doi:10.21077/ijf.2023.70.3.123684-08

Available online at: epubs.icar.org.in/index.php/IJF

Standardisation of stocking density for raising fingerlings of farm-bred peninsular carp *Barbodes carnaticus* (Jerdon, 1849)

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Keywords:
Carnatic carp, *Puntius carnaticus*, Seed rearing, Species diversification

Received : 06.05.2022
Accepted : 13.09.2023

Abstract

A 90-day trial was conducted to determine the optimal stocking density for raising fingerlings of *Barbodes carnaticus* (Jerdon, 1849). The fish were reared in cement tanks of 24 m^2 at stocking densities of 15, 30, 45, 60, 75, 90, 105 and 120 m^{-2}. Initially, cow dung was applied at a basal rate of 3 t ha^{-1} in the experimental rearing tanks. After a week of manuring, the tanks were stocked with fry of *B. carnaticus* (mean length 0.98±0.04 cm; weight 4.55±0.04 mg). During the first month, the fish were fed a mixture of groundnut oil cake and rice bran (1:1) at 10% of body weight. A sinking pellet feed (3 mm, 35% crude protein) based on fishmeal was fed to satiation in the second and third months. The harvested fish weight ranged from 0.50 g in 120 m^{-2} to 3.53 g in 15 m^{-2} densities, whereas fish length varied from 3.55 cm in 120 m^{-2} to 6.66 cm in 15 m^{-2} densities. The results showed that the stocking density inversely correlated with final length and weight. The condition factor ranged between 1.01 and 1.20, while survival rate varied from 85.66 to 91.47%, with no differences ($p>0.05$) between treatments. The highest fish biomass per tank was recorded under stocking densities of 30 and 45 m^{-2}, which indicates that 45 m^{-2} is the optimal stocking density for fry to fingerling rearing of *B. carnaticus*.

Introduction

The Carnatic carp *Barbodes carnaticus* (Jerdon, 1849), is an endemic fish to the Western Ghats of India. There are numerous factors threatening the habitat of *B. carnaticus,* such as degradation caused by destructive fishing methods like poisoning and dynamiting, altered river flow due to dam construction, competition from exotic carps, and contamination from point sources. This fish which does not normally breed under captive conditions was first bred successfully in 2012 by Basavaraja *et al.* (2012). The Bangalore Regional Research Centre of ICAR-Central Institute of Freshwater Aquaculture (CIFA), succeeded in adapting this fish to pond culture, raising the broodstock and their successful induced breeding in the same year. Initial results indicated that it could be induced bred at farm conditions from July to November. However, with better management practices and ideal water quality conditions, we were able to extend the breeding window of this species to almost throughout the year, which can lead to its seed availability during all seasons. *B. carnaticus* is presently being evaluated for its growth performance under commercial aquaculture. The maximum recorded weight and length of this species is 12 kg and 90 cm, respectively (Talwar and Jhingran, 1991), greater than the rest of the *Puntius* genus. Its higher growth rate and a number of other favourable characteristics make *B. carnaticus* a reliable candidate for freshwater aquaculture (Manojkumar and Kurup, 2010). The need for diversifying fish species in aquaculture (NAC/FAO, 2000) has led to the consideration of this minor carp species as an alternative or addition to the major carps in aquaculture.

One of the basic requirements for establishing/developing successful package for culture of any fish species is the availability of good quality fingerlings. Many researchers have reported fingerling rearing of Indian major carps using a variety of inputs (Aravindakshan *et al.*, 1997; Jena *et al.*, 2005; Biswas *et al.,* 2006). However, there is little information available on the seed rearing of minor carps and barbs, except for the limited information on olive barb, *Puntius sarana* (Jena *et al.,* 2007), gonia, *Labeo gonius* (Rahman *et al.,* 2008), reba carp, *Cirrhinus ariza* (Rahman *et al.,* 2009), fringe-lipped carp, *Labeo fimbriatus* and olive barb (Pawar *et al.,* 2009), fringe-lipped carp and silver barb, *Puntius gonionotus* (Jena *et al.,* 2011), bata, *Labeo bata* (Ahmed *et al.,* 2019) and *Hypselobarbus pulchellus* (Barlaya *et al.*, 2021). Fish stocking density is one of the main determinants of a production system's economic viability (Papst *et al.,* 1992). The present investigation was undertaken for standardising the stocking density of *B. carnaticus* during fry to fingerling rearing in nursery tanks.

