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Diversity and community structure of Odonata (Insecta) in two land use types in Purba Medinipur District, West Bengal, India

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Abstract: The present study recorded a total of 45 species of Odonata, of which one species, *Ischnura mildredae*, was recorded for the first time from West Bengal in India. Thirty-eight species were found in Tamluk Municipality as compared to 21 species in Haldia Industrial Belt (IB), with 14 species common to both the localities. Index of similarity revealed that the two localities were slightly dissimilar in odonate faunal composition as only 47% of species were shared. In both the localities, Anisoptera was more abundant, comprising over 69% of the total odonates. Libellulidae was the most abundant Anisopteran family in both the localities, comprising over 66% of the total odonates. Coenagrionidae was the most abundant Zygopteran family in both the localities. Thirteen species of Anisoptera and 11 species of Zygoptera were found only in Tamluk whereas two species of Anisoptera and five species of Zygoptera were found only in Haldia IB. *Crocothemis servilia*, *Pantala flavescens*, and *Ceriagrion coromandelianum* were the dominant species in Tamluk while *Brachythemis contaminata* and *Orthetrum sabina* were the dominant species in Haldia IB. Based on the values of Shannon index, Tamluk was considered unpolluted (=3.16) and Haldia IB moderately polluted (=2.43). Higher equitability index (J=0.87) and very low dominance index (0.06) in Tamluk indicated homogeneity in community composition and relatively stress-free equitable environment. The present investigation suggests that Odonata can be used as bioindicators of industrial pollution.

Keywords: Anisoptera, Coenagrionidae, dominance index, ecological indicator, equitability index, Haldia Industrial Belt, Libellulidae, Shannon index, Tamluk Municipality, Zygoptera.

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Author Contribution: PRP designed the research work and contributed in writing. SSM has contributed in field work, data collection & documentation. SM has also contributed in field work, data collection, documentation and preparation of graphs & tables for manuscript. TB has contributed in data analysis, interpretation & write-up and overall supervision.

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INTRODUCTION

Odonates play a crucial role in ecosystem stability and act as indicators of environment changes since the larvae of some species are sensitive to pollutants (Villalobos-Jimenez et al. 2016). Being predators both in aquatic and aerial lives, these are good bio-controlling agents for mosquitoes and blood-sucking flies (Nair 2011). The order Odonata includes 6,256 species under 686 genera worldwide, of which 487 species under 152 genera and 18 families are found in India (Subramanian & Babu 2017). Early taxonomy of Indian Odonata was provided by Fraser (1933, 1936). Odonates of West Bengal were studied by Ram et al. (1982), Srivastava & Sinha (1993), and Mitra (2002). Srivastava & Sinha (1993) recorded 178 species of odonates from West Bengal. In the present study, odonate fauna under two land use types, a semi-urban area and an industrial area, was investigated to explore how human alteration of environment may influence the density and diversity of odonate species.

MATERIALS AND METHODS

The present study was carried out in two different localities representing different land use types (Fig. 1) from July to December 2017. Samples were collected fortnightly between 10.00–16.00 h. The first study site, the district town of Tamluk, is a semi-urban municipal area (22.260–22.304 ^{0}N & 87.902–87.935 ^{0}E, altitude 6m, average rainfall 1,550mm, temperature 13.6–35.6 ^{0}C) harbouring many small water bodies, most of which are fish ponds studded with aquatic weeds. The town is located on the bank of the river Rupnarayana. Small canals and tributaries of Rupnarayana are the main lotic systems of the area. The second locality, Haldia Industrial Belt (IB; 22.029–22.093 ^{0}N & 88.085–88.181 ^{0}E, altitude 8m, average rainfall 1,450mm, temperature 14.1–34 ^{0}C), is an industrial area with a port located at the junction of the rivers Hoogly and Haldi. Indian Oil Corporation Ltd., Haldia Petrochemicals Ltd., TATA Chemicals Ltd., Emami Biotech Ltd., Mistubisi Chemical Corporation, Exide Industries Ltd., Shaw Wallace India

