Zoodiversity, **58**(5):419–428, 2024
DOI 10.15407/zoo2024.05.419

Morphology

UDC 597.551.2(540)

MORPHOMETRIC AND MERISTIC CHARACTERS OF A SMALL INDIGENOUS FRESHWATER BALITORID, *TRIPLOPHYSA MARMORATA* (CYPRINIFORMES, NEMACHEILIDAE), FROM MANASBAL LAKE, KASHMIR, INDIA

S. T. Mushtaq*, S. A. Mushtaq, T. H. Shah & F. A. Bhat

Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir, Rangil, Ganderbal-190006, India
**Corresponding author*
E-mail: syedtalia2020@gmail.com

S. T. Mushtaq (https://orcid.org/0000-0003-2353-5625)
S. A. Mushtaq (https://orcid.org/0000-0003-4903-6365)
T. H. Shah (https://orcid.org/0000-0003-4670-6044)
F. A. Bhat (https://orcid.org/0000-0002-8741-5334)

urn:lsid:zoobank.org:pub:551D1691-76EB-4388-99B3-4C9D2F1131A0

Morphometric and Meristic Characters of a Small Indigenous Freshwater Balitorid, *Triplophysa marmorata* (Cypriniformes, Nemacheilidae), from Manasbal Lake, Kashmir, India. Mushtaq, S. T., Mushtaq, S. A., Shah, T. H., Bhat, F. A. — The current study provides the morphometric and meristic characteristics of a small indigenous freshwater balitorid, *Triplophysa marmorata* (Heckel, 1838), thriving in Manasbal Lake, Kashmir, India. The research involved the collection of 360 samples of *T. marmorata* from Manasbal Lake. The analysis revealed that the morphometric measurements were dependent on body size and there was a gradual increase in body length. Regression analysis was performed between the independent variables TL and the dependent variables viz. SL, FL, PrAL, PrVL, PrDL, BD, HL, CFL, PFL and PVL as well as between the dependent variables HL and the dependent variables ED, SnL, PrOL and PoL. The results indicated a positive relation between various morphometric characters and both TL and HL, displaying correlations that ranged from medium to high strength. On the other hand the fish showed constant meristic characters where there was no change in meristic counts with the increase of body length. The fin formula is derived as D 6–9; P 8–10; V 6–7; A 4–6; C 13–18. The findings demonstrated characteristic morphometric traits exclusive to *T. marmorata* in Manasbal Lake establishing crucial data for future investigations into the biological dynamics and conservation objectives pertaining to the fish.
Key words: Manasbal Lake, morphometric characters, meristic characters, *Triplophysa*, conservation, biological dynamics.

Introduction

The genus *Triplophysa* Rendahl, 1933 is a diversified group of fishes within the family Balitoridae, subfamily Nemacheilinae (Chen & Yang, 2005; Fricke et al., 2020) with almost 160 species. The genus is widely distributed in Western and Central Asian seas, interior drainages of Balochistan, Northwest to Western Mongolia, and from the Qinghai-Tibet Plateau to the Yunnan-Guizhou Plateau in China (Zhu, 1989; Wu & Wu, 1992; Prokofiev, 2017). This genus has been documented to exist in the upper Indus river drainages in Jammu and Kashmir as well as in the Lahul and Spiti parts of Himachal Pradesh (Scheimer, 1993) which are home to innumerable rivers and streams (Kullander et al., 1999). Heckel (1838) described two species of scaleless fishes of the family Balitoridae as *Cobitis marmorata* and *C. vittata* currently considered under names *Triplophysa marmorata* and *T. kashmirensis* (Kullander et al., 1999).

Triplophysa marmorata is a small fish with an elongated, scaleless body, two rostral and one maxillary set of barbels in its inferior mouth, and eyes high on the head. Brownish or greyish patches of varying widths are also dispersed along the dorsal surface, marking the sides and head. *Triplophysa* species are characterised by a caudal peduncle that is comparatively thin and "whiplike." These species display a notable sexual dimorphism: males have raised skin bearing tubercles on both sides of the head, a broad dorsal tuberculated pad, and wider pectoral-fin rays (Zhu, 1989). *Triplophysa* species typically range in length from 60 to 190 mm (Bashir et al., 2015; Mushtaq et al., 2015; Sheikh and Ahmad, 2019). *T. marmorata* is characterised by the presence of a shorter caudal peduncle and lateral line length.

