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An updated list of Odonata of southwestern Bangladesh

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Abstract: An odonate survey was conducted throughout the southwestern region of Bangladesh, concentrating on eight districts and the Sundarban, from August 2014 to August 2016. A total of 50 species under 30 genera belonging to six families was recorded during the study period. Among these, 31 species belonged to Anisoptera and 19 to Zygoptera suborders. Libellulidae and Coenagrionidae were the most dominant anisopteran and zygopteran families with 28 and 17 species, respectively. One Zygoptera species *Mortonagrion varalli* was newly added to the odonate fauna of Bangladesh.

Keywords: Damselflies, dragonflies, habitat associations, *Mortonagrion varalli*, Odonata, species richness, Sundarban.

Odonates (dragonflies and damselflies) were one of the earliest winged insects that evolved in the Permian period (Kalkman et al. 2008) and distributed all over the world except in Antarctica (Silsby 2001; Grimaldi & Engel 2005; Trueman 2007). Although odonates are highly distributed in diverse ecological niches, they are sensitive to the alteration of their habitats. Hence, odonates are considered as indicators of the status of freshwater ecosystems (Watson et al. 1982; Brown 1991; Martin & Maynou 2016). Odonates are also extensively studied in evolutionary and ecological research (Córdoba-Aguilar 2008). At present, 5,740 species of odonates are known from the world (Subramanian 2009).

Odonates are considered freshwater insects as the females lay eggs on water or submerged plants and the larval development occurs underwater (Hornung & Rice 2003). Unlike the larva, the adults are aerial. Their foraging and reproductive success, however, depends heavily on the availability of freshwater resources. Hence, odonate assemblage is higher in aquatic habitats (Oppel 2005). Odonate diversity also varies in different climatic zones (Balzan 2012). Similar to other insect orders, the majority of the dragonfly species inhabits tropical and subtropical climate zones (Dumont 1991). The Indo-Malayan region is one of the most diverse habitats of highly endangered odonates (Clausnitzer et al. 2009). Bangladesh, being located in the Indo-Burma biodiversity hotspot zone, is expected to possess high odonate diversity (Chowdhury & Mohiuddin 2011). Along with geographic variation, seasonal variation such as temperature, humidity, and rainfall influences species richness of odonates. Bangladesh has six seasons with warm and wet summer, monsoon, and autumn from April to September. The temperature starts to fall after

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September and late monsoon, winter, and spring are dry and cold although the temperature barely drops below 10°C.

Bangladesh is a rich habitat for odonate diversity because of its geographic location and abundance of water bodies (Chowdhury & Mohiuddin 2011). Very few studies, however, were carried out to annotate the odonate fauna of the country. Chowdhury & Mohiuddin (2011) listed 96 species of odonates from the eastern region while Khan (2015b) reported 76 species from the northeastern region of Bangladesh. In recent years, a few species were added to the odonate fauna of Bangladesh and at present 108 species are known from the country (Khan 2015a, in press). The odonate survey till date, however, focused mainly on the eastern region while surveys are lacking in other parts of Bangladesh, especially in the southwestern region, which has diverse freshwater resources.

The southwestern region of Bangladesh is administratively mainly under Khulna Division. This division consists of 10 administrative districts and covers a large area of 22,285km^2. The largest tract of mangrove forest of the world, the Sundarban, is also situated under this division and is distributed over three districts, namely, Khulna, Bhagerhat, and Satkhira. Many rivers, canals, ponds, and lakes occur in this part of the country. These freshwater resources are excellent habitats for odonates (Khan 2015b). Biswas et al. (1980) took the first approach to annotate the odonates of this region; however, their study was limited to Bagerhat District. Since this last odonatological survey in the region, there were no attempts to study odonates. In the present study, we conducted a broad survey in the southwestern region of Bangladesh to document odonates of the area.

