

\*Corresponding author: Shampa Mandal

According to the research of Das et al., 2019,[17] it is feasible to stock up to 50 fry per m<sup>3</sup> for rearing of pengba from fry to fingerling stage in concrete tanks. In growth and survival of aquatic organisms, the quality of the water environment plays an important role. Quality of water can be assessed using different parameters like temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD) etc [18, 19]. DO acts as a crucial metric for water quality assessment and is regarded as a significant factor for influencing fish health and various aquatic organisms [20, 21, 22]. As per Central Pollution Control Board (CPCB), Government of India, DO level must be 4 mg/L or more to support fish propagation [23]. The DO level should exceed 5.0 mg/L for higher fish production [24]. To culture Pengba successfully, a higher dissolved oxygen is necessary for productivity improvement [25]. Purulia, a district in West Bengal, India, suffers from underdeveloped socioeconomic condition. The human population in this district consists mainly of resource limited social groups, primarily marginal farmers and daily wage workers [26, 27]. This study emphasizes the culture prospects of Pengba with Indian Major Carps (IMCs) in this area and the potential of this fish as a significant candidate species for diversification of polyculture, generating extra income and improving livelihood.



**Figure 1** Pengba fish from the ponds of Bhangra village of Purulia district

---

## 2. Materials and Methods

### 2.1. Study area

The present study was conducted in Bhangra village under the PuruliaII Block of Purulia district (Figure2) from September 2023 to August 2024. Bhangra is a small village in Purulia district and surrounded by green nature with many ponds, bills. The study was carried on three earthen ponds (A: Lat. 23°22'21''N, Long.86°26'23''E; B: Lat. 23°22'19''N, Long. 86°26'22''E and C: Lat.23°22'19''N, Long. 86°26'23''E) in that village of approximately 0.14 ha size. Pengba was included with IMCs such as for polyculture diversification in this area. The culture was continued for 12 months.

