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Odonata diversity as a bioindicator of habitat quality in an urban landscape: Insights from Tripura university campus, Northeast India

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Abstract
Odonates (dragonflies and damselflies) are widely recognised as ecological bioindicators due to their sensitivity to environmental conditions and habitat integrity. This study documents the diversity and community structure of Odonata within the semi-urban landscape of Tripura University campus, Northeast India, over a one-year period (April 2024-March 2025). A total of 33 species belonging to 25 genera and 5 families were recorded, comprising 23 species of Anisoptera and 10 of Zygoptera, representing 44% of the known odonate fauna of Tripura. The family *Libellulidae* was the most dominant, with *Rhyothemis variegata* identified as the only eudominant species. Diversity indices, the Shannon index (2.335) and the Simpson index (0.8288), indicated moderate to high diversity, whereas low evenness (0.3129) reflected community dominance by a few generalist species. The presence of both pollution-sensitive and pollution-tolerant taxa highlights habitat heterogeneity and potential anthropogenic impacts. Distribution patterns revealed a predominantly clumped assemblage, linked to habitat patchiness and resource concentration. The results underscore the ecological value of urban green spaces in sustaining odonate biodiversity and provide a baseline for long-term monitoring and regional conservation strategies.

Keywords: Odonata diversity, anisoptera, zygoptera, urban ecology, bioindicators, dragonflies, damselflies

Introduction
The class Insecta represents the most taxonomically diverse group of organisms on Earth, comprising an estimated 5.5 million species and accounting for approximately 75% of all described faunal taxa (Loxdale, 2016; Stork, 2018) [24, 37]. Insects contribute critically to ecosystem functioning through their roles in nutrient cycling, pollination, and trophic regulation, and are increasingly employed as biological indicators due to their sensitivity to environmental perturbations, rapid life cycles, and ease of sampling (Dangles & Casas, 2019; Chowdhury *et al*., 2023) [7, 6]. Among them, the order Odonata (comprising dragonflies and damselflies) is particularly well-suited for bioassessment owing to its dual reliance on aquatic and terrestrial habitats across larval and adult stages, making it highly responsive to changes in habitat integrity and water quality (de Oliveira-Junior *et al.*, 2015; Júnior *et al.*, 2015; Martín & Maynou, 2016) [9, 17, 28].

Odonates exhibit a cosmopolitan distribution and occupy a wide range of ecological habitats, including freshwater bodies, brackish wetlands, forest margins, marshes, and semi-arid zones (Kalkman *et al.*, 2008) [20]. At the global scale, approximately 6,463 species, representing 687 genera, have been described (Paulson *et al.*, 2025) [32]. Within South Asia, including India, Nepal, Bangladesh, Bhutan, Sri Lanka, and Pakistan, a total of 588 odonate taxa (including 559 valid species) have been documented (Kalkman *et al.*, 2020) [19]. India supports a rich odonate fauna, with 488 species, 154 genera, and 18 families (Subramanian & Babu, 2017) [38]. In the northeastern Indian state of Tripura, initial inventories recorded 37 species (Srivastava & Sinha, 2000) [36], which were later expanded by 25 species (Majumder *et al.*, 2014) [27]. The most recent checklist now includes 75 species across 49 genera comprising 28 genera under Anisoptera and 21 under Zygoptera, distributed among nine families (Datta *et al.*, 2023) [8].

Odonates serve as valuable proxies for assessing ecological health and habitat degradation, particularly in systems impacted by anthropogenic stressors such as pollution, urbanisation,

and land-use change (Yang *et al.*, 2017; Seidu *et al.*, 2018) [46, 34]. Their ecological versatility and trophic significance make them model organisms in studies of habitat quality, community ecology, and conservation biology (Villalobos-Jiménez *et al.*, 2016) [44]. Routine and spatially explicit documentation of odonate assemblages is essential for tracking biodiversity trends and assessing ecosystem responses to environmental change (Vilenica *et al.*, 2021) [43].

Despite their ecological relevance, the odonate fauna of many urban and peri-urban environments in Northeast India remains poorly documented. Notably, no comprehensive survey has yet been conducted on the Odonata communities inhabiting the Tripura University campus, a semi-urban green space with aquatic and terrestrial habitat mosaics. The present study was therefore designed to evaluate the species richness, taxonomic composition, and community structure of Odonata within the campus, contributing baseline data for future monitoring and conservation planning.

The specific objectives of this study were as follows

- To document the species richness and compile a systematic checklist of dragonflies (Anisoptera) and damselflies (Zygoptera) occurring in the Tripura University campus.
- To assess the Odonata community structure, including their Key ecological traits, Distribution patterns, relative abundance, and diversity profile.