Materials and Methods

Study Site

Khulna Division lies between 21.643°N to 24.181°N and 88.561°E to 89.942°E (Fig. 1). The study area has a tropical climate with a mild winter from October to March, a hot and humid summer from March to June, and a humid, warm, rainy monsoon from June to October. Temperature varies all the year round: the temperature falls to the lowest in January and December at 12–15 °C and reaches the highest in April–June at 41–45 °C. Daily relative humidity fluctuates between 50% and 90%, which is the lowest in the evening and highest in the morning. The maximum precipitation is experienced in July with 20–25 days of rain with 368mm precipitation (Bangladesh Bureau of Statistics 2014).

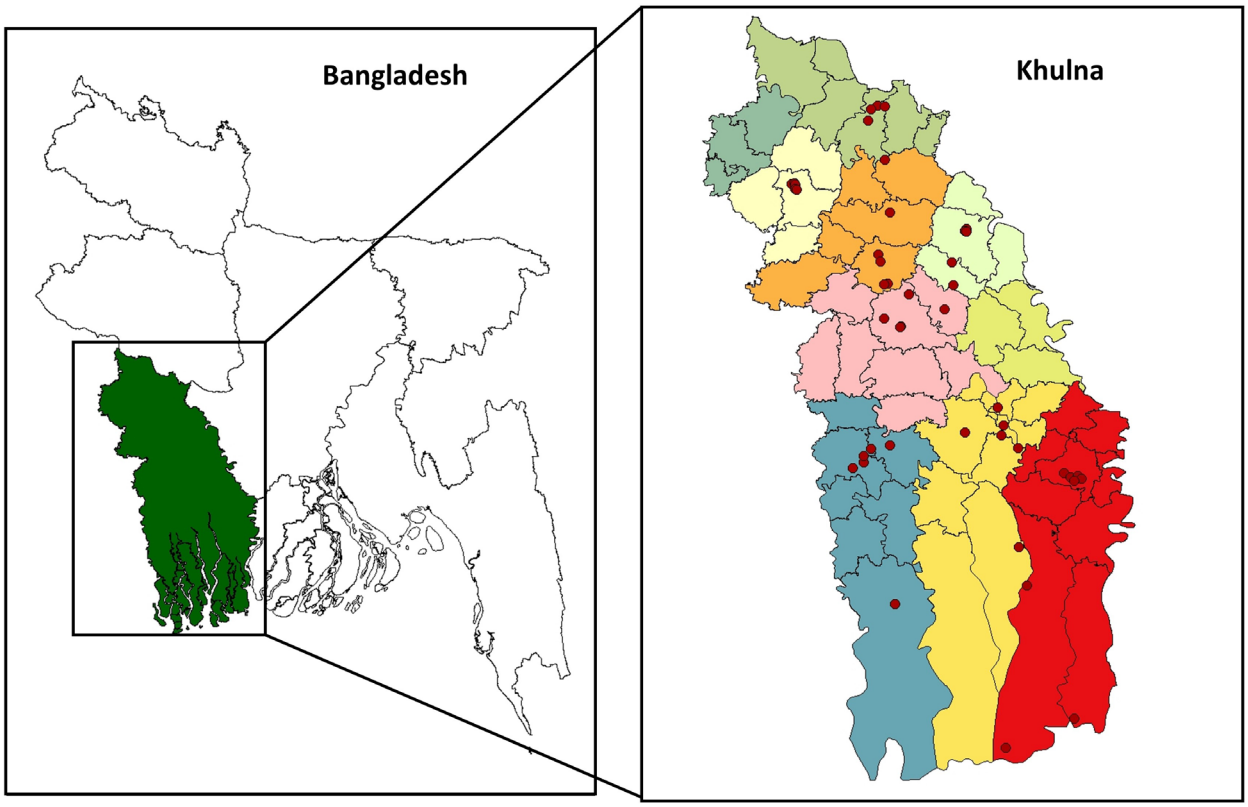

Figure 1. Reference map of southwestern region (Khulna Division) of Bangladesh marked with surveyed sites

We conducted fieldwork in the southwestern region of Bangladesh (concentrated on Khulna Division) from August 2014 to August 2016. We surveyed eight districts (namely, Khulna, Kushita, Jessore, Bagherhat, Chuadanga, Satkhira, Magura, and Jhinaidha) and the Sundarban during the study period. We randomly selected five sites from each district, at least 2km apart, by considering the accessibility and diversity of the habitat. In total, we selected 45 sites across the entire study area (Fig. 1). We did a regular survey (weekly, Bi-weekly, monthly, or bi-monthly) in the sampling sites (n=9) under Khulna and Jessore districts (Table 1), and one or two opportunistic surveys in the rest of the sites (n=36). We recorded GPS quadrate for all surveyed sites with a GPS device (Garmin GPSMAP 76CSx).

