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Original Article

Length-weight relationships and condition factor of Asian sheat catfish, *Wallago attu* (Bloch & Schneider, 1801) inhabiting different rivers of India

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Abstract
Wallago attu is a freshwater catfish and has been classified as 'Vulnerable' in Red Data List of threatened species by IUCN. Length-weight relationship (LWR) of wild populations helps in understanding the pattern of fish growth that could be useful in fisheries management. The current work was carried out to the LWR and condition factor (*K*) of *W. attu* collected from five rivers of India (Ganga, Yamuna, Hooghly, Gomti and Pampa). A total of 261 fish specimens were sampled for LWR study. The value of *b* for the population of river Gomti (t=1.0312), Ganga (t=1.4109) and Yamuna (t=0.3365) was not significantly different from isometric growth (b=3) in Pauly's t-test whereas the populations of Hooghly (t=10.3609) and river Pampa (t=3.4593) were significantly different (p<0.001) indicating positive allometric growth in the fish of rivers Hooghly and Pampa. Linear plot of log *a* over *b* resulted in straight line showed strong relationship. Low *K* value (K<1) indicated the poor health conditions of the fish in all five rivers. This study would provide information regarding the status of LWRs of *W. attu* in five rivers of India that could serve as a baseline data for future sustainable management and conservation of this vulnerable fish.

Keywords: condition factor; Ganga; growth; isometric; length-weight relationship; *Wallago attu*

1 | INTRODUCTION

Wallago attu is one of the world's largest freshwater fish (Stone 2007), belonging to the family Siluridae and considered a massive ferocitic catfish that is why it is known as freshwater shark. In different parts of India, it is known as padihan, mali, boal, mulle etc. Distribution of *W. attu* is described by Talwar and Jhingran (1991) and Mirza (2003). It is commonly found in Bangladesh, Pakistan, Nepal, India and Indonesia (Giri *et al.* 2002; Parvez *et al.* 2023). The utmost length of *W. attu* is about 2 m and can weigh up to 45 kg (Talwar and Jhingran 1991). Overfishing in many areas have resulted in large-scale population declines (Patra *et al.* 2005; Montana 2011) and the species at present has been classified as "Vulnerable" in Red Data List of threatened species by International Union for Conservation of Nature (IUCN) (Ng *et al.* 2019). It is considered that the study on length-weight relationships (LWRs) of threatened and commercially essential fishes are extremely significant for their proper management and conservation in natural water bodies.

The LWR is a familiar dimension in fisheries and conservation studies (Froese 2006) to calculate fish biomass at a given length. Le Cren (1951) proposed that the mathematical relationship between length and weight of fishes is a realistic index appropriate for understanding their growth, maturity, reproduction and general wellbeing.

LWR is also broadly used for translation of the growth-in-length equation to growth-in-weight for further use in stock analysis and evaluation of biomass examining length of fish (Moutopoulos and Stergiou 2002). Similar to any other morphometric features, the LWR can be used as a distinguishing feature for the delineation of taxonomic units and the relationship changes with the different developmental stages in life such as growth, metamorphosis and beginning of maturity (Thomas *et al.* 2003). Moreover this, LWR can also be helpful to compare life history and morphology of populations belonging to different regions (Sani *et al.* 2010). Although several researchers (e.g. Yousuf *et al.* 2009; Sani *et al.* 2010; Khan *et al.* 2011; Achakzai *et al.* 2013; Sarkar *et al.* 2013; Rufus *et al.* 2015) reported LWRs in *W. attu*, but still there is paucity of information on LWR of this species from different water bodies of India. Therefore, the present research work aimed to study the LWRs of *W. attu* from different rivers of India.