Manasbal Lake is a freshwater lake located in Ganderbal district of the state of Jammu and Kashmir. It is located about 30 kms towards Northwest of Srinagar. It is situated at an altitude of 1583 m and covers an area of 2.81 km^2 (Lawrence, 1895; Raina, 1981). It is a warm subtropical monomictic marl lake (Hutchinson, 1957). The surroundings are predominantly rural comprising of villages of Kondabal, Jarokabal and Gratabal.

Morphometric and meristic characteristics offer a quantitative description for fish identification and are regarded as dynamic features that are frequently employed to quantify the differences between populations of the same fish species (Cadrin, 2000; Doherty & McCarthy, 2004). In fact, a variety of ecological variables, such as temperature, radiation, dissolved oxygen, water depth, and water velocity, regulate the morphological differences across fish populations (Turan, 1999). Not only are morphometric characters and meristic counts crucial for comprehending taxonomy, but variations in their characteristics are likely associated with the habitat of the variants in other species (Turan et al., 2004; Randall & Pyle, 2008). Hence this study was carried out in order to establish baseline information on the morphological parameters of *Triplophysa marmorata* from Manasbal Lake, Kashmir.

Material and Methods

A total of 360 fish samples were randomly collected from commercial catches in various sites of Manasbal Lake. Using conventional techniques, the morphometric characteristics of these fish samples were recorded in the laboratory in a fresh condition (Lagler et al., 1962; Laevastu, 1965). Total length (TL), standard length (SL), pre pectoral length (PPL),

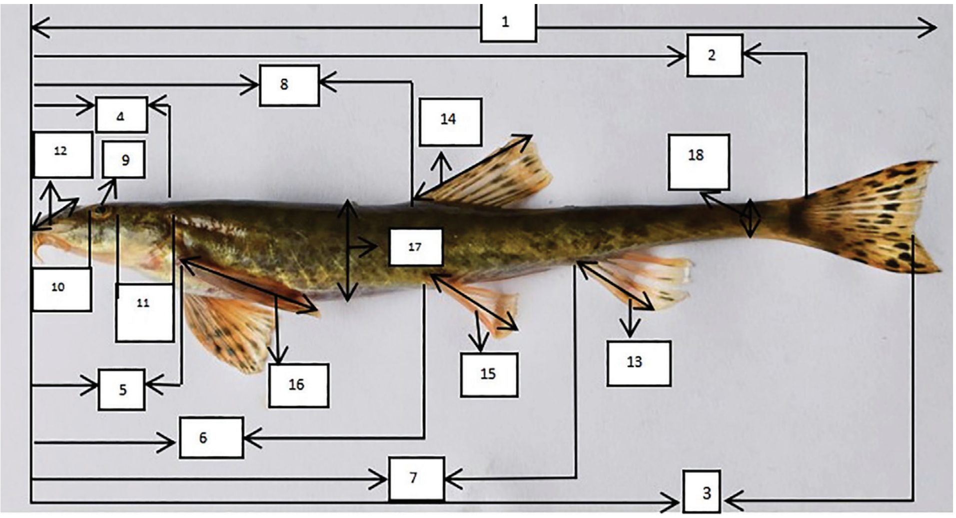

Fig 1. Morphometric measurements of *Triplophysa marmorata* from Manasbal Lake, Kashmir, India: 1 — total length; 2 — standard length; 3 — fork length; 4 — head length; 5 — pre pectoral length; 6 — pre pelvic length; 7 — pre anal length; 8— pre dorsal length; 9— eye diameter; 10 — pre orbital length; 11 — post orbital length; 12 — snout length; 13 — anal fin length,14 — dorsal fin length; 15 — pelvic fin length; 16 — pectoral fin length; 17 — body depth; 18 — caudal peduncle length.

pre dorsal length (PDL), head length (HL), snout length (SNL), eye diameter (ED), post orbital length (POL), inter orbital length (IOL), caudal fin length (CFL), pre anal length (PAL), and caudal peduncle depth (CPD) were the morphometric traits measured. Using the least squares method, linear regressions were carried out for the contrasted features (Scenedor & Cochran, 1967). The number of rays in the anal (AFR), caudal fin (CFR), ventral (PVR), dorsal (DFR) and pectoral (PFR) fins were counted for meristic features. The meristic analysis was conducted using descriptive statistics.

Results

Throughout the study, a total of 18 morphometric characters and 5 meristic counts were studied. Correlation coefficient and regression equations were calculated for all variables, except for pre orbital length, post orbital length, snout length and eye diameter in relation to the total length of the fish. However, pre orbital length, post orbital length, snout length and eye diameter showed correlation with head length of the fish. Among the parameters studied in relation to total length, standard length and fork length showed the highest correlations at 0.988 and 0.980 respectively (table 1). However meristic counts such as dorsal fin ray, anal fin ray, pelvic fin ray, pectoral fin ray and caudal fin ray showed notable difference (table 2). The correlation analysis highlights a consistent proportional adjustment in all morphometric characteristics with increasing total length. However, all meristic counts showed significant difference among each other. This observation suggests that meristic counts are dependent on the body size of fish.

