Diversity of aquatic insects of Dibru River near Dibru Saikhowa National Park, Assam, North East India

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Abstract: ***A study was conducted on aquatic insect community of Dibru River at three sites, Guiijan ghat (DS1), Kaliapani ghat (DS2) and Khantigwali ghat (DS3) of Dibrugarh district near Dibru Saikhowa National Park. The sampling of aquatic insects and water was done in replicates during September 2014-2015. The study recorded 4 orders, 8 families, 12 genera and 12 species of aquatic insects. Highest density of order Hemiptera was recorded in pre monsoon and lowest and same density was recorded of order Odonata and Coleoptera in monsoon and winter. Seasonal variations of environmental variables of water were found moderate. Density of aquatic insects showed significant negative relationship with phosphate. The study revealed low Shannon Weiner Diversity Index values of aquatic insects (Shanon H<1) in all the sites indicating perturbed conditions of water. Canonical Correspondence Analysis (CCA) showed that the species environmental correlations of axis 1 and axis 2 were high.***

Keywords: Aquatic insects, Dibru River,lotic,density, Dibru Saikhowa National Park.

1. Introduction

Aquatic insects are among the most prolific animals on earth [1]. They are an important component of invertebrate assemblages in aquatic ecosystem where they are a controlling group in food webs. At the larval stage, they constitute the principal nutritive fauna of fish [2, 3]. Although there are a few studies on aquatic insects of lotic systems of north east India [4 ,5, 6] till date no study on aquatic insects of Dibru River is in record.

Dibru Saikhowa National Park (27˚30′ N to 27˚45′N and 95˚10 E to 95˚45′E), one of the famous National Park of Assam is situated in between the districts of Dibrugarh and Tinsukia in Upper Assam. Situated in the flood plain of the Brahmaputra, Dihang, Dibang, Lohit and Dibru rivers, the area presents immense biodiversity values which are reflected in its location in a Biodiversity hotspot. The Dibru River falls to the south of this National Park which is actually a water channel of river Brahmaputra. The Brahmaputra River flows along the northern margin of Dibru Saikhowa National Park and being a braided system forms the channel known as Dibru River which flow along the other side i.e south of the National Park. Although studies are there on the ecology in relation to the fisheries of this river system [7-10], there is no study on aquatic insect community. A qualitative and quantitative assessment of the aquatic insect community and environmental variables of water of this part of the river will enrich the aquatic fauna data base and reflect the water quality status of the river as well.

2. Materials and Methods

For this study three sites of river Dibru in the south west of Dibru Saikhowa National Park were selected. The sites are Guiijan ghat (DS1, 27˚57′ N and 95˚32′E), Kaliapani ghat (DS2, 27˚57′ N and 95˚34′E) and Khantigwali ghat (DS3, 27˚57′ N and 95˚35′ E) (Fig 1).Aquatic insects were collected seasonally in replicates by a hand net having a mesh size of 60 µm fixed to a square wrought iron frame by “ 1 minute Kick” method [11] whereby the vegetation was disturbed and the net was dragged through the system for a unit time [12]. Three such drags constituted a sample. They were sorted, enumerated and preserved in 70% ethyl alcohol and identification was done using Magnus (Olympus Model MSZ-TR) and Stereozoom microscope (Motic, Model – SMZ-168). Taxonomic identification was carried out using standard keys [13-24].

For analysing dissolved oxygen (DO), water samples were collected in 300 ml BOD bottle in replicates from each site. For analysing free CO_2 (F CO_2), pH, electrical conductivity (EC), total dissolved solid (TDS), total alkalinity (TA), nitrate (NO_3^-) and phosphate (PO_4^{3-}) water samples were collected in polyethylene bottles from each sampling site. Air temperature (AT) and water temperature (WT) were recorded itself in the site by mercury bulb thermometer. Rainfall (RF) data were collected from Sessa Tea state, Dibrugarh district, Assam. pH was determined with the help of pH meter (Digital pH meter MK VI). Electrical conductivity (EC) was estimated by conductivity meter. DO, F-CO_2, TA, NO_3^- and PO_4^{3-} were estimated by standard methods [25-27]. Soil samples were also collected from the selected sites and analysis was done by hydrometer method [28].

