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Assessment of Aquatic Faunal Diversity in the Ratargul Swamp Forest at Sylhet in Bangladesh

M. S. Islam[1*], M. A. Islam[1], N. A. Sweety[1], M. A. R. Hossain[2] and M. H. Kabir[1]

[1]Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Tangail-1902, Bangladesh

[2]Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

[*]Corresponding author: islammstazu@yahoo.com

Abstract

The study was conducted to asses the aquatic faunal diversity in the Ratargul Swamp Forest during the period from November 2014 to October 2015. For the systematic study of aquatic fauna, the quadrate method along with transect was used where 4 transects were selected in the swamp forest each with 5 stations based on topography and vegetation. A total of 24 species of aquatic fauna belonging to 18 families were identified during the period, which were crustaceans (7), molluscs (4), fishes (12) and annelid (1). Among them, fishes were the most dominant and abundant groups. The crustaceans, molluscs, fishes and annelid were shown different pattern of density and diversity within the Transects. The density of individuals in Ratargul Swamp Forest varied from station to station within a range of 8 to 40 $Indm^{-2}$. The lowest Simpson's Index of Diversity was 2.76 in T-4, which was situated in the transitional area between forested land and relatively deep lake within the forest. *Leptocarpus potamiscus*, *Nandus nandus*, and *Pila globosa* were the dominant shrimp, fish and mollusc species in the T-4, respectively. The highest Simpson's Index of Diversity was 3.89 in T-3, which was situated along the bank of a small channel within the forest. *Nematopalaemon tenuipes*, *Puntius ticto*, and *Pila globosa* were the dominant shrimp, fish and mollusc species in T-3, respectively.

Key words: Aquatic fauna, Biodiversity and Swamp forest

Introduction

Swamps and marshes are physio-geographic features of low-lying areas resulting from hydrologic and geomorphic peculiarities (Taylor *et al*., 1990). They support characteristic vegetation types subjected to seasonal flooding. In the tropics, such vegetation occurs frequently amid natural forests and along the flood plains of major rivers (Brown *et al*., 1979). Swamp forests are associated with soils that are saturated or inundated because of a high water table (Kurtz *et al.,* 2013). Fresh water swamps are the typical habitat where water oozes from the soil surface. At these places the subsoil water maintains constant level throughout the year above the surface of the soil (Sharma and Joshi, 2008). Fresh water swamps are the unique ecosystems having very specific vegetation. Water is the prime requisite of the vegetation of the swamp forests (Manhas *et al*., 2009). The formation of forest swamp needs specific climate and physiognomy conditions (Yongxing, 2003).

Biodiversity is the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (IUCN, 2010). The preservation of biodiversity is now a central issue of world conservation strategies. Bangladesh is a part of the Indo-Burma region which is one of the ten global hot spot areas for biodiversity (Mittermeier *et al.*, 1998). Due to its unique geophysical location Bangladesh is a heritage of rich biological diversity (Nishat *et al.*, 2002). Aquatic biodiversity is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change (Gupta *et al*., 2008).

Swamps play a vital role in landscaping with a wide variety of flora and fauna. Due to variation in topography, a distinct floristic diversity is seen which is quite varied from the surrounding area (Sharma and Joshi, 2008). They support characteristic vegetation on account of specialized edaphic conditions, as influenced by free water accumulation (Gupta *et al.,* 2006). They form integral part of the wetland ecosystems, serving as habitats, nursery grounds and sources of food for many organisms (Brown *et al*.,1979). Forest swamp has important hydrological support functions including providing water storage space, adjusting and saving the flood peak, keeping the underground water level, recharging runoff, taking the degradation of pollution and purifying water quality etc. (Xu and Chunjing, 2015). Ratargul Swamp Forest was decleared as Reserved forest under the Assam Forest Act in 1993. The existing ecosystem of this area consists of a few different types of habitats such ss river, lowland with vegetation and depressions (Choudhury *et al*., 2004). The objectivest of the study were i) to identify the species of aquatic fauna based on morphometric characteristics, and ii) to estimate aquatic faunal diversity of Ratargul Swamp Forest.

Materials and Methods

Study area

Ratargul Swamp Forest is located at about 45Km in the North-West of Sylhet town on the bank of the river Goyain (Fig. 1). The river Goyain is originated from the hilly areas of Meghalaya and falls into the Surma River. Ratargul Swamp Forest is on the south-east bank of Goyain river. Administrative location of the swamp is under the upazilla of Goainghat in Sylhet district. The administrative beat office is situated at latitude 25°00.025´N and longitude 91°58.180´E (Choudhury *et al*., 2004). The total area of the forest is 3325.61 acre

(BFD, 2013). It has unique floral and faunal composition than other forested areas of Bangladesh.

