World Applied Sciences Journal 38 (4): 278-286, 2020
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2020.278.286

Length-Weight, Length-Length Relationships and Condition Factor of Schilbid Catfish *Neotropius atherinoides* (Bloch, 1794) from the Padma River, Rajshahi

[1]*Layla Khasrun Zannat,* [1]*Saleha Jasmine,* [2]*Shaharior Hossen,* [1]*Md. Yeamin Hossain,*
[3]*Antara Ghosh,* [4]*Afshana Ferdous,* [5]*Newton Saha and* [3]*Shahrear Hemal*

[1]Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi 6205, Bangladesh
[2]Department of Fisheries Science, Chonnam National University, Yeosu 59626, Korea
[3]Department of Aquaculture, Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh
[4]Department of Marine Fisheries and Oceanography,
Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh
[5]Department of Fisheries Management,
Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh

Abstract: The present study describes the length-weight (LWR) and length-length (LLR) relationships, as well as the condition factors of Schilbid catfish *Neotropius atherinoides* from the Padma River, Rajshahi. A total of 426 specimens were caught using traditional fishing gears from January to December 2014. For each individual, the total (TL) and standard (SL) lengths were measured using digital slide calipers. Individual body weight (BW) was also taken through a digital balance. All relationships were highly significant ($P < 0.01$), with r^2 values being greater than 0.95. The generalized relationship of standard length and total length for combined population were SL = 0.224 + 0.635 TL. The results indicated that the LLR were highly significant ($r^2 > 0.914$; $P < 0.01$). The calculated allometric coefficient *b,* 2.87 (TL) and 2.93 (SL) for *N. atherinoides* smaller than isometric value (b ≈ 3.000). The generalized relationships for total length and body weight and standard length and body weight were $BW = 0.005TL^{2.872}$ and $BW=0.014SL^{2.936}$ respectively. The LWRs indicated negative allometric growth in *N. atherinoides*. Fulton's condition factor *K* showed significant variation (Kruskal-Wallis test, $P < 0.001$, with best performance of *N. atherinoides*, calculated as 0.366 ± 0.017 (TL) and 1.257 ± 0.058 (SL).

Key words: Population Biology · Condition Factors · *N. atherinoides* · Padma River

INTRODUCTION

Bangladesh has the unique advantage of possessing the world's largest river delta, the Ganges Delta which offers a vast and varied fisheries potentials in its fresh, brackish and marine waters [1-8]. Inland open water fishery resources play a significant role in the economy, culture, tradition and food habits of the people of Bangladesh [9-16]. As a riverine country, the economy of Bangladesh depends upon agriculture, livestock and fisheries [17-20]. Fish and fisheries sector play a significant role in the economy of Bangladesh in terms of animal protein supply, employment, foreign currency earning and poverty alleviation [21-30]. This sector contributes 4.37% to Gross Domestic Product (GDP) and 2.01% of export earnings and 60% of the total protein supplies in the diet of the people of Bangladesh [31-36]. The present per capita annual fish intake is about 19.30 kg against the actual demand of 21.90 kg and this shortfall is considered as one of the main causes of malnutrition in Bangladesh [31].

Small Indigenous Species (SIS) plays an important role in the national diet of Bangladesh. These small indigenous fishes were available in rivers, beels, canals, haors, ditches and floodplain of Bangladesh. But in recent years, due to indiscriminate exploitation of brood and young SIS by using destructive fishing gears and methods leads SIS to a high level of risk of extinction. Among 260 species of freshwater fishes, 143 may be considered as Small Indigenous Species (SIS). Small

Corresponding Author: Layla Khasrun Zannat, Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi 6205, Bangladesh.

Indigenous Species of fish grow to a maximum length of 25 cm and can multiply rapidly in any freshwaters and also in captivity [31].

In Bangladesh, 260 indigenous freshwater bony fish species, suitable for human consumption, belonging to 145 genera and 55 families, constitute a very rich aquatic bio-diversity in Bangladesh [37]. Siluriformes are the most abundant group among these fishes [37]. The Schibid catfish (family Siluriformes) *Neotropius atherinoides* (Bloch, 1794) is an important SIS of rivers and connected water bodies in Bangladesh. Length-weight relationships (LWRs) and length-length relationships (LLRs) are still scarce for most tropical and sub-tropical fish species [38-41]. The length weight relationship (LWR) of fishes in a given geographic zone in important in fisheries biology because it allows estimation of the average weight at a given length. Length-weight relationships for fish were originally used to provide information on the condition of fish and to determine whether somatic growth as isometric or allometric [42, 43]. Due to scarcity of length- weight and length-length relationship study of *N. atherinoides* from the Padma River in Bangladesh, the present study is most important. The objectives of this study were to measure the relationship of length-length, length-weight and observe the condition factor regarding body growth of *N. atherinoides*.

MATERIALS AND METHODS

Study Area: The study area (Figure 1) of the experiment was the Padma River at the point of Talaimari (24.50° N, 88.26° E), Rajshahi, Bangladesh.