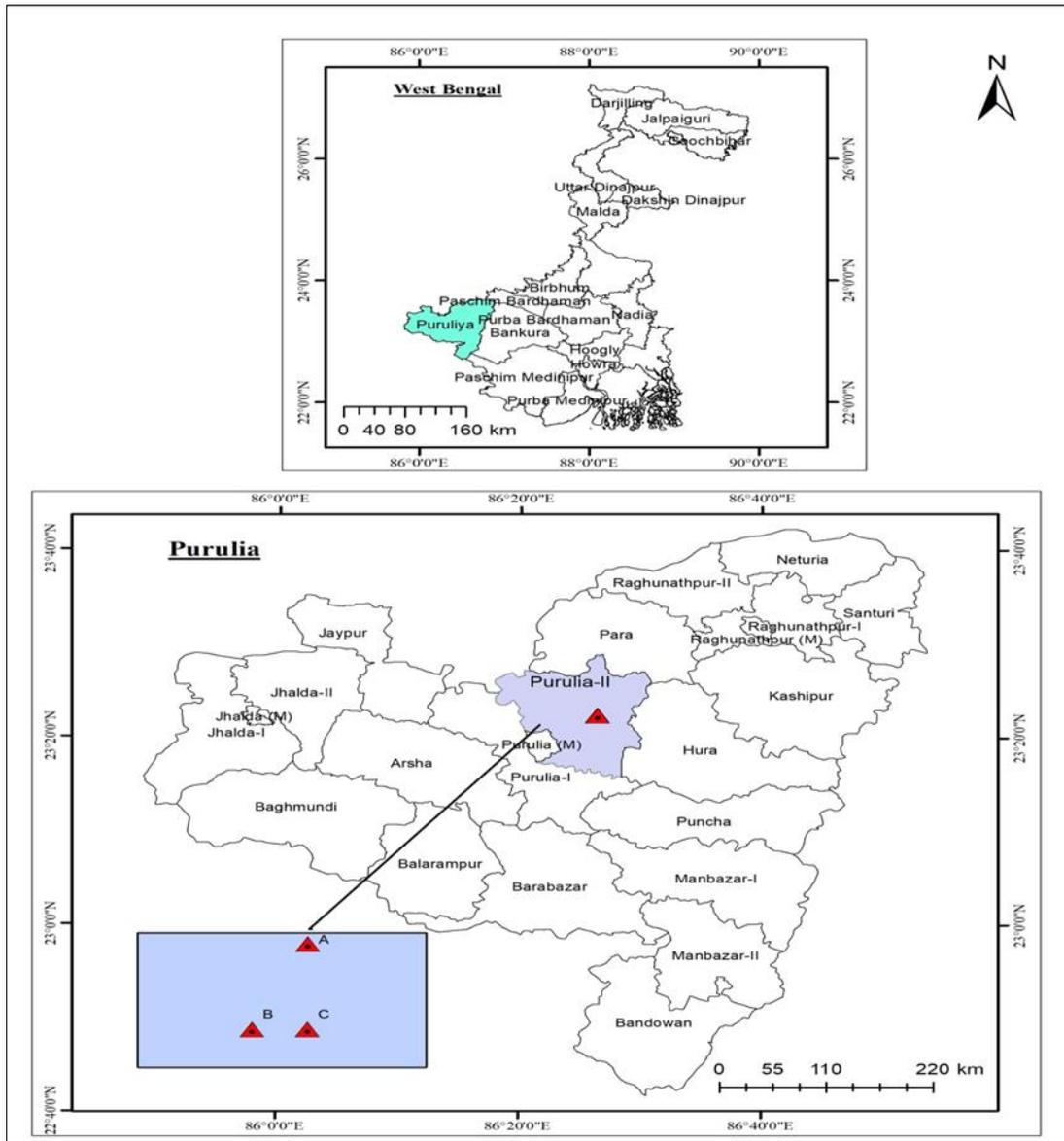


Figure 2 Location map of study area

## 2.2. Pre-stocking pond preparation

Pre-stocking pond preparation is greatly required before introducing the fish species. Standard procedures of pond preparation include removal of predatory and weed fishes and other insects by using mosquito net and application of basal fertilizer containing cowdung and single super phosphate at 30 kg/ha before 10-15 days of stocking [28]. According to protocol liming was done at 200 kg/ha in all three ponds before 5-6 days of stocking.

## 2.3. Stocking and feeding of fish

The ponds were stocked with three IMCs viz., *Labeo rohita* (rohu), *Catla catla* (catla), *Cirrhinus mrigala* (mrigal) and *Osteobrama belangeri* (pengba). The each ponds were stocked @ 5 fingerlings per m<sup>2</sup> with a ratio of species of 40% surface feeder (catla) : 20% column feeder (rohu) : 30 % bottom feeder (mrigal) : 10% macrophyte feeder (pengba) at a combined density of 6500 fingerlings / ha. Fish fingerlings of all the four species were brought from Naihati fish market of North 24 Pargana of West Bengal. 15 individuals of each species were randomly selected for measurement of length and weight. The average length and weight of the fishes at the time of stocking were: *Labeo rohita* (7.37 cm, 5 gm), *Catla catla* ( 5.52 cm, 1.96 gm), *Cirrhinus mrigala* (6.5 cm, 2.46 gm), *Osteobrama belangeri* (4.75 cm, 2.12 gm ).

All the four stocked fish were fed with a mixture of rice bran and mustard oil cake (1:1) @8% of body weight once a day for 3 months and then @ 5% of body weight for the rest 9 months.

## 2.4. Sampling of water and plankton

Water sample of the ponds were collected at monthly basis from 20 to 30 cm depth below surface water between 8.00 a.m to 9.00 a.m. Different water parameters like temperature, pH, dissolved oxygen (DO), total alkalinity, total hardness, phosphate, ammonia, total dissolved solids (TDS) were done by the standard method [29].

Sample water for plankton was also collected with plankton net by filtering 50 lit of water and preserved in 5% formalin for quantitative estimation in later time. Plankton counting was done with Sedgewick Rafter chamber [30].

## 2.5. Growth performance of fish, their survival and production

Fish in the ponds were sampled at 3 months interval to monitor growth and health conditions. Sampling was done with netting and length and weight of 15 randomly selected fish of each species were measured. The fishes were cultured for 12 months and then transferred to another pond for further growth. Growth performance was assessed by calculating weight gain% (WG%) and specific growth rate (SGR). Different response parameters were calculated by following formulas [31].

$$\text{WG\%} = 100 \left[ \frac{\text{FW} - \text{IW}}{\text{IW}} \right]$$

$$\text{SGR} = 100 \left[ \frac{\ln(\text{FW}) - \ln(\text{IW})}{\text{experimental period}} \right]$$

$$\text{Survival (\%)} = \left( \frac{\text{Number of fish harvested}}{\text{number of fish stocked}} \right) * 100$$

$$\text{Fish production (FP): } S \times \text{SD} \times \text{GI}$$

Here, ln = natural logarithm, FW = final weight, IW = initial weight, S = survival rate, SD = stocking density and GI = growth increment.

## 2.6. Pond management after stocking

Lime was applied in all the ponds at monthly intervals @ 200 kg/ha [32] to maintain the ideal pH and alkalinity level. The regular fertilization was skipped occasionally based on the pond's water quality parameters.

