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continued on the back inside cover

Cover: Indian Grey Wolf *Canis lupus pallipes* and Smooth-coated Otter *Lutrogale perspicillata* sharing the territory in Chambal basin. Digital art on Procreate by Aakanksha Komanduri.

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ARTICLE

Study of Odonata in the coastal-influenced area of Purba Medinipur District with a note on seasonal fluctuations and species composition

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Abstract: The present study provides an updated record checklist of Odonata in the coastal regions of Purba Medinipur District, West Bengal. A total of 60 species (59 identified to species level and one unidentified *Agriocnemis* sp.) belonging to 40 genera and seven families were recorded. Twenty-five species of Zygoptera (damselflies) were classified under three families: Coenagrionidae, Lestidae, and Platycnemididae, represented by 17, three, and five species, respectively. Thirty-five species of Anisoptera (dragonflies) were classified under four families, with Libellulidae accounting for 28 species, Aeshnidae and Gomphidae for three species each, and Macromiidae for one species. Notably, *Disparoneura quadrimaculata* was recorded for the first time from Purba Medinipur, District, extending its known range within southern West Bengal. The highest species richness and density were observed during the monsoon season.

Keywords: Anisoptera, checklist, coastal wetland, damselfly, *Disparoneura quadrimaculata*, dragonfly, habitat preference, pond size, water quality, Zygoptera.

Editor: Anonymity requested.

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Author contributions: SK—conceptualization, investigation, methodology, photography, writing (original draft), writing (review & editing). SJ—investigation, methodology, software, writing (review & editing). SB—software, writing (Original draft), writing (review & editing). SKG—supervision, validation, writing (review & editing).

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INTRODUCTION

The order Odonata encompasses two main groups of insects: dragonflies (Anisoptera) and damselflies (Zygoptera) (Mitra 1999), carnivorous insects belonging to the group of uniramian arthropods. Odonata are aquatic paleopterous insects that are commonly known as amphibious insects due to their semi-aquatic life cycle. Their larvae live in water, while the adults are aerial predators (Corbet 1980). Odonate larvae and adults function as important intermediate predators in aquatic and terrestrial ecosystems, respectively. By preying on a wide range of smaller invertebrates while also serving as prey to birds, spiders, fish, and amphibians, they play a key role in maintaining the trophic balance and energy flow within ecosystems (Chovanec & Waringer 2001). Additionally, these larvae prey on mosquito larvae and other pest insects. Adult odonates also contribute to pest control by preying on harmful insects in crop fields and other blood-sucking pests (Samways & Steytler 1996). Odonates have been present since the Permian era (Corbet 1999).

There are currently 6,442 known species worldwide (Paulson et al. 2025), of which 504 are found in India, with 175 being endemic (Subramanian & Babu 2024). Odonates are among the most ancient extant lineages of winged insects and are widely used as indicator taxa, because their sensitivity to pollution, habitat quality and hydrological change makes them reliable reporters of overall ecosystem health (Pattanayak et al. 2020). The main habitats for odonates include rain-fed canals, ponds, swamps, lowlands, and lakes in the study area and its surroundings. During the monsoon season, odonates also utilize paddy fields and other grasslands as breeding grounds. Due to their carnivorous feeding habits, odonates play a crucial role in biological control measures against insect pests, particularly in areas where agriculture is the primary source of livelihood (Rana & Bhatia 2025). The larval stages of odonates are equally significant for controlling mosquito larvae (Priyadarshana & Slade 2023).

The present study aimed to assess the current status of Odonata diversity in coast-influenced areas of Purba Medinipur. Additionally, an attempt has been made to investigate the condition of certain aquatic ecosystems in the study area that are experiencing significant threats to the larvae of aquatic Odonata, as well as other aquatic insects.

Some previous studies have been conducted on adult odonates in Purba Medinipur District. One of the distinct works has been done by Payra & Tiple (2016) on the diversity of Odonata in Purba Medinipur District. Another remarkable work which shows the community structure of Odonata has been done by Pahari et al. (2019). The diversity and abundance of Odonata larvae in freshwater lentic systems have been well studied by Pattanayak et al. (2020). Odonata diversity in Egra and its adjoining blocks has been studied by Samanta et al. (2023). Purba Medinipur is the southernmost district in West Bengal and is influenced by the marine environment, which impacts the diversity of many species. The present study was carried out in the coast-influenced area of Purba Medinipur District.

MATERIALS AND METHODS

The study was conducted from June 2021 to May 2023. Initially, many sites were randomly visited and from these, nine: Egra-1, Khar-2, Panchetgarh-3, Kudi-4, Panchol-5, Depal-6, Pakarghat-7, Kourda-8, and Erenda-9, were selected for repeated sampling (Image 1) (Table 1). In each study area there are several types of water bodies and land features (Image 2). Pond habitats were categorized based on surface area: small ponds (< 0.3 ha), medium ponds (0.3–0.8 ha), and large ponds (> 0.8–1.5 ha). Small ponds were mostly seasonal, while medium and large ponds were perennial with varying degrees of vegetation and human activity. The study area comprises a mosaic of aquatic and terrestrial habitats. Expressed as a percentage of the total mapped surface area of the nine sites, large ponds occupy approximately 13%, medium-sized ponds 7%, and small ponds together with seasonal puddles 33%. Wetlands cover 10%, low-lying areas 5%, and polluted ponds a further 10%. Agricultural land comprises rice fields (6%) and peanut fields (9%), while plantations and forested patches together account for the remaining 7%, these nine categories sum to 100% (Image 3). To assess seasonal variation in odonatan abundance, field surveys were conducted across all nine sampling sites throughout the year. Each site was visited four times per month during the study period, ensuring consistent and continuous monitoring. For analytical purposes, data were categorized into three seasonal phases: pre-monsoon (March–May), monsoon (June–September), and post-monsoon (October–February). This seasonal classification was based on regional climatic patterns to evaluate shifts in species composition and abundance across seasons.