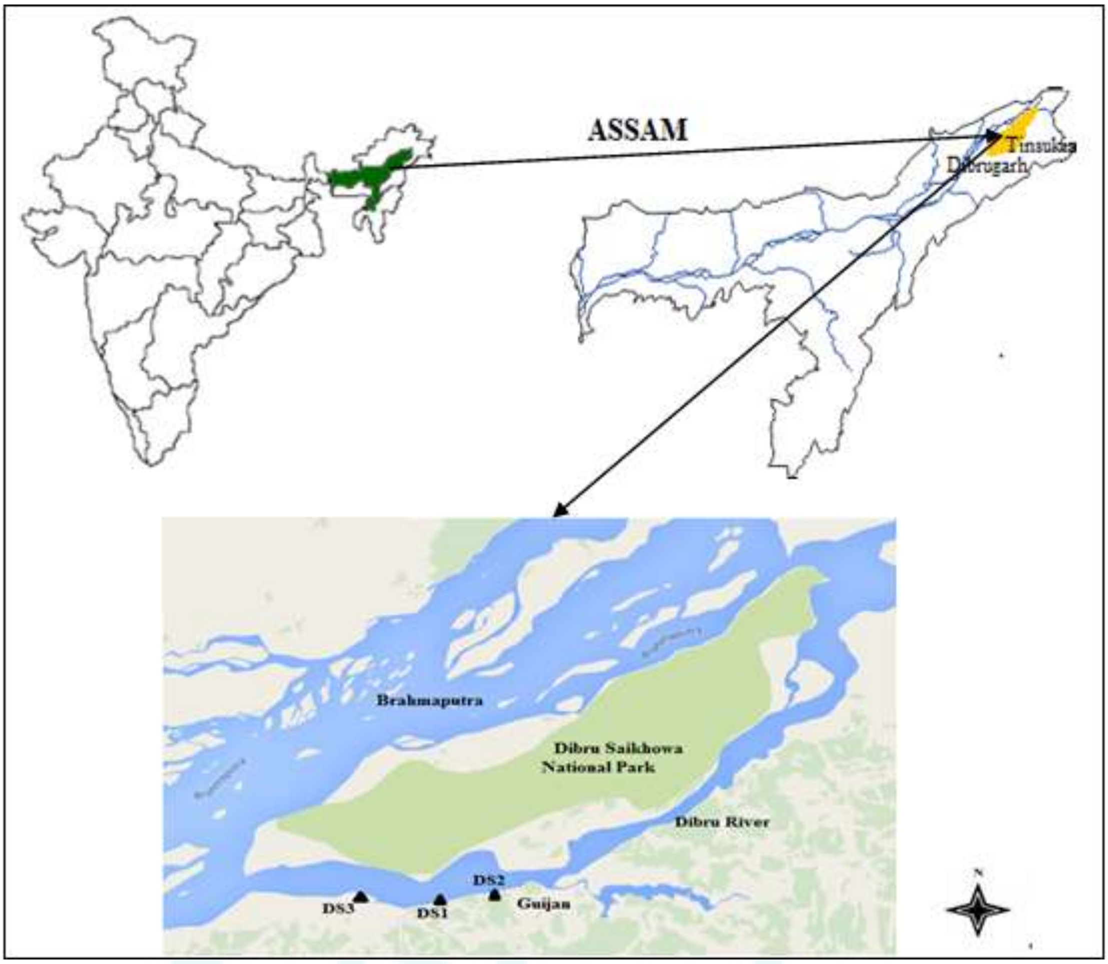

Figure 1: Map of India followed by map of Assam showing the collection sites at Dibru River near Dibru Saikhowa National Park

Diversity indices like Margalef Index (M), Shanon – Wiener Index (H/), Eveness Index (J), and Berger Parker Index of Dominance (d) for the insect community were worked out using the package Biodiversity Professional Version 2 for Windows 1997 (The Natural History Museum and Scottish Association for Marine Science). The dominance status of insect species was evaluated following Engelmann's scale based on relative abundance [29]. SIGNAL (Stream Invertebrate Grade Number-Average Level), a family-level water pollution index based on the known tolerances of aquatic macro-invertebrate families to various pollutants was worked out by the standard method [30]. BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scores were computed by standard methods [31]. HKHbios (Hindu Kush-Himalayan biotic Score) was worked out using standard methods [32]. Statistical analyses were done by using package SPSS 20.0 for Windows 7. Canonical Correspondence analysis (CCA) was done to see the relationship of insect abundance to environmental variables in the four seasons using CANOCO package for windows 4.5 [33].

