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Some Life History Traits with Reference to Gonadal Cyclicity of Invasive African Sharptooth Catfish, *Clarias gariepinus* from River Yamuna in Delhi Region, India

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Abstract: **The purpose of the present study was to investigate the growth performance of an invasive alien species, *Clarias gariepinus* from river Yamuna (Delhi segment) in Indian waters by utilizing Length-Weight Relationship (LWR) and Condition Factor (K) with respect to different maturity stages. In females, the value of regression coefficient 'b' was observed to be less than 3 during different reproductive phases i.e. immature stage, not ripe stage, ripe stage, running ripe stage and spent stage. In males, the value of 'b' was observed to be less than 3 with maximum in mature males and minimum in immature males. In total, value of 'b' was found to be higher in females ($p<0.01$) as compared to males. The mean values of condition factor (K) for both sexes were found to be < 1. In addition, individuals of smaller length sizes and in early stages of reproductive cycle of both sexes were found in better condition than larger sized individuals in later maturity stages. Despite of negative allometric growth pattern and not so good health status of river, it has successfully colonized the river because of certain physiological adaptations.**

Index words: **Allometric, Condition Factor, Growth Performance, Invasive, Yamuna**

I. INTRODUCTION

Growth is a natural phenomenon involving an irreversible proportionate increase in length and weight over a period of time in a species in specific set of environmental conditions. In fishery science, length-weight relationship (LWR) serves as a significant mathematical tool which has pronounced role in weight estimation from length observations and vice-versa; thereby, aiding in analyzing the growth pattern in fish populations (Kumar et al., 2005). Various factors *viz*. genetic make-up of the species, intrinsic (endocrine profile, physiology, prebiotic, probiotic) and extrinsic factors (light, food, rainfall, competition/predation) determines the pace of growth in different species.

LWR finds numerous applications in scrutinizing various aspects of fish population dynamics such as estimating age structure (Petrakis & Stergiou, 1995); comparisons between different stages in life history and between fish populations from regions or habitat groups (Gonçalves et al., 1997) and tracing seasonal variations in fish growth (Richter et al., 2000). In addition, knowledge of morphometric characteristics of a fish such as body length and weight also explains spawning season of the fish (Morgan et al., 1995) thereby, describing reproductive status of the species. The morphometric data also provide means of finding out the condition factor (K) which serves as an index of growth and feeding intensity (Fagade, 1972), indicating the "wellbeing of the fish". Condition factor (K) reflects the condition of fish species and the entire community and is of high significance for management and conservation of natural populations (Muchlisin et al., 2010).

In the recent past, the fisheries of river Yamuna have been facing challenges due to degrading ecological conditions, anthropogenic pressures and augmented prevalence of alien invasive species. These invasive species are deliberate or intentional introductions done with purpose of improving local fishery potential and promoting aquaculture expansion so as to meet rising demand for food and nutritional security (Raman et al., 2013). However, such exotic species have started harboring the feeding niche of native fishes and posing serious threat to them. The African Sharptooth Catfish, *Clarias gariepinus*, an exotic species is efficaciously thriving in the river basin, particularly in Delhi segment and wiping away the native population. The

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widespread prevalence of this exotic species highlights the need to understand its growth performance (LWR and Condition factor) with respect to different maturity stages of its reproductive cycle in Indian waters. The information generated will be useful in formulating management strategies aiming to exterminate this alien species and long-term conservation of ecosystem in the region.

II. MATERIAL AND METHODS

A total of 325 specimens (185 females and 140 males) were sampled in order to calculate the length-weight relationship and the Fulton's condition factor. Total length (cm) and body weight (gm) were recorded using vernier calipers (nearest to 0.1 cm) and digital weighing balance (nearest to 0.1 gm) respectively. On the basis of gross morphology of gonads, whole reproductive cycle of fish was categorized into different maturity stages following Tyor and Pahwa (2017); Yalcin et al., (2001). The length-weight relationship was calculated by the least square method applying the Le Cren (1951) formula:

$$W = aL^b.$$

Where, W = Weight (g), L = Length (cm), 'a' & 'b' are Constant

The theoretical value of 'b' in length weight relationship is reported as 3 (Cube's law) for isometric growth pattern i.e. body form of fish remains constant at different lengths. However, if b<3, the growth is said to be negative allometric growth and when b>3 it depicts positive allometric growth (Shingleton, 2010). The co-efficient of determination (r^2) and coefficient of correlation (R) were calculated as an indicator of the quality of the linear regression & to study the relationship between length and weight respectively.