To accommodate different habitat types, multiple methods were applied. In terrestrial zones like rice fields,

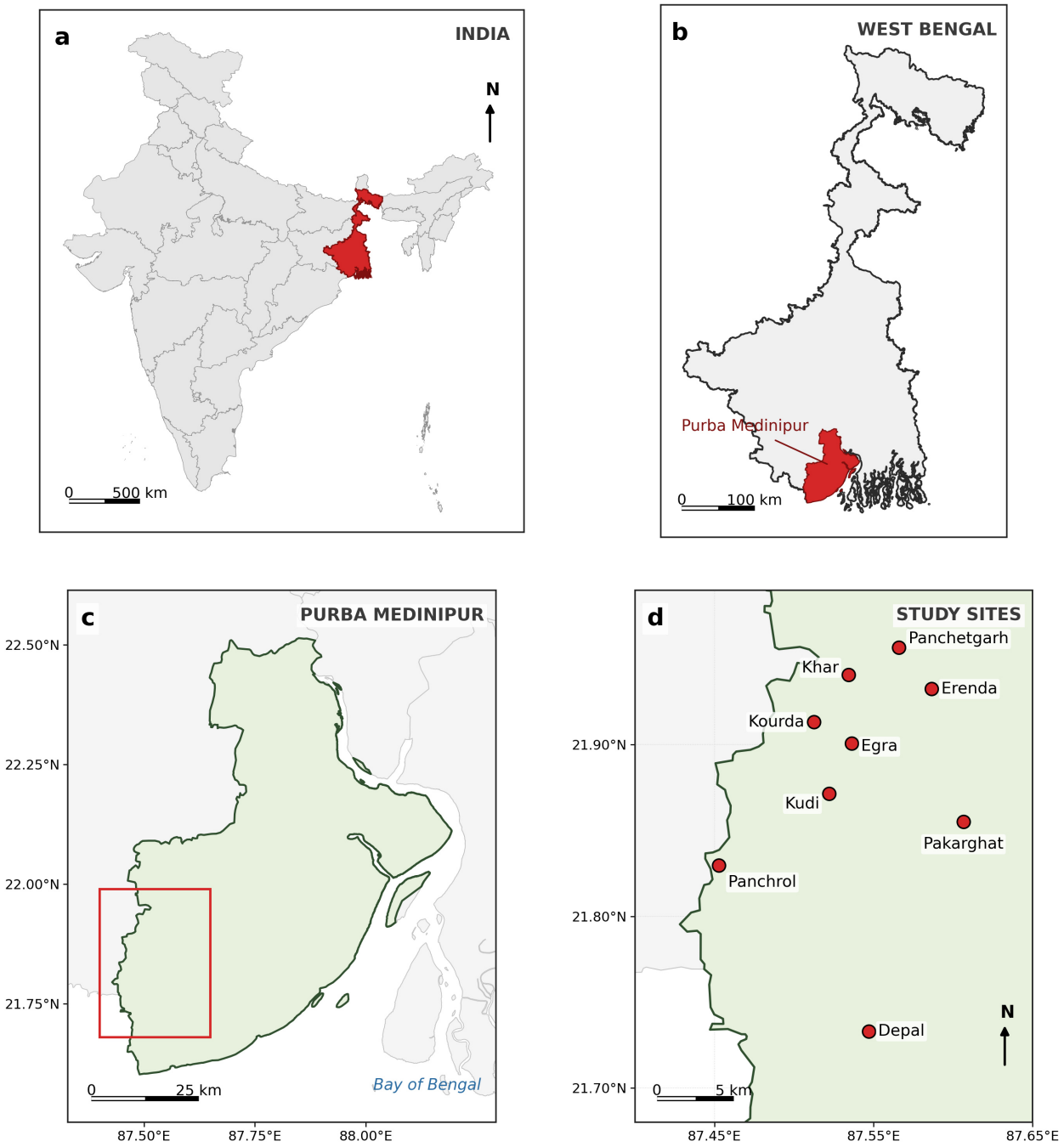

Image 1. Map showing the selected study sites in the coastal-influenced region of Purba Medinipur district, West Bengal. Nine sites—Egra, Khar, Panchetgarh, Kudi, Panchol, Depal, Pakarghat, Kourda, and Erenda—were chosen for repeated sampling between June 2021 and May 2023.

plantations, and forest edges, 500 m line transects were combined with Pollard walks, where observers recorded odonates within a fixed width while walking at a steady pace. For aquatic habitats such as ponds and wetlands, the belt transect method (10 × 100 m) was used along the shoreline to effectively observe species active near water. These methods ensured comprehensive coverage across diverse microhabitats and were conducted during different seasons and times of day. Photographic documentation was carried out in the field using Canon 90D DSLR with 18–55 mm and 70–250 mm lens. In some cases species identification was challenging due to the presence of cryptic species with similar morphological features. Most of the site sampling was conducted at 0800–1400 h, as odonates exhibit peak activity during this time to regulate their body temperature in sunlight

(Subramanian 2014; Koli et al. 2015).

The Margalef's index was used as a simple measure of species richness, calculated using the formula: Margalef's index = (S - 1) / ln(N)

S = Total number of species

N = Total number of individuals in the sample

In = Natural logarithm

Specimens were captured using an insect net, and abundance was recorded through visual encounter surveys and noted in a field notebook. Captured specimens were euthanized using ethyl acetate in a killing jar to minimize damage to morphological features, which is essential for accurate identification. After euthanasia, adult specimens were pinned and dried for long-term preservation. Larval forms were collected using hand nets and scooping methods from submerged vegetation, pond edges, and shallow water zones. Collected larvae were then fixed in 70% ethanol for long-term storage. Identification was carried out based on standard larval identification keys (Corbet 1999; Subramanian 2005; Hacet et al. 2010; Nesemann et al. 2011), considering morphological features such as labial mask, caudal gills, and wing pad development.

Aquatic plants were collected from the field for subsequent identification because plant composition is one of the key determinants of the community structure of Odonata (Samways & Steytler 1996). The identification of aquatic plants was performed using the i-Naturalist field guide ((iNaturalist 2024).

The common plants present in the study sites are *Marsilea minuta* L., *Nelumbo nucifera* Gaertn., *Nymphaea* sp., *Monochoria hastata* Solms, *Scirpus articulatus* L., *Cyanotis axillaris* Roem. & Schult., *Aeschynomene aspera* L., *Hygroryza aristata* Nees, *Hydrocotyle asiatica* Nees, *Hygrophila difformis* L.f., *Utricularia stellaris* L.f., *Jussiaea repens* L., *Nymphoides indica* L., *Eichhornia crassipes* (Mart.) Solms, *Hydrilla verticillata* Casp., *Chara* sp., *Nitella* sp., *Pistia stratiotes* L., *Lemna* sp., *Cyperus* sp., *Ipomoea aquatica* Forsk., *Enhydra fluctuans* Lour., *Sphenoclea zeylanica* Gaertn., *Trapa* sp., *Ceratophyllum demersum* L., *Polygonum* sp., *Alternanthera* sp., and *Gomphrena sessilis* L.

A measuring tape was used to record the dimensions of the waterbodies (length and breadth) at each study site to estimate surface area and categorize pond sizes. Water parameters such as CO_2, alkalinity and dissolve oxygen were measured following different methods. CO_2 was measured using the acid-base titration method (APHA 2017), alkalinity was measured using Anderson & Robinson (1946) titrimetric method, and dissolved oxygen (DO) was measured using the Winkler method (Grasshoff et al. 2009). Identification of species was conducted with the help of field identification guide given by Andrew et al. (2008), Nair (2011), and Subramanian (2014). Data analysis was performed using PAST software version 3.02. The abundance status of species was categorized based on field observations across multiple sites: Very Common (VC) indicates presence in more than 50% of sites, Common (C) refers to species found in 20–50 % of sites, Occasional (O) for those found in less than 20% but more than 5% of sites refers to species that are commonly found only in specific locations, Rare (R) indicates occurrence in less than 5% of the sites, and Very Rare (VR) includes species recorded only once or twice during the entire study period.