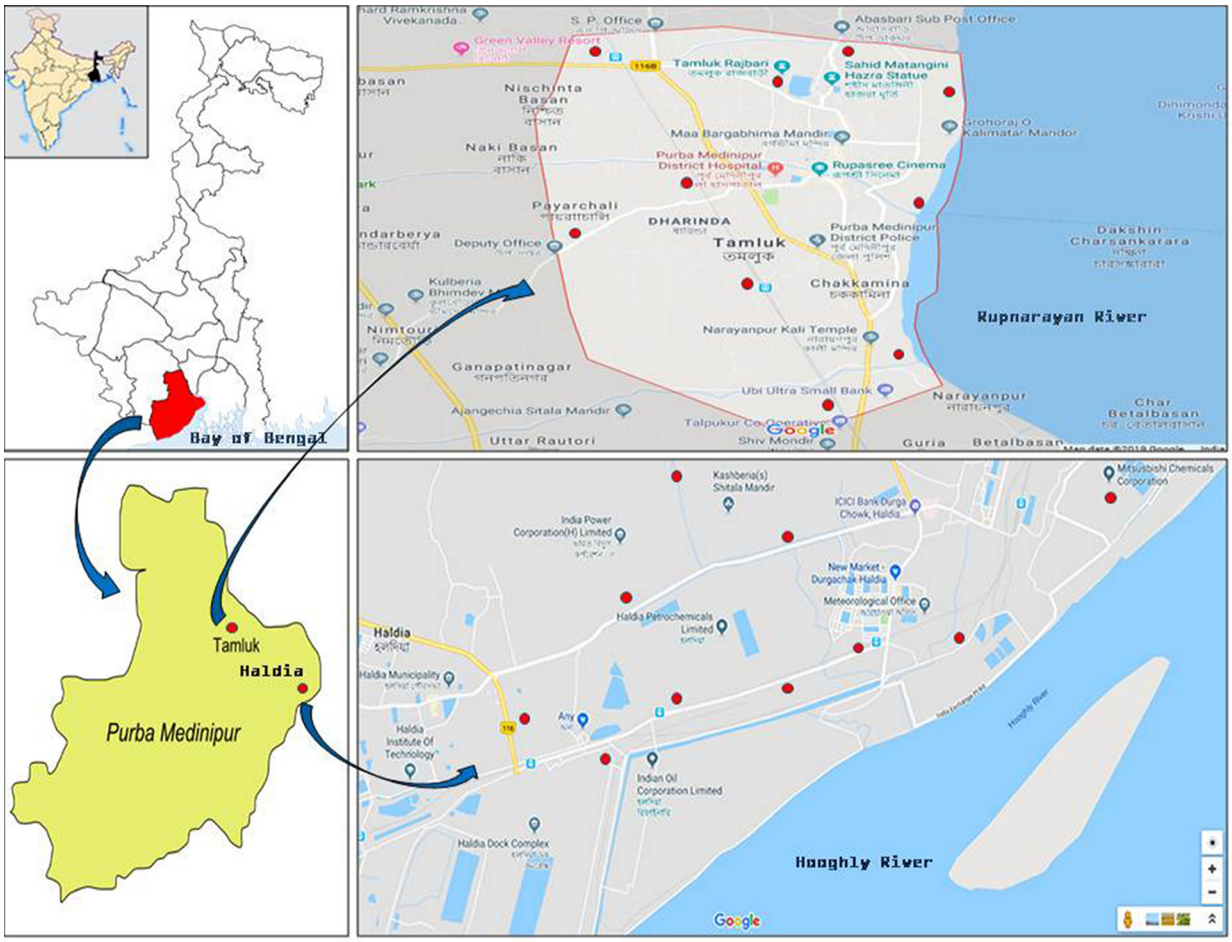

Figure 1. Study sites with sampling locations in Purba Medinipur District, West Bengal, India.

Ltd., Electrosteel Casting Ltd., Shree Renuka Sugars Ltd., and Dhunseri Petrochem & Tea Ltd. are the main industries in this area. According to a report of the West Bengal Pollution Control Board (2009–2010), Haldia IB has a very high concentration of air pollutants like SO_x, NO_x, CO, CO_2, and O_3. Both localities are situated at an aerial distance of only 32km. From each locality, 10 sampling sites were selected representing different habitats.

Collection, preservation, documentation, and identification

Adult odonates were sampled from each study site using insect nets. Quantitative measurements of odonates were done through the line transect method following Burnham et al. (1980). Specimens were photographed with a digital camera (Sony HX200V). Species were identified following Subramanian (2005) and also by using the webpage indiaodonata.org. The Odonate community structure was analyzed with the help of PAST software. The dominance status of each species was ascribed on the basis of relative abundance following Engelmann's Scale (Engelmann 1973). Faunal similarity or otherwise between the localities was determined using Sørensen's index (Sørensen 1948).

