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Odonate (Dragonflies and Damselflies) Diversity as a Marker of Water Quality in Sivasagar, Assam, India

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ABSTRACT: The present study was conducted in four different wetlands of Sivasagar district, Assam to determine whether diversity and abundance of odonates have any relationship with water quality. The Water Quality Index, Shannon-Weiner diversity index, Simpson's diversity index and species abundance values were calculated. Highest species richness and abundance were recorded in the site with highest water quality index and status good. The area with lowest water quality index showed lowest species richness and abundance. *Brachydiplax chalybea, Camacinia gigantean, Diplacodes nebulosa, Agriocnemis kalinga and Ceriagrion olivaceum* prefer habitat with slightly acidic water, moderate conductivity and higher concentration of DO. While species like *Neurobasis chinensis*, *Orthetrum glaucum*, *Lathrecista asiatica* and *Palpopleura sexmaculata* prefer habitas with neutral water, higher conductivity and higher concentration of DO. Odonata surveys can be used widely to assess site quality, monitor restoration, and as incremental benchmarks of ecological quality.

Keywords: Odonate diversity as marker of Water Quality in Sivasagar

Abbreviations: WQI, Water Quality Index; EC, Electrical Conductivity; TDS, Total Dissolved Solids; DO, Dissolved Oxygen; ICMR, Indian council of Medical Research.

I. INTRODUCTION

The aquatic environment with its water quality is considered to be the main factor controlling the state of health and disease of aquatic organisms. The availability of water and its physic-chemical as well as biological composition determines the ability of aquatic environments to sustain healthy ecosystem. In developing countries, only a small proportion of waste water produced by severed communities is treated. Therefore, the quality of water needs to be evaluated thoroughly to set up the baseline information for proper health of the inhabitants.

Dragonflies and damselflies collectively called Odonates, are one of the most common insects flying over forest, fields, meadows, ponds and rivers. About 6,000 extant species are distributed all over the world. India is highly diverse with more than 500 known species [1]. Odonata fauna of India is known by 3 sub orders, 17 families, 139 genera and 499 species and subspecies [2]. Many species of damselflies were reported from north-eastern part of India but documentation of abundance and distribution is still not known for most of the species in this part of the world. Odonates are inextricably linked to water bodies of various kinds. Some species prefer standing water bodies like reservoirs, lakes, backwaters, ponds or even seasonal rain water puddles while others prefer running water like rivers, rivulets, hill streams etc. Being supreme predators both during their adult and larval stages, Odonates play crucial role in ecosystem functioning and serve to keep other insects including those harmful to humans (like mosquitoes, blood-sucking flies, etc.) under control. Apart from functioning as predators in the ecosystem, their value as indicators of habitat quality has also been widely appreciated in recent times. Anecdotal observations suggest that some Odonates are so habitat specific that even minor changes can lead to their disappearance [1]. Thus the present study was aimed to evaluate whether there is any association between odonate diversity with physico-chemical properties of water in selected ponds, lakes and rivers of Sivasagar district, Assam.

II. MATERIALS AND METHODS

Study area. The survey was conducted in four selected aquatic habitats of Sivasagar District, Assam for a period of eight months from May-December, 2016.

Sampling site 1. The Joysagar tank (26º56' N and 94º37' E) is situated about 5 km. south-west to the district head-quarter of Sivasagar, Assam. The tank covers a total area of about 4, 80,000 square metre. It has a varying depth; the periphery is rather shallow (= 0.5 m.), but is gradually deeper and the maximum depth (>10 m.) reaches at its centre [3].

Sampling site 2. Moridikhow, an oxbow lake situated in the Dikhowmukh area (26º98' N and 94º46' E), about 25 km away from Sivasagar town. It is a perennial water body, mostly choked with aquatic macrophyte especially during dry months. Entire bank of the lake is occupied by local villagers and they use water and other aquatic resources for their livelihood [4].

Sampling site 3. The river Dorika (27º00' N and 94º38' E), flowing on the heart of the NH37 connecting

Dibrugarh to Sivasagar situated about 1.6 km away from Sivasagar town.

Sampling site 4. The small ditch Jamuna, present along the Jamuna Road on the east, situated (26º98' N and 94º63' E) about 980 m away from Sivasagar town.

The physico-chemical parameters were computed according to the standard methods described in APHA [5]. Parameters such as pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were recorded in the field using Eli co, digital meter which gives direct values. Modified Winkler's method was followed for the analysis of Dissolved Oxygen (DO) [6].

Field notes, photographs (camera: Nikon d5100) and observations were taken during the day light hours. The population trends were monitored during the study period using transects counting method [7, 8]. At each location the same route of inspection was followed each time to reduce the number of variables present. Individual images of Odonates were photo-documented and identified by cross-checking with standard references and photo guides [9-14].