RESULTS

A total of 60 species of odonata (59 identified to species level and one unidentified *Agriocnemis* sp.) were recorded, belonging to 40 genera and seven families. Among these, 25 species of Zygoptera have been classified under three families, and 35 species of Anisoptera have been categorized under four families. Within the Zygoptera, Coenagrionidae was represented by 17 species, Platycnemididae by five and Lestidae by three. Within the Anisoptera, Libellulidae was represented by 28 species, Aeshnidae and Gomphidae by three species each, and Macromiidae by one (Image 5). Anisoptera accounted for 58.3% and Zygoptera for 41.7% of the total taxa recorded (Image 4). Coenagrionidae showed the highest diversity among the Zygoptera, and Libellulidae among the Anisoptera.

The abundance of species during different seasons has been studied: pre-monsoon (March–May), monsoon (June–September), and post-monsoon (October–January) (Image 6). The monsoon season has exhibited a higher density of species abundance, while the post-monsoon period has shown lower abundance levels.

Diversity is also influenced by the seasonal changes. The monsoon season tends to display greater diversity, whereas the post-monsoon season shows lower diversity. Among the areas under study, medium ponds exhibit the highest diversity, followed by forests and plantations as the second most diverse regions. In contrast, peanut fields display lower diversity compared to the other study areas. Interestingly, both polluted ponds and forest areas demonstrate similar levels of diversity throughout the year (Image 7).

To study species composition in various habitats, five ponds of different sizes with varying vegetation were

Table 1. Geographical coordinates, altitude, and habitat types of the nine selected study sites in the coastal-influenced region of Purba Medinipur District, West Bengal. These sites represent a range of aquatic and semi-aquatic habitats including ponds, wetlands, rice fields, plantations, forests, and polluted water bodies.

	Name	Latitude (° N)	Longitude (° E)	Altitude (m)	Habitat types
1.	Egra	21.900	87.538	170	Large pond, medium pond, low land, polluted pond.
2.	Khar	21.874	87.542	4	Forest, plantation, medium And small pond.
3.	Ponchet	21.943	87.570	30	Large pond, medium pond, plantation, peanut field, rice field.
4.	Kudi	21.871	87.522	19	Forest, plantation, rice field, wet land, medium and small pond.
5.	Panchrol	21.832	87.455	19	Small cannel, medium and small pond, rice field, polluted pond, peanut field, low land.
6.	Depal	21.733	87.547	4	Forest, plantation, small pond, polluted pond wet land.
7.	Pakarghat	22.085	87.026	5	Wet land, low land, small pond, polluted pond, peanut field.
8.	Kourda	21.912	87.512	19	Medium and small pond, forest, rice field, peanut field.
9.	Erenda	21.931	87.586	5	Large and medium pond, forest, rice field, peanut field.

Image 2. Photographs of different study sites surveyed in the coastal-influenced region of Purba Medinipur District, West Bengal: a—agricultural field during harvesting | b—eucalyptus plantation near waterlogged habitat | c—temporary water pools in open fields | d—vegetated canal with slow-flowing water | e—urban polluted waterbody adjacent to settlements | f—irrigated paddy field | g—moist grassy field with shallow water | h—large village pond surrounded by vegetation | i—natural pond with floating vegetation (water lilies). © © Suvabrata Khatua.

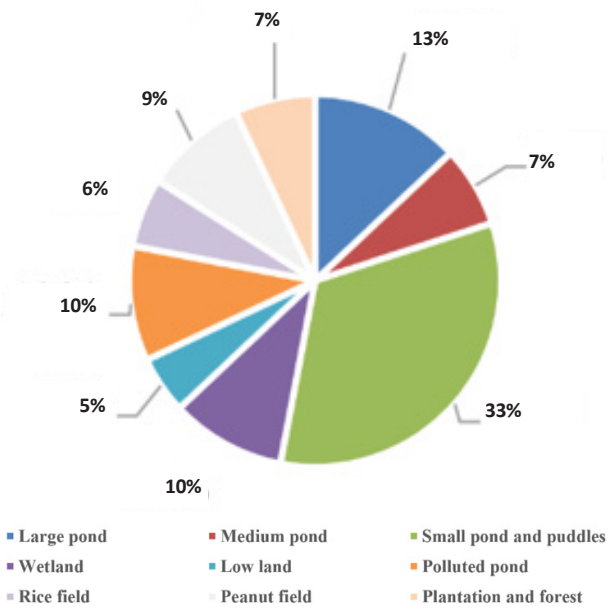

Image 3. Percentage contribution of each habitat type to the total mapped surface area of the nine study sites (values are percentages of area, not of species).

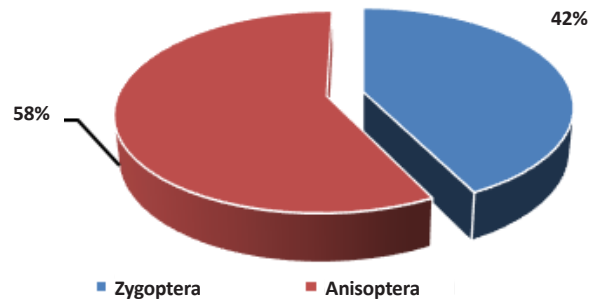

Image 4. Suborder-wise composition of the recorded Odonata, expressed as the percentage of the 60 taxa recorded.

selected.

Study site 1 is located at Kudi, Rason. It is a medium-sized pond with abundant vegetation, including free-floating plants. The dissolved oxygen (DO) concentration at this site measures around 10 ppt. The most abundant species observed here are *Rhodothemis rufa* and *Urothemis signata.*

Pond 2 is located at Pakarghat, and it is a medium-sized pond with a high abundance of emergent plants. The dissolved oxygen (DO) concentration at this pond is approximately 3.8 ppt. The dominant species observed in this habitat are *Acisoma panorpoides*, *Brachydiplax sobrina*, and *Ceriagrion coromandelianum.*

Pond 3 is located at Egra and is a large-sized pond with very little vegetation, primarily comprising floating plants. The dissolved oxygen (DO) concentration at this pond is 7 ppm. The dominant species observed in this habitat are *Pseudagrion rubriceps*, *Ischnura senegalensis*, and *Agriocnemis kalinga.*

Pond 4 is located at Panchetgarh, and it is a medium-sized pond with no vegetation. The dissolved oxygen (DO) concentration at this pond is approximately 24 ppm. The dominant species observed in this habitat are *Crocothemis servilia and Ictinogomphus rapax*.

