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43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

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Cover: Common Keeled Skink *Eutropis carinata* in oil pastels, colour pencils, & micron pen adapted from photograph by H. Byju © Pooja Ramdas Patil.



INTRODUCTION

The amphibiotic order Odonata, including dragonflies and damselflies, attracts a lot of attention due to the vibrant colours and exquisite flight patterns (Andrew et al. 2008). They are predominantly found in tropical subtropical and oriental regions, although a small number of species have also been found in the temperate zone, specifically in Japan and China (Kalkman et al. 2008) and are found in close proximity of freshwater body, including streams, lakes, marshes, or transient stagnant rainfall pools. They are hemimetabolous insects that go through three life cycle stages: a brief egg stage (a few weeks), the longest larval stage (ranging from months to year) (Stoks & Córdoba-Aguilar 2012), and finally reaching adulthood. Odonata larvae are aquatic and must go through several moult stages (e.g., 10 moults) before becoming terrestrial flying adults (Stoks & Córdoba-Aguilar 2012; Tiple et al. 2012) and their crucial role is notified in the food web and ecosystem as predators (both nymphs and adults). Odonates are considered as excellent model for studying insect evolution and ecology due to their phenotype and ecological diversity (Tiple & Koparde 2015; Bybee et al. 2016) and reliable bioindicators (Tiple et al. 2013; Siddika et al. 2017).

Globally, 6,406 species in 693 genera of odonates have been reported (Paulson & Schorr 2023) of which, 498 species and 27 subspecies in 154 genera and 18 families are known from India (Babu 2019; Tiple et al. 2022). By recording approximately 22 species from Kolkata, Selys (1891) launched the study of Odonata in West Bengal and subsequently, Mitra (2002) reported 65 species from the District, Howrah and Kolkata. Srivastava & Sinha (1993) documented 178 species in West Bengal, (Srivastava 1993). Recent studies on the Odonata fauna of Purba Medinipur by Payra & Tiple (2019) and Pahari et al. (2019) recorded 49 and 45 species, respectively. Dwari & Mondal (2018) documented 17 species from the agricultural fields of the Howrah district and 63 Odonata species were reported from the industrial areas of Paschim Bardhaman district, by Nayak & Roy (2016, 2021). Paschim Medinipur was explored by Jana et al. (2021) and 19 species of damselflies were recorded. Odonata diversity of Chinsurah, Baidyabati and Purbasthali were documented by Ghosh (2022) with the finding of 40 species. Latest updated checklist of odonates of West Bengal consists of 240 species from 114 genera (Dawn 2021, 2022).

MATERIALS AND METHODS

Study area

Burdwan district was bifurcated into two districts Purba and Paschim Bardhaman on 7 April 2017. These two districts are topographically different. Paschim Bardhaman is predominantly arid region with dry deciduous forests, patchy grasslands and two major rivers Damodar and Ajay, whereas Purba Bardhaman extends towards the Gangetic delta, which is more humid and dominated by flat alluvial plainlands. Purba Bardhaman lies almost in the middle of southern West Bengal, consisting of several perennial freshwater bodies, adjacent to major rivers like the Ajay, Damodar, and Ganges and small streams like Khari, Kunur, Banka, Kana Damodar to name a few. Bibliographic data on odonata species implies no such comprehensive record or published checklist from Purba Bardhaman district (all the information were collected from www.purbabardhaman.nic.in).

Purba Bardhaman district is encircled by six distinct districts: Murshidabad and Birbhum are located in the north, Nadia covers the east, and south is bounded by Hooghly and a portion of Bankura, and the west side by Paschim bardhaman. The district covers an area of approximately 5,432.69 Km² and is located between 23°53'–22°56' N and 88°25'–87°56' E (purbabardhaman.nic.in). Annual rainfall ranges from 1,200 to 1,400 mm (Ruidas et al. 2021).

Five different sites (Image 1), which covers a significant part of the district and the district bordering areas, were surveyed for the study of Odonata distribution and abundance. The details of each site are described in the Table. 1.

Sampling, Documentation, and Identification

Extensive field work was carried out from March 2021, to catalogue the diversity, distribution patterns of odonates in various niches and habitats at bordering areas of adjacent districts by potent described methodology.

The survey of odonate fauna was carried out throughout the year from March 2021 to February 2023. Data was gathered between 0700 h and 1400 h. Each of the sites were visited at least once in each month (2–5 hours of observation on each day). Each of the sampling area covered at least 1.5 km² (150 ha) of land or more. Among each of the study sites there were multiple small patches which were surveyed separately and samples were collected using proper labels (e.g., Site 1, pond 1 near XX village or river) and photographs of each of