## 2.7. Proximate composition of fish muscle

The proximate composition of the fish muscle was assessed following standard methods [33]. To determine the moisture content, samples were dried to a constant weight at 100°C, Kjeldahl method was used to measure the crude protein, Soxhlet was used for crude lipid determination and ash is determined by burning the ash in muffle furnace for 6 hours at 550°C. Nitrogen free extract (NFE) was calculated by differences as 100 - (moisture% + CP% + CL% + ash%).

## 2.8. Statistical analysis

The collected data from the study were analysed by using MS-Excel 2010, and data were represented as mean ± standard deviation.

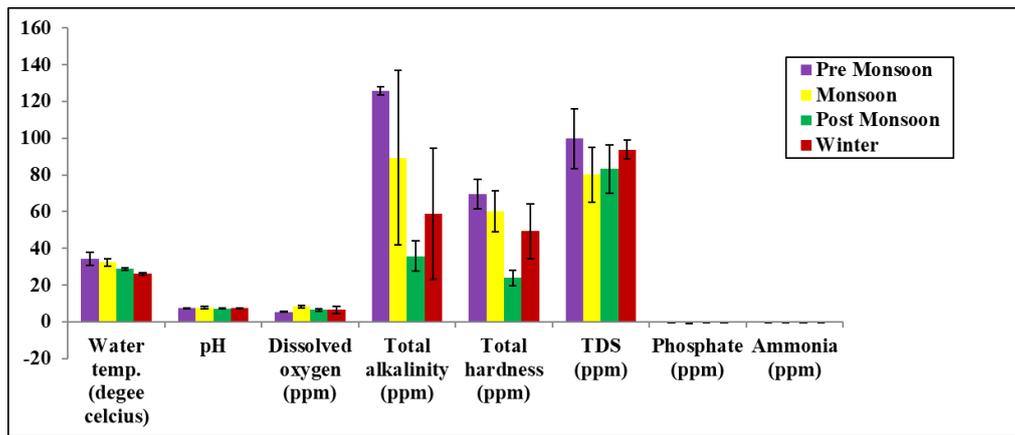
## 3. Results

### 3.1. Quality of water during the study period

Seasonal variation was seen among the different physicochemical parameters (Table1) of water during the study period. Water temperature is an important factor for aquatic environment. In the present study water temperature varied from 26.2 °C to 34.3 °C. The temperature shows highest value in pre monsoon month and lowest in winter season. The average value of p<sup>H</sup> in the selected ponds of Bhangra village ranges between 7.3 to 7.7. In this study period minimum dissolved oxygen concentration was seen in pre monsoon month i.e. 5.5 mg/L and maximum value was seen in monsoon month i.e. 8.3 mg/L. Total alkalinity values in this study varied in between 35.8 to 125.66 mg/L during four seasons of which maximum value recorded in pre monsoon month 125.66 mg/L and minimum value was seen during the post monsoon period i.e. 35.8 mg/L. Total hardness value ranged from 23.96 – 69.6 mg/L in four seasons. Highest TDS value observed in monsoon period i. e 99.8 mg/L and minimum value recorded in Monsoon period i. e. 80.13 mg/L. Inorganic nutrients such as phosphate and ammonia show no such variation in this study period (Figure 3).

**Table 1** Seasonal variation of water parameters during 12 months culture period in the ponds of Bhangra village, Purulia

Water Parameters	Pre Monsoon	Monsoon	Post Monsoon	Winter
Water temp.(°C)	34.33 ± 3.49	32.4 ± 1.99	28.76 ± 0.60	26.2 ± 0.72
p <sup>H</sup>	7.4 ± 0.2	7.7 ± 0.6	7.3 ± 0.2	7.4 ± 0.17
Dissolved oxygen (mg/L)	5.5 ± 0.23	8.3 ± 0.7	6.63 ± 0.65	6.5 ± 1.85
Total alkalinity (mg/L)	125.66 ± 2.15	89.36 ± 47.58	35.8 ± 8.2	58.93 ± 35.65
Total hardness (mg/L)	69.6 ± 7.9	60.16 ± 10.97	23.96 ± 4.30	49.46 ± 14.96
TDS (mg/L)	99.8 ± 16.28	80.13 ± 14.91	83.2 ± 13.21	93.8 ± 5.18
Phosphate (mg/L)	0.003 ± 0.001	0.07 ± 0.01	0.02 ± 0.008	0.01 ± 0.001
Ammonia (mg/L)	0.13 ± 0.05	0.1 ± 0.004	0.03 ± 0.005	0.06 ± 0.03



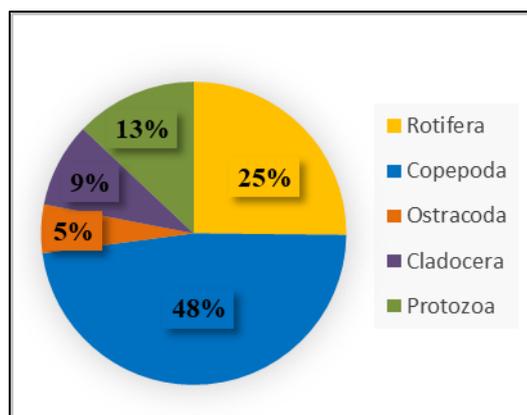
**Figure 3** Different water quality parameters in ponds of Bhangra village of Purulia during 12 months culture period