Sample collection

Collection of aquatic species was done in daytime from 20th to 22th December 2014. For a systematic study of aquatic fauna, the quadrate method along with transect was used. Four transects (T-1, T-2, T-3 and T-4) were selected in the swamp forest each with five station (Fig. 2). The length of each transect was fixed at 100m long. Transect-1 was situated behind the forest office and run from west to east direction along the bank of a small channel. At this point, the transect crosses some bushes of *Clinogyne dichotoma* (1.5-2.0m) as under story vegetation and *Pongamia pinnata* (12-13m) and *Barringtonia acutangula* (8-9m) as over story vegetation. In T-1, *Pongamia pinnata* was the predominant tree species. Transect-2 started from west direction and run towards east direction. Transect-2 was situated on the northward side in relation to the T-1. It was a grass field with shallow water area. The height of the grass was about 0.5-1.0m. Transect-3 started from north and run towards south direction along the bank of a small channel and it was situated on northward side in relation to the T-2. Transect-3 crosses a dense stand of *Clinogyne dichotoma* (1.5-2.0m). *Rosa involucrata* (1.0-1.5m), *Barrintonia acutangula* (7-9m) and *Pongamia pinnata* (12-13m) were also found in the way of the transect. Transect-4 started from a low land in east and run towards west along the bank of a lake. It is mainly a transitional area between forested land and relatively deep lake. *Pongamia pinnata* (12-14m) was the predominant tree species in this transect. It was situated on southward side in relation to the T-3.

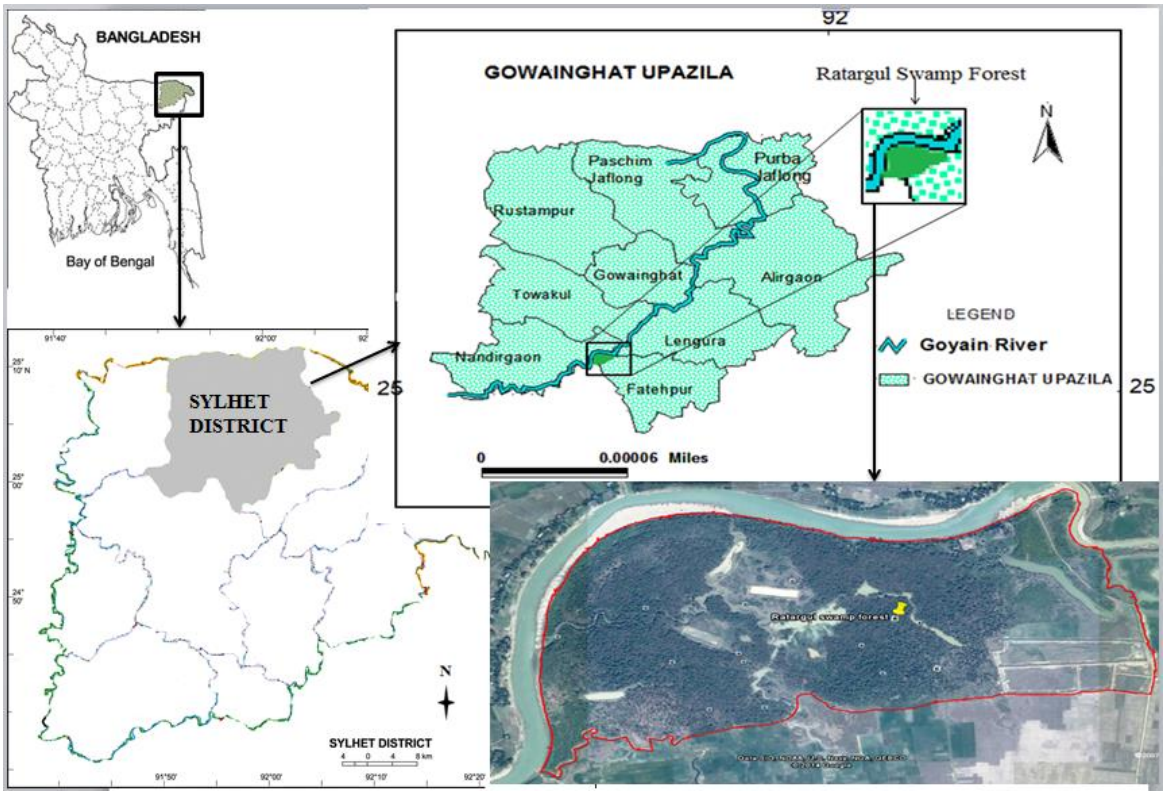

Fig. 1. Map showing the study area at Ratargul Swamp Forest in Sylhet district

Five stations (St) were selected randomly in eact transect. In Transect-1, water depth not more than 50cm. In Transect-2, the water depth (45-30cm) decreased gradually from St-1 to St-5. In Transect-3, the water depth of all five stations was not exceeded 45cm. In Transect-4, St-1 and St-2 were situated on lowland with a water depth of 35cm, where St-3, St-4 and St-5 were situated on the bank of a lake with a depth not more than 50cm.