Pond 5 is located at Kourda, and it is a small pond with a dense growth of vegetation, including floating leaf plants. The dissolved oxygen (DO) concentration at this pond is around 3 ppm. The dominant species observed in this habitat are *Ceriagrion coromandelianum*, *Brachydiplax ephippiger*, *Brachydiplax sobrina*, and *Acisoma panorpoides*.

The comparative analysis of Anisoptera and Zygoptera at the five study ponds shows clear variation in their

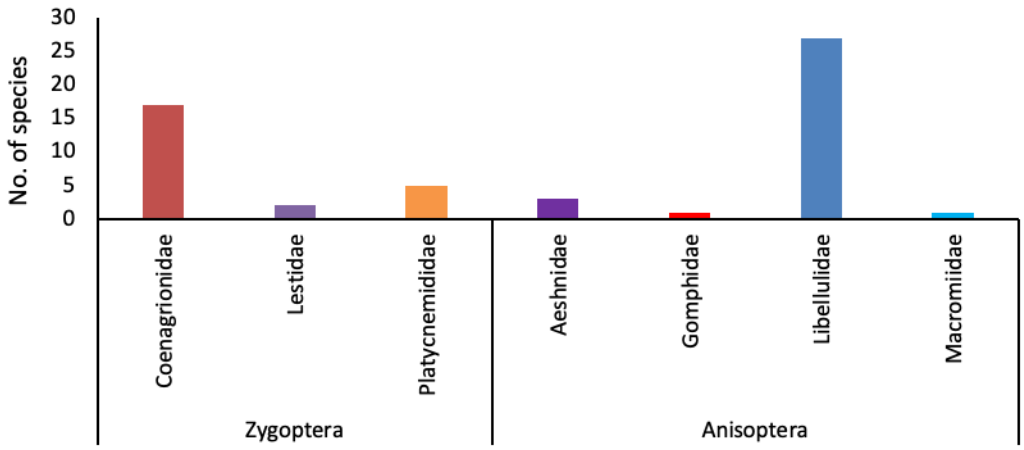

Image 5. Family-wise composition of the recorded Odonata, expressed as the number of species per family.

Table 2. List of Odonata fauna of coastal influenced area of Purba Medinipur District: VC—Very Common (>50%) | C—Common (20–50 %) | O—Occasional (5–20 %) | R—Rare (< 5%) | VR—Very Rare | *—first time reported from district.

	Scientific name	Common name	IUCN Red List status	Local status	Egra	Khar	Panchet Garh	Kudi	Panchrol	Depal	Pakarghat	Kourda	Erenda
Suborder: Zygoptera Family: Coenagrionidae													
1.	*Agriocnemis pygmaea* (Rambur, 1842)	Pygmy Dartlet	LC	VC	+	+	+	+	+	-	+	+	+
2.	*Agriocnemis kalinga* (Nair & Subramanian, 2014)	Indian Hooded Dartlet	NE	VC	+	+	+	+	+	-	+	+	+
3.	*Agriocnemis femina** (Brauer, 1868)	Pinhead Wisp	LC	CE	+	+	+	+	+	-	+	+	+
4.	*Agriocnemis lacteola* (Selys, 1877)	Milky Dartlet	LC	O	+	-	-	+	+	-	+	-	+
5.	*Agriocnemis pieris* (Laidlaw, 1919)	Indian White Dartlet	LC	R	+	-	-	-	-	-	-	-	+
6.	*Agriocnemis* sp.	-	-	VR	-	-	-	-	-	-	-	-	+
7.	*Ceriagrion coromandelianum* (Fabricius, 1798)	Coromendel Marsh Dart	LC	VC	+	+	+	+	+	+	+	+	+
8.	*Ceriagrion cerinorubellum* (Brauer, 1865)	Orange Tailed Murshed Dart	LC	C	+	+	+	+	+	-	+	+	+
9.	*Ceriagrion olivaceum* (Laidlaw, 1914)	Rushty Mursh Dart	LC	R	+	-	-	-	+	-	-	-	-
10.	*Pseudagrion microcephalum* (Rambur, 1842)	Blue Dart	LC	C	+	-	-	+	-	-	-	-	+
11.	*Pseudagrion decorum* (Rambur, 1842)	Three-lined Dart	LC	C	-	-	-	-	-	-	-	-	+
12.	*Pseudagrion rubriceps* (Selys, 1876)	Saffron-faced Blue Dart	LC	C	+	-	-	+	-	-	+	-	+
13.	*Ischnura senegalensis* (Rambur, 1842)	Senegal Golden Dartlet	LC	VC	+	-	+	+	+	-	+	-	-
14.	*Ischnura rubilio** (Selys, 1876)	Western Golden Dartlet	LC	C	+	+	+	+	-	-	-	-	+
15.	*Paracercion malayanum* (Selys, 1876)	Malayan Lilly Squatter	LC	C	-	-	-	+	+	+	-	-	-
16.	*Aciagrion pallidum* (Selys, 1891)	Pale Slender Dartlet	LC	O	-	+	-	+	-	+	-	+	+
17.	*Mortonagrion aborense* (Laidlaw, 1914)	-	LC	R	+	-	-	-	-	-	-	-	+
Family: Lestidae													
18.	*Lestes concinnus* (Hagen in Selys, 1862)	Brown Spread Wing	DD	R	-	-	-	-	-	+	-	-	-
19.	*Lestes viridulus* (Rambur, 1842)	Emerald Striped Spread Wing	LC	R	-	-	-	-	-	+	-	-	-
20.	*Lestes elatus* (Hagen in Selys, 1862)	Emerald Spread Wing	LC	R	-	-	-	-	-	+	-	-	+
Family: Platycnemididae													
21.	*Pseudocopera ciliata* (Selys, 1863)	Pied Bush Dart	LC	O	+	-	-	+	+	-	-	-	+
22.	*Copera marginipes* (Rambur, 1842)	Yellow Bush Dart	LC	O	+	-	-	-	-	+	-	-	-
23.	*Copera vittata* (Selys, 1863)	Blue Bush Dart	LC	O	-	-	-	-	-	-	+	-	-
24.	*Onychargia atrocyana* (Selys, 1865)	Black Mash Dart	LC	R	+	-	-	+	-	-	-	-	+
25.	*Disparoneura quadrimaculata** (Rambur, 1842)	Black-winged Bamboo Tail	LC	VR	-	-	-	-	-	+	-	-	-
Suborder: Anisoptera Family: Aeshnidae													
26.	*Anaciaeschna jaspidea* (Burmeister, 1839)	Rusty Darner	LC	R	+	-	-	+	-	-	-	-	-
27.	*Gynacantha dravida* (Lieftinck, 1960)	Brown Darner	DD	VR	-	-	-	+	-	-	-	-	-
28.	*Anax guttatus* (Burmeister, 1839)	Blue Tail Green Darner	LC	O	-	-	-	+	+	-	-	-	-
Family: Gomphidae													
29.	*Ictinogomphus rapax* (Rambur, 1842)	Common Clubtail	LC	C	+	-	+	+	+	+	-	-	+
30.	*Macrogomphus annulatus* (Selys, 1854)	Deccan Bowtail	DD	R	+	-	-	-	-	-	-	-	+
31.	*Paragomphus lineatus* (Selys, 1850)	Lined Hooktail	LC	C	+	-	-	-	-	-	-	-	+
Family: Libellulidae													
32	*Acisoma panorpoides* (Rambur, 1842)	Trumpet Tail	LC	VC	+	+	-	+	+	+	+	+	-

