



Research Note

Length-Weight Relationships and Growth Patterns of Five Loach Species from the Perennial River Burhi Gandak, India

Dupare R. R.¹, Mogalekar H. S.^{1*}, Sahil¹, Sanjay¹, Nayak S. K.¹, Jamwal A.¹, Mohan C. O.² and Shivendra Kumar¹

¹College of Fisheries (Dr. Rajendra Prasad Central Agricultural University), Dholi, Muzaffarpur - 843 121, Bihar, India

²ICAR-Central Institute of Fisheries Technology, Willingdon Island, Kochi - 682 029, Kerala, India

The Burhi Gandak River, a vital tributary of the Ganges, supports a rich diversity of loaches, yet their growth dynamics remain largely unstudied; this research analyses the length-weight relationships (LWRs) of five key species. A total of 2,453 specimens were sampled using gill nets, traps, and cast nets from September 2021 to August 2022. The LWR parameters were derived for total length (TL), standard length (SL), and head length (HL) relative to body weight (Wt). The results revealed distinct growth patterns among the species. *Botia dario* and *Acanthocobitis botia* exhibited positive allometric growth ($b > 3$), whereas *Lepidocephalichthys guntea* and *Botia lohachata* showed negative allometric growth ($b < 3$). *Canthophrys gongota* displayed a relatively weaker TL-Wt correlation. Total length was the most robust predictor of body weight for most species, while head length demonstrated limited predictive reliability. This study provides the first comprehensive LWR data for these species in Bihar, providing essential baseline information for their sustainable management and conservation in this understudied riverine ecosystem.

Keywords: Length-weight relationship (LWR), loach species, growth patterns, Burhi Gandak River, biometric analysis.

Received 3 December 2024; Revised 12 October 2025; Accepted 13 October 2025

Handling Editor: Dr. V. R. Madhu

*Email: mogalekar.hs10@gmail.com

The order Cypriniformes, comprising two major superfamilies—Cobitoidea (loach-like fishes) and Cyprinoidea (carp-like fishes) represents one of the most diverse groups of freshwater fishes globally (Nelson, Grande, & Wilson, 2016). Loaches, which belong to the superfamily Cobitoidea, are ecologically significant benthic dwellers to the superfamily Cobitoidea, are ecologically significant benthic dwellers, with approximately 1,043 valid species across 111 genera worldwide (Kottelat, 2012; Nelson et al., 2016; Fricke, Eschmeyer, & Van Der Laan, 2022). These small indigenous species, typically under 25 cm in length, are valued for their ecological roles in nutrient cycling, sediment turnover, and prey-predator dynamics, as well as for their aesthetic and dietary importance (Kottelat, 2012; Nasren et al., 2023; Samad, Mahfuj, Ahmed, Rahman, & Hossain, 2023). In India, loaches contribute significantly to freshwater biodiversity, with many species being endemic and increasingly threatened by habitat degradation, overexploitation, and climate change (Keskar, Raghavan, Kumkar, Padhye, & Dahanukar, 2017; Chinglemba, Rameshori, & Vishwanath, 2021; Singh & Kosygin, 2022). Despite their ecological and commercial significance, particularly in the ornamental fish trade, studies on their population biology and fishery status remain poorly documented, especially in northern India (Raut, Kumar, Bhatt, Singh, & Kumar, 2020).

The Burhi Gandak River, a vital tributary of the Ganges system in North Bihar, supports a rich diversity of ichthyofauna, including several loach

species (Baitha et al., 2018; NBFGR, 2019; Sahil et al., 2022; Chandravanshi et al., 2023; Sahu et al., 2024). It is home to 73 fish species belonging to 8 orders, 22 families, and 53 genera (NBFGR, 2019). However, the population dynamics and exploitation status of loaches in this riverine ecosystem are poorly understood (Baitha et al., 2018). Key population parameters such as growth patterns, mortality rates, and exploitation levels are essential for sustainable fisheries management and conservation (Sparre & Venema, 1998; Kharat, Khillare, & Dahanukar, 2008; Kharat & Dahanukar, 2013). Among these, the length-weight relationship (LWR) is a fundamental tool for assessing fish growth, condition factors, and stock health, while length-length relationships (LLRs) provide insights into ontogenetic changes and morphological variations (Froese, 2006, 2007; Hossen et al., 2016).

