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Length-weight relationships of eighteen species of freshwater fishes from Panchet Reservoir in Ganges basin, Jharkhand, India

K. M. SANDHYA [1, 3], GUNJAN KARNATAK[1], LIANTHUAMLUAIA [1], UTTAM KUMAR SARKAR[1], SUMAN KUMARI[1], P. MISHAL[1], VIKASH KUMAR[1], DEBABRATA PANDA[2], YOUSUF ALI[1] AND BABLU NASKAR[1]

[1]*ICAR - Central Inland Fisheries Research Institute, Barrackpore - 700 120, West Bengal, India*
[2]*ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar - 751 002, Odisha, India*
[3] *ICAR-Central Institute of Fisheries Technology, Willingdon Island, Kochi - 682 029, India*
e-mail: *sandhyafrm@gmail.com*

ABSTRACT

The present study describes the length-weight relationships (LWRs) of 18 fish species from a large tropical reservoir, Panchet, in the Damodar River basin, one of the main tributary of the largest river Ganga in India. A total of 2419 individuals represented by 18 species belonging to 9 families were sampled between November 2014 and June 2016. The *b* values ranged from 2.469 for *Trichogaster chuna* to 3.428 for *Ailia coila*. All the regressions were highly significant ($p<0.001$). The results revealed positive allometric growth for seven species ($b>3$, $p<0.05$), negative allometric growth for seven species ($b<3$, $p<0.05$) and isometric growth for four species ($b=3$, $p>0.05$). This study represents the first reference on the length-weight relationship of *Trichogaster chuna* from a reservoir ecosystem. This is the first report on LWRs of five fish species *viz*., *Puntius terio, Pethia conchonius, Sperata seenghala, Ailia coila* and *Trichogaster chuna* from an Indian reservoir. This study provides basic data for future stock assessment studies and management programmes from Panchet Reservoir as well as for complementing the comparisons of LWRs from other ecosystems.

Keywords: Growth, Length-weight relationships, Panchet, Reservoir, Stock assessment

Introduction

Length-weight relationship (LWRs) has extensively been used in fisheries research as this enables the conversion of weight of fishes when only their size is known; indicate the type of weight gain and helps formulating management programmes for exploitation of commercial species (Le Cren, 1951; Bolger and Connolly, 1989; Pinheiro and Fiscarelli, 2009). Moreover, this tool also facilitates morphometric comparison between species and populations and life history comparisons between regions (Weatherley and Gill, 1987; Petrakis and Stergeou, 1995; King, 1996; Goncalves *et al*., 1997). The LWR is also used to define a population, where fish length is measured and the predicted average weight is assigned to all fish in a given length group (Oscoz *et al*., 2005). This is faster and more convenient than weighing fish individually, especially when large numbers of live fishes are sampled. In fishery biology studies, LWRs are required for conversion of growth-in-length equations to growth-in-weight for using in stock assessment models and to estimate stock biomass from limited sample sizes (Basusta *et al*., 2013). It is frequently used to track seasonal changes in fish growth (Richter *et al*., 2000).

Most of the studies in Indian reservoirs are mainly restricted to ecological aspects and fisheries management strategies through fingerling stocking (Sarkar *et al*., 2018; Lianthuamluaia *et al*., 2019). LWR studies from tropical inland waters are reported mostly from rivers. Such studies are scarce from Indian reservoirs which form an important inland fisheries resource in the country (Hassan *et al*., 2017; Sarkar and Mishal, 2017). Present study describes the length-weight relationships of 18 fish species from a tropical large reservoir, Panchet in India comprising commercially important species as well as some of the small indigenous fishes. Only a few fish faunal studies have been reported from this reservoir; mostly limited to catch, fish diversity and LWRs of very few species (Sarkar and Banerjee, 2010; Sandhya *et al*., 2016, 2017, 2019; Suman *et al*., 2018). Information on the length-weight relationship of *Puntius terio, Pethia conchonius, Sperata seenghala, Ailia coila* and *Trichogaster chuna* from Indian reservoirs is lacking. Hence the results from this study will provide basic data which would be useful for stock assessment and fisheries management of the species studied as well as for comparisons of LWRs from other ecosystems.

