



Growth and survival of hatchery produced and feed weaned striped murrel *Channa striata* (Bloch, 1793) fingerlings in cement tanks

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ABSTRACT

The growth and survival of hatchery produced and feed weaned fingerlings of striped murrel *Channa striata* (Bloch, 1793) was estimated in cement tanks in a subtropical climate. Each tank was stocked with 215 fingerlings (20 fingerlings m⁻³) of length 6.7±1.0 cm and weight 2.21±1.05 g and fed exclusively on commercial floating pellet diets of two grades (crude protein CP 40-45%, lipid 8-10% and fibre 3-5%). Fish attained a total length of 28.0±2.8 cm and weight 202.7±59.1 g with 85% survival in 330 days of rearing in a subtropical climate in freshwater having a temperature regime of 15±1.5 to 29±2.5°C. The estimated fish biomass was 3.5 kg m⁻³, which was found exceptionally high. 'W' values were found to follow Fulton's cube law with exponent 'b', 'R²' and 'K' in the range 2.072-3.216, 0.776-0.943 and 0.715-0.915 respectively. The values of b, R² and K were found size and temperature dependent. The present study revealed that cannibalism in this species could be controlled to a negligible level with hatchery produced and feed weaned fingerlings.

Keywords: Condition factor, Growth, LWR, Production, Survival

Introduction

Striped murrel or 'striped snakehead' *Channa striata* (Bloch, 1793) is a freshwater fish of high commercial value due to its excellent meat quality, therapeutic and antinociceptive properties. The species is widely distributed in Western to South-east Asian countries including Bangladesh, Cambodia, China, India, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam (Chaudhary, 2019). It is supposed to be introduced in countries like Fiji, New Caledonia (Welcomme, 1988), Madagascar (Stiassny and Raminosa, 1994) and Hawaii (Courtenay *et al.*, 2004).

Globally, 92523 t of striped murrel is produced, of which the major share of 70802 t is contributed from capture fisheries and 21721 t from aquaculture (FAO, 2016). Capture fisheries of striped murrel are quite stable in terms of global production, aquaculture of the species is still in its infancy stage due to several bottlenecks associated with its farming such as non-availability of hatchery raised seed, its carnivorous and cannibalistic nature and non-acceptance of artificial diet in grow-out ponds unless weaned on artificial diet before stocking. Recent studies have shown higher survivals and production when seed procured from wild resources are fed a floating pellet diet before stocking in grow-out ponds (Rahman *et al.*, 2012;

So *et al.*, 2012; Haiwen *et al.*, 2014; Farhana *et al.*, 2016) in contrast to those which are fed small-size fishes or other meat items (Devraj, 1973; Wee, 1981; Diana *et al.*, 1985). Though survivals have been found to improve in these studies, cannibalism remains a critical issue. The reason being the cannibalism in striped murrel starts at an early age (~48 h post-hatch onwards, authors unpublished data) and the cannibals do not leave the habit of cannibalising the siblings once it is developed, resulting in lowering the survival. To overcome this critical gap, the authors produced hatchery seed through induced breeding and weaned them from hatchling to fingerling size under a strategic diet plan to finally get feed weaned fingerlings, which readily accepted floating pellet diet. Therefore, the present study aimed to estimate the growth, survival and production of hatchery produced and feed weaned fingerlings in cement tanks under intensive rearing conditions.

Materials and methods

Study area

The experimental culture of striped murrel was undertaken at the farm facility of ICAR-National Bureau of Fish Genetic Resources (ICAR-NBFGR), Lucknow, India (lat. 26.7858°N; long. 80.9339°E) from 1 October 2019 to 31 August 2020 (330 days). The climate of the area is subtropical warm with air temperatures of a minimum

average 8.8°C in January and a maximum average of 41.1°C in June. It has three seasons of winter (November-February), monsoon (July-September) and rest summer.