Sample analysis

To measure species density within a given area, a 0.25×0.25 m quadrate were taken for the sampling of aquatic fauna and all the specimens within this area, both on the surface to the bottom were collected for further identification and measurement. Density was calculated for each sampling station using the formula, Density: d = # Species / Area sampled and species diversity for each station was calculated using Simpson's Index of Diversity: $D = 1 / \sum II^2$, where $\sum II^2 = \sum (n_i / N)^2$, N = total number of individuals, n_i = number of individuals in "i"th species (Islam *et al*., 2003). Collected samples were preserved with 8% formalin in plastic jar.

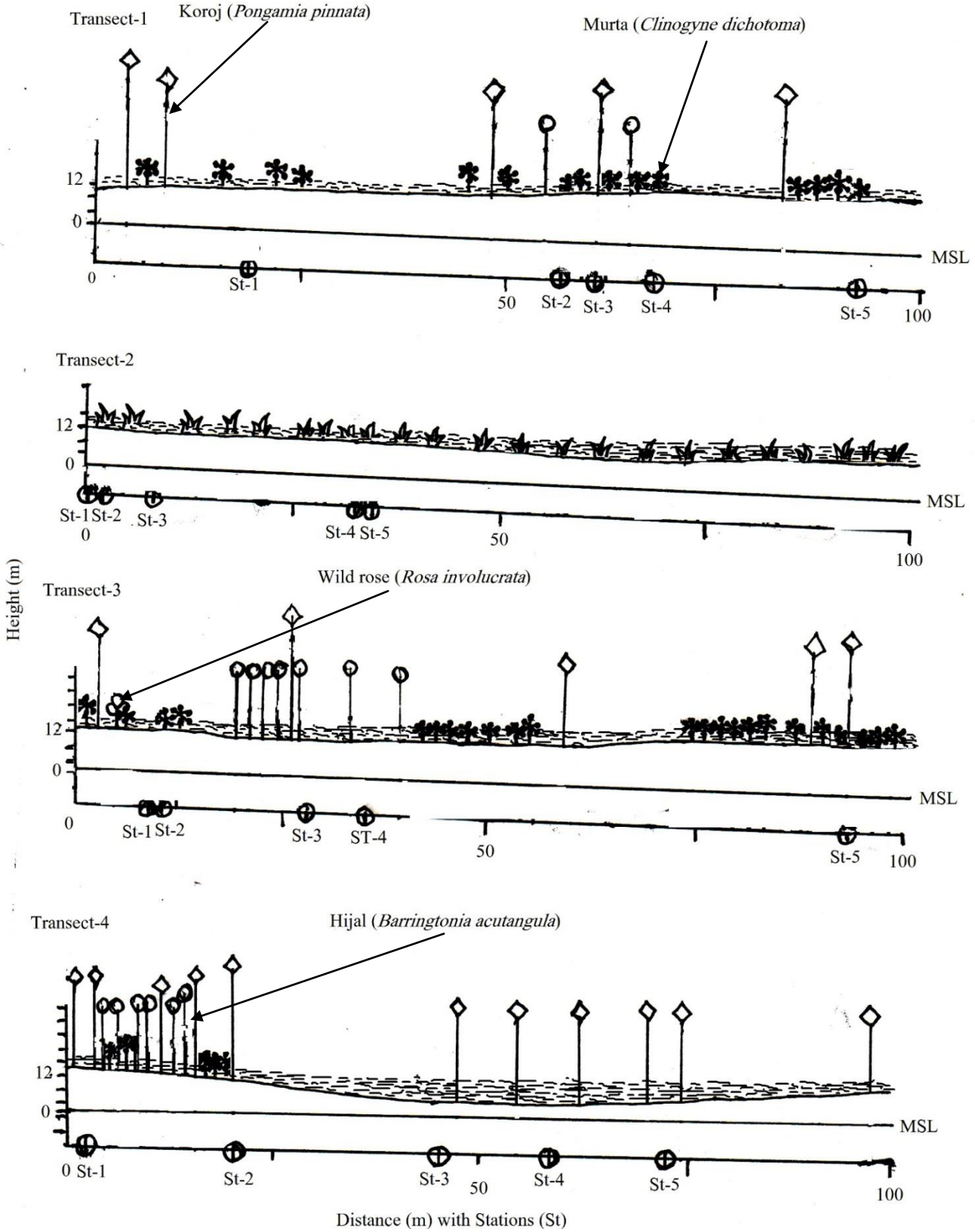

Fig. 2. Schematic profiles of the study stations at each transect of Ratargul Swamp Forest in Sylhet (MSL indicated Mean Sea Level)

