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Study on biometric growth parameters in different fish species of family Bagridae from Harike wetland, Punjab, India

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Abstract
The present study was based on biometric growth parameters and their relationship in different fish species of family Bagridae from Harike wetland, a Ramsar site in Punjab. During the study period from March 2017 to November 2017, three major species of family Bagridae viz. *Sperata seenghala*, *Sperata aor* and *Rita rita* were encountered in fish catch from Harike wetland. Biometric growth parameters like-length-weight relationship (LWR), length-length relationship (LLR), condition factor (K) and relative condition factor (Kn) were analysed in all reported species of Bagridae. LWR showed negative allometric growth pattern in *S. seenghala* (b = 2.74) while isometric growth in *S. aor* (b= 3.02) and *R. rita* (b = 3.05). The length parameters revealed strong relationship between total length, standard length and fork length with correlation coefficient range of 0.89-0.99 in all reported species of Bagridae. Relative condition factor (Kn) value varied considerably from 1.65-1.73 while condition factor ranged from 0.45-1.31 which may be attributed to different environmental conditions of wetland. This study may serve as baseline information in formulation of action plan for management and conservation of these species.

Keywords: Harike wetland, length-weight relationship, condition factor, relative condition factor, Bagridae

1. Introduction

India is endowed with invaluable aquatic resources in the form of inland open waters as well as coastal marine waters. Inland resources play an important role in food and nutritional security, livelihood generation and socio-economic development of the country. Inland open water ecosystems are repositories of valuable fish diversity and have also been considered as a source of fish and fish germplasm. Among these resources, wetlands are high value ecosystems, recognized for their role in conserving fish diversity, as these ecosystems are used by fishes as a refuge for breeding, feeding and nesting purposes at one or other stages of their life cycle [1]. Now -a-days, degradation of these aquatic resources have been observed due to pollutants and toxicants from agricultural lands, industrial effluents, domestic discharge associated with impaired flows, affecting their biodiversity and sustainability. Harike, one of the largest man made wetland of Northern India, is situated at the meeting point of three districts of Punjab viz. Taran Taran, Kapurthala and Ferozepur. It came into existence in 1952 due to diversification of water resources of river Sutlej and Beas from their confluence point at 'Hari-ke-pattan' [2]. The wetland thus formed became a natural reserve for a variety of fauna and flora and was declared as 'Ramsar' site by International Union for Conservation of Nature (IUCN) in 1990 making it a wetland of international significance and priority zone for "Biodiversity conservation" [2]. Moreover, this wetland is most important fisheries resource of the state. In recent past, wetland degradation was observed due to siltation, macrophyte infestation and pollution brought mainly by river Sutlej and to lesser extent by river Beas [3]. Natural population of many fish species have experienced drastic reduction in number, largely due to the effects of overexploitation, habitat alterations due to changing hydrobiology with negative impact on sustainability of many fisheries resources [4]. Most of the fishes from Harike wetland are now enlisted in near-threatened / vulnerable fish species of India according to IUCN status. For effective management of a species, it is necessary to identify the reason for its decline and knowledge of biometric growth parameters of target species [5]. Till now, no published study on biometric characterization of fishes from Harike wetland is reported.

Biometric growth parameters are essential for biological, physiological and ecological studies of exploited population. These parameters are used to differentiate the species taxonomically, identifying the stock of fish and separate different morphotypes [6-8] Length-weight relationship (LWR) and condition factor are important to provide information regarding growth patterns and the condition of fish species in their habitat [9]. LWRs are often used for estimating the average weight of a fish from a given length group of that species by establishing a mathematical relationship between them [10] while LLRs for comparative growth studies of a fish population [11]. Studies on various biometric growth parameters have been conducted by various workers in many fish species like- *Clarias batrachus* [12], *Wallago attu* [13], *Mystus cavasius* [14], *M. bleekeri* [15], *Rita rita* [16], *Oncorhyncus mykiss* [17] and many other food as well as ornamental fishes [18].