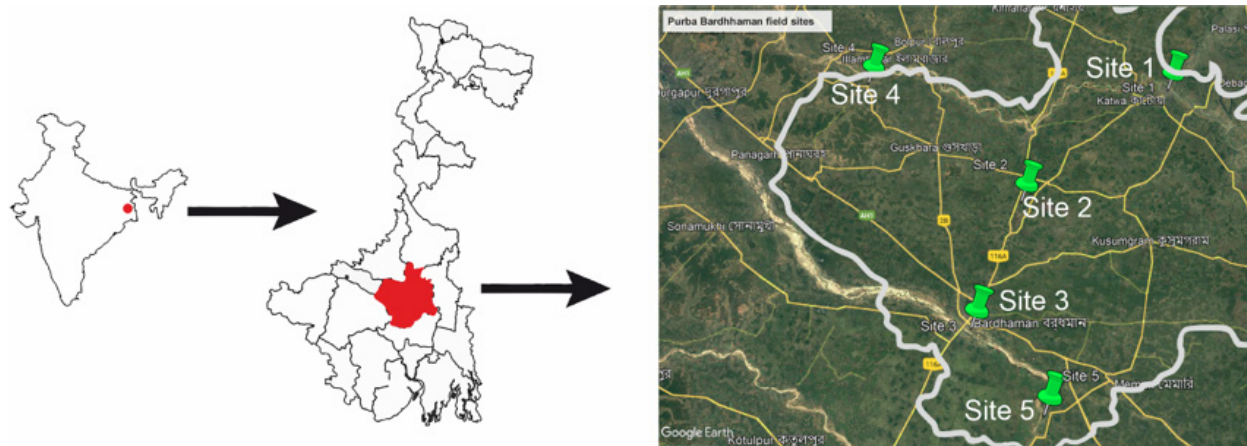


Figure 1. Field site: Panel (a) shows the geographical location of PurbaBardhaman district within India (shown as red dot). Panel (b) shows the centralised position of PurbaBardhaman district in southern part of West Bengal (the boundary of the district is filled in red). Panel (c) shows the geographical location of five field sites. The sites are namely site 1 Katwa and surroundings, site 2 Bhatar, Karjana and surroundings, site 3 Bardhaman town and surroundings, site 4 Ausgram and surroundings, site 5 Jamalpur, Raina and surroundings.

Table 1. A brief description of selected study sites along with the co-ordinates and habitat types.

Site	Latitude(N)	Longitude (E)	Sub-sites	Habitat types
Site 1: Katwa	23.6404°	88.1299°	Ajay river bank, Bank of Ganges near Nayachar	Grasslands, river bank, few seasonal and few perennial waterbodies, dry deciduous forest patches
Site 2: Bhatar	23.4191°	87.9163°	Bhatar village, Karjana pakhiralay	Seasonal marshes and water puddles, seven perennial ponds with low to moderate hydrophyte population, paddy fields, mango groves, Khori River bank and surrounding grasslands.
Site 3: Bardhaman	23.2324°	87.8615°	Bardhaman University campus, Agricultural University campus, Bhattachhala, Damodar bank and DVC canal areas at Palla-Srirampur, Hatshimul, Barshul, Rathhala	Dry deciduous forest patches with high canopy and moderate understory, more than 15 perennial ponds with low to moderate hydrophyte population, seasonal pools and marshes, bamboo groves, Damodar River bank, DVC canal bank and surrounding areas
Site 4: Aushgram	23.5256°	87.6630°	Uttar Ramnagar, Gopalpur, Ullaspur, Maliyara, Malacha Ajay river bank and surrounding areas	Bamboo groves, paddy fields, 11 different perennial ponds, Ajay River bank, dry deciduous forest patches, shrubland areas near Ajay River and two different irrigation canals.
Site 5: Jamalpur	23.0736°	87.8918°	Dadpur, Sarangpur	DVC canal banks (dense patches of mixed trees with thick understory), Damodar River banks, grasslands, seasonal puddles, four different perennial ponds.

those sites were taken along with co-ordinates using Angle Cam software. The sampling was conducted using the line transect approach (Burnham et al. 1980) and the opportunistic sighting method. For line transect method the lines were of a length of 0.5 to 1 km and number of lines varied from 2–5 in each site according to habitat and accessibility. Walking with uniform speed was used to cover the whole transect line, and all Odonata species on either side of the line were recorded. Photographs taken from a variety of viewpoints were used for documentation. Canon 80D and Nikon D500 cameras were used for taking photographs of individual sightings in field and collected samples. Collected photographic data as well as samples (both dry and wet) were assembled, and specified into monsoon, post monsoon,

and pre-monsoon season. Odonate identification was primarily performed in the field with field identification guide, previous literatures describing Odonata species, and websites such as www.indianodonata.org and (Fraser 1933a,b, 1936; Subramanian 2009). Some of the species which were difficult to identify instantly, so the cryptic specimens were captured by insect net. The damselflies were preserved in 70% alcohol in 5 ml plastic vials, and the dragonflies were collected in butter paper envelopes for further dry preservation. Dragonfly specimens were stretched with the help of insect pin to display all the key characters for identification. Identification was done with the help of taxonomic keys (Fraser 1933). Taxonomy and systematic arrangements were followed by Subramanian & Babu (2017).



Image 1. Different habitats from the sampling areas across five sites: The photographs show different habitats from the areas sampled across five different sites in Purba Bardhaman district. The habitats were diverse ranging from river banks to seasonal pools and canopy covered shrubland areas. All the photographs have the unique name code for each of the microhabitats along with the GPS location. Photographs were taken using Anglecarn software. Photograph courtesy © Kushankur Bhattacharyya.