Materials and methods

Panchet, a large tropical reservoir along the basin of the river Damodar, one of the main tributary of river Ganga, the largest river in India. Data were collected between November 2014 and June 2016 from Panchet Reservoir (23° 41' 04"N and 86° 44' 56"E), situated in Dhanbad District in Jharkhand. Fish samples were collected bimonthly using gillnets of mesh size ranging from 25-120 mm and seine nets of mesh size 10-20 mm from various landing sites including upstream, middle and downstream zones of the reservoir. Fishes were identified to the species level and total length was measured to the nearest 0.1 cm and weighed individually with an accuracy of 0.01 g. The length-weight relationship was derived using the equation $W = aL^b$ where W = weight of fish in g; L = length of fish in cm; 'a' and 'b' are intercept and slope of the regression line respectively (Ricker, 1973). The log-log plots of length and weight of all fishes were made before regression analysis and outliers were removed following the recommendations of Froese (2006). Values of *a* and *b* were estimated by regression analysis based on log values: log W = log a + b log L. Box-Whiskers plots were prepared to describe the distribution of *b* values. The degree of association between the variables was computed by the determination coefficient, r^2. The Student's t test was used to test whether the estimated *b* value was significantly different from the isometric value of 3 at 5% significance level ($p<0.05$) (Sokal and Rohlf, 1987). Comparison between the estimated values of *b* and respective critical values allowed the determination of statistical significance of *b* values and their inclusion in the isometric range (b=3) or allometric ranges, *i.e.*, positive allometric (b>3) or negative allometric (b<3).

Results

The sample size, minimum and maximum lengths and weights, parameters of length-weight relationships, standard error of *b* values, coefficient of determination (r^2) and growth type are shown in Table 1. Box-Whiskers plot showing distribution of *b* values is given in Fig. 1. A total of 2419 individuals represented by 18 species belonging to 9 families were sampled. The most diverse family was Cyprinidae with 6 species. The *b* values ranged from 2.469 for *Trichogaster chuna* to 3.428 for *Ailia coila*. The median value of *b* was 3.996 and 50% of *b* values ranged between 2.832 and 3.130 (Fig. 1). All regressions were highly significant ($p<0.001$) with the co-efficient of determination (r^2) ranging from 0.908 for *Parambassis lala* to 0.998 for *Oreochromis niloticus*. The coefficient of determination was greater than 0.95 for 17 species and the remaining one species had r^2 of the order of 0.90. The results revealed positive allometric growth for seven species (b>3, $p<0.05$), negative allometric growth for seven species (b<3, $p<0.05$) and isometric growth for four species (b=3, $p>0.05$).

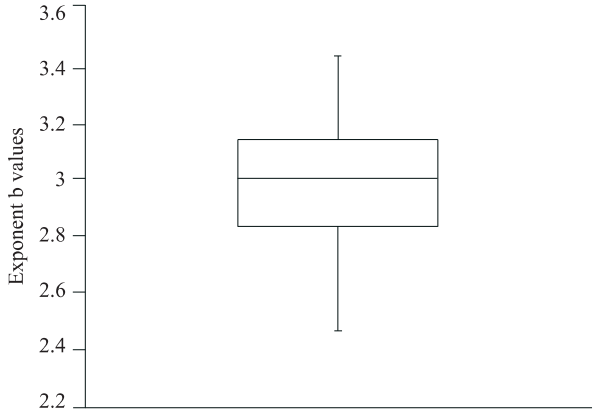

Fig. 1. Box-Whiskers plot of the exponent b values in the length-weight relationships of 18 species from Panchet Reservoir. Central box covers 50% of data values, the horizontal lines show the median values and vertical lines show the range of values

Discussion

This is the first report on the length-weight relationship of the species *Trichogaster chuna* from a reservoir ecosystem. The findings from this study also form first report on length-weight relationship parameters for 5 fish species *viz., Puntius terio, Pethia conchonius, Sperata seenghala, Ailia coila* and *Trichogaster chuna* from an Indian reservoir as most of the reports are from rivers and wetlands (Table 2). Of these, *A. coila* is in Near Threatened category (IUCN, 2017) which further highlights the importance of the study with respect to conservation aspects.