3. Results and Discussion

3.1. Diversity and density

The study recorded 4 orders, 8 families, 12 genera and 12 species of aquatic insects. The orders were Coleoptera, Hemiptera, Odonata and Ephemeroptera. The families were Coenagrionidae, Libellulidae, Baetidae, Gerridae, Corixidae, Hydrophilidae, Veliidae and Noteridae. (Table 1). Density and relative abundance of order Hemiptera was found highest in pre monsoon, DS2 and lowest and same density was recorded of the order Odonata at DS1 in monsoon and Coleoptera at DS2 in winter (Fig.2 & 3). A study in the lower reach of Moirang River in Manipur, N.E. India also recorded high Hemiptera diversity and density [34]. This may be because of their ability to survive in water bodies with low levels of dissolved oxygen by utilizing atmospheric oxygen [35] and their broad range of habitats within a water body [36]. Hemipterans belonging to family Gerridae were relatively abundant at DS2 in post monsoon and at DS1 in winter respectively (Fig 3). According to Engelmann's Scale the eudominant species recorded were *Gerris lepcha* in post monsoon and *Microvelia plumbea* in monsoon. *Aquarius conformis* was found eudominat in post monsoon and winter seasons respectively [37] (Table 1). This is because during winter adults of Gerridae move to protected sites on land [38]. The causes of fluctuations in insect abundance and distribution include macroclimatic and microclimatic changes and variation in the availability of food resources [39, 40, 41, 42, 43].

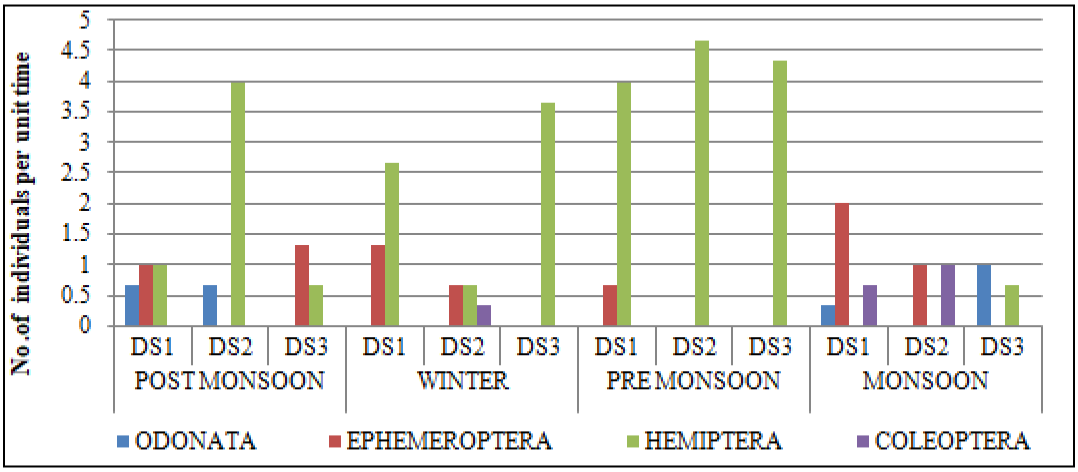

Figure 2: Seasonal variations in density (no. of ind/ unit time) of different orders of aquatic insects in three sites of Dibru River

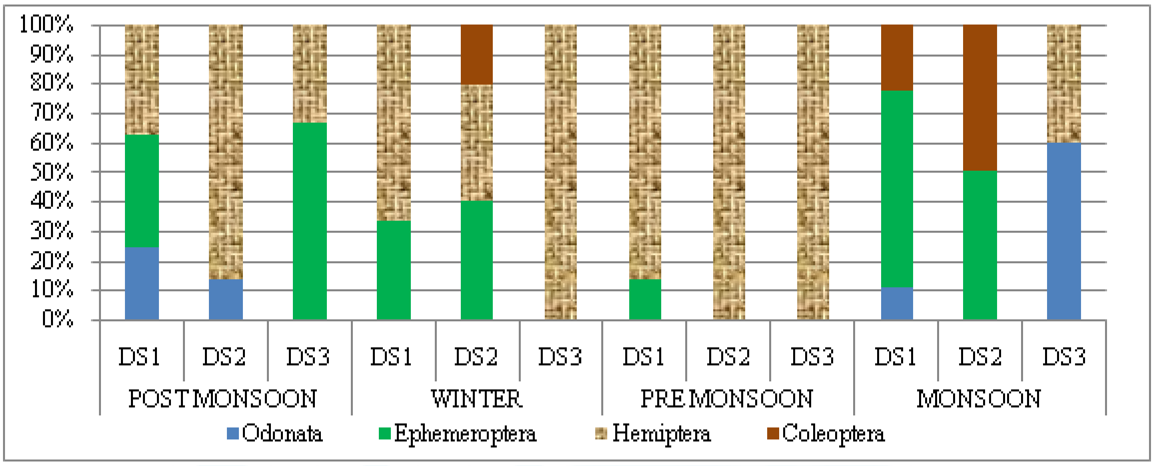

Figure 3: Seasonal variations in relative abundance (%) of different orders of aquatic insects in three sites of Dibru River