Materials and methods

The study was conducted in outdoor cement tanks with a water spread area of 24 m^2 (6 x 4 x 1.2 m; water holding capacity 24,000 l) and a soil base of 10 cm. A depth of 100 cm of water was maintained in the tanks over the 90 days experimental duration by adding water from a nearby bore-well to all the tanks at fortnightly intervals to compensate for evaporation loss. The rearing tanks were initially manured with cow dung at a rate of 3 t ha^{-1} (CIFA, 2009). After a week of manuring, the tanks were stocked with fry of initial length 0.98±0.04 cm and weight 4.55±0.04 mg. In order to eradicate predatory insects in the tanks, soap-oil emulsion was applied a day before stocking (CIFA, 2009). The following day, before stocking the fry, the floating dead insects were netted out. Stocking densities of 15, 30, 45, 60, 75, 90, 105 and 120 fish per m^2 were tested in duplicate. During the first month, the fish were fed a combination of groundnut oil cake powder and rice bran (1:1) at 10% of body weight. Fish were fed to satiation with 3 mm sinking pellets containing 35% crude protein in the second and third months (Barlaya *et al.,* 2021). The fish were fed once a day in the morning. Feed was provided in plastic trays suspended in the water column. The unconsumed feed from the previous day's feeding was removed and the trays were cleaned prior to feeding afresh. Table 1 gives the ingredient proportion and proximate composition of the pelleted feed. The ingredients used were sieved through a 0.5 mm screen. The required quantity of each ingredient was weighed, mixed thoroughly and then a dough was made by mixing with boiling water. Vitamin and mineral mixture was added to the dough after cooling, mixed well and the dough was pressed through a hand pelletiser to get uniformsised pellets (3 mm). The pellets were sun-dried and packed in an airtight bag.

The proximate composition of the feed was analysed following AOAC (1990) method. Starting on the day of stocking, major water quality parameters were measured at monthly intervals (APHA, 1998). Fish sampling was carried out at monthly intervals to estimate the fish biomass and for calculating feed quantity. A minimum number of 30 fish per tank was netted out, their length was measured and weight recorded using an electronic balance. All the surviving fish were collected at the end of the 90 days rearing period by repeated netting, followed by draining out the tanks and hand picking the remaining fish. From each tank, 30 representative fish samples were measured individually for their length and weight. The values of final length, weight, specific growth rate (SGR) and condition factor (K) are based on measurements of 60 fish from each stocking density (2 tanks and 30 fish from each tank). The condition factor was calculated using the formula: $K = 100 \times W / L^3$ (Ricker, 1975), where W = weight in grams and L = length in centimetres. One-way analysis of variance and Duncan's multiple range test were used to compare different treatments for various parameters (Duncan, 1955; Snedecor and Cochran, 1968).

Results and discussion

The water quality parameters measured during the experimental period are presented in Table 2. No significant difference (p>0.05) in water quality parameters was recorded during the study period. Water temperature ranged between 22.10 and 23.3°C. Oxygen level fluctuated from 6.10 to 7.20 ppm. The tank water was alkaline in nature with pH ranging from 8.08 to 8.89 and total alkalinity from 286.81 to 339.38 ppm. The water was slightly harder with hardness varying from 192.12 to 223.33 ppm. These parameters were within the acceptable range for nursery rearing of warm water fish (Jena *et al.,* 2011; Barlaya *et al.,* 2021).