This study focuses on the length-weight relationships (LWR) and growth patterns of five loach species, *L. guntea*, *C. gongota*, *B. dario*, *B. lohachata*, and *A. botia* from the Burhi Gandak River. Notably, this is the first study to report LWRs for these five species in Bihar, making a significant contribution to the existing knowledge of fish biology in the region. By analyzing these relationships, the research aims to provide critical baseline data for

monitoring population trends, assessing potential overexploitation, and informing sustainable management strategies for these ecologically and economically important species. The findings will contribute to the broader understanding of loach biology and support conservation efforts in this understudied riverine ecosystem.

The study was conducted in the middle stretch of the Burhi Gandak River, a significant left-bank tributary of the Ganga River in North Bihar, India. Originating from Chautarwa Chaur in West Champaran district, the river traverses six districts, covering approximately 320 km with a catchment area of 12,500 sq km, before merging with the Ganga in Khagaria district (Sahil et al., 2022; Chandravanshi et al., 2023; Sahu et al., 2024). Sampling was carried out monthly from September 2021 to August 2022 at four strategically selected sites: Muzaffarpur (26°02'49" N, 85°34'37" E), Dholi (26°00'13" N, 85°36'32" E), Pusa (25°59'48" N, 85°39'38" E), and Samastipur (25°51'46" N, 85°46'51" E) based on preliminary surveys and local fisherfolk knowledge indicating a higher abundance of loaches in this mid-stretch region (Fig. 1). Specimens were collected using gill nets (15-30 mm mesh size), traps (1 mm mesh size), and cast nets (1-5 mm mesh size).

Table 1. Length-Weight Relationships ($W = aL^b$) for Loach Species from the Burhi Gandak River

Species	n	Length Type	a	b	95% CI for b	r ²
<i>L. guntea</i>	448	TL	0.02833	2.556	2.474-2.638	0.866
		SL	0.06843	1.740	1.658-1.815	0.809
		HL	1.33242	2.283	2.137-2.423	0.690
<i>C. gongota</i>	267	TL	0.00258	3.054	2.706-3.410	0.568
		SL	0.00524	2.769	2.458-3.092	0.572
		HL	0.66564	0.544	0.122-0.956	0.028
<i>B. dario</i>	458	TL	0.12233	3.262	3.227-3.297	0.889
		SL	0.43867	2.207	2.119-2.295	0.842
		HL	0.62563	4.278	4.134-4.422	0.882
<i>B. lohachata</i>	400	TL	0.21697	2.638	2.585-2.690	0.961
		SL	0.55211	1.877	1.835-1.919	0.951
		HL	0.84789	3.327	3.283-3.492	0.891
<i>A. botia</i>	880	TL	0.05475	2.886	2.834-2.939	0.850
		SL	0.12797	1.489	1.433-1.544	0.757
		HL	0.22878	1.821	1.716-1.926	0.137

All lengths in mm, weight in g.

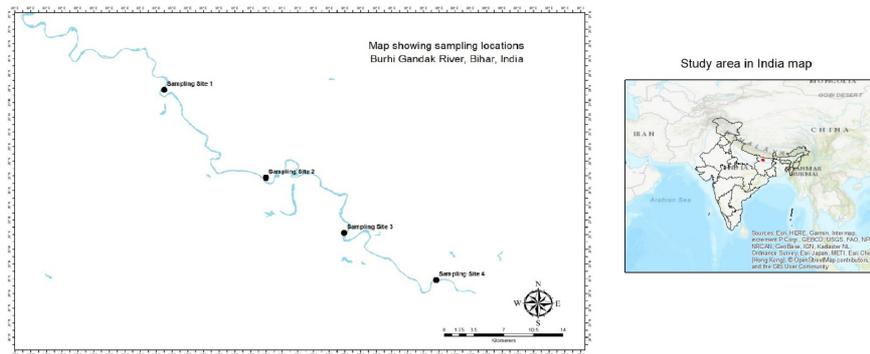


Fig. 1. Map showing sampling locations

Species were identified based on standard taxonomic keys (Menon, 1987; Jayaram, 2012), with verification against FishBase and the Catalogue of Fishes. For each specimen, total length (TL), standard length (SL), and head length (HL) were measured to the nearest 0.1 mm using a digital vernier caliper. Body weight (Wt) was recorded to the nearest 0.01 g using a precision balance. All morphometric measurements were taken from the left lateral side.

The length-weight relationship (LWR) was estimated using the power function: $W = aL^b$, where W is the body weight (g), L is the length (mm), a is the intercept, and b is the slope (Le Cren, 1951). Data were log-transformed, and parameters a and b were calculated using least-squares linear regression: $\log W = \log a + b \log L$ (Zar, 1984). Regressions were performed in Microsoft Excel, combining data for both sexes due to the impracticality of sex determination for many specimens. The coefficient of determination (r^2) was computed to assess the model fit (Bagenal & Tesch, 1978), and 95% confidence intervals (CI) for parameters a and b were derived from their standard errors (Ricker, 1973). Data for both sexes were combined, and outliers were excluded following established criteria (Froese, 2006).