The identification of species and their taxonomic classification were followed i) Freshwater Fishes of Bangladesh (Rahman, 2005); ii) Inland Fishes of India and Adjacent Countries (Talwar and Jhingran, 1992);

iii) Encyclopedia of Flora and Fauna of Bangladesh: Molluscs (V.17), Asiatic Society, Bangladesh; iv) Commercial and Medicinal Important Molluscs of Sundarbans, India (Dey, 2008); v) Encyclopedia of Flora and Fauna of Bangladesh: Arthropoda: Crustacea (V. 18, Part-II), Asiatic Society, Bangladesh; vi) FAO Species Catalogue: V. 1. Shrimps and Prawns of the world (Holthuis, 1980); vii) The Caridean Shrimps of the Albatross Philippine Expedition, (Fenner *et al*., 1993) and viii) FAO species identification guide for fishery purposes (Carpenter and Niem, 1998).

Some renowned websites such as Fish Base (www.fishbase.org), Encyclopedia of life (www.eol.org), ITIS report (www.itis.gov) and The IUCN Red List of Threatened Species (www.iucnredlist.org) were also followed for recent classification and relevant taxonomic information of species. Preserved specimens were identified in laboratory. For identification of fish species fin-formula was used. The fin-formula is constructed with the letters D for dorsal; D_1, D_2 if two dorsals are present, P_1 for pectoral, P_2 for pelvic, A for anal and C for caudal fins. Roman figures indicate true and hard spines, arabic figures indicate soft rays. To differentiate the spines from the rays or branched from the unbranched rays the formula is used as follows:

D. VII-IX/12 - 15 = Dorsal fin composed of 7-9 spines, 12-15 soft rays.
D. 3/8 = Dorsal fin composed of 3 unbranched and eight branched rays.
A. 2-3/8-10 = Anal fin composed of 2 or 3 unbranched and 8-10 branched rays.
P_1. I/10-12 = Pectoral fin composed of one spine and 10-12 soft rays.
P_2. 1/5 = Pelvic fin composed of one unbranched and five branched rays.
D_1. X; D_2. I/10-12 = First dorsal fin composed of 10 spines and second dorsal fin composed of one spine and 10-12 soft rays (Rahman, 2005).

Results and Discussion

A total of 7 different species of crustaceans belonging to 3 families as Gecarcinucidae, Palaemonidae and Atyidae (Tables 2 and 3), 12 species of fishes belonging to 10 families as Cyprinidae, Cobitidae, Badidae, Bagridae, Nandidae, Channidae, Gobiidae, Balitoridae, Mastacemelidae, Anabantidae (Tables 4 and 5) 4 species of molluscs belonging to 4 families as Unionidae, Ampullariidae, Thiaridae and Viviparidae (Tables 6 and 7), and 1 species of annelid belonging to family Hirudinidae (Table 8) were collected quantitatively.

A total of 4 species of shrimps, 5 species of fishes, and 2 species of molluscs were found from T-1. Among the crustacean species *Macrobrachium equidens* was the dominant shrimp species. The fish *Macrognathus pancalus* was dominant along the bank of a small channel behind the forest office. *Bellamya bengalensis* was the dominant mollusc species in T-1. A total of 5 species of shrimps, 1 species of crab, 3 species of fishes, and 1 species of annelid were recorded from T-2. *Nematopalaemon tenuipes* and *Puntius ticto* were the dominant shrimp and fish species respectively in the grass field with shallow water depth within the forest. A total of 6 species of shrimps, 1 species of crab, 6 species of fishes, and 3 species of molluscs were collected in T-3. *Nematopalaemon tenuipes*, *Puntius ticto*, and *Bellamya bengalensis* were the dominant shrimp, fish, and mollusc species respectively in this transect. A total of 3 species of shrimps, 2 species of fishes, 3 species of molluscs, and 1 species of annelid were collected from T-4. Among the crustacean species *Leptocarpus potamiscus* was the dominant shrimp species in T-4. *Nandus nandus* and *Bellamya bengalensis* were the dominant fish and mollusc species respectively in T-4.

