

LENGTH–WEIGHT RELATIONS OF 24 FISH SPECIES (ACTINOPTERYGII) FROM HIRAKUD RESERVOIR, ODISHA STATE OF INDIA

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Abstract. Length–weight relations were estimated for 24 fish species sampled from the Hirakud Reservoir (Odisha State, India): *Salmostoma bacaila* (Hamilton, 1822); *Salmostoma phulo* (Hamilton, 1822); *Labeo rohita* (Hamilton, 1822); *Labeo bata* (Hamilton, 1822); *Cirrhinus reba* (Hamilton, 1822); *Labeo calbasu* (Hamilton, 1822); *Puntius sophore* (Hamilton, 1822); *Puntius chola* (Hamilton, 1822); *Pethia ticto* (Hamilton, 1822); *Systomus sarana* (Hamilton, 1822); *Pethia phutunio* (Hamilton, 1822); *Osteobrama cotio* (Hamilton, 1822); *Amblypharyngodon mola* (Hamilton, 1822); *Rasbora rasbora* (Hamilton, 1822); *Parambassis ranga* (Hamilton, 1822); *Parambassis lala* (Hamilton, 1822); *Channa punctata* (Bloch, 1793); *Macrornathus pancalus* (Hamilton, 1822); *Notopterus notopterus* (Pallas, 1769); *Chanda nama* (Hamilton, 1822); *Xenentodon cancila* (Hamilton, 1822); *Glossogobius giuris* (Hamilton, 1822); *Ompok bimaculatus* (Bloch, 1794); *Gudusia chapra* (Hamilton, 1822). They represented 10 families: Cyprinidae (14 species), Ambassidae (2 species), Channidae, Mastacembelidae, Notopteridae, Centropomidae, Belonidae, Gobiidae, Siluridae, and Clupeidae (1 species each). The *b* values ranged from 2.62 to 3.44. Nine of the species displayed isometric growth ($b = 3$), seven species negative allometric growth ($b < 3$), and eight species represented positive allometric growth ($b > 3$). New maximum lengths are provided for two species.

Keywords: Length–weight relations, Hirakud reservoir, Cyprinidae, Ambassidae, Channidae

In fish biology, length and weight are two basic morphological traits at the individual as well as at the population level. The weight of fishes is closely related to their length and it determines whether somatic growth was isometric or allometric (Le Cren 1951, Froese 2006, Froese et al. 2011). Length–weight relation (LWR) has been used widely for fisheries management and conservation. It provides information on the condition factor and somatic growth type (isometric or allometric) of fish species (Le Cren 1951, Froese 2006, Froese et al. 2011) and therefore it is used for the determination of the biomass, enabling the conversion of length to weight. This relation has also been used in life history studies (Petrakis and Stergiou 1995, Froese 2006, Froese et al. 2011), for comparison of species growth between sexes, different seasons, and regions (Froese 2006, Moutopoulos et al. 2013) as well as an index of habitat trophic state (Tsoumani et al. 2006, Moutopoulos et al. 2011).

From the last decade, there has been an increasing interest in the scientific literature regarding fish length–weight relations (Froese et al. 2011). Up to now, from

33 500 fish species reported in FishBase, LWRs of 4793 species (14.3% of species) is available from this database (Froese and Pauly 2017).

Hirakud (Dam) Reservoir (21°30'–21°50'N, 83°30'–84°05'E) is the first major multi-purpose river valley project in India. Country's largest (in area) man-made reservoir (or Lake), the Hirakud (25.8 km long) is situated on the Mahanadi River of Odisha State has a surface area of 743 km².

In the presently reported study, LWR parameters have been estimated for 24 fish species sampled from the Hirakud Reservoir, representing the following families: Cyprinidae (14 species), Ambassidae (2 species), Channidae, Mastacembelidae, Notopteridae, Centropomidae, Belonidae, Gobiidae, Siluridae, and Clupeidae (1 species each) (Table 1). For these species, information about LWRs is limited. For one species, namely *Osteobrama cotio* (Hamilton, 1822), there is no records of LWRs, while for thirteen species there are one to three records, for six species three to six records, and for three species seven to ten LWR records in FishBase

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(Froese and Pauly 2017; 13 Aug 2017), respectively. The relevant FishBase data come from freshwater bodies of the Indian subcontinent, Indonesia, China, Taiwan, and South Africa. Regarding the conservation status, 22 species were ranked in the IUCN Red List of Threatened Species (Anonymous 2017) as least concern (LC) and two—*Parambassis lala* (Hamilton, 1822) and *Ompok bimaculatus* (Bloch, 1794)—as near threatened (NT) (Table 1).

