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Performance of hatchery-produced and feed-weaned fingerlings of striped murrel *Channa striata* (Bloch, 1793) in biofloc system in the subtropical climate

Sudhir Raizada[1*], Anurag Rawat[1] and Prem Prakash Srivastava[2]

[1]ICAR-National Bureau of Fish Genetic Resources, Canal Ring Road, P. O. Dilkusha, Lucknow-226 002, Uttar Pradesh, India
[2]Dr Rajendra Prasad Central Agricultural University, Samastipur-848 125, Bihar, India

Abstract

The performance of hatchery-produced and pellet-feed-weaned fingerlings of striped murrel, *Channa striata* (Bloch, 1793) was assessed in the biofloc tanks for growth and survival, in a subtropical climate. The rearing was undertaken in two phases with an increase in fish size. In the first phase, fingerlings (weight 1.94±0.71 g, length 6.29±0.81 cm) were stocked @ 200 m^{-3} in the biofloc tanks, which were reduced to 15 m^{-3} in the second phase using the same stock. The fish attained a length of 25.44±1.81 cm and weight of 149.60±28.58 g in 10 months with overall survival of 93% at the end of the second phase. The total fish biomass recorded was 9.7 kg m^{-3} at the final harvest. The growth parameters were found temperature-dependent, which recorded 15±1.0 to 28±1.5ºC and 'W' values were found to follow Fulton's cube law during the entire culture period. The exponent (b) of 3.278 was recorded as highest in July 2020 and lowest at 2.210 in December 2020. The lowest R^2 was 0.768 and highest 0.943 during December and April respectively whereas, the recorded 'K' of 0.611 was the lowest in winter and highest being 0.908 in August. The study demonstrated a higher culture potential of striped murrel with hatchery-produced and feed-weaned seed in the biofloc system with zero-water exchange.

*Correspondence e-mail:
sudhirraizada@hotmail.com

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Introduction

Burgeoning fish demand and space limitations has necessitated future aquaculture needs to be more intensive even in less space but sustainable with significantly low usage of water and land resources. However, intensive fish farming causes quick deterioration of water quality due to the accumulation of toxic substances which are lethal to fish. Biofloc Technology (BFT) can however, provide fish production at high stocking density in a condition that is sustainable and biologically safe (Ray *et al.*, 2010; Zhao *et al.*, 2012; Schveitzer *et al.*, 2013) as it allows conversion of toxic ammonia, excreted by the fish into the rearing system to safer nitrate products, besides, the heterotrophic microbes which becomes a source of natural food for the filter-feeding fishes and shrimps (Avnimelech, 2009; Cardona *et al.*, 2015; Ray and Lotz, 2017). Several past studies have demonstrated suitability of BFT for the farming of Pacific white-leg shrimp (*Penaeus vannamei*) and Nile tilapia (*Oreochromis niloticus*) owing to their better filter-feeding efficiency in the biofloc system (Xu *et al.*, 2012; Martins *et al.*, 2020; Nguyen *et al.*, 2021; Suarez-Puerto *et al.*, 2021). Studies have also indicated that BFT not only serves as a feeding media but also provides positive effects on fish immunity and reproductive performances (Eksari *et al.*, 2014, 2016; Cardona *et al.*, 2016). Biofloc has also been reported to perform better in terms of growth and survival for the larval rearing and grow-out productions of many species including those which are omnivorous and carnivorous such as grey mullet (*Mugil cephalus*), common carp (*Cyprinus carpio*), tench (*Tinca tinca*), rohu (*Labeo rohita*), African catfish (*Clarias gariepinus*), channel catfish (*Ictalurus ictalurus*), silver catfish (*Rhamdia quelen*), striped catfish (*Pangasianodon hypophthalmus*), Pangas catfish (*Pangasius pangasius*), largemouth bass (*Micropterus salmoides*), hybrid striped bass (*Morone chrysops* x *M. saxatilis*) (Poli *et al.*, 2015; Ekasari *et al.*, 2016; Dauda *et al.*, 2017; Bakhshi *et al.*, 2018; Green *et al.*, 2018; Vinatea *et al.*, 2018; Nageshwari *et al.*, 2019; Sukardi *et al.*, 2019; Battisti *et al.*, 2020; Green *et al.*, 2020; Romano *et al.*, 2020; Vadhel *et al.*, 2020).