Production of hatchery-seed and weaning on pellet diet

Induced breeding was undertaken using the protocol of Rawat *et al.* (2020). The practice of weaning the seed on feed was initiated when the larvae attained the age of 48 h posthatch (hph) by feeding them freshly hatched brine shrimp nauplii (BSN) *ad libitum*. The larvae were continued to be fed on freshly hatched BSN 3-4 times daily till 7 days post-hatch (dph). Live mixed pond plankton was given to the larvae from 8 dph onwards till 25 dph, initially two feeds of mixed plankton during day time followed with a night feed of BSN, up to 15 dph. The larvae were exclusively fed on mixed pond plankton from 16 to 25 dph three times daily. The mixed plankton was procured from the ICAR-NBFGR farm ponds, washed thoroughly and filtered with fine netting to avoid entry of large-size plankton and aquatic insects. The larvae were subsequently weaned on fresh fish mash for 3 days and mixed mash of fresh fish and grounded pellet diet (crude protein CP 45%, lipid 10% and fibre 3.5%) two times daily *ad libitum* for 7-8 days with the gradual replacement of about 15% fresh fish mash with that of grounded pellet diet. The fingerlings were then fed on a mix of grounded pellet diet and pellet diet (size 1.2 mm) till larvae were weaned exclusively on the pellet diet. Thus the fingerlings were weaned on pellet diet in 45 days time.

Rearing systems and protocol

Experimental culture of striped murrel with hatchery produced and feed weaned fingerlings was undertaken in two identical cement tanks (5x3x1.2 m). The tanks were provided a soil base of 6-inch depth and filled with freshwater from a tube well to a depth of 0.5 m for the first 2 months which was subsequently raised to 0.7 m (total volume of water 10.5 m³) till completion of the experiment. Each tank was stocked with 225 hatchery produced and pellet weaned fingerlings (length 6.7±1.0 cm, weight 2.2±1.05 g), to get a stocking density of 20 fingerlings m⁻³. The fingerlings were fed with similar floating pellet diet which was used for weaning the fingerlings on pellet diet (CP 45%, lipid 10%, fibre 3.5%; pellet size 1.2 mm) for two months and with the increase in size, the next graded feed of the same brand (CP 40%, lipid 8%, fibre 3.5%; pellet size 1.8 mm) was given two times a day *ad libitum*. The feeding frequency was however reduced to one time during March-May due to lockdown of the country on account of Covid-19 Pandemic due to limited access to the site. The tanks were covered from the top with netting (mesh size 2") to avoid predation of fish by the birds. Partial change of tank water

was done on monthly basis. The fishes were reared for 11 months (330 days) and harvesting was done by complete draining of the tanks.

Sampling and analysis of growth indices

The fishes were harvested with a netting cloth and sampled for lengths and weights on monthly basis. The length-weight of 50 fishes was taken on a random basis by pooling fishes of both the rearing tanks. The length of the fish was measured with the help of a digital vernier caliper and weight using a digital balance. The weight of small size fishes having a weight less than 5 g were measured using an electronic balance (Sartorius, precision 0.001 g), whereas larger ones with a digital pan balance (ATCO, precision 1 g). All the fishes were returned to the tanks immediately after recording length and weight parameters and giving them a bath of potassium permanganate (2 mg l⁻¹).

The LWR and growth indices were analysed using the following equation in M.S. Excel (2007).

- (a) 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' is the regression intercept, and 'b', the regression slope or exponent.

The logarithmic transformation of the above formula was:

$$\log W = \log a + b \log L$$

- (b) Fulton's condition factor (K) was calculated according to Htun-Han (1978) equation as given under:

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

where, W=weight of fish (g), L=total length of fish (cm)

- (c) Specific growth rate (SGR) was calculated with the following formula:

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

where weight is in g

The coefficient of determination (R²) was estimated by drawing the regression line using X and Y variables in M. S. Excel (2007), where 'X' was log length and 'Y' was log weight.

- (d) Survival was estimated by the following formula:

$$\text{Survival percentage} = \frac{\text{Number of fishes at harvest}}{\text{The initial number of fishes}} \times 100$$