	Scientific name	Common name	IUCN Red List status	Local status	Egra	Khar	Panchet Garh	Kudi	Panchrol	Depal	Pakarghat	Kourda	Erenda
33.	*Aethriamanta brevipennis* (Rambur, 1842)	Scarlet Marsh Hawk	LC	C	-	-	-	+	-	+	-	-	+
34.	*Brachydiplax sobrina* (Rambur, 1842)	Little Blue Marsh Hawk	LC	VC	+	+	-	+	-	+	+	+	+
35.	*Brachydiplax chalybea* (Brauer, 1868).	Rufous-backed Marsh Hawk	LC	VC	+	-	-	+	-	-	+	+	-
36.	*Brachydiplax farinosa* (Kruger, 1902)	Emerald-flanked Marsh Hawk	LC	C	+	-	-	-	-	-	-	-	+
37.	*Brachythemis contaminata* (Fabricius, 1793)	Ditch Jewel	LC	VC	+	+	+	+	+	+	+	+	+
38.	*Diplacodes trivialis* (Rambur, 1842)	Ground Skimmer	LC	VC	+	+	+	+	+	-	+	+	+
39.	*Diplacodes nebulosa* (Fabricius, 1793)	Black-tipped Ground Skimmer	LC	VC	+	-	-	-	-	-	+	-	-
40.	*Orthetrum sabina* (Drury, 1770)	Green Marsh Hawk	LC	R	+	+	+	+	+	-	+	+	+
41.	*Orthetrum pruinosum* (Burmister, 1839)	Crimson-tailed Marsh Hawk	LC	R	+	-	-	-	-	-	+	+	+
42.	*Neurothemis tullia* (Drury, 1773)	Pied Paddy Skimmer	LC	C	+	-	-	-	-	+	-	-	+
43.	*Neurothemis fulvia* (Drury, 1773)	Fulvous Forest Skimmer	LC	O	-	+	-	+	-	+	-	+	-
44.	*Neurothemis intermedia* (Rambur, 1842)	Paddy Field Parasol	LC	C	-	-	-	-	-	+	-	-	+
45.	*Crocothemis servilia* (Drury, 1770)	Ruddy Marsh Skimmer	LC	C	+	+	+	+	+	-	+	+	+
46.	*Urothemis signata* (Rambur, 1842)	Greater Crimson Glider	LC	C	-	-	-	+	-	-	-	-	+
47.	*Pantala flavescens* (Fabricius, 1798)	Wandering Glider	LC	C	+	+	+	+	+	+	+	+	+
48.	*Rhodothemis rufa* (Rambur, 1842)	Rufous Marsh Glider	LC	C	+	+	-	+	+	-	-	+	-
49.	*Rhyothemis variegata* (Linnaeus, 1763)	Common Picture Wing	LC	R	+	+	+	+	+	+	+	+	+
50.	*Zyxomma petiolatum* (Rambur, 1842)	Brown Dusky Hawk	LC	VR	-	+	-	-	-	+	-	+	-
51.	*Bradinopyga geminata* (Rambur, 1842)	Granite Ghost	LC	VR	+	-	-	-	-	+	-	-	-
52.	*Potamarcha congener* (Rambur, 1842)	Yellow-tailed Ashy Skimmer	LC	R	+	-	-	+	-	-	-	-	+
53.	*Tholymis tillarga* (Fabricius, 1798)	Coral-tailed Cloud Wing	LC	C	+	-	-	+	-	-	-	-	-
54.	*Cratilla lineata* (Foerster, 1903)	Emerald Banded Skimmer	LC	VR	-	-	-	-	+	-	-	-	-
55.	*Macrodiplax cora* (Brauer, 1867)	Estuarian Skimmer	LC	R	-	-	-	-	+	-	-	-	+
56.	*Tramea basilaris* (Palisot de Beauvois, 1805)	Red Marsh Torter	LC	C	-	-	+	+	-	-	-	-	-
57.	*Tramea limbata* (Desjardins, 1832)	Black Marsh Torter	LC	O	-	-	+	+	-	-	-	-	-
58.	*Trithemis pallidinervis* (Kirby, 1889)	Long-tailed Marsh Glider	LC	C	+	-	+	-	+	-	+	-	+
59.	*Lathrecista asiatica* (fabricius, 1798)	Asiatic Blood Tail	LC	VR	-	-	-	+	-	+	-	-	-
Family: Macromiidae													
60.	*Epophthalmia vittata* (Burmeister, 1839)	Common Torrent Hawk	LC	R	+	-	-	+	-	+	-	-	-

relative abundance (Image 8). Anisoptera predominated at Panchetgarh (59 of 72 individuals, 81.9%), Pakarghat (90 of 126, 71.4%) and Kudi (73 of 127, 57.5%), whereas Zygoptera predominated at Egra (198 of 307, 64.5%) and Kourda (31 of 54, 57.4%). The Zygoptera-dominated ponds were those with dense marginal or floating vegetation and appreciable shade, whereas open ponds with little vegetation supported proportionally more Anisoptera. These results highlight the influence of local habitat structure on Odonata community composition.

DISCUSSION

The results of the present study indicate that the study area in southern parts of West Bengal, India, exhibits a rich diversity of dragonflies and damselflies, with a total of 60 species identified. The study also provides essential baseline information for future quantitative research on odonate diversity in this specific region. During the study, habitat preference studies were conducted for various species throughout the research period. The observed habitat preferences

of zygopterans for vegetated zones and anisopterans for more open water habitats may be influenced not only by vegetation structure but also by other interacting factors such as pond size and water quality parameters, which together contribute to shaping Odonata assemblages. The behavioural study has revealed that most aeshnids were crepuscular. They tend to perch in dense forested areas and often appear near light sources in the evening. *Anax guttatus* (Burmeister, 1839) was observed to be active throughout the day, continuously flying over water and seldom perching on twigs. On the other hand, *Ictinogomphus rapax* (Rambur, 1842) was found alongside large ponds or lakes, frequently perching on sticks near the water.