Sampling design

We surveyed the odonates by walking opportunistically through the roadsides, canal banks, river banks, pond sides, lakesides, open fields, forest paths, crop fields, grasslands, and urban and semi-urban areas of the study sites from 08:00h to 17:00h. We photographed the specimens for various identification keys such as wing venation, colour, patterns of thorax and abdomen, and shape of the anal appendages with a Nikon-3200D camera using Nikkor 55–300 mm AF-S DX and Micro-Nikkor 105mm FX AF lenses. We collected specimens that were difficult to identify from visual inspection and images by using an insect sweeping net. We did not collect any endangered odonates or sample from any protected areas, hence no permission was required for the collections. We identified the odonates with the help of taxonomic keys provided by Fraser (1920, 1933, 1934, 1936), Asahina (1967), Lahiri (1987), Mitra (2002), Subramanian (2005), and Nair (2011) and classified them according to Dijkstra et al. (2013).

Results

In total, 50 species belonging to 30 genera and six families were recorded from the study area (Table 2). Among them, 31 species (62%) belonging to 22 genera were recorded from Anisoptera suborder while 19 species (38%) comprising eight genera were reported from Zygoptera suborder (Table 2). Libellulidae was the most dominant family with 56% (28 species) of the total species count (Fig. 2). Coenagrionidae showed next highest dominance with 34% (17 species) species count, followed by Platycnemididae (4%), Protoneuridae (2%), Gomphidae (2%), Aeshnidae (2%), and Corduliidae (2%) (Fig. 2). Libellulidae was the best represented anisopteran family with 28 species whereas Coenagrionidae was the most abundant zygopteran family with 17 species (Fig. 2).

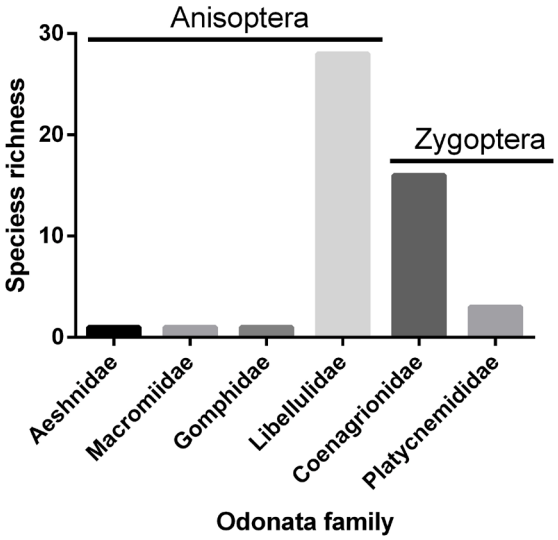

Figure 2. Species richness of the Odonata family recorded from the southwestern region of Bangladesh in the current study

A maximum of 47 species was recorded from Khulna District followed by Kushita (36), Jessore (32), Bagherhat (32), Chuadanga (27), Satkhira (24), Magura (22), and Jhinaidha (22) districts. A total of 25 species was recorded from the Sundarban mangrove area. Thirteen species were commonly found in all districts of the study area (Table 2). Three species, *Agriocnemis pygmaea, Ischnura senegalensis*, and *Diplacodes trivialis*, were recorded from all 45 study sites. *Mortonagrion varalli* was recorded for the first time from Bangladesh from a single female collected from the Khulna University campus (22.800^{0}N and 89.535^{0}E).

Discussion

We updated the checklist of the southwestern region of Bangladesh, which now consists 50 species or 47% of the known odonate fauna of the country. One species of damselfly, *Mortonagrion varalli*, is a first record to the country. Another rare dragonfly *Epophthalmia vittata* was recorded during the opportunistic survey. Similar to previous studies (Koparde et al. 2014; Khan 2015b), the current study also suggests opportunistic survey as important for observing odonates.

