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LENGTH–WEIGHT RELATIONS OF FISHES (ACTINOPTERYGII) FROM CHILIKA LAGOON, INDIA

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Abstract. The LWRs of 37 fish species from Chilika Lagoon belonging to 29 genera of 24 families were estimated. The following species were examined: *Acanthopagrus berda*, *Acanthopagrus longispinnis*, *Ambassis ambassis*, *Ambassis gymnocephalus*, *Anabas testudineus*, *Aplocheilus panchax*, *Atherinomorus duodecimalis*, *Cirrhinus reba*, *Daysciaena albida*, *Dendrophysa russelii*, *Eleutheronema tetradactylum*, *Elops machnata*, *Epinephelus coioides*, *Etroplus suratensis*, *Glossogobius giuris*, *Labeo rohita*, *Lutjanus indicus*, *Lutjanus johnii*, *Mystus gulio*, *Nematalosa nasus*, *Notopterus notopterus*, *Pelates quadrilineatus*, *Platycephalus indicus*, *Pomadasys argenteus*, *Pomadasys kaakan*, *Puntius chola*, *Puntius sophore*, *Rhabdosargus sarba*, *Scatophagus argus*, *Siganus canaliculatus*, *Siganus javus*, *Sillago vincenti*, *Terapon jarbua*, *Terapon puta*, *Terapon theraps*, *Triacanthus nieuhofii*, and *Xenentodon cancila*. The coefficient a of the LWR ranged from 0.001 (*X. cancila*) to 0.032 (*S. argus*) while b ranged from 2.861 (*T. jarbua*) to 3.259 (*C. reba*). The study is a first report of the LWR of seven fish species not reported yet in FishBase.

Keywords: length–weight relations, Chilika Lagoon, India

INTRODUCTION

For fisheries management conservation, particularly for catch regulation and estimation of biomass of any fish species, information on fish weight is a pre-requisite. Estimation of the standing stock biomass and yield of fish population requires both length and weight data of fishes, hence length and weight measurements need to be recorded. But, during the collection of field data, it is more convenient to record length than weight especially when there is a large number of fish specimens to be processed and when the measurements are to be taken while on board small vessels (Karna et al. 2017). Indeed, measurements of both length and weight of specimen from an unsorted catch is time consuming and costly (Karna 2017). The relation between fish length and weight is commonly described by a length–weight relation (LWR). The LWR is used to convert the length data into the corresponding weight of individual fish specimens. This relation also facilitates comparison of life history parameters as well as morphological characters of fish and growth from various populations and habitats (Gonçalves et al. 1997, Froese 2006, Froese et al. 2011). For a quick assessment, body weight (W) can be predicted from length (L) with the LWR of the form

$$W = aL^b$$

where parameter b indicates isometric growth in body proportions if $b \sim 3$ (Froese 2006). Therefore, LWR database may estimation of biomass. The coefficient 'a' of LWR describes body shape and condition if $b \sim 3$ (Froese 2006).

A number of reports on LWR of fishes from Chilika have already been published (Panda et al. 2016, Karna 2017, Karna et al. 2017, 2018a, 2018b, 2018c), but information for several taxa are still lacking. Here, we report LWR of 37 fish species from Chilika Lagoon in India.

MATERIALS AND METHODS

Chilika Lagoon (19°28′–19°54′N, 85°05′–85°38′E), the largest brackish water lagoon in Asia and a designated Ramsar site of international importance, is situated along the east coast of India. The lagoon is one of the most diverse aquatic ecosystems in the tropics and a hotspot of biodiversity. The lagoon covers 906 km^2 (dry season) to 1165 km^2 (monsoon season) with a maximum of 6.2 m water depth (Mohanty et al. 2015). Samples of the 37 fish species were collected from the lagoon once every three months from January 2015 to June 2016 from fishers' catch using mono-filament gill nets (mesh: 12 mm, 22–24 mm, 34–38 mm, 42 mm, and 60–72 mm), screen barrier

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net (mesh: 12–26 mm), seine nets, cast nets, hook and line. After collection, the samples were packed in polythene bags and transported in ice to the laboratory. The identity of each species was confirmed following standard taxonomy literature (Day 1878, Fischer and Bianchi 1984, Rao 2009). Total lengths (TL) were measured to the nearest 0.1 cm with a digital calliper and weight (W) was recorded to the nearest 0.1 g with an electronic balance. Care was taken to collect all available size groups including the largest, smallest and mid-size specimens.

