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Growth parameters and mortality rates of giant river-catfish *Sperata seenghala* from the Indus river, Pakistan

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Length frequency of *Sperata seenghala*[1] from the Indus River were collected during the months of February, March, April, May and June in 2011. The sample consisted of n= 133 pairs of length and weight data. The length ranged from 46 to 113 cm TL (65.661±15.995 cm), while the weight varied from 500 to 7500 g TW (1806.391±1481.456 g). Length-weight relationship was calculated as a= 0.04, b= 3.047 (R^2= 0.99). The von Bertalanffy growth function parameters for *S. seenghala* were L_∞= 117.60 (TL cm) and K= 0.370 year^{-1}, while the age at zero length was t_0= -0.513 year. The total instantaneous mortality rate (Z) was estimated at 95% CI of 0.77-1.22 (Z= 1.00 year^{-1}) in the Indus River. The natural mortality (M) was computed as M= 0.556 year^{-1} at an average annual temperature of surface water of 21^{o}C, whereas the fishing mortality was estimated as F= 0.444 year^{-1}. Therefore, exploitation ratio (E= F/Z) was calculated as E= 0.444. The growth performances indices for L_∞ and W_∞ were computed Φ'= 3.709 and Φ= 2.175 respectively. When t_c was at 1, the yield per recruit analysis found that F_{max} was at 0.85 year^{-1} and $F_{0.1}$ at 0.75 year^{-1}. The current age at first capture was about 1 year, the $F_{current}$ rate was 0.444 year^{-1}. Thus the current fishing mortality rate was smaller than F_{opt}= 0.556 year^{-1}, F_{max}= 0.85 year^{-1} and $F_{0.1}$= 0.75 year^{-1}. Therefore, we can assume that the current stock of this important fishery resource is not over-fished.

[Key words: Indus River, *Sperata seenghala*, Growth, Mortality, FiSAT, Pakistan]

Introduction

Bagridae family is commonly named as catfishes and has great commercial value. The Giant River Catfish, *Sperata seenghala*[1] is the most important family members, which is locally known as "seenghari" in Pakistan[2]. It spreads across Pakistan, Bangladesh, Nepal, Afghanistan, India, Thailand, and Myanmar[3], and accessibility of this species was also accounted by Jayaram[4] in Chinese waters. It is discovered in the beds, canals, ditches, rivers, lakes, reservoirs, flooded fields and other areas of freshwater[3]. It is a freshwater, brackish, demersal and potamodromous fish[5]. It may reach at the maximum size of 150cm in total length and attains the common length of TL at 40[3]cm.

In recent years, the natural stock of *S. seenghala* has decreased greatly after a decline in its natural habitats, particularly in Bangladesh. This fish species was declared as a threatened species[6]. On the other hand, the value of this commercial fish also makes it a prospective contestant for aquaculture in Pakistan. Therefore, sustainable use of fisheries within Pakistan is required[7]. Some previous works have been conducted on various aspects of their morphology, biology and fisheries from all over the world[8, 9]. Currently there is no published work to estimate the growth and mortality parameters of the species in the Indus River based on length frequency data.

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The purpose of this study was to estimate the growth and mortality parameters of *S. seenghala* in the Indus River waters. Ultimately on the basis of the estimated biological reference points, we can give information regarding the sustainable exploitation of this fish for the fishery managers in local management.

Material and Methods

Field studies

Total 133 specimen of both sexes of *S. seenghala* were sampled during monthly period of February to June from the small-scale fisheries landings in the center of Jamshoro District, Sindh, Pakistan at Kotri Barrage in 2011 (Fig. 1). Out of them 69 were male and 64 were female with an average length of 65.661cm (±15.995) TL and with an average weight of 1806.391 cm (±1481.456) TW.