The present study was conducted to analyze the length-weight relationship, length-length relationship, condition factor and relative condition factor of the species of family Bagridae in Harike wetland to have an idea about growth pattern as well as condition of the fish in their habitat.

2. Material and Methods

Fish catch composition from the wetland was observed at nearby Harike fish market cum landing centre during the study period from March to November 2017. Fishes encountered in catch were assessed up to species level with the help of taxonomic key [19, 20, 21]. These assessments were further revalidated with the information at www.fishbase.org. A total of 68 specimens of all three species of family Bagridae i. e. *Sperata seenghala. Sperata aor* and *Rita rita* were collected for length-weight studies. Morphometric characters were measured with the help of wooden measuring board and measuring scales to the closest 0.1cm. All the fish samples were weighed on an electronic balance closest to 0.1g.

2.1 Length-weight relationship (LWR) and Length-length relationship (LLR)

The length-weight relationship was analysed by measuring the length and weight of the collected fish samples. The relation between length and weight can be calculated by using the cube formula [22].

$W= a L^b$

Where, W= weight of the fish (g), L= length of the fish (mm), a= constant, b= exponential

The relationship ($W = aL^b$) may be converted in the form of logarithmic equation as Log W = Log a + b Log L and produce a linear relationship when plotted graphically, where ‘b’ represents the slope of the line and ‘a’ is the constant. The parameters ‘a’ and ‘b’ were estimated by least square- linear regression analysis.

The relations between the different length measurements were estimated by linear regression analysis as Length-length relationships (LLRs) between, Total length (TL) vs Fork length (FL); Total length (TL) vs Standard length (SL); Standard length (SL) vs Head length (HL); Head length (HL) vs Total length (TL); Head length (HL) vs Fork length (FL) and Standard length (SL) vs Fork length (FL). These length relationships were represented by the equation Y = a + bX

Where, Y= a dependent variable (various body lengths)
X = an independent variable (total length)
a = constant (intercept)
b = regression coefficient (slope)

2.2 Condition factor (K) and Relative Condition Factor (Kn)

Condition factor (K) was calculated by using the formula given below [23]

$K = W \times 100/ L^3$

Where, W = weight of the fish (g), L = length of fish (cm) and 100 is a factor to bring the value of ‘K’ near unity.

The relative condition factor (Kn) was described as the ratio between the actual weight (observed weight) and the calculated weight based on length-weight equation [22].

$Kn = W/\hat{W}$

Where, W= Observed weight (g), Wˆ= Calculated weight (log W $\times$ log L / log L^2)

2.3 Statistical analysis

Statistical analysis including calculation of regression coefficient, correlation coefficient (r) and determination coefficient (r^2) was carried out by using the SPSS 16.0. The length-weight relationships were estimated as ($Y= aX^b$) and the length-length relationships (LLRs) were established using linear regression analysis (y= bx + a).

3. Results and Discussion

3.1 Length-weight relationship

The results of the present study showed that exponent ‘b’ varied between 2.74 to 3.05 for all reported species of Bagridae (Table1). Value of ‘b’ for *S. aor* and *Rita rita* showed isometric growth pattern in Harike wetland while *S. seenghala* indicated negative allometric growth with a value of 2.74. In case of *S. aor* and *Rita rita*, b is equal to 3 which means the length and weight increases proportionally [24].

Table 1: Length-Weight Relationship (LWR) parameters of three species of family Bagridae

Species	Length (cm)		Weight (gm)		a	b	r	r^2
	Min	Max	Min	Max				
Sperata seenghala	41	69	342	1720	- 4.326	2.749	0.951	0.905
Sperata aor	42	62.5	326	1082	- 5.492	3.023	0.985	0.970
Rita rita	24	33	164	728	- 4.519	3.050	0.918	0.843

If the b < 3 (negative allometric), weight will decrease with increase in fish length [25]. Negative allometric growth pattern of fishes in a water body may be attributed to unsuitable environmental conditions as well as by many biotic and abiotic factors such as food availability, predation, water quality parameters etc [26].

