Length Weight Relationship Of Three Cobitid Loaches From Manipur, An Indo-Burma Biodiversity Hotspot Region In India

Ningombam Pratima[1]*; W.Vidyarani Devi[2]; Wangjam Kabita Devi[3]; Mutum Robin Singh[4]

[1*,2,3,4]Department of Zoology, Manipur University, Canchipur-795003 Manipur, India

***Corresponding Author:** Ningombam Pratima
Email: pratimaningombam@manipuruniv.ac.in

Abstract
The Length-weight relationship (LWR) of three cobitid loaches: *Lepidocephalichthys berdmorei* (Blyth, 1860), *Pangio pangia* (Hamilton, 1822), and *Lepidocephalichthys irrorata* (Hora, 1921) were studied quarterly between March 2021 and May 2022. Fish were collected from selected sampling sites in Manipur using traditional fishing methods. Length and weight measured were calculated by the allometric growth formula (Ricker, 1973) for the three loaches and the condition factor (Fulton,1904) was also calculated. The value of b was found to be 3.12 in *L. berdmorei*, 2.58 in *P. pangia,* and 2.98 in *L. irrorata*. The regression coefficient (r^2) was observed to be 0.97,0.96 and 0.92 respectively. The condition factor (K) value ranges from 0.528 to 0.734 in *L. berdmorei,* 0.335 to 0.474 in *P. pangia, and* 0.408 to 0.595 in *L. irrorata*. It can be concluded from the study that *L. berdmorei* shows positive allometric growth while *L. irrorata* and *P. pangia* show negative allometric growth. This biological parameter in these species has never been explored before from Manipur.

Keywords: *Lepidocephalichthys berdmorei, Pangio pangia, Lepidocephalichthys irrorata,* length-weight relationship, condition factor, Manipur

Abbreviations
LWR - length-weight relationship
r^2 - regression coefficient
K- condition factor
L. berdmorei- Lepidocephalichthys berdmorei
L. irrorata- Lepidocephalichthys irrorata
P. pangia- Pangio pangia

INTRODUCTION

As a biological parameter, the Length-weight relationship (LWR) helps assess population characteristics. Biomass can be determined when the length-weight data is available (Hanif *et al*., 2020). Growth, survival, maturity, reproduction, and general well-being can be understood from this relationship (Le Cren,1951). There are 33 species under Genus *Pangio* and 18 under Genus *Lepidocephalichthys,* under the family Cobitidae. The hillstream loach, *Lepidocephalichthys berdmorei* (Blyth, 1860) is found in Manipur and is widely distributed in India, Myanmar, and Thailand. *Lepidocephalichthys irrorata* is endemic to lakes and streams of Manipur Valley and the Chindwin basin. Characteristics of these species are that males can be easily distinguished from females by the presence of lamina circularis, formed by the fusion of the seventh and eighth pectoral fin rays, which is absent in females (Havird and Page, 2010) and is not distinguishable in juveniles. *Pangio pangia* is widely distributed in India, Bangladesh, Nepal, Myanmar, and Indonesia, and the body is eel-like. Due to their ornamental value, these cobitid loaches can also be utilized in the aquarium trade.
Fishes exhibit growth in length and weight during their lifetime. However, the habitat condition of the fish has a direct influence on such developments. Many factors, such as the physicochemical parameters of water and soil, affect the fish's food source, size, and population (Kachari, 2017). According to Fulton (1904), fishes increase in weight more than the increase in length, and the weight for a given length differs in different species. The ratio varies at different places and seasons within a species, with a sudden weight loss after spawning. Le Cren (1951) concluded that a single regression cannot adequately describe the length-weight relationship as it is different for different life stages, sexes, stages of gonad development, and different seasons. The condition factor reflects the overall condition and well-being of fish. Assessing the condition factors of different fish species is essential for maintaining the ecosystem balance, and comparing the fishes that inhabit similar environments also helps to monitor the feeding habits. (Imam *et al.,* 2021, Alam *et al*.,2014 and Anyanwu *et al.,* 2007).
There is no recorded information on the length-weight relationship for these species from Manipur in FishBase and other scientific literature. Thus, this present study estimates the length-weight relationship and condition factor of *Lepidocephalichthys berdmorei, Pangio pangia,* and *Lepidocephalichthys irrorata* in Manipur, India.