Fish samples were collected during June–July 2015 (monsoon), November–December 2015 (post-monsoon), and February 2016 (pre-monsoon). The samples were collected by fishermen using the most common fishing gears in the Hirakud reservoir i.e., cast nets, gill nets, stake nets with long lines, and shore seines. After collection, the specimens were brought to the research laboratory in polythene bags. The fish species were confirmed by following Day (1876), Talwar and Jhingran (1991), and Jayaram (1999) and measured for total length (L) to the nearest 0.01 cm with a digital calliper and weight (W ; wet weight) to the nearest 0.01 g with digital balance.

Length–weight relations were estimated using the equation:

$$W = aL^b$$

where a and b are the equation parameters calculated by the least squares method using the logarithmic form of the equation:

$$\text{Log } W = \log a + b \cdot \log L$$

The statistical significance level of the coefficient of determination (r^2) and 95% confidence intervals (95%CI) of a and b were also estimated (Zar 1999). Obvious outliers were identified and removed, according to the plot of the $\log W$ over $\log L$ (Froese 2006). The b value of each species was tested by Student's t -test (Zar 1999) to verify if it was significantly different from isometric growth ($b = 3, P < 0.05$) (Froese et al. 2011).

A total of 2626 fish individuals were measured. The species name, sample size (n), L and W ranges, intercept a , slope b , 95% confidence intervals of a and b , P values of b and coefficient of determination (r^2) are summarized in Table 2. The length and weight data were pooled together for each species without sampling site and sex discrimination. The sample size ranged from 6 individuals

Table 1

List of fish species sampled from Hirakud Reservoir, Odisha State, India

Family	Species	Common name	FishBase	Countries	IUCN
Cyprinidae	<i>Salmostoma bacaila</i> (Hamilton, 1822)	Large razorbelly minnow	1	BD	LC
	<i>Salmostoma phulo</i> (Hamilton, 1822)	Finescale razorbelly minnow	1	BD	LC
	<i>Labeo rohita</i> (Hamilton, 1822)	Roho labeo	7	IN, PH, BD	LC
	<i>Labeo bata</i> (Hamilton, 1822)	Bata	1	BD	LC
	<i>Cirrhinus reba</i> (Hamilton, 1822)	Reba carp	3	BD	LC
	<i>Labeo calbasu</i> (Hamilton, 1822)	Orangefin labeo	4	IN, BD	LC
	<i>Puntius sophore</i> (Hamilton, 1822)	Pool barb	5	IN, BD	LC
	<i>Puntius chola</i> (Hamilton, 1822)	Swamp barb	3	LK, IN	LC
	<i>Pethia ticto</i> (Hamilton, 1822)	Ticto Barb	5	BD, IN	LC
	<i>Systemus sarana</i> (Hamilton, 1822)	Olive barb	3	LK, IN	LC
	<i>Pethia phutunio</i> (Hamilton, 1822)	Spottedsail barb	1	IN	LC
	<i>Osteobrama cotio</i> (Hamilton, 1822)		0		LC
	<i>Amblypharyngodon mola</i> (Hamilton, 1822)	Mola carplet	4	BD, IN	LC
	<i>Rasbora rasbora</i> (Hamilton, 1822)	Gangetic scissortail rasbora	1	IN	LC
Ambassidae	<i>Parambassis ranga</i> (Hamilton, 1822)	Indian glassy fish	1	BD	LC
	<i>Parambassis lala</i> (Hamilton, 1822)	Highfin glassy perchlet	2	BD, IN	NT
Channidae	<i>Channa punctata</i> (Bloch, 1793)	Spotted snakehead	10	BD, IN	LC
Mastacembelidae	<i>Macroglyptus pancalus</i> (Hamilton, 1822)	Barred spiny eel	1	BD	LC
Notopteridae	<i>Notopterus notopterus</i> (Pallas, 1769)	Bronze featherback	7	IN, TW, PK	LC
Centropomidae	<i>Chanda nama</i> (Hamilton, 1822)	Elongate glass-perchlet	1	BD	LC
Belonidae	<i>Xenentodon cancila</i> (Hamilton, 1822)	Freshwater garfish	1	TH	LC
Gobiidae	<i>Glossogobius giuris</i> (Hamilton, 1822)	Tank goby	7	CN, PH, ID, BD, ZA	LC
Siluridae	<i>Ompok bimaculatus</i> (Bloch, 1794)	Butter catfish	4	IN	NT
Clupeidae	<i>Gudusia chapra</i> (Hamilton, 1822)	Indian river shad	4	BD, IN	LC