A total of 37 fish species from Chilika Lagoon belonging to 29 genera of 24 families were examined: *Acanthopagrus berda* (Forsskål, 1775); *Acanthopagrus longispinnis* (Valenciennes, 1830); *Ambassis ambassis* (Lacepède, 1802); *Ambassis gymnocephalus* (Lacepède, 1802); *Anabas testudineus* (Bloch, 1792); *Aplocheilus panchax* (Hamilton, 1822); *Atherinomorus duodecimalis* (Valenciennes, 1835); *Cirrhinus reba* (Hamilton, 1822); *Daysciaena albida* (Cuvier, 1830); *Dendrophysa russelii* (Cuvier, 1829); *Eleutheronema tetradactylum* (Shaw, 1804); *Elops machnata* (Forsskål, 1775); *Epinephelus coioides* (Hamilton, 1822); *Etroplus suratensis* (Bloch, 1790); *Glossogobius giuris* (Hamilton, 1822); *Labeo rohita* (Hamilton, 1822); *Lutjanus indicus* Allen, White et Erdmann, 2013; *Lutjanus johnii* (Bloch, 1792); *Mystus gulio* (Hamilton, 1822); *Nematalosa nasus* (Bloch, 1795); *Notopterus notopterus* (Pallas, 1769); *Pelates quadrilineatus* (Bloch, 1790); *Platycephalus indicus* (Linnaeus, 1758); *Pomadasys argenteus* (Forsskål, 1775); *Pomadasys kaakan* (Cuvier, 1830); *Puntius chola* (Hamilton, 1822); *Puntius sophore* (Hamilton, 1822); *Rhabdosargus sarba* (Forsskål, 1775); *Scatophagus argus* (Linnaeus, 1766); *Siganus canaliculatus* (Park, 1797); *Siganus javus* (Linnaeus, 1766); *Sillago vincenti* McKay, 1980; *Terapon jarbua* (Forsskål, 1775); *Terapon puta* Cuvier, 1829; *Terapon theraps* Cuvier, 1829; *Triacanthus nieuhofii* Bleeker, 1852; and *Xenentodon cancila* (Hamilton, 1822).

The length parameters (minimum and maximum) and weight parameters (minimum and maximum) were then determined from the data. The parameters of the LWR were calculated by the least-squares' method through the transformed equation,

$$\log W = \log a + b \cdot \log L$$

where, a is the intercept and b is the slope of the linear regression (Froese 2006). Prior to linear regression analysis, outliers in the log–log plots were identified and removed from the data (Froese 2006). The statistical significance, 95% confidence intervals (CI) of the parameter b and coefficient of determination (r^2) were also estimated.

RESULTS AND DISCUSSION

A total of 3448 specimens were measured. The results of the LWR estimates i.e., number of specimens (N), length range, weight range, values (a, b, and r^2) derived from the regression analysis are described in Table 1.

The highest number of specimens was measured for *Nematalosa nasus* (482) while a minimum of 10 each for *Acanthopagrus berda* and *Epinephelus coioides*. The estimated values of coefficient (a value) from LWR ranged from 0.001 (*Xenentodon cancila*) to 0.032 (*Scatophagus argus*) while, the exponent (b value) ranged from 2.861 (*Terapon jarbua*) to 3.259 (*Cirrhinus reba*). The LWR of all species was highly significant ($P < 0.001$).

According to Carlander (1969) and Froese (2006), the exponent b in LWR should be within the range of 2.5–3.5 and indeed the estimated b values in the presently reported study were within this range. Similarly, the confidence intervals (95%) in this study were also found within the range and overlapped with the Bayesian confidence limits (Froese et al. 2014, Froese and Pauly 2018). On the contrary, the upper range of the 95% confidence intervals of the b values of *Acanthopagrus berda*, *Acanthopagrus longispinnis*, *Rhabdosargus sarba*, *Pomadasys kaakan*, *Pomadasys argenteus*, *Nematalosa nasus*, *Scatophagus argus, Puntius chola*, and *Notopterus notopterus* were higher than the limits given in FishBase, while the lower range of 95% confidence intervals for *Terapon jarbua*, *Terapon theraps*, *Acanthopagrus longispinnis*, *Lutjanus indicus*, *Pomadasys argenteus*, *Glossogobius giuris*, *Siganus canaliculatus*, *Epinephelus coioides*, *Puntius sophore*, *Puntius chola*, and *Notopterus notopterus* species were below the minimum range reported in FishBase (Froese and Pauly 2018). According to Moutopoulos and Stergiou (2002) and Froese (2006), such differences may be due to some factors known to influence the LWR in fish, such as habitat, growth phase, season, stomach fullness, gonad maturity, sex, size range, health, fish conditions, and preservation techniques.