RESULTS

The data from all of the sites revealed a total of 47 species, 35 genera, and six families. The sites chosen contained 32 species under the suborder Anisoptera and 15 species under the suborder Zygoptera. The Libellulidae family was found to be the most abundant (24 species). Together with the Libellulidae, other families were also found, including Coenagrionidae (11 species), Gomphidae (5 species), Aeshnidae (3 species), Platycnemididae (3 species), and Chlorocyphidae (1 species). The detailed record of the species along with its occurrence in different seasons and in different sites is listed in Table 1.

Suborder Zygoptera Selys, 1854

Family Chlorocyphidae Cowley, 1937

Libellago indica Fraser, 1928

Labrum dark brownish-yellow, abdomen 14–16 mm, black in colour with yellow markings on the sides of segments and broad mid-dorsal black stripes, differentiating it from *Libellago lineata*. Brown eyes. Black prethorax with citron yellow markings. Black thoracic segments with citron or greenish yellow markings. Legs are black, wings are hyaline, and the bases of all have a little amber tinge. Forewing's apical black patch is noticeably longer (See Image 4d).

Family Coenagrionidae Kirby, 1890***Agriocnemis kalinga* Nair & Subramanian, 2014**

A small damselfly, possibly the smallest described from India to date, with an abdomen measuring about 13–14 mm and a hindwing measuring 8–11 mm. The superior anal appendages are longer than the inferior ones, and the male's tergum 2 is marked with a distinctive cobra hood-like pattern. The ground colour is bright yellow with black on the dorsum, yellow pterostigma, with a bright yellow tip. The males on the other hand are dark green coloured with a black line running through

the dorsal side of the abdomen. The anal appendages on occasions appeared yellow or orangish-yellow and the thorax also had black line markings (Image 4a).

Suborder Anisoptera Selys, 1854**Family Gomphidae Rambur, 142*****Platygomphus dolabratus* Selys, 1854**

Abdomen is about 41 mm. Bright yellow labium, labrum, and face. Fronts are completely yellow; vertex is black with a sizable yellow mark behind the ocelli; and the occiput is a bright yellow. Bottle-green eyes. Prothorax



Image 2. Odonata of Purba Bardhaman: a—*Macrogomphus montanus* (side view) | b—*Macrogomphus montanus* (dorsal view) | c—*Macrogomphus montanus* (side view of head and thorax close-up) | d—*Macrogomphus montanus* (anal appendages close-up) | e—*Platygomphus dolabratus* | f—*Paragomphus lineatus*. Photograph courtesy @ Kushankur Bhattacharyya.

is black on dorsum, sides yellow. Thorax is yellow with black markings. Wings hyaline that occasionally have a slight yellow hue. Legs are yellow with black markings. Anal appendages have a black border and are yellow or yellowish-brown in colour (Image 2e).

***Macrgomphus montanus* Selys, 1869**

Length of abdomen, 45 mm. Black head with yellow markings. Labrum has two oval basal patches, as does the entire labium. Brown colored occiput. Unmarked prothorax is black in colour. Stripes are visible on the black thorax. Widely yellow sides with two neatly marked black lateral sutures. Hyaline, palely enfumed, brown wings with a tight reticulation. Dark blackish-brown legs. Black abdomen with yellow markings. The apical half of the divaricate, point-tipped anal appendages are thick at the base (Image 2a,b,c,d).

DISCUSSION

This is the first comprehensive study of odonate diversity to cover a significant portion of the Purba

Bardhaman district, though there were some individual sighting reports from a few small pockets and another study that covered Purbasthali, within the district's territory (Ghosh 2022). We attempted to incorporate various types of habitats in this study, ranging from seasonal pools to perennial rivers, resulting in the listing of 47 species from 35 genera. Our results were in cohesion with the detailed report by Dawn (2022).

It reveals from the results (see Table. 2) that the family Aeshnidae is noticed in Site 1, 2, 3, 4 but not in 5; out of which *Anax indicus* (Lieftinck, 1942) appeared to be a more common species and is noticed in Site 1, 2 & 3 site in monsoon period but *Anax guttatus* (Bermeister, 1839) and *Gynacantha* sp. in Site 3 during post monsoon period. *Anax indicus* was found mostly flying over small waterbodies and sometimes hanging from the leaves or branches of mango trees. *Gynacantha* sp. was found in the middle of Bardhaman town near an old house.