FishBase = LWR record in FishBase (Froese and Pauly 2017; 13 Aug 2017); BD = Bangladesh, IN = India, PH = Philippines, LK = Sri Lanka, TW = Taiwan, TH = Thailand, PK = Pakistan, CN = China, ID = Indonesia, ZA = South Africa; IUCN = IUCN Conservation Status: CR = critically endangered, EN = endangered, LC = least concern, NT = near threatened.

Table 2
Estimated parameters of the length–weight relations for 24 fish species from Hirakud reservoir, Odisha State, India

Species	<i>n</i>	<i>L</i> range	<i>W</i> range	<i>a</i> ($\times 10^{-2}$)	95% CI of <i>a</i> ($\times 10^{-2}$)	<i>b</i>	95% CI of <i>b</i>	<i>r</i> ²	Growth	<i>t</i> -test
<i>Salmostoma bacaila</i>	73	3.10–14.70	0.19–21.40	0.816	0.708–0.940	2.835	2.767–2.903	0.990	–	4.84
<i>Salmostoma phulo</i>	204	3.20–9.30	0.24–7.50	0.608	0.528–0.698	3.032	2.950–3.113	0.964	=	0.78
<i>Labeo rohita</i>	26	7.00–43.50	1.03–918.00	0.478	0.099–2.285	3.271	2.754–3.788	0.877	=	1.08
<i>Labeo bata</i>	45	5.50–23.90	1.40–135.86	0.744	0.638–0.865	3.093	3.034–3.151	0.994	+	3.22
<i>Cirrhinus reba</i>	72	4.05–20.70	0.66–93.60	0.786	0.686–0.900	3.052	2.988–3.115	0.993	=	1.64
<i>Labeo calbasu</i>	52	4.40–36.80	1.00–664.70	1.163	1.024–1.319	3.013	2.968–3.057	0.993	=	0.58
<i>Puntius sophore</i>	301	2.50–10.80	0.20–21.08	1.001	0.911–1.098	3.201	3.151–3.249	0.982	+	8.04
<i>Puntius chola</i>	14	6.30–11.20	3.32–21.26	0.913	0.590–1.411	3.225	3.019–3.430	0.990	+	2.39
<i>Pethia ticto</i>	40	3.60–6.10	0.70–3.70	1.359	0.895–2.062	3.066	2.794–3.337	0.932	=	0.49
<i>Systemus sarana</i>	21	12.30–23.10	25.50–235.00	0.662	0.436–1.003	3.294	3.142–3.444	0.991	+	4.07
<i>Pethia phutunio</i>	96	1.90–3.70	0.13–0.78	2.398	2.083–2.761	2.623	2.484–2.761	0.937	–	5.40
<i>Osteobrama coito</i>	81	3.40–11.20	0.30–15.30	0.562	0.474–0.665	3.265	3.173–3.355	0.985	+	5.80
<i>Amblypharyngodon mola</i>	305	2.50–7.20	0.20–3.39	1.306	1.165–1.463	2.821	2.741–2.900	0.942	–	4.45
<i>Rasbora rasbora</i>	6	4.00–4.80	0.60–1.11	0.511	0.388–0.673	3.438	3.251–3.625	0.941	+	6.50
<i>Parambassis ranga</i>	330	1.60–8.20	0.09–10.90	2.236	2.087–2.394	2.794	2.743–2.844	0.973	–	8.03
<i>Parambassis lala</i>	193	1.60–3.50	0.07–0.79	2.175	1.910–2.475	2.864	2.741–2.986	0.918	–	2.20
<i>Channa punctata</i>	30	3.00–19.20	0.30–78.80	1.176	1.006–1.374	2.985	2.917–3.051	0.993	=	0.47
<i>Macrognathus pancalus</i>	9	6.50–16.60	1.03–21.46	0.218	0.174–0.272	3.282	3.191–3.373	0.960	+	7.35
<i>Notopterus notopterus</i>	76	7.80–30.10	3.01–256.10	0.286	0.239–0.341	3.369	3.307–3.429	0.980	+	12.03
<i>Chanda nama</i>	443	1.60–10.10	0.05–10.03	1.223	1.135–1.318	2.858	2.806–2.909	0.980	–	5.40
<i>Xenentodon cancila</i>	10	12.10–18.60	3.47–15.26	0.125	0.034–0.453	3.180	2.711–3.647	0.960	=	0.88
<i>Glossogobius giuris</i>	129	2.30–22.50	0.09–106.06	1.059	0.978–1.145	2.914	2.871–2.956	0.980	–	4.01
<i>Ompok bimaculatus</i>	42	13.00–34.70	10.59–228.42	0.376	0.265–0.532	3.117	2.997–3.236	0.980	=	1.98
<i>Gudusia chapra</i>	28	2.80–11.60	0.20–14.47	0.895	0.762–1.050	3.039	2.955–3.122	0.990	=	0.96
Min	6			0.125		2.623		0.877		
Max	443			2.398		3.438		0.994		
Median	62			0.856		3.059		0.980		
Quartile 25%	27			0.524		2.876		0.947		
Quartile 75%	177			1.212		3.255		0.990		