Shannon-Weiner Diversity Index (H)

The Shannon-Wiener diversity index (H) is a measure of diversity that combines species richness (the number of species in a given area) and their relative abundances. The index is computed by using the following formula,

$$H = \sum_{i=1} - (P_i * \ln P_i)$$

where,

H = Shannon-Weiner diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

$\sum$ = sum from species from 1 to species S

Simpson's index (D)

$$D = \frac{\Sigma n(n-1)}{\Sigma N(N-1)}$$

where,

D = Simpson's index

n = number of individuals of a certain species

N = total number of individuals of all species

Simpson's Diversity index (1-D)

The value of this index ranges between 0 and 1, but the greater the value, the greater the sample diversity.

Species Abundance

The abundance of species in each site were calculated by using the abundance formula.

$$\text{Abundance} = \frac{\text{No. of individuals of a certain species}}{\text{Total number of individuals}} \times 100$$

Water Quality Index (WQI)

In order to calculate WQI four important parameters, pH, electrical conductivity (EC), total dissolved solids (TDS) and Dissolved oxygen (DO) have been selected. The numerical value obtained from the analysis is then multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting value is added together to arrive at an overall water quality index (WQI) [15].

$$WQI = \sum Wi \times Vr$$

where,

Wi = Unit weight of factor

Vi = maximum permissible limits as recommended by ICMR

Table 1: Vi and Wi values used for the calculation of WQI.

Parameters	Vi	Wi
Turbidity	300	0.08
pH	6.5-8.5	0.19
TDS	500	0.0033
D.O	5	0.3317

The Water Quality Index is equal to the product of rating (Vr) and unit weight (Wi) of all the parameters selected

$WQI = \sum Wi \times Vr = Wi(pH) \times Vr(pH) + Wi(EC) \times Vr(EC) + Wi(TDS) \times Vr(TDS) + Wi(DO) \times Vr(DO)$

Table 2: The rating scale for value of WQI quality of water.

90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very Bad

III. RESULTS AND DISCUSSION

During the present study a total of 34 species of odonates belonging to four families were recorded. Among the four families, Libellulidae was the most dominant with 23 species [16-18] followed by Coenagrionidae with 9 species, and Gomphidae and Calopterygidae with 1 species each. The highest number of species 29 with 135 individuals was recorded at sampling site I, 26 species with 78 individuals at sampling site II, 17 species with 39 individuals at site III and 17 species with 29 individuals at site IV were recorded respectively. Shannon-Weiner diver index classified the sites in the same order. Site I showed highest species richness (3.175), followed by site II (2.970), site III (2.711) and site IV (2.577). Similar pattern of results were observed for Simpson's diversity index. This index was recorded highest in site I (0.957). It was followed by site II (0.942), site III (0.936) and site IV (0.930) respectively (Table 4). *Ceriagrion coromandelianum* was the most dominant species in site I; *Agriocnemis lacteola* in site II and *Tholymis tillarga* in site III and IV.

Water Quality Index was calculated using the Vi and Wi values presented in table 1. In this study, highest WQI with status good was recorded in site I (71.59) where we observed maximum number of odonates, followed by site II (65. 47) and site III (61.21) with both status medium and finally by site IV (49.49) with status bad. Critical analysis followed by comparison of biodiversity indices with WQI clearly suggested that number of species and individuals of odonates gradually increases with improvement of water quality from bad, medium to good. Similar results were obtained in various studies involving odonates as bioindicators comparing polluted and non-polluted water [19-22]. The species *Brachydiplax chalybea, Camacinia gigantean, Diplacodes nebulosa, Agriocnemis kalinga and Ceriagrion olivaceum* were found to be selective in their aquatic habitats preferring habitat with slightly acidic water, moderate conductivity and higher concentration of DO.

Table 3: List of odonates recorded with their relative abundance.

