



## Biometric evaluation of Gangetic pool barb *Puntius sophore* (Hamilton, 1822) from the River Ganga, Bihar, India

S. K. AHIRWAL, JASPREET SINGH, TARKESHWAR KUMAR, VIVEKANAND BHARTI, KAMAL SARMA AND DEVA NARAYAN

ICAR-Research Complex for Eastern Region, Patna - 800 014, Bihar, India

e-mail: surendraahirwal@gmail.com

### ABSTRACT

The Gangetic pool barb *Puntius sophore* (Hamilton, 1822) is widely distributed in the freshwater ecosystems of the Indian subcontinent and it is reasonably well-priced due to its nutritional value. A study was conducted to assess the morphometry, length-frequency distribution (LFD), length-weight relationship (LWR), condition factor (CF) and sex ratio of *P. sophore* collected from the Digha Ghat Patipul in Patna, between March 2019 and February 2020. Fifteen morphometric characters and nine meristic counts of 137 specimens were examined for biometric evaluation and 982 samples (1.56-22.09 g TW, 51.06-115.11 mm TL) were analysed for LFD, LWR and CF, respectively. LFD revealed that 28.49% of the males sampled were in the 75-80 mm length class, while 15.94% of the total females sampled were in the 70-75 mm length class. In morphometric analysis, significant correlations were found across the variables and the highest correlation was observed between total length and standard length ( $r > 0.981$ ). LWR exponent value showed positive allometric growth patterns for male, female, and combined sexes, respectively. Condition factor showed no significant variation between the sexes and the observed average values were 1.06 and 1.24 for males and females, respectively ( $p < 0.05$ ). Analysis of the sex ratio showed that females outnumbered males from the 85-90 mm length group onwards and no male specimens were found beyond the 105-110 mm length group.

Keywords: Condition factor, Length-weight relationship, Morphometry, *P. sophore*, Sex ratio

### Introduction

The Gangetic pool barb *Puntius sophore* (Hamilton, 1822), belongs to the family Cyprinidae and is widely distributed in the freshwaters of the Indian subcontinent, including Afghanistan, Bangladesh, Bhutan, India, Myanmar, Nepal and Pakistan (Talwar and Jhingran, 1991). It is usually found in rivers, streams, beels and floodplain areas of India. It fetches a good market price due to its nutritional value and delicious taste (Jayaram, 1991). It plays a significant role in India's economy and livelihood and contributes as an economic source of protein and income for local people. Besides its utilisation in human food consumption, it also has value in the Indian ornamental fish market due to its bright colouration, small size and adaptability to the confined ecosystem (Collins *et al.*, 2012). Rapid human expansion and anthropogenic activities drastically declined the *P. sophore* stock in the Kolli Hills-Western Ghat and Harike wetland-Ramsar site, and it is now considered as a near-threatened species (Balasundaram *et al.*, 2000; Dua and Prakash, 2009).

Length frequency distribution (LFD) studies provide information on fish life history traits such as stock conditions, health status and spawning periodicity

(Ranjan *et al.*, 2005). Morphometric measurements and meristic counts are frequently used to identify fish species (Nayman, 1965). They play a vital role in determining the possible differences between separate unit stocks of the same species (King, 2007) and also help determine whether a stock is heterogeneous or homogeneous based on the interrelationship between different length variables (Ahirwal *et al.*, 2017). Length-weight relationship (LWR) is an important tool for estimating weight from the known length and *vice-versa*, duration of gonad development and maturity of fishes (Le-Cren, 1951). It provides valuable information for the estimation of stock assessment parameters such as mean length, age structures and the growth rate of fish (Kolher *et al.*, 1995). Condition factor evaluates fish's health status, growth and feeding intensity (Froese, 2006). Observations on the sex ratio indicate the patterns of dominance of the two sexes in a population (Ahirwal *et al.*, 2021) and may reveal differential fishing, and differences in the growth rates of the two sexes (Qasim, 1966). Previously studies on morphometry, LWR and condition factor have been carried out on *P. sophore* from different geographical areas of India and adjacent countries (Hamilton, 1822; Day, 1878; Murty, 1975; Graff, 1985; Jayaram, 1991; Reddy and Rao, 1992; Halls *et al.*, 1999; Mitra *et al.*, 2005;

Hossain *et al.*, 2006; Ahamed *et al.*, 2012; Pal *et al.*, 2013; Kaushik and Bordoloi, 2015; Rahman *et al.*, 2018).

