THE FISHWORLD
ISSN: 3049-138X
Vol.3(04) April 2026, 482-489

Effects of crowding on Growth Performance, Feed Efficiency and Water Quality in *Lepidocephalichthys thermalis*

R Bhargavi, Bhanuprakash Ch, Ishani.S.Gowda
Tamil Nadu Dr J Jayalalithaa Fisheries University,Nagapattinam,Tamil Nadu-611002
doi.org/10.5281/FishWorld.20142928

Introduction

Loaches are freshwater fish that thrive in hill streams and belong to the order Cypriniformes. The Western Ghats host 44 identified species across 13 genera, representing the families Botiidae, Cobitidae, Balitoridae, and Nemacheilidae. Among these, 18 species face the threat of extinction (Dahanukar et al., 2004; Dahanukar and Raghavan, 2013). *Lepidocephalichthys thermalis*, a type of cobitid fish, is found in a range of environments including seasonal and year-round ponds, shallow channels and conduits, rice fields that flood during the monsoon, and the shallow edges of streams and rivers where the current is weak. This species is commonly seen in Kerala, located in the south western part of peninsular India (Kumari and Nair, 1979).

Loaches are native to India and Sri Lanka, this species is commonly known as the common spiny loach, spotted loach, or Indian spiny loach (Shaji, 2000). Similar species are also reported across regions such as Indo-China, Myanmar, Nepal, Pakistan, Bangladesh, the Malay Archipelago, Thailand, and Vietnam. The fish is omnivorous, primarily consuming insect larvae, which classifies it as a micro-predator (Keskar et al., 2014). It is noted for its high-quality protein and vitamins and is recognized for its medicinal benefits (Pankaj et al., 2024). In addition, it holds considerable market value in many areas of India and is esteemed as a culinary delicacy.

Lepidocephalichthys thermalis , can reach a length of up to 80mm (Talwar, 1991). Its prolonged breeding season can affect the length-weight relationship (LWR) depending on when samples are collected. The condition factor of wild *Lepidocephalichthys thermalis*, is notably higher compared to those raised in a laboratory setting (Kumari and Nair, 1978). Most loach species typically have a lifespan of five to six years, with females generally outliving males (Caleta et al., 2015).

Stocking density is an important factor to take into account when ranking families or progeny groups for growth performance. Fish density is a key factor affecting growth and maturation of wild and cultured fish besides food supply and its quality, genetics and environmental conditions (Smith et al. 1978; Khattab et al.,2004). In many cultured species, growth is inversely related to stocking density and this can be attributed to social interactions (Holm et al. 1990; Haylor, 1991; Miao, 1992; Huang and Chiu, 1997; Canario et al., 1998; Irwin et al., 1999).Ellis et al., (2002) demonstrated that rearing fish at inappropriate stocking densities may impair growth and reduce immune competence due to factors such as social interactions and deterioration of water quality, which can affect both feed intake and conversion efficiency of the fish. Growth in several farmed species, including as Thai magur (*clarias gariepinus),* Rainbow trout (*oncorhynchus mykiss*), and tilapia (*oreochromis* spp.), is inversely correlated with stoking density (Malik et al., 2014 and Silva et al., 1985).

Lepidocephalichthys thermalis , commonly referred to as the Indian spiny loach, is very valuable in Tamil Nadu's market and regarded as a delicacy. There are now relatively few fish farmers that practice the culture of loaches, and most of them are reluctant to start because this specific species does not have any commercial culture technology and available and more over there is no studies about the stocking density of loaches. If the optimum stocking densities are developed for loaches, it will be boon to fish farmers to take up this culture.

Geographical pattern of loach

Loaches are freshwater fish found in hill streams that are comes under the order of Cypriniformes. There are numerous genera and species of loaches distributed around the world (Nelson et al., 2016). Generally, they are categorized into four families: Nemacheilidae, Balitoridae, Botiidae, and Cobitidae. Apart from India, this species wide spread in Asian countries, such as Thailand, the Mekong basins, and Myanmar (Talwar and Jhingran, 1991), as well as Bangladesh (Rahman, 1989, 2005).