Condition factor of a fish indicates the well-being of the fish in a particular environment. It was assessed for comparisons among different sex, maturity stages and size groups. It can be numerically determined by using the formula of Fulton (1904).

$$K = \frac{W \times 100}{L^3}$$

Where, K= Condition factor, W = Weight (g), L = Length (cm)

III. RESULTS

On the basis of gross morphology of gonads, the whole reproductive cycle of fish was categorized into different maturity stages. The number of specimens belonging to each maturity stage, total weight range, total length range, parameters of length-weight relationships (a & b; r^2; R), condition factor (K) are given in Table I and II.

In females, five different maturity stages were identified (Tyor & Pahwa, 2017) i.e. immature or previtellogenic stage (stage I; 30 specimens), not ripe stage or early vitellogenic stage (stage II; 40 specimens), ripe stage or vitellogenic stage (stage III; 35 specimens), running ripe or mature vitellogenic stage (stage IV; 50 specimens) and regressed or spent stage (stage V; 35 specimens). Overall, total length of the female specimens studied ranged from 26.5-66 cm and total weight between 160-1650 gm. The value of regression coefficient 'b was observed to be less than 3 during different reproductive phases i.e. immature stage (b=2.633), not ripe stage (b=2.231), ripe stage (b=2.852), running ripe stage (b=2.747) and spent stage (b=2.165). The coefficient of correlation for the relationship between log total length and total weight of specimens belonging to different maturity stages (immature, not ripe, ripe, running ripe and spent stage) was 0.973, 0.916, 0.921, 0.898 and 0.948 respectively, which were highly significant (Table I). The coefficient of determination (r^2) ranged between 0.806-0.946. The computed logarithmic transformation for female specimens belonging to different maturity stages were as follows (Fig. 1):

Immature stage: log W = -1.554+ 2.633 log L
Not Ripe stage: log W = - 0.904 + 2.231 log L
Ripe stage: log W = - 0.1894 + 2.852 log L
Running Ripe stage: log W = -1.694 + 2.747 log L
Spent stage: log W = - 0.797 + 2.165 log L
Total female specimens: log W=-1.685+2.72logL

Table I. Estimated Parameters of Logarithmic Length Weight Relationship, Correlation and Regression Coefficient of female *Clarias gariepinus.*

Sex	Maturity Stage	N	Weight (gm)	Size (cm)	a	b	K	r^2	R
Female (n=185)	**Immature stage**	30	160-550	26.5-42.8	-1.554	2.633	0.62-0.90	0.946	0.973**
	Not Ripe stage	40	200-390	28.9-37.1	-0.094	2.231	0.72-1.02	0.839	0.916**
	Ripe stage	35	242.5-880	32.4-48.4	-1.894	2.852	0.49-0.93	0.849	0.921**
	Running Ripe	50	340-1650	36.8-66	-1.694	2.747	0.53-1.65	0.806	0.898**
	Spent stage	30	350-700	37.1-49.8	-0.797	2.165	0.56-0.85	0.899	0.948**
	Total	185	160-1650	26.5-66	-1.685	2.729	0.49-1.65	0.919	0.959**

*n=number of specimens, a=constant, b= slope, K= condition factor, r2= regression coefficient, r= correlation coefficient