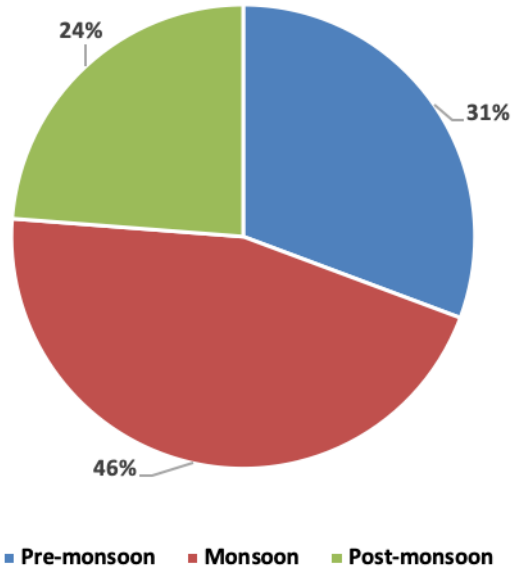

Image 6. Seasonal variation in Odonata abundance, expressed as the percentage of the total number of individuals recorded across all nine study sites.

Libellulids are the most abundant and diverse group in any habitat. Dragonfly species like *Aethriamanta brevipennis* (Rambur, 1842), *Brachydiplax farinosa* (Kruger, 1902), *Lathrecista asiatica* (Fabricius, 1798), and *Neurothemis fulvia* (Drury, 1773) are generally found inside well-shaded forested areas, sometimes away from water. Conversely, *Urothemis signata* (Rambur, 1842), *Rhodothemis rufa* (Rambur, 1842), *Crocothemis servilia* (Drury, 1770), and *Brachydiplax chalybea* Brauer, 1868 are very common near open water bodies. *Pantala flavescens* (Fabricius, 1798), *Rhyothemis variegata* (Linnaeus, 1763), and *Tramea basilaris* (Palisot de Beauvois, 1805) are sometimes seen flying in swarms at considerable heights. Odonates with weak flight, such as *Acisoma panorpoides* Rambur, 1842, *Neurothemis tullia* (Drury, 1773), and *Diplacodes nebulosa* (Fabricius, 1793) are often found residing in grasslands with long grasses associated with water bodies. *Bradinopyga geminata* (Rambur, 1842) is always found near man-made water reservoirs or seen perched on dirty walls. *Orthetrum sabina* (Drury, 1770), *Orthetrum pruinosum* (Burmeister, 1839), and *Diplacodes trivialis* (Rambur, 1842) are commonly seen sitting on the ground or on twigs very close to the ground. On the other hand, *Potamarcha congener* (Rambur, 1842) and *Cratilla lineata* Foerster, 1903 are mostly found perched on electrical fixtures. Some dragonflies, such as *Zyxomma petiolatum* Rambur, 1842, *Macrodiplax cora* (Brauer, 1867), and *Tholymis tillarga* (Fabricius, 1798), frequently visit lights at night.

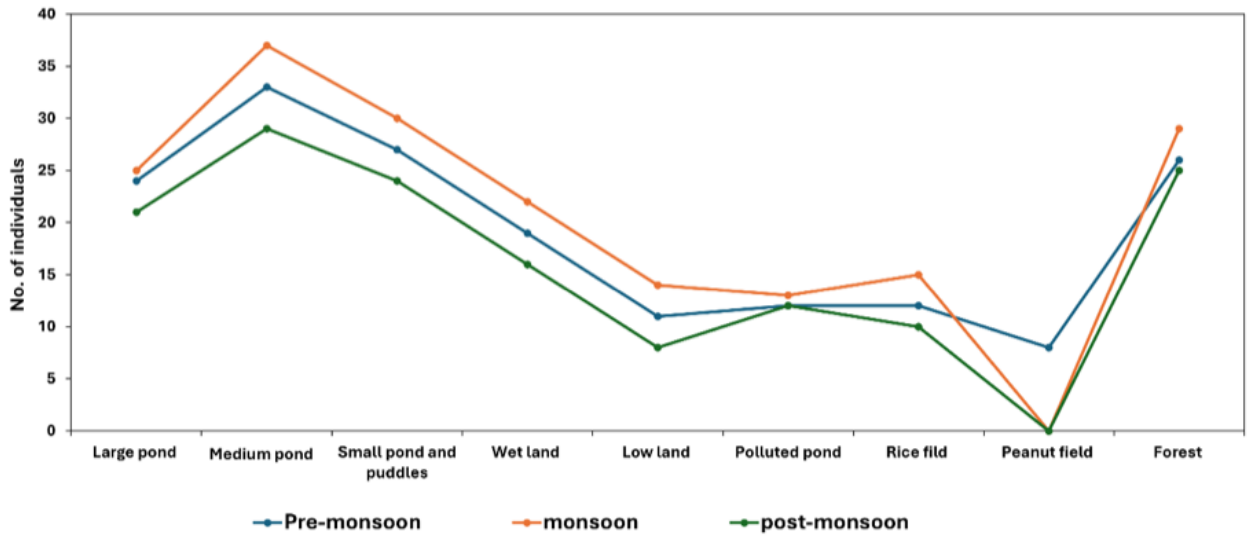

Image 7. Habitat wise graphical representation of seasonal fluctuation of Odonata species.

Table 3. List of Odonata in five different sized ponds.

	Egra	Pakarghat	Ponchetgarh	Kourda	Kudi
Pond size	Large	Medium	Medium	small	Medium
vegetation	very less vegetation with floating plant	maximum vegetation with emergent plant	no vegetation	maximum vegetation with floating leaves plant	maximum vegetation with free floating plant
DO	7 ppm	3.8 ppm	24 ppm	3 ppm	10 ppm
Co_2	6	28	3	23	10
Alkalinity	80 ppm	160 ppm	90 ppm	190 ppm	70 ppm
Brachythemis contaminata	71	3	28	5	5
Diplacodes trivialis	14	3	4	0	0
Orthetrum sabina	8	0	4	0	0
Crocothemis servilia	12	7	11	0	0
Ictinogomphus rapax	4	0	2	0	0
Agriocnemis pygmaea	30	4	0	10	18
Agriocnemis kalinga	21	1	0	2	4
Agriocnemis femina	17	1	0	0	11
Ceriagrion coromandelianum	32	27	3	13	13
Ischnura senegalensis	48	0	5	0	0
Ischnura rubilio	13	0	1	0	0
Pseudagrion rubriceps	37	0	4	0	0
Rhyothemis variegata	0	7	0	0	4
Brachydiplax sobrina	0	13	0	3	5
Brachydiplax chalybea	0	5	0	6	0
Acisoma panorpoides	0	45	0	7	4
Aethriamanta brevipennis	0	7	0	0	4
Ceriagrion cerinorubellum	0	3	0	6	0
Tramea limbata	0	0	3	0	0
Trithemis pallidinervis	0	0	7	0	0
Rhodothemis rufa	0	0	0	2	25
Urothemis signata	0	0	0	0	22
Tholymis tillarga	0	0	0	0	4
Onychargia atrocyana	0	0	0	0	8