Table 1: Dominance status of different species of aquatic insect community found in Dibru River based on Engelmann's scale (1978). Relative Abundance < 1 % = Subrecedent (SR); 1.1 - 3.1 % = Recedent (R); 3.2 - 10 % = Subdominant (SD); 10.1 - 31.6 % =Dominant (D), > 31.7 % = Eudominant (ED)

Order	Family	Taxa	Post monsoon			Winter			Pre monsoon			Monsoon		
			DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3	DS1	DS2	DS3
Odonata	Coenagrio-nidae	*Pseudagrion microcephalum (Rambur,1842)*	25 D	7.14 SD	–	–	–	–	–	–	–	11.11 D	–	60 ED
	Libellulidae	*Trithemis aurora(Burmeister,1839)*	–	7.14 SD	–	–	–	-	–	–	–	–	–	–
Ephemeroptera	Baetidae	*Cloeon inscriptum (Bengtsson,1914))*	37.5 ED	–	66.67 ED	33.3 ED	40 ED	–	14.29 D	–	–	66.67 ED	50 ED	–
Hemiptera	Gerridae	*Gerris lepcha (Fabricius,1794)*	37.5 ED	35.71 ED	33.33 ED	16.67 D	–	–	21.43 D	14.29 D	-	–	–	–
		Aquarius confor-mis (Uhler,1878)	–	42.86 ED	–	50 ED	–	63.64 ED	35.71 ED	21.43 D	–	–	–	–
	Corixidae	*Micronecta scutellaries. (Kirkaldy,1897)*	–	7.14 SD	–	–	40 ED	36.36 ED	–	–	–	–	–	–
	Vellidae	*Microvelia plumbea (Westwood,1834)*	–	–	–	–	–	–	28.57 D	64.29 ED	46.15 ED	–	–	40 ED
Coleoptera	Hydrophilidae	*Laccobius* sp. *(Erichson,1837)*	–	–	–	–	20 D	–	–	–	–	–	–	–

		Cymbiodyta sp. (Bedel,1881)	–	–	–	–	–	–	–	–	–	–	16.67 D	–
		Phaenonotum sp. *(Sharp,1882)*	–	–	–	–	–	–	–	–	–	11.11 D	–	–
	Noteridae	*Pronoterus* sp. *(Sharp,1882)*	–	–	–	–	–	–	–	–	–	11.11 D	–	–
		Suphisellus sp. *(Crotch,1873)*	–	–	–	–	–	–	–	–	–	–	33.33 ED	–

3.2. Diversity indices

Diversity index can also be used to measure environmental stress [44]. The seasonal variations in the diversity indices of aquatic insects are presented in Table 2. The Shannon Weiner Diversity Index was found to be maximum in pre-monsoon (0.58) and minimum in post monsoon (0.28). Maximum Berger-Parker Index of Dominance value in monsoon (0.67) indicated that the system was occupied by dominant species thus justified the lowest Shannon H' in that season. Evenness index was highest in post monsoon (0.99), which was near to 1.

Table 2: Seasonal variations of diversity indices of Dibru River during 2014-15

Seasons	Shannon H’ log Base 10			Evenesss’ J			Berger Parker Dominance(d)			Margaleff M base 10		
	DS1	DS2	DS3	DS1	DS2	DS3	DS 1	DS 2	DS3	DS1	DS2	DS3
Post monsoon	0.47	0.56	0.28	0.99	0.81	0.92	0.38	0.43	0.67	5.53	4.36	6.43
Winter	0.44	0.46	0.29	0.92	0.96	0.95	0.50	0.4	0.64	3.71	5.72	3.84
Pre monsoon	0.58	0.39	0.30	0.96	0.81	1.00	0.36	0.64	0.54	2.62	2.62	2.69
Monsoon	0.44	0.44	0.29	0.72	0.92	0.97	0.67	0.5	0.60	6.29	7.71	8.58

3.3 Biological monitoring

The Biological Monitoring Working Party Score (BMWP) (9-24) indicated poor to moderate water quality of the system (Table 3). However the ASPT score in the present study ranged from 4.5- 6 which indicated moderate to clean water quality [45 ,46]. Signal scores of the sites (2.3-4.67) indicated that the system was severely to moderately polluted [47]. HKH bios score ranged from 5 -7 which indicated poor to moderate water quality of the system.