2 | METHODOLOGY

2.1 Sample collection

A total 261 specimens of *W. attu* were randomly collected using cast and drag nets with the help of local fisherman during November 2018 – November 2019 from four rivers (Ganga, Gomti, Yamuna and Hooghly) of Ganga Basin and from Pampa River, the longest river of Kerala, which originates from Western Ghats (Figure 1; Table 1). Gomti and Yamuna are tributaries of the river Ganga meeting at Saidpur (Ghazipur, Uttar Pradesh) and Sangam (Prayagraj, Uttar Pradesh) respectively. Hooghly is a distributary, also called 'Kati Ganga', of the river Ganga that bifurcates from Ganga at Giria, Murshidabad in West Bengal. River Yamuna travels a distance of approximately 1400 km originating at Yamunotri glacier at a height of 20955 ft before merging into the river Ganga, whereas river Gomti extends to 960 km from its origin and then finally merges into the river Ganga. Hooghly is just a 260 km long distributary of the river Ganga.

Since, *W. attu* is listed as a Vulnerable species on IUCN redlist, the specimens obtained were released back into their respective rivers after photography and required measurements i.e. total length (TL) and weight (W). Fishes were weighs with an electronic balance to the 0.001 g and measured with the help fine callipers to the nearest mm.

TABLE 1 Details of sample size of *Wallago attu* from five different rivers of India.

Rivers	Sampling sites	Sample size (*n*)	Total length (TL) (cm)	Mean TL (cm)
Ganga	Kanpur	50	29.5 – 37.5	33.2 ± 2.30
Gomti	Lucknow	65	20.5 – 45.2	32.39 ± 6.89
Hooghly	Kolkata	49	20.3 – 38.4	34.17 ± 4.98
Yamuna	Agra	47	19.4 – 33.6	27.45 ± 3.51
Pampa	Kerala	50	37.2 – 51.2	47.79 ± 2.92

FIGURE 1 Google map showing sampling sites for *Wallago attu*.

2.2 Length-weight relationship (LWR)

The LWR study was carried out using the log transformed least square formula as suggested by Ricker (1973)

$$\text{Log } W = \text{Log } a + b \text{ Log TL}$$

Where, log *a* and *b* are constants. Constant *a* measures the initial growth index and *b* represents the slope of the regression line. TL and W are the total length (cm) and body weight (g) of the fish respectively.

The Fulton's condition factor (*K*) was calculated using the equation: $K = (W \times 100) / L^3$, where factor 100 is used to bring *K* close to unity. The coefficient of determination (r^2) was calculated in order to indicate the quality of linear regression.

Deviation of slope (*b*) from the isometric growth (value of 3) was tested with the value of Pauly's *t*-test as suggested by Pauly (1984) using the following equation:

$$t = \left[\frac{SDx}{SDy}\right] * \left[\frac{|b-3|}{\sqrt{1-r^2}}\right] * \sqrt{n-2}$$

Where, SDx is the standard deviation of the log L values and SDy is the standard deviation of the log W values, *n* being the number of fish used in the computation. *b* is slope of regression line and the value of *b* is different from isometric growth value of 3 if *t* is greater than the tabled value of *t* for *n*–2 difference at 5% significance level.

3 | RESULTS

The details of the equations of LWR, value of *b*, 95% confidence level of *a* and *b*, values of coefficient of determination (r^2) of *W. attu* are shown in Tables 2 and 3 and Figure 2. The weight in different populations of the fish deviated from the cube of its length (*b* = 2.92 to 3.64). The value of *b* for the fish population of river Gomti (*t* = 1.0312), Ganga (*t* = 1.4109) and Yamuna (*t* = 0.3365) was not significantly different from isometric growth (*b* = 3) in Pauly's *t*-test whereas the populations of river Hooghly (*t* = 10.3609) and river Pampa (*t* = 3.4593) were significantly different from isometric growth. For the pooled data of the fish populations, the *b* value was 3.05 which was not significantly different from isometric growth (*b* = 3) in the Pauly's *t*-test (*t* = 1.07). Linear plot of log *a* over *b* resulted in straight line indicating strong relationship (Figure 3). The average value of condition factor (*K*) ranged between 0.41 and 0.50 in the five populations of *W. attu* (Table 2). The *K* was the highest for river Pampa followed by Hooghly, Ganga, Gomti and Yamuna rivers.