This study establishes the first comprehensive length-weight relationships (LWRs) for five loach species (*L. guntea*, n=448; *C. gongota*, n=267; *B. dario*, n=458; *B. lohachata*, n=400; *A. botia*, n=880) in Bihar, analysing 2,453 specimens from the Burhi Gandak River. The derived LWR parameters (TL, SL, and HL against Wt) revealed significant interspecific variation in growth patterns, providing critical insights into their biology and the state of their habitat (Table 1).

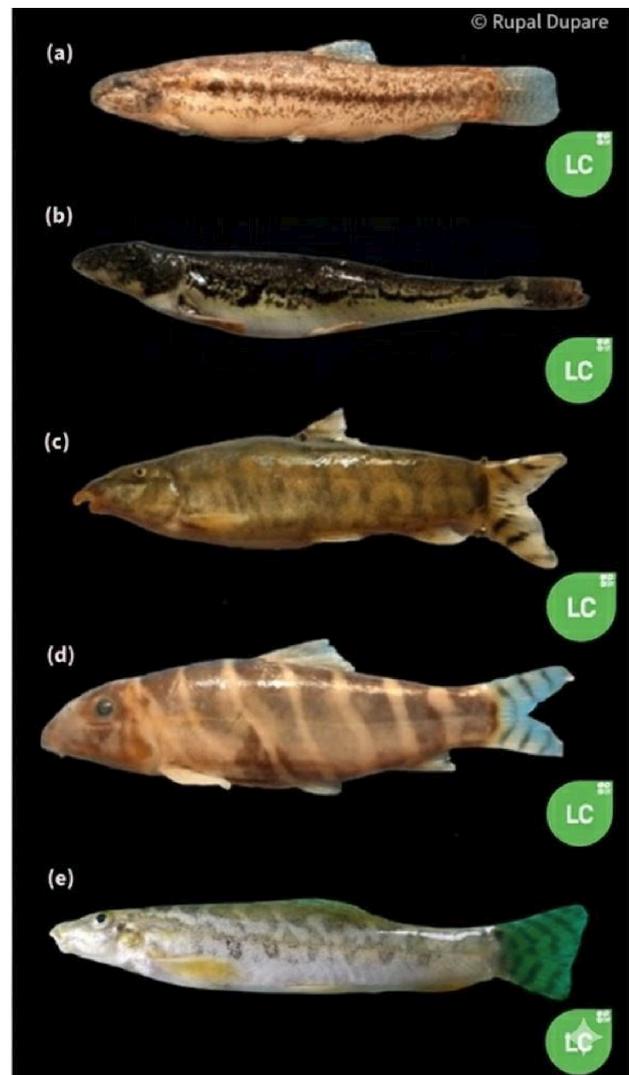


Fig. 2. Loaches from Burhi Gandak River a) *Lepidocephalichthys guntea*, b) *Canthophrys gongota*, c) *Botia dario*, d) *Botia lohachata*, e) *Acanthocobitis botia*

The growth coefficient (b) varied among species, indicating different resource allocation strategies. *B. dario* ($b = 3.262$) exhibited strong positive allometric growth, meaning it becomes progressively heavier for its length. This pattern, also observed in *A. botia* ($b = 2.886$), may reflect an adaptation for benthic life, requiring a heavier, more robust body for stability in river currents (Kottelat, 2012). In contrast, *L. guntea* ($b = 2.556$) and *B. lohachata* ($b = 2.638$) displayed negative allometric growth ($b < 3$), where length increases at a faster rate than weight. For *L. guntea*, this finding is consistent with a previous report from Tripura, India (Biswas, Jena, Panda, & Jena, 2018), suggesting a conserved growth strategy for the species. However, the b value for *B. lohachata* in this study (2.638) is notably lower than the 3.345 reported from Bangladesh (Hossen et al., 2016). This discrepancy highlights how growth dynamics can be influenced by regional environmental conditions, such as differences in food availability and habitat quality (Froese, 2006).