Table 3: BMWP, ASPT , SIGNAL and HKH bios scores of Dibru River during 2014-15

Seasons	Sites	BMWP	ASPT	SIGNAL	HKHbios
Post monsoon	DS 1	15	5	4	5
	DS2	24	6	3.25	5.67
	DS3	9	4.5	4.67	6
Winter	DS1	9	4.5	4.4	7
	DS2	14	4.67	3	6
	DS3	10	5	3.7	6
Pre monsoon	DS1	14	4.67	3.83	7
	D 2	10	5	3.4	7
	DS3	10	5	3.5	7
Monsoon	DS1	20	5	3.83	5
	DS2	14	4.67	4	5
	DS3	11	5.5	2.33	6

BMWP score: 0-16=Poor water quality; 17-50=Moderate water quality; 51-100=Good water quality; 101-150=High water quality; 151+=Very high water quality

ASPT score: >6= Clean water, 5-6= Doubtful quality, 4-5 = Probable moderate pollution, <4 = Probable severe pollution. SIGNAL Score: Greater than 6= Healthy habitat, between 5 and 6= Mild pollution, between 4 and 5=Moderate Pollution, Less than 4=Severe pollution, HKHbios: ≥7.5= Reference/good; ≥6.5= good/moderate;≥5.3=moderate/poor; ≥4= poor/bad

3.4 Environmental variables, correlation and Canonical Correspondence Analysis

Several factors are known to influence the distribution of aquatic macroinvertebrates but the important factors likely to affect the diversity and abundance in an aquatic ecosystem are water temperature, water velocity, nutrient availability etc. Ward and Standford also suggested that water flow, temperature and substrates are the major factors determining the composition and abundance of benthic invertebrates [48].The environmental variables such as WT, AT, pH, DO, F-CO_2, TA, EC, TDS, PO_4^{3-}, NO_3^- were estimated in different seasons (Table 4). The range of pH between 6.3 and 7.4 is normally acceptable as per BIS [49] and WHO [50]. Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters [51].