MATERIALS AND METHODS

Sampling was done quarterly. The fish were caught using a traditional cast net, the Longthrai (local net), with the help of local fishermen from the sampling sites between March 2021 to May 2022. Freshly caught fish specimens were measured and identified using standard manuals (Vishwanath *et al*., 2014). The total length (TL), standard length (SL), and body depth were recorded using digital calipers, and body weight (BW) was taken to an accuracy of 0.001 g using the digital weighing machine. The gut content of the fish was not emptied before weighing.

The length-weight relationship was calculated using the allometric growth formula of Ricker (1973), $W= aL^b$, and logarithmically transferred into a linear relationship, i.e., log W= log a + b log L, (Le Cren, 1951) where W= weight of the specimen (in gm), L= Total length of the sample (in cm), a= intercept and b= slope of the regression line. The coefficient of determination (r^2) and the 95 % confidence limits of parameters (a and b) were determined. Parameter b indicates isometric growth in body proportions if b= 3; a is the parameter describing body shape and condition (Froese 2006, 2013). The value of b remains unaffected if the parameters are presented in units other than centimeters and grams. Nevertheless, the intercept, a, must be converted if the length was given in mm and weight in gm as $a' = a10^b$.

The degree of well-being of fish in their habitat, also known as the condition factor, was calculated using the following equation: $K = \frac{100W}{L^3}$ where K = condition factor; W=fish weight (g); and L =fish length (cm), (Fulton, 1904 and Froese,2006).

All statistical analyses were performed on MS Excel 2019.

RESULTS

The length-weight frequency was calculated on the randomly selected samples of *L. berdmorei. P. pangia and L. irrorata*. The regression plot is established by taking log10 values of total length as the independent variable(X-axis) while the weight is the dependent variable (Y-axis). The regression equation of LWR of the three fish species is represented logarithmically as follows: - y = 3.12x- 2.33 (*L. berdmorei*); y = 2.58x -2.06 (*P. pangia*) and y = 2.98x-2.31(*L. irrorata*). The estimated parameters for length-weight relationships, i.e., sample size(n), total body length (TL) and body weight(W), the maximum and minimum range of weight and length, regression parameters a and b with their 95% confidence limits, the coefficients of determination (r^2) along with all the descriptive statistics are given in Table 1.

Table 1: Descriptive statistics and estimated length-weight relationship parameters for the three species of cobitid loaches in Manipur, India.

Species	Collection sites	n	Total length (cm)		Weight (g)		Regression Parameters		95% CL				r^2
									a		b		
			Min	Max	Min	Max	a	b	lower	upper	lower	upper	
L. berdmorei	Loushi Pat, Manipur (24.505321, 94.009439)	58	5.5	9.8	0.99	5.45	0.004	3.12	0.003	0.005	2.99	3.25	0.97
P. pangia	Nambol Kongkham, Manipur (24.693307, 93.826997)	72	4.9	7.8	0.72	1.59	0.1303	2.58	0.118	0.143	2.44	2.67	0.96
L. irrorata	Nambol Naorem, Manipur (24.696384, 93.833857)	109	3	4.3	0.13	0.38	0.0997	2.98	0.09	0.11	2.81	3.15	0.92

n = number of specimens; Min = Minimum; Max = Maximum; a = intercept; b = slope; CL = Confidence Limits; r^2= co-efficient correlation or determination

The b value in length-weight relationship (LWR) for *L. berdmorei*, *P. pangia*, and *L. irrorata* is 3.12, 2.56, and 2.98, respectively. The correlation coefficient (r^2) was observed to be 0.97,0.96 and 0.92, respectively. The log–log plots of length and weight values were performed to inspect outliers visually (Froese, 2006).