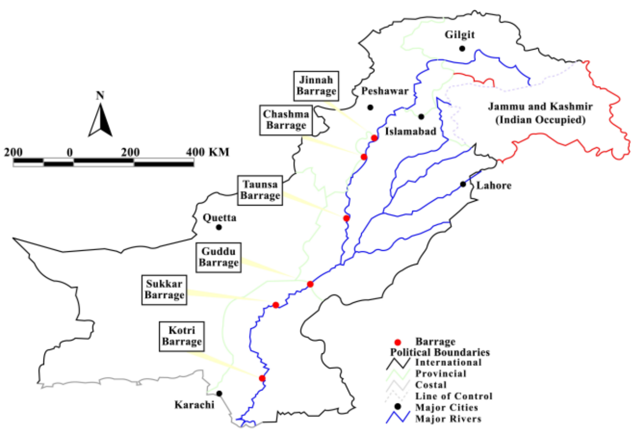

Fig. 1— Map showing the location of sampling site of Kotri Barrage on the Indus River, Sindh, Pakistan

Analysis of data

The computer software package FiSAT-II (FAO-ICLARM stock assessment tool)[10] version 1.2.2 was used for the analysis of the data of length frequency. In the present study, growth parameters, mortality rate, biological reference points, growth performance index, and relative yield per recruit analysis were evaluated.

Length-weight relationship

We used the power function for estimating the length -weight relationship for *S. seenghala* $W = aL_t^b$, here in this mathematical expression constant condition factor was represented by a, allometric growth parameter was indicated by b, weight of fish by W was (in g) and L_t total length (in cm).

Growth

The growth of *S. seenghala* was calculated using the von Bertalanffy growth function (VBGF)[11]:

$$L_t = L_\infty (1 - \exp(-K(t - t_0)))$$

where length at age t was (L_t), the asymptotic length was (L_∞), the growth coefficient was (k) and the hypothetical age at zero length was (t_0) which can be calculated by the empirical equation[12]:

$$\log_{10}(-t_0) = -0.3922 - 0.275 \log_{10} L_\infty - 1.038 \log_{10} K$$

Mortality estimation model

According to Pauly[12], the length converted catch curve method was used for total annual natural mortality rate (Z). Catch curves were obtained by using the length frequency data for each month. The annual natural mortality was evaluated by using following empirical formula by Pauly[13]:

$$\log_{10} M = 0.0066 - 0.279 \log_{10} L_\infty + 0.6541 \log_{10} K + 0.4634 \log_{10} T$$

T was the mean annual surface water temperature of Indus River which was 21°C. Fishing mortality (F) was computed as Z-M. The exploitation ratio (E) was calculated from fishing mortality (F) divided by total mortality (Z) i.e F/Z.

Biological reference points

Biological reference point was proposed by Gulland[14], optimal fishing mortality rate is $F_{opt} = M$.

Beverton-Holt Y / R analysis model

The Beverton-Holt yield per recruit model was represented by the following formula:

$$Y_w / R = FW_\infty e^{-M(t_c - t_r)} \sum_{n=0}^{3} \frac{Q_n e^{-nK(t_c - t_0)}}{F + M + nK} \left(1 - e^{-(F+M+nK)(t_\lambda - t_c)}\right)$$

wherein Y_w/R was the yield per recruit, t_c was the mean age at the first capture, t_r was the recruitment age, t_λ was the asymptotic age, Q_n was a constant of 1, -3, 3 and -1 if n was 0, 1, 2 or 3[15].

Growth performance index model

Mathematical expressions of Pauly and Munro[16] were used to estimate growth performance indexes as compared to total mortality of *S. seenghala* from the Indus River which are as follow:

$$\varnothing' = \log_{10} k + 2\log_{10} L_\infty$$
$$\varnothing = \log_{10} k + \tfrac{2}{3}\log W_\infty$$

Results

Length-weight relationship

The total 133 pairs of length and weight of *S. Seenghala* were studied. The length ranged from 46 to 113 TL (65.661±15.995 cm), while the weight varied from 500 to 7500 TW (1806.391±1481.456 g) (Fig. 2). The length weight relationship of both sexes combined of *S. seenghala* from Indus River were estimated as W= 0.004 $L^{3.047}$ and R^2 = 0.99 (Fig. 2). The dominant length and weight ranged of 50 to 62 cm (TL) (Fig. 3) and 500 to 1200 g (TW).