2. Materials and Methods

2.1 Study Area

The present study was conducted in the Tripura University Campus, in Suryamaninagar area (Lat 23.7641940 Long 91.2624790), under the Dukli block of West Tripura District (Fig. 1). It is located 9 Km away from the state capital city, Agartala, besides NH44. Warm and humid sub-tropical climatic conditions prevail in Tripura, with an average annual rainfall of about 2100 mm from the southwest monsoon. Average annual temperatures range between 10-36°C, with altitudes varying from 15-850 m (Majumder *et al*., 2013) [26]. The campus occupies 79 acres (31.9702 ha) of land area with freshwater wetland, permanent buildings, naturally growing patches of *Acacia auriculiformis*, strip plantation of *Michelia champaca*, *Anacardium occidentale*, *Polyalthia longifolia*, *Hyophorbe lagenicaulis*, *Cassia fistula*, *Mimusops elengi*, *Ficus benghalensis*, *Litchi chinensis*, *Mangifera indica*, *Artocarpus heterophyllus*, *Psidium guajava*, *Carica papaya*, *Plumeria pudica*, *Peltophorum pterocarpum*, *Moringa oleifera*, *Neolamarckia cadamba*, *Murraya koenigii*, *Monoon longifolium*, *Murraya paniculata*, *Delonix regia*, bambusetum etc (Deb *et al.*, 2016) [10].

2.2 Sampling Protocol

The study was conducted from March 2024 to February 2025. Abundance-based data were collected by searching and direct observation methods (Sutherland, 2006) [40] at the potential habitats of odonates. For this purpose, a point-based sampling method was adopted. Randomly selected sampling points were searched visually for a minimum of 15 minutes. During the study, 33 sampling points were made, and each point was sampled at least 6 times. All the samplings were made from 7 a.m. to 10 a.m. and 3 p.m. to 5 p.m. on the same day. Care had been taken to cause minimal disturbance to the habitat. In case of difficulty in field identification, some species were captured using insect nets for proper documentation and then released back to their respective habitats. Photographs were taken using a digital camera. Geo-tagged Photographs of the explored habitat were also recorded with the help of a GPS map camera and a timestamp application.

2.3 Identification and Data Analysis

Species Identification was made by available literature (Subramanian, 2005; Majumder *et al.*, 2014; Datta *et al.*, 2023) [39, 27, 8], and with an online database, www.indianodonata.org. Data was analysed by using PAST (Hammer *et al.*, 2001) [14] and BioDiversity Pro (McAleece, 1998) [29] software. The dominance of species was ascertained based on relative abundance using Engelmann's scale (Engelmann, 1973) [11]. The conservation status of the recorded odonates of this study was according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2025) [41].

3. Results and Discussion

A total of 33 Odonata species were recorded from the Tripura University (TU) campus (Tables 1 and 2; Photo plate 1), accounting for 44% of the known odonate diversity in Tripura, which comprises 75 species (Datta *et al.*, 2023) [8]. This substantial representation indicates that the campus harbours a relatively diverse assemblage of dragonflies and damselflies. The recorded species were distributed across 25 genera and five families. Of these, 23 species belonged to the suborder Anisoptera (dragonflies) (Table 1), while 10 species were members of Zygoptera (damselflies) (Table 2).

3.1 Taxonomic Composition and Habitat Associations

Anisoptera was represented by three families: *Libellulidae*, *Aeshnidae*, and *Gomphidae*. *Libellulidae* was the most dominant family, comprising 20 species across 15 genera (Table 1). This family is known to consist of large, strong-flying dragonflies that typically inhabit open, sunlit environments (Seidu *et al.*, 2018) [34]. Their prevalence aligns with previous studies reporting similar dominance in tropical and subtropical regions (Adu *et al.*, 2015, 2016; Kemabonta *et al.*, 2016) [3, 2, 22]. Members of *Libellulidae* exhibit considerable ecological plasticity, being capable of surviving in varied aquatic conditions and requiring high sunlight intensity for thermoregulation (Fitriana, 2016; Irawan & Rahadi, 2018; Abdillah *et al.*, 2019) [13, 15, 1]. Aeshnidae was represented by two species (*Anax guttatus* and *Gynacantha subinterrupta*), while *Gomphidae* was represented solely by *Ictinogomphus rapax*.

The remaining species belonged to Zygoptera, represented by two families: *Coenagrionidae* (8 species across 5 genera) and *Platycnemididae* (2 species across *Copera* and *Pseudocopera*) (Table 2). *Coenagrionidae* dominance among damselflies may be attributed to their broad environmental tolerance and frequent occurrence in human-modified habitats such as agricultural fields, urban edges, and mining areas (Seidu *et al.*, 2018) [33].