RESULT AND DISCUSSION

Forty-five species of Odonata were recorded under two suborders and six families from the study sites. Of these, one species, *Ischnura mildredae*, was recorded for the first time from West Bengal and five species, namely, *Neurothemis intermedia, Aciagrion pallidum*, *Agriocnemis lacteola*, *A. pieris*, and *Ceriagrion olivaceum* were reported for the first time from Purba Medinipur District (Table 1). Tamluk, an area with many weed infested waterbodies, had 38 species as compared to 21 species in Haldia IB, with 14 species common to both the localities. Sørensen's Index of similarity being 0.47 indicates that 47% of species are common and that the two localities are slightly dissimilar in odonate species composition.

While 23 species of Anisoptera and 15 species of Zygoptera were recorded from Tamluk, 12 species of Anisoptera and nine species of Zygoptera were recorded from Haldia IB. Interestingly, in Haldia IB, the families Gomphidae and Macromiidae were absent, which were represented by one species each in Tamluk. A higher number of species recorded from a less disturbed area and a lower number of species from a more disturbed industrial area as found in this study is supported by the earlier works of Allen et al. (2010), Subramanian (2010), and Nayak & Roy (2016). Tiple & Koparde (2015) opined that aquatic vegetation has a regulatory role in the faunal distribution of Odonata. This might explain the higher numbers of species in Tamluk. In Tamluk and Haldia IB, Anisoptera was numerically more abundant comprising 69.5% and 77.3% as compared to Zygoptera which comprised 30.5% and 22.7%, respectively (Fig. 2).

The peponderance of Anisoptera over Zygoptera as in the present study was also reported by Manwar et al. (2016) in Maharashtra, who accounted this to be due to their higher dispersal ability, wide range of habitat preferences, and higher tolerance level as compared to Zygoptera. Moore (1957), however, was of the view that dragonflies are more sensitive to pollutants than damselflies. In Tamluk and Haldia IB, Libellulidae, with 19 and 11 species, respectively, was the most abundant Anisopteran family, representing 66.2% and 76.6% of the total odonates (Fig. 3).

Such a preponderance of Libellulidae over other families was also well-established in different regions of India by earlier works, namely that of Arulprakash & Gunathilagaraj (2010), Tiple et al. (2012), and Nayak & Roy (2016). In both Tamluk and Haldia IB, Coenagrionidae was the most common Zygopteran family with 13 and eight species, respectively, representing 27.2%

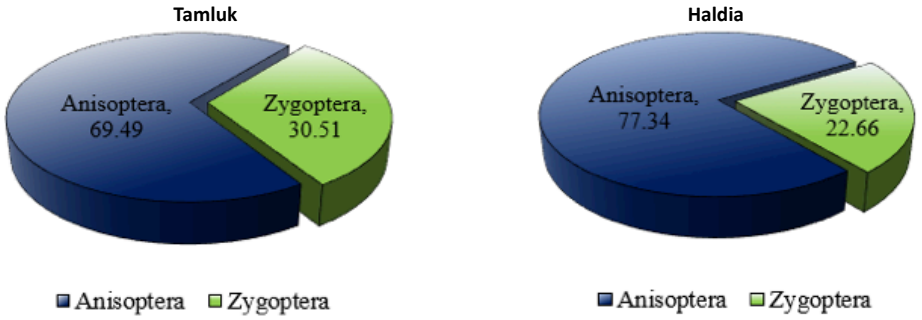

Figure 2. Relative abundance of Anisoptera and Zygoptera in Tamluk Municipality and Haldia Industrial Belt in Purba Medinipur District, West Bengal, India.

Table 1. Diversity of Odonata in Tamluk Municipality and Haldia Industrial Belt in Purba Medinipur District, West Bengal, India.