Growth parameters

By using the von Bertalanffy growth function (VBGF) the growth parameters were calculated as L_∞= 117.60 (TL cm) and K= 0.370 year^{-1} (Fig. 4) and t_0= - 0.513 year^{-1} for *S. seenghala*. Length data grouped in 3 cm interval were used in FiSAT-II analysis. Data file of the length frequency is characterized by the limitations of the lower and upper class, the size of a certain class by the size of the variable class can be grouped by class interval. FiSAT-II is not required entering the input of the upper and lower class restriction, but the use of the size of the class or interval, the smallest in length, which makes it possible to calculate the length of the middle of the next class.

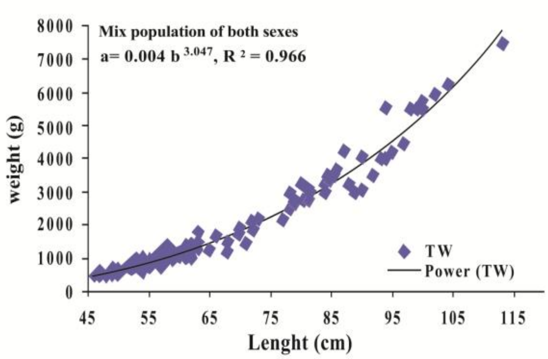

Fig. 2- Length weight relationship of *S. seenghala* from the Indus River in 2011

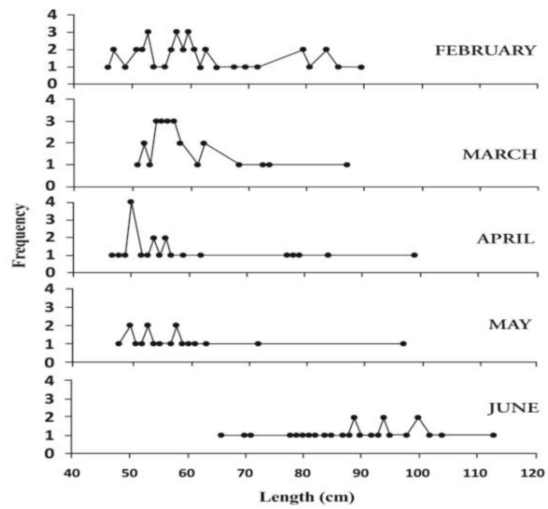

Fig. 3: Length frequency distribution of *S. seenghala* from the Indus River in 2011

Mortality estimation model

Mortality estimation was done by using length converted catch curve (LCCC). The total mortality was estimated as Z= 1.00 year^{-1} (Fig. 5). The natural mortality was calculated as M= 0.556 year^{-1}. Thus, fishing mortality (F) was calculated by (F= Z-M) as F= 0.444 year^{-1}, and the ratio of exploitation (E) was achieved by (E= F/Z) as E= 0.444.

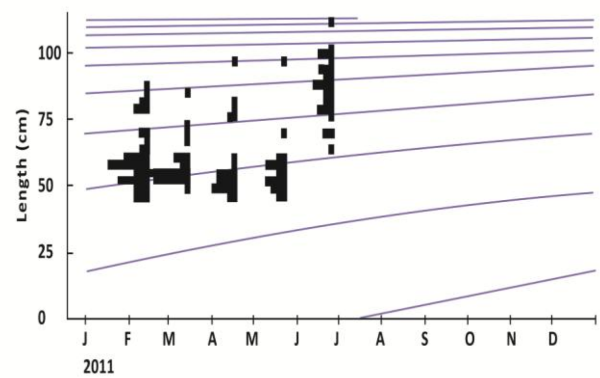

Fig. 4- Length-frequency distribution data and the growth curves estimated using ELEFAN- I method for *S. seenghala* from the Indus River in 2011

Biological reference points

When age at first capture t_c was assumed at 1, the F_{max} and $F_{0.1}$ was evaluated at 0.85 year^{-1} and 0.75 year^{-1} by yield per recruit analysis. The current age at first capture was about one year, because $F_{current}$ was 0.444 year^{-1}. $F_{current}$ was less than F_{max} and $F_{0.1}$. The stock of S. *seenghala* in the Indus River was in safe condition. Gulland[17] used a biological reference point F_{opt} of M=

0.556 year^{-1}. Current fishing mortality rate F_{now}= 0.444 year^{-1} was lower than the target biological reference points (BRP) in the Indus River.