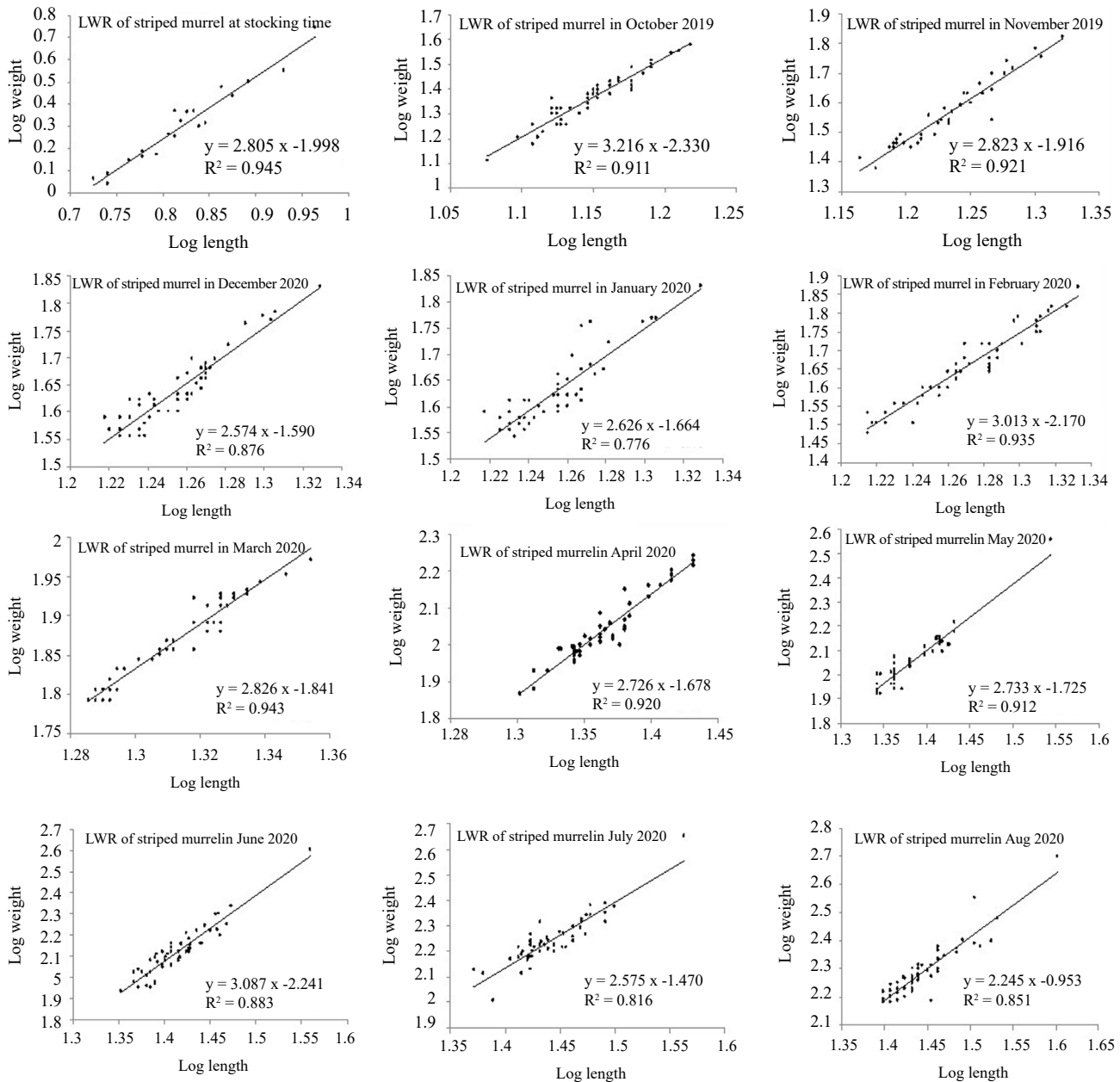


Fig. 2. Month-wise (October, 2019 to August, 2020) linear regression and scatter diagrams of striped murrel cultured in cement tanks

procurement from wild resources has also shown higher survival in pond culture in past studies (Rahman *et al.*, 2012; So *et al.*, 2012; Farhana *et al.*, 2016; Rao and Narasimha, 2020). The absence of cannibalism, therefore, seems to be due to proper weaning of fingerling on well acceptable floating pellet feed. Yadav *et al.* (2014) have also obtained higher growth and survival with a feed having CP 50% and fat 9% in comparison to low CP diets in *Channa marulius*.