4. Seasonal variations in environmental variables of water (Mean±SD) of Dibru River during 2014-15

	Post-monsoon, 2014	Winter, 2015	Pre-monsoon, 2015	Monsoon, 2015

	DS1	DS2	DS3	Mean±SD	DS1	DS2	DS3	Mean±SD	DS1	DS2	DS3	Mean ±SD	DS1	DS2	DS3	Mean±SD
AT (˚C)	32.13 ±1.85	26.3 ±1.83	24.9 ±3.8	27.8 ±10.4	14.47±1 58	14± 1.71	17.23 ±2.14	15.2 ± 1.8	30.63±0 45	24.63±4 71	25.6 ±1.3	27 ± 2.2	37.4 ±0.70	32.6 ±1.0	28.17 ±1.12	32.7 ± 1.0
WT (˚C)	22.7 ±0.47	22.63 ±0.21	23.2 ±0.3	22.9 ±7.8	17.53 ±0.25	16.8 ±0.4	16.73 ±0.35	17.0 ±0.3	27.37 ±0.38	27.1 ±0.30	27.13 ±0.55	27.2 ± 0.4	25.07±0.2 5	25.6 ±0.2	26.23 ±0.50	25.6 ±0.3
pH	7.44 ±0.11	7.13 ±0.07	6.87 ±0.26	7.1 ±0.1	6.77 ±0.05	6.7± 0.08	6.82 ±0.07	6.8 ±0.1	6.65 ±0.13	6.72 ±0.11	6.7 ±0.06	6.7 ± 0.1	6.39 ±0.04	6.34 ±0.1	6.31 ±0.10	6.3 ±0.1
EC (μS cm^{-1})	297.6 ±9.87	291.6 ±10.2	270± 1234	286.7±1 0.8	100 ±0.82	101.1±0 8	100.13± 0.7	100.4± 0.8	93.43 ±1.76	90.8 ± 1.51	84.13 ±2.2	89.5 ± 1.8	150.06±5. 9	155.2±1. 18	156.33±2 .47	153.9±3. 2
TDS (mgl-1)	189.8±2.39	189.27 ±7.3	185.47 ±9.3	188.2 ±6.3	65.8 ±0.56	65.6±1.2	65.4 ±0.72	65.6 ± 0.8	60.8 ±0.66	60.13 ±1.01	57.97 ±0.87	59.6 ± 0.8	94.73±1.6 5	99.7 ±0.70	101.03±1 .36	98.5 ±1.2
DO (mgl-1)	8.4 ±0.53	8.3± 0.61	8.93 ±0.12	8.6 ±0.4	9.3 ±0.31	9.53 ±0.2	9.5 ±0.12	9.4 ±0.2	8.67 ±0.31	8.73±69 20	8.47 ±0.12	8.6± 18.7	8.3±0.12	8.53±0.1 2	8.3± 0.12	8.4 ± 0.1
F-CO2 mgl-1	7.32 ±1.15	5.98 ±2	6.66 ±1.15	6.7 ±1.4	5.32 ±1.15	6.67 ±1.15	5.9 ±2.0	6.0 ±1.4	8.65 ±1.15	7.99±1.8 5	6.66 ±1.15	7.8± 19.7	6.67±1.15	6.66±1.1 5	7.3± 1.15	6.9± 1.2
TA (mgl-1)	147.3±2.31	142.6 ±1.15	142.6 ±1.15	144.2±1. 5	86.67 ±1.15	85.3±2.3	84.67 ±1.15	85.6 ± 1.5	85.3 ±5.03	94.67±6 43	100.67± 6.1	93.6± 5.9	80.13±0.2 3	86.67±1. 15	84.67 ±1.15	83.8 ±0.8
NO_3^-(mgl-1)	0.12 ±0.01	0.15 ±0.04	0.11 ±0.00	0.1 ±0.0	0.23 ± 0.06	0.2 ±0.14	0.73 ±1.10	0.4 ±0.4	0.31 ±0.06	0.23 ± 0.10	0.21 ±0.08	0.2 ± 0.1	0.19 ±0.06	0.2 ±0.07	0.2 ±0.13	0.2 ±0.1
PO_4^{3-}(mgl-1)	0.20 ±0.14	0.370 ±0.12	0.29 ±0.07	0.3 ±0.1	0.20± 0.07	0.25 ±0.13	0.29 ±0.07	0.2 ±0.1	0.45 ±0.14	0.29 ±0.07	0.25 ±0.13	0.3 ± 0.1	0.01±0.00	0.014±0. 00	0.025 ±0.00	BDL
RF (mm)	115.05± 163.09	115.05 ±163.09	115.05± 163.09	115.05± 163.09	20.57±2 4.5	20.57±2 4.5	20.57 ±24.5	20.57 ± 24.5	192.35 ±157.02	192.35 ±157.02	192.35 ±157.02	192.35±1 57.02	354.4±52. 27	354.4±52 .27	354.4±52 .27	354.4±52 .27
Sand (%)	83.3±1.53	78.3 ±1.53	75.67 ±0.58	79.1 ± 1.2	76± 1.00	74.33±1 5	74.67 ±3.79	75.0 ± 2.1	74.67 ±1.53	75± 1.00	74± 1.00	74.6 ± 1.2	76.33±1.1 5	71±1.00	74 ± 1.00	73.8 ±1.1
Silt (%)	4.3± 0.58	3.33 ±0.58	3.3 ±0.58	3.7 ±0.6	3.67 ± 0.58	3± 1.00	5.3 ±1.53	4.0±1.0	4.67 ±2.08	6± 1.00	5.67± 1.53	5.4± 1.2	4±1.	3.33±1.5 3	5± 1.00	4.1 ±1.2
Clay (%)	12.3 ±1.15	18.33 ±2.08	21 ±1.00	17.2 ± 1.4	20.33 ±1.53	23± 2.65	20 ±3.6	21.1 ± 2.6	20.67 ±3.21	19± 1.73	20.33±2 52	20 ± 2.5	19.67±1.5 3	25.67±1. 53	21 ±2.00	22.1 ±1.7

(AT= Air temperature, WT= Water temperature, EC= Electrical Conductivity, TDS= Total Dissolve Solid, DO= Dissolve Oxygen, TA= Total Alkalinity, NO_3^-= Nitrate, PO_4^{3-}= Phosphate, RF= Rainfall, BDL= Below Detectable Limit)

Alkalinity measures the various substances related to the basic property of water and high TA value is associated with poor quality of water. In the present study, the range of TA was found within the desirable limit of drinking water according to Indian Standard Specifications for Drinking Water (IS: 10500-1992) [52]. The ranges of PO_4^{3-} and NO_3^- were also found within desirable limit as per BIS [49] and WHO [50]. DO did not show much fluctuation and highest DO values were found in winter season. Similar DO values were recorded in River Ganga and Yamuna by several workers [53, 54]. Water variable like PO_4^{3-} was found to have significant negative correlation with density of insects (Table 5). Significant positive relationship of density of aquatic insects with species richness was recorded.