Damselflies such as *Agriocnemis pygmaea* (Rambur, 1842), *Agriocnemis lacteola* Selys, 1877, and *Ischnura aurora* (Brauer, 1865) were commonly found in fields with small grasses. Species like *Copera ciliata* (Selys, 1863) and *Copera marginipes* (Rambur, 1842) were restricted to shaded bushes or ponds. *Ceriagrion coromandelianum* (Fabricius, 1798), *Onychargia atrocyana* (Selys, 1865), and *Ischnura senegalensis* (Rambur, 1842) were sometimes seen visiting forests or gardens away from water, but *Pseudagrion decorum*, *Pseudagrion microcephalum* (Rambur, 1842), *Pseudagrion rubiceps* (Selys, 1876), and *Paracercion malayanum* (Selys, 1876) were typically confined near water bodies. These damselflies were observed flying over more or less clear water with some water lilies or other submerged vegetation. They were often seen perched on twigs, flowers, or floating leaves of these plants. A few species, namely, *Ceriagrion cerinorubellum* (Brauer, 1865) and *Agriocnemis femina* (Brauer, 1868), were mainly found near ponds covered with water hyacinths.

Habitat preferences differed markedly within the Libellulidae. *Rhodothemis rufa* preferred large open ponds, while *Brachydiplax sobrina* and *Acisoma panorpoides* were associated with well-vegetated ponds. *Neurothemis fulvia* preferred shaded forest interiors,

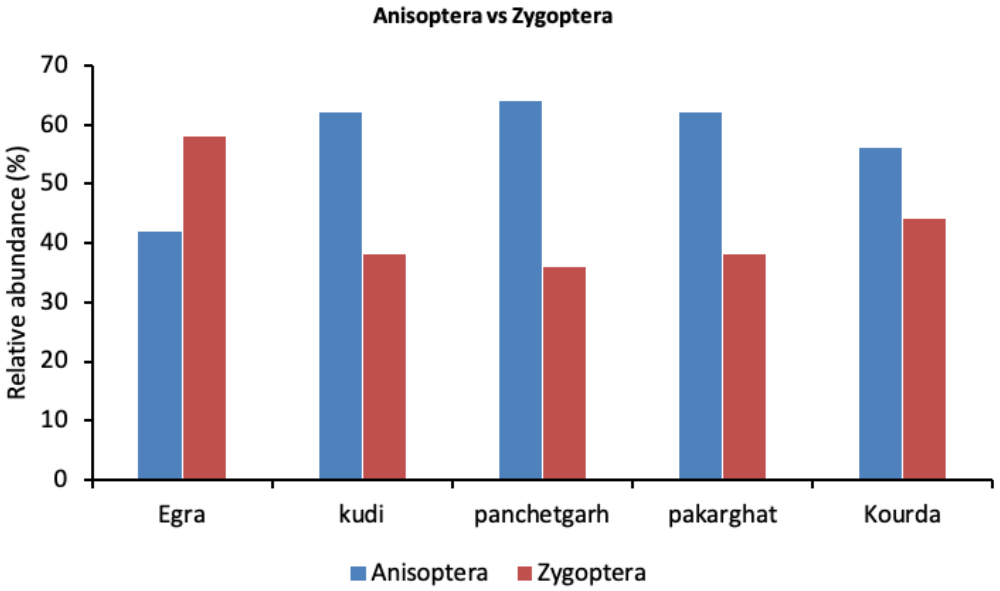

Image 8. Suborder-wise relative abundance of Odonata at the five study ponds. Y-axis—relative abundance (% of individuals recorded at each pond) | X-axis—study pond.

whereas *Brachythemis contaminata* preferred open ponds without vegetation; within the narrow range of values recorded here, the measured water parameters did not appear to be a significant factor influencing their abundance. The Gomphidae (*Ictinogomphus rapax*, *Macrogomphus annulatus*, and *Paragomphus lineatus*) were confined to the margins of large perennial ponds and canals. The crepuscular species were most active at dusk, when they largely avoided overlap with the diurnally active and frequently encountered species, namely *Agriocnemis pygmaea*, *Agriocnemis kalinga*, *Ceriagrion coromandelianum*, & *Ischnura senegalensis* among the Zygoptera and *Acisoma panorpoides*, *Brachythemis contaminata*, *Diplacodes trivialis*, *Orthetrum sabina*, & *Crocothemis servilia* among the Anisoptera. Conversely, *Disparoneura quadrimaculata* among the Zygoptera and *Gynacantha dravida* & *Lathrecista asiatica* among the Anisoptera were very rare in field observations. Of the 60 taxa recorded, 10 (16.7%) were very common, 19 (31.7%) common, eight (13.3%) occasional, 15 (25.0%) rare, and seven (11.7%) very rare; the local status of *Agriocnemis femina* remains to be assigned. According to the IUCN Red List, 55 of the recorded species are assessed as 'Least Concern', three as 'Data Deficient', and one as 'Not Evaluated', while the unidentified *Agriocnemis* sp. cannot be assessed.

CONCLUSION

The present study area, located along the coastal influenced area of southern Purba Medinipur, is supplied with water through small canals, reservoirs, and a good number of ponds and lakes. These water bodies serve as excellent breeding grounds for aquatic and semi-aquatic insects, including Odonata. The study reveals significant differences in the distribution of odonatan species among different types of habitats within the study area. During the course of this study, it became evident that several species previously reported from this region were not recorded, and some species were only rarely observed throughout the study period. The aquatic ecosystem used for pisciculture showed a noticeable decline in odonatan diversity due to habitat modifications such as the clearing of aquatic vegetation and other associated anthropogenic pressures. Pesticides were directly applied to submerged crop fields to control pest insects, leading to insecticide effluent entering adjacent water bodies, posing a serious threat to the aquatic fauna across the region. Further taxonomic and ecological studies on Odonata in this region may unveil additional interesting information. Some prior work has been conducted in Purba Medinipur, but this study represents the updated record checklist from the coastal influenced areas of the district and reports the zygopteran *Disparoneura quadrimaculata* (Platycnemididae) for the first time from Purba Medinipur District. This record extends the

Image 9. A—*Anax guttatus* | B—*Anaciaeschna jaspidea* | C—*Gynacantha* sp. | D—*Gynacantha dravida* | E—*Ictinogomphus rapax* | F—*Macrogomphus annulatus* | G—*Paragomphus lineatus* | H—*Acisoma panorpoides* (Male) | I—*Acisoma panorpoides* (Female) | J—*Aethriamanta brevipennis* | K—*Brachydiplax chalybea* | L—*Brachydiplax sobrina* (Male) | M—*Brachydiplax sobrina* (Female) | N—*Brachythemis contaminata* (Male) | O—*Brachythemis contaminata* (Female) | P—*Bradinopyga geminata*. © Suvabrata Khatua.

known distribution of the species within southern West Bengal; it is a range extension of a previously described species and not a new taxon. This finding underscores the need for more extensive research to develop an updated checklist for Purba Medinipur. Odonata species in the area display activity patterns influenced by various times of the day and temperature conditions. Therefore, careful observation of photoperiodicity and additional experiments are necessary to better understand their behaviour.