Sample Collection: The specimens were collected at random regularly every month. All the specimens studied were collected during the period from January 2014 to December 2014. During this period a total of 426 specimens were collected for this experiment. The specimens were collected from the Padma river located at Rajshahi. The fishes were caught by means of the traditional fishing gears Jhaki Jal (Cast net), seine net etc. During the collection of these species, precautions were taken to save the species from spoilage and any damage.

Preservation: Just after collection the fishes were washed and preserved in 10% formalin solution in separate jars on monthly basis for the laboratory studies.

Measurement of Length and Weight: The fishes, preserved with formalin were washed with running tap water to eliminate any filthy substances and absorbed excess water with blotting paper from the body and finally left in room temperature for about half an hour for removal of all moisture. Total length (TL) was measured in (cm) from the most anterior to the most posterior point with the tail of the fish compressed to exhibit the longest possible length. Standard length (SL) was taken in (cm) from the snout up to the end of the base of the caudal fin. Total weight (TW) of the fish was measured by using Digital balance with 0.01g accuracy after absorbing all its body moisture and water particles by using blotting paper.

Determination of Length-Weight Relationship: Length-weight relationship were determined based on the following formula:

$W = aL^n$ [42]

where, W = Weight; L = Length; a = Constant; and, n = another constant to be calculated empirically.

The general equation, $W = aL^n$ can be expressed in logarithmic form as:

Log TW = Log a + nLog TL
This is Y = a+bX

where, a = Log a; b = n; Y = Log TW; X = Log TL (which is a linear relation between Y and X).

The value of the constant (a) and (n) can be determined by the following equations,

$$\text{Log a} = \frac{\sum LogTW \times \sum LogTL^2 - \sum LogTL \times \sum (LogTL \times LogTW)}{N \times \sum LogTL^2 - (\sum LogTL)^2}$$

$$\text{and, n} = \frac{\sum Log\ TW - N \times Log\ a}{\sum \text{Log TL}}$$

where "N" indicates the number of specimens.

To express the degree of linear association on correlation between two variables, the correlation co-efficient, r was estimated by:

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\left\{\sum x^2 - \frac{\left(\sum x\right)^2}{n}\right\}\left\{\sum y^2 - \frac{\left(\sum y\right)^2}{n}\right\}}$$