BFT is becoming very popular in India as it requires comparatively smaller landholdings and less water, which are the immediate and future needs of the farmers. The government is also popularising it by providing good incentives to farmers and entrepreneurs. The species presently cultured in BFT are striped catfish to a greater extent and GIFT strain of Nile tilapia to a lesser, depending on the availability of seed. However, both are low-value species and the farming of these species may not be economically viable in BFT due to the higher cost of production. Therefore, BFT requires high-value fish species suitable for the system for its sustenance.

Striped murrel or striped snakehead *Channa striata* (Bloch, 1793) is a high-value and very hardy fish in terms of tolerance to high levels of total dissolved solids (TSS), temperature fluctuations, and low dissolved oxygen conditions in water as it is an air-breathing species. Recent interventions have made the possibility of mass-scale production of hatchery-seed of *C. striata*, which could also be weaned on a commercial pellet diet for an almost complete elimination of cannibalism (Rawat *et al.*, 2020; Raizada *et al.*, 2021). Therefore, the present study was aimed at exploring the suitability of striped murrel culture in the BFT system using hatchery-produced and feed-weaned seed in tropical and sub-tropical climatic conditions. Since BFT requires a small area and almost zero-water exchange, it would meet the requirements of small farmers and entrepreneurs to produce it on low inputs. This will also help in increasing the income of the farmers as it is a high-value species.

Materials and methods

Study area

The experimental culture of striped murrel was undertaken at a private biofloc fish farm in Lucknow City, Uttar Pradesh, India (26.7651°N; 80.9571°E). The climate of the area is subtropical warm with air temperatures of a minimum average of 8.8ºC in January and a maximum average of 41.1ºC in June. It has three seasons consisting of winter (November-February), monsoon (July-September), and rest summer.

Fish

The hatchery-produced and pellet-weaned seed of striped murrel *C. striata* were sourced from the ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Lucknow, India located at about 5 km distance from the experimental BFT farm site. The seed was transported in oxygen-packed polythene bags. The seed was acclimatised to the water quality of the BFT farm site and subsequently with biofloc media of the experimental tanks before stocking in the first-phase rearing tanks.

Rearing systems

The rearing of *C. striata* was undertaken in two phases in BFT tanks, partly open from two sides to get sufficient sunlight. The first-phase rearing was undertaken in winter (November 2019-March 2020) during which early-fingerlings were reared to advanced-fingerlings size. To reduce the effect of cold temperature, the tank area was covered from all sides with 200 microns thick transparent HDPE sheet. Two circular HDPE-lined tanks of dia. 2.5 m and height 0.9 m (water depth 0.7 m, volume 3400 l) were used for fish rearing. The tanks were covered with nylon netting to prevent any loss due to the jumping of fish. The second-phase rearing was undertaken during summer and monsoon (April-August 2020) in two oval-shaped cement tanks of 10 t capacity for raising juveniles by restocking the advanced fingerlings produced in the first phase.

Rearing protocol

The biofloc was developed and maintained in the tanks following the protocol of Avnimelech (2009). The main carbon source used for the production of biofloc was jaggery, which was supplemented with commercial as well as home-made probiotics. The tanks were provided continuous aeration from a portable air-blower (Grand HAP-120, Hailea Hi-blow). In the first phase, each circular tank was stocked with 700 fingerlings (weight 1.97±0.67 g and length 6.29±0.81 cm) equivalent to a stocking density of 200 fingerlings of striped murrel per m^3. The fish were fed with commercial floating pellets containing crude protien (CP) 45%, lipid 10%, and fibre 3.5% (pellet size 1.2 mm) in the first-phase rearing, which was the same feed on which the fingerlings were weaned at the sourced hatchery. The tanks of the first-phase rearing were harvested in March 2020. In the second phase, the harvested fishes from the first-phase rearing were restocked the same day after giving a prophylactic bath of 2 mg l^{-1} of potassium permanganate at a stocking density of 686 fish per tank of 10 m^3 size (weight 23.26±5.83 g and length 14.06±1.02 cm), which was equivalent to a stocking density of 68.6 m^{-3} and reared till August 2020. The fishes were given a pellet diet of CP 40%, lipid 8%, and fibre 3.5% (pellet size 1.8 mm). The feed was given *ad libitum* 2-3 times a day. The quantity and frequency of feed were adjusted depending on feed acceptability at different fish sizes and temperature regimes. The quantity of biofloc was monitored in the tanks on every alternate day with Imhoff cone and maintained between 25-40 ml l^{-1} by adding various nutrients used for the development of biofloc at an initial stage.