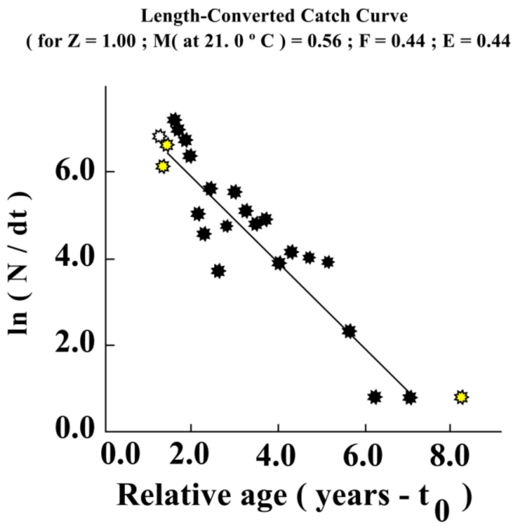

Fig. 5-Estimation of total mortality using length converted catch curve analysis for the combined data of five months of *S. seenghala* from the Indus River in 2011

Growth performance index

Growth performance indexes Phi prime (Ø') were computed by using the estimated growth parameter values of asymptotic length (L_∞) and growth co-efficient (K) as Ø'= 3.709 and Ø= 2.175 for *S. seenghala* from Indus River in 2011 respectively.

Beverton-Holt Y / R Analysis

In Fig. 6, yield per recruit contour map showed that optimum exploitation ratio (E) is about 0.6 and the optimum L_c/L_∞ is also about 0.6.

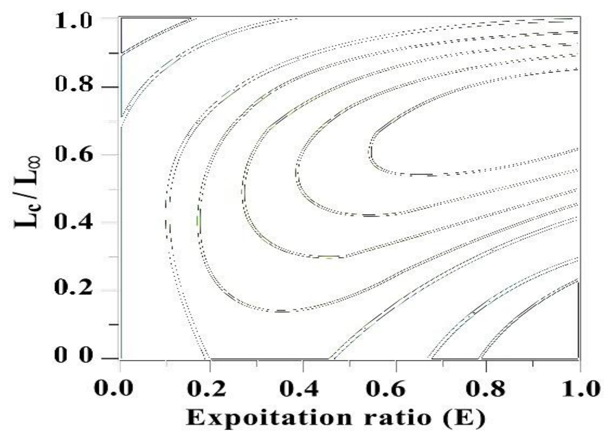

Fig. 6- Yield per recruit contour map for *S. seenghala* from the Indus River in 2011

Table 1- Length frequency data of *S. seenghala* taken from the Indus River at the Kotri Barrage (landing points) from February to June 2011 (Class 3 cm interval of n = 133)

Month wise length (cm)	*February*	*March*	*April*	*May*	*June*	*Total*
46	3		2	2		7
49	3	1	5	3		12
52	6	7	4	4		21
55	3	9	4	2		18
58	8	2	1	4		15
61	5	3	1	2		11
64	2				1	3
67	1	1				2
70	2	1		1	2	6
73		1				1
76			2		1	3
79	3		1		3	7
82	2		1		2	5
85	1	1			2	4
88	1				4	5
91					2	2
94					3	3
97			1	1	1	3
100					3	3
103					1	1
106						
109						
112					1	1
∑	40	26	22	19	26	133

Table 2- Estimated key parameters of growth, mortality, exploitation and yield of *S. seenghala* from the Indus River in 2011

Population parameters	***Sperata seenghala from Indus River***
Intercept (*a*)	0.004
Exponent (*b*)	3.047
Coefficient of determination (R^2)	0.99
Asymptotic length (L_∞)	117.6
Growth coefficient (*K*)	0.370
Theoretical age (t) at zero length (t_0)	-0.513 year
Goodness of fit (R_n)	0.362
Total mortality (*Z*)	1
Natural mortality (*M*)	0.556
Fishing mortality (*F*) $F = Z - M$	0.444
Exploitation rate (E) $E = F/Z$	0.444
GPI Φ' (L_∞)	3.709
GPI Φ (W_∞)	2.175

