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Technical note

Length–weight relationships of 14 Indian freshwater fish species from the Betwa (Yamuna River tributary) and Gomti (Ganga River tributary) rivers

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Summary

The length-weight relationships (LWRs) were studied of 588 fish covering eight families, 13 genera and 14 species (*Notopterus notopterus*, *Gudusia chapra*, *Labeo calbasu*, *Puntius sarana*, *Cirrhinus mrigala*, *Ompok bimaculatus*, *Mystus tengara, Mystus cavasius*, *Sperata aor*, *Sperata seenghala, Eutropiichthys vacha*, *Wallago attu, Rhinomugil corsula*, and *Mastacembelus armatus*) captured in the Betwa River (tributary of the Yamuna River) and Gomti River (tributary of the Ganga River) from December 2007 to January 2009. The b values varied between 2.4 (*M. armatus*) and 3.52 (*P. sarana*), with the mean $b = 2.96$ at $P < 0.001$ for all species. The observations are significant for conservation and management because the Betwa River has been approved under India's first interlinking plan with the Ken River, and no length-weight data had thus far been reported for the Gomti River. The objective was to evaluate the LWRs of these two unstudied rivers for fisheries management.

Introduction

Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indexes (Anderson and Gutreuter, 1983; Ecoutin and Albaret, 2003). Biomass has been used as an indirect estimate of production (Geisler et al., 1979) and is a prerequisite for calculating production using the Ricker algebraic method (Watson and Balon, 1984). Biomass is often estimated from length–weight regressions because direct weight measurements can be time-consuming in the field. Length–weight relationships (LWRs), condition factors (K), growth, recruitment, and mortality of fishes are important tools for the study of fishery biology, mainly when the species are at the base of the higher food web. Establishment of a relationship between weight and length is essential for the calculation of production and biomass of a fish population (Anderson and Gutreuter, 1983; Safran, 1992; Petrakis and Stergiou, 1995; Dulcic and Kraljevic, 1996; Moutopoulos and Stergiou, 2002), allowing also for morphological comparisons among species or among populations of the same species from different habitats and / or regions (Moutopoulos and Stergiou, 2002). L–W is frequently used to follow seasonal variations in fish growth and to estimate condition indexes (Anderson and Gutreuter, 1983; Safran, 1992; Richter et al., 2000).

Regression data are available for most European and North American freshwater fishes, but are lacking for most tropical fish (Zaret, 1980; Kilambi, 1986; De Silva, 1991). Our study estimates L–W relationships of 14 species in eight families (Notopteridae, Clupidae, Cyprinidae, Bagridae, Siluridae, Schilbeidae, Mugilidae and Mastacembelidae) having economic and conservation values. Of the 14 species studied, three are listed in the category of endangered (EN) and three as vulnerable (VU) in India (Lakra and Sarkar, 2006).

The Betwa River is a tributary to the Yamuna River fall within the Bundelkhand region of central India (77°15′, 79°45′N; 23°5′, 25°55′E) and harbours many endangered fish species, including mahseer (*Tor tor*). The Betwa River at 475 m above mean sea level originates in the Raisen district, Madhya Pradesh, and joins the Yamuna River near Hamirpur in Uttar Pradesh, a distance of about 590 km and draining a total area of about 43 319 m^2. The topography and elevation (700–300 m above mean sea level) offer variable land use from flat, open wheat- and grain-growing areas to steep forest-covered hills (Pandey et al., 2008). Overall habitation in the Betwa River has been altered by dams, barriers, and urban agglomeration. Upstream, Betwa is highly fragmented into small pools due to reduced flow and water scarcity. The plan to interlink this river with the Ken River has been approved by the Government of India (NWDA, 2005). The Betwa River supports a rich freshwater biodiversity and contributes to the food and nutritional security of the local people. However, fish diversity in the river is highly threatened and as many as seven species have been listed in the endangered category (Lakra and Sarkar, 2006).

The Gomti River originates in a natural reservoir of the forested area (elevation ca. 200 m; 28°34′N; 80°07′E) near the town of Pilibhit, Uttar Pradesh, about 50 km south of the Himalayan foothills (Singh et al., 2004). The river flows through the central and eastern part of Uttar Pradesh, traversing about 730 km. The Gomti, although supporting a rich biodiversity and offering livelihood and nutritional security, has been less-studied from a biology, ecology and conservation point of view. The fish fauna of the river is also known to be highly threatened as a result of sewage pollution, extensive habitat alteration and the recent proliferation of exotic fish species. No information was available on the length–weight relationships of fishes, except for studies on biodiversity (Sarkar et al., 2009a).