**correlation significant at 0.01level

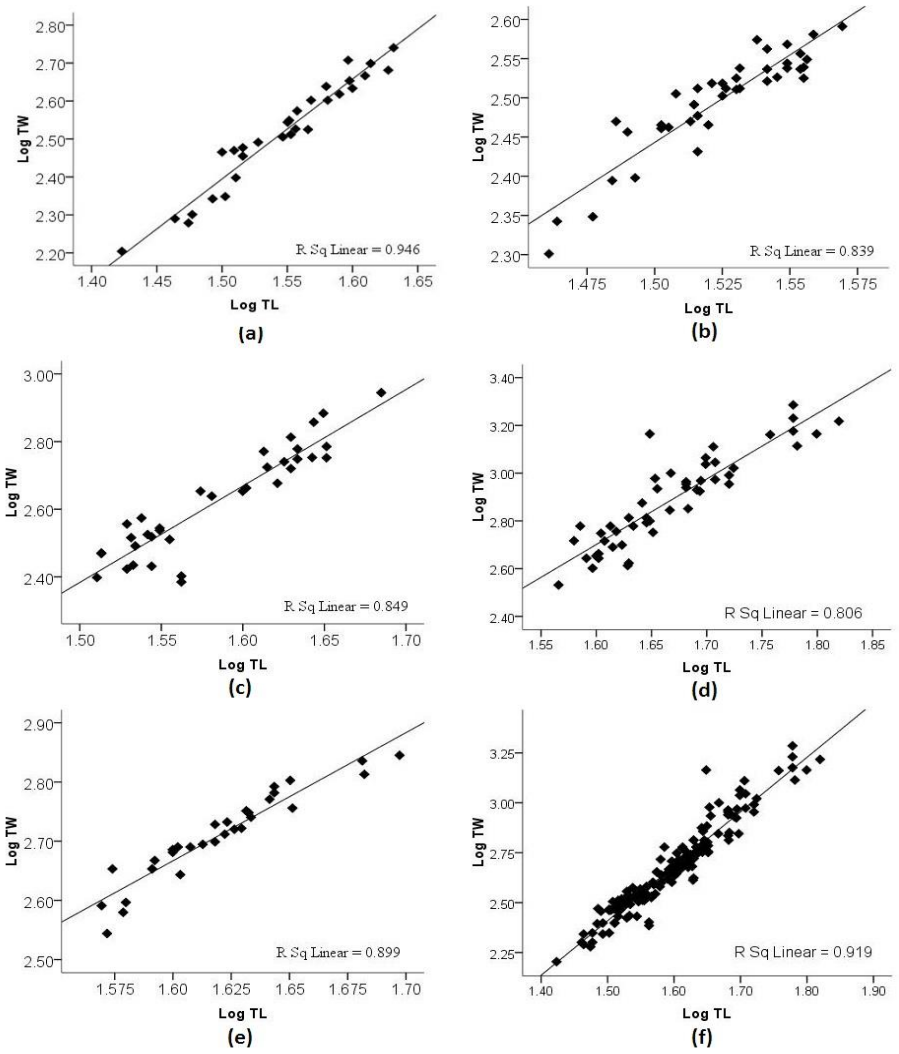

Fig. 1. Relationship between Log TL (cm) and Log TW (gm) of female specimens of *C. gariepinus* belonging to (a) immature or pre-vitellogenic stage, (stage I) (b) not ripe or early vitellogenic stage, (stage II) (c) ripe or vitellogenic stage, (stage III) (d) running ripe or mature vitellogenic stage, (stage IV) (e) regressed or spent stage, (stage V) (f) all maturity stages

In males, four different maturity stages were identified (Yalcin et al., 2001) i.e. immature stage (stage I; 30 specimens), maturing stage (stage II; 30 specimens), mature stage (stage III; 50 specimens), spent stage (stage IV; 30 specimens). Overall, total length of male specimens belonging to four different reproductive stages ranged from 29-67.5cm and total weight between 225-1900gm. The value of 'b' was observed to be maximum in mature males (2.655) and minimum in immature males (1.764). Furthermore, 'b' value for males belonging to maturing and spent stage was reported to be 2.065 and 2.20 respectively. The coefficient of correlation for relationship between log total length and total weight of specimens belonging to different maturity stages (immature, maturing, mature and spent stage) was 0.907, 0.967, 0.921 and 0.965 respectively (Table II), which were highly significant. The findings of present investigation revealed that females had significantly ($p<0.01$) higher regression coefficient (b=2.729) than males (b=2.671). The computed logarithmic transformation for male specimens belonging to different maturity stages were as (Fig. 2):