Table 1. Morphometric characters of *Triplophysa marmorata*

No	In the percentage of total fish Length	Range	Range difference	Mean, mm	Correlation coefficient	Regression equation
1	standard length	25.24–146.98	121.74	79.86	0.988	y = 0.824x + 2.5067
2	fork length	22.26–162	139.97	88.59	0.980	y = 0.9865x –4.0216
3	pre anal length	18.65–89.56	70.91	60.24	0.942	y = 0.5997x +3.9392
4	pre dorsal length	16.89–68	51.11	41.97	0.955	y = 0.4113x + 3.3725
5	pre pectoral length	4.26–34	29.74	19.32	0.904	y = 0.1872x + 1.7363
6	pre pelvic length	19.26–75.33	56.07	45.37	0.796	y = 0.393x + 8.4787
7	body depth	4.85–32.56	27.71	15.86	0.818	y = 0.1934x – 2.2857
8	head length	4.99–38	33.01	18.31	0.799	y= 0.2173x – 2.0802
9	caudal peduncle length	1.32–25	23.68	7.36	0.734	y = 0.0979x – 1.8171
10	dorsal fin length	3.25–26.35	23.1	14.10	0.888	y = 0.1416x + 0.8078
11	pelvic fin length	3.9–24	20.1	11.77	0.871	y = 0.123x + 0.2321
12	anal fin length	2–25.36	23.36	10.76	0.729	y = 0.1106x + 0.3879
13	caudal fin length	6.01–22.57	16.56	14.79	0.809	y = 0.1048x + 4.9601
14	pectoral fin length	4–25	21	13.27	0.876	y = 0.1453x – 0.3574
15	eye diameter	1–5.86	4.86	3.51	0.670	y = 0.1173x + 1.3649
	Percent with respect to head length					
16	snout length	1.89–22	20.11	8.79	0.914	y = 0.6969x – 3.9603
17	pre orbital length	2.01–26.63	24.62	12.13	0.738	y = 0.1589x – 2.7648
18	post orbital length	2.86–24	21.14	9.74	0.899	y = 0.1182x –1.3443

Table 2. Meristic characters of *Triplophysa marmorata*

Meristic characters	Range
Dorsal fin ray	6–9
Anal fin ray	4–6
Caudal fin ray	13–18
pectoral fin ray	8–10
pelvic fin ray	6–7

Note. Fin formula = D. 6–9, P. 8–10, V. 6–7, A. 4–6, C. 13–18.