Our observation has significance for conservation and management as one of the rivers (the Betwa) has been approved under India's first interlinking plan, and because thus far no length–weight data for the Gomti River has been reported. Of the 14 species described here, no previous reports were available from these two rivers; however, the LWR information of five species was available for some other

waterbodies (Froese and Pauly, 2007). In view of the above, our study constitutes the first information on LWRs in the Betwa and Gomti rivers.

Materials and methods

The fishes were captured from December 2007 to January 2009. Samples were collected from five sites in each of both rivers, and selected in upstream, midstream, and downstream areas to cover all representative habitats. The ichthyofauna was sampled using various fishing gear such as drag nets (100×20, 1/2''), cast nets (9', 1''; 9', 1/2''), gillnets (75×1.3 m, 2''; 50×1 m, 3''; 30×1 m, 2.5'') and mosquito nets. After collection, specimens were preserved in 10% formalin solution, identified according to Jayaram (1981) and Talwar and Jhingran (1991), then measured. Total length (TL) of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin nearest 0.1-mm by digital caliper (Mitutiyo) and weighed to the nearest 0.01 g (total weight) by digital weighing machine (ACCULAB Sartorious Group).

Some species were far more abundant than others, thus the sample size varied accordingly. A minimum of 13 individuals was considered acceptable for analysis, but varied up to n = 96 for *O. bimaculatus* (Table 1). The LWR was estimated by using the equation $W = aL^b$ (Ricker, 1973).

All data were log-transformed and the ensuing least squares linear regressions (Zar, 1984) performed by Graphpad Prism 5, with the weight as the dependent variable following the well-known length–weight relationship $Log\ W = Log\ a + b\ Log\ L$ (Beckman, 1948). Linear regressions on log-transformed data were highly significant ($P < 0{\cdot}001$) for all species studied (Table 1).

Results

Overall, 588 specimens of 14 fish species belonging to eight families were sampled: *Notopterus notopterus* (Pallas, 1769), *Gudusia chapra* (Hamilton, 1822), *Labeo calbasu* (Hamilton, 1822), *Puntius sarana* (Hamilton, 1822), *Cirrhinus mrigala* (Bloch, 1795), *Ompok bimaculatus* (Bloch, 1794), *Mystus tengara* (Hamilton, 1822), *Mystus cavasius* (Hamilton, 1822), *Sperata aor* (Hamilton, 1822), *Sperata seenghala* (Sykes, 1839), *Eutropiichthys vacha* (Hamilton, 1822), *Wallago attu* (Bloch and schneider, 1801), *Rhinomugil corsula* (Hamilton, 1822), and *Mastacembelus armatus* (Lacépède, 1800). Sample size, minimum and maximum length and maximum reported length (Froese and Pauly, 2007) for each species as well as LWR, coefficient of determination (r^2), slope regression (b), 95% confidence range for *b*, antilog of *a* (intercept of regression) with antilog of 95% confidence range (i) are presented in Table 1. The calculated linear regression indicates significant differences between the slopes (ii) of the L-W relationship among species. These differences may be attributed to availability of food as well as changes in the maturity stage (Weatherly and Gill, 1987).

In our study values of *b* varied from 2.4 for *M. armatus* (Baam), to 3.52 for *P. sarana* (Putti) in the Betwa River and 2.6 for *W. attu* to 3.5 for *C. mrigala* in the Gomti River. The mean value of *b* for all species was 2.95 in the Betwa and 2.99 in the Gomti. The coefficient of determination (r^2) for Betwa River ranged from 0.95 (*G. chapra, N. notopterus, G. chapra* and *R. corsula*) to 0.98 for *P. sarana*, with a median value of 0.96; five out of a total of nine regressions presented r^2 values higher than 0.95, where as in River Gomti the value of r^2 ranged from 0.97 (*W. attu, E. vacha, C. mrigala*) to 0.99 for *S. seenghala*, with a median value of 0.98; in this river all eight species presented r^2 values higher then 0.95. All linear regressions were highly and statistically significant ($P < 0.001$). According to Hile (1936) and Martin (1949) the value of '*b*' usually remains constant at 3.0 for an ideal fish. However, Beverton and Holt (1957) suggested that the departure of the '*b*' value from three is rare in adult fishes. In the present study most of the fishes showed deviations from the ideal value. For the Betwa River the value of $b = 2.40$ and 2.91 for *M. cavasius* and *M armatus,* respectively,

Table 1
Descriptive statistics and estimated parameters of length-weight relationships ($W = aL^b$) for 14 fish species, Betwa and Gomti rivers, Uttar Pradesh, India