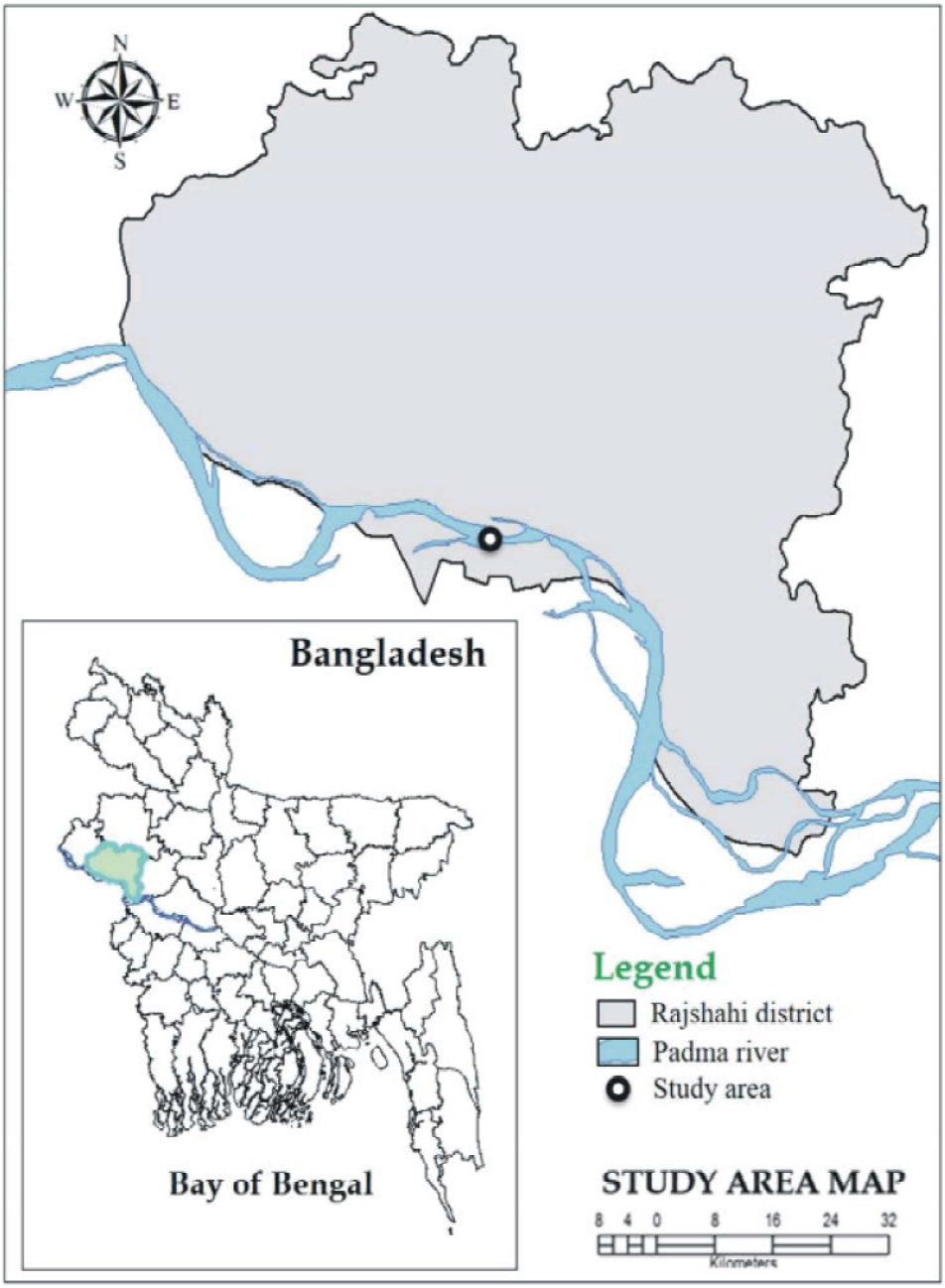

Fig. 1: Sampling site of the Padma River Rajshahi, Bangladesh, where the species was captured

The co-efficient of determination r is the square of the correlation co-efficient, an indicator of the quality of the liner regressions. The 95% confidence limits of parameters *a* and *b* and the coefficient of determination r^2 were also estimated.

Determination of Condition Factor: The relative conditional factor (k_n) for each individual was calculated by the following formula:

$$K_n = TW/(a \times TL^b)$$

The Fulton's condition factor, K was calculated by using the following formula:

$$K = (TW/TL^3) \times 100$$

where, K = Fulton's condition factor, TW= Total body weight, TL = Total body length. Here, factor 100 is used to bring K close unity.

Statistical Analysis: Statistical analyses were performed using computer software SPSS 16.0 (Statistical Package for Social Science) and statistical programming language R-3.02.

RESULTS

A total of 426 *N. atherinoides* catfish were collected from the Padma River in Rajshahi city, Bangladesh during the study. Descriptive statistics on the length and weight measurements are given in Table 1. The minimum observed total length of all individuals captured was 5.31 cm, corresponding to a specimen of *N. atherinoides*, weighting 0.60 g.

Length-Length Relationships: The relationships between total length (TL) and standard length (SL) is study in this section for the specimen *N. atherinoides*. The sample size (n), regression parameters a and b of the LLR, 95% confidence intervals of a and b, the coefficient of determination (r^2) of *N. atherinoides* are given in Figure 2 and Table 2.

The LLRs were highly significant ($P < 0.01$), with the coefficient of determination values being > 0.895.

Length-Weight Relationships: The relationships between body weight (BW) among total length (TL) and standard length (SL) are study in this section for the specimen *N. atherinoides*. The sample size (*n*), regression parameters *a* and *b* of the LWR, 95% confidence intervals of *a* and *b*, the coefficient of determination (r^2) and growth type of *N. atherinoides* are given in Figure 3, 4 and Table 3.

All relationships were highly significant ($P < 0.01$), with r^2values being greater than 0.95. The calculated allometric coefficient *b,* 2.87 (for TL) and 2.93 (for SL) for *N. atherinoides* smaller than isometric value (b ˜ 3.000). The LWRs indicated negative allometric growth in *N. atherinoides*.

Fulton's Condition Factor: In this section Relative condition factor (*Kn*) and Fulton's condition factor (*K*) of *N. atherinoides* are described. Descriptive statistics of Relative condition factor (*Kn*) and Fulton's condition factor (*K*) are given in Table 4.

The relative condition factor (*Kn*) is calculated as 1.020±0.045 (TL) and 1.086±0.049 (SL) for *N. atherinoides*. Fulton's condition factor *K* showed significant variation (Kruskal-Wallis test, $P < 0.001$, with best performance of *N. atherinoides*, calculated as 0.366 ± 0.017 (TL) and 1.257±0.058 (SL) (Table 4). The Pearson's correlation test showed significant correlation between *K* and TL and BW for *N. atherinoides*. Positive correlations were extracted between *K*n-BW for *N. atherinoides* ($P < 0.01$).