The tanks of the second-phase rearing were finally harvested in August 2020. The same biofloc media was continuously used during the entire culture period except for topping off the water level due to evaporation loss.

Sampling and analysis of growth indices

Around 100 fishes were harvested from each tank by dragging a netting on a monthly basis. They were sampled for length and weight assessment during the entire culture period. The length-weight of 50 fish was taken on a random basis by pooling fishes from both the rearing tanks. The length of the fish was measured with the help of a digital vernier calliper and weight by a digital balance. The weight of the small-size fishes measuring less than 5 g was taken with an electronic balance (Sartorius, precision 0.001 g) whereas, larger ones with a digital single pan-balance (ATCO, precision 1 g). All the fish were returned to the tanks immediately after recording lengths and weights and giving a short-bath in 2 mg l^{-1} of potassium permanganate.

The length-weight relationship (LWR) and growth indices were analysed using MS Excel (2007). The length-weight relationship (log-transformed) was determined by linear regression analysis and scatter diagrams following the cube law given by Le Cren (1951) using the formula:

$W = aL^b$

where, W=Weight of fish (g), L= Total length (cm), 'a'= Regression intercept, and 'b' = Regression slope or exponent.

The logarithmic transformation of the above formula.

Log W = log a + b log L

Fulton's Condition Factor (K) was calculated using the equation given by Htun-Han (1978):

$$K = \frac{W \text{ X } 100}{L^3}$$

where, W=Weight of fish (g), L=Total length of fish (cm)

Specific growth rate (SGR) was calculated using the formula:

$$SGR = \frac{\text{log (Final weight)-log (Initial weight) X 100}}{\text{Culture duration}}$$

where weights are in gram

The coefficient of determination (R^2) was estimated by drawing the regression line using X and Y variables in MS Excel (2007), where 'X' was the log length and 'Y' was the log weight.

Survival was estimated using the following formula:

$$\text{Survival \%} = \frac{\text{No. of fishes at harvest X 100}}{\text{Initial no. of fishes}}$$

Water quality

Water quality was analysed all throughout the culture period. Water temperature, pH, and dissolved oxygen (DO) were recorded on a daily basis whereas; ammonia, nitrite, and nitrates were recorded on a weekly basis and total dissolved solids (TDS), and total alkalinity on a fortnightly basis. Temperature was measured with a mercury thermometer (0-110°C); pH with a digital pH meter (make Hanna); TDS by a digital TDS meter (make Hanna); ammonia, nitrite, and nitrates by the Lifesonic Master Water Test kit [Lifesonic Innovations (P) Ltd., India], dissolved oxygen (DO) and total alkalinity (TA) by titration method (APHA, 2005).

Results

The monthly data on the weight-length relationship (WLR), growth, and survival are given in Table 1 and their graphical presentation in Fig.1, 2 and 3.

Growth and survival

The striped murrel was found to grow well in biofloc media with survivals of 98 and 93% at the end of the first phase (winter) and the second phase (monsoon-summer) rearing (Table 1) respectively. The fish showed continuous growth both in lengths and weights at a temperature regime of 15±1.0 to 28±1.5°C, which was found directly proportional to each other (Fig. 1). During 300 days of rearing, the growth in terms of both lengths and weights was found to increase despite the fact that there were large differences in the temperature regime from a low of 15±1.0 to a high of 28±1.5°C (Table 1, Fig. 1). The SGR was found highest (1.967%) in the small size-group at normal temperature of rearing whereas, it was negative (-0.086) during January-February when water temperature dropped to 15±1.0°C. However, the rate of growth was faster at higher water temperatures. The survival at the end of first-phase rearing was recorded at 98% whereas, overall 93% at the end of second-phase rearing (Table 1).