Discussions

Background

Kotri Barrage was formerly known as the lower Sindh Kotri Barrage and renamed Ghulam Muhammad Barrage built in 1955[18]. The area is positioned in the latitude 25º 26' N and longitude 68º 22'E and situated on the on the right bank of the Indus River. The air temperature is in the range between 9.3°C to 40.4°C with considerable extreme rainfall in the basin[19]. It is the last barrage on the Indus River measuring about 0.575 miles across the Indus River, near Hyderabad city in southern Pakistan, the river runs about 100 km below, and goes into the Arabian Sea near Thatta district in Sindh, Pakistan. Kotri is one of the most important fishing centers along the Sindh over the lower reaches of the Indus River [20].

Length weight relationship

The monthly length frequency data of *S. seenghala* from February to June was shown in Table 1. Figure 3 of monthly length frequency distribution showed that the April sample was the most diverse, maximum length difference was 52 cm, in contrast the March sample was least diverse, maximum length difference was 35 cm.

The value of a and b, according to Ricker[21] may be different between the calculations performed by the grouped and individual data. In general, when the value of regression coefficient (b) of the length weight relationship equals three, it means that the growth of fish species is isometric[22] and if it does not equal at the three is considered allometric growth[23]. In the analysis of the present study of length weight relationship values of a, b and Coefficient of determination (R^2) of *S. seenghala* for pooled months was considered identical isometric (Table 2).

Length weight relationship parameters of 131 fish specimen of *S. seenghala* from the Indus River were obtained by Jatoi[2]. The estimated values were a = 0.004, b = 3.05 and R^2 = 0.99. The results obtained in this study was almost the same as the estimated results of previous research carried out by Jatoi[2] from the Indus River, Sarkar[24] reported 3.07 value from India Gomti River, and according to the FishBase data Sharma[25] also reported from Ravi River India the exponent b value of 3.045 that is also close to our result.

Table 3- Instantaneous rates of mortality based on monthly data using the length converted catch curve analysis for *S. seenghala* from the Indus River in 2011

Sampling month	***Z***	***$_{95}$% CI_Z***	***M***	***F***	***E***	***R^2***
February	1.18	0.24-2.13	0.56	0.62	0.53	0.543
March	2.44	1.66-3.22	0.56	1.88	0.77	0.882
April	1.29	0.76-1.82	0.56	0.73	0.57	0.638
May	1.84	1.14-2.54	0.56	1.28	0.7	0.694
June	0.87	0.62-1.12	0.56	0.31	0.36	0.855