Table 1: Descriptive statistics on the length (cm) and weight (g) measurements of the catfish *N. atherinoides* from the Padma River, northwestern Bangladesh during January 2014 to December 2014

Species	*n*	Measurements	Minimum	Maximum	Mean±SD
N. atherinoides	426	TL	5.31	10.49	7.99 ± 0.88
		SL	3.67	6.82	5.29 ± 0.57
		BW	0.6	4.19	1.93 ± 0.61

Note: n, sample size; TL, total length; BW, body weight; SD, standard deviation

Table 2: Morphometric relationships between total length (TL) and standard length (SL) for *N. atherinoides* catfish from the Padma River, Rajshahi, Bangladesh during January 2014 to December 2014

Species	*n*	Equation	*a*	*b*	95% Cl of *a*	95% Cl of *b*	r^2
N. atherinoides	426	$SL = a + b \times TL$	0.224	0.634	0.128-0.319	0.622- 0.646	0.96

Note: n, sample size; SL, standard length; TL, total length; a, intercept; b, slope; CI, confidence intervals; r^2, coefficient of determination

Table 3: Descriptive statistics and estimated parameters of the length-weight relationships for *N. atherinoides* catfish from the Padma River, Rajshahi, Bangladesh during January 2014 to December 2014

Species	*n*	Equation	*a*	*b*	95% Cl of *a*	95% Cl of *b*	r^2	Growth type
N. atherinoides	426	$BW = a \times TL^b$	0.005	2.87	0.0043-0.0051	2.83-2.91	0.98	A-
		$BW = a \times SL^b$	0.013	2.93	0.012- 0.014	2.89-2.97	0.97	A-

Note: n, sample size; BW, body weight; TL, total length; *a*, intercept; *b*, slope, r^2, coefficient of determination; A -, negative allometric growth.

Table 4: Relative condition factor (*Kn*) and Fulton's condition factor (*K*) of *N. atherinoides* from the Padma River, northwestern Bangladesh during January 2014 to December 2014

			Relative condition factor (*Kn*)			Fulton's condition factor (*K*)		
Species	n	Type of length	Min	Max	Mean ± SE	Min	Max	Mean ± SE
N. atherinoides	426	TL	0.895	1.199	1.020 ± 0.045	0.317	0.437	0.366 ± 0.017
		SL	0.954	1.249	1.086 ± 0.049	1.108	1.462	1.257 ± 0.058

Note: n, sample size; TL, total length; BW, body length; Min, Minimum; Max, maximum; SD, standard deviation; Cl, confidence level

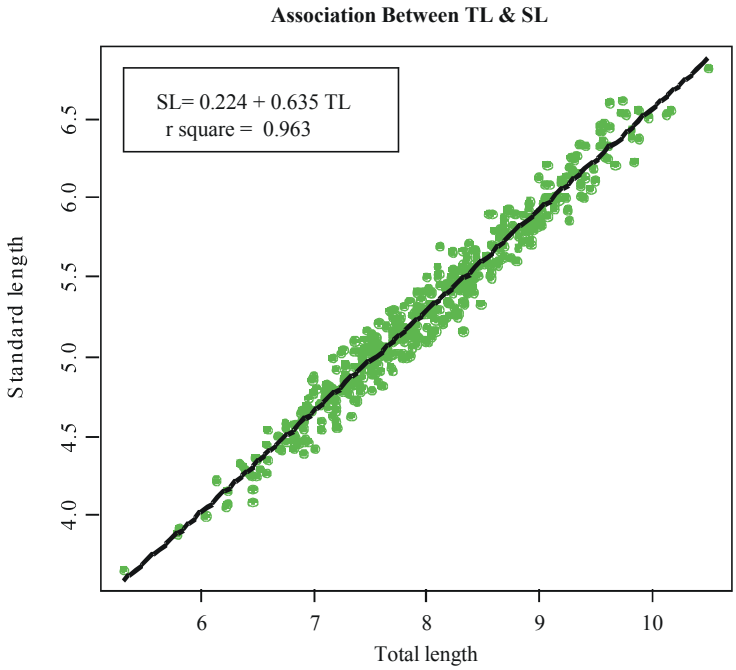

Fig. 2: Relationship between total length and standard length of *N. atherinoides*