Immature stage: log W = -0.242+ 1.764 log L
Maturing stage: log W = -0.680 + 2.065 log L
Mature stage: log W = - 1.571 + 2.655 log L
Spent stage: log W = - 0.856+ 2.20 log L
Total male specimens: log W = -1.618 + 2.671ogL The variation in the number of fishes of *C. gariepinus* recorded in different size groups are presented in Fig. 3 after grouping at intervals of 6cm. Maximum number of fishes were found distributed in 32.5 to 38.5 cm. size group (33.84%) followed by 38.5 to 44.5 cm. size group (28.30%) indicating that former size group is predominant in the region during study period. The remaining fish belonged to different size group viz. 26.5-32.5 cm (9.84%), 44.5-50.5cm (14.15%), 50.5-56.5 cm (9.84%), 56.5-62.5 cm (2.46%), 62.5-68.5 cm (1.53%).

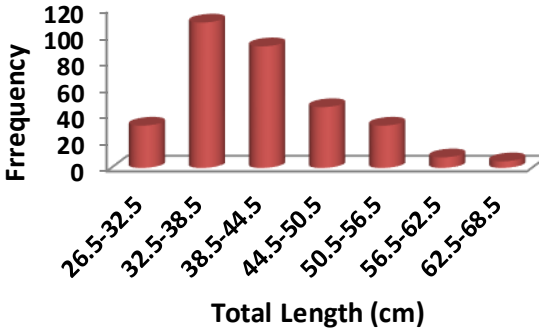

Fig. 3: Length- Frequency distribution of different size groups of *C. gariepinus*

Table II. Estimated Parameters of Logarithmic Length Weight Relationship, Correlation and Regression Coefficient of male *Clarias gariepinus.*

Sex	Maturity Stage	N	Weight (gm)	Size (cm)	a	b	K	r^2	R
Male (n=140)	**Immature stage**	30	225-340	29-36.4	-0.242	1.764	0.65-0.92	0.82	0.907**
	Maturing stage	30	260-450	31.6-41	-0.680	2.065	0.63-0.85	0.93	0.967**
	Mature stage	50	430-1900	40-67.5	-1.571	2.655	0.48-1.04	0.84	0.921**
	Spent stage	30	450-1120	38.1-55.5	-0.856	2.20	0.54-0.81	0.93	0.965**
	Total	140	225-1900	29-67.5	-1.618	2.671	0.48-1.04	0.95	0.978**

*n=number of specimens, a=constant, b= slope, K= condition factor, r2= regression coefficient, r= correlation coefficient