Five different species were found under family Gomphidae and among them, *Ictinogomphus rapax* (Rambur, 1842) and *Paragomphus lineatus* (Selys, 1850) were found in all seasons near large waterbodies and canals. *Macrgomphus montanus* (Selys, 1869) was

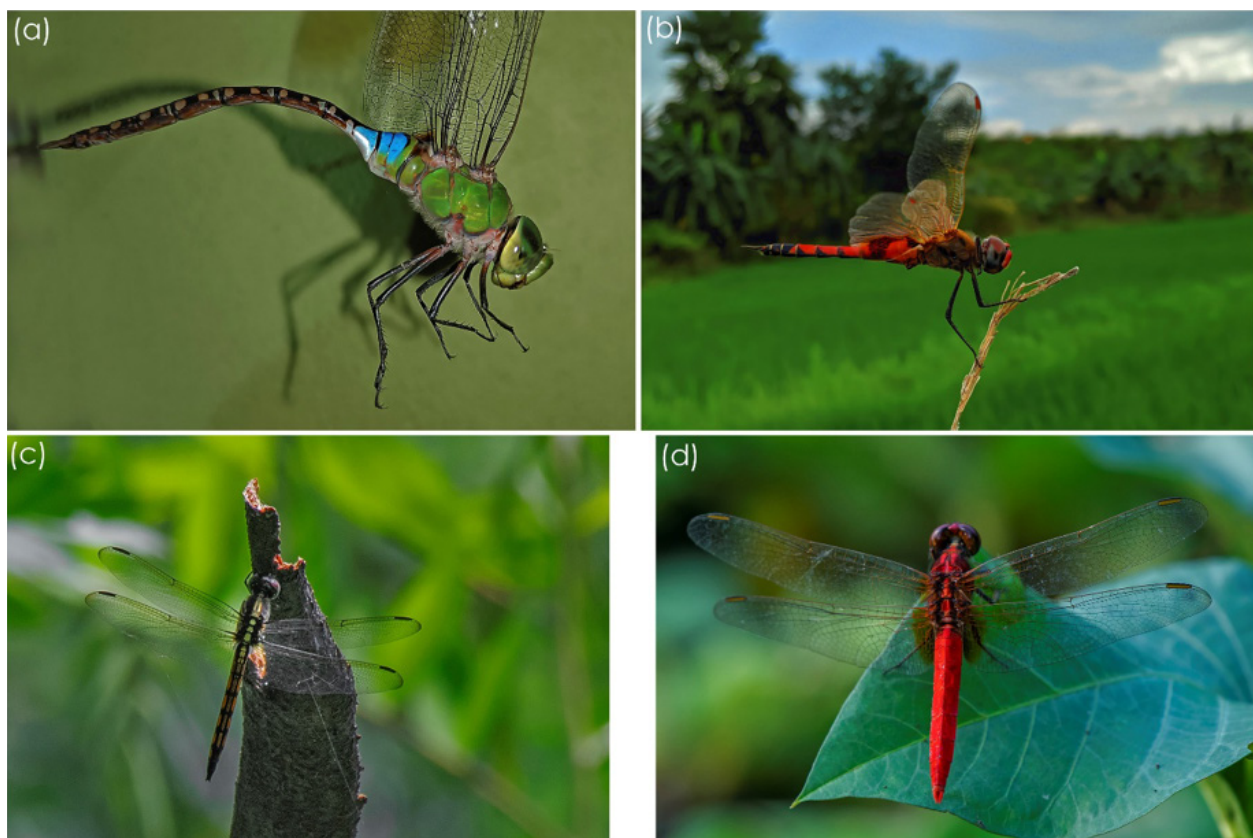


Image 3. Odonata of Purba Bardhaman: a—*Anax guttatus* | b—*Tramea basilaris* | c—*Lathrecista asiatica* | d—*Rhodothemis rufa*.

© Kushankur Bhattacharyya.

only found in Site 3 during monsoon in the shades of shrubby patch with high canopy trees over the shrubby patch. This species was reported only twice from West

Bengal before this study (from Kolkata in 2002 and from Paschim Bardhaman in 2021) (Mitra 2002; Nayak & Roy 2021).

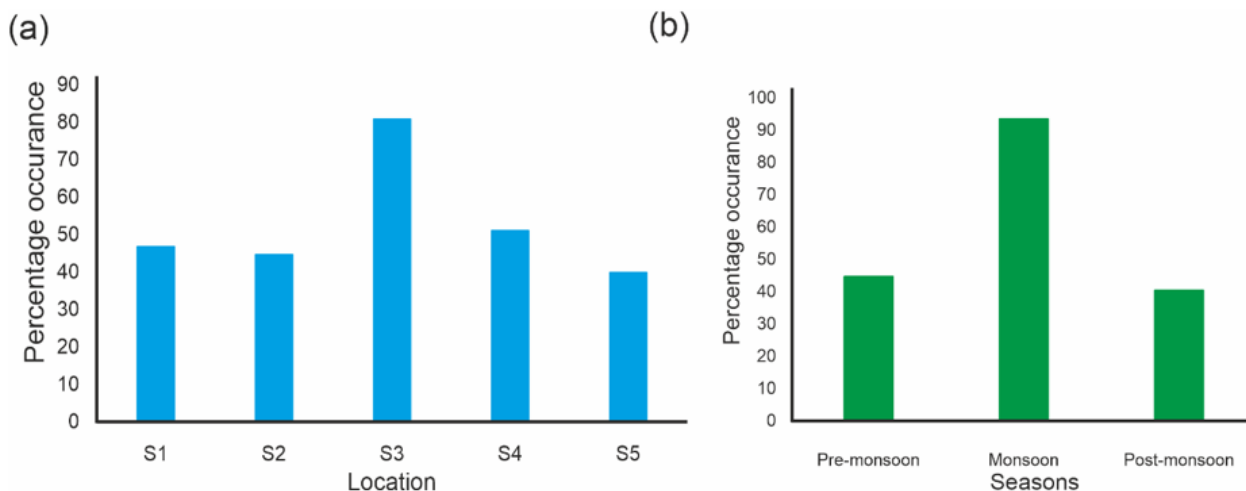


Figure 2. Percentage of odonate diversity from different sites and in different seasons.