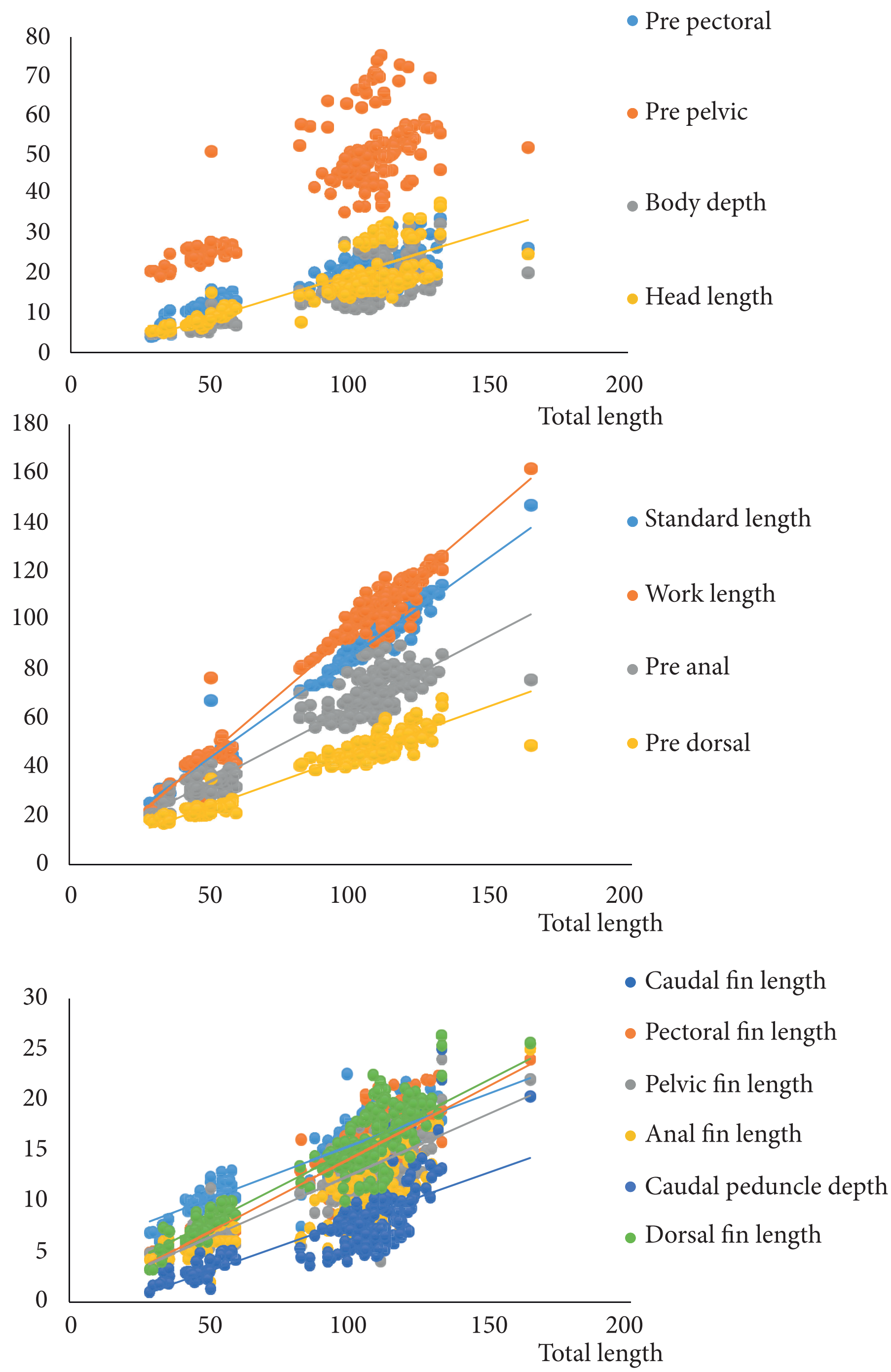

Fig. 2. Relationship of total length with standard length (SL), fork length (FL), pre anal length (PrAL), pre dorsal length (PrDL), pre pelvic length (PrVL), body depth (BD), head length (HL), caudal fin length (CFL), pectoral fin length (PFL) and pelvic fin length (PVL).

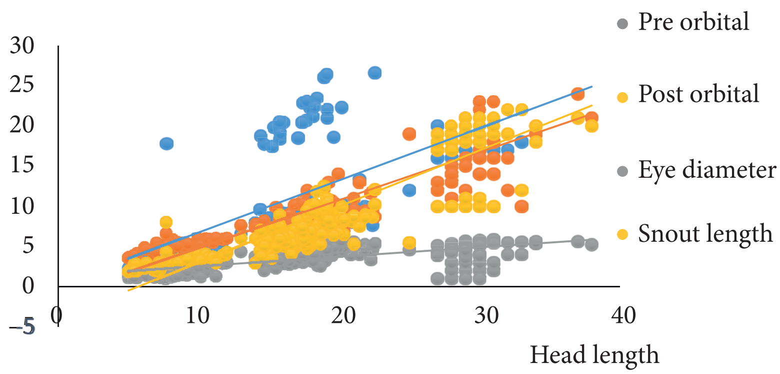

Fig. 3. Relationship of head length with pre orbital length (PrOL), post orbital length (POL), snout length (SL) and eye diameter (ED).

Fig. 4. Lateral, dorsal and ventral views of *Triplophysa marmorata* from Manasbal Lake, Kashmir, India.

Fig. 5. Dorsal and ventral views of the head of *Triplophysa marmorata* from Manasbal Lake, Kashmir, India.

Discussion

Morphometric and meristic characters of the fishes are a conventional method for identification of sex, race, species, hence possesses wide taxonomic importance (Mekkawy, 1987, 1994; Mahmoud, 1988, 1991, 1993; Harabawy, 1993, 2000; Khalil et al., 1983, 1984; Oliveira & Almada, 1995; Osman, 2000; Mekkawy & Mohammad, 2011; Abbas et al., 2013; Safi et al., 2014). Morphometric studies play a key role in developmental patterns of fishes, habitat conditions, health of the fish , development stages , sexual category, size, maintenance (Jisr et al., 2020; Khatun et al., 2021). These characters have been widely used in stock identification and are known to have a lot of significance in fisheries science (Turan, 1999). They have proven to be the simplest and easiest method of species identification. Determination of various parameters in fisheries is highly dependent on morphometric and meristic characters. The growth rate of the fish is analyzed by measuring some parts of the morphological structure of fish. Meristic characters are the numerical counts on the fish used in order to determine the species and class of the fish (Soliman et al., 2018).