Intracohort cannibalism (ICC) *i.e.* feeding own siblings is very high in striped murrel both in natural

and under culture conditions (Wee, 1982; Ng and Lim, 1990) and is dependent on several parameters such as size difference, population density, availability of weaker siblings, food availability, food type, the nutritional composition of food and its metabolism in the body, temperature, photoperiod, shape and colour of internal walls of rearing tanks (Hecht and Pienaar, 1993; Baras *et al.*, 2000). The positive effect of feed application in the case of striped murrel has been well demonstrated in a heterogeneous population by Qin and Fast (1996a). According to them, when two different sized larval

populations; larger fish of size 57.0 ± 5.7 mm TL and smaller fish 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 feeding ration was provided @ 5 and 15% of larval body weight in 6 days period (Qin and Fast, 1996b). ICC is a critical bottleneck in the farming of striped snakehead, which once starts becomes difficult to control at later stages even in the presence of plenty of quality artificial feed, though it may help in reducing the rate of cannibalism (Fox, 1975; Qin and Fast, 1997; Kumari *et al.*, 2018). However, cannibalism is first mediated by size heterogeneity in a population and is more intense among fast-growing larvae and young juveniles than among older fish (Hecht and Pienaar, 1993; Baras, 1998). If size heterogeneity that provides chances of cannibalism is controlled in a population at a right time, the cannibalism is likely to reduce to either a negligible level or even stop thereafter (Qin and Fast, 1996b; Raizada *et al.*, 2021). This hypothesis was successfully adopted in the present study. The hatchery seed was produced through captive spawning and was weaned on diets based on ontogenic requirements of fish larvae using brine shrimp nauplii, pond plankton, fresh fish mash and finally on commercial artificial pellet diet through a strategic diet plan.

The total biomass produced per tank (volume of water 10.5 m^3) was estimated to be 37 kg (3.5 kg m^{-3}) or $35000 \text{ kg ha}^{-1} \text{ m}^{-3}$, which was observed to be an extremely higher production in comparison to 3300 kg ha^{-1} in 342 days (Haiwen *et al.*, 2014), $2143.7 \text{ kg ha}^{-1}$ in 180 days (Farhana *et al.*, 2016) and 20930 kg ha^{-1} in 8 months (Rao, 2020) obtained in the pond system with fingerlings obtained from wild resources and weaned on a pellet diet. The present study further revealed that, the major growth period was only 7-8 months and there was poor growth during winter months due to low water temperature and also one-time application of feed due to the lockdown of the country because of Covid-19 Pandemic.

Length-weight relationship (LWR)

The 'W' values were found to follow Fulton's cube law during the entire culture period. The values of exponent 'b' were positive allometric (>3) during October, February and June with the highest of 3.216 in October 2019 and negatively allometric in other months with the lowest of 2.072 in April. The coefficient of determination (R^2) was found to range between 0.776 in January 2020 and highest (0.943) in March 2020. Similarly, ponderal index (K) was found to range between 0.715 in February to 0.915 in August (Table 1, Fig. 3). The scatter regression line diagrams drawn from month-wise data on lengths and weights have shown straight line regression having

few outliers continuously available all through the culture period (Fig. 2).

There are very few reports available on LWR for striped murrel. Past studies revealed that this species in general exhibited more of a negative allometric growth pattern ($b < 3$) than positive ($b > 3$) in samples collected from the natural population (Table 2). The value of 'b' however showed a positive allometric growth trend in small size groups under culture conditions (Table 1). The negative allometric growth in large specimens may be attributed to their less rounded body and low fecundity. The value of 'b' recorded in the present study ranged between 2.072-3.216 in captive conditions with the lowest value of 2.072 in April indicating more weight increment than length, probably due to sudden rise of temperature and onset of maturity in fish.

The scatter regression line diagrams drawn from the month-wise data on length and weight showed a straight line regression that confirms an increase in weight corresponds to an increase in length (Fig. 2). The coefficient of determination (R^2) with respect to length and weight data in striped murrel, in general follows a good fit, except during severe stress conditions (Table 2). The factors that affect the value of b in LWR also influence the value of R^2 . The lowest R^2 value of 0.776 (January) obtained in the present study clearly showed that a continuous drop in temperature in winter could be the sole reason for it. Though no trend in their values was seen, higher values were obtained either in small size or also when there was a rise in temperature (Fig. 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 LWR equation is the appropriate method for estimating weight from length. LWR in fishes can be affected by various