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Image 10. A—*Crocothemis servilia* (Male) | B—*Crocothemis servilia* (Female) | C—*Diplacodes trivialis* (Male) | D—*Diplacodes trivialis* (Female) | E—*Lathrecista asiatica* | F—*Macrodiplax cora* | G—*Neurothemis fulvia* (Male) | H—*Neurothemis fulvia* (Female) | I—*Neurothemis tullia* (Male) | J—*Neurothemis tullia* (Female) | K—*Orthetrum luzonicum* | L—*Orthetrum pruinosum* | M—*Orthetrum sabina* | N—*Pantala flavescens* | O—*Potamarcha congener* | P—*Rhodothemis rufa*. © Suvabrata Khatua.

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Image 11. A—*Rhyothemis variegata* (Male) | B—*Tramea basilaris* | C—*Tramea limbata* | D—*Trithemis aurora* | E—*Trithemis pallidinervis* | F—*Tholymis tillarga* (Male) | G—*Urothemis signata* (Male) | H—*Urothemis signata* (Female) | I—*Zyxomma petiolatum* (Male) | J—*Zyxomma petiolatum* (Female) | K—Copula of *Epophthalmia vittata* | L—*Agriocnemis kalinga* (Male) | M—*Agriocnemis kalinga* (Female) | N—*Agriocnemis lacteola* | O—*Agriocnemis pygmaea* | P—*Ceriagrion cerinorubellum*. © Suvabrata Khatua.

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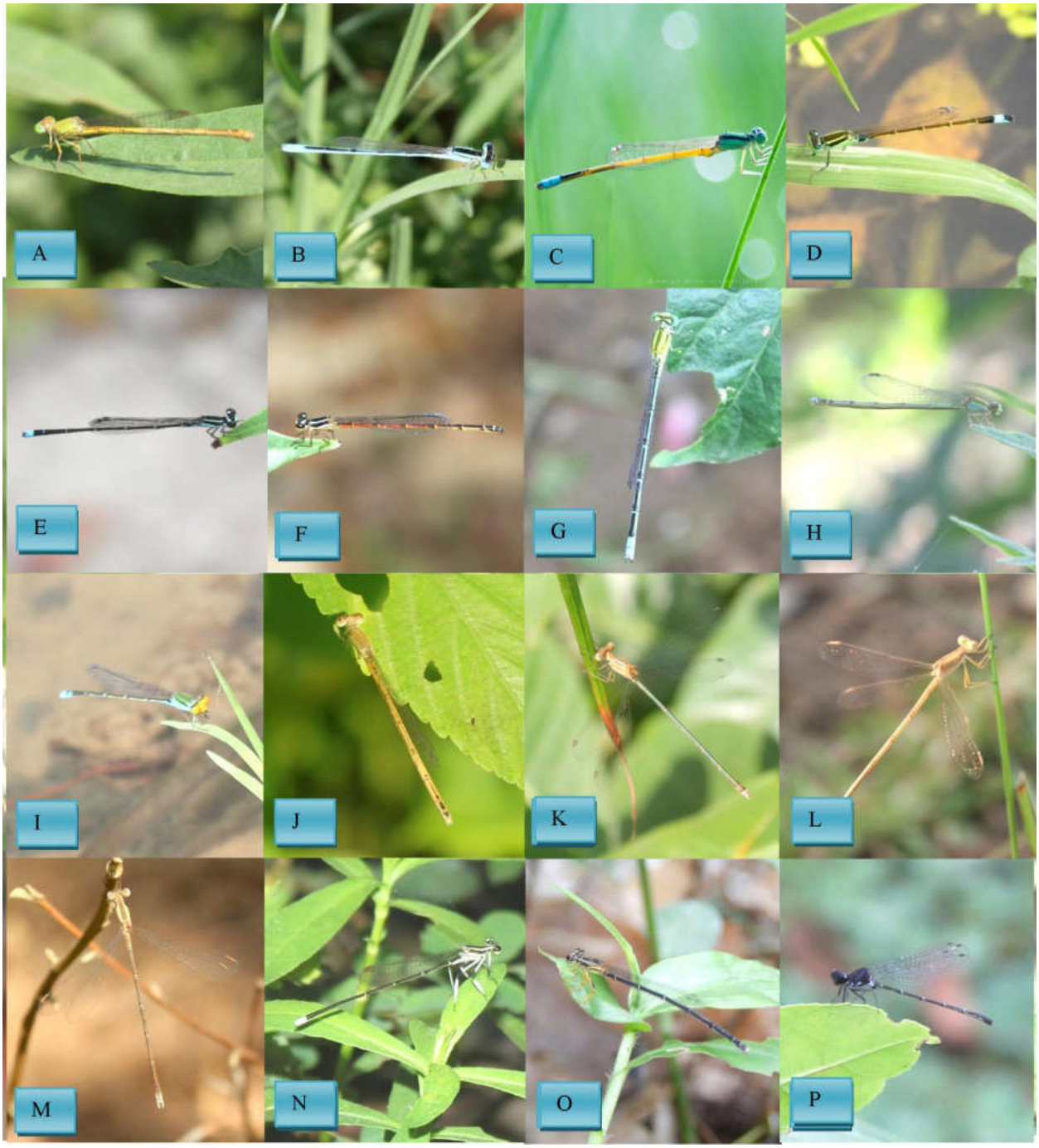

Image 12. A—*Ceriagrion coromandelianum* | B—*Amphiallagma parvum* | C—*Ischnura aurora* | D—*Ischnura senegalensis* | E—*Mortonagrion aborense* (Male) | F—*Mortonagrion aborense* (Female) | G—*Pseudagrion decorum* | H—*Pseudagrion microcephalum* | I—*Pseudagrion rubriceps* | J—*Pseudagrion spencei* | K—*Lestes elatus* | L—*Lestes umbrinus* | M—*Lestes viridulus* | N—*Pseudocopera ciliata* | O—*Copera marginipes* | P—*Onychargia atrocyana*. © Suvabrata Khatua.

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