The bar graphs in panel (a) shows percentage of odonates found in different field sites. S1, S2, S3, S4, S5 denotes Site 1, 2, 3, 4, 5, respectively. The bar graphs in panel (b) shows percentage of odonates found in different seasons. Each season is denoted by different colour. These are Bar graphs plotting the respective percentages. The X axis shows locations (panel (a)), and seasons (panel (b)). The Y axis shows the percentage of occurrence of species from different locations and different seasons.

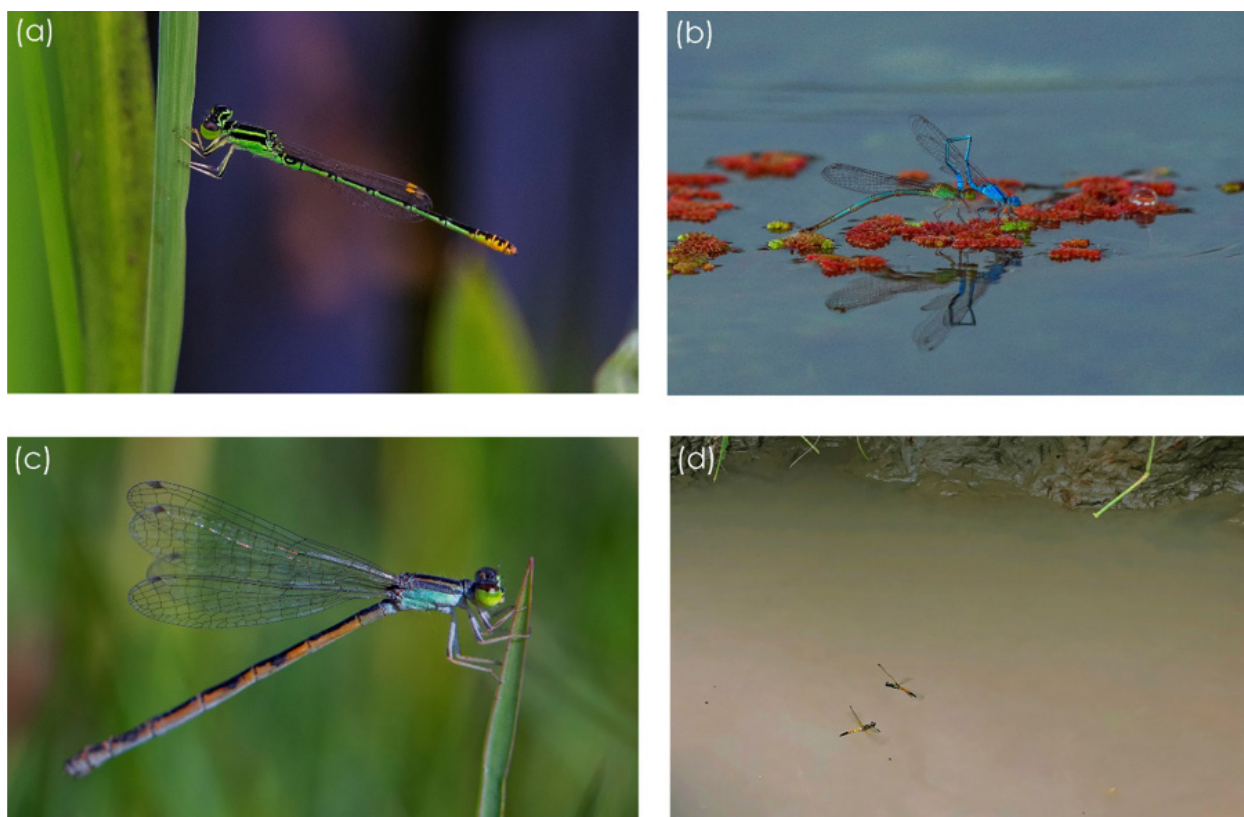


Image 4. Odonata of Purba Bardhaman: a—*Agriocnemis kalinga* male, panel | b—*Amphiallagma parvum* male and female | c—*Ischnura nursei* female | d—*Libellula indica*. © a-c—Kushankur Bhattacharyya, d—Kalyan Ghosh.



Image 5. Odonata of Purba Bardhaman: a—*Gynacantha* sp. | b—*Macrodiplax cora* | c & d—*Pseudocoperia ciliata* | e—*Pseudagrion decorum* | f—*Brachydiplax chalybea*. © Kushankur Bhattacharyya.