Length–weight relations ($W = aL^b$, *W* in g and *L* in cm); *n* = sample size; *a* and *b* : parameters of the relation; 95% CI : confidence intervals (significance level 0.95) for the two parameters; *r*² : coefficient of determination (all *P* value of relation ≤ 0.001); *t*-test for isometry: “=” = isometric growth, “–” = negative allometric growth, “+” = positive allometric growth.

for *Rasbora rasbora* and 9 for *Macrornathus pancalus* to 330 for *Parambassis ranga* and 443 for *Chanda nama*.

All relations were statistically significant ($P < 0.001$), with high r^2 values ranging from 0.877 (*Labeo rohita*) to 0.994, with median value 0.980. For five species (*Labeo bata*, *Cirrhinus reba*, *Labeo calbasu*, *Systomus sarana*, and *Channa punctata*) the estimated r^2 were higher than 0.991.

The a values obtained ranged from 0.00125 (*Xenentodon cancila*) to 0.0239 (*Pethia phutunio*). The median value of a was 0.00856 while the 50% of central values (values included between the quartiles of 25% and 75%) ranged from 0.00524 to 0.01211. The values of b ranged from 2.623 for *P. phutunio* to 3.438 for *R. rasbora*. The median of b was 3.059 while the 50% of central values ranged from 2.876 to 3.255.

For the 14 species, the a and b values cited in FishBase (Froese and Pauly 2017) were on the 95% CI of a and b estimated in the presently reported study. For *Puntius chola*, *R. rasbora* and *Macrornathus pancalus* the b values cited in FishBase (Froese and Pauly 2017) were lower than the lowest of 95% CI of estimated b while for the *Cirrhinus reba* and *Amblypharyngodon mola* were higher than the upper limit of 95% CI of estimated b , respectively. A number of factors are known to influence the LWR in fish (i.e., habitat, growth phase, season, the degree of stomach fullness, gonad maturity, sex, size range, health, fish condition, and preservation techniques) (Froese 2006). In particular, for the three above-mentioned species, the b values could be considered overestimated due to that the small number of sample (14, 6, and 9 individuals, respectively) and to that they cover a narrow range of length (Froese 2006). In all cases, described b values correspond to the observed length ranges and so, extrapolation of these parameters to different length ranges or seasons should be handled with caution (Petrakis and Stergiou 1995).

Nine of the species displayed isometric growth ($b = 3$), seven species negative allometric growth ($b < 3$) and eight species positive allometric growth ($b > 3$). To the best of our knowledge, herein, new maximum lengths are presented for *P. phutunio* ($L_{\max} = 37$ mm) *R. rasbora* ($L_{\max} = 48$ mm).

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