Weight-length relation (WLR)

The 'W' values were found to follow Fulton's cube law during the entire culture period in biofloc media. The values of exponent 'b' of 3.278 were highest in July 2020 and lowest *i.e.*, 2.210 in December 2020. The coefficient of regression (R^2) was 0.768 being lowest in December (winter) and highest (0.943) during April (summer). Similarly, the lowest value of

Table 1. Details of LWR, survival and growth data of striped murrel reared in BFT for 300 days

Parameter	Stocking details (23.10.19)	30 days (23.11.19)	60 days (23.12.20)	90 days (23.01.20)	120 days (23. 02.20)	150 days (23.03.20)	180 days (23.04.20)	210 days (23.05.20)	240 days (23.06.20)	270 days (23.07.20)	300 days (23.08.20)
Water temperature (°C)	27±2.0	25±2.0	17±1.5	15±1.0	18±2.0	21±2.0	23±1.0	27±1.5	28±1.5	27±1.5	28±1.5
Mean total length (cm)	6.29 ±0.81	9.42 ±0.77	10.80 ±0.93	11.30 ±0.78	12.00 ±1.12	14.06 ±1.02	16.50 ±0.80	18.28 ±1.75	23.96 ±1.36	25.31 ±1.09	25.44 ±1.81
Max length (cm)	8.2	10.7	13.2	13.1	14.3	16.5	18.2	21.5	26.8	29.0	29.1
Min length (cm)	4.9	8.0	8.5	9.5	9.5	12.5	15.0	12.4	20.4	23.0	22.0
Mean weight (g)	1.97 ±0.675	7.48 ±1.75	10.53 ±2.40	12.56 ±2.54	14.93 ±3.53	23.26 ±5.83	32.60 ±3.93	45.82 ±11.57	108.26 ±19.00	133.88 ±21.63	149.60 ±28.58
Max weight (g)	3.9	12.0	18.0	19.0	22.0	38.0	43.0	72.0	156.0	196.0	216.0
Min weight (g)	1.1	5.0	16.0	7.0	8.0	16.0	24.0	16.0	62.0	100.0	94.0
Proportionality constant 'a'	-1.679	-1.680	-1.268	-1.949	-1.605	-2.318	-1.208	-0.1.814	-1.926	-2.278	-1.312
Exponent 'b'	2.454	2.614	2.210	2.887	2.567	3.201	2.233	2.745	2.868	3.278	2.477
Coefficient of determination 'R^2'	0.936	0.858	0.768	0.899	0.826	0.929	0.943	0.946	0.850	0.806	0.851
Ponderal Index 'K'	0.792	0.895	0.836	0.868	0.611	0.835	0.725	0.749	0.786	0.825	0.908
SGR (%) per day	-	1.967	0.481	0.250	-0.086	0.730	0.502	0.449	1.234	0.311	0.147
Survival (%)	-	-	-	-	-	98	-	-	-	-	93

Ponderal Index (K) was found at 0.611 in February (winter) and the highest at 0.908 in August (Table 1, Fig. 2). The scatter regression line diagrams drawn from the month-wise data on lengths and weights have shown straight regression lines without showing any potential outliers (Fig. 3).

Water quality

There were large differences in water temperature during the winter and summer seasons. The minimum temperature of 15.0±1.0°C was observed in January 2020 during extreme winter and a maximum of 28±1.5°C during June and August 2020 during the summer season. The water quality parameters recorded were: pH 8.0±0.5; TDS 650±79 mg l^{-1}, total alkalinity 230±9 mg l^{-1}, DO 5.2±0.4 mg l^{-1}, unionised ammonia 0.35±0.12 mg l^{-1}, nitrite 0.27±0.10 mg l^{-1}, and nitrate 0.42±0.21 mg l^{-1}, which were found in the normal range for the biofloc media.

Discussion

The higher survivals of 98 and 93% respectively, in the first and the second-phase rearing were remarkable after 10 months