A total of 24 species belonging to Libellulidae family of Anisoptera were recorded from the study areas, making it the most abundant family. *Pantala flavescens* (Fabricius, 1798) and *Urothemis signata* (Rambur, 1842) are available in pre monsoon and monsoon period with *P. flavescens* mostly flying in good numbers at a height near waterbodies, whereas *U. signata* was mostly seen sitting atop small shrubby patches. *Orthetrum sabina* (Drury, 1770) was seen very commonly and across seasons, and on some occasions seen feeding on other Odonata species like *Brachythemis contaminata* (Fabricius, 1793)

was often seen sitting on small hydrophytes in small and stagnant waterbodies. It often showed obelisk posture while sitting. *Potamarcha congener* (Rambur, 1842) was often seen sitting on wires or dry bamboo sticks. *Crocothemis servilia* (Drury, 1770) was very commonly found near waterbodies even in the banks of rivers and *Diplacodes trivialis* (Rambur, 1842) was often found sitting on the ground and feeding on mosquitos, mayflies and other small insects. *Brachydiplax sobrina* (Rambur, 1842) was found near waterbodies with loads of hyacinths and shady areas; *Tramea basilaris* (Palisot

Table 2. List of Odonates found and their seasonal occurrence.

	Species	Site of occurrence	Season of occurrence
	Suborder: Anisoptera		
	Family: Aeshnidae		
01	<i>Anax indicus</i> Lieftinck, 1942	S1, S2, S3	Monsoon
02	<i>Anax guttatus</i> Burmeister, 1839	S4	Post-monsoon
03	<i>Gynacantha dravida</i> Lieftinck, 1960	S3	Post-monsoon
	Family: Gomphidae		
04	<i>Cyclogomphus ypsilon</i> Selys, 1854	S2, S3	Monsoon
05	<i>Ictinogomphus rapax</i> Rambur, 1842	S1, S2, S3, S4	All season
06	<i>Macrogomphus montanus</i> Selys, 1869	S3	Monsoon
07	<i>Paragomphus lineatus</i> Selys, 1850	S1, S2, S3	All season
08	<i>Platygomphus dolabratus</i> Selys, 1854	S1	Monsoon
	Family: Libellulidae		
09	<i>Acisoma panorpoides</i> Rambur, 1842	S3, S4, S5	Pre-monsoon, Monsoon
10	<i>Aethriamanta brevipennis</i> Rambur, 1842	S2, S3	Monsoon
11	<i>Brachydiplax chalybea</i> Brauer, 1868	S1, S3	Monsoon
12	<i>Brachydiplax farinosa</i> Krüger 1902	S3	Monsoon
13	<i>Brachydiplax sobrina</i> Rambur, 1842	S1, S3, S4	Monsoon, Post-monsoon
14	<i>Brachythemis contaminata</i> Fabricius, 1793	S2, S3, S4, S5	All season
15	<i>Bradinopyga geminata</i> Rambur, 1842	S1, S2, S3	Pre-monsoon, Monsoon
16	<i>Crocothemis servilia</i> Drury, 1773	S1, S3, S4, S5	All season
17	<i>Diplacodes nebulosa</i> Fabricius, 1793	S3	Monsoon
18	<i>Diplacodes trivialis</i> Rambur, 1842	S1, S3, S4, S5	All season
19	<i>Lathrecista asiatica</i> Fabricius, 1798	S3	Monsoon
20	<i>Macrodiplax cora</i> Brauer, 1867	S3, S5	Monsoon
21	<i>Neurothemis fulvia</i> Drury, 1773	S2, S3	Monsoon
22	<i>Neurothemis tullia</i> Drury, 1773	S3, S4	Pre-monsoon, Monsoon
23	<i>Orthetrum sabina</i> Drury, 1770	S1, S2, S3, S4, S5	All season
24	<i>Pantala flavescens</i> Fabricius, 1798	S1, S2, S3, S4, S5	Pre-monsoon, Monsoon