Family	Species	Total length (cm)			Max. known length (cm)	Regression parameters		95% CL of *a*	95% CL of *b*	r^2
		n	Min	Max		10^a	b			
Notopteridae	*Notopterus notopterus* (B)	45	7.3	29	60.0	0.0176	2.99	−2.3 to −1.8	3.9–2.80	0.95
	Notopterus notopterus (G)	41	5.7	27.6	60.0	0.0089	2.95	−2.21 to −1.89	2.81–3.08	0.98
Clupeidae	*Gudusia chapra* (B)	30	8.5	15	20.0	0.0079	2.98	−2.40 to −1.8	2.69–3.27	0.95
Cyprinidae	*Labeo calbasu* (B)	30	12.5	37	90.0	0.010	2.94	−2.3 to −1.63	2.75–3.13	0.95
	Puntius sarana (B)	30	7.5	21	42.0	0.0081	3.18	−2.31 to −1.88	2.99–3.38	0.98
	Cirrhinus mrigala (G)	22	18.0	31.6	100.0	0.0019	3.52	−3.12 to −2.27	3.21–3.83	0.97
Siluridae	*Ompok bimaculatus* (B)	30	13.5	29	45.0	0.0039	3.12	−2.81 to −2.01	2.82–3.43	0.96
	Ompok bimaculatus (G)	90	7.1	25.2	45.0	0.0059	3.08	−2.43 to −2.22	2.99–3.17	0.98
	Wallago attu (G)	13	10.5	78.0	240.0	0.0250	2.56	−2.05 to −1.17	2.26–2.85	0.97
Bagridae	*Sperata aor* (B)	30	12.4	45	180.0	0.0059	2.98	−2.55 to −1.90	2.76–3.20	0.97
	Sperata aor (G)	28	9.8	48.0	180.0	0.0043	3.02	−2.64 to −2.11	2.83–3.20	0.98
	Sperata seenghala	19	13.5	85.0	150.0	0.0062	2.97	−2.48 to −1.93	2.78–3.15	0.99
	Mystus cavasius (B)	30	7	27.4	40.0	0.0120	2.91	−2.22 to −1.6	2.65–3.17	0.96
Schilbeidae	*Eutropiichthys vacha* (G)	23	8.4	21.5	40.2	0.0138	2.73	−2.08 to −1.63	2.52–2.93	0.97
	Clupisoma garua (G)	48	5.4	36.6	60.9	0.0056	3.10	−2.37 to −2.12	2.99–3.21	0.98
Mugilidae	*Rhinomugil corsula* (B)	50	6.5	34	45.0	0.0109	2.94	−2.22 to 1.7	2.75–3.13	0.95
Mastacembelidae	*Mastacembelus armatus* (B)	29	12.4	45.1	90.0	0.0288	2.40	−1.9 to −1.2	2.17–2.62	0.97

B, Betwa River; G, Gomti River; n, total no. samples; Min & Max, minimum and maximum; a, intercept; 10^a, anti log of a; b, slope; r^2, coefficient of determination.

showing that the rate of increase in body length is not proportional to the rate of increase in body weight when compared with the mean exponent $b = 2.95$, while values of b for *N. notopterus* (2.99), *P. sarana* (3.18), *G. chapra* (2.98) and *O. bimaculatus* (3.12) are higher when compared with the mean exponent $b = 2.94$. In the Gomti River, *W. attu* (2.56), *E. vacha* (2.73) and *N. notopterus* (2.95) showed less value of b when compared with the mean b value (2.99) whereas *O. bimaculatus* (3.08), *C. garua* (3.10), *S. aor* (3.02) and *C. mrigala* (3.52) were found to be higher when compared with the same.