The *b* values in LWRs determine the growth pattern of the fish species. When *b* is equal to 3 or close to 3, growth in the fish is said to be isometric *i.e.*, fish maintain their form with increasing length (Froese, 2006). Similarly when *b* is far less or greater than 3, growth in the fish is allometric *i.e.,* the fish becomes thinner or fatter with increase in length (Froese, 2006). In our study, all species had *b* values within the expected range of 2.50-3.50 (Pauly and Gayanilo, 1997; Froese, 2006). All LWRs reported were highly significant with all r^2 values >0.900 and they were compared with the available literatures from various ecosystems. When comparing with studies from reservoir, for species such as *Labeo calbasu, Puntius sophore, Pethia phutunio, Chanda nama, Parambassis lala, Parambassis ranga, Notopterus notopterus* and *Channa punctata,* the growth type reported in the present study is similar to the findings from Hirakud Reservoir in Odisha, India (Subodh *et al*., 2018). Similarly, growth pattern of *Oroechromis niloticus*

Table 1. Descriptive statistics and estimated parameters of length-weight relationship of 18 fish species from Panchet Reservoir

Species	N	Length (cm)		Weight (g)		Regression parameters			r^2	Growth type
		Min	Max	Min	Max	a	b	S.E. (b)		
Cyprinidae										
Amblypharyngodon mola	84	2.5	9.4	0.19	8.03	0.0120	2.950	0.048	0.983	I
Labeo calbasu	92	4.8	48.5	2	1387.2	0.0122	3.009	0.077	0.986	I
Puntius terio	55	2.6	5.8	0.3	3.01	0.0115	3.147	0.054	0.974	A+
Puntius sophore	138	3.4	10.5	0.5	19.2	0.0094	3.223	0.033	0.987	A +
Pethia conchonius	145	3.6	6.7	0.6	4.5	0.013	3.077	0.033	0.977	A +
Pethia phutunio	147	1.8	3.6	0.12	0.64	0.0219	2.677	0.036	0.950	A -
Ambassidae										
Chanda nama	454	2.2	6.7	0.1	2.9	0.0114	2.827	0.052	0.960	A -
Parambassis lala	330	1.7	3.7	0.12	0.78	0.0276	2.526	0.041	0.908	A -
Parambassis ranga	305	1.6	8.9	0.1	10.9	0.0179	2.946	0.017	0.990	A -
Bagridae										
Sperata seenghala	85	12.1	85.8	9.84	1250	0.0078	2.848	0.056	0.988	A -
Sperata aor	63	8.5	65	4	1231	0.0124	2.743	0.049	0.995	A -
Gobidae										
Glossogobius giuris	158	2.4	13.8	0.16	25.14	0.0091	2.983	0.065	0.989	I
Schilbeidae										
Ailia coila	121	7.2	15.8	0.86	14	0.0012	3.428	0.039	0.968	A +
Cichlidae										
Oreochromis niloticus	57	10	44	17	1784	0.0146	3.130	0.039	0.998	A +
Notopteridae										
Notopterus notopterus	60	4.5	31	0.79	283.3	0.0046	3.202	0.064	0.989	A +
Osphronemidae										
Trichogaster chuna	55	2.5	13.7	0.2	25.4	0.0387	2.469	0.082	0.986	A -
Siluridae										
Ompok bimaculatus	62	11.6	31.7	9.1	170.5	0.0038	3.131	0.042	0.982	A +
Channidae										
Channa punctata	68	3.6	23.1	0.5	135.9	0.0103	3.025	0.035	0.992	I

