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Technical contribution

Length–weight relationships (LWRs) of 12 Indian freshwater fish species from an un-impacted tropical river of Central India (River Ken)

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Summary

The length–weight relationships (LWRs) were studied of 441 fish individuals covering six families, eight genera and 12 freshwater species (*L. dyochilus, L. calbasu, L. gonius, L. fimbriatus, P. sarana, L. boggut, C. mrigala, W. attu, B. bagarius, E. vacha, N. notopterus* and *S. aor*) captured in the River Ken (tributary of the Yamuna River) from December 2007 to January 2009. The b value ranged from 3.52 for *Cirrihinus mrigala*, to 2.11 for *Labeo gonius*, with a mean of 3.03 at $p < 0.001$ for all species. The present observations are significant for conservation and management because the Ken River has been approved under India's first interlinking plan with the River Betwa. The objective was to evaluate the LWRs of the freshwater fish species of an unimpacted and understudied river, which serves as a baseline for comparison to other relatively altered tropical Indian rivers.

Introduction

Length–weight relationships have been used extensively for the conversion of growth-in-length equations to growth-in-weight for use in stock assessment models to estimate the stock assessment biomass from a limited sample size as indicators of fish condition, to compare the life histories of certain species among regions and other aspects of fish population dynamics (Binohlan and Pauly, 1998; Moutopoulos and Stergiou, 2002). In addition, the data on length and weight can also provide important clues to climate and environmental changes, and change in fishery practices. Thus a change in size over a certain period of time may show a change in average age as a result of these factors (Samat et al., 2008).

The aim of this work was to produce LWRs for the fish species living in the relatively unimpacted tropical River Ken, to enable predictions on the effect of future morphodynamics changes (in the post-interlinking phases) and also to serve as baseline for other, relatively altered tropical rivers. Of the 12 species studied, three are listed in India in the category of endangered (EN) and three as vulnerable (VU) (Lakra and Sarkar, 2006).

Materials and methods

Twelve fish species were collected from the River Ken, which is one of the important tributaries of the River Yamuna (a tributary of the River Ganga) and one of the least polluted rivers in India. (http://panna.nic.in/tiger.htm) that has been identified as India's first interlinking project with the River Betwa (National Water Development Agency, 2004). The interlinking project of the Ken-Betwa link involves building a dam on the Ken River and diverting the water to the Betwa by crossing several rivers/streams. The total length of the river from its origin to the confluence with the River Yamuna is 427 km, of which 292 km lies in Madhya Pradesh, 84 km in Uttar Pradesh, and 51 km that forms a common boundary between Uttar Pradesh and Madhya Pradesh. The river basin lies between lat. 23°12′N, 25°54′N and long. 78°30′E, 80°36′E. Protected areas on the upper stretch and forest cover on the mid-stretch of the river tend to have a positive impact on its aquatic habitat. A review of the literature shows a complete lack of information on the biodiversity and biology of the freshwater fishes of this river. Of the 12 species described here, no previous reports on the length weight relationship were available; however, LWR information for five species was available for some other waterbodies (Froese and Pauly, 2010).

The fishes were captured from December 2007 to January 2009. Samples were collected from five sites selected upstream, midstream, and downstream to cover all representative habitats. Gear included cast nets (5–9 m radius, mesh size 1–5 cm), gill nets (length 30–75 m, mesh size 1–4 cm), drag nets (with varying mesh sizes) and mosquito nets. After collection, specimens were preserved in 10% formalin solution, identified according to Jayaram (1981) and Talwar and Jhingran (1991), and 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 sizes varied accordingly. 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 length–weight relationship $\log W = \log a + b \log L$ (Beckman, 1948). Linear regressions on log-transformed data were highly significant ($P < 0.001$) for all 12 species studied (Table 1).

Results

Totals of 441 specimens belonging to 12 fish species (Table 1) corresponding to six families were used for calculation of length-weight relationships. Cyprinidae (58.3%) was the most abundant family and *Labeo boggut* the dominant species. Sample size, minimum and maximum reported length (Froese and Pauly, 2010) for each species as well as LWR, coefficient of

Table 1
Descriptive statistics and estimated parameters of length–weight relationships ($w = aL^b$) for 12 fish species, River Ken, India

