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Population dynamics of *Puntius sophore* (Hamilton, 1822) of river Sutlej in Punjab (India)

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Abstract

Aim: The aim of the present paper was to describe first and comprehensive picture on length-weight relationship and population dynamics of riverine *Puntius sophore*. The findings of the investigation will be an imperative part of the ecological database from river Sutlej.

Methodology: The length-frequency data of 579 specimens of *P. sophore* captured from different stretches of river Sutlej were collected fortnightly from Tajpur fish market and Haibowal fish market (Devnagar) during April 2019 to March 2020. All the population parameters were analyzed using FISAT II analytical package developed by FAO.

Results: The estimated length-weight relationships (LWRs) of combined male and female was derived as $W=0.1471 L^{3.0605}$ ($r=0.98$). The growth parameters were $L_{\infty}=123.5$ mm, $K=1.18$ yr⁻¹, $t_0=-0.7672$ yr⁻¹, $R_n=0.215$ and $\phi'=4.241$. The estimated natural mortality coefficient (1.25 per yr) was greater than fishing mortality (1.03 yr⁻¹). The present level of exploitation ($E=0.45$, $U=0.40$) of *P. sophore* stock indicated that stocks were under-exploited. Prediction of maximum length from extreme values at 95% confidence interval was calculated as 112.48-138.24 mm. The recruitment pattern of *P. sophore* showed peaks during May and June.

Interpretation: The *P. sophore* stock was under-exploited. The fishing intensity may be standardized to obtain optimum yield per recruit and thereby ideal maximum sustainable yield. This baseline information will help in further studies on the stock assessment and formulating strategies for rational exploitation of the species.

Key words: LWRs, Population dynamics, *Puntius sophore*, River Sutlej

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Introduction

Puntius sophore famous as Pool barb is a small indigenous fish belonging to the family Cyprinidae, which manifest variation of color pattern on the epidermis, fin and fin rays. This species is broadly distributed in the Indian sub-continent and Asian countries (Patel *et al.*, 2020 and Kumar *et al.*, 2020). The genus *Puntius* has greater prominence in economic view. Several fish species of this genus are significant as ornamental species, while some particular fish species are used for food and oil extraction (Abdul *et al.*, 2002). Pethiyagoda *et al.* (2012) observed that this genus *Puntius* comprised as many as 120 valid species in tropical Asian region. In freshwater ecosystem, the species of this genus occur in pond, wetland, lake, rivers and also in hill-stream freshwater ecosystem (Craig *et al.*, 2004; Kumar *et al.*, 2020). The comprehensive nutrient profile of Pool barb is recognized to be opulent source of animal proteins, fatty acid, micronutrient and vitamins (Mahanty *et al.*, 2014). Still small in size, it has high value in the market and plays an important role to meet the nutritional requirements of rural people. However, the abundance of *P. sophore* stock from natural resources are diminishing rapidly either due to over exploitation of resources by fisherman or because of aquatic pollution and gradual siltation causing alteration of ecological habitat, which has made adverse impact on the ecological niche (Mukherjee *et al.*, 2002).

This species is classified under IUCN as LRlc (Lower Risk-Least Concern) in the Western Ghat region (Balasundaram *et al.*, 2000), in Harike wetland (Punjab)—a Ramsar wetland (Dua and Parkash, 2009) and in Gomti river, a tributary of Ganga river (Sarkar *et al.*, 2010). Several attempts have been made to study the reproductive features and length-weight relationship in Indian waters (Alam *et al.*, 2014; Choudhury *et al.*, 2015 and Kant *et al.*, 2016) and breeding ground profile in Damodar River System (Sarkar and Banerjee, 2010). Studies on population parameters are necessary to formulate fishing management policy to obtain the maximum sustainable yield. This study describes the population parameters of *P. sophore* from river Sutlej using length frequency distribution data. The river Sutlej water is distributed under the Indus river system and mostly diverted for irrigation proposes through the canals in Punjab (India). River Sutlej along district Ludhiana supports small indigenous fishes despite deteriorating water quality in the region as per the existing scenario (Kumar *et al.*, 2020). The rivers are facing threat due to increasing industrial pollution (Jaidka and Hundal, 2016).