	Scientific name	Tamluk	Haldia
Suborder: Anisoptera			
Family: Aeshnidae			
1	*Anaciaeschna jaspidea* (Burmeister, 1839)	+	-
2	*Anax guttatus* (Burmeister, 1839)	-	+
3	*Gynacantha dravida* (Lieftinck, 1960)	+	-
Family: Gomphidae			
4	*Ictinogomphus rapax* (Rambur, 1842)	+	-
Family: Libellulidae			
5	*Acisoma panorpoides* (Rambur, 1842)	+	-
6	*Brachydiplax chalybea* (Brauer, 1868)	-	+
7	*B. sobrina* (Rambur, 1842)	+	+
8	*B. contaminata* (Fabricius, 1793)	+	+
9	*Crocothemis servilia* (Drury, 1770)	+	+
10	*Diplacodes nebulosa* (Fabricius, 1793)	+	-
11	*D. trivialis* (Rambur, 1842)	+	+
12	*Neurothemis fulvia* (Drury, 1770)	+	-
13	*N. intermedia* (Rambur, 1842)**	+	-
14	*N. tullia* (Drury, 1770)	+	+
15	*Orthetrum sabina* (Drury, 1770)	+	+
16	*Pantala flavescens* (Fabricius, 1798)	+	+
17	*Potamarcha congener* (Rambur, 1842)	+	+
18	*Rhodothemis rufa* (Rambur, 1842)	+	-
19	*R. variegata* (Linnaeus, 1763)	+	+
20	*Tholymis tillarga* (Fabricius, 1798)	+	-
21	*Tramea basilaris* (Palisot de Beauvois, 1805)	+	-
22	*Trithemis pallidinervis* (Kirby, 1889)	+	-
23	*Urothemis signata* (Rambur, 1842)	+	+
24	*Zyxomma petiolatum* (Rambur, 1842)	+	-
Family: Macromiidae			
25	*Epophthalmia vittata* (Burmeister, 1839)	+	-
Suborder: Zygoptera			
Family: Coenagrionidae			
26	*Aciagrion pallidum* (Selys, 1891)**	-	+
27	*Agriocnemis kalinga* (Nair & Subramanian, 2014)	-	+
28	*A. lacteola* (Selys, 1877)**	+	-
29	*A. pieris* (Laidlaw, 1919)**	+	-
30	*A. pygmaea* (Rambur, 1842)	+	+
31	*Ceriagrion cerinorubellum* (Brauer, 1865)	+	+
32	*C. coromandelianum* (Fabricius, 1798)	+	+
33	*C. olivaceum* (Laidlaw, 1914)**	+	-
34	*Ischnura aurora* (Brauer, 1865)	+	-
35	*I. mildredae* (Fraser, 1927)*	-	+
36	*I. rubilio* (Selys, 1876)	+	-
37	*I. senegalensis* (Rambur, 1842)	+	+
38	*Mortonagrion aborense* (Laidlaw, 1914)	+	-
39	*Onychargia atrocyana* (Selys, 1877)	-	+
40	*Pseudagrion decorum* (Rambur, 1842)	+	-
41	*P. microcephalum* (Rambur, 1842)	+	-
42	*P. rubriceps* (Selys, 1876)	+	-
Family: Platycnemididae			
43	*Copera ciliata* (Selys, 1863)	-	+
44	*C. marginipes* (Rambur, 1842)	+	-
45	*C. vittata* (Selys, 1863)	+	-
Sørensen's similarity index = 0.47			

[* first report from West Bengal; ** first report from Medinipur]

and 21.96% of the total odonates. Large body size and wide range of distribution might be the reason behind this as suggested by Norma-Rashid et al. (2001). Members of the families Macromiidae and Gomphidae were recorded only from Tamluk. These families are highly habitat-sensitive and localized to small areas as pointed out by Subramanian (2005) and Koparde et al. (2015). The 14 species common to both the study sites (Table 1) perhaps have a broad range of tolerance gradient. Two dragonfly species, *Anax guttatus and Brachydiplax chalybea, and five damselfly species, namely, Aciagrion pallidum, Agriocnemis kalinga, Ischnura mildredae, Onychargia atrocyana,* and *Copera ciliata,* were restricted to Haldia IB. As such, these species might be considered to be pollution-tolerant. Thirteen species of Anisoptera and 11 species of Zygoptera were found only in Tamluk Municipality. These species might be considered sensitive to pollutants. Jana et al. (2006) also reported some species of Lepidoptera, Hemiptera, and Orthoptera which were susceptible to pollutants and not found in Haldia IB. Based on relative abundance (Table 2), it was found that in Tamluk, three species, namely, *Pantala flavescens, Crocothemis servilia,* and *Ceriagrion coromandelianum,* were dominant (RA 10.1–31.6 %) and six species were subdominant (RA 3.2–10 %). The rest were either recedent (17 species) or subrecedent (12 species). In Haldia IB, two species, namely, *Orthetrum sabina* and *Brachythemis contaminata*, were dominant, eight species were subdominant, and the rest were recedent and subrecedent (Table 3). In the present investigation, no species belonged to the eudominant category.