The condition factor (K) value ranges from 0.528 to 0.734 in *L. berdmorei*, 0.335 to 0.474 in *P. pangia, and* 0.408 to 0.595 in *L. irrorata*.

DISCUSSION

The genera *Lepidocephalichthys* and *Pangio* within the family Cobitidae are known for their diverse group of loach species. The present finding of the relation between length and weight shows that the correlation coefficient of total length and body weight between the three cobitid species shows a highly significant value. The available information on the biological aspects, including the LWRs of these loaches is inadequate and insufficient from this region. The value of b in *L. berdmorei* shows positive allometric growth (b>3) and negative allometric growth in *L. irrorata* and *P. pangia* (b<3). This indicates that the fishes of *L. berdmorei* show their weight increases more than their length increase as opposed to

the others, *L. irrorata* and P. *pangia*, where an increase in length does not parallel with the increase in weight. Among the sexes, males generally have low values, which may be due to decreased body weight as energy is expended during the breeding season (Das *et al*., 2015). However, in females, their body weight might be increased due to the enormous development of gonads during the breeding season. The values of b in this study of *L. berdmorei*, *P. pangia*, and *L. irrorata* are within the expected range (2.5-3.5), as reported by Carlander, 1969. The values differ from *L. goalparensis*, a loach from the same family Cobitidae, which have b values of 2.774,2.993, and 2.883, respectively, for males, females, and combined sexes, where overall species show negative allometric growth (Das and Bordoloi, 2013). *L. guntea* has b values ranging between 2.66-2.91 in males and 2.76-3.76 in females, showing negative and positive allometric growth, respectively, with overall combined b values ranging from 2.81-3.22 (Gohain and Deka, 2017; Kumar, R. *et al*., 2017 and Biswas *et al*., 2018). The value of b of *L. berdmorei* from the Jatinga River Barak drainage was reported to be 2.92 unsexed (Choudhury *et al*., 2018). The b values of males, females, and combined were negatively and positively allometric in *L. guntea* (2.74,3.45, and 2.81) as reported by Mandal and Mandal, 2021 from Kangshabati River, India. Basumatary *et al*., 2017 reported the value of b as 2.71 for *P. pangia.* Better nutritional conditions favor smaller-sized individuals during sampling (Froese, 2006). The b value in LWR for *L. berdmorei*. *P pangia* and *L irrorata* are well in between the value 2.5-3.5 (Froese, 2006) and were observed to be within the range. Also, the length and weight regression coefficients were highly significant in all the species. However, no single regression will adequately describe the length-weight relationship of fish (Le Cren, 1951).

Seasonal shifts, notably in temperature and food availability, emerged as influential factors impacting the body condition of the various fishes. Also, diet plays an important role in the weight fluctuations of different fish species. Geographical and ecological variables might affect the LWR of fishes (Zhang *et al*.,2017; Xia *et al*.,2016; Zhu *et al*.,2015). The variations in the condition factors of the fishes reveal the differences in their growth status. The condition factor could also differ among different types of fish in various habitats. The present study also has the possibility to split up into groups of various maturity levels, age groups, and sexes for further research. The length-weight relationship of *L. berdmorei*, *P. pangia, and L. irrorata* is within the range. It reveals a good correlation between length and weight in all three fish species. Hence, it can be concluded that the species were in healthy conditions in their natural habitats.

Since the data obtained were based on freshly caught fishes, the limitations of the length-weight relationship estimate in other studies carried out from the data derived from the formaldehyde-preserved specimens by other authors are hugely omitted. The shrinkage and weight loss of preserved samples due to dehydration over some time (Anzueto-Calvo *et al*., 2017) are avoided in this work as the samples are measured fresh. This has been the major limitation of previous studies. These fishes also have great cultural significance in the region. In recent years, the fish population has dwindled in the wild, and their price in the market is very high. The life traits, behavior, breeding, maturity, and spawning season of these fish need to be studied extensively to conserve them. This information could support fishery biologists in the sustainable and judicious management and conservation of these species.