TABLE 2 Logarithmic regression equation of weight on total length in *Wallago attu*. r^2, coefficient of determination; K, condition factor.

Rivers	Regression Equation	r^2	*K*
Ganga	Log W = -2.853 + 3.34 Log L	0.7984	0.45
Gomti	Log W = -2.236 + 2.92 Log L	0.9451	0.44
Hooghly	Log W = -3.397 + 3.64 Log L	0.9862	0.46
Yamuna	Log W = -2.327 + 2.98 Log L	0.9727	0.43
Pampa	Log W = -3.301 + 3.58 Log L	0.9035	0.47
Combined	Log W = -2.443 + 3.05 Log L	0.9734	0.44

TABLE 3 Parameters of logarithmic regression equation of length-weight relationship of *Wallago attu*.

Rivers	Slope *b*	95% CL of *b*	Intercept *a*	95% CL of *a*	*t*-value
Ganga	3.34	2.85 - 3.83	0.0014	0.0002 - 0.0076	1.4109
Gomti	2.92	2.76 - 3.08	0.0058	0.0033 - 0.0102	1.0312
Hooghly	3.64	3.52 - 3.77	0.0004	0.0003 - 0.0006	10.3609*
Yamuna	2.98	2.82 - 3.12	0.0047	0.0028 - 0.0076	0.3365
Pampa	3.58	3.24 - 3.93	0.0005	0.0001 - 0.0017	3.4593*
Combined	3.05	2.99 - 3.11	0.0036	0.0030 - 0.0046	1.07

*t-values are significant at $p < 0.05$

4 | DISCUSSION

The current study reported the LWR and condition factor of *W. attu* collected from five different rivers of India. The value of *b* ranged from 2.92 to 3.64 in the present study. Carlander (1997) suggested the range for regression coefficient of *b* as 2.0 to 4.0. According to Wootton (1998) the value of *b* more than 3 indicates that the fish is getting heavier and lighter if the value is less than 3.

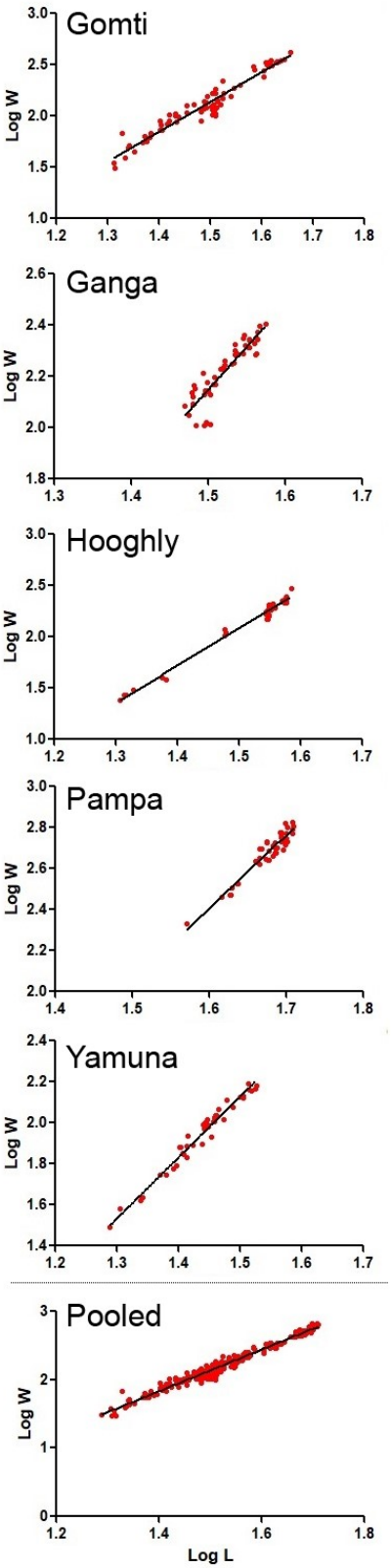

FIGURE 2 Length-weight relationships of Wallago attu in different rivers of India.