Sl. No.	Scientific Names	Common Names	Abundance			
			Site I	Site II	Site III	Site IV
Family: Gomphidae						
1.	*Ictinogomphus rapax*	Common Clubtail	4.43	2.2	0	0
Family: Libellulidae						
2.	*Acisoma panorpoides*	Trumpet Tail	9.14	3.11	2.25	0.71
3.	*Brachydiplax chalybea*	Rufous-backed Marsh Hawk	0.97	0	0	0
4.	*Brachydiplax sobrina*	Little Blue Marsh Hawk	7.12	2.29	0	1.21
5.	*Brachythemis contaminata*	Ditch Jewel	12.2	5.1	1.21	2.92
6.	*Camacinia gigantea*	Giant Forest Skimmer	2.12	0	0	0
7	*Cratilla lineata*	Emerald-banded Skimmer	5.21	0	2.11	0
8.	*Crocothemis servilia*	Ruddy Marsh Skimmer	12.13	4.1	1.43	2.1
9.	*Diplacodes nebulosa*	Black-tipped Ground Skimmer	1.16	0	0	0
10.	*Diplacodes trivialis*	Ground Skimmer	10.3	2.12	0.92	1.4
11.	*Hydrobasileus croceus*	Amber-winged Marsh Glider	6.3	3.1	0	0
12.	*Lathrecista asiatica*	Asiatic Bloodtail	0	2.11	0	0
13.	*Neurothemis fulvia*	Fulvous Forest Skimmer	16.1	11.3	6.21	1.22
14.	*Orthetrum glaucum*	Blue Marsh Hawk	0	3.2	0	0
15.	*Orthetrum luzonicum*	Tricoloured Marsh Hawk	8.4	4.43	0	0.21
16.	*Orthetrum pruinosum*	Crimson-tailed Marsh Hawk	13.1	6.54	3.21	0.96
17.	*Orthetrum sabina*	Green Marsh Hawk	18.2	8.21	2.22	3.2
18.	*Palpopleura sexmaculata*	Blue-tailed Yellow Skimmer	0	0.89	0	0
19.	*Pantala flavescens*	Wandering Glider	15.1	6.11	4.34	0.85
20.	*Rhodothemis rufa*	Rufous Marsh Glider	7.0	5.54	3.2	0
21.	*Rhyothemis variegata*	Common Picture Wing	0	0.92	0.67	0
22.	*Tholymis tillarga*	Coral-tailed Cloud Wing	15.7	10.12	5.32	4.89
23.	*Trithemis aurora*	Crimson Marsh Glider	9.2	2.1	0	0
24.	*Trithemis pallidinervis*	Long-legged Marsh Glider	5.1	0	0.87	0
Family: Calopterygidae						
25.	*Neurobasis chinensis*	Stream Glory	0	1.11	3.35	0
Family: Coenagrionidae						
26.	*Aciagrion occidentale*	Green-striped Slender Dartlet	8.5	0	0	2.32
27.	*Agriocnemis femina*	Pruinosed Dartlet	8.2	4.12	0	0.34
28.	*Agriocnemis kalinga*	Indian Hooded Dartlet	0.92	0	0	0
29.	*Agriocnemis lacteola*	Milky Dartlet	18.2	18.12	6.42	3.25
30.	*Ceriagrion cerinorubellum*	Orange-tailed Marsh Dart	7.1	2.13	1.19	4.53
31.	*Ceriagrion coromandelianum*	Coromandel Marsh Dart	21.2	12.22	2.32	4.32
32.	*Ceriagrion olivaceum*	Rusty Marsh Dart	2.1	0	0	0
33.	*Ischnura aurora*	Golden Dartlet	11.1	3.1	0	0
34.	*Onychargia atrocyana*	Black Marsh Dart	9.2	2.12	0	0.87

Table 4: Summary of results of various indices undertaken in this study.

Results	Site I	Site II	Site III	Site IV
Shannon-Wiener Index (H)	3.175	2.970	2.711	2.577
Simpson's diversity Index (1-D)	0.957	0.942	0.936	0.930
Water Quality Index (WQI)	71.59	65.47	61.21	49.49
Status	Good	Medium	Medium	Bad

While species like *Neurobasis chinensis*, *Orthetrum glaucum*, *Lathrecista asiatica* and *Palpopleura sexmaculata* prefer habitas with neutral water, higher conductivity and higher concentration of DO. The rest of the species were found to be generalized for all kind of habitats as they were recorded in almost all the four selected sites. Moreover, population density of odonate fauna was found higher at the peripheral region than the central part of the selected sites I, II and III. It might be due to the restricted presence of floating and submerged vegetations near the peripheral region and absence of such vegetations towards the centre of the sites. Diversity of odonates was high during the month of December because the water levels were considerably high and the temperature was quite low compared to the other months of the study period. The water levels were maintained from the previous monsoon rains although there was not much amount of rainfall received during the months of December and January. From the integrative reports of the physico-chemical parameters and the diversity of dragonflies in the selected wetlands of our study it is lucid that odonate diversity not only depends on the quality of the water parameters but also on the type, time and distribution of aquatic vegetation across the habitats.

IV. CONCLUSION

There is no doubt that the insect order Odonata has a great potential for use in efficiently indicating the quality of water in respect to its effects on biota, at least on a local scale. The mere presence of a high diversity of species at any newly restored wetland could be used as an indication of some level of return to a natural or ecologically functional state. However, Odonata should not yet be used as a sole indicator, but rather in conjunction with traditional chemical water analysis techniques and a general overview of the biotic composition of any given wetland site. Theoretically, Odonata surveys can be used widely by resource managers and conservationists to assess site quality, monitor restoration, and mark incremental benchmarks of ecological quality. Odonate surveys focusing on this region of the province should continue as these findings will significantly contribute to baseline data and address the lack of long-term monitoring of donates within Assam.

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