Discussion

Most of the estimates for b values obtained in the present work conform with those of earlier researchers, e.g. Ahmed and Saha (1996) in Kapati Lake, Bangladesh; Parameswaran and Sinha (1966) and Sarkar et al. (2009b) in the Ganga basin; Ramakrishniah (1988) in Nagarjunasagar reservoir, India; and Pet et al. (1996) in Sri Lankan reservoirs. Out of 14 species, information on length–weight relationships was available for five species in the FishBase database (Froese and Pauly, 2007). The length–weight relationship of *N. notopterus* was reported by Parameswaran and Sinha (1966) from some ponds and wild tanks of Orissa, and the values of regression coefficients (2.97) were similar and close to the calculated values (2.99 and 2.95) from the Betwa and Gomti rivers, respectively. The value of the regression coefficient for *C. mrigala* was 3.53 in the Gomti River. Such a high value of regression coefficient with a b value of 3.05 was also reported by Khan (1972). The same trend of regression coefficient was also found for two other Cyprinidae: *L. calbasu* (2.94) and *P. sarana* (3.18) from the Betwa River when they were compared with the data of Ahmed and Saha (1996) and Pet et al. (1996). The value of regression coefficient for *O. bimaculatus* (3.12 for Betwa and 3.08 for Gomti) was higher in comparison with previous work by Sivakami (1987) from the Bhavanisagar reservoir in Tamil Nadu. In the family Bagridae the regression coefficient of *S. aor* in both rivers showed near to an equal value, as reported by Ramakrishniah (1988) from Nagarjunasagar reservoir. On the contrary, for *M. armatus* the slope regression (b) was quite a bit lower, as reported by Narejo et al. (2003) from Mymensingh, Bangladesh. The literature indicated that no data was available for such fishes as *E. vacha,* S. *seenghala, M. cavasius, C. garua* or *R. corsula*. By comparing the species common to both rivers, the values of b in *N. notopterus, S. aor* and *O. bimaculatus* were observed to be very close together. Species having the 'standard' cyprinid body shape or 'heavy body' show near-similar values of b and growth patterns, such as *C. mgigala*, *P. sarana* and *L. calbasu*. Species that are compressed laterally show few differences in growth pattern trends, as observed in *M. armatus, M. cavasius, G. chapra* and *N. notopterus***.** Our observation also indicated, except for *G. chapra*, a declining trend of maximum growth of the fishes in the two rivers as compared to the known maximum length (Table 1), for which the riverine health ecosystem might be the causative factor.

Differences in b values can be attributed to the combination of one or more factors: (i) number of specimens examined; (ii) area / seasonal effect; (iii) habitat; (iv) degree of stomach fullness; (v) gonadal maturity; (vi) sex; (vii) health and general fish condition; (viii) preservation technique; and (ix) differences in the observed length ranges of the specimens caught (Tesch, 1971; Wooten, 1998), all of which were not accounted for in the present study. All regressions were highly significant ($P < 0.001$) with the coefficient of determination (r^2 ranging from 0.95 to 0.99). The LWR results obtained could well be considered when fish populations are subject to fishing regulation, recovery programmes, or other fisheries management activities in the respective rivers.

In conclusion, our study has provided the first basic and baseline information on the length–weight relationships of 14 indigenous fishes from the Betwa and Gomti rivers that would be beneficial for fishery biologists and conservationists to impose adequate regulations for sustainable fishery management and conservation for both rivers as well as for other rivers of the Yamuna and Ganga basins in India.

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References

Ahmed, K. K.; Saha, S. B., 1996: Length–weight relationships of major carps in Kapati Lake, Bangladesh. Naga ICLARM Q. **19,** 22.

Anderson, R.; Gutreuter, S., 1983: Length, weight and associated structural indices. In: Fisheries Techniques. L. Nielsen, D. Johnson (eds). American Fish Soc., Bethesda, MD, pp. 283–300.

Beckman, W. C., 1948: The length-weight relationship, factors for conversion between standard and total lengths, and coefficients of condition for seven Michigan fishes. Trans. Am. Fish. Soc. **75,** 237–256.

Beverton, R. J. H.; Holt, S. J., 1957: On the dynamics of exploited fish population. Fish. Invest. Series 11 **19,** 533.

De Silva, K. H. G. M., 1991: Population dynamics and production of the rocky stream-dwelling fish *Garra ceylonensis* (Cyprinidae) in Sri Lanka. J. Trop. Ecol. **7,** 289–303.

Dulcic, J.; Kraljevic, M., 1996: Weight-length relationships for 40 fish species in the eastern Adriatic (Croatian waters). Fish. Res. **28,** 243–251.

Ecoutin, J. M.; Albaret, J. J., 2003: Length-weight relationship of 52 fish species from West African estuaries and lagoons. Cybium **27,** 3–9.

Froese, R.; Pauly, D. (eds), 2007: FishBase. World wide web electronic publication, http://www.fishbase.org, version.

Geisler, R..; Schmidt, G. W.; Sookvibul, S., 1979: Diversity and biomass of fishes in three typical streams of Thailand. Internat. Revue Gesamte Hydrobiol. **64,** 673–697.

Hile, R., 1936: Age and growth of the *Cisco Leucichthys artedi* (Lesueur) in the lake of Northeastern highlands Wisconsin. Bull. U. S. Bureau Fish. **48,** 311–317.

Jayaram, K. C., 1981: The freshwater fishes of the indian region. Narendera Publ. House, New Delhi. 551 P.

Khan, R. A., 1972: Studies on the biology of some important major carps. Thesis, Dept. Zool., Aligarh Muslim Univ., Aligarh. 185 p.