Biology of *L.thermalis*

The species *Lepidocephalichthys sp.* is known to inhabit diverse environments, which encompass marshlands, flooded agricultural fields, hill streams, and paddy fields (Kottelat, 1992). Its presence has been documented throughout the Malay Archipelago, as well as in Thailand, Vietnam, India, Indo-China, Myanmar, Nepal, Pakistan, Sri Lanka, and Bangladesh (Jayaram et al., 1999). *Lepidocephalichthys* is an important genus of small loaches (Havird and Page 2010). Although, a globally more than thousand different loach species has recorded so far (Kottelat, 2012).

Food and feeding habitat of loaches

Watanabe and Hidaka (1983) has reported that the fishes belong to the cobitidae family, they locate their feed particles by sensing. In addition, a few researchers have examined and documented the feeding biology of Cobitidae of spiny loaches (Robotham 1977; Kumari and Nair 1978 a, b). In view of Bateson (1890), *Nemacheilus barbatula* is never began feeding on available feed in culture tanks, but rather waited until the meal's scent had spread throughout the tank. Caleta et al. (2015) described the feeding behaviour of the spiny loach, noting that it is active and feeds at night while spending much of the day burrowing into the sandy substrate.

Effect of crowding on Growth of fish

Narejo et al. (2010) investigated the impact of stocking density on the growth and survival rates of *Labeo rohita*. Their research revealed that the optimal growth rate for *Labeo rohita* occurred at a low stocking density of 15 fish per tank. Conversely, an increase to a density of 20 fish per tank resulted in a marked reduction in growth rate. In a separate study, Hasan et al. (2010) assessed the growth and productivity of GIFT tilapia over a period of 100 days. Their findings indicated that the highest individual weight gain was linked to a lower stocking density of 150 fish per declare, with T3 yielding a greater total biomass (2972 kg) compared to T1 and T2 (3820 kg). Additionally, Kapinga et al. (2014) found that mono sex Nile tilapia raised in low-density ponds for five months demonstrated significantly enhanced specific growth rates, average daily gains, and overall weight gains when compared to those in high-density environments, where growth was considerably diminished (86.1±2 g).

Canario et al. (1998) investigated the impact of varying stocking densities (0.35, 1.35, and 3.2 kg/m3) on the growth rates of gilthead seabream, *S. aurata.* Their findings revealed that individuals in the highest density category exhibited a growth rate that was 25% slower compared to those in the lowest density category. Additionally, other species such as Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum) (Martin & Wittheimer 1989), African catfish (Haylor 1991), and *Arctic charr, S. alpinus* (Gensen et al., 1993) demonstrated a negative correlation between stocking density and growth metrics. Furthermore, Silva et al. (2000) examined the effects of stocking densities (2, 3, and 4 kg/m3) on tetra-hybrid red tilapia and concluded that lower stocking densities resulted in significantly greater final body weight gains.

The study conducted by Collett et al. (2011) focused on the effects of crowding on *Argyrosomus japonicas*, indicating that juvenile fish exhibited comparable feed conversion ratios (FCR) and growth rates across crowding densities of 10, 30, and 50 kg m^3. Labonte et al. (1994) reported that tilapia demonstrated superior weight gain at lower stocking densities in cage culture compared to higher densities. In their research, Kaiser et al. (1995) analyzed the effects of stocking densities (1.2, 0.6, and 0.3 fish/cm²) on the growth and survival of African catfish, determining that a stocking density of at least 1.2 larvae/cm² of bottom surface area is essential for achieving high production levels. Additionally, Yengkokpam et al. (2020) established that the optimal stocking density for *L. brain* net cages is 75 fingerlings per m³, with their findings indicating an inverse relationship between growth performances and stocking density.

Effect of crowding on growth, stress, and survival rate.

Fish density in aquaculture systems may be expressed as crowding density (kg m-3) or loading density (kg m3 water flow h-1) (Wedemeyer 2000). Crowding is approaching or exceeding the maximum space density limit (fish weight per unit water volume) (Wedemeyer, 1996).

Overcrowding is a common contributor to chronic stress in aquaculture, leading to elevated plasma cortisol levels over time (Pickering and Pottinger, 1989). This physiological response can have detrimental effects on fish health (Barton and Iwama, 1991). One notable consequence of high stocking density is the inhibition of growth (Vijayan et al., 1990), which has been linked to various factors such as reduced food intake (Refstie et al., 1977) and compromised water quality (Pickering and Stewart, 1984).The increased density of fish results in heightened energy requirements, necessitating metabolic adaptations, including modifications in gluconeogenic and glycolytic enzyme activities (Vijayan et al., 1990, 1997). In these circumstances, diminished food consumption coupled with elevated energy expenditure leads to reliance on bodily reserves, ultimately resulting in stunted growth (Vijayan and Leatherland, 1988).