The fish in this study has been utilised to measure various morphometric characteristics, expressed as percentages of the total fish length and head length. It has been observed that certain morphometric traits, such as standard length, fork length, pre-dorsal length, and pectoral length as a percentage of total fish length, exhibit notably high correlation coefficients. This suggests a strong direct proportionality among these traits. Conversely, characters like body depth, dorsal fin length, pelvic fin length, caudal fin length, and pectoral fin length as a percentage of total fish length demonstrate moderate correlation coefficients. Lastly, traits such as pre-pelvic length, head length, caudal peduncle length, and anal fin length as a percentage of total length display the least correlation coefficients among the measured morphometric characteristics (table 1). Linear relationships were identified among all independent and dependent characters, as depicted in figure 2. Specifically, four morphometric traits expressed as a percentage of head length were assessed for correlation coefficients. The analysis revealed that post-orbital length and snout length exhibited a moderate correlation coefficient, whereas eye diameter and pre-orbital length displayed the least correlation coefficient, as detailed in table 1. Notably, a linear relationship was observed among these parameters.

Fish are highly responsive to environmental shifts, swiftly adjusting their morphological characteristics as needed for adaptation. It is widely recognised that morphological traits exhibit significant plasticity in response to variations in environmental factors like food availability and temperature (Allendorf & Phelps, 1988; Swain et al., 1991; Wimberger, 1992). Fish phenotypic variations can lead to fixed traits, or traits that change more slowly than the environment (Scheiner, 1993), which result from adaptation in response to natural selection or other evolutionary forces, or they can lead to phenotypic plasticity, or the ability to respond plastically to changing environments (Prince et al., 2003). In the latter case, populations of fish that belong to the same species or different species may exhibit morphological and genetic differences that reflect the environmental conditions of the rivers they inhabit (Bower et al., 2021; Kirk et al., 2022). In the current study, it was noted that thirteen characters exhibited genetic control, while four fell within an intermediate category, and one character was observed to be influenced primarily by environmental factors when expressed as a percentage of total length. Across the spectrum of head length percentages, all observed characteristics were found to be under genetic control. The phenotypic plasticity of fish is notably robust, enabling rapid adaptation through physiological and behavioural adjustments in response to environmental shifts. These adaptations ultimately lead to modifications in their morphology. Generally, fish exhibit greater variability in morphological traits within and among populations compared to other vertebrates. They also display a higher susceptibility to environmentally induced changes in morphology (Stearns, 1983; Allendorf et al., 1987; Wimberger, 1992). Among *Gadusia chapra* from the Gobind Sagar population, it was determined that 13 morphological traits in relation to total length are under genetic control (Tandon et al., 1993). In *Tor putitora* (Hamilton, 1822) from Gobind Sagar reservoir in Himachal Pradesh, it was found that 13 morphological traits relative to total length, are genetically controlled. Additionally, a study reported that among 22 morphometric characters in *Tor putitora* from Pong dam reservoir in Himachal Pradesh, 12 were found to be genetically controlled while 5 showed influences from environmental factors (Johal et al., 1994). In *Tor putitora* sampled from the foothill section of the Ganges, 12 morphological traits in relation to total length were identified as genetically controlled, two fell into an intermediate category, and only one character was determined to be environmentally influenced. Additionally, concerning head length, three characters were categorised as intermediate while two were found to be environmentally controlled (Bhatt et al., 1998). In another study, among the 18 measured characters in *Tor putitora* from Pong Dam reservoir in Himachal Pradesh, it was observed that 11 characters were genetically controlled, 5 exhibited intermediate characteristics, and 2 were determined to be environmentally influenced (Johal et al., 2003).

This suggests that the surrounding area remains relatively undisturbed from an environmental point of view. Additionally, a notably high correlation coefficient was observed concerning total length. The characters like standard length, fork length, pre dorsal length and pre pectoral length in relation to total fish length shows high value of correlation coefficient. Dube & Dubey (1987) reported a strong correlation between total length and head length, snout length, height of caudal peduncle, minimum body girth, and maximum body girth within a *Tor tor* (Hamilton, 1822) population from the Narmada River. Conversely, they found a weaker correlation between total length and eye diameter as well as the length of the caudal peduncle. Nautiyal et al. (1998) demonstrated that postdorsal distance exhibited the most significant correlation among variables studied, whereas Johal et al. (1994) identified standard length as the most correlated body part within the *Tor putitora* population from Gobindsagar. Bhatt et al. (1998) noted the eye diameter as the least correlated variable, which aligns with findings from the current study. Additionally, Johal et al. (2003) demonstrated that nearly all the characters displayed a high degree of correlation coefficient.