Despite all the above studies, there is no collective information on LFD, morphometry, LWR, condition factor and sex ratio of *P. sophore* from the Ganga River. Hence, the present study was conducted to establish baseline data on important biometric parameters of *P. sophore* from the Ganga River, Patna, Bihar.

## Material and methods

### Sampling sites

Patna lies on the southern bank of the Ganga, where it joins with other important rivers such as Ghaghara, Gandak, Son and Punpun to create a unique aquatic ecosystem. In the current study, 982 specimens (51.06-115.11 mm in TL, 1.56-22.09 g TW) were collected monthly by the *Current Jal* or drift gillnet (80-100 m long, 10-15 mm mesh size, operation time 4 h) and *Khairil Jal* (length 7-8 m, mouth width 10 m, cod-end width 1 m, cod-end mesh size 5-10 mm) operated near to the shore of Digha Ghat Patipul (25°40'8.4"N; 85°0'18"E) of Ganga River, Patna. Each individual's total length was measured between the tips of the snout and the caudal fin to the nearest 1 mm using a digital vernier caliper (Insize - 0/150 mm) and weight was recorded to the nearest 1 g using a digital balance (WENSAR TM-MAB 220).

### LFD and morphometry

The LFDs were plotted using 5 mm length intervals to observe the male and female population structure. The fifteen morphometric measurements analysed were: Total length (TL), Standard length (SL), Pre-dorsal length (PDL), Pre-pectoral length (PPL), Pre-ventral length (PVL), Pre-anal length (PAL), Head length (HL), Body depth (BD), Dorsal fin length (DFL), Caudal fin length (CFL), Caudal peduncle depth (CPD), Snout length (SNL), Eye diameter (ED), Post-orbital length (POL) and Inter-orbital length (IOL) (Fig. 1). Nine meristic counts taken for analysis included: number of rays in dorsal fin (DFR), pectoral fin (PFR), ventral fin (VFR), anal fin (AFR) and caudal fin (CFR); number of gill rakers on first left gill arch (GR), number of pre-dorsal scales (PDS), number of scales on transverse line (STL) and number of scales on lateral lines (SLL).

The scatter diagram of morphometric characters was plotted and a linear regression was fitted using the least square method (Snedecor and Cochran, 1967). The relationship was represented as  $Y=a+bx$ , where  $a$ ,  $b$  and  $r$  are the intercept, regression co-efficient and correlation coefficient, respectively. The descriptive statistics for

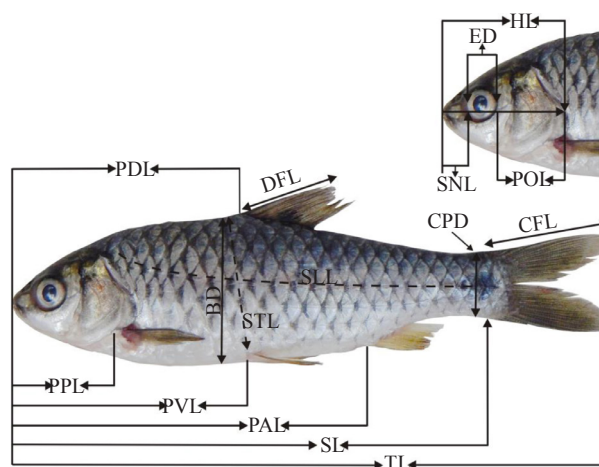


Fig. 1. Selected morpho-meristic characters of *P. sophore*. TL - Total length, SL - Standard length, PDL - Pre-dorsal length, PPL - Pre-pectoral length, PVL - Pre-ventral length, PAL - Pre-anal length, HL - Head length, BD - Body depth, DFL - Dorsal fin length, CFL - Caudal fin length, CPD - Caudal peduncle depth, SNL - Snout length, ED - Eye diameter, POL - Post-orbital length, STL - Scales on transverse line, SLL - Scales on lateral lines

meristic characters, including mean, mode, median, standard error and coefficient of variation, were calculated.