### 3.2. Planktons

In this study, total five group of zooplanktons (Fig. 4) were found. These were Rotifera, Copepoda, Protozoa, Ostracoda and Cladocera. Occurrence of different zooplankton groups were given in the following table (Table2)

**Table 2** Composition of different group of Zooplankton

Group	Composition (%)
Rotifera	25
Copepoda	48
Protozoa	13
Ostracoda	5
Cladocera	9



**Figure 4** Composition (%) of zooplankton in the ponds of Bhangra in Purulia.

Highest composition was seen in Copepoda (48%) followed by Rotifera (25%), Protozoa, (13%), Cladocera (9%), and Ostracoda (5%).

### 3.3. Fish Growth and Survival

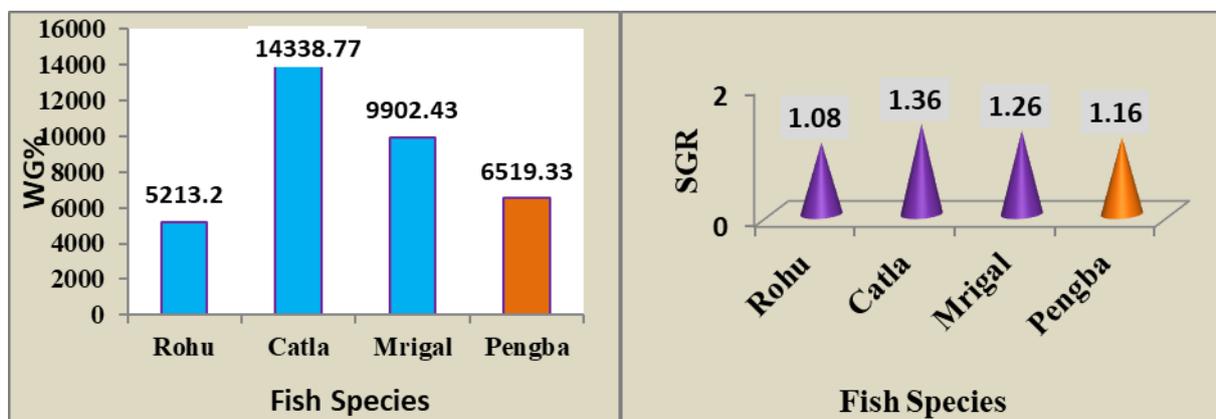
Length and weight of randomly selected 15 fishes of the four species measured during the time of stocking and after twelve months of culture period, their survivability were seen in the following table (Table3):

**Table 3** Growth and survival of four fish species cultured in the ponds of Purulia for 12 months.

Species	Initial length (cm)	Initial weight (gm)	Final length (cm)	Final weight (gm)	Survival (%)
<i>Labeo rohita</i>	7.37±0.12	5.0±0.03	29.96±2.32	265.66±3.42	90
<i>Catla catla</i>	5.52±1.62	1.96±0.01	27.64±5.21	283±6.31	85
<i>Cirrhinus mrigala</i>	6.5±1.4	2.46±0.02	27.0±4.2	246.06±3.12	80
<i>Osteobrama belangeri</i>	4.75±0.34	2.12±0.03	20.04±2.12	140.33±6.35	73

Data are represented as mean ± standard deviation (n=15)

Survival of the fish varied from 73% (pengba) to 90% (rohu). The weight gain% and specific growth rate was seen in the following figure. Highest weight gain % was seen in catla followed by mrigal, pengba and lowest weight gain was in rohu fish. Highest SGR was observed in catla (1.36) and lowest in rohu (1.08).



**Figure 5A** Weight gain percent (WG%) and **5B.** Specific Growth Rate (SGR) of four fish species cultured for 12 months in the ponds of Bhangra of Purulia