Table 5: Significant correlations of aquatic insect density and species richness with environmental variables of water of Dibru River

Variables	R value
ID vs PO_4^{3-}	-.447**
ID vs SR	.627**

ID-Insect density; SR-Species richness; PO_4^{3-}-Phosphate

The CCA association of the aquatic insect species, environmental variables and season with sites of Dibru River are graphically displayed in Figure 4. Eigen values associated with each axis equal the correlation coefficient between species scores and site scores [55, 56]. Eigen value close to 1 will represent a high degree of correspondence between species, sites and seasons and an Eigen value close to zero will indicate very little correspondence [57]. In the present study, a total eigen value (2.43) was found which indicated a high degree of correspondence between aquatic insect species, environmental variables and seasons with sites at Dibru River. The eigen values 0.675, 0.474 and 0.438 for the axes 1, 2 and 3 explained 27.8%, 47.3% and 65.3% of variance respectively and the species environment correlations of CCA axis1 was found to be 1.00 (Table 6)

Table 6: Summary statistics of CCA between aquatic insect species and environmental variables for first four axes in four seasons of three sites of Dibru River

	Axis 1	Axis 2	Axis 3	Total
Eigen values	0.675	0.474	0.438	2.43
Cum. Percentage variance of species data	27.8	47.3	65.3	
of species-environment relation	27.8	47.3	65.3	
of species-environment correlation	1.00	1.00	1.00	

The CCA ordination revealed that species and sites with seasons of Dibru River are placed in four groups differentiating wet and dry seasons. The sites DS2 and DS3 in dry seasons were governed by phosphate, nitrate and DO. On the other hand sites DS1 and DS2 in wet seasons were governed by rainfall, water temperature and to some extent EC and TDS. The position of *Gerris lepcha* in the centre and *Cloeon inscriptum* close to the centre showed that they are equally influenced by all the parameters. Occurrence of *Cymbiodyta* sp. close to the site DS2 in monsoon as outlier showed that both site and species are far from the influence of environmental parameters . The species *Aquarius conformis* in DS2 in winter is found to be strongly associated with phosphate. Dissolved Oxygen was found to be the driving force for the distribution of species like *Micronecta scutellaries* in DS1 during winter. *Pseudagrion microcephalum* was found strongly associated with Rainfall.