Variations in meristic characters have been documented in several fish species, including *Nematalosa nasus* (Bloch, 1795) (Al Hassan, 1987), *Pseudobagrus ichikawai* Okada & Kubota, 1957 (Watanabe, 1998), and *Pterophyllum scalare* (Schultze, 1823) (Bibi Koshy et al., 2008). Variation in meristic traits in fish is mainly expected as a consequence of the current temperature increase and of changes in other environmental parameters such as salinity and dissolved oxygen (Barlow, 1961). In the current research, it was observed that meristic counts are correlated with body size, exhibiting changes as body length increases. Jayaram (2010) reported on *Tariqilabeo latius* (Hamilton, 1822) (as "*Crossocheilus latius* (Hamilton-Buchanan)") found in the Gangetic watershed of the Himalayas, as well as in other regions across India and reported lateral line scales to be 37–39 from those areas. In the current investigation, it has been observed that meristic counts are influenced by body size, displaying alterations as body length increases. Hubbs (1992) and Taning (1944) noted variations in the number of rays in unpaired fins across several species, often attributed to adaptations to varying water densities and movement. Sfakianakis et al. (2011) explored meristic variation related to temperature, while Yousefian (2011) reported that genetic factors affecting meristic counts. Additionally, Hazarika et al. (2011) reported that meristic characters remained consistent despite increases in body length and weight.

In conclusion, our knowledge of this specific species from this area has grown as a result of our research, which has highlighted its special characteristics. The taxonomy of fish and conservation initiatives pertaining to the lake's ecology may benefit greatly from this work. Understanding the morphometric and meristic characteristics can help with accurate species identification and categorization, improving conservation efforts and provide information for the region's sustainable fishing sector.

References

Al Hassan, L. A. J. 1987. Variations in meristic characters of *Nematalosa nasus* from Iraqi and Kuwaiti waters. *Japanese Journal of Ichthyology*, **33** (4), 422. https://doi.org/10.1007/BF02904109

Allendorf, F. W. & Phelps, S. R. 1988. Loss of genetic variation in hatchery stock of cut throat trout. *Transactions of the American Fisheries Society*, 109, 537–543. https://doi.org/10.1577/1548-8659

Allendorf, F. W., Ryman, N. & Utter, F. 1987. *Genetics and fishery management: past, present and future in population genetics and fisheries management*. University of Washington press, Seattle, WA & London, 1–20.

Barlow, G. W. 1961. Causes and significance of morphological variation in fishes. *Systematic Zoology*, 10, 105–117.

Bashir, A., Bisht, B. S. & Singh, R. 2015. Morphometric and Meristic Characteristics of *Triplophysa marmorata* (Heckel, 1838) from Kashmir Valley, India. *World Journal of Fish and Marine Science*, **7** (1), 01–04.

Bhatt, J. P., Nautiyal, P. & Singh, H. R. 1998. Racial structure of Himalayan mahseer, *Tor putitora* (Ham.) in the river Ganga between Rishikesh and Hardwar. *Indian Journal of Animal Sciences*, 68, 587–590.

Bibi Koshy, E., Oyyan, Selvaraj & Sekaran, M. 2008. Variation in meristic characters of four strains of Malaysian freshwater angelfish *Pterophyllum scalare* (L.). *Malaysian Journal of Science*, **27** (1), 69–73.

Bower, L. M. , Saenz, D. E. & Winemiller, K. O. 2021. Widespread convergence in stream fishes. *Biological Journal of the Linnean Society*, 133, 863–879.

Cadrin, S. X. 2000. Advances in morphometric identification of fishery stocks. *Review of Fish Biology and Fishery*, **10** (1), 91–112. https://doi.org/10.1023/A:1008939104413

Chen, X. Y. & Yang, J. X. 2005. *Triplophysa rosa* sp. nov.; a new blind loach from China. *Journal of Fishery Biology*, 66, 599–608. https://doi.org/10.1111/j.0022-1112.2005.00622.x

Dube, K. & Dubey, G. P. 1987. Biometric studies of Indian mahseer *Tor tor* (Ham.) from Narmada River. *Matsya*, 12–13, 126–132.

Harabawy, A. S. A. 1993. *Biological, Biometric and Electrophoretic Studies on two Bagarid Fishes Bagrus bayad (Forskal, 1775) and Bagrus docmac (Forskal, 1775) from the Nile at Assiut*. M. Sc. Thesis, Assiut University, Egypt.