Although two references have been mentioned in FishBase for LWR information of *Terapon puta*, the length ranges (about 10–12 cm TL) used for their studies were very narrow. Similarly, two references have also been available for *Dendrophysa russelii* in FishBase, but both have used only single length data for estimation. In the case of *Cirrhinus reba*, there were three references available in FishBase but none of those has indicated the TL range used for their estimation. Therefore, the presented estimates of LWR for *Terapon puta*, *Dendrophysa russelii*, and *Cirrhinus reba* seems to be more authentic than the previous reports. Presently reported estimates might be considered as species specific because the TL range covered in this study is much wider as well as nearer to their L_{max}.

The sample size for 14 species in the presently reported study is less than 30, which may not have covered the full-size range representing small, medium and large individuals of the species. Therefore, the LWR information for these species may be considered with caution.

Based on FishBase, the presently reported study constitutes the first report of the LWR of seven species, namely: *Acanthopagrus longispinnis*, *Sillago vincenti*, *Lutjanus indicus*, *Siganus javus*, *Atherinomorus duodecimalis*, *Triacanthus nieuhofii* and *Aplocheilus panchax* (see Froese and Pauly 2018). Similarly, 17 species (*Terapon jarbua*, *Terapon puta*, *Terapon theraps*, *Pelates quadrilineatus*,

Table 1

Estimated parameters of length–weight relation of fishes from the Chilika Lagoon, India