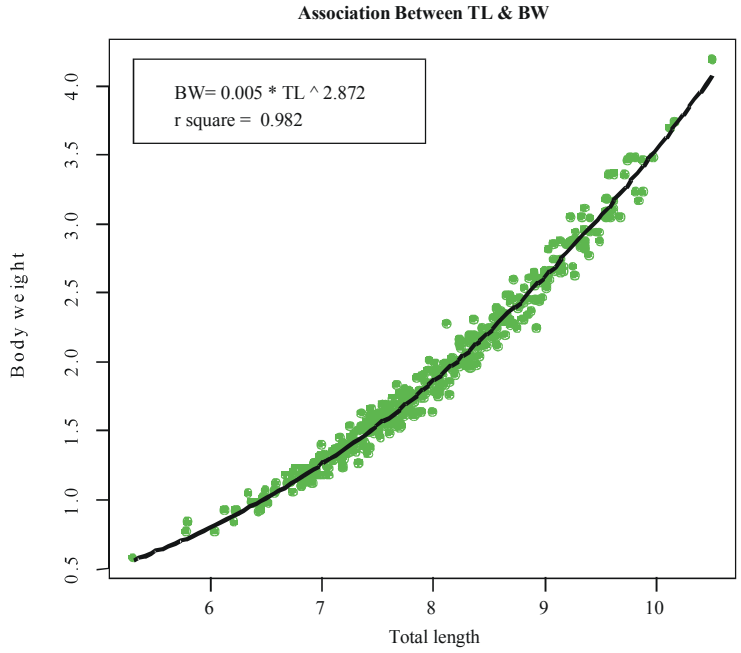

Fig. 3: Relationship between total length and body weight of *N. atherinoides*

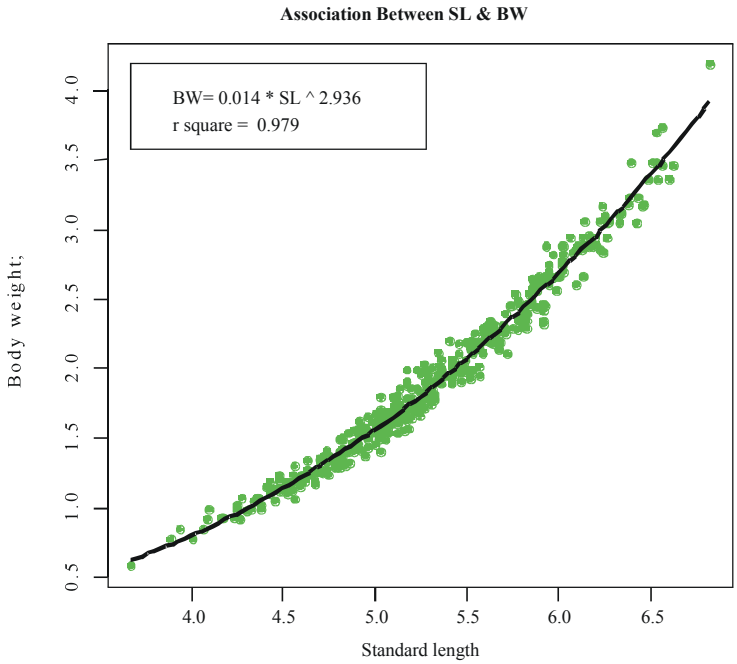

Fig. 4: Relationship between standard length and body weight of *N. atherinoides*

DISCUSSION

The present study used a large number of specimens with different body sizes captured by some traditional fishing gears [9, 15]. The present study recorded the maximum size of *N. atherinoides* in the Padma River as 10.49 cm TL which was nearest to the maximum recorded value of 10.7cm TL in Padma River Northwestern Bangladesh [44].

The values of b were within the limits 2.5-3.5 reported by Froese [43] for most fishes. The calculated allometric coefficient b value is 2.87 for *N. atherinoides* in the present study which is nearest to the estimated b value 2.89 in Padma River Northwestern Bangladesh [44].

In general and despite the many variation in fish forms between species, b is close to 3, indicating that fish grow isometrically; values significantly different from 3.0 indicate allometric growth [45].

The length-weight relationship in fishes can be affected by several factors including habitat, area, seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observes length ranges of the specimen caught [45-54], all of which were not accounted for the present study. Since samples of the species included individuals collected over several seasons, the parameters a and b would be treated as mean annual values.

In case of *N. atherinaides,* Hossain, *et al.* [41], recorded the negative allometric growth from the Bangladeshi waters, which is also in accordance with the present study. However, for the studied species presented in this study, the b values were mostly in agreement with the results for fishes of the same family obtained from the same and /or other geographical areas [40, 44, 55]. All LLRs were highly correlated and they were compared with the available literature.

CONCLUSION

Fisheries is an integral part of agriculture sector and play a vital role in the socio-economic development. This study provides an important baseline study on the length-weight relationship, length-length relationship and condition factors of *N. atherinoides* in Padma river, Bangladesh.

The results of the study initiate early management strategies and regulations for the sustainable conservation of the remaining stock of these species in the Padma River ecosystem.

The result of the present study will provide some new and updated information on the morphometric characters of *N. atherinoides* will be helpful to the fisheries scientists and play an important role in the management and conservation of the specimens.