Hazarika, A., Baroh, U. & Lily, B. 2011. Studies on morphometric measurements and meristic counts of Hill Trout (Barilius bendelisis, Hamilton) from river Buroi at the boundary areas of Assam and Arunachal Pradesh, India, *Indian Journal of Fundamental and Applied Life Sciences*, 3, 194–198.

Heckel, J. J. 1838. *Fischeaus Cashmirgesammelt und herausgegeben von Carl Freiherrn v. Hügel*. Mechitaristen, Wien, 110, 13 pls.

Hutchinson, G. E. 1957. *A treatise on limnology. Geography, physics, and chemistry. Volume 1*. John Wiley and Sons, New York.

Jayaram, K. C. 1981. *The freshwater fishes of India, Pakistan, Bangladesh, Burma, Sri Lanka: A handbook*. (Calcutta): Zoological Survey of India, 475.

Johal, M. S., Negi, R. K. & Negi, T. 2003. Age and growth of golden mahseer *Tor putitora* from Pong reservoir, Himachal Pradesh, India. *Himalayan Journal of Environment and Zoology*, **17** (1), 17–29.

Johal, M. S., Tandon, K. K. & Sandhu, G. S. 1994. Mahseer in Lacustrine Waters, Gobindsagar Reservoir. Morphometry of *Tor putitora*. *In*: Nautiyal, P., ed. *Mahseer the Game Fish*. Jagdamba, Prakashan Publisher, Srinagar, Garhwal, 67–85.

Khalil, A., Yoakim, E. G., & MEKKAWY, L. 1983. Biometric studies on the nile charcoid fish *Alestes baremose* from assiut. *Assiut Veterinary Medical Journal*, **11** (21), 52–59.

Khalil, A., Yoakim, E. G. & Mahmoud, U. M. 1984. Biometric and meristic studies on the Nile cyprinoid fish, *Labeo niloticus*, from Lake Nasser. *Assiut Veterinary Medical Journal*, **12** (24), 7l–78. https://doi.org/10.21608/avmj.1984.191092

Kirk, M. A., Rahel, F. J. & Laughlin, D. C. 2022. Environmental filters of freshwater fish community assembly along elevation and latitudinal gradients. *Glob. Ecol. Biogeogr*, 31, 470–485.

Kullander, S. O., Fang, F., Delling, B. & Ahlander, E. 1999. The fishes of the Kashmir Valley. *In*: Nyman, L., ed. *River Jhelum, Kashmir Valley, Impact on the aquatic environment*.

Lawrence, S. W. R. 1895. *Kashmir Gazetteer, History of Kashmir Valley (II)*, 189– 190.

Mahmoud, U. M. 1988. *Taxonomic studies on some Nile Siluriform fishes*. Ph.D. Thesis, Assiut University, Egypt.

Mahmoud, U. M. 1991. Bivariate and multivariate size allometry and sexual dimorphism of *Labeo horie* and *Labeo forskalii* from the Nile at Assiut, Egypt. *Bulletin of the Faculty of Science, Assiut University, Egypt*, 20 (2–E), 39–58.

Mahmoud, U. M. 1993. On morphometrics and allometry of *Bagrus bayad* (Forsskal, 1775) and *Bagrus docmac* (Forsskal, 1775) from the Nile Egypt. *Assiut Veterinary Medical Journal*, **28** (56), 44–70. https://doi.org/10.21608/avmj.1993.186372

Mekkawy, I. A. A. 1995. Description of *Oreochromis ismailiaensis* sp. n., and its hybrid with *Oreochromis niloticus* (Linnaeus, 1758) (Perciformes; Cichlidae) from Egypt**.** *Bulletin of the Faculty of Science, Assiut University, Egypt*, **24** (2–E), 1–27.

Mekkawy, I. A. A. & Mohammad, A. S. 2011. Morphometrics and Meristics of the three Epinepheline Species: *Cephalopholis argus* (Bloch And Schneider, 1801), *Cephalopholis miniata* (Forsskal, 1775) and *Variola louti* (Forsskal, 1775) from the Red Sea. *Egypt. Journ. Biological Sciences*, **11** (1), 10–21. https://doi.org/10.3923/jbs.2011.10.21

Mekkawy, I. A. A. 1987. *Taxonomic studies on some Nile Mormyriform fishes*. Ph.D. Thesis, Assiut University, Egypt.