N=sample size; a and b= parameters of length-weight relationship; S.E. = Standard error; r^2 = Co efficient of determination; I = Isometry; A^+= Positive allometry; A^- = Negative allometry

reported from Ero Reservoir, Nigeria is in conformity with the present study (Adebola *et al*., 2016). In contrary, the species like *Amblypharyngodon mola* and *Glossogobius giuris* showed isometric growth in the present study whereas it was reported as negative allometric growth from Hirakud Reservoir. Also in our study, we observed positive allometry for *Ompok bimaculatus* whereas it was isometric growth from Hirakud Reservoir (Subodh *et al*., 2018). Some variations could be attributed to the combination of one or more factors such as number of specimens examined, area/seasonal effect, habitat, degree of stomach fullness, gonadal maturity, sex, health and general fish condition, preservation technique and differences in the observed length ranges of the specimens caught, ecological conditions of the habits or the physiology of animals (Le Cren, 1951; Wootton, 1999). Similarly, the parameter *a* may vary seasonally, daily and/or between different habitats whereas the parameter *b* which is characteristic of species usually does not vary significantly throughout the year (Bagenel and Tesch, 1978). Since samples have been collected over an extended period of time, these data are not representative of a particular season or time of the year and should be considered as mean annual values for comparisons as suggested by Goncalves *et al*. (1997).

The present study is the first to report on the length-weight relationship of *Trichogaster chuna* from a reservoir ecosystem as the previous report is from a wetland ecosystem (Borah *et al*., 2017). Most of the previous studies on the LWRs of the 18 species studied are from rivers, wetlands and a few from reservoirs. Hence the results in this study represented additional contribution to the available LWR data from other geographical areas and will be useful for the comparisons of LWRs from different ecosystems. To the best of our knowledge, this study presents the preliminary references on the LWR of 18 fish species from Panchet Reservoir in India. Information of individual body length-weight relationships in the

Table 2. Length-weight relationships of freshwater fish species from previous studies

Species	N	Total length range (cm)	Max. known length (Froese and Pauly, 2019)	b	Locality	r^2	Reference	Growth type
Cyprinidae								
Amblypharyngodon mola	184	4-8-7.4	20	3.758	Padma River, Bangladesh	0.951	Hossain (2010)	A +
	366	2.8-7.0		3.397	Mathabhanga River, Bangladesh	0.947	Hossain *et al.* (2006)	A +
	297	2.5-9		3.115	Saguna Wetland, West Bengal, India	0.9236	Suresh *et al*. (2007)	I
	305	2.5-7.2		2.821	Hirakud Reservoir, Odisha, India	0.942	Subodh *et al*. (2018)	A -
	210	3.7-5.9		3.34	Ganga River, North-west Bangladseh	0.975	Hossain *et al*. (2009)	A +
	367	4.8-8.9		3.25	Balarampur Wetland, West Bengal, India	0.923	Gupta and Banerjee (2015)	A +
Labeo calbasu	32	9.5-40.0	90.0	3.084	Godavari River, India	0.98	Lal *et al*. (2016)	A +
	188	12.7-79		2.831	Brahmaputra River, Assam, India	0.941	Choudhury *et al*. (1982)	
	30	12.5-37		2.940	Betwa River, India	0.95	Sani *et al.* (2010)	A +
	283			3.169	Kali River, India	0.893	Chatterji *et al*. (1980)	
	52	4.4-36.8		3.013	Hirakud Reservoir, Odisha, India	0.993	Subodh *et al*. (2018)	I
	1212	20.5-64		3.132	Kapati Lake, Bangladesh	0.904	Ahmed and Saha (1996)	
Puntius terio	317	2.7-8.7	10	3.039	Khlasi Wetland, West Bengal, India	0.9212	Sandhya *et al*. (2016)	
	16	4.3-9.4		3.2	Indus River, Pakistan	0.81	Muhammad *et al.* (2016)	A +
Puntius sophore	441	3.1-10.2	20.0	3.05	Mathabhanga River Bangladesh	0.966	Hossain *et al*. (2006)	
	372	4.0-10.2		3.027	Rupsha River, Bangladesh	0.927	Hossain *et al*. (2013)	I
	119	4.4-12.2		2.951	Ganga River, India	0.926	Gupta and Tripathi (2017)	A -
	90	4-10.9		3.215	Gomti River, India	0.955	Gupta and Tripathi (2017)	A +
	91	5-12.1		3.231	Sai River, Uttar Pradesh, India	0.941	Gupta and Tripathi (2017)	A +
	29	6-10.7		3.104	Som River and Jaisamand Lake, India	0.91	Lal *et al*. (2016)	
	301	2.5-10.8		3.2	Hirakud Reservoir, Odisha, India	0.982	Subodh *et al.* (2018)	A +
	132	3-8.5		3.18	Indus River, Pakistan	0.84	Muhammad *et al.* (2016)	
	185	3.62-9.02		3.396	Chalan Wetland, North Central Bangladesh	0.945	Rahman *et al*. (2012)	A +
Pethia conchonius	175	7-11.1	14	3.33	Tetulia River, Southern Bangladesh	0.969	Hossain *et al.* (2015)	
	50	3.8-11		2.548	Ganga River, India	0.971	Gupta and Tripathi (2017)	A -
	69	4.1-10.2		2.636	Gomti River, India	0.912	Gupta and Tripathi (2017)	A -
		3.8-8.4		2.94	Dal Lake, Jammu and Kashmir, India	0.87	Shafi and Yousuf (2012)	
	38	4.5-10.2		2.665	Sai River, Uttar Pradesh, India	0.933	Gupta and Tripathi (2017)	A -