Table 1. Species number, density and diversity index of aquatic fauna at each station of Transects 1 to 4 in Ratargul Swamp forest

Transects	**Stations with distance (m)**	**Number (per 0.25 m²)**	Diversity Index (D)
Transect-1	St-1 (18)	2	2.00
	St-2 (56)	7	4.46
	St-3 (60)	4	2.66
	St-4 (68)	10	3.85
	St-5 (92)	5	3.57
	Mean ± SD	5.6 ± 3.05	3.31 ± 0.98
Transect-2	St-1 (00)	6	2.99
	St-2 (01)	7	4.46
	St-3 (07)	2	2.00
	St-4 (27)	3	3.00
	St-5 (33)	4	2.00
	Mean ± SD	4.4 ± 2.07	2.89 ± 1.01
Transect-3	St-1 (09)	5	2.27
	St-2 (10)	9	2.80
	St-3 (28)	10	6.25
	St-4 (35)	9	5.38
	St-5 (94)	5	2.78
	Mean ± SD	7.6 ± 2.41	3.89 ± 1.79
Transect-4	St-1 (02)	5	1.47
	St-2 (20)	8	3.53
	St-3 (45)	4	2.66
	St-4 (58)	5	3.57
	St-5 (72)	6	2.57
	Mean ± SD	5.6 ± 1.52	2.76 ± 0.86

Table 2. Distribution of crustaceans in Transects 1 and 2 of Ratargul Swamp forest

Species	Stations (St)					**Total** no.	IUCN G C
	St-1	**St-2**	**St-3**	**St-4**	**St-5**		
Transect-1							
Family Gecarcinucidae							
Sartoriana spinier (Wood-Mason, 1871)	Nf	Nf	Nf	Nf	Nf	Nf	LC
Family Palaemonidae							
Macrobrachium lamarrei (H. Milne-Edwards, 1837)	Nf	1	Nf	Nf	Nf	1	LC
Family Palaemonidae							
Macrobrachium equidens (Dana, 1852)	1	1	2	1	Nf	5	LC
Family Palaemonidae							
Leptocarpus potamiscus (Kemp, 1917)	Nf	2	Nf	2	Nf	4	LC
Family Palaemonidae							
Nematopalaemon tenuipes (Henderson, 1893)	Nf	Nf	Nf	Nf	1	1	-
Total number	1	4	2	3	1	11	
Transect-2							
Family Gecarcinucidae							
Sartoriana spinigera (Wood-Mason, 1871)	Nf	Nf	1	Nf	Nf	1	LC
Family Palaemonidae							
Macrobrachium lamarrei (H. Milne-Edwards, 1837)	Nf	Nf	Nf	1	Nf	1	LC
Family Palaemonidae							
Leptocarpus potamiscus (Kemp, 1917)	1	Nf	Nf	1	Nf	2	LC
Family Palaemonidae							
Nematopalaemon tenuipes (Henderson, 1893)	3	2	Nf	Nf	2	7	-
Family Palaemonidae							
Macrobrachium idella (Hilgendorf, 1898)	1	1	Nf	Nf	Nf	2	LC
Family Atyidae							
Caridina weberi (De Man, 1892)	Nf	2	Nf	Nf	Nf	2	LC
Total number	5	5	1	2	2	15	

Note: Nf=Not found, "-"=No data, LC=Least Concern, GC= Global Category.

Table 3. Distribution of crustaceans in Transects 3 and 4 of Ratargul Swamp forest

Species	**Stations (St)**					**Total** no.	IUCN G C
	St-1	**St-2**	**St-3**	**St-4**	**St-5**		
Transect-3							
Family Gecarcinucidae							
Sartoriana spinier (Wood-Mason, 1871)	Nf	Nf	1	Nf	Nf	1	LC
Family Palaemonidae							
Macrobrachium lamarrei (H. Milne-Edwards, 1837)	Nf	1	Nf	1	Nf	2	LC
Family Palaemonidae							
Macrobrachium equidens (Dana, 1852)	Nf	Nf	Nf	Nf	2	2	LC
Family Palaemonidae							
Leptocarpus potamiscus (Kemp, 1917)	Nf	Nf	2	Nf	2	4	LC
Family Palaemonidae							
Nematopalaemon tenuipes (Henderson, 1893)	3	1	Nf	2	Nf	6	-
Family Atyidae							
Caridina weberi (De Man, 1892)	1	Nf	Nf	2	1	4	LC
Family Palaemonidae							
Macrobrachium idella (Hilgendorf, 1898)	Nf	Nf	1	Nf	Nf	1	LC
Total number	4	2	4	5	5	20	
Transect-4							
Family Gecarcinucidae							
Sartoriana spinigera (Wood-Mason, 1871)	Nf	Nf	Nf	Nf	Nf	Nf	LC
Family Palaemonidae							
Leptocarpus potamiscus (Kemp, 1917)	4	3	1	Nf	2	10	LC
Family Palaemonidae							
Nematopalaemon tenuipes (Henderson, 1893)	Nf	2	2	Nf	1	5	-
Family Palaemonidae							
Macrobrachium equidens (Dana, 1852)	1	Nf	Nf	Nf	3	4	LC
Total number	5	5	3	-	6	19	

Note: Nf=Not found, "-"=No data, LC=Least Concern, GC= Global Category.