In order to manage the stock effectively, it is essential to recognize the cause for declining the fishery resources and understand the ecology of the species. Though, unlike marine environment, data on exploited population of fish species in riverine resources are meager (Maccord *et al.*, 2007; Dwivedi and Nautiyal, 2012). The management and sustainable utilization of a species is easier by knowing the population dynamics of that species. Subsequently, the aim of the present work is to describe first and comprehensive picture of population dynamics and length-weight relationships (LWRs) of the riverine *P. sophore*.

Materials and Methods

The data on length and weight composition were collected fortnightly from Tajpur fish market (30°55'8.12"N, 75°54'1.48"E) and Haibowal fish market (Devnagar) (30°55'05.3"N, 75°47'29.9"E) during April 2019 to March 2020. The fishes were mainly caught by the indigenous traditional fishing gears like drag net, gill net and lift net from different stretches of river Sutlej near Ludhiana, Punjab (India). A total of 579 specimens of *P. sophore* in the size range of 40-120 mm were randomly collected during field visit and used for analysis. Total length of the fish was measured nearest to 0.1mm (tip of snout to lower caudal lobe) and weight 0.01g. Fish were identified up to species level by using standard taxonomic keys (Froese and Pauly, 2020). LWRs of *P. sophore* was evaluated by the formula, $W=aL^b$. Fulton's condition factor (K) was evaluated by the equation: $K=100 \times (W/L^3)$.

ELEFAN 1 method was applied to access the von Bertalanffy growth variables viz. asymptotic length (L_∞) and growth co-efficient (K). Pauly's equation " $\log_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$ " (Pauly *et al.*, 1983) was used to interpret another growth parameter, i.e., age at length zero (t_0). Growth performance index (ϕ') was computed by the formula " $\phi' = \log_{10} K + 2 \log_{10} L_\infty$ ". Estimates of maximum length (L_{max}) were obtained using extreme value theory as applied in the FiSAT (Gayanilo *et al.*, 2005). The natural mortality rate (M) was interpreted by Pauly's empirical equation (L_∞ was taken in mm); taking mean Sutlej river water temperature at 24.2°C Sharma *et al.* (2018). The exploitation ratio (E) was calculated as " $E = F/Z$ " and the exploitation rate was computed as " $U = F/Z (1 - e^{-Z})$ ". Length structured-Virtual Population Analysis (VPA) was used to acquire fishing mortalities (F) per length class. The relative biomass (B'/R) and relative yield (Y'/R) at different fishing levels were estimated by Beverton and Holt's relative yield per recruit analysis method using FiSAT II analytical packaged developed by FAO-ICLARM (Gayanilo *et al.*, 2005).

Results and Discussion

The total length-weight data of *P. sophore* were pooled to a single equation and found to be $\log W = -1.9188 + 3.0605 \log L$ and the parabolic equation derived as $W = 0.1471 L^{3.0605}$. A positive correlation ($r=0.98$) was interpreted between length and weight. The 'b' value of 3.0605 sign posted that LWRs followed the correlation with positive allometric growth pattern. The b values were within the projected limits as stated 2.5–3.5 (Froese, 2006). In this study, the 'b' value (>3) indicated a positive allometric growth for *P. sophore* and fish remained in a healthy condition. The asymptotic length (L_∞) was found to be 123.5 mm in the present study. Similarly, asymptotic length (L_∞) 135 mm was recorded by Mustafa and Graaf (2008) and 130 mm was reported by de Graff (2003) from the Brahmaputra (Jamuna) River, Tangail, Bangladesh which is in accordance with the present study. Branstetter (1987) categorized fish species based on 'K'

Fig. 1: von Bertalanffy restructured growth curve of *P. sophore* superimposed on the restricted length frequency histogram with normal length-frequency histograms ($L_{\infty} = 123.5$ mm, $K = 1.18$ per yr, $t_0 = -0.7672$ per yr, $C = 0$, $WP = 0$ and $R_n = 0.215$). Lines superimposed on the histograms link successive peaks of growing cohorts as extrapolated by the model.