$_{95\%}$ CI_z = 95% confidence intervals of total mortality

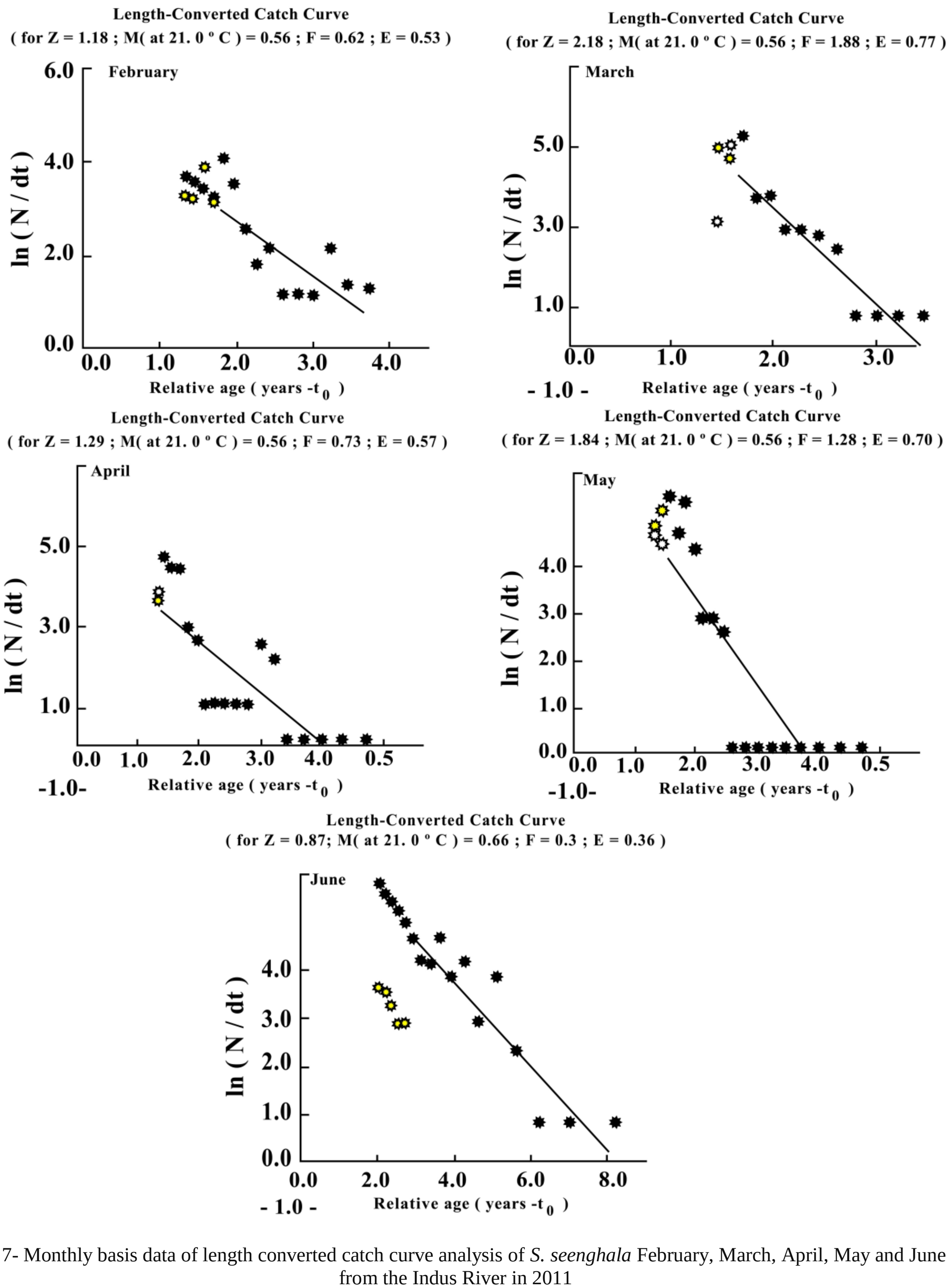

Fig. 7- Monthly basis data of length converted catch curve analysis of *S. seenghala* February, March, April, May and June from the Indus River in 2011

Growth parameters

Von Bertalanffy growth function (VBGF) parameters were determined by ELEFAN-I method using FiSAT-II software package (FAO ICLARM Stock Assessment Tools FiSAT II)[10].

The total length frequency distribution data are grouped at three cm interval (Table 1 and Figure 4). The growth parameters L_∞ and K were calculated as L_∞ = 117.60 (TL cm) and K = 0.370 year^{-1} and

t_0 = - 0.513 for *S. seenghala* (Table 2). The value of t_0 is an indicator of growth rate in juveniles and adults as well. Its negative value means higher rate of growth in juveniles as compared to adults and vice versa. Beverton and Holt[26] suggested that the coefficient of natural mortality M is proportional to the growth coefficient K of a fish and inversely proportional to the length of the asymptotic L_∞ and longevity. In our estimation the growth coefficient K and asymptotic length L_∞ was higher than the estimates by Ramakrishniah[27] for *Sperata aor* L_∞ = 86.0, K = 0.23, t_0 = -0.55 and Ø' = 3.23 values from Nagarjunasagar reservoir India. But Mustafa[28] calculated values for *Mystus tengara* L_∞ = 16.0, K = 1.00 and Ø' = 2.41 from Medi beel, Netrokona District from Bangladesh, however the calculated value of K was higher as compared to our finding. Conversely, there was an estimate of the goodness of fit of the model R_n = 0.362 (Table 2), which is between 0 and 1 and when close to 1 showing better fit[29]. The goodness of fit index or score R_n can be used for the seasonally oscillating growth curves that fits bests in the length frequency data and identify the K values for the growth analysis through the ELEFAN-I method.