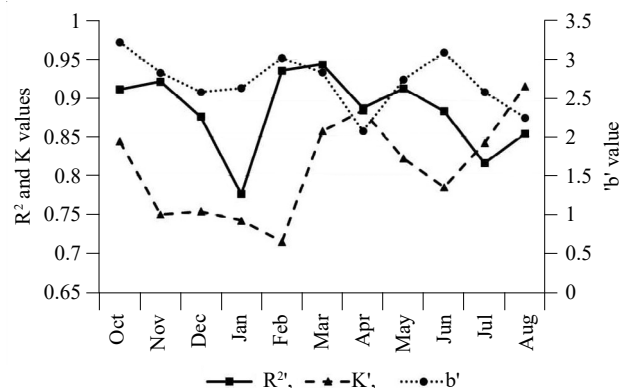


Fig. 3. Month-wise 'b', 'R²' and 'K' values of striped snakehead in cement tank

Table 2. Values of exponent 'b', coefficient of determination (R²) and condition factor in striped murrel in different studies

Stock type and place	Fish size (cm)	b	R ²	K/Kn	Reference
Captive stock, Lucknow	6.70-28.08	2.072-3.216	0.776-0.945	0.715-0.915	Present study
Capture stock, Ganga River	-	2.929	0.970	-	Khan <i>et al.</i> (2011)
Capture stock, Chi River, Thailand	-	2.94	-	-	Satrawaha and Pilasamorn (2009)
Capture stock, Sungai River, Indonesia	-	2.9223	0.9725	-	Ahmadi (2018)
Capture stock, River Siang, India	-	1.612	-	-	Das <i>et al.</i> (2015)
Rawa Sekayu	20.73	2.812	0.952	-	Muthamainnah (2013)
Rawa Mariana (Capture stock from Wetlands)	20.84	2.543	0.881	-	
Capture stock, Lake Vembanad	-	2.73	0.6113	-	Ali <i>et al.</i> (2013)
Captive stock, Chennai	-	0.9628- 1.127	0.9836-0.9965	-	Sugumaran <i>et al.</i> (2018)
Capture stock, Nadia (W.B.)	13-40	3.06-3.10	-	1.02-1.22 (Kn)	Chakraborty <i>et al.</i> (2017)
Capture stock, Lucknow	22.9-42.4	3.407-3.958	0.9333	-	Dayal <i>et al.</i> (2012)

factors such as temperature, pH, dissolved oxygen (DO), seasonal changes, habitat, age, gonadal maturity, sex, stomach fullness, health and preservation technique (Tesch, 1968; Bagenal and Tesch, 1987). The factors that affect the value of 'b' in LWR 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 (0.715) in February in the present study when there was a sudden increase in temperature from the previous month (January), which showed different trends both from 'b' and 'R²' values that are more affected when dropping down in temperature was higher (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 (0.915) was recorded in August due to an increase in fish girth size.

Water quality

There were large differences in water temperature during the winter and the summer seasons. The lowest temperature of 15.0±1.5°C was observed in December during extreme winter and the maximum of 29.5±2.5°C in May being the summer season. The mean water quality parameters recorded were: pH 8.1±0.5, TDS 275±25 mg l⁻¹, total alkalinity 220±10 mg l⁻¹, DO 5.5±1.6 mg l⁻¹, free CO₂ 8.0±3.1 mg l⁻¹, unionised ammonia 0.25±0.12 mg l⁻¹, nitrite 0.23±0.10 mg l⁻¹ and nitrate 0.57±0.21 mg l⁻¹, which were found in the normal range for culture of this species.

The performance of hatchery produced and feed weaned seed with a production of 3.5 kg m⁻³ and survival of 85% in 330 days was found to be significantly high in comparison to production in ponds in the past studies. The species tolerated a low temperature of 15±1.5°C in the cement tank system and growth was found to increase at a temperature regime of 15±1.5 to 29±2.5°C. The values of exponent 'b', coefficient of determination 'R²' and ponderal index 'K' were found temperature dependent with low values in winter and higher in summer months and were observed to be normal when compared with natural stocks. The study thus revealed that hatchery

produced and feed weaned seeds could be cultured in an intensive farming system with higher survival and production. More research is needed for the optimisation of stocking density to get larger size fish within a shorter period.

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