Kilambi, R. V., 1986: Age, growth and reproductive strategy of the snakehead, *Ophiocephalus striatus* Bloch, from Sri Lanka. J. Fish Biol. **29,** 13–22.

Lakra, W. S.; Sarkar, U. K., 2006: Freshwater fish diversity of central india. National Bureau of Fish Genetic Resources, Lucknow. 200 p.

Martin, W. R., 1949: The mechanics of environmental control of body form in fishes. University of Toronto Studies in Biological Series 58. Ontario Fish. Res. Lab. **70,** 1–72.

Moutopoulos, D. K.; Stergiou, K. I., 2002: Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). J. Appl. Ichthyol. **18,** 200–203.

Narejo, N. T.; Rahmatullah, S. M.; Mamnur Rashid, M., 2003: Length-weight relationship and relative condition factor (Kn) of

freshwater spiny eel, *Mastacembelus armatus* (Lacepede) from Mymensingh, Bangladesh. Indian J. Fish. **50,** 81–87.
NWDA (National Water Development Agency): 2005 / Tech.III / 122 / 17 / 2005.V.http: / / http://www.nwda.gov.in.
Pandey, R. P.; Mishra, S. K.; Singh, R.; Ramasastri, K. S., 2008: Stream flow drought severity analysis of Betwa River system (India). Water Resour. Manage. **22,** 1127–1141.
Parameswaran, S.; Sinha, M., 1966: Observation on the biology of the featherback, *Notoptyerus notopterus* (Pallas). Indian J. Fish. **13,** 232–250.
Petrakis, G.; Stergiou, K. I., 1995: Weight-length relationships for 33 fish species in Greek waters. Fish. Res. **21,** 465–469.
Pet, J. S.; Gever, G. J. M.; Van Desen, W. L. T.; Vijverberg, J., 1996: Management options for a more complete utilization of the biological fish production in Sri Lankan reservoirs. Ecol. Freshwat. Fish. **5,** 1–14.
Ramakrishniah, M., 1988: Age, growth and fishery of *Mystus aor* (Hamilton) from Nagarjuasagar reservoir. In: The first indian fisheries forum proceedings, M. Mohan Joshep (Ed.). Asian Fisheries Society, India Branch, Mangalore, pp. 185–198.
Richter, H. C.; Luckstadt, C.; Focker, U.; Becker, K., 2000: An improve to access fish condition on the basis of length weight relationship. Arch. Fish. Mar. Res. **48,** 255–264.
Ricker, W. E., 1973: Linear regressions in fisheries research. J. Fish. Res. Board Can. **30,** 409–434.
Safran, P., 1992: Theoretical analysis of the weight-length relationships in fish juveniles. Mar. Biol. **112,** 545–551.
Sarkar, U. K.; Gupta, B. K.; Lakra, W. S., 2009a: Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of River Gomti, a tributary of River Ganga (India). Environmentalist. DOI: 10.1007/s10669-009-9237-1.
Sarkar, U. K.; Deepak, P. K.; Negi, R. S., 2009b: Length–weight relationship of clown knifefish *Chitala chitala* (Hamilton 1822) from the River Ganga basin, India. J. Appl. Ichthyol. **25,** 232–233.
Singh, K. P.; Malik, A.; Mohan, D.; Sinha, S., 2004: Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India) – a case study. Water Res. **38,** 3980–3992.
Sivakami, S., 1987: Length–weight relationship and relative condition factor in *Ompok Bimaculatus* (Bloch) from Bhavanisagar reservoir (Tamil Nadu). Indian J. Fish. **34,** 202–207.
Talwar, P. K.; Jhingran, A. G., 1991: Inland fishes of india and adjacent countries. Oxford and IBH Publishing Co, New Delhi.
Tesch, F. W., 1971: Age and growth. In: Methods for assessment of fish production in fresh waters, W. E. Ricker (ed.). Blackwell Scientific Publications, Oxford, pp. 98–130.
Watson, D. J.; Balon, E. K., 1984: Structure and production of fish communities in tropical rain forest streams of northern Borneo. Can. J. Zool. **62,** 927–940.
Weatherly, A. H.; Gill, H. S., 1987: The biology of fish growth. Academic Press, San Diego, CA.
Wooten, R. J., 1998: Ecology of teleost fishes. Kluwer Academic Publishers, Dordrecht, The Netherlands.
Zar, J. H., 1984: Biostatistical analysis. Prentice Hall, New Jersey. 718 P.
Zaret, T. M., 1980: Life history and growth relationships of *Cichla ocellaris*, a predatory South American cichlid. Biotropica **12,** 144–157.

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