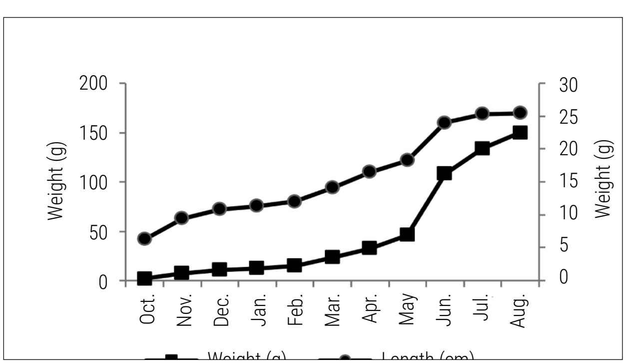

Fig. 1. Month-wise length and weight performance of striped murrel in BFT

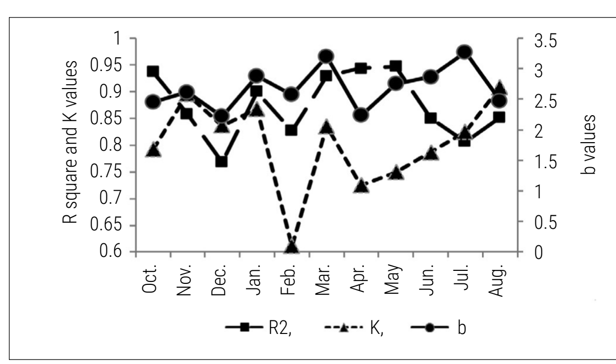

Fig. 2. Month-wise 'b', 'R2' and 'K' values of striped murrel in BFT

of rearing, considering that the species is highly carnivorous and cannibalistic (Ng and Lim, 1990). Devraj (1973) reported survival of only 19.3% in 3 months and 1.3% in 5 months culture in cement tanks when fingerlings of striped murrel procured from the wild resources were reared by feeding on fish liver. Past studies have revealed that weaning the seed on a pellet diet after its procurement from wild resources has shown higher survival in pond systems (Rahman *et al.*, 2012; So *et al.*, 2012; Farhana *et al.*, 2016; Rao, 2020). It is to be mentioned here that the mortality of 7% after 10 months of culture period was mainly due to mishandling of fish during monthly samplings. The mortality due to cannibalism was not absent as none of the fish was observed to have a distended belly, a characteristic of a cannibal, during monthly samplings. The absence of cannibalism, therefore, seems to be due to the proper weaning of fingerlings from the stage of hatchlings to fingerling-size on well-acceptable diets of live and inert feeds in the hatchery and thereafter in the rearing tanks. Yadav *et al.* (2014) have also reported that feed having CP 50% and fat 9% considerably increased survival and growth in *C. marulius*.

Striped murrels have largemouth gape; sharp jaw teeth for catching and grasping prey and can consume prey fish of more than half to two-thirds of its length (Wee, 1981; Diana *et al.,* 1985*;* Ng and Lim, 1990; Qin and Fast, 1996). It exhibits both filial and Intracohort cannibalism (ICC) in their life-cycle. Whereas filial cannibalism is the consumption of offspring by the parents during parental care under natural conditions, ICC has been observed both in natural and controlled rearing systems, where siblings prey upon each other in a population. Therefore, the major bottlenecks in the farming of striped murrel are its carnivorous and cannibalistic habit, and non-acceptance of artificial feed once it develops carnivore habits. According to Qin and Fast (1997) when two different size larval populations; larger fish of size 57.0+5.7 mm TL and small of size 18.1+1.8 mm TL in 1:2 ratio, were reared together without feed, 86% ICC was observed in captive conditions. However, cannibalism was reduced to 60 and 35% when a feeding ration was provided @ 5 and 15% of larval body weight in a 6 days period. The rate of cannibalism also depends on the quantity of feed application in a homogenous size population in this species. Cannibalism reduced from 12.23±1.94 to 3.31±1.90% with an increase in feed application rate from 2 to 8% body weight in a population of uniform size larvae (1.42±0.12 g) (Kumari *et al.,* 2018). Based on the above assumptions, the fingerlings stocked in the present trial were weaned on an artificial pellet diet before stocking in the biofloc media and fed *ad libitum* and hence there was no cannibalism at later stages resulting in higher survivals. Weaning striped murrel on an artificial diet also reduced size heterogeneity to a greater extent and that could also be one of the reasons for higher survival in the present study.

Though the fish survivals were higher in both the rearing phases but the growth was extremely slow in winter (October 2019 to March 2020) when the water temperature was extremely low (>8.8 ºC). However, higher survival of 98% after 5 months of winter rearing in indoor tanks without soil base has given an impression that the species is hard enough to tolerate this much low temperature in biofloc media. This would provide an option for over-winter rearing of fingerlings which could be utilised as a source of seed for grow-out productions in spring and summer seasons for getting maximum utilisation of growth period both in tropical and sub-tropical climatic conditions.