The predictive power of the LWRs also varied markedly. Total length was a robust predictor of weight for most species, with *B. lohachata* showing an exceptionally strong correlation ($r^2 = 0.961$). However, the relationship was weak for *C. gongota* ($r^2 = 0.568$), and its wide confidence interval for b suggests high phenotypic plasticity or inconsistent growth, possibly due to fluctuating resource availability or sub-optimal habitat conditions in the Burhi Gandak (Sparre & Venema, 1998). Furthermore, head length was a poor predictor of weight for *C. gongota* ($r^2 = 0.028$) and *A. botia* ($r^2 = 0.137$), indicating that head morphology in these species is highly variable and not a reliable indicator of overall body condition, potentially reflecting specialized feeding adaptations.

A noteworthy observation was the comparatively smaller maximum sizes recorded for all species relative to historical records (Talwar & Jhingran, 1991; Patiyal & Mir, 2017). For instance, the maximum TL for *L. guntea* was 88 mm, far less than the 150 mm previously documented. This stunting is a classic indicator of population stress, potentially driven by overexploitation for the ornamental trade, as noted by Raut et al. (2020) in North Bihar, and habitat degradation. The colder winter temperatures in this region (December-February) may also act as a growth-limiting factor.

The distinct LWRs documented here fill a critical

data gap for the Burhi Gandak River. The observed growth patterns and reduced maximum sizes provide a vital baseline and serve as an early warning, underscoring the need for targeted conservation efforts to mitigate anthropogenic pressures and ensure the sustainability of these ecologically valuable loach populations.

Acknowledgement

We are thankful to the College of Fisheries (Dr. Rajendra Prasad Central Agricultural University), Dholi, Muzaffarpur-843121, Bihar, India where research has been conducted.

References

- Bagenal, T. B., & Tesch, F. W. (1978). Age and growth. In T. Bagenal (Ed.), *Methods of assessment of fish production in fresh waters*. (pp. 101–136). Blackwell Scientific Publications.
- Baitha, R., Sinha, A., Koushlesh, S. K., Chanu, T. N., Kumari, K., Gogoi, P., Ramteke, M. H., Borah, S., & Das, B. K. (2018). Length weight relationship of ten indigenous freshwater fish species from Gandak River, Bihar, India. *Journal of Applied Ichthyology*, 34(1), 233–236. <https://doi.org/10.1111/jai.13555>.
- Biswas, P., Jena, A. K., Panda, A., & Jena, D. (2018). Length-weight relationship of *Lepidocephalichthys guntea* (Hamilton, 1822) from Haora River, Tripura, India. *Journal of Entomology and Zoology Studies*, 6(2), 572–575.
- Chandravanshi, S., Mogalekar, H. S., Sahu, O., Sudhan, C., Ram, R. K., & Kumar, S. (2023). Habitat ecology and shellfish diversity of River Burhi Gandak, North Bihar, India. *Pakistan Journal of Zoology*, 57(1), 375–381. <https://dx.doi.org/10.17582/journal.pjz/20221008091032>.
- Chinglemba, Y., Rameshori, Y., & Vishwanath, W. (2021). A new species of stone loach of the genus *Mustura* (Teleostei: Nemacheilidae) from Chindwin River drainage, Manipur, north-eastern India. *Zootaxa*, 5081(4), 551–565. <https://doi.org/10.11646/zootaxa.5081.4.6>.
- Fricke, R., Eschmeyer, W. N., & Van Der Laan, R. (2022). *Eschmeyer's catalog of fishes: genera, species, references*. Retrieved from <https://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>. Accessed on February 27, 2023.
- Froese, R. (2006). Cube law, condition factor, and weight-length relationships: history, meta-analysis, and recommendations. *Journal of Applied Ichthyology*, 22(4), 241–253. <https://dx.doi.org/10.1111/j.1439-0426.2006.00805.x>.
- Froese, R. (2007). Length weight relationships for 18 less studied fish species. *Journal of Applied Ichthyology*, 14(1