Fig. 2: Prediction of maximum length from extreme values. Predicted $L_{\max}$ for a given sample size n , and its confidence limits (here for 95% probability). The predicted $L_{\max}$ value and 95% confidence interval were obtained from the intersection of overall maximum length with the line y and x , z , respectively.

value as slowly growing species (0.05-0.10 per yr), average growing species (0.10-0.20 per yr) and rapidly growing species (0.20-0.50 per yr). Based on these criteria, *P. sophore* in River Sutlej showed rapid growth rate (1.18 per yr) whereas similar growth coefficient in *P. sophore* was recognized by Mustafa and Graaf (2008) 1.1 per yr and Ahamed *et al.*, (2012) 0.93 per yr for male and 1.03 per yr for female in their study.

The enumerated growth curves of *P. sophore* revealed over restructured length distribution of individual species (Fig. 1). The growth performance indices (ϕ') obtained for *P. sophore* (4.241) was excellent. Using extreme value theory, the

Fig. 3: Estimation of Z from length converted catch curve method with extrapolated data points.

observed length and predicted maximum length ($L_{\max}$) for *P. sophore* was calculated as 117.5 mm and 125.36 mm, respectively. The range at 95% confidence interval for extreme length was calculated as 112.48-138.24 mm (Fig. 2).

The value of Z was accounted to be $Z=2.26$, $M=1.25$ per yr and $F=1.01$ per yr (Fig. 3). In terms of consensus, for instance several investigators have observed mortality rate of *P. sophore* in their study viz., $\{Z=6.55, M=2.93, F=3.62$ per yr $\}$ (Mustafa and Graaf, 2008); $\{Z=2.99, M=1.43, F=1.60$ per yr $\}$ for male and $\{Z=3.11, M=1.56, F=1.51$ per yr $\}$ for female (Ahamed *et al.*, 2012). Hence, the present investigation describes the estimated natural

Fig. 4: Length structured VPA. The virtual population analysis revealed maximum fishing mortality (1.03 yr⁻¹) at the mid length of 117.5 mm.

Fig. 5: Recruitment percentage of pooled population of *P. sophore*. The recruitment pattern of *P. sophore* indicated continuous addition of individuals in the fishery throughout the year with the peaks during May and June.

Fig. 6: Probabilities of capture pattern of pooled population of *P. sophore*.

mortality coefficient was greater than fishing mortality. Mostly, the mortality may be caused by natural factors like diseases, predation, environmental transitions, hazards and toxic waste in the case of exploited stock. On the other hand, by applying F and Z values, the assessed exploitation ratio (E) was 0.45 whereas exploitation rate (U) was 0.40. The exploitation ratio of 0.45 indicates that *P. sophore* stocks are under exploited (Fig. 3). Gulland (1971) stated that the stock is considered to be exploited

optimally when $F=M$ or $E=0.50$ and, if E is greater than 0.50, the stock is usually overexploited. Mustafa and Graaf (2008) observed the mean exploitation rate for *P. sophore* was 0.75, i.e., overexploited. The virtual population analysis revealed maximum fishing mortality (1.03 per yr) at the mid length of 117.5 mm (Fig. 4). Mortality due to fishing (F) was recognized to be less than natural causes (M), and therefore it can be concluded that the stock is under exploited. The fishing pressure can be increased

Fig. 7: Relative yield per recruit and biomass per recruit as a function of exploitation.

Fig. 8: Yield isopleths diagram (Recruit analysis knife-edge).

until $E_{\max}$ (0.50) to get maximum sustainable yield for *P. sophore* in river Sutlej. The recruitment pattern of *P. sophore* indicated continuous addition of individuals in the fishery throughout the year with the peaks during May and June (Fig. 5).