ACKNOWLEDGMENT

The authors acknowledge the Manipur University for the financial assistance under the University Fellowship. Also, the authors acknowledge Dr Rameshori Yumnam and Chinglemba Yengkhom of FISA Lab, Manipur University, for helping identify the specimens.

CONFLICTS OF INTEREST

The authors declare no conflict of interest as all agreed to participate and for this contribution to be published.

ETHICS APPROVAL

This research work has been approved by the Institutional Animal Ethics Committee (IAEC) of Manipur University, India, and the data used for this contribution are included in the texts and/or exhibits.

ORCID

Pratima Ningombam Orcid ID- https://orcid.org/0000-0002-2736-298X

REFERENCE

1. Alam, M. M., Rahman, M. T. and Parween, S.2014. Morphometric characters and condition factors of five freshwater fishes from Pagla river of Bangladesh," *International Journal of Aquatic Biology*, vol. 2, no. 1, pp. 14–19, 2014.
2. Anyanwu, P. E., Okoro, B. C. Anyanwu, A. O. 2007. Length-weight relationship, condition factor, and sex ratio of African mud catfish (*Clarias gariepinus*) reared in indoor water recirculation system tanks. https://agris.fao.org/agrissearch/search.do?recordID=AV20120138244.
3. Anzueto-Calvo, M.J., Velázquez-Velázquez, E., Matamoros, W.A., Maza, B.G. and Nettel-Hernanz, A. ,2017. Effect of conservation of fish in formalin and ethanol on length-weight relationships and condition factor in Tlaloc labialis (Günther, 1866). *Journal of Applied Ichthyology*, 33(6), pp.1184–1186. doi:https://doi.org/10.1111/jai.13461.
4. Basumatary, S., Choudhury, H. and Sarma, D., 2017. Length-weight relationships of *Hara hara* (Hamilton, 1822), *Pangio pangia* (Hamilton, 1822) and *Setipinna brevifilis* (Valenciennes, 1848) from the lower Brahmaputra River, Northeast India. *Journal of Applied Ichthyology*, 33(6), pp.1279–1280. doi:https://doi.org/10.1111/jai.13481.
5. 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), pp.572–575.