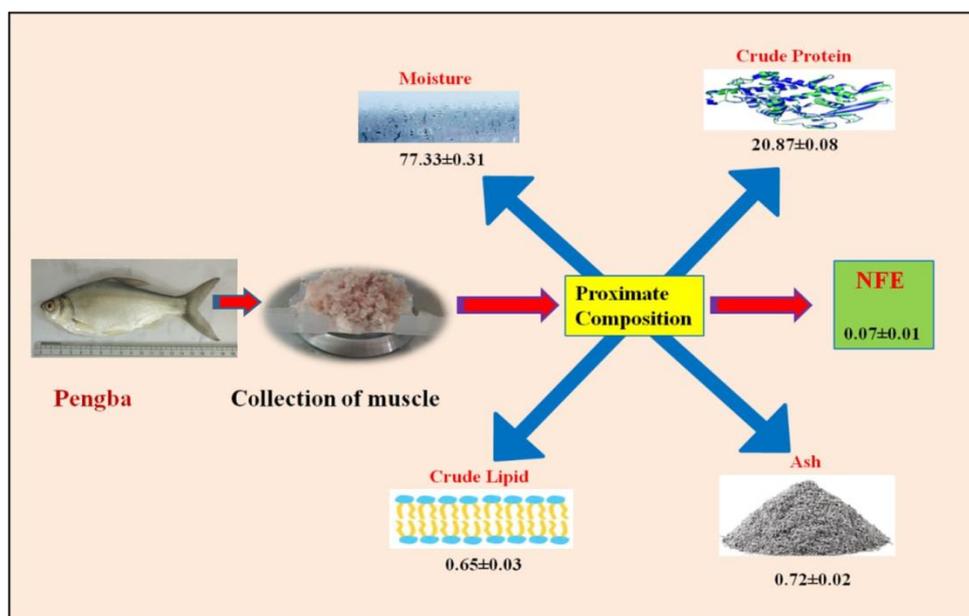
### 3.4. Proximate composition of fish muscle

At the end of the culture for 12<sup>th</sup> months, the proximate composition of the muscle of four fish species were analyzed (Table4). The moisture content ranged from 73.63 % to 77.9 %. Highest ash content was seen in rohu fish and lowest seen in mrigal. Maximum crude protein content was seen in *O.belangeri* (20.87%) followed by *C. catla* (15.06%), *L. rohita* (13.04%) and *C. mrigala* (11.93%). Crude lipid shown to be highest in *L. rohita* (1.35%) and lowest in *C.catla* (0.42%). Ash content in the fishes ranged from 0.72% to 1.14%.

**Table 4** Muscle proximate composition (% wet weight) of four fish species cultured in ponds of Purulia district

Fish species	Moisture	Crude protein	Crude lipid	Total ash	NFE
<i>Labeo rohita</i>	77.9±1	13.04±0.04	1.35±0.05	1.08±0.03	6.38±0.17
<i>Catla catla</i>	74.51±0.59	15.06±0.24	0.42±0.01	1.14±0.02	8.76±0.40
<i>Cirrhinus mrigala</i>	73.63±0.31	11.93±0.26	0.45±0.01	1±0.02	12.08±0.26
<i>Osteobrama belangeri</i>	77.33±0.31	20.87±0.08	0.65±0.03	0.72±0.02	0.07±0.01

Data are presented as mean ± standard deviation; n = 3



**Figure 6** Diagrammatic representation of proximate composition of *Osteobrama belangeri* fish

## 4. Discussion

The pH, DO value shows improvement in the monsoon period because in this time occurrence of rain dilutes the water. This dilution effect also causes reduction of both alkalinity and hardness [16]. The alkalinity, hardness of the water of ponds in the Pre monsoon period shows maximum value due to decreased rainfall and mineralization [34, 35, 36]. The variation in DO from 5.5 to 8.3 mg/L during 12 month culture period may be due to temperature difference in water [37]. Temperature value in this study period shows gradual decrease from pre monsoon to winter seasons [38, 39, 40]. Highest TDS value was seen in pre monsoon period and this may be due to less water in ponds. The available phosphate concentration of water bodies during the study period varied from 0.003 – 0.07 mg/L. Ammonia concentration varied from 0.03 – 0.13 mg/L. Maximum value was observed in pre monsoon period i.e. 0.13 mg/L and this was found due to low rainfall and stagnant water body. However different water quality parameters during the culture period are within the tolerance level for the carps [41, 42, 43, 44] and intermediate liming and fertilisation actions were implemented for maintaining preferred range of parameters of pond water.

For conservation of the pengba, culture and breeding of that fish has been successfully practiced in the ponds of Manipur [5]. But recently for few years the culture of this fish is not only confined to the Manipur but also other states like Odisha, Bihar, West Bengal tried to culture pengba in ponds. In Purba Medinipur district of West Bengal, pengba fish was