	Species	Site of occurrence	Season of occurrence
25	<i>Potamarcha congener</i> Rambur, 1842	S1, S2, S3, S4, S5	All season
26	<i>Rhodothermis rufa</i> Rambur, 1842	S3, S4, S5	Pre-monsoon, Monsoon
27	<i>Rhyothemis variegata</i> Linnaeus, 1763	S2, S3, S4	Pre-monsoon, Monsoon
28	<i>Tholymis tillarga</i> Fabricius, 1798	S1, S3, S4	All season
29	<i>Tramea basilaris</i> Palisot de Beauvois, 1805	S2, S3, S4, S5	Monsoon, Post-monsoon
30	<i>Tramea limbata</i> Desjardins, 1832	S1	Monsoon, Post-monsoon
31	<i>Trithemis pallidinervis</i> Kirby, 1889	S2, S4	Monsoon
32	<i>Urothemis signata</i> Rambur, 1842	S1, S2, S3, S4, S5	Pre-monsoon, Monsoon
	Suborder: Zygoptera		
	Family: Chlorocyphidae		
33	<i>Libellago indica</i> Fraser 1928	S1	Monsoon
	Family: Coenagrionidae		
34	<i>Agriocnemis kalinga</i> Nair & Subramanian, 2015	S3	Monsoon
35	<i>Agriocnemis pygmaea</i> Rambur, 1842	S1, S3, S4	All season
36	<i>Amphiallagma parvum</i> Selys, 1876	S1, S2, S3	All season
37	<i>Ceriagrion cerinorubellum</i> (Brauer, 1865)	S3, S5	Monsoon
38	<i>Ceriagrion coromandelianum</i> Fabricius, 1798	S1, S2, S3, S4, S5	Pre-monsoon, Monsoon
39	<i>Ischnura nursei</i> Morton, 1907	S3	Monsoon
40	<i>Ischnura rubilio</i> Selys, 1876	S1, S2, S3, S4, S5	Pre-monsoon, Monsoon
41	<i>Ischnura senegalensis</i> Rambur, 1842	S1, S3, S4, S5	All season
42	<i>Pseudagrion decorum</i> Rambur, 1842	S2, S4	Monsoon, Post-monsoon
43	<i>Pseudagrion microcephalum</i> Rambur, 1842	S5	Monsoon, Post-monsoon
44	<i>Pseudagrion rubriceps</i> Selys, 1876	S1, S2, S3, S4	Monsoon, Post-monsoon
	Family: Platycnemididae		
45	<i>Onychargia atrocyana</i> Selys, 1865	S2, S3, S4	All season
46	<i>Copera marginipes</i> Rambur, 1842	S3	Pre-monsoon
47	<i>Pseudocopera ciliata</i> Selys, 1863	S1, S2, S3	All season

de Beauvois, 1805) was mostly seen flying at a height. *Indothemis limbata* (Selys, 1891) was found only in Site 1.

During pre-monsoon and post-monsoon period *Acisoma panorpoides* (Rambur, 1842) was noticed near ponds with loads of hyacinth and other hydrophytes, with very less open water surface. *Bradinopyga geminata* (Rambur, 1842) was mostly found inside the Bardhaman town sitting on walls, sometimes well

camouflaged. *Neurothemis tullia* (Drury, 1773) was not so common and was seen in grassy areas near waterbodies on a few occasions. *Rhodothermis rufa* (Rambur, 1842) and *Rhyothemis variegata* (Linnaeus, 1763) in Site 3, 4, 5 and Site 2, 3, 4, respectively. *Tholymis tillarga* (Fabricius, 1798) was mostly found active during late afternoon and during daytime sitting in the shades.

Among suborder Zygoptera, *Libellago indica* (Fraser, 1928) belonging to Chlorocyphidae family and

Pseudocopera ciliata (Selys, 1863) of Platycnemididae family were found in monsoon only in Site 1 & 2. Eleven species of family Coenagrionidae are recorded of which *Ischnura senegalensis* (Rambur, 1842) and *Agriocnemis pygmaea* (Rambur, 1842) were found across seasons very commonly. *Agriocnemis pygmaea* was found mostly in shallow water patches sitting on vegetation. During pre-monsoon and monsoon *Ceriagrion coromandelianum* (Fabricius, 1798) and *Ischnura rubilio* (Selys, 1876) were noticed in all sites; whereas during monsoon and post monsoon period *Pseudagrion rubriceps* (Selys, 1876) was often observed guarding its mate or in tandem with the female and in very few occasions laying eggs on submerged twigs. *Pseudagrion decorum* (Rambur, 1842) was found near perennial waterbodies and small seasonal village ponds but *Pseudagrion microcephalum* (Rambur, 1842) was found near the Damodar River only. Other species like *Agriocnemis kalinga* Nair & Subramanian 2014, *Amphiallagma parvum* (Selys, 1876) were found in open water puddles and large waterbodies with grasses and other hydrophytes, whereas *Ceriagrion cerinorubellum* (Brauer, 1865) was found in shady areas and bushes. *Ischnura nursei* (Morton, 1907) was only found near Damodar River along with other damselflies like *Agriocnemis pygmaea*.

It appeared from the recorded data (Figure 2) of studied area that monsoon is the favourable period for completion of their life cycle, although they were noticed as well as were seen to breed throughout the seasons selectively. Highest percentage (85%) of species are recorded from Site 3 and 51.06%, 46.80%, 44.68%, & 31.91% from Site 4, 1, 2, & 5, respectively.

A possible limitation to the study is that many small pockets of the district which covers a number of other water bodies both seasonal and perennial were not surveyed, though we tried to cover as much area as possible. Future exploration of these sites and beyond can extend the list further and make the data even more robust. Seasonal variation of Odonata species and relative abundance in different locations are two other aspects that has to be investigated further.

The study overall sets a stepping stone for further studies related to the fascinating world of Odonates from this district and also advocates about greater possibilities of the district to have a secured place in the Odonata map of West Bengal.