6. Carlander, K. D., 1969. *Handbook of Freshwater Fishery Biology: Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. 3d ed. 1969*.
7. Choudhury, H., Thaosen, S., Dey, A., Basumatary, S. and Sarma, D. ,2018. Length-weight relationships of three fish species from the Jatinga River (Barak drainage) in Assam, India. *Journal of Applied Ichthyology*, 34(4), pp.1089–1090. doi:https://doi.org/10.1111/jai.13727.
8. Cren, E.D.L.,1951. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in the Perch (Perca fluviatilis). *The Journal of Animal Ecology*, 20(2), p.201. doi:https://doi.org/10.2307/1540.
9. Das, M.K. and Bordoloi, S, 2013. Length-weight relationship and condition factor of *Lepidocephalichthys goalparensis* Pillai and Yazdani, 1976 in Assam, India. *Journal of Applied Ichthyology*, 30(1), pp.246–247. doi:https://doi.org/10.1111/jai.12247.
10. Das, P., Rahman, W., Talukdar, K., Deka, P., 2015. Length-weight relationship and relative condition factor of *Heteropneustes fossilis* (Bloch) of Deepar Beel, a Ramsar site of Assam, India. International Journal of Applied Research. 2015;1(12):1024-1027.
11. Froese, R. and D. Pauly. Editors. 2022.FishBase. World Wide Web electronic publication. www.fishbase.org, (August 2022) (Accessed on 25 August 2022)
12. Froese, R., 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4), pp.241–253. doi:https://doi.org/10.1111/j.1439-0426.2006.00805.x.
13. Froese, R., Thorson, J.T. and Reyes, R.B., 2013. A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology*, 30(1), pp.78–85. doi:https://doi.org/10.1111/jai.12299.
14. Fulton, T.W., 1904. *The Rate of Growth of Fishes*. Twenty-second Annual Report, Part III. Fisheries Board of Scotland, Edinburgh,pp. 141-241
15. Gohain, A.B. and Deka, P. ,2017. Length-weight relationship and relative condition factor of Lepidocephalichthys Guntea (Hamilton, 1822) of Ghati Beel of Dhemaji district of Assam, India. *International Journal of Fisheries and Aquatic Studies*, 5(2), pp.514–517.
16. Hanif, M. A., Siddik M. A. B., and Ali, M. M., 2020. Length-weight relationships of seven cyprinid fish species from the Kaptai Lake, Bangladesh. *Journal of Applied Ichthyology*, 36(2), pp.261–264. doi:https://doi.org/ 10.1111/jai.14016.
17. Havird, J.C. and Page, L.M., 2010. A Revision of Lepidocephalichthys (Teleostei: Cobitidae) with Descriptions of Two New Species from Thailand, Laos, Vietnam, and Myanmar. *Copeia*, 2010(1), pp.137–159. doi:https://doi.org/10.1643/ci-08-240.
18. Imam, T. S., Bala, U., Balarabe, M. L. and Oyeyi, T. I.2021. "Length-weight relationship and condition factor of four fish species from Wasai Reservoir in Kano, Nigeria," *African Journal of General Agriculture*, vol. 6, no. 3, 2021.
19. Kachari, A., 2017. LENGTH- WEIGHT RELATIONSHIP (LWR) AND CONDITION FACTOR OF Amblyceps apangi NATH & DEY FROM ARUNACHAL PRADESH, INDIA. *Journal of Aquaculture Engineering and Fisheries Research*, pp.97–107. doi:https://doi.org/10.3153/jaefr17013.
20. Kumar, R., Abujam, S., Darshan, A., Kumari, A., Das, D.N., 2017. Length Weight Relationship of *Lepidocephalichthys guntea*(Hamilton,1822) from Dikrong River, Arunachal Pradesh. *Worldwide Journal of multidisciplinary research and Development*, 4(2), 197-200
21. Mandal, S., and Mandal, B., 2021. Study of Length-weight relationship and the condition factors of Lepidocephalichthys guntea (Hamilton, 1822) from Kangsabati river of district West Midnapore, West Bengal, India. *Journal of University of Shanghai for Science and Technology*, 23(08), pp.602–615. doi:https://doi.org/10.51201/jusst/21/08433.
22. Ricker, W.E. , 1973. Linear Regressions in Fishery Research. *Journal of the Fisheries Research Board of Canada*, 30(3), pp.409–434. doi:https://doi.org/10.1139/f73-072.
23. Vishwanath W., K. Nebeshwar, Y. Lokeshwor, BD Shangningam & Y. Rameshori. 2014. Freshwater Fish Taxonomy and A Manual for Identification of Fishes of Northeast India, 1-131
24. Xia, C. X., Chen, L., and Xiong, W.,2016. Length–weight relationships of three fish species from the Jinsha River, southwestern China. *Journal of Applied Ichthyology*, vol. 32, no. 3, pp. 513-514, 2016.
25. Zhang, D. F., Wang, W. and Liu Q. F., 2017. Length-weight relationships of four fish species from the Niulan River, China, *Journal of Applied Ichthyology*, vol. 33, no. 3, pp. 592-593, 2017.
26. Zhu, T. B., Yang, D. G., Liu, Y. and Li, F. 2015. Length-weight relationships of six fish species from the Zengqu River and the Ouqu River, southwest China, *Journal of Applied Ichthyology*, vol. 31, no. 6, pp. 1153-1154, 2015