Table 4. Distribution of fishes in Transects 1 and 2 of Ratargul Swamp forest

Species	**Stations (St)**					**Total** no.	IUCN G C
	St-1	**St-2**	**St-3**	**St-4**	**St-5**		
Transect-1							
Family Anabantidae							
Anabas testudineus (Bloch, 1792)	Nf	1	Nf	Nf	Nf	1	DD
Family Mastacemelidae							
Macrognathus pancalus (Hamilton, 1822)	Nf	2	1	2	Nf	5	LC
Family Balitoridae							
Schistura corica (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Family Chandidae							
Pseudambassis ranga (Hamilton, 1822)	Nf	Nf	Nf	Nf	1	1	LC
Family Gobiidae							
Gobiopsis macrostoma (Steindachner, 1861).	Nf	Nf	Nf	Nf	1	1	LC
Total number	-	3	1	3	2	9	
Transect-2							
Family Cyprinidae							
Puntius ticto (Hamilton, 1822)	Nf	Nf	1	Nf	2	3	LC
Family Chandidae							
Pseudambassis ranga (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Family Balitoridae							
Schistura corica (Hamilton, 1822)	Nf	1	Nf	Nf	Nf	1	LC
Total number	-	1	1	1	2	5	

Note: Nf=Not found, "-"=No data, LC=Least Concern, GC= Global Category, DD=Data Deficient.

Table 5. Distribution of fishes in Transects 3 and 4 of Ratargul Swamp forest

Species	Stations (St)					Total	IUCN
	St-1	St-2	St-3	St-4	St-5	no.	G C
Transect-3							
Family Mastacemelidae							
Macrognathus pancalus (Hamilton, 1822)	Nf	1	Nf	Nf	Nf	1	LC
Family Channidae							
Channa orientalis (Bloch and Schneider, 1801)	Nf	1	Nf	Nf	Nf	1	-
Family Cyprinidae							
Puntius sophore (Hamilton, 1822)	Nf	Nf	1	2	Nf	3	LC
Family Nandidae							
Nandus nandus (Hamilton, 1822)	Nf	Nf	1	Nf	Nf	1	LC
Family Bagridae							
Mystus tengara (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Family Badidae							
Badis badis (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Total number	-	2	2	4	-	8	
Transect-4							
Family Nandidae							
Nandus nandus (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Family Cobitidae							
Lepidocephalichthys guntea (Hamilton, 1822)	Nf	Nf	Nf	1	Nf	1	LC
Total number	-	-	-	2	-	2	

Note: Nf=Not found, "-"=No data, LC=Least Concern, GC= Global Category.

Table 6. Distribution of molluscs in Transects 1 and 2 of Ratargul Swamp forest

Species	**Stations (St)**					**Total** no.	IUCN G C
	St-1	**St-2**	**St-3**	**St-4**	**St-5**		
Transect-1							
Family Unionidae							
Lamellidens marginalis (Lamarck, 1819)	Nf	Nf	Nf	Nf	Nf	-	LC
Family Viviparidae							
Bellamya bengalensis (Lamarck, 1882)	Nf	Nf	1	4	2	7	LC
Family Thiaridae							
Melanoides tuberculatus (Muller, 1774)	Nf	Nf	Nf	Nf	Nf	-	LC
Family Ampullariidae							
Pila globosa (Swainson, 1822)	1	Nf	Nf	Nf	Nf	1	LC
Total number	1	-	1	4	2	8	
Transect-2							
Family Unionidae							
Lamellidens marginalis (Lamarck, 1819)	Nf	Nf	Nf	Nf	Nf	Nd	LC
Family Viviparidae							
Bellamya bengalensis (Lamarck, 1882)	Nf	Nf	Nf	Nf	Nf	Nd	LC
Family Thiaridae							
Melanoides tuberculatus (Muller, 1774)	Nf	Nf	Nf	Nf	Nf	Nd	LC
Family Ampullariidae							
Pila globosa (Swainson, 1822)	Nf	Nf	Nf	Nf	Nf	Nd	LC
Total number							

Note: Nf=Not found, Nd=No data, LC=Least Concern, GC= Global Category.

Table 7. Distribution of molluscs in Transects 3 and 4 of Ratargul Swamp forest

Species	Stations (St)					Total no.	IUCN G C
	St-1	St-2	St-3	St-4	St-5		
Transect-3							
Family Unionidae							
Lamellidens marginalis (Lamarck, 1819)	Nf	Nf	2	Nf	Nf	2	LC
Family Viviparidae							
Bellamya bengalensis (Lamarck, 1882)	1	5	Nf	Nf	Nf	6	LC
Family Thiaridae							
Melanoides tuberculatus (Muller, 1774)	Nf	Nf	2	Nf	Nf	2	LC
Family Ampullariidae							
Pila globosa (Swainson, 1822)	Nf	Nf	Nf	Nf	Nf	-	LC
Total number	1	5	4	-	-	10	
Transect-4							
Family Unionidae							
Lamellidens marginalis (Lamarck, 1819)	Nf	Nf	Nf	Nf	Nf	-	LC
Family Viviparidae							
Bellamya bengalensis (Lamarck, 1882)	Nf	1	1	2	Nf	4	LC
Family Thiaridae							
Melanoides tuberculatus (Muller, 1774)	Nf	Nf	Nf	1	Nf	1	LC
Family Ampullariidae							
Pila globosa (Swainson, 1822)	Nf	Nf	Nf	Nf	Nf	-	LC
Total number	-	1	1	3	-	5	

