

Seasonal variation of odonatan diversity in Mahamaya Reserve Forest, Kokrajhar District, Assam, India

Golphina Ahmed¹, Arup Nama Das^{1*}, Sudipta Nag¹ and Rezina Ahmed²

¹Department of Zoology, University of Science and Technology Meghalaya, Baridua, Ri-Bhoi-793101, India

²Department of Zoology, Rabindranath Tagore University, Hojai-782435, Assam, India

*Corresponding authors ✉: arupn8@gmail.com

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Abstract

The present study on the diversity of Odonata (Insecta) of Mahamaya Reserve Forest, Kokrajhar, Assam, India, documents 53 species from meadows, ponds, and forest ecosystems and agricultural fields nearby the reserve forest from April 2021 to August 2022. Of this biodiversity 33 species belong to the suborder Anisoptera, including 3 families and 24 genera, and 20 species belong to the suborder Zygoptera, which includes 4 families and 12 genera. The family Libellulidae was the most diverse in the Anisoptera with the 25 species and the family Coenagrionidae, in the Zygoptera was richest with 15 species. Five species of Odonata including *Gynacantha dravida*, *Gynacantha subinterrupta*, *Anax guttatus*, *Hemianax ephippiger*, and *Lestes praemorsus* were recorded for the first time from this area.

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Introduction

The ancient insect order Odonata - collectively dragonflies and damselflies - are one of the most common diurnal and active predatory insects flying and soaring over forest, cultivated fields, meadows, ponds and rivers. Odonatans are amphibious with the adults being terrestrial and the larvae aquatic. The majorities of the known species are highly specific to their habitats and are ideal models for the investigation of the impact of environmental warming and climate change, due to their tropical evolutionary history and adaptation to temperate climates (Smith et al., 2007; Silva et al., 2010). They are also known as excellent bio-indicators and are one of the flagship species in insect communities which indirectly influence the trophic levels of an ecosystem. They also play an important role in predator-prey dynamics in natural ecosystems (Das et al., 2012) and are used as food and medicinal resources by humans on a local scale (Kalkman et al., 2008; Shantibala et al., 2012). Globally, there are 5740 species of Odonata and 470 species in 139 genera across 19 families exist in India (Subramanian, 2009). Odonatan diversity is well-known

in Central India and studies on Odonatan fauna of the eastern region of the country have been done by various workers. For example, Nair (2011) reported 101 species from Odisha and Eastern India and the Manchabandha Reserve Forest, Baripada, Odisha has a total of 48 Odonatan species in 34 genera across 8 families (Kalita et al., 2014). Lahiri (1979) reported a total of 33 Odonatan species from Assam, Arunachal Pradesh, Manipur, and Mizoram from Northeast India and Mitra (1999) described the geographical distribution and zoogeography of 148 species from the state of Meghalaya. Historically, Laidlaw (1914) described 20 species of Odonata from Assam and Burma and Fraser (1936) reported *Brachybiplax chalybea*, a dragonfly species from Assam. A concrete study on the diversity and distribution of Odonata has not been carried out previously in the state of Assam. More studies are needed to assess the accurate diversity of Odonata in the entirety of Assam, India. In the present study, an initiative was taken to assess the diversity of Odonatan species in the Mahamaya Reserve Forest, Kokrajhar, Assam, India.

Material and Methods

Description of the site

The present study was carried out in the Mahamaya Reserve Forest in Kokrajhar district of Assam. The total area of these forests is about 9914 hectares which extends from 26°18'50" to 26°40'14" N latitude and from 90°06'44" to 90°26'67" E longitude and with an elevation ranging from 45-50 meters above sea level. The Kokrajhar district is surrounded by the Bhutan-Himalayan region in the north, the plains of the southern part of the Dhubri district and Brahmaputra river basin in the south, eastern part of the Chirang and Bongaigaon district in the east and West Bengal on the west (Fig. 1). The topography of the Kokrajhar district varies from low lying plains to highlands with small hillocks. The river Brahmaputra and the tributaries, Tipkai and Gaurang, are the main river systems of the district. Moreover, there are a large number of wetlands, *beels* (Lake), ponds which are all habitats for odonatan and other aquatic organisms. The climate of the region is the tropical monsoon type; with the summer season from March to July, the rainy season from June to September and the cool winter from October to February.