In contrast to present study, LWR studies of *S. seenghala* showed isometric growth pattern (b=3.0) for males and positive allometric growth (b= 3.17) for female from Indus river [27]. Similar growth pattern was also observed for *S. seenghala* from river Ravi in North-Western India with 'b' value of 3.04 [28] and from river Gomti with 'b' value of 2.97 [29].

In corroboration with present study, negative allometric growth was observed in *S. seenghala* from Ganga and Rapti river [18]. *Mystus cavasius* [14] and *Puntius sophore* [30] also showed same growth pattern from Chenab River due to high fishing pressure by the fishermen and local fisher community. A highly negative allometric growth pattern was observed in both male and female of *M. bleekeri* [15] with 'b' value range of 0.77-0.99 and *Rita rita* with 'b' value of 0.9-1.1 [16]. *Sperata aor* was reported with isometric growth pattern in river Betwa and Gomti which supports the findings of present study [29] while, positive allometry was reported in Ken River, a tributary of Yamuna River due to dominance of juveniles and an incomplete coverage of known size range [31]. The isometric growth pattern of *R. rita* in present study was not in corroboration with growth pattern of *R. rita* in river Ganga, Gomti and Rapti, where a negative allometric growth pattern was observed [18]. LWR of *Rita rita* stock reared in cemented ponds showed positive allometry growth for male while negative allometry for female [32].

Table 2: Logarithmic Length-Weight Relationship (LWR) of different species of family Bagridae

Species	Logarithmic equation of Length-Weight Relationship (LWR) as log W=log a +b log L
S. seenghala	logW= - 4.326 + 2.749 logL
S. aor	logW= - 5.492+ 3.023 logL
Rita rita	logW= - 4.519+ 3.050 logL

The 'a' and 'b' parameters of the length-weight relationships of fishes are affected by multiple factors, including sex, gonad maturity, health, season, habitat, nutrition, area, degree of stomach fullness, life history stages, differences in the length range of the caught specimen and type of fishing gear used [28,33, 34, 35], however, these factors were not considered in the present study. The value of LWR parameters 'a' and 'b' for the three species of family Bagridae i.e. *S. seenghala*, *S. aor* and *Rita rita*, fit within the range as suggested by the Bayesian length-weight approach [36]. Value of correlation coefficient (r) indicated strong correlation between length and weight in all three species (Table 1). Highest 'r' value was reported as 0.98 for *S. aor* followed by *S. seenghala* (0.95) and *Rita rita* (0.91). Higher values of coefficient of determination (r^2>0.9) in *S. seenghala* and *S. aor* revealed confidence in the information generated. However, low value of r^2 (0.84) for *Rita rita* might be due to inconsideration of outliers in the LWR calculation [37].