### LWR and growth pattern

The LWR was established separately for male, female and combined sexes using the formula  $W = aL^b$ , where  $W$  is the weight of fish in g and  $L$  is the total length of fish in mm,  $a$  is the intercept and  $b$  is the regression coefficient (Le-Cren, 1951). ANCOVA was attempted to determine variations in exponent  $b$  values among the sexes ( $p=0.05$  and  $p=0.01$ ). To test deviations of  $b$  values from isometry, student's t-test was employed. Isometric growth is considered for a fish species when the estimated exponent value  $b$  is close to 3. If  $b$  values deviate from 3, growth is said to be either negative allometric ( $b<3$ ) or positive allometric ( $b>3$ ).

### Condition factor and sex ratio

Condition factor for the species was calculated according to the formula:  $K=W*10^5/L^3$ , where  $W$  represents weight in gram and  $L$  represents length in centimeter (Fulton, 1904). The sex ratio was calculated using the chi-square method:  $\chi^2 = (O-E)^2/E$ , where  $O$  is the observed number of fishes and  $E$  expected number of fishes and significance ( $p=0.05$ ) was also noted (Snedecor and Cochran, 1967).

## Results

### LFD and morphometry

The LFD for 952 specimens of *P. sophore* (males, n = 524; females, n = 428) is given in Fig. 2. Observations revealed that 28.49% of the total males sampled were in the 75-80 mm length class, while 15.94% of the total females sampled were in the 70-75 mm length class. Females reached their maximum size of 115.11 mm while males reached 109.41 mm. The maximum weight of the species observed in the present study was 22.06 g.

A total of 137 specimens were observed for morphometric and meristic characters. Measurements of various morphometric characters, their range, mean, mode, median, standard error and coefficients of correlation revealed maximum value of coefficients of variation for ED (24.44%) and minimum (12.81%) for DFL (Table 1).

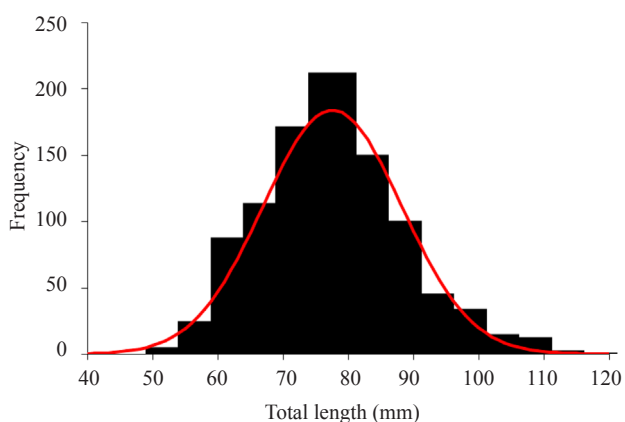


Fig. 2. Length-frequency distribution for combined sexes of *P. sophore*

Regressions of SL, PDL, PPL, PVL, PAL, HL, BD, DFL, CFL and CPD against TL and SN, ED, POL and IOL against HL, were also established. The correlation coefficient for TL against other morphometric characters ranged from 0.8010 to 0.9809. TL showed the maximum degree of association with SL while minimum with PDL. Similarly, HL showed the maximum degree of association with ED and minimum with IOL (Table 2).

Analysis of meristic characters indicated maximum coefficients of variation (10.37%) for GR and minimum for SLL (3.60%). The species possessed 8-10, 12-15, 7-9, 6-8 and 18-22 rays on dorsal, pectoral, ventral, anal and caudal fins, respectively. The number of lateral line scales, pre-dorsal and transverse lines varied from 22-26, 7-9 and 7-9, respectively. The number of GR on the left first gill

Table 2. Relationship of various morphometric characters (all lengths in mm) of *P. sophore*

Parameters	a	b	r
TL and SL	-3.729	0.841	0.981
TL and PDL	-1.061	0.406	0.946
TL and PPL	1.404	0.183	0.801
TL and PVL	-3.649	0.419	0.925
TL and PAL	-7.521	0.640	0.928
TL and HL	1.577	0.183	0.876
TL and BD	-10.609	0.381	0.879
TL and DFL	2.697	0.154	0.817
TL and CFL	4.744	0.145	0.815
TL and CPD	-1.255	0.120	0.826
HL and SN	0.919	0.263	0.818
HL and ED	-0.283	0.216	0.813
HL and POL	-0.256	0.497	0.854
HL and IOL	-0.841	0.547	0.864
BD and CPD	2.215	0.308	0.902

Table 1. Descriptive statistics of various morphometric characters (all lengths in mm) of *P. sophore*