REFERENCES

1. Nishat, A., S.M. Huq, S.P. Barua, A.A.H.M. Reza and A.S. Moniruzzaman, 2002. Bio-ecological Zones of Bangladesh. IUCN, Bangladesh, pp: 141.
2. Ali, M.M., M.L. Ali, M.J. Rahman and M.A. Wahab, 2020. Fish Diversity in the Andharmanik River Sanctuary in Bangladesh, Croatian Journal of Fisheries, 78(1): 21-32.
3. Hasan, H., M. Rahman, R. Sharker, M.M. Ali and S. Hossen, 2016. Fish Diversity and Traditional Fishing Activities of the River Padma at Rajshahi, Bangladesh. World Journal of Fish and Marine Sciences, 8(3): 151-157.
4. Hossain, M.Y., M.M. Rahman, M.M. Ali, M.A. Hossen, F. Nawer, A.H. Bahkali, M.S. El-Shikah, M.M. Islam, A.M. Elgorban and Z.F. Ahmed, 2016. Check list of fish species availability in Rupsa River, Bangladesh: Threat identification and recommendation for sustainable management. Indian Journal of Geo-Marine Sciences, 45(10): 1292-1298.
5. Sharker, M.R., S. Mahmud, M.A.B. Siddik, M.J. Alam and M.R. Alam, 2015. Livelihood Status of Hilsa Fishers Around Mohipur Fish Landing Site, Bangladesh. World Journal of Fish and Marine Sciences, 7(2): 77-81.
6. Mondal, M.A.H., M.K. Islam, M.E. Islam, S. Barua, S. Hossen, M.M. Ali and M.B. Hossain, 2018. Pearson's Correlation and Likert Scale Based Investigation on Livelihood Status of the Fishermen Living Around the Sundarban Estuaries, Bangladesh. Middle-East Journal of Scientific Research, 26(2): 182-190.
7. Ali, M.M., M.B. Hossain, M.A. Rahman and A. Habib, 2014. Diversity of Fish Fauna in the Chitra River of Southwestern Bangladesh: Present Status, Threats and Recommendations for Conservation. Asian Journal of Applied Sciences, 7(7): 635-643.
8. Ali, M.M., M.M. Rahman, M.Y. Hossain, M.Z. Rahman, M.A. Hossen, S.M.A. Naser, R. Islam, B.R. Subba, Z. Masood and M.A. Hoque, 2014. Fish Marketing System in Southern Bangladesh: Recommendations for Efficient Marketing. Our Nature, 12(1): 28-36.
9. Kibria, G. and K.K.U. Ahmed, 2005. Diversity of selective and nonselective fishing gear and their impact on inland fisheries in Bangladesh. NAGA, 28: 43-48.
10. Ali, M.M., M.M. Mufty, M.B. Hossain, Z.F. Mitul and M. Ash-Wadul Alam, 2015. A Checklist of Fishes from Lohalia River, Patuakhali, Bangladesh. World Journal of Fish and Marine Sciences, 7(5): 394-399.
11. Hossain, M.Y., S.R.M. Sayed, M.M. Rahman, M.M. Ali, M.A. Hossen, A.M. Elgorban, Z.F. Ahmed and J. Ohtomi, 2015. Length-weight relationships of nine fish species from the Tetulia River, southern Bangladesh. Journal of Applied Ichthyology, 31(5): 967-969.
12. Hanif, M.A., M.A.B. Siddik and M.M. Ali, 2020. Length-weight relationships of seven cyprinid fish species from the Kaptai Lake, Bangladesh. Journal of Applied Ichthyology, 36(2): 261-264.
13. Hossen, M.A., M.Y. Hossain, M.M. Ali, M.N.U. Pramanik, F. Nawer, M.A. Islam, M.A. Hossain, A.H. Bahkali and A.M. Elgorban, 2017. Seasonal Variations of Growth pattern and Condition of Paradise Threadfin Polynemus paradiseus (Polynemidae) from Tetulia River in Southern Bangladesh. Indian Journal of Geo-Marine Sciences, 46(3): 582-590.
14. Ali, M.M., M.B. Hossain, M. Al-Masud and M.A.W. Alam, 2015. Fish Species Availability and Fishing Gears Used in the Ramnabad River, Southern Bangladesh. Asian Journal of Agricultural Research, 9(1): 12-22.
15. Hasan, H., M. Rahman, R. Sharker, M.M. Ali and S. Hossen, 2016. Fish Diversity and Traditional Fishing Activities of the River Padma at Rajshahi, Bangladesh. World Journal of Fish and Marine Sciences, 8(3): 151-157.
16. Islam, M.K., S. Ahmad-Al-Nahid, M.S.R. Khan, M.E. Ahsan, K.A. Habib and M.M. Ali, 2015. Fishing gears used by the Fishers at Rupsha River in Khulna District, Bangladesh. International Journal of Fisheries and Aquatic Studies, 4(1): 29-33.
17. Hossen, S., K. Kubra, M.M. Ali, M. Azam, M. Rahman, M.R. Sharker, P. Roy, M.Y. Ali and M.B. Hossain, 2020. Best-Worst Scale and Pearson's Correlation Based Investigation on Socioeconomic Status of Fishermen in Sugondha River of Bangladesh. World Applied Sciences Journal, 38(2): 131-142.
18. Jahan, M.T., S. Hossen, M.R. Sharker, Z.P. Sukhan, M.B. Hossain, M.M. Ali and M.K.S. Shadin, 2020. Assessment of Fish Diversity in the Baleshwari River: Present Status, Threats and Conservation Perspectives. World Journal of Fish and Marine Sciences, 12(1): 06-15.