Among the six recorded families, species recorded from Aeshnidae, Corduliidae, and Gomphidae are lower in numbers in comparison to other families. A single species belonging to each of these families was sighted from the study area. In Bangladesh, only one species is known from Corduliidae family. On the other hand,

Table 1. A list of locations in the southwestern region of Bangladesh surveyed during the study period

	District	Location	Latitude	Longitude	No. of species	Date visited
1	Khulna	KU Campus	22.801°N	89.534°E	39	Weekly
2		Boyara	22.832°N	89.541°E	18	Monthly
3		Dumuria	22.809°N	89.413°E	24	Bi-monthly
4		Dhigholia	22.894°N	89.522°E	22	2.ix.2016
5		Jabusha	22.758°N	89.589°E	31	Bi-weekly
6	Jessore	Pouro Park	23.165°N	89.204°E	16	Bi-monthly
7		M.M. College	23.162°N	89.203°E	18	Bi-monthly
8		Borat Club	23.191°N	89.149°E	21	Bi-monthly
9		Labutala	23.272°N	89.231°E	29	Bi-monthly
10		Bagherpara	23.221°N	89.348°E	14	17.vi.2016
11	Satkhira	Satkhira Govt. College	22.710°N	89.085°E	19	6.ix.2016
12		Satkhira Medical College	22.691°N	89.047°E	14	6.ix.2016
13		BGB Camp	22.732°N	89.084°E	15	6.ix.2016
14		Binerpota	22.754°N	89.107°E	14	6.ix.2016
15		Patkelghata	22.767°N	89.169°E	18	6.ix.2016
16	Bagerhat	Satgomuj Mosque	22.674°N	89.737°E	17	9.ix.2016
17		Khanjahan Ali Majar	22.660°N	89.760°E	26	9.ix.2016
18		PC College	22.665°N	89.782°E	16	9.ix.2016
19		Pouro Lake	22.655°N	89.795°E	11	9.ix.2016
20		Pocha Dighi	22.648°N	89.772°E	8	9.ix.2016
21	Magura	Govt. HSS College	23.489°N	89.419°E	18	15.v.2015
22		Stadium Para	23.482°N	89.414°E	12	15.v.2015
23		District Fishery Office	23.480°N	89.419°E	17	15.v.2015
24		Arpara	23.377°N	89.371°E	11	15.v.2015
25		Salikha	23.302°N	89.375°E	16	15.v.2015
26	Jhinaidha	KC College	23.545°N	89.170°E	19	13.ix.2016
27		Kaligang	23.404°N	89.132°E	17	13.ix. 2016
28		Dulal-Mundia	23.380°N	89.139°E	7	13.ix.2016
29		Gazi-Kalu Mazar	23.308°N	89.163°E	13	13.ix.2016
30		Barobazar Railway Station	23.304°N	89.150°E	16	13.ix.2016, 13.viii.2017
31	Kushita	Kushtia Govt. College	23.901°N	89.128°E	32	3.v.2016, 16.ix.2016
32		Kushtia Soshan	23.899°N	89.152°E	14	16.ix.2016
33		Chourhas	23.889°N	89.108°E	9	16.ix.2016
34		Bot-toil	23.851°N	89.098°E	12	16.ix.2016
35		IU Campus	23.721°N	89.152°E	26	3.v.2016, 16.ix.2016
36	Chuadanga	Chuadanga Govt. College	23.639°N	88.849°E	18	18.ix.2016
37		Rail Para	23.642°N	88.858°E	23	18.ix.2016
38		Bus Terminal	23.637°N	88.860°E	11	18.ix.2016
39		Jafarpur	23.623°N	88.859°E	14	18.ix.2016
40		BGB Camp	23.620°N	88.864°E	15	18.ix.2016
41	Sundarban	Munsigong	22.237°N	89.185°E	17	3.ix.2015, 12.ii.2016
42		Koromjol	22.427°N	89.590°E	14	10.x.2014
43		Herbaria	22.299°N	89.616°E	17	11.x.2014
44		Dublar Char	21.757°N	89.548°E	11	14.viii.2015
45		Kotka	21.854°N	89.771°E	16	17.viii.2015

Table 2. A list of odonates in the current study. Khu=Khulna, Jes=Jessore, Sat=Satkhira, Bag=Bagherhat, Mag=Magura, Jhi=Jhinaidha, Kus=Kushita, Chu=Chuadanga, Sun=Sundarban. √ indicates the presence of a species in the study area. The species newly added to the odonate fauna of Bangladesh are marked with an asterisk (*).