Sampling and identification

The visual survey of odonatan was carried out from April 2021 to August 2022, randomly between 9 AM and 11 AM and from 4 PM to 6 PM on sunny days (total of 64 days). Survey was carried out over water bodies, open fields, open tracts of land and in forest areas. Specimens were photographed with mobile phones and in some cases the specimens were captured by using an insect net, photographed and then released. No odonatan specimens were killed or permanently collected during the survey.

The Odonata were identified down to the species level using standard taxonomic literature: Fraser (1933, 1934), Subramanian (2005, 2009, 2014), Andrew et al. (2008) and Kalita et al. (2014) and the internet. The conservation status of the various dragonfly species was determined based on the International Union for the Conservation of Nature (IUCN) red list of threatened species version 2020.3.1 (IUCN, 2020). Scientific names, including authors, were determined by using Odonata of India (2022) and India Biodiversity Portal (2022). Also, determination of species diversity indices was using PAST V4.

Seasonal variation

The climate of the districts of Northeast India experiences four seasons (Borthakur, 1986):

1. Pre-monsoon: Pre-monsoon begins in the early part of March and continues to the end of May. Temperatures start rising from the beginning of this season onwards.
2. Monsoon: The monsoon sets in during the last week of May or in early June and it lasts until September or the first part of October. It is the rainy

season when the state receives spells of continuous, moderate to heavy rains.

3. Post-monsoon: The southwest monsoon withdraws sometime in the last part of September and first part of October, with rainfall decreasing in this season.

4. Winter: The winter season begins in the middle of November and continues to the end of February.

Results

During the monsoon odonatan were abundant over water bodies, flooded crop fields, grasslands and swamps. The recording of 53 species of odonatan from the study region indicates that the region has high dragonfly and damselfly diversity. Out of 53 species of odonatan, 33 species of dragonflies, belonging to 3 families and 24 genera and 20 species of damselflies, belonging to 4 families and 12 genera were identified in the present study. Table 1 shows the complete list of species with their IUCN status and Table 3 shows the percentage of all families and number of genera and species. Libellulidae and Coenagrionidae were the most abundant families to be found in almost every habitat of the reserve forest. The number of species recorded from individual families was: Libellulidae 25 (47.2%), Coenagrionidae 15 (28.3%), Gomphidae 4 (7.5%), Aeshnidae 4 (7.5%), Chlorocyphidae 2 (3.8%), Platycnemididae 2 (3.8%), and Lestidae 1 (1.9%). There are 5 species recorded for the first time from the study area. These are *Gynacantha darvida* which was found earlier in Bhutan, Bangladesh and Maharashtra, Tripura, West Bengal, and Manipur, but was not recorded earlier from any region of Assam. *Gynacantha subinterrupta* was found only in the pre-monsoon and monsoon period for the first time in the study area, but earlier it was found in West Bengal, Tripura and Nagaland. Two individuals of *Anax guttatus*, *Hemianax ephippiger* were observed for the first time in the study area and the damselfly *Lestes praemorsus* was observed near waterbodies in the study area for the first time but was previously recorded earlier in Meghalaya, Nagaland, and Manipur from the northeastern side. Northeastern India is one of the biodiversity hotspots zones of the country and forms good habitat for both Lepidoptera and Odonata.

In the present investigation, a study of Odonata of Mahamaya Reserve Forest, Kokrajhar district showed a richer diversity of dragonflies as compared to damselflies. The diversity and abundance of *Crocothemis servilia*, *Diplacodes nebulosa*, and *Gynacantha dravida*, were mostly reported in the monsoon season but were also found in the pre-monsoon period, but *Anax guttatus* was only found in the monsoon season. However, some dragonfly species, such as *Brachythemis contaminata*, *Neurothemis tullia*, *Rhyothemis variegata*, *Acisoma panorpoides* and *Ortherum sabina* were found in almost every season (Table 2). Mann-Whitney Pair wise analysis shows the highest similarity between pre-monsoon and post-monsoon seasons (Table 4) and the highest diversity, as measured by several indices, was found during the monsoon season (Table 5). The dominance indexes, and some other diversity indices, were highest during the post-monsoon season (Table 5).