cultured along with other Indian Major Carps. An average size of 400 gm of pengba was harvested after 8 months of culture period [45]. The size of the fingerlings of pengba were 2 gm approximately at the time of stocking. Previously in Purulia district no attempt has been taken for culture of this fish. Culture of pengba along with other IMCs in this drought prone region has been recorded for the first time. Pengba recorded a SGR of 1.16 % i.e almost equal found by the study of Yengkokpam et al., 2019 [31]. This fish has been grown from 2.12 g to 200 g in 12 month culture period and it is less than the study of Sahu, S. K. 2020 [45]. This lower growth may be due to this fish is new for this region and less productivity of the ponds. But the survival of the pengba fish shown 73% and this is supported by the study of Yengkokpam et al., 2019 [31]. Better growth performance was noticed in catla followed by mrigal and pengba. Rohu showed less growth performance than pengba [16]. In the present experiment a total production of 905 kg /ha was produced after one year culture. Fish yield of 3362- 3962 kg/ha was produced in six months by rearing fingerlings of Indian Major Carps from pens in ox-bow lakes of Bihar, India [46]. 8 kg of pengba fish was obtained per decimal area in ponds of Haldia, Purba Medinipur [45].

The proximate composition of the cultured fishes at the end of culture period was analyzed to compare the nutrient composition among the different fish species. In this study pengba showed highest crude protein (20.87%) among the four fish species. It has low lipid (0.65%) and good moisture content (77.33%).

---

## 5. Conclusion

From this study it can be stated that pengba can be a potential candidate species for carp polyculture diversification. Though it attained a lower size in this region but this size is marketable and its silvery appearance and taste of the meat attract the consumers. The survival and nutritional quality of this fish made it important food fish for this region.

---

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

---

## References

- [1] Harvey, B., Soto, D., Carolsfeld, J., Beveridge., & Bartley, D. M. (2017). Planning for aquaculture diversification: the importance of climate change and other drivers. FAO technical workshop, 23-25 June 2016, FAO Rome. FAO Fisheries and Aquaculture Proceedings No. 47. Rome, FAO 166pp.
- [2] Ayyappan, S., Gopalakrishnan, A., & Kumar, B. G. (2009). Species diversification in aquaculture and domestic fish marketing in India., (pp 13-22). *In Indaqua 2009 Souvenir*, Bhubaneswar, Orissa. Kochi, Kerala : Marine Products Export Development Authority (MPEDA).
- [3] Sreekanth, G. B., Varghese, T., Mishal, P., Sandeep, K. P., & Praveen, K. V. (2015). Food security in India : is aquaculture a solution in the offing? *Internatonal Journal of Science and Research*, 4(3), 553-560.
- [4] Deepti, M., Meitei, M. M., Ngasotter, S., & Mahendrajit, A. (2023). Pengba, *Osteobrama belangeri* – a candidate species for diversification in aquaculture. *Aquaculture*, 27(2) : 25-29.
- [5] Behera, B.K., Meena, D. K., Das, P., Singh, N. S., & Pakrashi, S. (2015). Pengba, a prospective species for diversification of carp polyculture : conservation and future prospects. *World Aquaculture*, 46(4) : 52-54. [www.was.org](http://www.was.org)
- [6] Das, P. C., & Mishra, B. (2016). Multi-species farming of major and minor carps for enhancing production in freshwater aquaculture. *Indian Journal of Fisheries*, 63(2), 55-61. <https://doi.org/10.21077/ijf.2016.63.2.54038-08>
- [7] Muhammad, A. B. S., Nahar, A., Ahamed, F., Zubia, M., & Hossain, Y. (2013). Conservation of critically endangered olive barb *Puntius sarana* (Hamilton, 1822) through artificial propagation. *Our Nature*, 11(2), 96-104.
- [8] Singh, N. S., & Basudha, C. (2007). Induced spawning of *Osteobrama belangeri* (Val.), a critically endangered fish in India using carp pituitary and Ovaprim. *Aquaculture*, 8(2), 231-236.
- [9] Wahab, M. A., Rahman, M. M., & Milstein, A. (2002). The effect of common carp, *Cyprinus carpio* (L.) and mrigal, *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polyculture. *Aquaculture Research*, 33, 547-556.