Our earlier studies revealed that the fingerlings of *B. carnaticus* have a protein requirement of 35% (Sridhar *et al.,* 2017). Therefore, the pelleted feed used in the present study was formulated to have 35% crude protein. From the results of this experiment, it is apparent that final length and weight of *B. carnaticus* are inversely related to density of stocking (Table 3). Lakshmanan *et al.* (1971) stated that apart from supplemental feeding, stocking density is also a key factor that influences fry and fingerling growth and survival. There is evidence that stocking density influences stress levels in other species of Cyprinids (Nandeesha *et al.,* 2013); it has been shown to negatively impact fish growth, specifically during carp seed production (Rahman and Rahman, 2003; Rahman *et al.*, 2005; Das *et al.,* 2020; Barlaya *et al.,* 2021). The final length of *B. carnaticus*

Table 1. Ingredient proportion and proximate composition (mean± SD) of the pelleted feed

Ingredient	Incorporation (%)	Proximate composition	Value (%)
Fish meal	22	Moisture	4.50±0.21
Groundnut cake	30	Crude protein	34.89±0.35
Rice bran	38	Fat	10.31±0.02
Ragi (Finger millet)	8	Ash	8.93±0.12
Vitamin and mineral mixture*	2	Crude fibre	10.69±0.19
		NFE	30.64
		Gross energy (kJ g^{-1})	17.17

*Each kg contains: Calcium - 25.5%, Phosphorus-12.75%, Mangessium-6,000 mg, Suphur-0.72%, Sodium-5.9 mg, Potassium-100 mg, Copper-1,200 mg, Cobalt-150 mg, Zinc-9,600 mg, Iron-1,500 mg, Iodine-325 mg, Selenium-10 mg, Manganese-1,500 mg, Vitamin A-7,00,000 IU, Vitamin D3-70,000 IU, Vitamin E-250 mg, Nicotinamide-1000 mg, DLmethionine-1,929 mg, L-lysine-4,400 mg, *Lactobacillus* sp. 1.5 × 1,011 CFU, *Saccharomyces cerevisiae* −30,000 million CFU

Table 2. Major water quality parameters (mean±SD) recorded in rearing tanks during the study period*

Stocking density	Temperature (^{0}C)	pH	Dissolved oxygen (ppm)	Total alkalinity (ppm)	Hardness (ppm)
15	22.87±0.75	8.89±0.41	7.20±0.63	331.41±23.58	221.33±6.11
30	22.90±0.61	8.08±0.17	6.60±0.28	310.72±26.02	216.19±16.28
45	23.13±0.81	8.59±0.09	6.36±0.25	339.38±8.28	223.33±7.57
60	22.10±0.90	8.65±0.28	7.15±0.41	286.81±16.44	196.18±16.20
75	22.20±0.48	8.36±0.48	6.12±0.63	315.32±48.15	220.21±8.19
90	22.87±0.75	8.74±0.36	6.67±0.92	322.68±6.81	204.11±14.42
115	23.30±0.81	8.49±0.51	6.10±0.60	293.91±18.68	208.18±8.22
120	23.03±0.83	8.67±0.17	6.73±0.99	293.91±14.6	192.12±4.01

* No significant difference in values between treatments

Table 3. Growth parameters, survival and biomass (mean±SD) of *B. carnaticus* after the rearing period

Stocking density (No. m^{-2})	Length (cm)	Weight (g)	Condition factor	Survival (%)	Biomass per tank (g)
15	6.66±0.03^{e}	3.53±0.13^{f}	1.20±0.03^{a}	91.47±3.11^{a}	1166.55±66.41^{a}
30	6.10±0.23^{e}	2.56±0.41^{e}	1.12±0.05^{a}	91.31±3.51^{a}	1761.20±47.22^{b}
45	5.20±0.54^{d}	1.54±0.46^{d}	1.07±0.02^{a}	90.02±5.61^{a}	1511.86±54.46^{ab}
60	4.71±0.14^{d}	1.06±0.08^{cd}	1.01±0.01^{a}	87.01±6.75^{a}	1325.28±88.65^{a}
75	4.13±0.11^{c}	0.72±0.03^{b}	1.03±0.11^{a}	88.74±4.82^{a}	1142.54±55.82^{a}
90	3.97±0.11^{c}	0.67±0.12^{ab}	1.07±0.11^{a}	86.99±3.74^{a}	1285.37±90.56^{a}
115	3.79±0.13^{bc}	0.60±0.10^{ab}	1.10±0.06^{a}	87.82±6.78^{a}	1369.67±97.33^{a}
120	3.55±0.14^{ab}	0.50±0.03^{a}	1.07±0.23^{a}	85.66±6.91^{a}	1277.50±42.45^{a}