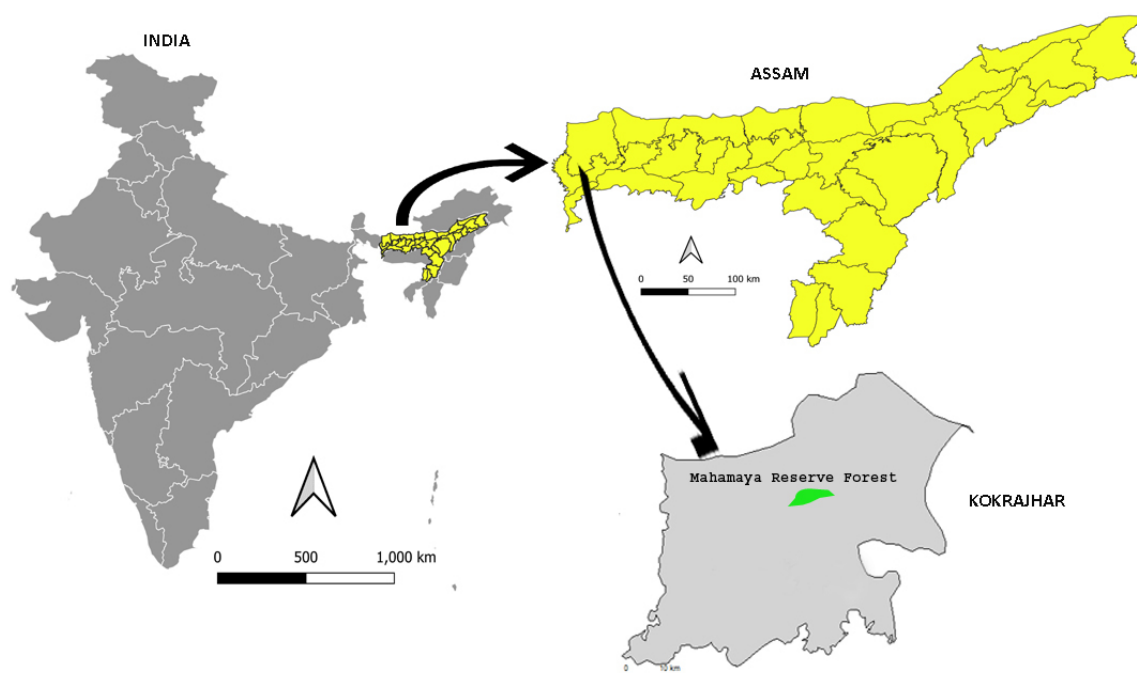


Figure 1: The map of the Mahamaya Reserve Forest, Kokrajhar, Assam, India (Source: Google Earth Pro).

Discussion

The recording of 53 species (Table 1) in the study region demonstrates the ecological richness of the area, with a significant presence of both dragonflies and damselflies. The findings indicate a healthy ecosystem that supports a wide range of odonatan species, suggesting the availability of suitable breeding and foraging habitats. Among dragonflies (suborder Anisoptera), the family Libellulidae dominates, featuring common species like *Brachydiplax farinosa*, *Neurothemis tullia* and *Orthetrum sabina* all of which are designated Least Concern (LC) status. Other dragonfly families, such as Gomphidae and Aeshnidae, include species like *Ictinogomphus decoratus* and *Gynacantha dravida*, with the latter being designated as Data Deficient (DD), highlighting the need for further study. For damselflies (suborder Zygoptera), the family Coenagrionidae is predominant, featuring species such as *Ceriagrion cerinorubellum* and *Pseudagrion microcephalum*. Other damselfly families, including Platynemididae, Chlorocyphidae, and Lestidae, also contribute to the region's diversity, with species like *Onychargia atrocyana* and *Lestes praemorsus* recorded. The recording of five species for the first time in the study area is particularly noteworthy, as it expands the known distribution of these species and contributes to the broader understanding of odonatan biodiversity.

One significant finding is the first-time recording of *Gynacantha dravida* in Assam. Previously known from Bhutan, Bangladesh and in Indian states like Maharashtra, Tripura, West Bengal, and Manipur, its

presence in Assam suggests either an expansion of its range or a lack of prior documentation in the state. This discovery emphasizes the importance of continued biodiversity surveys to update species distribution records and inform conservation strategies.

The abundance and diversity of odonatans found higher during the monsoon season across various aquatic and semi-aquatic habitats, including waterbodies, flooded crop fields, grasslands. These findings highlight the presence of niche-specific species that may require specialized conservation approaches. Harisha (2016) also observed similar types of composition of odonatans in Kondajji Lake, Karnataka, India.