Stocking density is recognized as a pivotal factor in intensive aquaculture, as it significantly affects the physiology, welfare, and behavior of cultured fish, as well as overall productivity (Schreck et al., 1997). Maintaining optimal stocking densities is crucial, as excessive density can hinder growth and diminish immune function due to social interactions and declining water quality, which in turn can adversely affect feed intake and conversion rates (Ellis et al., 2002). Research in aquaculture has consistently demonstrated that stocking density plays a vital role in determining survival rates, gene expression, and overall production outcomes (Jia et al., 2016; Yarahmadi et al., 2016). Consequently, to enhance management practices, maximize yield, and improve profitability, it is essential to ascertain the suitable stocking densities for each species across different developmental stages (Zhu et al., 2011).

Effect of crowding on Survival rate of fish

Shubha and Reddy (2011) investigated the influence of stocking density on the growth of *Oreochromis mossambicus*, revealing that a 100% survival rate was achieved at the lowest stocking density, which subsequently declined as stocking density increased across three different aquariums. Biswas et al. (2015) explored the effects of stocking density on *Labeo rohita* fry in cage culture, reporting survival rates ranging from 80% to 87% for rohu fingerlings raised in cages with stocking densities between 20 and 250 individuals per cubic meter.

Jena et al. (2011) found that Carp *P. gonionatus,* when cultivated in concrete tanks at densities of 25, 50, and 75 fry per square meter, exhibited survival rates of 38.0% to 72.5% after a period of 100 days. Debnath et al. (2016) assessed the effects of varying stocking densities on the growth and survival of *Ompok bimaculatus*, concluding that the highest survival rates were associated with lower stocking densities. OSofero et al. (2009) reported an inverse correlation between survival rates and stocking density in *Oreochromis niloticus*, noting that the highest survival rate occurred at a low stocking density of 100 juveniles per cage, while the lowest was observed at a higher density of 200 juveniles per cage.

Effect of crowding on water quality

Research has shown that increasing stock density adversely affects water quality indicators, such as dissolved oxygen (DO), ammonium (NH3), nitrate (NO3−), and carbon dioxide (CO2) levels, as evidenced in early aquaculture studies (Fivelstad et al., 1995, 1998). Recent investigations have indicated that variations in both fish density and water quality can significantly influence fish growth performance (North et al., 2006). High stocking densities are recognized to impede growth due to multiple factors, including suboptimal water quality, reduced food intake (Oppedal et al., 2011), diminished social interactions (Sloman et al., 2000), and further degradation of water quality (Fivelstad et al., 1995, 1998).

Two primary factors influence fish physiology in crowded environments. The water's capacity to supply oxygen and dilute metabolic by products can serve as a stressor, while the necessity for sufficient space is crucial for maintaining fish health. The limitations on carrying capacity are primarily dictated by the rates of oxygen consumption and ammonia excretion (Colt and Orwicz, 1991).

Loaches predominantly inhabit shallow waters, typically less than one meter in depth. These benthic fish are well-adapted to endure challenging environmental conditions, including high levels of ammonia and nitrate, low oxygen availability, and dehydration, thriving within a temperature range of 0 to 38 °C (Koetsier and Urquhart, 2012). As noted by Devi et al. (2017), fish generally favor a pH range between 6.4 and 8.3. The processes of respiration and digestion release carbon dioxide into the environment, which subsequently reacts with water to produce hydrogen ions and carbonic acid, leading to the acidification of the surrounding habitat (Mallasen et al., 2012).

Conclusion

Stocking density is a critical factor influencing growth, performance, and overall productivity in fish farming. The effects of stocking density on fish growth can vary, being either beneficial or detrimental, and these outcomes are often specific to the species being farmed.