- 2), 117–118. <https://doi.org/10.1111/j.1439-0426.1998.tb00626.x>.
- Hossen, M. A., Hossain, M. Y., Pramanik, M. N. U., Nawer, F., Khatun, D., Parvin, M. F., & Rahman, M. M. (2016). Morphological characters of *Botia lohachata*. *Journal of Coastal Life Medicine*, 4(9), 689–692. <https://doi.org/10.12980/jclm.4.2016J6-148>.
- Jayaram, K. C. (2012). *The freshwater fishes of the Indian region* (2nd ed.). Narendra Publishing House.
- Keskar, A., Raghavan, R., Kumkar, P., Padhye, A., & Dahanukar, N. (2017). Assessing the sustainability of subsistence fisheries of small indigenous fish species: fishing mortality and exploitation of hill stream loaches in India. *Aquatic Living Resources*, 30(1), Article 13. <https://doi.org/10.1051/alr/2016036>.
- Kharat, S. S., & Dahanukar, N. (2013). Population dynamics of the hill stream loach *Acanthocobitis mooreh* (Sykes, 1839) (Cypriniformes: Nemacheilidae) from Northern Western Ghats of India. *Journal of Threatened Taxa*, 5(11), 4562–4568. <https://doi.org/10.11609/JoTT.o3301.4562-8>.
- Kharat, S. S., Khillare, Y. K., & Dahanukar, N. (2008). Allometric scaling in growth and reproduction of a freshwater loach *Nemacheilus morreh* (Sykes, 1839). *Electronic Journal of Ichthyology*, 1, 8–17.
- Kottelat, M. (2012). Conspectus cobitidum: An inventory of the loaches of the world (Teleostei: Cypriniformes: Cobitoidei). *The Raffles Bulletin of Zoology, Suppl.* 26, 1–199.
- Le Cren, E. D. (1951). The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20(2), 201–219. <https://doi.org/10.2307/1540>.
- Menon, A. G. K. (1987). *The Fauna of India and Adjacent Countries: Pisces- Teleostomi- Cobitoidea, Homalopteridae* (Vol. 4.). Zoological Survey of India.
- Nasren, S., Rahman, M. Z., Islam, M. S., Mia, R., Mian, S., & Mamun, M. A. A. (2023). Length weight relationships (LWRs) of four Loach species of the Cobitidae family from the Surma River, Bangladesh. *Journal of Applied Ichthyology*, 2023(1), Article 6654237. <https://doi.org/10.1155/2023/6654237>.
- NBFG. (2019). *Annual Report 2019*. ICAR-National Bureau of Fish Genetic Resources.
- Nelson, J. S., Grande, T. C., & Wilson, M. V. H. (2016). *Fishes of the World* (5th ed.). John Wiley & Sons.
- Patiyal, R. S., & Mir, J. I. (2017). Length-weight relationships of 21 fish species from the upland Ganga River Basin tributaries of Central Indian Himalaya. *Journal of Applied Ichthyology*, 33(4), 861–863. <https://doi.org/10.1111/jai.13386>.
- Raut, S. M., Kumar, M., Bhatt, B. P., Singh, J., & Kumar, T. (2020). Potential and opportunity for ornamental fishes in North Bihar. *Biotica Research Today*, 2(7), 677–679.
- Ricker, W. E. (1973). Linear regressions in fishery research. *Journal of the Fisheries Research Board of Canada*, 30(3), 409–434. <https://doi.org/10.1139/f73-072>.
- Sahil, Mogalekar, H. S., Chandran, S., Nayak, S. K., Kumar, S., & Singh, S. K. (2022). Length-weight relationship and condition factor of selected small Cyprinid fishes from river Burhi Gandak in North Bihar, India. *Journal of Inland Fisheries Society of India*, 54(1), 27–32. <https://dx.doi.org/10.47780/jifsi.54.1.2022.132388>.
- Sahu, O., Mogalekar, H. S., Sahil, Chandravanshi, S., Rathore, P. K., Kumar, R., Nayak, S. K., Srivastava, P., & Brahmchari, R. (2024). Length-weight relationship and exploitation of Macrobrachium species in the Burhi Gandak River, North Bihar, India. *Indian Journal of Fisheries*, 71(3), 60–68. <https://doi.org/10.21077/ijf.2024.71.3.133789-07>.
- Samad, M. A., Mahfuj, M. S. E., Ahmed, F. F., Rahman, S. U., & Hossain, M. Y. (2023). Intraspecific morphological variations of the vulnerable loach, *Lepidocephalichthys annandalei* (Cypriniformes: Cobitidae) in inland waterbodies at southwestern Bangladesh. *Lakes & Reservoirs: Science, Policy and Management for Sustainable Use*, 28(1), Article e12428. <https://doi.org/10.1111/re.12428>.
- Singh, P., & Kosygin, L. (2022). *Aborichthys bajpaii*, a new species of loach (Nemacheilidae) from Eastern Himalaya, India. *Journal of Ichthyology*, 62, 707–714. <https://doi.org/10.1134/S0032945222050162>.
- Sparre, P., & Venema, S. C. (1998). *Introduction to tropical fish stock assessment. Part 1: Manual* (FAO Fisheries Technical Paper. No.306). FAO.
- Talwar, P. K., & Jhingran, A. G. (1991). *Inland fishes of India and adjacent countries*. CRC press.
- Zar, J. H. (1984). *Biostatistical Analysis* (2nd ed.). Prentice-Hall.