The seasonal abundance data for odonatan species provides valuable insights into their population dynamics and habitat preferences across different climatic conditions. Table 2 presents variation in species counts across the monsoon, post-monsoon, winter, and pre-monsoon seasons, highlighting the adaptability and differing ecological roles of these species of Odonata. Similar seasonal distribution patterns of Odonata was observed by Manwar et al. (2016) at Sawanga-Vithoba lake in India. In this study the highest number of individuals was recorded during the monsoon season, indicating that odonatans thrive in the presence of abundant water sources, which provide ideal breeding and foraging grounds. Notably, species like *Orthetrum sabina* (129), *Neurothemis tullia* (102 males, 95 females), and *Neurothemis fluvia* (71 males, 75 females) showed peak abundance, suggesting a preference for warm and wet conditions.

Table 1: List of dragonfly and damselfly species from the Mahamaya Reserve Forest, Kokrajhar, Assam, India with their common name and latest IUCN conservation status.

Suborder	Family	Sl. No.	Scientific name	Common name	IUCN status
Anisoptera	Libellulidae	1	<i>Brachydiplax farinosa</i> Kruger, 1902 Male	Black-tailed dasher	LC
		2	<i>Neurothemis tullia</i> (Drury, 1773)	Pied paddy skimmer	LC
		3	<i>Orthetrum sabina</i> (Drury, 1770) Male	Green marsh hawk	LC
		4	<i>Brachythemis contaminata</i> Fabricius, 1793	Ditch jewel	LC
		5	<i>Neurothemis fluvia</i> Drury, 1773	Fulvous forest skimmer	LC
		6	<i>Rhyothemis variegata</i> (Linnaeus, 1763)	Common picture wing	LC
		7	<i>Acisoma panorpoides</i> Rambur, 1842	Asian pin-tail	LC
		8	<i>Potamarcha congener</i> Rambur, 1842	Common chaser	LC
		9	<i>Urothemis signata</i> Rambur, 1842	Scarlet basker	LC
		10	<i>Crocothemis servilia</i> (Drury, 1773)	Ruddy marsh skimmer	LC
		11	<i>Diplacodes nebulosa</i> (Fabricius, 1793)	Black tipped ground skimmer	LC
		12	<i>Brachydiplax chalybea</i> Brauer, 1868	Blue dasher	LC
		13	<i>Diplacodes trivialis</i> Rambur, 1842	Ground skimmer	LC
		14	<i>Tramea basilaris</i> (Palisot de Beauvois, 1817)	Wheeling glider	LC
		15	<i>Pantala flavescens</i> Fabricius, 1798	Globe skimmer	LC
		16	<i>Mycrathyria aequalis</i> (Hagen, 1861)	Spot Tail dasher	LC
		17	<i>Bradinyopyga geminata</i> Rambur, 1842	Granite ghost	LC
		18	<i>Zyxomma petiolatum</i> Rambur, 1842	Brown dusk hawk	LC
		19	<i>Trithemis pallidinervis</i> (Kirby, 1889)	Dancing drop-wing	LC
		20	<i>Aethriamanta brevipennis</i> Rambur, 1842	Scarlet marsh hawk	LC
		21	<i>Tholymis tillarga</i> (Fabricius, 1798)	Coral tailed cloud-wing	LC
		22	<i>Trithemis aurora</i> Brumeister, 1839	Crimson marsh glider	LC
		23	<i>Palpopleura sexmaculata</i> Fabricius, 1787	-	LC
		24	<i>Orthetrum testaceum</i> Brumeister, 1839	Orange skimmer	LC
		25	<i>Trithemis festiva</i> Rambur, 1842	Black stream glider	LC
	26	<i>Ictinogomphus decoratus</i> Cowley, 1934	Common club-tail	LC	
	27	<i>Progomphus obscurus</i> (Rambur, 1842)	Common sand-dragon	LC	
	28	<i>Ictinogomphus rapax</i> Rambur, 1842	Indian common club-tail	LC	
	29	<i>Platygomphus dolabratus</i> Selys, 1854	-	LC	
	30	<i>Gynacantha dravida</i> Lieftinck, 1960	Brown darner	DD	
	31	<i>Anax guttatus</i> Brumeister, 1839	Lesser green emperor	LC	
	32	<i>Gynacantha subinterrupta</i> Rambur, 1842	Two-spined darners	LC	
	33	<i>Hemianax ephippiger</i> Brumeister, 1839	Yellow emperor	LC	
	34	<i>Ceriagrion cerinorubellum</i> Brauer, 1865	Orange-tailed marsh dart	LC	
	35	<i>Ceriagrion coromandelianum</i> Fabricius, 1798	Coromandel marsh dart	LC	
	36	<i>Ischnura rufostigma</i> Selys, 1876	Forktail	LC	
	37	<i>Pseudagrion microcephalum</i> Rambur, 1842	Blue river damsel	LC	
	38	<i>Agriocnemis pygmaea</i> Rambur, 1842	Pygmy dartlet	LC	
	39	<i>Ceriagrion chromothorax</i> Joshi and Sawant, 2019	Sindhudurg marsh dart	LC	
	40	<i>Agriocnemis lecteola</i> Selys, 1877	Milky dartlet	LC	
	41	<i>Ischnura aurora</i> (Brauer, 1865)	Golden dartlet	LC	
	42	<i>Agriocnemis femina</i> (Brauer, 1868)	Pinhead wisp	LC	
	43	<i>Aciagrion hisopa</i> Selys, 1876	-	LC	
	44	<i>Aciagrion pallidum</i> Selys, 1891	Pale slender dartlet	LC	
	45	<i>Ischnura forcipate</i> Morton, 1907	Forktail	LC	
	46	<i>Mortonagrion aborensis</i> Laidlaw, 1914	-	LC	
	47	<i>Pseudagrion rubriceps</i> Selys, 1876	Saffron-faced blue dart	LC	
	48	<i>Ceriagrion olivaceum</i> Laidlaw, 1914	Rusty marsh dart	LC	
	49	<i>Onychargia atrocyana</i> Selys, 1865	Black marsh dart	LC	
	50	<i>Copera marginipes</i> Rambur, 1842	Yellow bush dart	LC	
	51	<i>Libellago lineata</i> Burmeister, 1839	River heliodor	LC	
	52	<i>Libellago indica</i> Fraser, 1928	-	LC	
53	<i>Lestes praemorsus</i> Hagen and Selys, 1862	Scalloped spread wing	LC		