The rate of recruitment varied from 0.83 to 21.47 %. The highest recruitment was observed in June (21.47 %) whereas the lowest recruitment was observed during January and February. Phukon and Biswas (2012) and Langer (2013) reported the

breeding season of *P. sophore* mainly during May to June. Hasan *et al.* (2018) identified the breeding season of Pool barb through histological data and revealed that the spawning season of Pool barb begins from March till July with a peak during April to May. The estimated probability of length at first capture (L_c) is shown in Fig. 6. The data were corrected for selection using selection parameters. Length at 25 percent (L_{25}) of fish vulnerable to the gear was 50.92mm while L_{50} of fish vulnerable to the gear was 57.48 mm and L_{75} was 64.03 mm (Fig. 7). The L_c/L_{∞} and M/K

values were found to be 0.46 and 1.06, respectively. The evaluated M/K value was 1.06 which stipulated lower stress. The reliability of natural mortality was determined by M/K ratio, ranging between 1 and 2.5 for most of fishes and the value recorded is in agreement with Beverton and Holt (2012). The B'/R and Y'/R of *P. sophore* is furnished in Fig. 8. The Y'/R reached maximum at an exploitation rate ($E_{\max}$) of 0.704, and with simultaneous increase in the 'E', the Y'/R decreased (Fig. 8). It may be noted that the present 'E' (0.45) did not exceed the limit of maximum exploitation rate $E_{\max}=0.704$.

A study conducted by deGraaf (2003) for *P. sophore* showed the mean exploitation rate to be 0.40. Likewise $E_{0.1}$, the exploitation level at which the minimal rise in Y'/R was 10%. The values of $E_{0.1}$ and $E_{0.5}$ were evaluated to be 0.607 and 0.351, respectively. The yield isopleths diagram showed that optimum relative yield per recruit obtained at L_{∞}/L_0 of 0.55 and E of 0.5. The river Sutlej was considered with immense biodiversity and supporting diversity of fishes. From the study it can be concluded that *P. sophore* stock was under-exploited. The fishing intensity may be standardized to obtain optimum yield per recruit and there by ideal maximum sustainable yield. Furthermore, regular monitoring of *P. sophore* stock should be undertaken for determining its population status in river Sutlej. This study provides a strong baseline data for further research on Pool barb with an aim of establishing some aspect of reproductive biology. Moreover, in this way, the small indigenous species of our country can be sustainably exploited.

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Add-on Information

Authors' contribution: J. Kumar: Designed the study, performed the work (Length and weight), identification, data analysis and drafting manuscript; S. N. Datta: Manuscript correction and helped in writing result part mainly recruitment pattern and VPA; G. Tewari: Helped in data analysis particularly length-weight relationship of fish; S.S. Hassan: Collection of review literature and helped in writing discussion part of manuscript; S. Dubey: Helped in data analysis and interpretation of results particularly Rn scan for L_{∞} and prediction of extreme length.