Parameters	Min	Max	Mean±SE	Median	Mode	SD	CV (%)
TL	51.06	115.11	83.88±1.00	82.09	84.31	11.76	14.02
SL	40.59	92.71	67.00±0.83	65.63	65.15	9.69	14.47
PDL	24.34	45.25	32.81±0.39	31.84	38.84	4.58	13.94
PPL	12.43	23.54	16.93±0.21	16.58	17.39	2.29	13.51
PVL	21.19	44.23	31.53±0.41	30.53	31.31	4.81	15.24
PAL	30.91	63.35	45.81±0.61	44.36	49.59	7.16	15.63
HL	11.29	23.68	17.03±0.20	16.62	18.22	2.33	13.65
BD	13.47	30.36	20.95±0.35	19.67	27.76	4.04	19.28
DFL	11.95	21.89	15.63±0.17	15.23	15.23	2.00	12.81
CFL	9.91	24.8	17.01±0.21	16.96	16.62	2.49	14.63
CPD	6.28	12.61	8.73±0.12	8.47	8.04	1.37	15.65
SNL	3.79	7.04	5.40±0.23	5.24	5.29	0.75	13.84
ED	1.12	5.45	3.26±0.07	3.24	3.28	0.80	24.44
POL	5.85	12.12	8.38±0.12	7.94	8.98	1.37	16.32
IOL	5.93	12.55	8.32±0.11	8.21	8.29	1.24	14.89

arch varied from 15 to 23 (Table 3). Data analysis revealed no significant variation in the morphometric characteristics of *P. sophore* within the population, suggesting that a homogenous stock of the species occurs along the river Ganga. Based on present results, the fin formula for the species can be written as  $D_{8-10} P_{12-15} V_{7-9} A_{6-8} C_{18-22} PDS_{7-9} LLS_{22-26} STL_{7-9}$ .

#### LWR and growth pattern

The LWR was established as:  $W=0.00000632L^{3.1391}$  for male and  $W=0.00000833L^{3.0839}$  for female. ANCOVA did not indicate significant difference ( $p<0.05$ ;  $p<0.01$ ) between the sexes; hence a common equation was derived as  $W=0.00000633L^{3.1424}$  for the species (Fig. 3). The exponent value  $b$  for males, females and combined sexes were 3.139, 3.084 and 3.142, respectively, which confirmed positive allometric growth pattern.

#### Condition factor and sex ratio

Usually, the condition factor shows the physical and biological condition of the fish. In the present investigation, the mean value of the condition factor was 1.06 for males and 1.22 for females, which showed no

significant differences between the sexes. The estimated length-wise sex ratio for the species was 1:1.14. The  $\chi^2$  value for different length groups was significantly different, but the value for the pooled data was insignificant (Table 4). Males outnumbered females in most of the length groups. However, the proportions of males decreased from 85 mm onwards and no male specimen was found beyond 110 mm length.

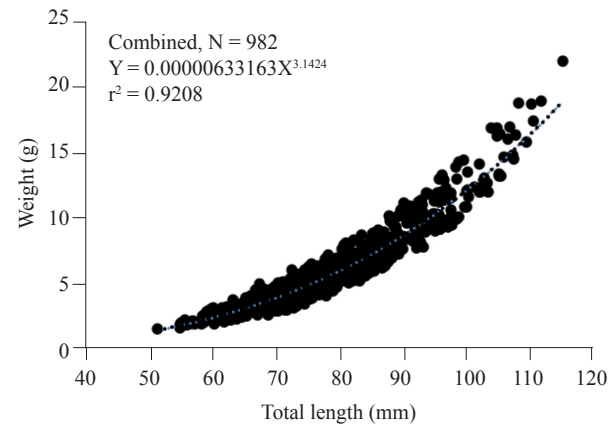


Fig. 3. Length-weight relationships in *P. sophore* (sexes pooled).