19. Mondal, M.A.H., K. Begum, M.R. Islam, Z.F. Mitul, S. Hossen and M.M. Ali, 2018. Pond fish culture in Southwestern Bangladesh: An overview of the post stocking management practices. International Journal of Fisheries and Aquatic Studies, 6(1): 170-173.
20. Hossain, S.A.A.M., W. Lixue, A.K.M. Adham, U.K. Navera and M.M. Ali, 2017. Utility of River Training Structures and Present Status in Patuakhali District Bangladesh. British Journal of Applied Science & Technology, 19(3): 1-12.
21. Hossen, S., M.M. Ali, M.R. Sharker, N. Jahan, M.B. Hossain, Z.P. Sukhan, A. Mahmud and P. Roy, 2020. Present Status of Fish Farming and Livelihood of Fish Farmers in Barisal Sadar Upazila of Barisal District, Southern Bangladesh. World Applied Sciences Journal, 38(2): 143-152.
22. Ali, M.M., M.B. Hossain, M.H. Minar, S. Rahman and M.S. Islam, 2014. Socio-Economic Aspects of the Fishermen of Lohalia River, Bangladesh. Middle-East Journal of Scientific Research, 19(2): 191-195.
23. Wahab, M.A., M.J. Reza, M.M. Ali, M. Nahiduzzaman and M.J. Philips, 2019. The Potential for Homestead Pond Polyculture of Tilapia and Carps in Coastal Bangladesh. Journal of Fisheries Science, 1(1): 15-25.
24. Ali, M.M., M.B. Hossain, M. Rahman and S. Rahman, 2014. Post Stocking Management Practices by the Pond Fish Farmers in Barisal District, Bangladesh. Global Veterinaria, 13(2): 196-201.
25. Haldar, R., S. Hossen, M.M. Hossain, M.M. Ali, P. Roy, N. Saha, M.B. Hossain, A. Mahmud and M.K.S. Shadin, 2020. Fish Availability and Marketing System of a Fish Market in Manikganj, Bangladesh. World Journal of Fish and Marine Sciences, 12(1): 16-23.
26. Hossen, S., M.R. Sharker, A. Ferdous, A. Ghosh, M.B. Hossain, M.M. Ali and Z.P. Sukhan, 2020. Pearson's Correlation and Likert Scale Based Investigation on Socio-Economic Status of Fisher's Community in Kirtankhola River, Southern Bangladesh. Middle-East Journal of Scientific Research, 28(3): 160-169.
27. Kubra, K., M.S. Hoque, S. Hossen, A.U. Husna, M. Azam, M.R. Sharker, S. Hemal, M.B. Hossain, P. Roy and M.M. Ali, 2020. Fish Drying and Socio-Economic Condition of Dried Fish Producers in the Coastal Region of Bangladesh. Middle-East Journal of Scientific Research, 28(3): 182-192.
28. Ali, M.Y., S. Hossen, S.M.O. Azad, M.S. Alom, M.A. H. Mondal, M.M. Ali and M.B. Hossain, 2017. Fish Availability and Marketing System at Local Markets of a Coastal District, Southern Bangladesh. Asian Journal of Animal Sciences, 11(5): 221-229.
29. Sumi, K.R., M.R. Sharker, M.L. Ali, S.N. Pattader, Z. Ferdous and M.M. Ali, 2015. Livelihood Status of Gher Farmers of Beel Dakatia in Khulna district, Bangladesh. International Journal of Aquatic Science, 6(1): 45-53.
30. Mahmud, S., M.L. Ali and M.M. Ali, 2015, Present Scenario on Livelihood Status of the Fishermen in the Paira River, Southern Bangladesh: Constraints and Recommendation. International Journal of Fisheries and Aquatic Studies, 2(4): 23-30.
31. DoF (Department of Fisheries), 2019. National Fish Week Compendium, Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh, pp: 160.
32. Hossen, S., M.M. Ali, M.A. Rahman, A.M. Shahabuddin, M.S. Islam, M.T.H. Chowdhury and M.K. Islam, 2018. A comprehensive analysis of socioeconomic structure and constraints of Fishers community of the Tetulia River in Bangladesh. Australian Journal of Science and Technology, 2(2): 83-89.
33. Debnath, S., S. Hossen, M.R. Sharker, A. Ghosh, A. Ferdous, L.K. Zannat and M.M. Ali, 2020. Fish Seed Producing Hatcheries in Southern Bangladesh: An Overview. Middle-East Journal of Scientific Research, 28(3): 199-206.
34. Hossen, S., Z.P. Sukhan, M.R. Sharker, M.B. Hossain, M.M. Ali, M.A. Alam and M.B. Rahman, 2020. Ichthyofaunal Diversity of a Coastal River in Bangladesh: Status and Conservation Measures. Middle-East Journal of Scientific Research, 28(3): 170-181.
35. Ali, M.M., M.L. Ali, M.S. Islam and M.Z. Rahman, 2016. Preliminary assessment of heavy metals in water and sediment of Karnaphuli River, Bangladesh. Environmental Nanotechnology, Monitoring and Management, 5: 27-35.
36. Ali, H., M.M. Haque, K. Murshed-e-Jahan, M.L. Rahid, M.M. Ali, M. Al-Masud and G. Faruque, 2016. Suitability of different fish species for cultivation in integrated floating cage aquageoponics system (IFCAS) in Bangladesh. Aquaculture Reports, 4: 93-100.