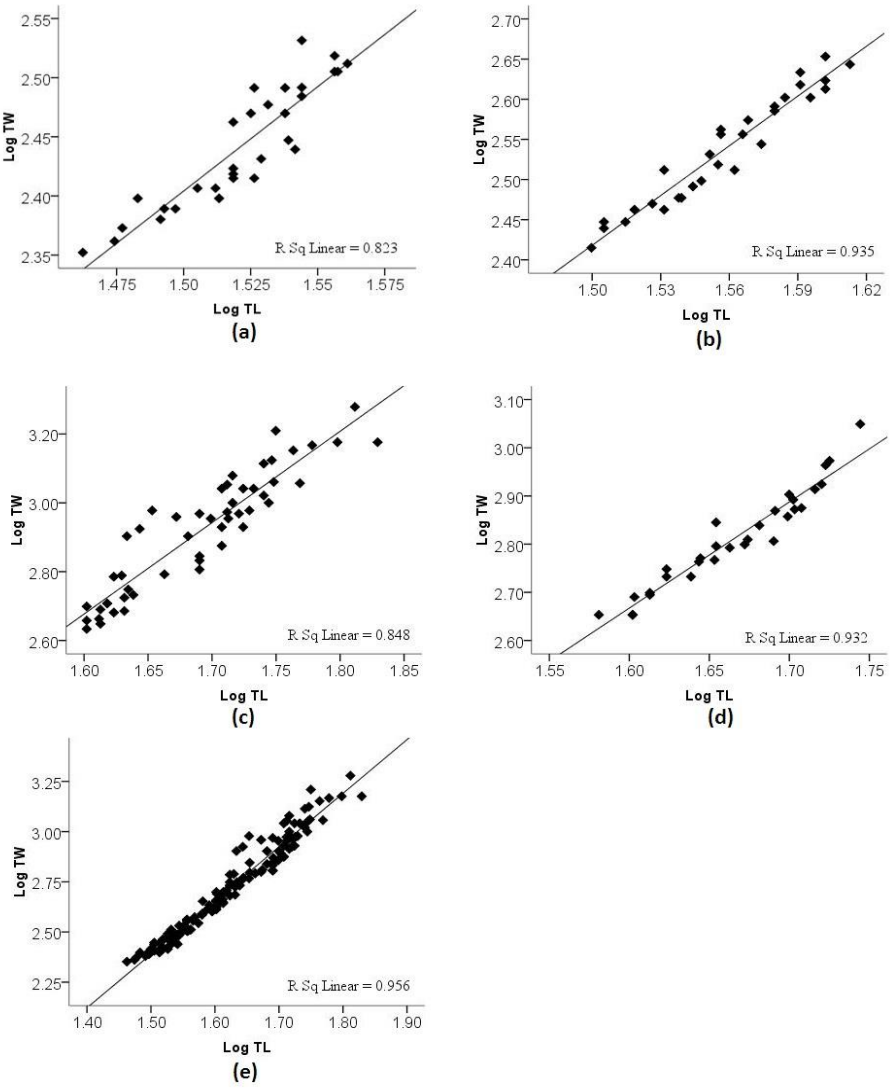

Fig. 2: Relationship between Log TL (cm) and Log TW (gm) of male specimens of *C. gariepinus* belonging to (a) immature stage, (stage I) (b) maturing stage, (stage II) (c) mature stage, (stage III) (d) spent stage, (stage IV) (e) different maturity stages.

TL: Total Length, TW: Total Weight

The graphical presentations of Fulton's condition factor (K) for 185 female specimens and 140 male are shown in Fig.4. The mean values of condition factor (K) recorded in the present study for female, male and total specimens were 0.77 ± 0.008, 0.71 ± 0.007 and 0.74±0.006 respectively (Fig. 4). Both male and female of smaller length sizes i.e. 26.5-32.5cm had greater condition factor (K=0.84) as compared to those of larger length size 62.5-68.5cm i.e. K= 0.57 and 0.59 of female and male respectively (Fig 5a, b). Furthermore, it was also noticed that condition factor showed variations during different maturity stages in both sexes. The not ripe / Early vitellogenic stage (stage II) in females depicted greater condition factor (K=0.84) as compared to other maturity stage (Fig. 5c). However, in males fish from inactive phase of reproductive cycle i.e. immature stage were generally in better condition (*K*= 0.75) than the fish caught post spawning (*K*= 0.65) (Fig. 5d).

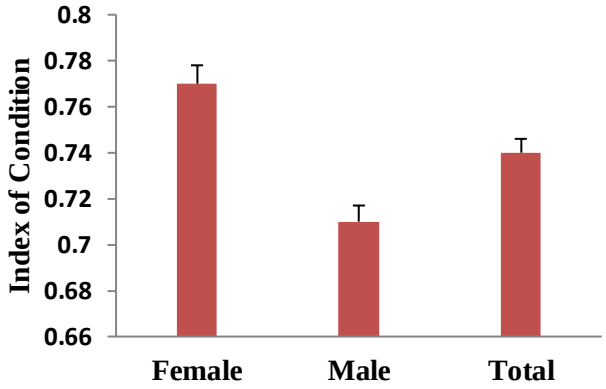

Fig. 4. Mean condition factor of female, male and total specimens of *C. gariepinus.*