	Species	Khu	Jes	Sat	Bag	Mag	Jhi	Kus	Chu	Sun
Suborder: Anisoptera										
Family: Aeshnidae (1)										
1	*Gynacantha subinterrupta* Rambur, 1842	√	√							
Family: Macromiidae (1)										
2	*Epophthalmia vittata* Burmeister, 1839		√							
Family: Gomphidae (1)										
3	*Ictinogomphus rapax* (Rambur, 1842)	√	√		√	√	√	√	√	√
Family: Libellulidae (28)										
4	*Acisoma panorpoides* Rambur, 1842	√	√	√	√	√	√	√	√	
5	*Aethriamanta brevipennis* (Rambur, 1842)	√			√					
6	*Brachydiplax chalybea* Brauer, 1868	√	√	√	√	√		√		√
7	*Brachydiplax farinosa* Krüger, 1902	√	√	√	√	√	√	√	√	√
8	*Brachydiplax sobrina* (Rambur, 1842)	√	√	√	√		√	√		√
9	*Brachythemis contaminata* (Fabricius, 1793)	√	√	√	√	√	√	√	√	√
10	*Bradinopyga geminata* (Rambur, 1842)	√								
11	*Crocothemis servilia* (Drury, 1773)	√	√	√	√	√	√	√	√	√
12	*Diplacodes nebulosa* (Fabricius, 1793)	√	√		√	√		√	√	
13	*Diplacodes trivialis* (Rambur, 1842)	√	√	√	√	√	√	√	√	√
14	*Lathrecista asiatica* (Fabricius, 1798)	√								
15	*Macrodiplax cora* (Brauer, 1867)	√								√
16	*Neurothemis fulvia* (Drury, 1773)	√	√	√	√	√	√	√	√	√
17	*Neurothemis tullia* (Drury, 1773)	√	√		√			√	√	√
18	*Orthetrum chrysis* (Selys, 1891)	√								
19	*Orthetrum glaucum* (Brauer, 1865)	√	√							
20	*Orthetrum pruinosum* (Burmeister, 1839)	√						√		
21	*Orthetrum sabina* (Drury, 1773)	√	√	√	√	√	√	√	√	√
22	*Pantala flavescens* (Fabricius, 1798)	√	√	√	√			√		√
23	*Potamarcha congener* (Rambur, 1842)	√	√		√		√	√	√	√
24	*Rhodothemis rufa* (Rambur, 1842)	√			√					
25	*Rhyothemis variegata* (Linnaeus, 1763)	√	√	√		√		√		√
26	*Tholymis tillarga* (Fabricius, 1798)	√	√	√	√	√		√	√	
27	*Tramea basilaris* (Palisot de Beauvois, 1805)	√								√
28	*Trithemis festiva* (Rambur, 1842)	√		√	√					
29	*Trithemis pallidinervis* (Kirby, 1889)	√	√	√	√	√	√	√	√	√
30	*Urothemis signata* (Rambur, 1842)	√	√	√	√	√		√		√
31	*Zyxomma petiolatum* (Rambur, 1842)	√	√							
Suborder: Zygoptera										
Family: Coenagrionidae (16)										
32	*Agriocnemis femina* (Brauer, 1868)	√	√	√	√	√	√	√	√	√
33	*Agriocnemis kalinga* Nair & Subramanian, 2014	√						√		
34	*Agriocnemis lacteola* Selys, 1877	√					√	√		
35	*Agriocnemis pieris* Laidlaw, 1919	√					√	√	√	