37. Craig, J.F., A.S. Halls, J.J.F. Barr and C.W. Bean, 2004. The Bangladesh floodplain fisheries. Fisheries Research, 66: 271-286.
38. Harrison, T.D., 2001. Length-weight relationships of fishes from South African estuaries. Journal of Applied Ichthyology, 17: 46-48.
39. Ecoutin, J.M., J.J. Albaret and S. Trape, 2005. Length-weight relationships for fish populations of a relatively undisturbed tropical estuary: The Gambia. Fisheries Research, 72(2-3): 347-351.
40. Hossain, M.Y., S. Jasmin, A.H.M. Ibrahim, Z.F. Ahmed, M.M. Rahman and J. Ohtomi, 2009. Length-weight and Length-length relationships of 10 small fish species from the Ganges Bangladesh, Journal of Applied Ichthyology, 25: 117-119.
41. Hossain, M.Y., Z.F. Ahmed, P.M. Leunda, S. Jasmine, J. Oscoz, R. Miranda and J. Ohtomi, 2006. Condition, length-weight and length-length relationships of the Asian striped catfish Mystus vittatus (Bloch, 1794) (Siluriformes: Bagridae) in the Mathabhanga River, southwestern Bangladesh. J. Appl. Ichthyol., 22: 304-307.
42. Le Cren, E.D., 1951. The length weight relationship and seasonal cycle in gonad weights and condition in the perch (Perca fluviatilis). J. Anim. Ecol., 20: 201-219.
43. Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board. Can., 191. pp: 382.
44. Hossain, M.Y., 2010. Length weight length length relationships and condition factor of three schilbid catfishes from the Padma river, Northwestern Bangladesh. Asian Fisheries Science, 23: 329-339.
45. Tesch, F.W., 1971. Age growth. In: methods for assessment of fish production in fish waters. Ricker, W.E. (Ed). Blackwell Scientific Publications, Oxford, pp: 99-130.
46. Ali, M.M., M.L. Ali, R. Proshad, M.S. Islam, M.Z. Rahman, T.R. Tusher, T. Kormoker and A.A. Mamun, 2019. Heavy metal concentrations in commercially valuable fishes with health hazard inference from Karnaphuli river, Bangladesh. Human and Ecological Risk Assessment: An International Journal, doi: 10.1080/10807039.2019.1676635.
47. Ali, M.M., M.L. Ali, M.S. Islam and M.Z. Rahman, 2018. Assessment of toxic metals in water and sediment of Pasur River in Bangladesh. Water Science and Technology, 77(5): 1418-1430.
48. Habibullah-Al-Mamun, M., M.K. Ahmed, M. Raknuzzaman, M.S. Islam, M.M. Ali, M. Tokumura, S. Masunaga, 2017. Occurrence and assessment of perfluoroalkyl acids (PFAAs) in commonly consumed seafood from the coastal area of Bangladesh. Marine Pollution Bulletin, 124: 775-785.
49. Islam, M.S., M.K. Ahmed, M. Habibullah-Al-Mamun, M. Raknuzzaman, M.M. Ali and D.W. Eaton, 2016. Health risk assessment due to heavy metal exposure from commonly consumed fish and vegetables. Environment Systems and Decisions, 36(3): 253-265.
50. Bhuyan, M.S., M.A. Bakar, A. Akthar, M.B. Hossain, M.M. Ali and M.S. Islam, 2017. Heavy metal contamination in surface water and sediment of the Meghna River, Bangladesh. Environmental Nanotechnology, Monitoring and Management, 8: 273-279.
51. Ali, M.M., M.A. Rahman, M.B. Hossain and M.Z. Rahman, 2014. Aquaculture Drugs Used for Fish and Shellfish Health Management in the Southwestern Bangladesh. Asian Journal of Biological Sciences, 7(5): 225-232.
52. Zaman, M.A., M.A.S. Jewelm, M.Y. Hossain, S.J. Provhat, S. Jasmine, M.M. Ali and M.I. Hossain, 2013. Impact Assessment of Sluice Gate on Fishing Activity, Fisheries Diversity, Riverine Habitability and Livelihood Stability of the Fishermen in the Northwestern Bangladesh. International Journal of Research in Applied, Natural and Social Sciences (IJRANSS), 1(2): 99-110.
53. Islam, M.K., K.A. Habib, M.E. Ahsan, M.M. Ali and S.K. Basak, 2015. Fish biodiversity at Sibsa River in South- Western Bangladesh: status and conservation Requirements. International Journal of Fisheries and Aquatic Studies, 4(1): 24-28.
54. Basak, S.K., M.M. Ali, M.S. Islam and P.R. Shaha, 2015. Aquatic weeds of Haor area in Kishoregonj district, Bangladesh: Availability, Threats and Management Approaches. International Journal of Fisheries and Aquatic Studies, 5(6): 151-156.
55. Hossain, M.Y., S. Jasmine, A.H.M. Ibrahim, Z.F. Ahmed, M.M. Rahman and J. Ohtomi, 2009. Length-weight and length-length relationships of ten small fish species from the Ganges of Bangladesh. Journal of Applied Ichthyology, 25 1): 117-119.