IUCN Category: LC - Least Concern, DD - Data Deficient, Sl. No. - Serial Number.

Table 2: Odonata abundance in different seasons in Mahamaya Reserve Forest, Kokrajhar, Assam, India.

Sl. No.	Species name	Pre-Monsoon	Monsoon	Post-monsoon	Winter
1	<i>Brachydiplax farinosa</i>	21	25	12	10
2	<i>Neurothemis tullia</i> (Male)	46	102	60	38
	<i>Neurothemis tullia</i> (Female)	70	95	75	40
3	<i>Orthetrum sabina</i>	78	129	62	52
4	<i>Brachythemis contaminata</i>	35	46	28	15
5	<i>Neurothemis fluvia</i> (Male)	52	71	12	25
	<i>Neurothemis fluvia</i> (Female)	48	75	8	13
6	<i>Rhyothemis variegata</i> (Male)	12	56	13	25
	<i>Rhyothemis variegata</i> (Female)	22	45	10	29
7	<i>Acisoma panorpoides</i> (Male)	12	15	26	25
	<i>Acisoma panorpoides</i> (Female)	18	25	28	10
8	<i>Potamarcha congener</i> (Male)	25	30	24	11
	<i>Potamarcha congener</i> (Female)	18	26	20	14
9	<i>Urothemis signata</i>	20	15	25	2
10	<i>Crocothemis servilia</i>	28	24	24	8
11	<i>Diplacodes nebulosa</i>	35	21	20	24
12	<i>Brachydiplax chalybea</i>	25	28	3	08
13	<i>Diplacodes trivialis</i>	15	19	3	06
14	<i>Tramea basilaris</i>	25	18	8	04
15	<i>Pantala flavescens</i>	16	26	7	18
16	<i>Mycrathyria aequalis</i>	10	15	9	8
17	<i>Bradynopyga geminata</i>	8	15	9	02
18	<i>Zyxomma petiolatum</i>	9	14	25	03
19	<i>Trithemis pallidinervis</i>	14	19	07	11
20	<i>Aethiamanta brevipennis</i>	05	11	10	03
21	<i>Tholymis tillarga</i>	25	28	06	5
22	<i>Trithemis aurora</i>	02	8	2	3
23	<i>Palpopleura sexmaculata</i>	04	18	11	4
24	<i>Orthetrum testaceum</i>	0	2	8	0
25	<i>Trithemis festiva</i>	2	10	3	0
26	<i>Ictinogomphus decoratus</i>	1	0	1	0
27	<i>Progomphus obscurus</i>	0	1	0	1
28	<i>Ictinogomphus rapax</i>	1	1	1	0
29	<i>Platygomphus dolabratus</i>	4	10	3	5
30	<i>Gynacantha dravida</i>	1	5	0	0
31	<i>Anax guttatus</i>	0	3	0	0
32	<i>Gynacantha subinterrupta</i>	1	2	0	0
33	<i>Hemianax ephippiger</i>	0	5	2	1
34	<i>Ceriagrion cerinorubellum</i>	7	12	4	20
35	<i>Ceriagrion coromandelianum</i>	0	7	1	2
36	<i>Ischnura rufostigma</i> (Male)	3	10	8	2
	<i>Ischnura rufostigma</i> (Female)	6	11	1	0
37	<i>Pseudagrion microcephalum</i>	7	10	0	0
38	<i>Agriocnemis pygmaea</i>	8	10	3	5
39	<i>Ceriagrion chromothorax</i>	9	11	4	4
40	<i>Agriocnemis lecteola</i>	0	8	2	02
41	<i>Ischnura aurora</i>	2	4	1	0
42	<i>Agriocnemis femina</i>	3	6	3	1
43	<i>Aciagrion hisopa</i>	2	12	2	3
44	<i>Aciagrion pallidum</i>	1	2	2	0
45	<i>Ischnura forcipata</i>	0	10	12	09
46	<i>Mortonagrion aborense</i>	5	6	3	02
47	<i>Pseudagrion rubriceps</i>	2	5	5	0
48	<i>Ceriagrion olivaceum</i>	2	5	1	1