Lepidocephalichthys thermalis is an important native species of the Western Ghats. It can be found in the hill streams to paddy fields, stream bottoms, swamps, and flooded fields. *Lepidocephalichthys* species have been recorded across several countries, including India, Indo-China, Myanmar, Nepal, Pakistan, Sri Lanka, Bangladesh, Thailand, Vietnam, and the Malay Archipelago. Fish belonging to the superfamily Cobitioidea are generally referred to as loaches, and over a thousand distinct species have been identified so far. It is very nutritious and has a significant market demand (₹1500-2000/kg).

Like other freshwater fishes, this species also has a culture potential but there is no attempt made for its culture in the state even in the nation. The species diversification and promotion of culture practices for any species would need scientific culture technology for achieving it is sustainable fish production. In addition to that, through culture, certain species stock possibly enhance in the natural system. Considering all views, to eliminate the limited knowledge on loach farming, this preliminary study was undertaken to determine the suitable stocking densities through different crowding effects in outdoor conditions to standardize the desired density level for its production.

References

Adineh, H., Naderi, M., Hamidi, M. K., and Harsij, M., 2019. Biofloc technology improves growth, innate immune responses, oxidative status, and resistance to acute stress in common carp (*Cyprinus carpio*) under high stocking density. *Fish & shellfish immunology*, 95, 440-448.

Ahmad, I., Hamid, T., Fatima, M., Chand, H. S., Jain, S. K., Athar, M., and Raisuddin, S., 2000. Induction of hepatic antioxidants in freshwater catfish (*Channa punctatus* Bloch) is a biomarker of paper mill effluent exposure. *Biochimica et Biophysica Acta (BBA)-General Subjects*, 1523(1), 37-48.

Ahmed, G. U., Haque, A. K. M., Islam, A. A., and Haque, M. M., 1984. Intensive culture of *Labeo rohita* (Hamilton) in floating ponds with special reference to different stocking densities. *Bangladesh Journal of Fisheries* (*Bangladesh)*, 6(1).

Ahmed, K. K., Haque, M. K. I., Paul, S. K., and Saha, S. B., 2002. Effect of stocking density on the production of common carp (*Cyprinus carpio* Lin.) in cages at Kaptai lake, Bangladesh.

Baker, R. F., and Ayles, G. B., 1990. The effects of varying density and loading level on the growth of Arctic charr (*Salvelinus alpinus L.)* and rainbow trout (*Oncorhynchus mykiss*). *World Aquaculture*, 21(1), 58-62.

Banerjea, S. M., 1967. Water quality and soil condition of fish ponds in some states of India in relation to fish production. *Indian journal of Fisheries*, 14(1 & 2),115-144.

Barlaya, G., Narasimhan, S., Basumatary, P., Huchchappa, R. C., Kumar, A., and Kannur, H.,2021. Effect of stocking density on the growth and survival of the critically endangered peninsular carp *Hypselobarbus pulchellus* (Day, 1870) in fingerling rearing. *Aquaculture Research*, 52(6), 2901-2906.

Çagiltay, F., Erkan, N., Ulusoy, Ş., Selcuk, A., and Özden, Ö.,2015. Effects of stock density on texture-colour quality and chemical composition of rainbow trout (*Oncorhynchus mykiss*).

Caleta, M., Buj, I., Mrakovčić, M., Mustafić, P., Zanella, D., Marčić, Z., and Katavić, I., 2015. Endemic fishes of Croatia. Communities. Cyprinidae. *Bijdragen tot de Dierkunde*, 33-35.

da Paixao Lemos, C. H., Ribeiro, C. V. D. M., de Oliveira, C. P. B., Couto, R. D., and Copatti, C. E., 2018. Effects of interaction between pH and stocking density on the growth, haematological and biochemical responses of Nile tilapia juveniles. *Aquaculture*, *495*, 62-67.

Dahanukar, N., and Raghavan, R., 2013. Freshwater fishes of Western Ghats: Checklist MIN-Newsletter of IUCN SSC. *WI, FFCNSA*, *1*, 6-16.

Ellis, T., North, B., Scott, A. P., Bromage, N. R., Porter, M., and Gadd, D., 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of fish biology*, *61*(3), 493-531.

Fivelstad, S., Schwarz, J., Strømsnes, H., and Olsen, A. B., 1995. Sublethal effects and safe levels of ammonia in seawater for Atlantic salmon postsmolts (*Salmo salar* L.). *Aquacultural Engineering*, *14*(3), 271-280

Gargotra, P., and Antony, C., 2024. Effect of Vitamins A, C and E on the Bio-Growth Performance and Captive Maturation of *Lepidocephalichthys thermalis*. *Pakistan Journal of Zoology*, *56*(2).