Table 3. Descriptive statistics of different meristic characters of *P. sophore*

Meristic characters	Min	Max	Mean	Median	Mode	SD	CV%
DFR	8	10	9.09±0.03	9	9	0.34	3.69
PFR	12	15	13.84±0.90	14	14	0.90	6.50
VFR	7	9	8.64±0.53	9	9	0.53	6.12
AFR	6	8	6.75±0.45	7	7	0.45	6.74
CFR	18	22	19.44±1.11	19	19	1.11	5.69
GR	15	23	18.15±1.88	18	18	1.88	10.37
PDS	7	9	8.04±0.62	8	8	0.62	7.77
STL	7	9	8.09±0.57	8	8	0.57	7.00
SLL	22	26	23.69±0.85	24	24	0.85	3.60

Table 4. Length-wise sex ratio and condition factor of *P. sophore* in the Ganga River, Patna

Length group (mm)	Sex ratio			Significance	Condition factor	
	Males (%)	Females (%)	$\chi^2$ (df=1)		Males	Females
50-55	0.76	0.22	0.90	NS	1.02	1.24
55-60	3.44	1.53	2.42	NS	1.17	1.23
60-65	11.45	6.11	5.82	S	1.17	1.18
65-70	12.02	11.14	0.63	NS	1.11	1.20
70-75	18.70	15.94	1.83	NS	1.15	1.22
75-80	25.95	16.59	8.49	S	1.19	1.20
80-85	18.89	14.19	3.52	NS	1.15	1.17
85-90	6.87	12.01	1.98	NS	1.11	1.22
90-95	0.95	9.39	15.4	S	1.28	1.27
95-100	0.57	6.77	11.3	S	1.25	1.26
100-105	0.19	2.84	5.14	S	1.05	1.20
105-110	0.19	2.40	4.17	S	1.07	1.23
110-115	0.00	0.66	1.50	NS	0.00	1.23
115-120	0.00	0.22	0.50	NS	0.00	1.45
Pooled data	53.36	46.64	2.22	NS	1.06	1.24

NS-Not significant ( $p<0.05$ )

## Discussion

Fish biometric studies are essential for the proper identification of the species. The LFDs provide timely information about fish and their population structure, which may prove crucial to fisheries management. In the present study, maximum size of *P. sophore* was found to be 109.41 mm for males and 115.11 mm for females, which is much lower than the maximum recorded value of 180 mm in India (Froese and Pauly, 2019). In contrast, Rahman *et al.* (2018) reported that the maximum length of *P. sophore* was 113.4 mm from the Padma River, Bangladesh, while Ahamed *et al.* (2012) observed that the maximum size was 114 mm from the old Brahmaputra River, Bangladesh, which is comparable with the present study. However, Shrestha (1994) and Shan *et al.* (2000) reported the maximum size of this fish to be 100 mm from Nepal and 75 mm from Beijing, respectively, which is smaller than any population from India or Bangladesh. The maximum weight recorded in the present study (22.06 g) was much lower than the maximum weight (70 g) recorded in Maharashtra, India (Archarya and Iftikhar, 2000). These differences can be attributed to selectivity of region-specific fishing gears with different

mesh sizes, resulting in sampling bias. Fishing gear selectivity plays a significant role in catching target individuals, which might impact the LFD, causing biased estimation of maximum fish size (Hossain *et al.*, 2012). In the present study, females were found to be larger and heavier than males. Previous authors have reported similar results on the same species, with the females dominating the males throughout the study period (Ahmed *et al.*, 2012; Rahman *et al.*, 2018). Most of the estimated morpho-meristic characteristics are similar to earlier studies; only CFR counts agreed with Hamilton (1822) but were incongruent with the findings of others. Table 5 shows the comparison of meristic counts of the species with the previous reports from different localities.

The LWR derived in the present study indicated that males and females show positive allometric growth, which agrees with earlier results from the old Brahmaputra River and the Padma River in Bangladesh (Ahamed *et al.*, 2012; Rahman *et al.*, 2018). Table 6 shows that several authors have reported both, positive and negative allometric growth patterns for the pooled data or combined sexes from different geographical areas and water bodies. In these findings, some reports

Table 5. Comparison of meristic characters of *P. sophore* with previous reports

Authors	DFR	PFR	VFR	AFR	CFR	GR	PDS	STL	SLL
Hamilton (1822)	10	14	9	7	19	-	-	-	-
Day (1878)	11-12	17	9	8	19	-	-	9-10	23-26
Murty (1975)	III-IV, 8	14-17	9	III, 5	19	-	8-10	8-9	22-26
Jayaram (1991)	II-III, 8	14-15	I, 8	I-II, 5	17-19	-	8-9	8-10	23-25
Pethiyagoda <i>et al.</i> (2012)	11-12	14-16	9	8	19	-	9	9-10	24-25
Present study (2020)	8-10	12-15	7-9	6-8	18-22	15-23	7-9	7-9	22-26