Family	Species	*N*	TL range [cm]	*W* range [g]	*a*	95% CI of *a*	*b*	95% CI of *b*	r^2
Terapontidae	*Terapon jarbua*[#]	74	5.5–15.7	3.01–52.03	0.020	0.016–0.027	2.861	2.748–2.975	0.972
	Terapon puta[#]	282	**3.5–15.6**	0.84–43.52	0.009	0.008–0.011	3.049	2.982–3.115	0.967
	Terapon theraps[#]	23	**4.6–18.4**	1.32–98.0	0.013	0.009–0.019	3.019	2.848–3.189	0.985
	Pelates quadrilineatus[#]	16	**5.6–13.3**	2.71–33.55	0.014	0.011–0.018	3.009	2.896–3.122	0.995
Sparidae	*Acanthopagrus berda*[#]	10	10.5–**38.2**	21.04–1130.00	0.013	0.008–0.022	3.120	2.946–3.295	0.995
	Acanthopagrus longispinnis[$]	11	13.8–31.4	47.83–566.44	0.021	0.011–0.039	2.955	2.753–3.157	0.991
	Rhabdosargus sarba	79	5.9–34.3	4.25–780.00	0.018	0.015–0.021	2.981	2.920–3.042	0.992
Sillaginidae	*Sillago vincenti*[$]	75	4.5–26.3	0.94–153.62	0.007	0.006–0.008	3.022	2.956–3.088	0.991
Lutjanidae	*Lutjanus johnii*[#]	50	**6.9**–30.7	5.00–489.00	0.016	0.014–0.019	2.987	2.920–3.055	0.994
	Lutjanus indicus[$]	11	8.9–18.9	11.23–108.59	0.016	0.011–0.025	2.963	2.800–3.125	0.994
Haemulidae	*Pomadasys kaakan*[#]	73	3.0–16.5	0.34–71.00	0.011	0.011–0.012	3.134	3.094–3.175	0.997
	Pomadasys argenteus[#]	23	5.0–16.2	1.98–69.00	0.014	0.009–0.021	3.010	2.837–3.183	0.984
Anabantidae	*Anabas testudineus*[#]	11	6.4–16.7	5.01–83.54	0.021	0.017–0.027	2.932	2.849–3.025	0.998
Platycephalidae	*Platycephalus indicus*	21	8.2–**50.1**	3.04–589.71	0.005	0.004–0.007	3.024	2.925–3.123	0.995
Clupeidae	*Nematalosa nasus*	482	5.1–**27.2**	1.00–217.65	0.008	0.008–0.009	3.063	3.028–3.099	0.982
Gobiidae	*Glossogobius giuris*[#]	135	4.9–**29.1**	0.94–208.57	0.008	0.007–0.009	3.011	2.959–3.064	0.989
Bagridae	*Mystus gulio*	244	**4.9–23.4**	0.94–132.15	0.010	0.008–0.012	3.005	2.943–3.068	0.973
Siganidae	*Siganus javus*[$]	35	8.9–32.5	11.34–564.65	0.013	0.009–0.018	3.117	2.981–3.253	0.984
	Siganus canaliculatus[#]	16	10.5–22.8	15.38–149.21	0.015	0.013–0.017	2.943	2.886–2.999	0.989
Atherinidae	*Atherinomorus duodecimalis*[$]	13	6.4–9.3	1.95–6.24	0.007	0.006–0.009	3.028	2.914–3.141	0.996
Ambassidae	*Ambassis ambassis*[#]	65	5.2–12.2	1.98–25.13	0.012	0.009–0.015	3.017	2.884–3.151	0.969
	Ambassis gymnocephalus[#]	79	3.9–**12.8**	1.03–23.89	0.011	0.008–0.014	3.007	2.873–3.142	0.962
Serranidae	*Epinephelus coioides*	10	14.0–35.2	33.0–555.0	0.010	0.008–0.013	3.051	2.989–3.113	0.999
Sciaenidae	*Daysciaena albida*	403	5.2–64.5	0.89–2680.05	0.008	0.007–0.008	3.059	3.029–3.088	0.991
	Dendrophysa russelii[#]	30	7.4–38.3	3.64–584.02	0.008	0.006–0.010	3.106	3.014–3.198	0.995
Triacanthidae	*Triacanthus nieuhofii*[$]	303	5.3–24.3	2.03–181.55	0.012	0.010–0.013	2.948	2.895–3.002	0.975
Scatophagidae	*Scatophagus argus*[#]	33	4.1–24.7	2.17–535.75	0.032	0.024–0.042	3.000	2.889–3.112	0.989
Belonidae	*Xenentodon cancila*[#]	32	**11.7–25.9**	3.42–42.55	0.001	0.001–0.002	3.229	3.049–3.410	0.978
Cyprinidae	*Labeo rohita*	42	8.3–60.5	7.48–2458.55	0.010	0.008–0.012	3.045	2.967–3.123	0.994
	Cirrhinus reba[#]	40	**9.4–28.2**	7.03–254.77	0.005	0.004–0.006	3.259	3.151–3.367	0.989
	Puntius sophore	53	4.3–10.3	1.12–15.82	0.013	0.010–0.017	3.029	2.895–3.164	0.976
	Puntius chola	21	4.7–9.4	1.45–12.58	0.012	0.008–0.018	3.064	2.843–3.284	0.978
Notopteridae	*Notopterus notopterus*	20	7.2–37.8	2.64–412.58	0.006	0.005–0.008	3.044	2.947–3.140	0.995
Elopidae	*Elops machnata*[#]	37	7.9–42.7	2.44–375.45	0.004	0.003–0.005	3.044	2.980–3.108	0.996
Polynemidae	*Eleutheronema tetradactylum*	333	**5.2–63.8**	1.02–2155.00	0.006	0.005–0.006	3.059	3.028–3.089	0.991
Cichlidae	*Etroplus suratensis*	137	**3.9**–20.3	1.16–227.30	0.023	0.020–0.025	3.043	2.998–3.087	0.992
Aplocheilidae	*Aplocheilus panchax*[$]	26	2.3–6.0	0.13–2.41	0.009	0.008–0.011	3.063	2.937–3.189	0.991

N: number of specimens, TL: total length; *W*: body weight; *a*: intercept; *b*: slope; CI: confidence intervals; r^2: coefficient of determination; first LWR report in FishBase ($), First LWR report from Indian waters (#), TL in bold: new TL range (lowest or highest) observed in this estimation and is different from the previous reports.

Acanthopagrus berda, *Lutjanus johnii*, *Pomadasys kaakan*, *Pomadasys argenteus*, *Anabas testudineus*, *Glossogobius giuris*, *Siganus canaliculatus*, *Ambassis ambassis*, *Ambassis gymnocephalus*, *Dendrophysa russelii*, *Xenentodon cancila*, *Cirrhinus reba*, and *Elops machnata*) constitutes the first LWR information from Indian waters (Froese and Pauly 2018). The presently reported study also provides updated LWR information for many species considering extended length range (either new minimum or new maximum TL in respect to previous studies) being used for this estimation. Therefore, the results of the present investigation will be useful to improve knowledge on basic fisheries parameters for future management of these species.

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