Figures in the same column with same superscript do not differ significantly.

fingerlings increased from 3.55 to 6.66 cm and the final weight from 0.50 to 3.53 g with decrease in stocking density. In a similar study conducted for 90 days with another medium carp, *Hypselobarbus pulchellus,* Barlaya *et al.* (2021) recorded final length and weight ranging from 3.42 to 6.11 cm and 0.41 to 2.68 g respectively, for stocking densities decreasing from 120 to 15 m^{-2}. Samad *et al.* (2017) compared the growth performance of Black carp *Mylopharyngodon piceus* at 24, 27 and 30 m^{-2} densities in fingerling production and found the lowest density to achieve the highest final weight. Several factors contribute to the low growth of fingerlings in higher density rearing, including increased competition for food or space (Bolasina *et al.,* 2006; Chakraborty and Mirza, 2007; Coulibaly *et al.,* 2007), social stress (Zeng *et al.,* 2010) and social interaction (Irwin *et al.,* 1999). However, in the present study, the lower growth of fish at higher stocking density cannot be attributed to competition for food since fish in all groups were fed to satiation. Lack of natural food could be a factor for the lower growth at higher stocking densities. High density of fingerlings as well as increased amount of food in the rearing system is reported to produce a stressful environment and toxic substances, which result in poor growth (Larsen *et al.,* 2012; Chattopadhyay *et al.,* 2013). There have been previous reports on growth variation in the fingerlings of fathead minnows (*Pimephales promelas*) (Smith *et al.,* 1978), reba carp (*Cirrhinus reba*) (Rahman *et al.,* 2009) and common carp (*Cyprinus carpio*) (Samad *et al.,* 2016) reared at various densities, but fed uniform amounts or *ad libitum.*

Among the treatments, the condition factor ranged from 1.01 to 1.20. Typically, a fish is considered to be in good condition when the condition factor is greater than 1 and in poor condition when it is less than 1 (Nash *et al.*, 2006). Under similar conditions, over a 90 day rearing period, Barlaya *et al.* (2021) recorded a condition factor ranging from 0.95 to 1.17 for another medium carp, *H. pulchellus.* The condition factor of adequately fed fish is greater than 1 (Gupta *et al.,* 2012; Hemaprasanth *et al.,* 2016). The condition factor of above 1 obtained in this study is a sign of appropriate isometric growth, attributable to an adequate feeding.

The survival rate of *B. carnaticus* ranged from 85.66 to 91.47%, with no significant difference ($p>0.05$) between different stocking densities. Under similar conditions, in an earlier study with another peninsular carp, *H. pulchellus*, the survival ranged from 81.24 to 89.54% without any statistically significant difference between densities (Barlaya *et al.,* 2021). Nevertheless, it was apparent that the survival rate under low stocking was higher. In higher densities, survival may be reduced because of competition for food and space among individuals. Similar inverse relationship between survival and stocking density was recorded in sarpunti (*Puntius sarana*) fingerlings in nursery ponds (Chakraborty *et al.,* 2003), mahseer (*Tor putitora*) fingerlings during nursery pond rearing (Rahman *et al.,* 2005), dover sole (*Solea solea*) juveniles in glass tank rearing (Schram *et al.,* 2006), bata (*Labeo bata*) fingerlings in nursery ponds (Chakraborty and Mirza, 2007), vundu catfish (*Heterobranchus longifilis*) juveniles during cage culture (Coulibaly *et al.,* 2007) and burbot (*Lota lota*) juveniles in tank rearing (Wocher *et al.,* 2011). Harvest biomass of fingerlings was the highest (1761.20 g) and comparable under the stocking densities 30 and 45 per m^2. The biomass of fish fingerlings (g tank^{-1}) at harvest, survival and weight, were higher under stocking densities of 30 and 45 fish m^{-2}, compared to all the other treatments. Therefore, stocking densities up to 45 individuals m^{-2} is considered optimal for fry to fingerling rearing of *B. carnaticus* in nursery tanks.

Acknowledgements

The authors are grateful to the Director, ICAR-CIFA, Bhubaneswar, India, for the infrastructure facility provided for conducting the study.

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