Table 6. Comparative LWRs of *P. sophore*, from different geographical locations

Author	Sex	n	a	b	r <sup>2</sup>
Graff (1985)	Combined	-	0.0300	2.440	-
Reddy and Rao (1992)	Combined	780	-	3.029	-
Halls <i>et al.</i> (1999)	Combined	-	0.0001	3.210	-
Mitra <i>et al.</i> (2005)	Male	226	0.0115	2.783	0.947
	Female	226	0.0077	3.017	0.955
	Combined	682	0.1773	2.869	0.952
Hossain <i>et al.</i> (2006)	Combined	441	0.0134	3.050	0.978
Ahamed <i>et al.</i> (2012)	Male	813	0.00003	3.034	0.982
	Female	942	0.00003	3.042	0.988
Hossain <i>et al.</i> (2012)	Combined	905	0.0155	2.980	0.966
Pal (2013)	Combined	483	0.1188	3.242	0.871
Kaushik and Bordoloi (2015)	Combined	291	0.0080	3.302	0.965
Rahman <i>et al.</i> (2018)	Male	518	0.0101	3.120	0.943
	Female	682	0.1187	3.070	0.954
Present study (2020)	Male	524	0.00000632446	3.139	0.906
	Female	458	0.00000832754	3.084	0.922
	Combined	982	0.00000633163	3.142	0.921

corroborated our results (Reddy and Rao, 1992; Halls *et al.*, 1999; Hossain *et al.*, 2006; Pal *et al.*, 2013; Kaushik and Bordoloi, 2015) and some deviated from the exponent values for combined sexes (Graff 1985; Mitra *et al.*, 2005; Hossain *et al.*, 2012). A comparison of results from different studies is given in Table 6. The variation in the exponent value depends on the well-being and health status of the sampled individuals (Bagenal and Tesch, 1978), environmental conditions (Kumar *et al.*, 2012) and diet composition (Ahirwal *et al.*, 2018). In the present study, the mean value of the condition factor was 1.06 for males and 1.24 for females, which indicated that the species thrives well in the selected stretch of river Ganga. Females were in much better condition than males in all the length groups. Similar results were obtained on *P. sophore* from river Mouri in Bangladesh, where the mean condition factor values for males and females were 1.07 and 1.14, respectively (Tareque *et al.*, 2009).

Analysis of the sex ratio showed that females outnumbered males from 85-90 mm length group onwards and no male specimens were found beyond 105-110 mm. In the pooled data, males (53.36%) were proportionately higher than females (46.64%) and the overall sex ratio was 1:1.14. From Kolleru Lake, a similar observation was made in *P. sarana*, where females outnumbered males in a larger length group and the optimum sex ratio was 1:1.15 (Murthy, 1975). There is a lack of information on sex ratio of this species from other localities in India. In a natural ecosystem, the optimum sex ratio is expected to be 1:1, although it can depend on the age group, size and habitat (DC *et al.*, 2015). It is important to provide information on seasonal sex segregation, population behaviour (Beevi *et al.*, 2005) and the relative abundance of males or females during the spawning season (Ahirwal *et al.*, 2021).

Morpho-meristic characters provide valuable information for species identification and characterisation. There are not many comprehensive reports on the different biological parameters of *P. sophore* from the river Ganga or other riverine stretches of India, even though it is one of the abundantly available fish species in this area providing nutritional security especially to the low income group of people. From a conservation point of view, the present study is very relevant and the results presented can be used as baseline information for future studies on the food and feeding habits in different stages of life, nutritional quality and breeding behaviour.

### Acknowledgements

The authors are grateful to the Director, ICAR Research Complex for Eastern Region, Patna for providing the necessary facilities to carry out the study.