49	<i>Onychargia atrocyana</i> (Male)	3	6	0	0
	<i>Onychargia atrocyana</i> (Female)	0	3	0	1
50	<i>Copera marginipes</i>	1	2	2	0
51	<i>Libellago lineata</i>	1	0	1	0
52	<i>Libellago indica</i>	1	1	0	1
53	<i>Lestes praemorsus</i>	1	3	1	1

Table 3: Showing the total number of genera and species in different families of Odonata in the Mahamaya Reserve Forest, Kokrajhar, Assam, India.

Sub-order	Family	Genera	Species	Total
Anisoptera	Libellulidae	18	25	33
	Gomphidae	3	4	
	Aeshnidae	3	4	
Zygoptera	Coenagrionidae	8	15	20
	Platycnemididae	2	2	
	Chlorocyphidae	1	2	
	Lestidae	1	1	

Table 4: Similarity of seasonal variation of Odonata diversity (MANN Whitney Pairwise) in the Mahamaya Reserve Forest, Kokrajhar, Assam, India.

Seasons	Pre-monsoon	Monsoon	Post-monsoon	Winter
Pre-monsoon		0.01618	0.5929*	0.09483
Monsoon	0.01618		0.001169	3.01E-05*
Post-monsoon	0.5929*	0.001169		0.2413
Winter	0.09483	3.01E-05*	0.2413	

* - Significant

Table 5: Odonata diversity indices by season for the Mahamaya Reserve Forest, Kokrajhar, Assam, India during the study period.

Diversity indices	Pre-monsoon	Monsoon	Post-monsoon	Winter
Taxa_S	52	58	52	45
Individuals	772	1202	621	477
Dominance_D	0.046	0.044	0.052	0.050
Simpson_1-D	0.954	0.956	0.948	0.950
Shannon_H	3.378	3.502	3.340	3.293
Brillouin	3.254	3.403	3.193	3.130
Menhinick	1.872	1.673	2.087	2.060
Margalef	7.670	8.038	7.930	7.134
Fisher_alpha	12.580	12.720	13.510	12.190
Berger-Parker	0.101	0.107	0.121	0.109

After the monsoon, odonatan populations showed a decline, likely due to habitat changes such as receding water levels and reduced prey availability. Species like *Neurothemis tullia* (males: 60, females: 75) and *Orthetrum sabina* (62) still maintained moderate numbers, indicating their resilience to seasonal changes. Winter saw a significant reduction in odonatan populations, with some species completely absent, or recorded in very low numbers. Many species, including *Ictinogomphus decoratus*, *Progomphus obscurus*, and *Gynacantha dravida*, were either completely absent or recorded only once. This suggests that colder temperatures and reduced water availability negatively impact odonatan numbers and diversity (Table 2 and 5). As the pre-monsoon period approaches, certain species showed a resurgence in numbers, possibly due to rising temperatures and improved aquatic habitat conditions. Species like *Neurothemis tullia* (males: 46, females: 70) and *Orthetrum sabina* (78) showed a steady recovery, reinforcing the importance of environmental cues in odonatan population cycles.