Mortality estimation model

The estimated values of Z, M and F for *S. seenghala* were shown in Table 2 and Figure 5. Mortality parameters are total mortality, natural mortality and fishing mortality ratio which may not stop at a stable level, but may change from time to time[30]. The high mortality was seen in March while the lowest mortality was recorded in June (Table 3 and Fig. 7). This may be attributed to the factors such as no availability of food supply rate, development and spawning period of the gonads[31]. No literature was found describing mortality parameters of *S. seenghala* or even any other fish belonging to Bagridae family.

Biological reference points

The current exploitation rate E= 0.444 was lower than the optimum exploitation ratio of E_{opt}= 0.556 $year^{-1}$ according to Gulland[17]. This indicates that the fishery resource of *S. seenghala* in Indus River is not over-fished in Pakistan.

Conclusion

The current fishing mortality rate of *S. seenghala* in Indus River F= 0.444 $year^{-1}$ was below the biological reference point F_{opt} = 0.556 $year^{-1}$, F_{max} = 0.85 $year^{-1}$ and $F_{0.1}$= 0.75 $year^{-1}$. From these revealed results we can assume that the fishery resource of *S. seenghala* in Indus River has strength for the exploitation in Pakistan. This is the first attempt to estimate growth and mortality parameters by using the method of the length converted catch curve analysis and presents the basic information of the stock of this magnificent species, which would be beneficial to the sustainable management of the species in the area.

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References

1. Sykes, W.H., On the fishes of the Deccan. *Proceedings of the general Meetings for Scientific Business of the Zoological Society of London 1838*, 6(1839): p157-165.
2. Jatoi, S., Baloch, W.A., Soomro, A.N., Gachal, G.S., Length-weight relationship of the Silurid catfish *Sperata seenghala* Sykes 1839 (Bagridae) from Indus River, Sindh, Pakistan. *Sindh Uni. Res. J*. (Science Series), 45(2013): p661-664.
3. Talwar, P.K., Jhingran, A.G., *Inland fishes of India and adjacent countries*. Oxford and IBH publishing Co-New Delhi, 2(1991): p545.
4. Jayaram, K.C., *Catfishes of India*. Narendera Publishing House, Delhi, India, (2006): p383.
5. Riede, K., Global register of migratory species from global to regional scales. Final report of the R&D-Projekt 808 05 081. *Federal Agency for Nature Conservation, Bonn, Germany*, (2004): p329.
6. Rahman, M.A., Arshad, A., Amin, S.M.N., Evaluation of growth and production of the threatened giant river catfish, *Sperata seenghala* (Sykes) in polyculture with indigenous major carps. *Afr. J. Biotechnol*, 10(2011): p2999-3008.
7. Sandhu, A.A., Lone, K.P., Food and feeding habits of some catfishes of Pakistan. *Pak. J. Zool*, 35(2003): p71-74.
8. Rahman, M.A., Arshad, A., Yusoff, F.M., Amin, S.M.N., Marimuthu, K., Ara, R., Development of Captive Breeding and Seed Production Techniques for Giant River Catfish *Sperata seenghala*. *N. Am. J. Aquacult*, 76(2014): p97-103.