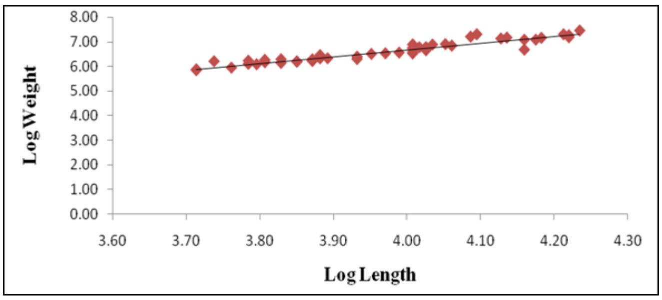

Fig 1: Log length and Log weight relationship of *S. seenghala* in

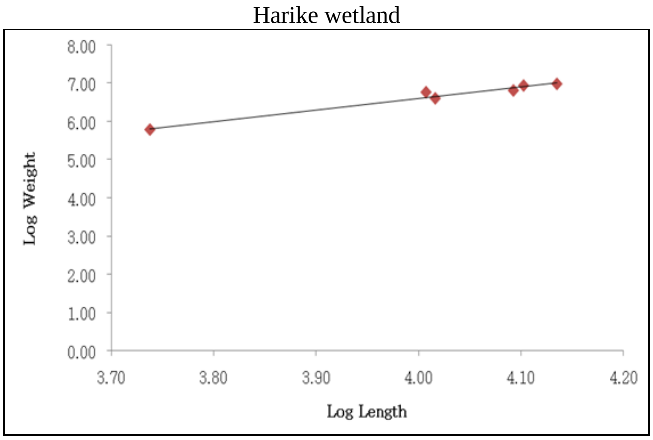

Fig 2: Log length and Log weight relationship of *S. aor* in Harike wetland

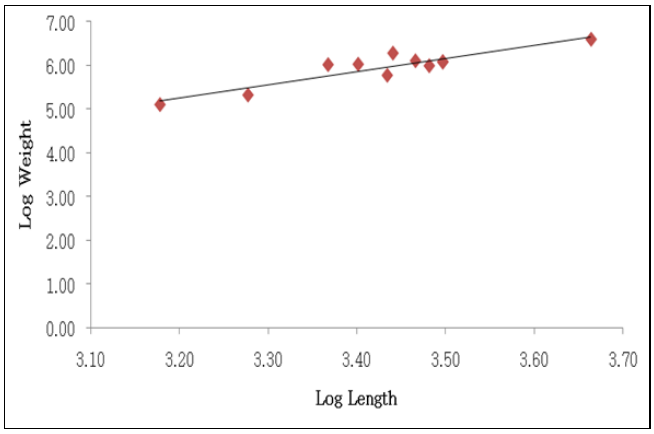

Fig 3: Log length and Log weight relationship of *R. rita* in Harike wetland

3.2 Length-length relationship

Relationships between total length (TL), standard length (SL), fork length (FL) and head length (HL) in the form of regression equation, correlation coefficient (r) and coefficient of determination (r^2) were presented for all reported species of family Bagridae (Table 3-5). The present study showed that all length-length relationships were highly correlated to each other in *S. aor* (Table 4). While in case of *S. seenghala*, higher correlations were recorded between TL, SL and FL (r = 0.89-0.96) and lower with HL (r = 0.53-0.56). *R. rita* also showed same pattern as *S. seenghala*. Coefficients of determination (r^2) were noted with lower values in relationships of HL-TL, SL-HL and HL-FL in case of *S. seenghala* and *R. rita*. The estimated parameters of LLR equations indicated that all body lengths were proportional to the total length except head length in case of *S. seenghala* and *R. Rita*. However, *S. aor* revealed greater correlation of all the body lengths (FL, SL and HL) with total length which were in corroboration with other similar studies [38, 39, 40]. In present study, low value of correlation coefficient (r <0.60) for *S. seenghala* explained the disproportionate growth of head length in related to total length, standard length and fork lengths. The minimum relationship between total length and head length might be due to the least growth changes in the parameter over the fish size [41].

Table 3: Length-Length Relationship (LLRs) of *S. seenghala* from Harike wetland

Relationships	Y = a + bX	r^2	r
TL vs FL	Log Y = 0.017 + 0.939 log X	0.857	0.926
TL vs SL	Log Y = 0.079 + 0.917 log X	0.798	0.893
SL vs FL	Log Y = 0.164 + 0.967 log X	0.930	0.964
SL vs HL	Log Y = 0.613 + 0.462 log X	0.288	0.536
HL vs TL	Log Y = 2.496 + 0.634 log X	0.314	0.560
HL vs FL	Log Y = 2.319 + 0.619 log X	0.283	0.532