- [10] Das, P. C., Kamble, S., Velmurugan, P., & Pradhan, D. (2019). Evaluation of minor carps inter-cropping in carp polyculture vis-a-vis other grow-out cropping patterns of carp farming. *Aquaculture Research*, 50(1574-1584), 1-11. <https://doi.org/10.1111/are.14034>
- [11] Basudha, C., & Singh, N. S. (2008). Conservation of *Osteobrama belangeri* (Valenciennes) in Manipur : Current Status and future strategies. In L. Kosygin, (Ed.), *Wetlands of North East India : Ecology, Aquatic Bioresources & Conservation* 270 pp. New Delhi : Akansha Publishing House.
- [12] Ramesh, R., Dube, K., Reddy, A. K., Prakash, C., Tiwari, V. K., Rangacharyulu, P. V., & Venkateshwarlu, G. (2014). Growth and survival of pengba, *Osteobrama belangeri* (Valenciennes) larvae in response to co-feeding with live feed and microparticulate diet. *Ecology Environment & Conservation*, 20(4), 1751-1721.
- [13] CAMP. (1997). Draft Report. Conservation assessment and management plan workshop for freshwater fishes of India. National Bureau of fish genetic research, Lucknow, Sept, 22-26.
- [14] Khuman, O. N., Singh, Y. J., Sarkar, A., Upadhyay, A. D., Pal, P., & Patel, A. B. (2019). Present status of pengba (*Osteobrama belangeri*) farming in the valleys of Manipur. *Indian Journal of Hill Farming*, 32(2) : 283-286.
- [15] Basudha, C., & Viswanath, V. (1993). Nutritive value and growth responses of formulated aquatic fern *Azolla* based diets on advanced fry of endemic medium carp, *Osteobrama belangeri* (Valenciennes). *Journal of Freshwater Biology*, 5: 159-164.
- [16] Das, P. C., Sahoo, P. K., Kamble, S. P., Murmu, K., & Basudha, C. (2019). Compatibility of pengba, *Osteobrama belangeri* (Valenciennes) with Indian major carps and evaluation of its ideal incorporation level in carp polyculture system in planes of India. *Aquaculture*, 518(2020), 734845.
- [17] Das, P. C., Sahoo, P. K., Mohanty, S., Mishra, M., & Swain, S. K. (2019). Growth performance of pengba, *Osteobrama belangeri* (Valenciennes, 1844) and water quality changes during fingerling rearing with varied stocking density in large outdoor concrete tanks. *Aquaculture Research*, 2019, 1-7.
- [18] Bhateria, R., & Jain, D. (2016). Water quality assessment of lake water : a review. *Sustainability of Water Resource Management*, 2, 161-173. <https://doi.org/10.1007/s40899-015-0014-7>
- [19] Mahanta, C., Sarma, A. K., & Sarma, B. (2011). Water quality degradation in the tributaries of the Brahmaputra-Barak Basin and their environmental management strategy. *World Environmental and Water Resources Congress 2011: Bearing Knowledge for Sustainability*, 658-661. [https://doi.org/10.1061/41173\(414\)483](https://doi.org/10.1061/41173(414)483)
- [20] Even, S., Mouchel, J. M., Servais, P., Flipo, N., Poulin, N., Blanc, M., & Paffoni, C. (2007). Modeling the impacts of combined sewer overflows on the river seine water quality. *Science of the Total Environment*, 375, 140-151. <https://doi.org/10.1016/j.scitotenv.2006.12.007>
- [21] Liu, S., Yan, M., Tai, H., Xu, L., & Li, D. (2012). Prediction of dissolved oxygen content in aquaculture of *hyriopsis cumingii* using elman neural network. *IFIP Advances in Information and Communication Technology*, 370 AICT, 508-518. <https://doi.org/10.1007/978-3-642-27275-2-57>
- [22] Yin, Z., Yu, N., Liang, B., Zeng, J., & Xie, S. (2016). Experimental study of dissolved oxygen transport by regular waves through a perforated breakwater. *Journal of Ocean University of China*, 15, 78-82. <https://doi.org/10.1007/s11802-016-2690-9>
- [23] CPCB. (2008). Guidelines for water quality monitoring Central Pollution Control Board, 1-35.
- [24] Banerjea, S. M. (1967). Water quality and soil condition of fishponds in some states of India in relation to fish production. *Indian Journal of Fisheries*, 14(1-2) : 115-144.
- [25] Khwairakpam, E., Khosa, R., Gosain, A., & Nema, A. (2019). Habitat suitability analysis of pengba fish in Loktak lake and its river basin. *Ecohydrology*, 2020(13) : e2164. <https://doi.org/10.1002/eco.2164>
- [26] Bagli, S., & Tiwari, G. (2019). Multidimensional poverty : an exploratory study in Purulia district, West Bengal. *Economic Affairs*, 64(3), 517-527.
- [27] Guchhait, S. K., & Sengupta, S. (2020). Determinants and decomposition of poverty of rural India : glimpses from the Purulia district of West Bengal. *Journal of Asian and African Studies*, 56(6), 1251-1270.
- [28] Jena, J. K., Das, P. C., Das, B. K., Mohapatra, B. C., Sarangi, N., Modayil, M. J., Vass, K. K., Ravichandran, P., Ponniah, A. G., Syda Rao, G., Eknath, A. E., & Ayyappan, S. (2009). *Aquaculture technologies for farmers*, revised edition. ICAR, New Delhi, pp. 126