### References

- Ahamed, F., Ahmed, Z. F., Hossain, Y. and Ohtomi, J. 2012. Growth Study of the pool barb *Puntius sophore* (Cyprinidae: Barbinae) through Multi-Model Inferences. *Zool. Stud.*, 51(7): 1077-1085.
- Ahirwal, S. K., Jaiswar, A. K. and Chakraborty, S. K. 2017. Biometric analysis of oil sardine, *Sardinella longiceps* (Valenciennes, 1847) from Mumbai coast of Maharashtra, India. *Indian J. Geo-Mar. Sci.*, 46(09): 1810-1817.
- Ahirwal, S. K., Jaiswar, A. K. and Chakraborty, S. K. 2018. Diet composition of oil sardine, *Sardinella longiceps* (Valenciennes, 1847) from Mumbai waters of Maharashtra, India. *Indian J. Geo-Mar. Sci.*, 47(09): 1880-1887.
- Ahirwal, S. K., Jaiswar, A. K., Chakraborty, S. K., Sarma, K., Kumar, T., Singh, J. and Bavithra, R. 2021. Analysis of reproductive patterns of *Sardinella longiceps* (Valenciennes, 1847) from the Mumbai Sea, Maharashtra, India. *Indian J. Geo-Mar. Sci.*, 50(12): 1037-1042.
- Archarya, P. and Iftekhar, M. B. 2000. Freshwater ichthyofauna of Maharashtra State. In: *Endemic fish diversity of Western Ghats*. ICAR-National Bureau of Fish Genetic Resources, Lucknow, India. 144 pp.
- Bagenal, T. B. and Tesch, A. T. 1978. *Conditions and growth patterns in freshwater habitat*. Blackwell Scientific Publications, Oxford, UK, 136 pp.
- Balasundaram, C., Arumugam, R. and Murugan, P. B. 2000. Fish diversity of Kolli Hills, Western Ghats, Salem District, Tamil Nadu. *Zoos. Print. J.*, 16(16): 403-406.
- Beevi, K. S. J. and Ramachandran, A. 2005. Sex ratio in *Puntius vittatus* Day in the freshwater bodies of Ernakulum District, Kerala. *Zoos. Print. J.*, 20(9): 1989-1990.
- Collins, R. A., Armstrong, K. F., Meier, R., Brown, S. D. J., Cruickshank, R. H., Keeling, S. and Johnston, C. 2012. Barcoding and border biosecurity: Identifying cyprinid fishes in the aquarium trade. *PLoS One*, 7: 28381. doi: 10.1371/journal.pone.0028381.
- Day, F. 1878. *The fishes of India being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon, vol. I*, Norman and Sons, London, UK, 579 pp.
- Dua, A. and Prakash, C. 2009. Distribution and abundance of fish populations in Harike Wetland-a Ramsar Site in India. *J. Environ. Biol.*, 30: 247-251.
- Froese, R. 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. *J. Appl. Ichthyol.*, 22: 241-253. DOI:10.1111/j.1439-0426.2006.00805.x.
- Froese, R. and Pauly, D. 2019. *Puntius sophore* (Hamilton, 1822). Fish Base. <https://www.fishbase.org>.
- Fulton, T. W. 1904. *The rate of growth of fishes. 22<sup>nd</sup> Annual report, Part-III*. Fisheries Board of Scotland, Edinburgh.