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Tamil Nadu 641006, India
ravi@threatenedtaxa.org

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Articles

Unearthing calf burials among Asian Elephants *Elephas maximus* Linnaeus, 1758 (Mammalia: Proboscidea: Elephantidae) in northern Bengal, India

– Parveen Kaswan & Akashdeep Roy, Pp. 24615–24629

Coexistence of Indian Pangolin *Manis crassicaudata* (Geoffroy, 1803) (Mammalia: Pholidota: Manidae) and Indian Crested Porcupine *Hystrix indica* (Kerr, 1792) (Mammalia: Rodentia: Hystricidae) in Purulia District, West Bengal, India

– Debosmita Sikdar, Shwetadri Bhandari & Sanjay Paira, Pp. 24630–24645

Avifaunal assemblage patterns in Bharathapuzha River Basin, Kerala, India

– Pazhayattuparambil Narayanan Anoop Raj, Avadhoot Dilip Velankar & Padmanabhan Pramod, Pp. 24646–24657

Desmids of Brahmaputra valley, a major southern Asian river basin

– Soumin Nath & Partha Pratim Baruah, Pp. 24658–24693

Communications

Distribution status and roost characteristics of Indian Flying Fox *Pteropus medius* Temminck, 1825 (Mammalia: Chiroptera: Pteropodidae) in Kurukshetra district, Haryana, India

– Ritu Devi & Parmesh Kumar, Pp. 24694–24706

Avifauna of four protected areas of Terai-Arc Landscape, India: significant records and a checklist of species

– Shariq Safi, Tanveer Ahmed, Junid Nazeer Shah, Meraj Anwar & Kamlesh K. Maurya, Pp. 24707–24729

Monitoring observations of the southernmost breeding population of Long-billed Vultures *Gyps indicus* (Scopoli, 1786) (Aves: Accipitriformes: Accipitridae) in the Nilgiri Biosphere Reserve, India

– S. Manigandan, H. Byju & P. Kannan, Pp. 24730–24736

Observations on Indian Skimmer *Rynchops albicollis* Swainson, 1838 (Aves: Charadriiformes: Laridae) breeding colonies in Middle Ganges stretch, India

Kumar Ankit, Mujahid Ahamad, Vivek Ranjan, Sanjay Kumar, Syed Ainul Hussain & Govindan Veeraswami Gopi, Pp. 24737–24745

Avifaunal diversity in urban greenspaces within Cotabato city, Mindanao Island, Philippines

– Joan Rhea Mae L. Baes, Peter Jan D. de Vera, John Paul A. Catipay, Marian Dara T. Tagoon & Elsa May Delima-Baron, Pp. 24746–24751

Waterbird count at Narathali waterbody, Buxa Tiger Reserve in northern Bengal for a decade (2009–2019) with a note on raptors

– Sachin Ranade & Soumya Sundar Chakraborty, Pp. 24752–24759

First confirmed reproduction by a translocated female Siamese Crocodile *Crocodylus siamensis* (Crocodylidae: Crocodilia) with observations of nest attendance and nest-associated fauna

– Steven G. Platt, Sounantha Boutxakittilath, Oudomxay Thongsavath, Samuel C. Leslie, Lonnie D. McCaskill, Randeep Singh & Thomas R. Rainwater, Pp. 24760–24768

Erode Ground Gecko *Cyrtodactylus speciosus* (Beddome, 1870) (Squamata: Gekkonidae) from peri-urban common-lands of Coimbatore, India, with comments on habitat associations

– S.R. Ganesh, N.A. Swaathi & Usha Ravindra, Pp. 24769–24774

Assessment of diversity of Odonata fauna in selected sites of Purba Bardhaman district, West Bengal, India

– Sulagna Mukherjee & Rabindranath Mandal, Pp. 24775–24785

A preliminary assessment of butterfly diversity from Mekhliganj town, Cooch Behar District, West Bengal, India

– Abhirup Saha, Prapti Das & Dhiraj Saha, Pp. 24786–24794

Utilization of *Afzelia africana* Sm. ex Pers. (Magnoliopsida: Fabales: Fabaceae) in Nigeria and its implications for conservation

– Samuel Oloruntoba Bamigboye, Muhali Olaide Jimoh, Falilat Abeni Lawal, Zainab Temitope Osiyemi, Charles Petrus Laubscher & Learnmore Kambizi, Pp. 24795–24803

Short Communications

Gastrointestinal parasites of the Indian Flying Fox *Pteropus medius* in Nagpur City: a seasonal study through faecal sample analysis

– Ruchika R. Sangale & Priya Gawande, Pp. 24804–24806

***Plagiochila javanica* (Sw.) Nees & Mont. (Marchantiophyta: Plagiochilaceae) rediscovered from the Western Ghats after 180 years**

– M.S. Sajitha, C.N. Manju, B. Mufeed, K.P. Rajesh & K.K. Rawat, Pp. 24807–24811

A new record of genus *Synedrus* Graham, 1956 with description of male of *Synedrus kasparyani* Tselikh, 2013 from India

– Mubashir Rashid & Arvind Kumar, Pp. 24812–24815

Note

***Hunteria zeylanica* (Retz.) Gardner ex Thwaites (Magnoliopsida: Gentianales: Apocyanaceae)—new addition and first genus record to the flora of Karnataka**

– G. Ramachandra Rao, Pp. 24816–24818

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