Table 4: Length-Length Relationship (LLRs) of *S. aor* from Harike wetland

Relationships	Y = a + bX	r^2	r
TL vs FL	Log Y = 0.017 + 0.939 log X	0.940	0.969
TL vs SL	Log Y = -0.219 + 0.988 log X	0.961	0.980
SL vs FL	Log Y = 0.195 + 0.958 log X	0.994	0.997
SL vs HL	Log Y = -1.445 + 1.005 log X	0.822	0.907
HL vs TL	Log Y = 1.768 + 1.019 log X	0.831	0.912
HL vs FL	Log Y = -1.626 + 1.044 log X	0.817	0.904

Table 5: Length-Length Relationship (LLRs) of *Rita rita* from Harike wetland

Relationships	Y = a + bX	r^2	r
TL vs SL	Log Y = -0.179 + 0.994 log X	0.942	0.970
TL vs FL	Log Y = -0.107 + 0.992 log X	0.957	0.978
SL vs FL	Log Y = 0.147 + 0.974 log X	0.969	0.985
SL vs HL	Log Y = -0.134+ 0.647 log X	0.456	0.676
HL vs TL	Log Y = -0.305 + 0.659 log X	0.452	0.672
HL vs FL	Log Y = -0.372 + 0.707 log X	0.533	0.730

3.3 Condition Factor and Relative Condition Factor

The condition of a fish is affected to great variations due to physiological, environmental, nutritional and biological factors. In studies of population dynamics, high condition factor or Ponderal Index (K) values indicates favorable environmental conditions [42]. Relative condition factor (Kn) is also used by various workers to compare the general well-being, fatness or the state of development of gonad [43]. The condition factor (K) was used for understanding the changes in weight for length assuming that the length-weight relationship obeys the cube law. In present study, mean value of condition factor varied between 0.49-1.31 in all three species of family Bagridae (Table 6). Minimum value of 'K' was reported for *S. aor* (0.455) followed by *S. seenghala* (0.492) and maximum for *R. rita* (1.31). Variations in the condition of different species may be in relation to their reproductive stage, feeding rhythm, age, physiological status and other unknown factors [22, 44].

Table 6: Condition Factor (K) and Relative condition factor (Kn) of different species of family Bagridae

Species	Condition Factor (K)	Relative Condition Factor (Kn)
S. seenghala	0.492 ± 0.01	1.66 ±0.01
S. aor	0.455 ± 0.01	1.65 ±0.02
Rita rita	1.31 ± 0.06	1.73 ± 0.02

Relative condition factor (Kn) was recommended in preference to condition factor (K) as the later will be highly influenced by many environmental and biological factors [22]. Condition factor measures the deviation from a hypothetical ideal fish where as relative condition factor measures the deviation from the average weight or length of fish. The 'Kn' values reported in present study are indicative of favourable conditions and suitability of habitat for all three species. Maximum average 'Kn' value was recorded for *Rita rita* (1.73) followed by *S. seenghala* (1.66) and *S. aor* (1.65). Higher values of 'Kn' in pond reared stock of *R. rita* [32] supported the finding of present study. Similar to present study, *Rachycentron canadum* (cobia) captured from Mumbai waters was reported with higher values of 'Kn' and lower 'K' value [45]. Biometric growth parameters (L-W relationship, conditions and form factor) are important for estimating the present and future population success [46]. This invaluable information may be used for proper management and conservation of the wild fish population [34, 47].

4. Conclusion

In view of this study, it may be concluded that biometric growth parameters assessed for Bagridae species of Harike wetland are more or less in optimal condition with normal growth pattern but they may face deviation or changes from ideal values in near future due to increasing fishing pressure and changing hydrobiology of wetland. This study provides first baseline information on Length-weight relationship and condition factor of the Bagrids from Harike wetland which may be useful in formulation of strategic action plan for conservation of these species. In addition, management and conservation of the wetland is also needed to maintain its ecology and valuable fish diversity.

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