The fish picked up growth with an increase in water temperature from April (23±1.0 ºC) that continued till August (28±1.5ºC). During this period, the average length of fish increased from 16.50±0.80 to 25.44±1.81 cm and weight from 32.60±3.93 to 149.60±28.58 g. Thus, there was a weight gain of about 117 g per fish within 4 months at a stocking density of 15 fingerlings m^{-3}. The estimated total biomass produced per tank (10 t) therefore was observed to be 97 kg (9.7 kg m^{-3}), which is extremely a higher production in comparison to the pond and hapa rearing systems, where seed procured from wild resources have been used as stocking material and fed pellet diet (Rahman *et al.*, 2012; So *et al.,* 2012; Haiwen *et al.,* 2014; Farhana *et al.,* 2016). This is perhaps the first study on biofloc in which hatchery-produced and pellet-diet-weaned striped murrel has been cultured with high survival and production rates. In a recent study, Rao (2020) demonstrated production of 20.93 t under intensive farming in the earthen pond (0.6 ha) in 8 months with 95% survival by stocking feed-weaned fingerlings of striped murrel at a stocking density of 2.6 fingerling m^{-2}, which confirms the possibility of a higher fish production with this species and hence their study strongly supports the present finding.

It is a general assumption that biofloc is suitable for only filter-feeding fish/shrimp species as they can utilise biofloc, a highly proteinaceous diet for their growth. However, in some of the recent studies, BFT has been found highly suitable for the culture of catfishes as well as African catfish, channel catfish, striped catfish, and pangas catfish, which have shown higher survivals and production rates (Nageswari *et al.*, 2019; Sukardi *et al.*, 2019; Chen *et al.*, 2020; Green *et al.*, 2020). The major advantage of biofloc is the maintenance of healthy water quality with almost zero-water exchange, which has become one of the biggest concerns recently, and further, it is operable at small and large-scale as per the need of the farmers and the entrepreneurs.

Weight-length relationship (WLR), coefficient of determination (R^2), and condition factor (K, Ponderal Index) of the fish were estimated on a monthly basis to determine the weight corresponding to a given length, Goodness of fit, and comparing the 'condition', 'fatness' or ' well-being' of fish (Tesch, 1968) in biofloc media, based on the assumption that heavier fish of given length is in better condition (Table 1, Fig. 2).

The scatter regression line diagrams drawn from month-wise data on length and weight have shown a straight-line regression that confirms an increase in weight corresponding to an increase in length and there were no major outliers in the population and hence chances of cannibalism were probably not there (Fig. 3). There are very few reports available on WLR for murrels including striped murrel. Past studies revealed that murrels in general exhibit more of a negative allometric growth pattern ($b < 3$) than positive ($b > 3$) (Table-2), which may be attributed to their less rounded body and low fecundity even at full maturity. The value of 'b' recorded in the present study ranged from 2.210-3.278 in captive conditions with the lowest value of 2.210 in December, which might have occurred due to a sudden drop of water temperature from 25±2.0 to 17±1.5ºC within about 30 days and would have caused serious stress on fish. The highest 'b' of 3.278 was obtained in July when the temperature of the system rose to 27±1.5ºC and fish developed mature gonads as this species starts attaining maturity in the first year of its life (Table 1 and Fig. 2).

The coefficient of determination (R^2) in murrels, in general, follows a good fit concerning length and weight data sets except in severe stress conditions (Table 2). The factors

Table 2. Statistical values of exponent 'b', coefficient of determination (R^2) and condition factor of striped murrel in wild and captive stock