Nautiyal, P., Bhatt, J. P., Rawat, V. S., Kishor, B., Nautiyal, R. & Singh, H. R. 1998. Himalayan Mahseer: magnitude of commercial fishery in Garhwal hills. *NATCON Publication, Muzaffarnagar*, 5, 107–114.

Oliveira, R. F. & Almada, V. C. 1995. Sexual dimorphism and allometry of external morphology in *Oreochromis mossambicus*. *Journal of Fish Biology*, 46, 1055–1064. https://doi.org/10.1111/j.1095-8649.1995.tb01409.x

Osman, A. G. M. 2000. *Taxonomical and Biological studies of some species of genus Epinephelus (Family: Serranidae) from the Red Sea, Egypt*. M. Sc. Thesis, AlAzhar Univ., Cairo.

Prokofiev, A. M. 2017. *Loaches of the subfamily Nemacheilinae of the World*. Filigran, Yaroslavl, 1–315.

Raina, R. 1981. *Plankton Dynamics and Hydrobiology of Bod-Sar lake of Kashmir*. Ph.D. thesis, Kashmir University.

Rendahl, H. 1933. "Stüdien über Innerasiatische Fische", *Arkiv Zool.* 25, Ser. A (11), 1–51.

Scheiner, S. M. 1993. Genetics and evolution of phenotypic plasticity. *Annual Review of Ecology, Evolution, and Systematics*, 24, 35–68.

Sfakianakis, D. G., Leris, I., Laggis, A. & Kentouri, M. 2011. The effect of rearing temperature on body shape and meristic characters in zebrafish (*Danio rerio*) juveniles. *Environmental Biology of Fishes*, **92** (2), 197–205. https://doi.org/10.1007/s10641-011-9833-z

Soliman, F. M., Mehanna, S. F., Soliman, H. A. & Baker, T. S. 2018. Meristic and morphometric characteristics of five-lined snapper, *Lutjanus quinquelineatus* (Bloch, 1790) from the Red Sea, Egypt. *Egyptian Journal of Aquatic Biology & Fisheries*, **22** (1), 41–48. https://doi.org/10.21608/ejabf.2018.7723

Swain, D. P., Ridell, B. E. & Murray, C. B. 1991. Morphological differences between hatchery and wild populations of coho salmon (*Oncorhynchus kisutch*): environmental versus genetic origin. *Canadian Journal of Fisheries and Aquatic Sciences*, 48, 1783–1791. https://doi.org/10.1139/f91-210

Tandon, K. K., Johal, M. S. & Bala, S. 1993. Morphometry of *Cirrhinus reba* (Ham.) from Kanjli wetland, Punjab India. *Research Bulletin of the Panjab University,* Science, **43** (1–4), 73–79.

Taning, A. V. 1944. *Experiments on Meristic and Other Characters in Fishes: On the Influence of Temperature on Some Meristic Characters in Sea-trout and the Fixation-period of these Characters*. CA Reitzels Forlag.

Turan, C. 1999. A Note on The Examination of Morphometric Differentiation Among Fish Populations: The Truss System. *Turkish Journal of Zoology*, 23.

Turan, C., Ergüden, D., Gürlek, M., Başusta, N. & Turan, F. 2004. Morphometric structuring of the anchovy (*Engraulis encrasicolus* L.) in the Black, Aegean and Northeastern Mediterranean Seas. *Turkish Journal of Veterinary & Animal Sciences*, **28** (5), 865–871.

Watanabe, K. 1998. Meristic variation in the endangered bagrid catfish, *Pseudobagrus ichikawai*. *Ichthyological Research*, **45** (1), 99–104. https://doi.org/10.1007/BF02678581

Wimberger, P. H. 1992. Plasticity of fish body shape the effects of diet, development, family and age in two species of Geophagus (Pisces, Cichlidae). *Biological Journal of the Linnean Society*, 45, 197–218. https://doi.org/10.1111/j.1095-8312.1992.tb00640.x

Wu, Y. F. & Wu, C. Z. 1992. *The Fishes of the Qinghai Xizang Plateau. Sichuan Publ*. House of Sci. and Tech nol., Chengdu.

Yousefian, M., Sharifrohani, M., Hosseinzadeh-Sahafi, H., Laloei, F. & Makhdoomi, C. 2011. Heritability estimation for growth-related traits in juvenile wild common carp (*Cyprinus carpio* L.) in the south of Caspian Sea. *Iranian Journal of Fisheries Sciences*, **10** (4), 740–748.

Zhu, S. Q. 1989. *The Loaches of the Subfamily Nemacheilinae in China (Cypriniformes: Cobitidae)*. Jiangsu Science and Technology Publishing House, Nanjing.

Received 27 April 2024
Accepted 16 October 2024