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References

- Abdul, M.A., A. Mandal and B. Bhuiya: Assessment of indigenous carp population in Andhra Pradesh. *Fishe. Bull. AP*, **12**, 31-48 (2002).
- Ahamed, F., Z.F. Ahmed, M.Y. Hossain and J. Ohtomi: Growth study of the pool barb *Puntius sophore* (Cyprinidae: Barbinae) through multi-model inferences. *Zool. Stud.*, **51**, 1077-1085 (2012).
- Alam, M.M., S. Ahmad and M.A. Hussain: Ovarian development and reproductive cycle of two freshwater barbs, *Puntius sophore* and *Puntius ticto*. *Front. Biol. Life Sci.*, **2**, 12-15 (2014).
- Alam, A., D.N. Jha, S.K. Verma, H. O. Verma, S. K. Mishra, S. C. S. Das, J. Kumar, V. R. Thakur, M. Gupta, B. K. Das: Length-weight relationships of four small indigenous freshwater fishes from the subtropical Ganga River, India. *Lak. Reserv.*, **25**, 419-422 (2021). <https://doi.org/10.1111/lre.12337>
- Balasundaram, C., R. Arumugam and P.B. Murugan: Fish diversity of Kolli hills, Western Ghats, Salem district, Tamil Nadu. *Zoos Print J.*, **16**, 403-406 (2000).
- Beverton, R. J. and S. J. Holt: On the dynamics of exploited fish populations. Fish & Fisheries Series. Springer Science & Business Media, **Vol. 11**, 538 pages (2012).
- Branstetter, S.: Age and growth estimates for black-tip, *Carcharhinus limbatus*, and spinner, *Carcharhinus brevipinna*, sharks from the North-western Gulf Mexico. *Copeia*, pp. 964-974 (1987).
- Choudhury, T.G., S.K. Singh, A. Baruah, A. Das, A. Parhi, P. Bhattacharjee and P. Biswas: Reproductive features of *Puntius sophore* (Hamilton 1822) from Rivers of Tripura, India. *Fish. Technol.*, **52**, 140-144 (2015).
- Craig, J.F., A.S. Halls, J.J.F. Barr and C.W. Bean: The Bangladesh floodplain fisheries. *Fish. Sci.*, **66**, 271-286 (2004).
- deGraaf, G.: Dynamics of floodplain fisheries in Bangladesh, results of 8 years fisheries monitoring in the Compartmentalization Pilot Project. *Fish. Manag. Ecol.*, **10**, 191-199 (2003).
- Dua, A. and C. Parkash: Distribution and abundance of fish populations in Harike wetland-A Ramsar site in India. *J. Environ. Biol.*, **30**, 247-251 (2009).
- Dwivedi, A.C. and P. Nautiyal: Stock assessment of fish species *Labeo rohita*, Tor tor and *Labeo calbasu* in the rivers of Vindhyan region, India. *J. Environ. Biol.*, **33**, 261-264 (2012).
- Froese, R.: Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *J. Appl. Ichthyol.*, **22**, 241-253 (2006).
- Gayani, F.C.Jr., P. Sparre and D. Pauly: FAO-ICLARM stock assessment tools II (FISAT II). Revised version, user's guide, FAO computerized information series (Fisheries). No. 8, Rome, FAO (2005).
- Gulland, J.A.: The Fish Resources of Ocean. West By fleet Survey Fishing News (Books) Ltd, FAO (1971).
- Hasan, T., M.F. Hossain, M. Mamun, M.J. Alam, M.A. Salam and S.M. Rafiquzzaman: Reproductive biology of *Puntius sophore* in Bangladesh. *Fishes*, **3**, 22 (2018).
- Jaidka, A. and S.S. Hundal: Histological changes in gills and liver of fishes in river Sutlej as an effect of Buddha Nullah pollution at Ludhiana. *Int. J. Life Sci.*, **5**, 87-92 (2016).
- Kant, K.J., K. Gupta and S. Langer: Fecundity in fish *Puntius sophore*