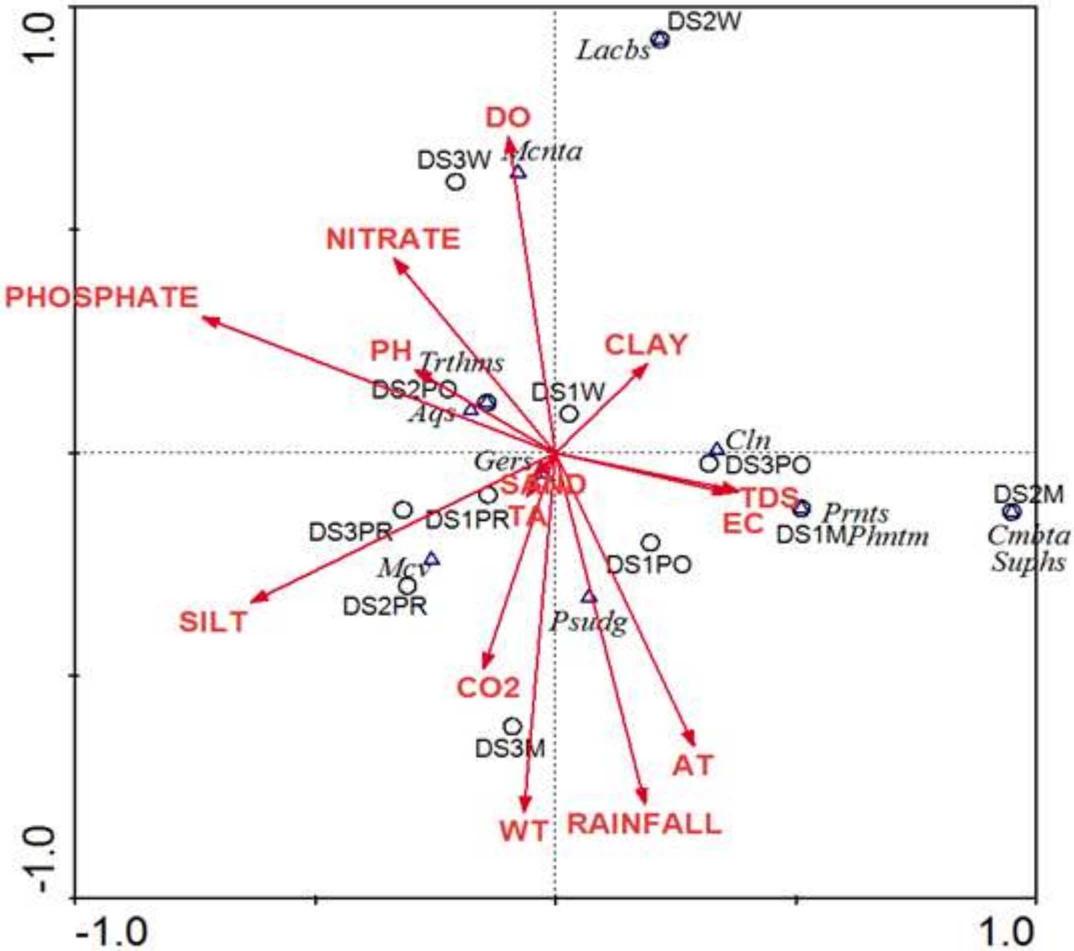

Figure 4: Triplot of Canonical correspondence analysis (CCA) ordination showing the association of aquatic insects species (Δ), environmental variables (→) and selected sites with seasons (0) of Dibru river during 2014-15. Abbreviations used for different aquatic insects are:Psudg= *Pseudagrion microcephalum*, Cln= *Cloeon inscriptum*, Gers= *Gerris* lepcha, Trthms= *Trithemis aurora*, Aqs= *Aquarius conformis*, Mcnta= *Micronecta scutellaries*, Lacbs= *Laccobius* sp., Mcv= *Microvelia* plumbea, Phntm= *Phaenonotum* sp., Suphs= *Suphisellus* sp., Cmbta= *Cymbiodyta* sp.

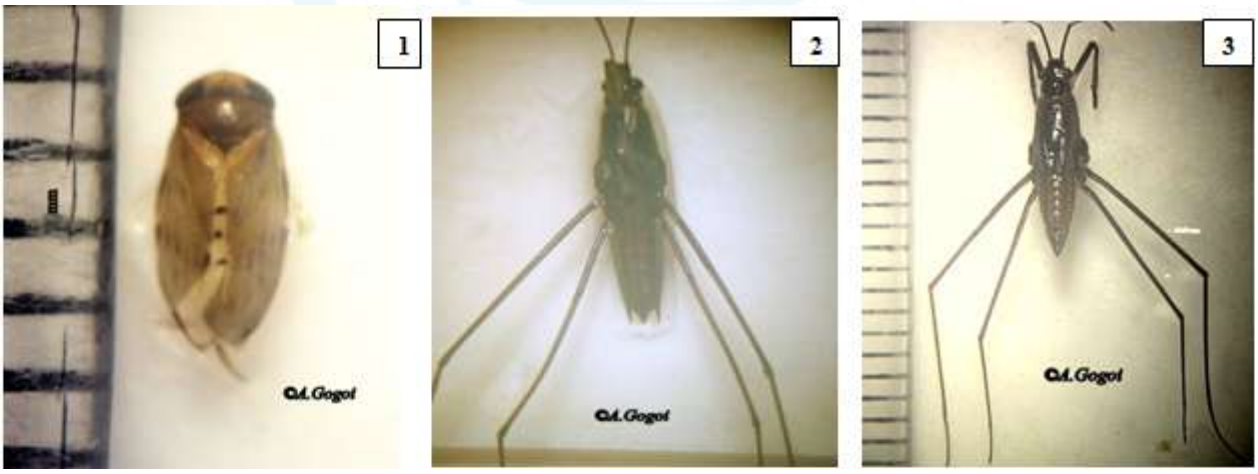

Plate 1: Images of some aquatic insects found in River Dibru during the study period. (1. *Micronecta scutellaries* 2. *Aquarius conformis* 3.*Gerris lepcha* 4.*Cloeon inscriptum* 5. *Microvelia plumbea* 6. *Pseudagrion microcephalum*

5. Conclusion

This is a preliminary study of aquatic insects at Dibru River of Dibrugarh district near Dibru Saikhowa National Park. A total of 12 species belonging to 12 genera, 8 families and 4 orders were recorded. A detail long term study might add some more species in the list of inventory. Hence a long term monitoring programme and use of variety of diversity and biotic indices might throw light on the health of the river and might influence the government policy of conservation of such rivers.

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