Contd.....

Species	N	Total length Range (cm)	Max known length (Froese and Pauly, 2019)	b	Locality	r^2	Reference	Growth type
Pethia phutunio	30	1.8-3.9	3.9	2.82	Gajner Floodplain Wetland, Bangladesh	0.98	Hossen *et al*. (2017)	
	117	1.98-3.3		2.8512	Khalsi Wetlnd, India	0.9220	Sandhya *et al.* (2016)	
	96	1.9-3.7		2.623	Hirakud Reservoir, Odisha, India	0.937	Subodh *et al.* (2018)	A -
Ambassidae								
Chanda nama	443	1.6-10.10		2.858	Hirakud Reservoir, Odisha, India	0.98	Subodh *et al.* (2018)	A -
		4.5-6.8		2.845	Pagla River, Bangladesh	0.933	Alam *et al*. (2013)	
	146	2.5-7		2.799	Deepor Wetland, Assam, India	0.94	Borah *et al*. (2017)	
	43	4-7.4		2.869	Bhramaputra River, Bangladesh	0.963	Islam *et al.* (2017)	
Parambassis lala	193	1.6-3.5		2.864	Hirakud Reservoir, Odisha, India	0.918	Subodh *et al*. (2018)	A -
	148	2.23-3.55		2.7026	Khalsi Wetland, West Bengal, India	.9013	Sandhya *et al.* (2016)	
	101	2.5-4		3.020	Deepor Wetland, Assam, India	0.88	Borah *et al.* (2017)	
Parambassis ranga	330	1.6-8.2		2.794	Hirakud Reservoir, Odisha, India	0.973	Subodh *et al.* (2018)	A -
	148	2.23-3.55		2.7026	Khalsi Wetland, India	0.9013	Sandhya *et al.* (2016)	
	595	2-5.2		2.67	East Kolkata Wetlands, West Bengal, India	0.857	Mahaptra *et al*. (2014)	A -
Bagridae								
Sperata seenghala	131	46-113		3.05	Indus River, Pakistan	0.99	Jatoi *et al.* (2013)	I
	205	40-115		2.866	Ganga River, India	0.95	Khan *et al.* (2011)	A -
	20	21.0-68.0	150.0	3.302	Som River and J aisamand Lake, India	0.99	Lal *et al*. (2016)	
	92	20-67		3.07	Gomti River, India	0.93	Sarkar *et al.* (2013)	
Sperata aor	184	72-95	180	3.249	Ganga River, India	0.98	Khan *et al.* (2011)	A +
	300	29-68		3.006	Nagarjuna Sagar, Andhra Pradesh, India		Ramkrishniah (1998)	
	30	12.4-45		2.98	Betwa River, India	0.97	Sani *et al.* (2010)	
Glossogobius giuris	159	8.7-17.9		3.03	Ganga River, North-west Bangladesh	0.958	Hossain *et al.* (2009)	
	129	2.3-22.5		2.914	Hirakud Reservoir, Odisha, India	0.98	Subodh *et al.* (2018)	A -
	31	8.4-27.0	50.0	2.974	Betwa River, India	0.98	Lal *et al.* (2016)	
	49	5.5-9.7		2.682	Bhramaputra River, Bangladesh	0.867	Islam *et al.* (2017)	A -
Schilbeidae								
Ailia coila	103	6.6-13		3.01	Ganga, North-west Bangladesh	0.981	Hossain *et al.* (2009)	
	105	8.1-15.6		3.076	Padma River, North-west Bangladesh	0.986	Hossain (2010)	I
Cichlidae								