Stock type and place	Fish size	b	R^2	K/Kn	References
Channa striatus					
Captive stock, Lucknow, India	6.29-25.44 cm	2.21.-3.278	0.768-0.946	0.611-0.908	Present study
Ganga River, India	-	2.929	0.970	-	Khan *et al.* (2011)
Chi River, Thailand	-	2.94	-	-	Satrawaha and Pilasamorn (2009)
Sungai River, Indonesia	-	2.9223	0.9725	-	Ahmadi (2018)
River Siang, India	-	1.612	-	-	Das *et al.* (2015)
Rawa Sekayu	20.73 cm	2.812	0.952	-	Muthmainnah (2013)
Rawa Mariana (Wetlands), Indonesia	20.84 cm,	2.543	0.881		
Vembanad Lake, Kerala, India	-	2.73	0.6113	-	Ali *et al.* (2013)
Captive stock, Chennai, India	-	0.9628-1.127	0.9836-0.9965	-	Sugumaran *et al.* (2018)
Capture, Nadia, West Bengal, India	13-40 cm	3.06-3.10	-	1.02-1.22 (Kn)	Chakraborty *et al.*. (2017)
Capture, Lucknow, India	22.9-42.4 cm	3.407-3.958	0.9333	-	Dayal *et al.*. (2012)
Channa marulius					
Captive stock, Lucknow, India	1-70 cm	2.428-4.205	0.556-0.855	0.589-0.924	Yadav *et al.* (2014)
Harike Reservoir, Punjab, India	29.02-73.52 cm 441.17-1557.57 g	2.15	0.9308	-	Dua and Kumar (2006)
Poongar Swamp, Bhavanisagar, Tamil Nadu, India	Larger size Small size	3.32 1.175	-	-	Devraj (1973)
Kali River, India	-	3.16	-	-	Ahmad *et al.*. (1990)
	-	2.962	-	-	Parameswaran (1975)
Ganga River, India	-	3.0	0.882	-	Khan *et al.* (2012)
Godavari River, India	-	1.45	0.935	-	Rathod *et al.*. (2011)
Pampa River, Kerala, India	-	1.54	0.882	-	Ali *et al.*. (2013)
Channa punctatus					
Beas River, Himachal Pradesh, India	30-170 mm,	2.803	0.998	-	Koundal *et al.*. (2014)
Hilna Beel	-	3.0537	0.812		Alam *et al.* (2018)
Kumari Beel, Bangladesh		2.5598	0.853		
Mathabhanga River, Bangladesh	-	3.37	0.978	-	Hossain *et al.* (2006)
Siruvani , Vellar, Caurvery and Tamirbrani rivers, Tamil Nadu, India	-	2.720- 3.200	0.724- 0.876	-	Haniffa *et al.*. (2006)
Wild pond, Multan, Pakistan	-	2.90	-	0.84-1.17	Ali *et al.* (2000)
Ludhiana, Punjab, India	21.67-22.16 cm	2.76-4.39	0.622-0.892	1.09-1.33	Datta *et al.*. (2013)
Channa micropeltes					
Pechipparai Reservoir, Kanyakumari, Tamil Nadu, India	-	2.734 2.583	0.8843 0.9779	-	Ebanasar and Jayaprakash (2005)
Channa diplogramma					
Pampa River, Vembanad Lake, Kerala, India	-	1.28	0.8732	-	Ali *et al.* (2013)