Note: Nf=Not found, "-"=No data, LC=Least Concern, GC= Global Category.

Table 8. Distribution of Annelid in Transects 1 to 4 of Ratargul Swamp forest

Species	Transects	Stations (St)					Total	IUCN
		St-1	St-2	St-3	St-4	St-5		G C
Family Hirudinidae	1	Nf	Nf	Nf	Nf	Nf	Nd	
Hirudo medicinalis (Linnaeus, 1758)	2	1	1	Nf	Nf	Nf	2	NT
	3	Nf	Nf	Nf	Nf	Nf	Nd	
	4	Nf	2	Nf	Nf	Nf	2	

Note: Nf = Not found, Nd= No data, LC = Least Concern, GC= Global Category.

Density of aquatic faunain T-1

It revealed from the study that in T-1, the density (In dm^{-2}) was calculated from 8 to 40 with the mean value of 22.4 and standard deviation 12.19 (Table 1). The density (In dm^{-2}) calculated for five stations in Transect-1, were 8, 28, 16, 40, and 20, for St-1, St-2, St-3, St-4, and St-5, respectively (Fig. 3).

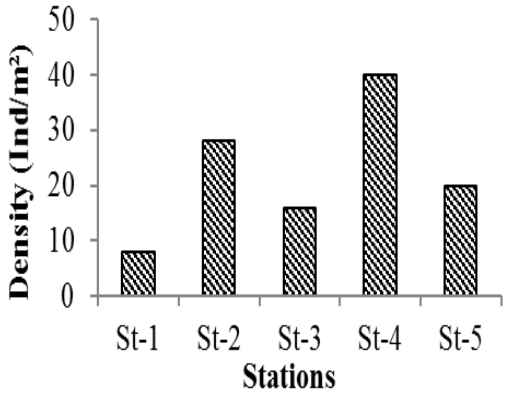

Fig. 3. Density (Ind m^{-2}) of aquatic fauna in Transect-1

In T-1, the lowest density was calculated 8 at St-1 and the highest density was 40 at St-4 (Fig. 3). It indicates that St-4 contains more species assemblages rather than St-1, because of the presence of *Clinogyne dichotoma*, which generally provides shelter for aquatic fauna. On the other hand there were no aquatic macrophytes near St-1 and this may be the reason of having low density at St-1. The total density in T-1 was 112. The study conducted by Long (2010) showed that, the total density was 179 at St-4 (Freshwater station), which was very high compared to present study.

Density of aquatic faunain T-2

It exposed from the study that, in T-2, the density (Ind m^{-2}) was varied from 8 to 28 with the mean value of 17.6 and standard deviation 8.29 (Table 1). The density (Ind m^{-2}) calculated for five stations in Transect-2, were 24, 28, 8, 12, and 16, for St-1, St-2, St-3, St-4, and St-5, respectively (Fig. 4).

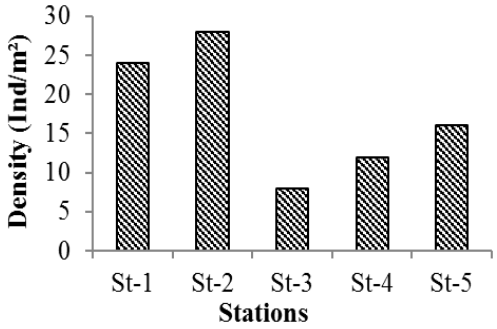

Fig. 4. Density (Ind m^{-2}) of aquatic fauna in T-2

It revealed from the study that, in T-2, the lowest density was calculated 8 at St-3 (Fig. 4). The reason may be there was a few aquatic macrophytes, which provide shelter for aquatic fauna. The highest density was 28 at St-2 (Fig. 4), this could be due to the excessive presence of aquatic macrophytes, which act as a sanctuary for aquatic fauna. In T-2, the total density was 88. Long (2010) stated that, the total density at St-5 (Freshwater station) was 77, which was low compared to present study.