Subramanian et al. (2008) opined that the presence

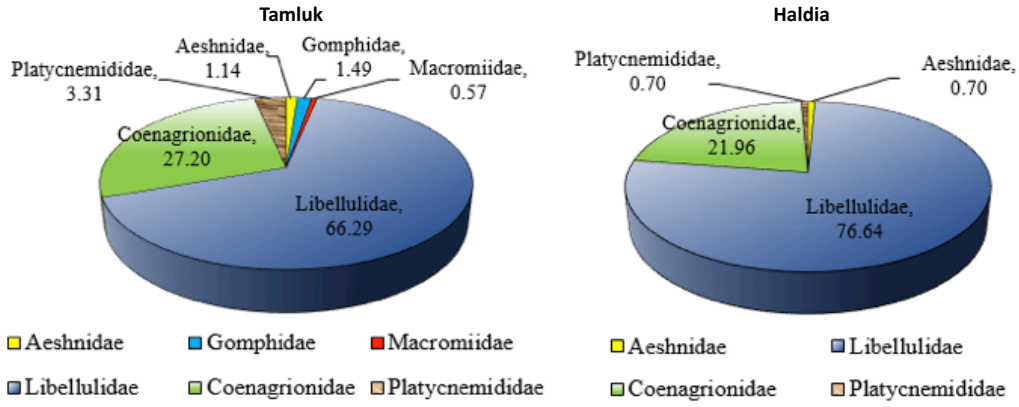

Figure 3. Relative abundance of odonate families in Tamluk Municipality and Haldia Industrial Belt in Purba Medinipur District, West Bengal, India.

Table 2. Dominance status of odonate species in Tamluk Municipality in Purba Medinipur District, West Bengal, India.

	Scientific name	No. of individuals	Relative abundance (%)	Dominance status
Suborder: Anisoptera				
Family: Aeshnidae				
1	*Anaciaeschna jaspidea*	6	0.69	SR
2	*Gynacantha dravida*	4	0.46	SR
Family: Gomphidae				
3	*Ictinogomphus rapax*	13	1.49	R
Family: Libellulidae				
4	*Acisoma panorpoides*	17	1.94	R
5	*Brachydiplax sobrina*	23	2.63	R
6	*Brachythemis contaminata*	35	4.00	SD
7	*Crocothemis servilia*	97	11.09	D
8	*Diplacodes nebulosa*	13	1.49	R
9	*D. trivialis*	61	6.97	SD
10	*Neurothemis fulvia*	17	1.94	R
11	*N. intermedia*	8	0.91	SR
12	*N. tullia*	48	5.49	SD
13	*Orthetrum sabina*	13	1.49	R
14	*Pantala flavescens*	126	14.40	D
15	*Potamarcha congener*	19	2.17	R
16	*Rhodothemis rufa*	9	1.03	R
17	*R. variegata*	24	2.74	R
18	*Tholymis tillarga*	28	3.20	SD
19	*Tramea basilaris*	7	0.80	SR
20	*Trithemis pallidinervis*	11	1.26	R
21	*Urothemis signata*	18	2.06	R
22	*Zyxomma petiolatum*	6	0.69	SR
Family: Macromiidae				
23	*Epophthalmia vittata*	5	0.57	SR
Suorder: Zogoptera				
Family: Coenagrionidae				
24	*Agriocnemis lacteola*	9	1.03	R
25	*A. pieris*	7	0.80	SR
26	*A. pygmaea*	32	3.66	SD
27	*Ceriagrion cerinorubellum*	9	1.03	R
28	*C. coromandelianum*	89	10.17	D
29	*C. olivaceum*	4	0.46	SR
30	*Ischnura aurora*	13	1.49	R
31	*I. rubilio*	3	0.34	SR
32	*I. senegalensis*	29	3.31	SD
33	*Mortonagrion aborense*	7	0.80	SR
34	*Pseudagrion decorum*	5	0.57	SR
35	*P. microcephalum*	8	0.91	SR
36	*P. rubriceps*	23	2.63	R
Family: Platycnemididae				
37	*Copera marginipes*	18	2.06	R
38	*C. vittata*	11	1.26	R