- and relationship of fecundity with fish length, fish weight and ovary weight from Jammu water bodies J & K (India). *Int. J. Fish. Aquac. Sci.*, **6**, 99–110 (2016).
- Kumar, J., S.S. Hassan, G. Tewari and S.N. Datta: Assessment of ichthyofaunal diversity of river Sutlej in district Ludhiana, Punjab (India). *J. Anim. Res.*, **10**, 01-07 (2020).
- Langer, S.: Reproductive cycle and oogenesis of *Puntius sophore* from Gho-Manhasan stream of Jammu region, India. *Int. J. Sci. Res. Pub.*, **3**, 1–4 (2013).
- Maccord, P.F.L., R.A.M. Silvano, M.S. Ramires, M. Clauzet and A. Begossi: Dynamics of artisanal fisheries in two Brazilian Amazonian reserves: Implications to co-management. *Hydrobiologia*, **583**, 365–376 (2007).
- Mahanty, A., S. Ganguly, A. Verma, S. Sahoo, P. Mitra, P. Paria, A.P. Sharma and B.P. Mohanty: Nutrient profile of small indigenous fish *Puntius sophore*: Proximate composition, amino acid, fatty acid and micronutrient profiles. *Natl. Acad. Sci. Lett.*, **37**, 39–44 (2014).
- Mukherjee, M., A. Praharaj and S. Das: Conservation of endangered fishstocks through artificial propagation and larval rearing technique in West Bengal, India. *Aquac. Asia*, **7**, 8–11 (2002).
- Munilkumar, S., Y. Rameshori, W.R. Mangang, M. Kamei, Y. Chinglemba, A. Pavan-Kumar, B. K. Mahapatra, A. Das, M. A. Hanif, M. A. B. Siddik: Length-weight relationships of six Nemacheilid fish species (Teleostei: Cypriniformes) from different rivers of Manipur, India. *J. Appl. Ichthyol.*, **37**, 356–358 (2021).
- Mustafa, M.G. and G.D.E. Graaf: Population parameters of important species in inland fisheries of Bangladesh. *Asian Fish. Sci.*, **21**, 147–158 (2008).
- Patel, M., M.S. Ashraf, A.J. Siddiqui, S.A. Ashraf, M. Sachidanandan, M. Snoussi, M. Adnan and S. Hadi: Profiling and role of bioactive molecules from *Puntius sophore* (Freshwater/Brackish Fish) skin mucus with its potent antibacterial, antiadhesion, and antibiofilm activities. *Biomolecules*, **10**, 920 (2020).
- Pauly, D.: Some simple methods for the assessment of tropical fish stocks. FAO, Fisheries Technical Paper No. 234, 52 pages (1983).
- Pethiyagoda, R., M. Meegaskumbura and K. Maduwage: A synopsis of the South Asian fishes referred to *Puntius* (Pisces: Cyprinidae). *Ichthyol. Explor. Freshw.*, **23**, 69–95 (2012).
- Phukon, H.K. and S.P. Biswas: Observation on the maturity index and fecundity of *Puntius sophore* (Ham-Buch) from upper Assam. *Asi. J. Exp. Biol. Sci.*, **3**, 247–250 (2012).
- Roul, S.K., A.R. Akhil, T.B. Retheesh, K.M. Rajesh, U. Ganga, E.M. Abdussamad and P. Rohit: Length-weight relationships of fifty fish species from Indian waters. *Thalassas: An Int. J. Mar. Sci.*, **36**, 309–314 (2020).
- Sidiq, M., I. Ahmed, Y. Bakhtiyar: Length-weight relationship, morphometric characters, and meristic counts of the coldwater fish *Crossocheilus diplocheilus* (Heckel) from Dal Lake. *Fisher. Aqua. Life*, **29**, 29–34 (2021).
- Sarkar, L. and S. Banerjee: Breeding ground profile of food fish species in Damodar river system. *Int. J. Bio.*, **2**, 51–61 (2010).
- Sarkar, U.K., B.K. Gupta and W.S. Lakra: Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India). *Environmentalist*, **30**, 3–17 (2010).
- Sharma, C., R. Jindal, U.B. Singh and A.S. Ahluwalia: Assessment of water quality of river Sutlej, Punjab (India). *Sust. Wat. Res. Manag.*, **4**, 809–822 (2018).
- Tsionki, I., O. Petriki, I.D. Leonardos, P.K. Karachle and M.T. Stoumboudi: Length-weight relationships of 6 fish species caught in a Mediterranean lake (Trichonis-NW Greece). *J. Appl. Ichthyol.*, **37**, 631–634 (2021).
- Zhu, L., X. Xue, G. Zhang and Z. Wang: Length-weight relationships of fish species from the Stung Russei Chrum River basin, Kingdom of Cambodia. *J. Appl. Ichthyol.*, **37**, 354–355 (2021).