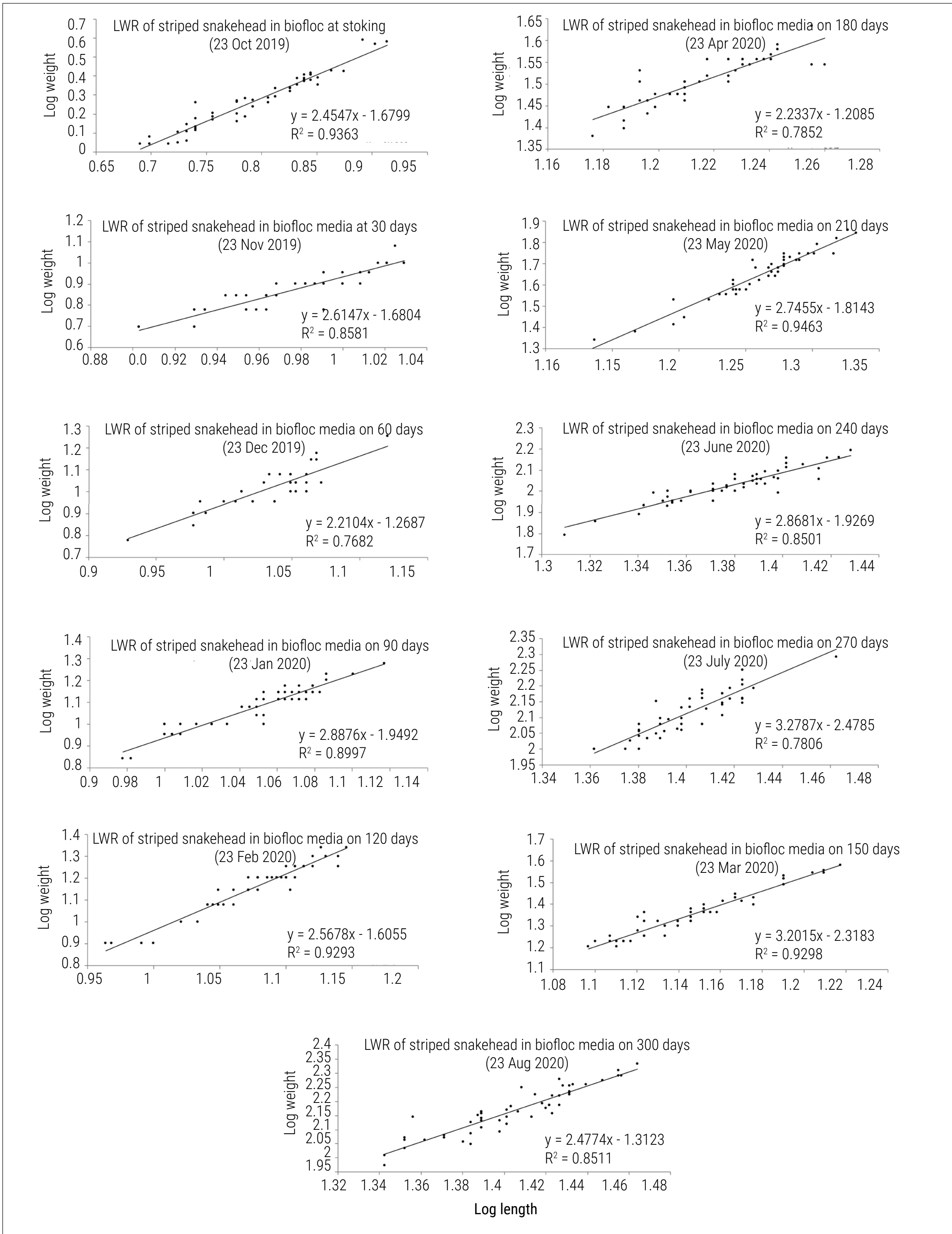

Fig. 3. Month-wise linear regression and scatter diagrams of striped murrel cultured in BFT

that affect the value of 'b' in WLR also influence the value of R^2. The lowest value of R^2 (0.768 in December) obtained in the present study clearly shows that a sudden drop in temperature could be the sole reason. Higher values were obtained either in small size or also when there was a rise in temperature (March) when fish took a fast pace in gaining both length and weight. However, these values were found low in June to July when fish attained higher weights in comparison to lengths probably due to the attainment of first maturity in comparison to the growth phase (Fig. 1, 2)

Studies on Fulton's condition factor or Ponderal Index (K) on murrels are scanty. According to Hile (1936), Fulton's condition factor is the appropriate method for comparing relative heaviness, whereas the WLR equation is the appropriate method for estimating weight from length. WLR in fishes can be affected by various factors such as temperature, pH, dissolved oxygen (DO), seasonal changes, habitat, age, gonadal maturity, sex, stomach fullness, health and preservation technique (Tesch, 1971; Bagenal and Tesch, 1987). The factors that affect the value of 'b' in WLR also influence the value of 'K' except in those which follow the cube law (Ali *et al.,* 2000). The value of K was observed lowest (0.611) in February (temperature 18±2.0 °C) when there was a sudden increase in temperature from the previous month (January), which showed different trends both from 'b' and 'R^{2}' values that are more affected when dropping down in temperature was high (25±2.0 to 17±1.5°C). The 'K' was found to increase with the onset of maturity from April to August and the highest 'K' (0.908) was recorded on attaining complete maturity due to an increase in the girth.

BFT was found highly suitable for rearing feed-weaned striped murrel with higher survivals both at fingerling (98%) and yearling (93%) stages. Production of 9.7 kg m^{-3} obtained in the study was found very high in comparison to production in ponds (Rao, 2020). The WLR data revealed that the species can tolerate a low temperature of 15±1.0°C without soil base in this system and growth was found to continue to increase at a temperature regime of 15±1.0 to 28±1.5°C and hence suitable for rearing in biofloc system in a sub-tropical climate. This perhaps accounts for the first report of rearing hatchery-produced and feed-weaned striped murrel in biofloc media.

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