- Graff, G. 1985. The flood pulse and growth of floodplain fish in Bangladesh. *Fish. Manag. Ecol.*, 10: 241-247.
- Halls, A. S., Hoggarth, D. D. and Debnath, D. 1999. Impacts of hydraulic engineering on the dynamics and production potential of floodplain fish populations in Bangladesh. *Fish. Manag. Ecol.*, 6: 261-285. <https://doi.org/10.1111/j.1365-2400.1999.tb00080.x>.
- Hamilton, F. 1822. *An account of the fishes found in the river Ganges and its tributaries*, A. constable and co., Edinburgh, 405 pp.
- Hossain, M. Y., Ahmed, Z. F., Leunda, P. M., Islam, A. K. M. R., Jasmine, S., Oscoz, J., Miranda, R. and Ohtomi, J. 2006. Length-weight and length-length relationships of some small indigenous fish species from the Mathabhanga River, southwestern Bangladesh. *J. Appl. Ichthyol.*, 22: 301-303. <https://doi.org/10.1111/j.1439-0426.2006.00801.x>.
- Hossain, M. Y., Rahman, M. M., Miranda, R., Leunda, P. M., Oscoz, J., Jewel, M. A. S., Naif, A. and Ohtomi, J. 2012. Size at first sexual maturity, fecundity, length-weight and length-length relationships of *Puntius sophore* (Cyprinidae) in Bangladeshi waters. *J. Appl. Ichthyol.*, 28: 818-822.
- Jayaram, K. C. 1991. Revision of the genus *Puntius*, Hamilton from the Indian region. *Record of Zoological Survey of India, Occasional Paper No. 135*. Zoological Survey of India, Kolkata, India.
- Kaushik, G. and Bordoloi, S. 2015. Length-weight and length-length relationships of four species of genus *Pethia* and genus *Puntius* from wetlands of Lakhimpur District, Assam, India. *J. Appl. Ichthyol.*, 3: 1150-1152. <https://doi.org/10.1111/jai.12841>.
- King, M. 2007. *Fisheries biology, assessment and management*, 2<sup>nd</sup> edn. Blackwell Scientific Publications, Oxford, UK, 381 pp.
- Kolher, N., Casey, J. and Turner, P. 1995. Length-weight relationships for 13 species of sharks from the western North Atlantic. *Fish. Bull.*, 93: 412-418.
- Kumar, T., Chakraborty, S. K., Jaiswar, A. K., Sandhya, K. M. and Panda, D. 2012. Biometric studies on *Johnnieops sina* (Cuvier, 1830) along Ratnagiri coast of Maharashtra. *Indian J. Fish.*, 59(1): 7-13.
- Le-Cren, C. P. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol.*, 20(2): 201-209.
- Mitra, K., Suresh, V. R., Vinci, G. K. and Naskar, B. 2005. Length-weight relation, reproductive characters and condition factor of *Puntius sophore* (Hamilton), from a floodplain wetland in West Bengal. *J. Inland Fish. Soc.*, 37(1): 16-22.
- Murty, V. S. 1975. Studies on maturation, spawning, fecundity and sex ratio in *Puntius sarana* (Hamilton-Buchanan) from Lake Kolleru, Andhra Pradesh. *Fish. Tech.*, 2: 131-144.
- Nayman, W. H. 1965. Growth and ecology of fish population. *J. Anim. Ecol.*, 20: 201-219.
- Pal, M., Mahapatra, B. K. and Mondal, B. 2013. Length-weight relationship and condition factor of *Puntius sophore* (Hamilton, 1822) collected from Kolkata and sub urban fish markets. *Environ. Ecol.*, 31(3): 1255-1259.
- Pethiyagoda, R., Meegaskumbura, M. and Maduwage, K. 2012. A synopsis of the South Asian fishes referred to *Puntius* (Pisces: Cyprinidae). *Ichthyol. Explor. Freshw.*, 23(1): 69-95.
- Qasim, S. Z. 1966. Sex ratio in fish populations as a function of sexual difference in growth rate. *Curr. Sci.*, 35: 140-142.
- Rahman, M. M., Hossain, M. Y., Jewel, M. A. S., Billah, M. M. and Ohtomi, J. 2018. Population biology of the pool barb *Puntius sophore* (Hamilton 1822) (Cyprinidae) in the Padma River, Bangladesh. *Zool. Ecol.*, 2-9.
- Ranjan, J. B., Herwig, W., Subodh, S. and Michael, S. 2005. Study of the length frequency distribution of sucker head, *Garragotyla gotyla* (Gray, 1830) in different rivers and seasons in Nepal and its applications. *J. Sci. Eng. Tech.*, 1: 1-14.
- Reddy, S. Y. and Rao, M. B. 1992. Length-weight relationship and relative condition factor of *Puntius sophore* (Hamilton-Buchanan) from the lake Hussain Sagar, Hyderabad, India. *J. Inland Fish. Soc.*, 24: 22-25.
- Shan, X., Lin, R., Yue, P. and Chu, X. 2000. Cyprinidae: Barbinae. In Yue, P. (Ed.), *Fauna Sinica. Osteichthyes. Cypriniformes III*. Science Press, Beijing, China, p. 3-170.
- Shrestha, J. 1994. *Fishes, fishing implements and methods of Nepal*. Lashkar (India) M.D. Gupta, India, 150 pp.
- Snedecor, G. W. and Cochran, W. G. 1967. *Statistical methods*, Oxford and IBH Publishing Co., New Delhi, India, 593 pp.
- Talwar, P. K. and Jhingran, A. G. 1991. *Inland fishes of India and adjacent countries. vol I*, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India, 541 pp.
- Tareque, A. M. H. B., Biswas, B., Hossain, M. S., Rahman, M. M. and Rahman, M. M. 2009. Some aspects of biology of *Puntius sophore* (Hamilton) collected from the Mouri River Khulna, Bangladesh. *J. Bangladesh Res. Publ.*, 2: 406-422.