Contd.....

Species	N	Total length Range (cm)	Max known length (Froese and Pauly, 2019)	b	Locality	r^2	Reference	Growth type
Oreochromis niloticus	189	9.7-16		2.313	Barur Reservoir, Tamil Nadu, India		Marx et al. (2014)	
	240			3.073	White Nile River, Sudan	0.9626	Karrar *et al.* (2016)	A +
	575	6.9-27.3		3.08	Wadi Hanifah Valley, Saudi Arabia	0.96	Mortuza and Misned (2013)	A +
	4676	4.1-26.1		3.43	ERO Reservoir, Nigeria	0.83	Adebola *et al*. (2016)	A +
				2.8006	El-Faraouny Canal, Al-Minufiya Province, Egypt	0.956	El- Kashief *et al.* (2015)	A -
Notopteridae								
Notopterus notopterus	300	8.1 -36.0	60.0	2.9015	Tilaiya Reservoir, Jharkhand, India	0.93	Khan (2003)	
	65	12-33		3.326	Godavari River, India	0.98	Lal *et al.* (2016)	
	76	7.8-30.1		3.368	Hirakud Reservoir, Odisha, India	0.98	Subodh *et al.* (2018)	A +
Osphronemidae								
Trichogaster chuna	115	2.6-6.3		3.215	Deepor Wetland, Assam, India	0.96	Borah *et al.* (2017)	
Siluridae								
Ompok bimaculatus	70	10.5-31.5	45.0	3.218	Godavari River, India	0.98	Lal *et al.* (2016)	
	44	16.0-43.0	45.0	3.027	Sonriver and Jaisalmer Lake, India	0.94	Lal *et al.* (2016)	
	314	21.1-31.5		2.778	Bhavanisagar Reservoir, Tamil Nadu, India	0.989	Sivakami (1987)	A -
	42	13-34.7		3.117	Hirakud Reservoir, Odisha, India	0.98	Subodh *et al.* (2018)	I
Channidae								
Channa punctata	284	16.8-29.8		3.12	Ganga River, India	0.94	Khan *et al*. (2011)	A +
	355	6-18.90		3.037	Mathabhanga River, Bangladesh	0.979	Hossain *et al.* (2006)	A +
	200	15-30		2.621	Hussain Sagar Lake, Andhra Pradesh, India	0.991	Kumari and Kumar (2015)	
	140			3.01	Gomti River, Lucknow, India	0.95	Kashyap *et al.* (2014)	I
	17	12.0-21.5	31.0	2.786	Som River and Jaisamand Lake, India	0.91	Lal *et al.* (2016)	
	42	13-34.7		3.117	Hirakud Reservoir, Odisha, India	0.98	Subodh *et al.* (2018)	I

N=Sample size; b = Growth parameters of length-weight relationship; r^2 = Co-efficient of determination; I = Isometry; A^+= Positive allometry; A^- = Negative allometry

population is often required for estimation of population size of a fish stock for the purpose of its rational exploitation (Dulcic and Kraljevic, 1996). Therefore the results from the present study could contribute to the knowledge of fish populations in this area and provide an important baseline for future studies in Panchet Reservoir in the Damodar River basin. The information generated from the study will be useful for formulating effective fisheries management strategies and in implementing regulations for conservation of the native fish stock.

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