Family	Species	Total length (cm)			Regression parameters					
		n	Min	Max	Max. known length (cm)	10^a	b	95% CL of a	95% CL of b	r^2
Notopteridae	*Notopterus notopterus* (Pallas, 1769)*	28	13	35.5	60.0	0.0012	3.32	−2.81 to −2.01	2.81–3.43	0.96
Cyprinidae	*Labeo boggut* (Sykes, 1838)*	73	10.0	25.2	29.0	0.0083	3.05	−2.25 to −1.91	2.91–3.19	0.96
	Labeo calbasu (Hamilton-Buchanan, 1822)	26	11.4	44.5	90.0	0.0380	2.67	−1.62 to −1.23	2.53–3.82	0.98
	Labeo dyochilus (McClelland, 1839)	29	16.8	39.0	90.0	0.0026	3.41	−2.29 to −2.24	3.17–3.64	0.97
	Labeo gonius (Hamilton–Buchanan, 1822)	42	12.4	38.0	150.0	0.0165	2.11	−1.27 to −0.06	1.39–2.29	0.97
	Labeo fimbriatus (Bloch, 1795)	44	15.6	23.0	91.0	0.0030	3.21	−2.74 to −2.28	3.03–3.38	0.97
	Puntius sarana (Hamilton–Buchanan, 1822)	38	6.50	24.5	42.0	0.0071	3.17	−2.21 to −1.88	2.79–3.88	0.98
	Cirrihinus mrigala (Hamilton–Buchanan, 1822)	26	17.5	36.2	100.0	0.0019	3.52	−3.12 to−2.24	3.11–3.54	0.97
Siluridae	*Walago attu** (Schneider 1801)	31	13.5	80.0	240.0	0.0074	3.05	−2.42 to−1.84	2.87–3.24	0.97
Bagridae	*Sperata aor (Hamilton–Buchanan, 1822)*	32	19.5	80.0	180.0	0.0029	3.12	−2.75 to−2.16	2.93– 3.31	0.97
Sisoridae	*Bagarius bagarius* (Hamilton–Buchanan, 1822)*	26	9.80	42.0	200.0	0.0093	2.81	−2.30 to −1.77	2.62–3.01	0.97
Schilbeidae	*Eutropiichtys vacha (Hamilton–Buchanan, 1822)*	46	5.50	38.2	40.2	0.0112	2.93	−2.16 to −1.74	2.76–3.10	0.96

* Samples with mostly juveniles included; n, total no. samples; Min & Max, minimum and maximum.
a, intercept; 10^a, anti log of a.
b, slope; r^2, coefficient of determination.

determination (r^2), slope regression (b), 95% confidence range for b, antilog of a intercept of regression with antilog of 95% confidence range is presented in Table 1. The calculated linear regression showed significant differences in the slopes of the LWRs among species. These differences may be attributed to availability of food as well as to changes in the maturity stage (Weatherly and Gill, 1987).

In this study, the values of the slope b ranged from 3.52 for *C. mrigala*, to 2.11 for *L. gonius*. Eight species showed positive allometric growth ($b > 3$): *L. dyochilus, L. fimbriatus, L. boggut, P. sarana, C. mrigala, W. attu, N. notopterus,* and *S. aor*; however, the data obtained mainly covered juveniles (see Table 1 for known maximum size of the respective species), therefore higher b values can be expected. Four species, *L. calbasu, Labeo gonius, B. bagarius,* and *E. vacha* showed negative allometric growth ($b < 3$). The coefficient of determination (r^2) ranged from 0.96 (*Notopterus notopterus, Labeo boggut* and *Eutropiichtys vacha*) to 0.98 (*P. sarana* and *Labeo calbasu*), with a median value of 0.96; nine of a total 12 regressions presented r^2 values higher than 0.96. All linear regressions were statistically significant ($P < 0.001$).

Discussion

A b value close to 3 shows that the fish grow isometrically and other values show allometric growth (Andreu-Soler et al., 2005). Most of the estimates for b values obtained in the present work show a similar trend with those of Sani et al. (2010) in tributaries of the Yamuna and Ganga, by Sarkar et al. (2009) in Ganga basin, Pet et al. (1996) in Sri Lankan reservoirs, Ahmed and Saha (1996) in Kapati Lake, Bangladesh, and by Sivakami (1987) and Ramakrishniah (1988) in the Nagarjunasagar reservoirs. However, in the present study, the high b value for some species may be due to the dominance of juveniles and an incomplete coverage of the known size range. Of the 12 species studied, no length weight relationship data is available for five of the species, whereas some information is available in Fish Base (Froese and Pauly, 2010) for the remaining seven species. The values of regression coefficient for *N. notopterus* (3.32) was higher in comparison with studies of Sani et al. (2010) from tributaries of the Yamuna and Ganga, and in another study reported by Parameswaran and Sinha (1966) from ponds of Orissa. The higher values of regression coefficient (3.05 to 3.52) for the Cyprinidae species are similar to those obtained in studies by Khan (1972), Ahmed and Saha (1996), Pet et al. (1996), Sarkar et al. (2009) and Sani et al. (2010). For catfishes such as *B. bagarius* and *W. attu,* there is no published source of information on their LWRs; the information presented here is new for the sub-region. Our observations also indicate a declining trend of maximum growth in River Ken fishes as compared to the known maximum lengths (Table 1), for which the riverine health ecosystem might be the causative factor.

In conclusion, as our collections were made from a river with minimum disturbances, these can therefore be considered as a reference for other studies. The present study must serve as a basis of comparison for the central and north Indian region, as other tropical rivers of the Yamuna basin have almost all been subjected to perturbations of various origins.

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