	Species	Khu	Jes	Sat	Bag	Mag	Jhi	Kus	Chu	Sun
36	*Agriocnemis pygmaea* (Rambur, 1842)	√	√	√	√	√	√	√	√	√
37	*Ceriagrion cerinorubellum* (Brauer, 1865)	√	√	√	√	√		√	√	√
38	*Ceriagrion coromandelianum* (Fabricius, 1798)	√	√	√	√	√	√	√	√	√
39	*Ceriagrion olivaceum* Laidlaw, 1914	√	√						√	
40	*Amphiallagma parvum* (Selys, 1876)								√	
41	*Ischnura aurora* (Brauer, 1865)	√	√	√	√	√	√	√	√	√
42	*Ischnura rufostigma* Selys, 1876							√	√	
43	*Ischnura senegalensis* (Rambur, 1842)	√	√	√	√	√	√	√	√	√
44	*Mortonagrion aborense* (Laidlaw, 1914)	√			√					
45	*Mortonagrion varalli* Fraser, 1920 *	√								
46	*Pseudagrion microcephalum* (Rambur, 1842)	√		√	√		√	√		√
47	*Pseudagrion rubriceps* Selys, 1876	√				√	√	√	√	
Family: **Platycnemididae (3)**										
48	*Copera marginipes* (Rambur, 1842)	√	√		√			√		
49	*Onychargia atrocyana* Sélys, 1865	√	√		√		√	√		
50	*Pseudocopera ciliata* (Selys, 1863)	√	√	√	√	√	√	√	√	√

Aeshnidae and Gomphidae represent six species each. Hence, the lower species number recorded from these families is a representation of the fewer known species of the families in Bangladesh. The present study recorded three species from Platycnemididae family of which *Pseudocopera ciliata* was frequently sighted in different study sites. All anisopteran species excluding *Lathrecista asiatica* and *Bradinopyga geminata* were frequently observed. Similarly, all Coenagrionidae species except mortonagrion species were frequently recorded.

Species diversity varies with change in habitat and microclimate. Some of the species were found only in distinct habitats whereas others adapted to broader landscapes were found in diverse habitats (Corbet 1999). *Agriocnemis femina*, *Agriocnemis kalinga*, *Agrioscemis pygmaea*, *Agriocnemis lecteola, Agriocnemis pieris*, and *Diplacodes trivialis* were found restricted to grassland habitats. *Ischnura senegalensis*, *Pseudagrion microcephalum*, and *Pseudagrion rubriceps* were observed mainly in water bodies. On the other hand, *Epophthalmia vittata*, *Lathrecista asiatica,* and *Gynacantha subinterrupta* were found only at the higher canopy of certain places. These observations provide evidence of habitat diversification and specialization of different species.

In the present study, 25 odonate species were recorded from the Sundarban mangrove forest. Due to high salinity and lack of freshwater, Sundarban is not well known for its odonate diversity. Previously, 26 species were recorded from the Indian part of the Sundarban region (Mitra & Mitra 2009). Among those, 17 species were also recorded in the current study from the Bangladeshi part of the Sundarban region. Also, eight species, which were unknown from the Sundarban region before, were recorded in the present study.

Water salinity is high in the southwestern region in comparison to the other areas of Bangladesh. Salinity is even higher in the mangrove areas and varies between 5ppt and 25ppt (Joshi & Ghose 2003). Pure, non-polluted water is important for odonate breeding (Carchini et al. 2005) and saline water has a negative influence on the odonate diversity (Needham & Westfall 1955). Hence, the lower odonate diversity in the southwestern region of Bangladesh (50 species in comparison to 96 species in the eastern region) can be a result of water salinity. The southwestern region also lacks the diversity of freshwater resources like waterfalls, streams, and tropical forest that are present in the eastern region.

In conclusion, we recorded 50 species of odonates in the current survey and updated the checklist of the southwestern region of Bangladesh. The present study is the first documentation of the odonate diversity in the Sundarban region of Bangladesh. Regional checklists are important to understand the diversity and conservation needs of a species and our study will fulfill that demand for the odonates of the region. Further long-term studies are required to understand the biology, population structure, threats, and conservation action needs of the

odonates of this region.

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