Family Libellulidae dominates across all seasons, with high numbers in the monsoon with a gradual reduction afterwards. Gomphidae and Aeshnidae presented low numbers throughout the year, indicating their more specialized habitat preferences (Table 3). Coenagrionidae exhibits fluctuating numbers, with a few species maintaining a presence across all seasons. This study had similar observations on species richness as observed in Miya et al. (2021) in Tanahun district of Nepal. *Orthetrum testaceum* and *Trithemis festiva* showed very low occurrences, indicating a more restricted distribution or sensitivity to environmental changes. *Pantala flavescens*, known for its migratory behavior, had fluctuating numbers across the seasons, reflecting its annual movement patterns. Species such as *Ceriagrion cerinorubellum* and *Ischnura rufostigma* showed moderate adaptability across seasons, maintaining low, but consistent, populations.

Table 4 presents the results of a Mann-Whitney pairwise test, which compares Odonata diversity across the four seasons: Pre-monsoon, Monsoon, Post-monsoon, and Winter. The *p*-values indicate the statistical significance of differences in species diversity between these seasons. Monsoon is the most favorable season for Odonata diversity, with a sharp decline in winter. Pre-monsoon and post-monsoon show similar diversity levels, but winter always shows a decline. Post-monsoon diversity is closer to winter than monsoon, showing that diversity starts decreasing significantly after the monsoon season.

Monsoon is the most favorable season for odonatan diversity and for population size, while winter is the least favorable for both. The highest number of species (S) was recorded in the monsoon (58), followed by pre-monsoon (52) and post-monsoon (52). The monsoon has the most balanced species distribution, whereas post-monsoon shows a slight increase in dominance by certain species. Simpson's Index (1-D) is highest in the monsoon (0.956) and lowest in post-monsoon (0.948). The monsoon shows the highest diversity, while winter has the lowest. The Shannon-Wiener Index (H) is highest in the monsoon (3.502), indicating the highest diversity. The Menhinick Index is highest in post-monsoon (2.087) and lowest in monsoon (1.673). The Margalef Index is highest in the monsoon (8.038) and lowest in winter (7.134). The Fisher's Alpha Index is highest in the post-monsoon (13.510), indicating a greater species diversity relative to total individuals. The Berger-Parker Index, which measures the dominance of the most abundant species, is highest in the post-monsoon (0.121) and lowest in pre-monsoon (0.101) (Table 5). These diversity indices found similar to the diversity analysis of Roy et al. (2022) in the Bankura district of West Bengal, India. The monsoon season is the most favorable for odonatan diversity, with the highest species richness, species diversity, and species evenness. The post-monsoon maintains species diversity but there is an increase in dominance by certain species. Winter has the lowest species diversity and species count, making it a critical period for conservation efforts.

Conclusion

Although Mahamaya Reserve Forest has a huge diversity of Odonata, the gradual increase in human pressure in and around open fields and water bodies is affecting the sustainability of these insects. It is important to monitor the abundance of these species and their richness in the reserve forest. As these insects are indicators of biodiversity, they play a significant role in presenting the ecological status of a given area. Future studies should focus on the impact of habitat changes, water quality, and climate variability on odonatan populations to ensure their long-term sustainability and conservation. The seasonal variation in odonatan populations highlights the necessity for sustained habitat conservation, especially during critical breeding seasons. Further studies should focus on factors influencing population declines, such as water pollution, habitat destruction, and climate change.

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Author contributions

Golphina Ahmed: Conception and collection of data. Arup Nama Das: Designing, data analysis and revision of manuscript. Sudipta Nag and Rezina Ahmed: Literature review and revising the manuscript. All authors contributed equally in developing the final version of the manuscript.

Conflict of interest

The authors declare that there are no conflicting issues related to this research article.

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