9. Gupta, S., Review on *Sperata seenghala* (Sykes, 1839), A Freshwater Catfish of Indian Subcontinent, *J Aqua. Res. & Develop*, 6(2015): p290.
10. Gayanilo, F.C., Sparre, P., Pauly, D., FAO ICLARM Stock Assessment Tool (FiSAT-II), User's guide. *FAO Computerized Information Series* (Fisheries), FAO, Rome, No. Worldfish Centrer, No 7(2005): p168.
11. Haddon, M., *Modelling and Quantitative Methods in Fisheries*. Chapman and Hall / CRC Press, London, (2011): p449.
12. Pauly, D., Some simple methods for the assessment of tropical fish stocks. FAO, *Fisheries Technical Paper No. 234*, Rome, Italy, (1983): p52.
13. Pauly, D., On the interrelationships between natural mortality, growth parameters and mean environment temperature in 175 fish stocks, *J. Cons. Int. Explor. Mer,* 39(1980): p175-192.
14. Gulland, J.A., Manual of Methods for Fish Stock Assessment. Part 1. Fish Population Analysis. *Fishery Resources and Exploitation Division*, FAO, Rome, (1969): p154.
15. Pitcher, T.J., Hart, P.J., *Fisheries ecology*. Chapman and Hall, London, (1982): p414.
16. Pauly, D., Munro, J.I., Once more on the comparison of growth in fish and invertebrates. *FishByte*, 2(1984): p21-23.
17. Gulland, J.A., *Fish resources of the ocean*. FAO Fisheries Technical Paper (97). West Byfleet: Survey, Fishing News Books Ltd., (1971): p425.
18. Mushtaq-ur-Rahman., *A Geography of Sindh Province, Pakistan. The Karachi Geographers Association* (Eds). Oxford University Press, Karachi, (1975): p93-96.
19. Suhail, M., Akhund, S., Jatt, T., Mangrio, A.M., Abro, H., Isolation and identification of Penicillium spp., from the bed of River Indus at kotri. *Pak. J. Bot*, 38(2006): p1289-1292.
20. Bhatti, M.A., Water Resource System of Pakistan. Status and Issues. *Pakistan Science Foundation, Islamabad*. ISBN. 969- 8040-14-5, (1999): p72.
21. Ricker, W.E., Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Canada*. 191(1975): p379-382.
22. Wootton, R.J., *Ecology of teleost fishes*. Chapman and Hall, London, (1990): p404.
23. Gayanilo, F.C., Pauly, D., FAO-ICLARM stock assessment tools (FiSAT), *Reference Manual Comparative Information Series* (Fish), Rome, 8(1997): p262.
24. Sarkar, U.K., Khan, G.E., Dabas, A., Pathak, A.K., Mir, J.I., Rebello, S.C., Pal, A., Singh, S.P., Length Weight relationship and condition factor of selected fresh water fish species found in River Ganga, Gomti and Rapti India. *J. Environ. Bio*, 34(2013): p951-956.
25. Sharma, N.K., Mir, J.I., Singh, R., Akhtar, M.S., Pandey, N.N., Length-weight relationships for eight fish species from the Ravi River, north-western India. *J. Appl. Ichthyol*, (2015) p1-2.
26. Beverton, R.J., Holt, H.S.J., A review of method for estimating mortality rates in exploited fish population, with special reference to source of bias in catch sampling. *Rapp. P. V. Reun. CIEM*. 140**(**1956): p67-83.
27. Ramakrishniah, M., Age, growth and fishery of *Mystus aor* (Hamilton) from Nagarjuasagar reservoir. In: The first Indian fisheries forum proceedings, M. Mohan Joshep (Ed.). *Asian Fisheries Society*, India Branch, Mangalore, (1988): p185–198.
28. Mustafa, M.G., Graaf, G., Population parameters of important species in inland fisheries of Bangladesh. *Asian Fish. Sci*, 21**(**2008): p147-158.
29. Gayanilo, F.C., Sparre, P., Pauly, D., FAO-ICLARM Stock Assessment Tools (FISAT-II) User's Guide. *Computerized Information Series*, FAO, Rome, Italy, (2002).
30. Sparre, P., Venema, S.C., Introduction to Tropical Fish Stock Assessment. Part 1. Manual, *FAO Fisheries Technical Paper No. 306/1*, FAO, Rome, (1992): 376p.
31. Bagenal, T.B., Tesch, F.W., *Age and growth*. In: T. Bagenal, Editor, Methods for Assessment of Fish Production in Fresh Waters. IBP Handbook No. 3 (3^{rd} eds). Blackwell Scientific Publications Oxford. 5(1978): p101–136.