[Relative abundance (RA) <1 = subrecedent (SR); 1–3.1 = recedent (R); 3.2–10 = subdominant (SD); 10.1–31.6 = dominant (D); >31.7 = eudominant (ED)]. [Engelmann 1973].

or absence of certain groups or species indicates the quality of the habitat. In Haldia IB, *Orthetrum sabina* and *Brachythemis contaminata* being dominant may be considered as the most tolerant and best-adapted odonate species. As in the present study, Nayek & Roy (2016) also noticed *B. contaminata* to be the most dominant

Table 3. Dominance status of odonate species in Haldia Industrial Belt in Purba Medinipur District, West Bengal, India.

	Scientific name	No. of individuals	Relative abundance (%)	Dominance status
Suborder: Anisoptera				
Family: Aeshnidae				
1	*Anax guttatus*	3	0.70	SR
Family: Libellulidae				
2	*Brachydiplax chalybea*	4	0.93	SR
3	*B. sobrina*	11	2.57	R
4	*Brachythemis contaminata*	61	14.25	D
5	*Crocothemis servilia*	31	7.24	SD
6	*Diplocodes trivialis*	22	5.14	SD
7	*Neurothemis tullia*	15	3.50	SD
8	*Orthetrum sabina*	119	27.80	D
9	*Pantala flavescens*	24	5.61	SD
10	*Potamarcha congener*	27	6.31	SD
11	*Rhyothemis variegata*	5	1.17	R
12	*Urothemis signata*	9	2.10	R
Suborder: Zygoptera				
Family: Coenagrionidae				
13	*Aciagrion pallidum*	1	0.23	SR
14	*Agriocnemis kalinga*	3	0.70	SR
15	*A. pygmaea*	17	3.97	SD
16	*Ceriagrion cerinorubellum*	4	0.93	SR
17	*C. coromandelianum*	29	6.78	SD
18	*Ischnura mildredae*	2	0.47	SR
19	*I. senegalensis*	36	8.41	SD
20	*Onychargia atrocyana*	2	0.47	SR
Family: Platycnemididae				
21	*Copera ciliata*	3	0.70	SR

[Relative abundance (RA) <1 = subrecedent (SR); 1–3.1 = recedent (R); 3.2–10 = subdominant (SD); 10.1–31.6 = dominant (D); >31.7 = eudominant (ED)]. [Engelmann 1973].

species in Asansol-Durgapur industrial area. Species diversity and equitability indices were found to be higher in Tamluk as compared to those of Haldia IB (Table 4).

Since Shannon diversity index was more than three in Tamluk, this land use type might be considered as relatively stress-free and unpolluted following the criteria of Wilhm & Dorris (1968). Haldia IB, on the contrary, could be regarded as moderately polluted as Shannon index was less than three but more than one. Higher equitability value and lower dominance value are indicative, respectively, of homogeneity and relatively stress-free equitable environment. Dominance index increases with the increase in the harshness of the environment

Table 4. Species diversity, evenness, and dominance indices in the study area in Purba Medinipur District, West Bengal, India.

Indices	Tamluk	Haldia
Shannon index (H')	3.16	2.43
Equitability index (J)	0.87	0.80
Dominance index (D)	0.06	0.13

and decreases with equitability of the environment (Karr 1971). Ghosh & Bhattacharya (2018) also opined that a low dominance index is indicative of homogeneity in community structures and reflects a relatively stress-free environment. Since dominance index is lower and equitability index is higher in the Tamluk as compared to the Haldia IB, it may be suggested that the former represents a less polluted and relatively stress-free environment as compared to the latter. It may, therefore, be concluded that shifts in land use type can alter the community structure of odonates and that odonates have the potentiality to be used as an ecologic indicator of the health of an environment since pollution and perturbance decrease their density and diversity. Further in-depth experimental studies, however, are needed to prove this contention beyond any doubt.

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Image 1. *Brachythemis contaminata* (male)

Image 2. *Crocothemis servilia* (female)

Image 3. *Pantala flavescens* (male)

Image 4. *Orthetrum sabina* (male)

Image 5. *Ceriagrion coromandelianum* (male)

Image 6. *Ischnura mildredae* (female)

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