Ghozlan, A., 2018. Effect of stocking density on growth performance, production trait, food utilization and body composition, of meagre (*Argyrosomus regius*). *World Journal of Engineering and Technology*, *6*(03), 37.

Haque, M. M., Islam, M. A., Ahmed, G. U., and Haq, M. S., 1984. Intensive culture of Java Tilapia (*Oreochromis mossambicus*) in floating ponds at different stocking densities. *Bangladesh J. fish*, *7*(1-2), 55-59.

Hasan, M. R., Haque, A. K. M., Islam, M. A., and Khan, E. U. M. K. 1992. Studies on the effect of stocking density on the growth of Nile tilapia in floating ponds. *Bangladesh J. Fisheries*, *2*, 73-81.

Ita, E. O., Madu, C. T., Omorinkoba, W. S., and Pandogari, A., 1989. Preliminary estimator of the survival rate of *Clarias angullaris* fry under outdoor hatchery management system. *Annu. Rep. Natl. Inst. Fish. Res.(Nigeria)*, 88-94.

Jayaram, K. C.,1999. *The freshwater fishes of the Indian region*.

Kumar, V., Lianthuamluaia, U. K., Roshith, C. M., Panda, D., Sandhya, K. M., Kumari, S., and Karnatak, G., 2017. New Record of Indian Hill Trout *Barilius bendelisis* (Cypriniformes: Cyprinidae) from Kangsabati Reservoir, West Bengal, India. *Int. J. Curr. Microbiol. App. Sci*, *6*(2), 104-110.

Lima, P. C. M., Silva, A. E. M., Silva, D. A., Silva, S. M. B. C., Brito, L. O., and Gálvez, A. O., 2021. Effect of stocking density of Crassostrea sp. in a multitrophic biofloc system with *Litopenaeus vannamei* in nursery. *Aquaculture*, *530*, 735913.

Masuma, S., Tezuka, N., and Teruya, K., 1993. Embryonic and morphological development of larval and juvenile coral trout, *Plectropomus leopardus*. *Japanese Journal of Ichthyology*, *40*(3), 333-342.

McKenzie, D. J., Höglund, E., Dupont-Prinet, A., Larsen, B. K., Skov, P. V., Pedersen, P. B., and Jokumsen, A., 2012. Effects of stocking density and sustained aerobic exercise on growth, energetics and welfare of rainbow trout. *Aquaculture*, *338*, 216-222.

Paul, P., Rahman, A., Hossain, M. M., Islam, S., Mondal, S., and Haq, M., 2016. Effect of stocking density on the growth and production of freshwater prawn (*Macrobrachium rosenbergii*). *International Journal of Fisheries and Aquaculture Sciences*, *6*(1), 77-86.

Ronald, N., Gladys, B., and Gasper, E., 2014. The effects of stocking density on the growth and survival of Nile tilapia (*Oreochromis niloticus*) fry at son fish farm. *Uganda. Journal of Aquaculture Research and Development*, 5(2), 222.

Schreck, C. B., Patino, R., Pring, C. K., Winton, J. R., and Holway, J. E., 1985. Effects of rearing density on indices of smoltification and performance of coho salmon, *Oncorhynchus kisutch*. *Aquaculture*, *45*(1-4), 345-358.

Sejr, M. K., Petersen, J. K., Jensen, K. T., and Rysgaard, S., 2004. Effects of food concentration on clearance rate and energy budget of the Arctic bivalve *Hiatella arctica* (L) at subzero temperature. *Journal of Experimental Marine Biology and Ecology*, *311*(1), 171-183.

Wurts, W. A., and Durborow, R. M., 1992. Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds.

Xia, B., Gao, Q. F., Wang, J., Li, P., Zhang, L., and Zhang, Z., 2015. Effects of dietary carbohydrate level on growth, biochemical composition and glucose metabolism of juvenile sea cucumber *Apostichopus japonicus* (Selenka). *Aquaculture*, *448*, 63-70.

Zhang, B., and Tang, Q., 2002. Influence of fish density on the growth rate and energy budget of *Sebastodes fuscescens*. *Marine Fisheries Reseaqrch*, *23*(2), 33-37.