Density of aquatic faunain T-3

It exposed from the study that, in T-3, the density (Ind m^{-2}) was ranged from 20 to 40 with the mean value of 30.4 and standard deviation 9.63 (Table 1). The density (Ind m^{-2}) calculated for five stations in T-3, were 20, 36, 40, 36, and 20, for St-1, St-2, St-3, St-4, and St-5, respectively (Fig. 5).

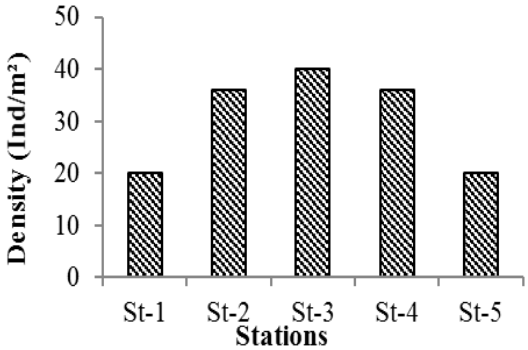

Fig. 5. Density (Ind m^{-2}) of aquatic fauna in T-3

In T-3, the lowest density was calculated 20 at St-1 and St-5 (Fig. 5). It represents less species assemblages at both St-1 and St-5 compared to St-3. St-1 was situated in a place where there was a few nesting materials for aquatic fauna and St-5 was situated in a place far behind

a large tree containing a few nesting materials. The highest density was calculated 40 at St-3 (Fig. 5), because St-3 had a large amount of leaf litter on the bottom of water, which was a source of nutrients for aquatic fauna, this may be the reason of high density at St-3. The total density was calculated in T-3 was 152. According to Long (2010), the total density at St-6 (Freshwater station) was 70, which was very low compared to present study.

Density of aquatic faunain T-4

It revealed from the study that, in T-4, the density (Ind m^{-2}) was recorded from 16 to 32 with the mean value of 22.4 and standard deviation 6.07. This is presented in Table 1. The density (Ind m^{-2}) calculated for five stations in T-4, were 20, 32, 16, 20, and 24, for St-1, St-2, St-3, St-4, and St-5, respectively (Fig. 6).

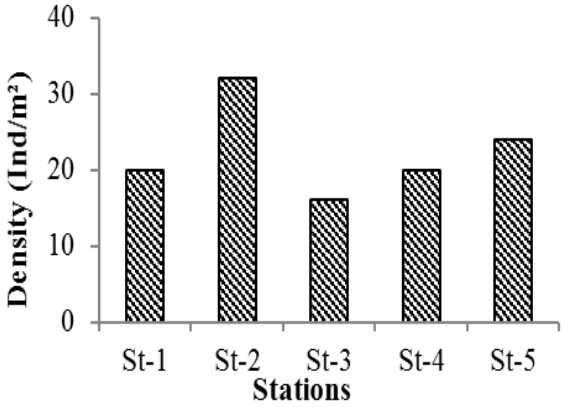

Fig. 6. Density (Ind m^{-2}) of aquatic fauna in T-4

It exposed that, in T-4, the lowest density was calculated 16 at St-3 (Fig. 6). The reason of having lowest density at St-3 may be the absence of *Clinogyne dichotoma* or presence of few aquatic macrophytes near St-3. The highest density was 32 at St-2 (Fig. 6), because there was a large amount of nesting materials, as St-2 was situated near a large tree and bushes of *Clinogyne dichotoma*. The total density in Transect-4 was 112. Long (2010) showed that, the total density was 91 at St-7 (Freshwater station), which was very low compared to present study.

Diversity of aquatic fauna at each transect in Ratargul swamp forest

The Simpson's Index of Diversity was D=3.31 in T-1, D=2.89 in T-2, D=3.89 in T-3, and D=2.76 in T-4, respectively (Table 1). It was apparent from the study that, the species diversity was low (2.76) in T-4, compared with the other Transects, which could be due to the food unavailability, water level fluctuation, topography or absence of small vegetation. The highest diversity was 3.89 in the T-3; because of the excessive presence of *Clinogyne dichotoma,* which provides shelter for aquatic organisms or the food availability at the small channel in the middle of the forest. The average species diversity was very low in Ratargul Swamp forest (D=3.21) when compared with the Cultivators Rice Field (D=3.86) of North West Kashmir, India (Bahaar and Bhat, 2011).

Conclusions

The present study shows that highest diversity occurs in the habitat bearing a dense stand of *Clinogyne dichotoma* (locally called murta) at the small channel in the middle of the forest, which provides undisturbed shelter for aquatic fauna. It indicates that a greater number of successful species were present in this habitat. The present study also shows that the lowest diversity occurs in the habitat situated in the transitional area between forested land and relatively deep lake, where there was a very little amount of small vegetation to provide shelter for aquatic fauna. It indicates that the environment was quite stressful with relatively few ecological niches and only a few organisms were really well adapted to that environment. Because of being a transitional zone this habitat faces human disterbance.

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