- [29] APHA. (2012). Standard Methods for the Examination of Water and Wastewater, 21<sup>st</sup> edn. USA, American Public Health Association. Washington, DC, USA.
- [30] Pradhan, A., & Bandyopadhyay, N. (2018). Seasonal variation of water quality parameters and zooplankton diversity in water bodies of Purulia district, West Bengal, India. *International Journal of Zoology and Applied Biosciences*, 3(3), 356-461.
- [31] Yengkokpam, S., Bhattacharjya, B. K., Debnath, D., & Yadav, A. K. (2019). Polyculture of *Osteobrama belangeri* with major carps in pen enclosures in Takmu lake of Manipur. *Journal of the Inland Fisheries Society of India*, 51 (1) : 125-132.
- [32] Jena, J. K., & Das, P. C. (2011). Carp culture. In: Verma, S.A., Kumar, A.T., Rahman, O., Pradhan, S. (Eds.), Hand Book of Fisheries and Aquaculture. Pp 1116, 2<sup>nd</sup> Revised edition. Directorate of Knowledge Management in Agriculture (DKMA), Indian Council of Agricultural Research, New Delhi, pp. 380-400.
- [33] AOAC. (1995). Official Methods of Analysis of AOAC . International by Cunniff, P. A. (ed), vol. 1, 16<sup>th</sup> Edn. AOAC International, Arlington, USA.
- [34] Diana, J. S., Szyper, J. P., Batterson, T. R., Boyd, C. E., & Piedrahita, R. H. (1997). Water quality in ponds. In H. S. Egna, & C. E. Boyd (Eds), *Dynamics of Pond Aquaculture*, 53-72. Boca Raton, FL, USA: CRC Press.
- [35] Avnimelech, Y. (1999). Carbon nitrogen ratio as a control element in aquaculture systems. *Aquaculture*, 176: 227-235.
- [36] Das, P. C., Ayyappan, S., & Jena, J. K. (2005). Comparative changes in water quality and role of pond soil after application of different levels of organic and inorganic inputs. *Aquaculture Research*, 36, 785-798. <https://doi.org/10.1111/j.1365-2109.2005.01288.x>
- [37] Kamal, D., Khan, A., Rahman, M., & Ahamed, F. (2007). Study on the physico-chemical properties of water of Mouri river, Khulna, Bangladesh. *Pakistan Journal of Biological Sciences*, 10(5), 710-717.
- [38] Singh, M., & Gupta, K. (2004). Physico-chemical studies of water of river Yamuna at Mathura. *Ecology Environment and Conservation*, 10, 193-196.
- [39] Sen, S., Paul, M. K., & Borah, M. (2011). Study of some physico-chemical parameters of pond and river water with reference to correlation study. *International Journal of Chemical Technology Research*, 3(4), 1802-1807.
- [40] Anukool, S., & Shivani, S. (2011). Assessment of physico-chemical properties and sewage pollution indicator bacteria in surface water of river Gomti in Uttar Pradesh. *International Journal of Environmental Sciences*, 2(1), 325.
- [41] Tripathi, S.D., Aravindakshan, P.K., Ayyappan, S., Jena, J. K., Muduli, H. K., Chandra, S., & Pani, K. C. (2000). New dimensions in intensive carp polyculture in India. *Journal of Aquaculture Tropics* 15: 119-128.
- [42] Jena, J. K., Ayyappan, S., & Aravindakshan P.K.(2002a). Comparative evaluation of production performance in varied cropping patterns of carp polyculture systems. *Aquaculture* 207(1-2):49-64. [https://doi.org/10.1016/S0044-8486\(01\)00800-6](https://doi.org/10.1016/S0044-8486(01)00800-6).
- [43] Sahu, P. K., Jena, J. K., Das, P.C., Mondal, S., & Das, R. (2007). Production performance of *Labeo calbasu* (Hamilton) in polyculture with three Indian major carps *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) with provision of fertilizers, feed and periphytic substrate as varied inputs. *Aquaculture* 262: 333-339. <https://doi.org/10.1016/j.aquaculture.2006.11.016>
- [44] Das, P. C., Mishra, S. S., Mishra, B., & Jayasankar, P. (2016). Influence of juvenile stunting on grow-out performance of rohu, *Labeo rohita* (Hamilton 1822). *Journal of Applied Ichthyology*, 32: 845-858. <https://doi.org/10.1111/jai.13131>
- [45] Sahu, S. K. (2020). Pengba, *Osteobrama belangeri* (Valenciennes, 1844) a prospective species for diversification of carp polyculture system and suggestions towards the adoption of scientific fish farming in Haldia, West Bengal. *International Research Journal of Basic and Applied Sciences*, 5, 54-58.
- [46] Rai, S. P., & Singh, R. C. (1990). Potential of pen culture in Ox-bow lakes, p. 13. In: Jhingran, A. G., Unnithan, V. K., & Ghosh, A. (eds), Proceedings of the Contributions to the fisheries of Inland open water systems in India, Inland Fisheries Society of India Publication, Barrackpore, India.