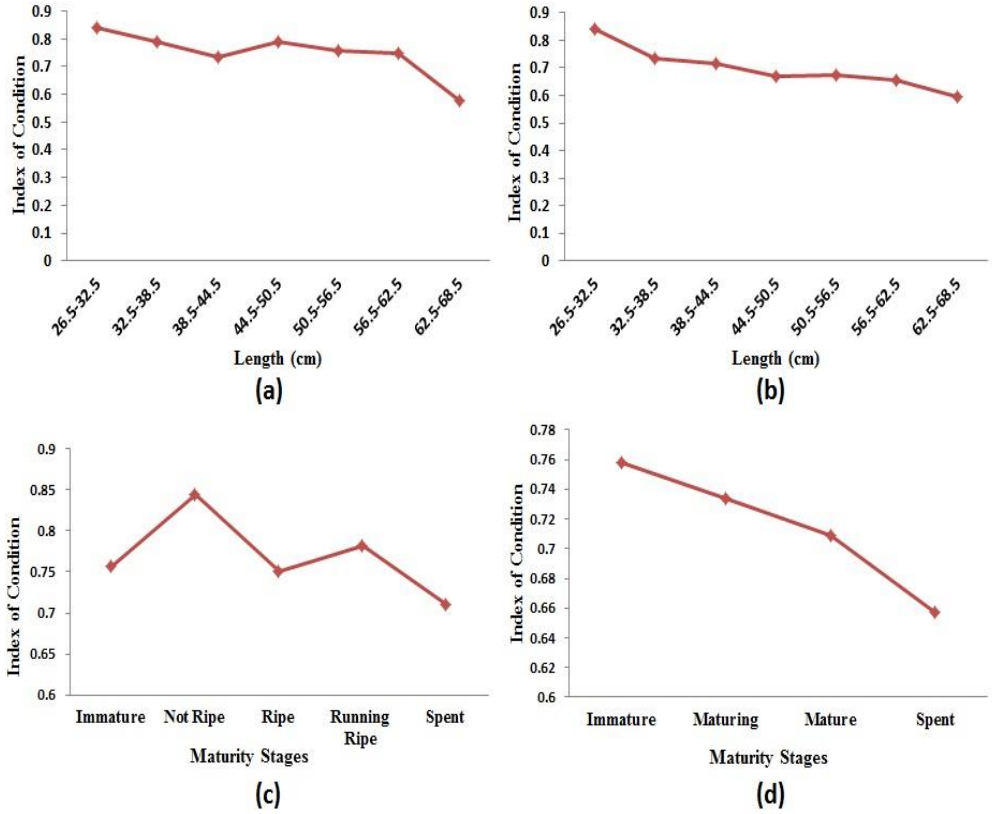

Fig. 5: Condition factor (K) of *C. gariepinus* in relation to (a) total length (cm) of female specimens (b) total length (cm) of male specimens (c) different maturity stages of female (d) different maturity stages of male.

IV. DISCUSSION

In fishery science, length-weight relationship is of great importance (Goncalves *et al*., 1997). The most important parameter in evaluating LWR is the slope of the regression line in logarithmic form, *i.e.* 'b' value (Froese, 2006). In the present study, length-weight data obtained for both females and males depicted different 'b' values. The exponent value of 'b' for female and male was found to be 2.72 and 2.67 respectively. However, the 'b' value for females (2.72) was noticed to be higher as compared to males (2.67) indicating better growth in females than males. In general, 'b' value less than 3 signifies less rotund body form of fish as the length increases. For most species and population 'b' value

is greater than 3 (Murphy and Willis, 1996) which describes stoutness of the body with increase in length, indicating positive allometric growth. Keyombe *et al*. (2015) also reported higher values of 'b' in female specimens of *C. gariepinus* inhabiting Lake Naivasha, Kenya. This may be related to greater fat accumulation and gonadal weight in females as compared to male, as also documented in *Terapon jarbua* by Nandikeswari *et al*. (2014). Hence, 'b' values for both the sexes less than 3, signifies deviation of LWR from cube law. Thus, the species exhibited negative allometric growth pattern in river water i.e. increase in length was not proportionate to increase in weight. This type of growth pattern is may be due to the degrading water quality condition of the basin or due to non-availability of food. Froese, (2006) reported several factors such as temperature, salinity, food, habitat and gonad development, spawning period season, sex, season to effect length-weight relationship.