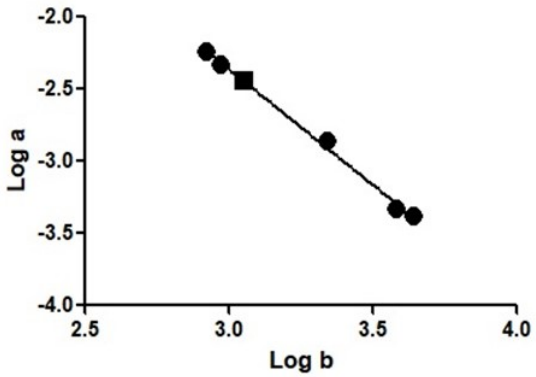

FIGURE 3 Plot of log *a* over *b* for length-weight relationships in five river populations of *Wallago attu*, ■ denotes the LWR of pooled samples (all populations).

The growth pattern assessed from the LWR confirmed that the fish of river Ganga, Gomti and Yamuna were following similar isometric growth pattern as the *b* value was not significantly different from the isometric value of 3. The overall *b* value (3.05) of pooled populations was also overlapping at 95% confidence limit (*b* = 2.81 – 3.27) of Bayesian predictions available on FishBase (Froese and Pauly 2022). Negative allometric growth (*b* < 3) in *W. attu* was reported in Ganga, Yamuna and Gomti rivers (Sani *et al.* 2010; Sarkar *et al.* 2013). In the present study, *b* value for the fish of river Pampa (3.58) and Hooghly (3.64) followed positive allometric growth pattern as their *b* values were significantly different from the isometric value. Several other researchers (e.g. Yousaf *et al.* 2009; Achakazai *et al.* 2013; Rufus *et al.* 2015) also reported positive allometric growth (*b* > 3) in *W. attu* from different water bodies. A number of factors including number of collected specimens, sites of collection, size range, sampling season, fishing time, temperature and salinity parameters of the study site, availability of food, metamorphosis, maturity stage, physical condition, reproductive periodicity and fishing gear used for sampling can affect the LWRs estimates (Ricker 1973; Safran 1992; Srivastava *et al.* 2003; Serajuddin 2005; Froese 2006; Pise *et al.* 2018; Gorule *et al.* 2019).

Condition factor is also an important parameter to calculate the overall productivity as well as the physiology of a fish population (Richter 2007). The belief that a fish is heavy at a particular length is also the best in its physical condition. In this way, the growth and nutrition intensity of fish can also be estimated by the condition factor (Mozsár *et al.* 2015). The condition factor can also be used to determine the potential difference between stocks (Froese 2006). In the present study, the *K* for all the populations was less than unity which indicated the poor health conditions and stress in the fish (Simon *et al.* 2013). However, *K* of the fishes in Hooghly and Pampa rivers was better than Ganga, Gomti and Yamuna. This could be attributed to the allometric growth in rivers Hooghly and Pampa samples. This signifies that the weight of *W. attu* does not increase proportionally as per growth in length of the fish in these two populations, whereas low and near about similar condition factor of the fishes in rivers Ganga, Gomti and Yamuna may be the cause of same isometric growth pattern observed in fish of these rivers.

5 | CONCLUSIONS

The present study provides the basic information about the LWRs parameters and condition factor of *W. attu* collected from northern (Gomti, Ganga, Yamuna), eastern (Hooghly) and southern (Pampa) rivers of India. Studies also revealed and suggested the existence of different environmental conditions which effects on LWR and conditions of the fish. Current study will also be useful for the fishery biologists and for further research, management and conservation of the fishes.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

GK designed the study, reviewed the literature, carried out the specimen collection and data, laboratory work and prepared the first draft of manuscript. AK carried out the statistical analysis of collected data and helped in preparation of first draft of manuscript. MS proposed and supervised the study, selected the species and revised the draft manuscript. All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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