The present findings endorse earlier reports of Kolding (1996) which documented similar growth pattern in *C. gariepinus* inhabiting Bangweulu swamps in Zambia. However, length-weight relationship studies by Britton and Harper (2006) and Keyombe *et al*. (2015) reported positive allometric growth in *C. gariepinus* in Lake Kariba, Lake Baringo and Lake Naivasha respectively. Thus, variations in the growth pattern of the same species have been observed in different water bodies. These variations are associated with environmental factors, feeding regime, food availability, season, sex life stage and other physiological factors (Le Cren, 1951).

During the present study, variation in fish sizes was also noticed indicating that the fish population comprised of immature specimens to fully matured ones. Length-weight equation for different maturity stages in both sexes was estimated. The calculated values of 'b' for length and weight were estimated to be less than 3 in all the maturity stages of female i.e. immature female (2.63), not ripe females (2.23), ripe female (2.85), running ripe female (2.74) and spent stage female (2.16). Similarly, $b<3$ was found in all the maturity stages for male i.e. immature male (1.76), maturing male (2.06), mature male (2.65) and spent stage male (2.20). The correlation coefficient ($p<0.01$) was found to be close to one signifying a good adjustment between length and weight of fish in the habitat. The high value of 'b' of the mature female and male specimens is attributed to the fact that adequate feeding and gonad development increases body weight and 'b' values (Nikolsky, 1963). However, lower value of 'b' (2.16, 2.20) of spent female and male respectively is associated with higher metabolic activities during spawning period. These results are also comparable to the findings of Nandikeswari & Sambasivam (2016) for *Terapon puta* where' b' value was noticed to be less in immature male and female as compared to mature male and female.

During the present investigation, the mean condition factor (K) of female, male and combined sex values were found to be < l indicating unhealthy status of fish in the river. However, mean condition factor for female specimens was recorded to be higher than males explaining their better condition than males in the river system. In contrast, Keyombe *et al*. (2015) reported higher mean condition factor (K) in males as compared to females of *Clarias gariepinus* and related lower values of female to the fact that a lot of metabolic energy is utilized for body building, egg laying and care of young ones. In the present study, condition factor (K) values were observed to be higher in the smaller length sizes (26.5-32.5 cm) as compared to larger length sizes indicating better adaptation to ecological status of the river. However, vice-versa results were reported in studies by Keyombe *et al*. (2015) on *Clarias gariepinus* from Lake Naivasha, Kenya.

Furthermore, during the present study, the K value was observed to be higher in females at early stage of growth and maturation as compared to spent stage. The decline in the K value in case of spent fishes is due to the fact that spawning is a physically demanding and stressful period which can affect also immune function thus affecting fish condition (Kortet *et al*., 2003). Vazzoler (1996) also confirmed lower K values during more developed gonadal stages which might be associated with mean resource transfer to the gonads during reproductive period. Hence, the condition factor and the accumulated fat is associated with the rhythm of the reproductive process where high values usually at beginning of the process is linked with fat accumulation and subsequent drop in K value is associated with decrease in fat (Lizama *et al*., 2002). It is, therefore, recommended to capture the individuals of smaller size and in early stages of reproductive cycle to control the population of exotic catfish. Hence, growth performance and condition factor of *C. gariepinus* in Yamuna basin is an indicative of degrading conditions for the fish in the waters. Despite of negative allometric growth pattern and not so good health status of fish, it has successfully colonized the river because of certain physiological adaptations.

CONCLUSION

- Among the various invasive species, African Sharptooth Catfish, *Clarias gariepinus* is efficaciously thriving in the river basin, particularly Delhi segment and is grave threat to native organisms
- The specimens of *C. gariepinus*, both male and female exhibited negative allometric growth pattern with respect to its different reproductive maturity stages, in riverine ecosystem.

- Fulton condition factor (K) of female, male and combined sex values were found to be < l indicating unhealthy status of fish in the river.

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