3.2 Species Preferences and Distribution Patterns

According to the IUCN Red List (2025) [41], all recorded species are categorised as Least Concern (LC). Most species were associated with wetlands, marshes, and riparian grasslands, while several Anisopteran taxa, such as *Rhyothemis variegata*, *Pantala flavescens*, and *Orthetrum sabina*, were also observed in open fields and terrestrial vegetation. Others, including *Neurothemis fulvia* and *Tholymis tillarga* (Tables 1 and 2), preferred canopied forest habitats, indicating habitat heterogeneity within the campus (Choudhury *et al.*, 2020) [5].

Distribution patterns revealed that 18 Anisopteran species exhibited aggregated distributions, while 5 species displayed a random spatial pattern. Among Zygopterans, 7 species were aggregated and 3 were randomly distributed (Tables 1 and 2), suggesting that most species exhibit clumped distributions, likely driven by habitat patchiness and resource concentration (Lee *et al.*, 2018) [23].

Table 1: List of Odonate species (order: Odonata, sub-order: Anisoptera) recorded in the TU campus

Sr. No.	Scientific name	Common name	Family	Habitat preference	Frequency	Relative abundance	IUCN status	Distribution
1.	*Crocothemis servilia*	Ruddy marsh skimmer	Libellulidae	Wetlands and marshes.	22.5	11.01	LC	Aggregated
2.	*Rhyothemis variegata*	Common picture Wing	Libellulidae	Wetlands, marshes and vegetation above ground.	35	33.28	LC	Aggregated
3.	*Diplacodes trivialis*	Ground skimmer	Libellulidae	Wetlands, open fields and urban gardens.	12.5	2.42	LC	Aggregated
4.	*Neurothemis fulvia*	Fulvous forest skimmer	Libellulidae	Wetlands, marshes and forests with canopies.	4.68	1.01	LC	Aggregated
5.	*Neurothemis tullia*	Pied Paddy skimmer	Libellulidae	Wetland edges and marshes.	7.81	2.02	LC	Aggregated
6.	*Neurothemis intermedia*	Paddy field parasol	Libellulidae	wetlands, open fields and urban gardens	1.25	0.20	LC	Aggregated
7.	*Acisoma panorpoides*	Trumpet tail	Libellulidae	Wetlands and marshes.	6.25	1.49	LC	Aggregated
8.	*Pantala flavescans*	Emerald-flanked marsh hawk	Libellulidae	Wetlands and marshes, vegetation above ground and urban gardens.	14.06	19.73	LC	Aggregated
9.	*Brachythemis contaminata*	Ditch jewel	Libellulidae	Wetlands and marshes.	11.87	2.82	LC	Aggregated
10.	*Brachydiplax sobrina*	Little blue marsh hawk	Libellulidae	Wetlands and marshes.	9.68	2.10	LC	Aggregated
11.	*Brachydiplax chalybea*	Rufous-backed marsh hawk	Libellulidae	Wetlands and marshes.	14.06	6.05	LC	Aggregated
12.	*Orthetrum sabina*	Green marsh hawk	Libellulidae	Wetlands, marshes, gardens and fields.	20.93	3.99	LC	Aggregated
13.	*Orthetrum pruinosum*	Crimson-tailed Marsh Hawk	Libellulidae	Wetlands, marshes, and vegetation above ground.	1.56	0.20	LC	Random
14.	*Trithemis pallidinervis*	Long-legged marsh glider	Libellulidae	Wetlands and marshes.	3.43	0.73	LC	Aggregated
15.	*Potamarcha congener*	Yellow-tailed Ashy Skimmer	Libellulidae	Wetlands and marshes.	0.62	0.08	LC	Random
16.	*Urothemis signata*	Greater crimson glider	Libellulidae	Wetlands and marshes.	3.12	0.77	LC	Aggregated
17.	*Tholymis tillarga*	Coral-tailed cloud wing	Libellulidae	Wetlands, marshes and forests with canopies.	1.87	0.73	LC	Aggregated
18.	*Zyxomma petiolatum*	Brown Dusk Hawk	Libellulidae	ponds, marshes and slow-flowing rivers	0.625	0.08	LC	Random
19.	*Brachydiplax farinosa*	Emerald flanked marsh hawk	Libellulidae	Marshes, swamps, weedy ponds.	1.25	0.24	LC	Aggregated
20.	*Palpopleura sexmaculata*	Blue-tailed Yellow Skimmer	Libellulidae	Swamps and marshes at forest edges	0.31	0.04	LC	Random
21.	*Gynacantha subinterrupta*	Dingy Dusk hawker	Aeshnidae	Wetlands and marshes.	1.87	0.24	LC	Random
22.	*Anax guttatus*	Lesser green emperor	Aeshnidae	Wetlands and marshes.	1.56	0.28	LC	Aggregated
23.	*Ictinogomphus rapax*	Common Clubtail	Gomphidae	Wetlands and marshes.	11.87	2.62	LC	Aggregated

Table 2: List of odonate species (order: Odonata, sub-order: Zygoptera) recorded in the TU campus

Sr. No.	Scientific name	Common name	Family	Habitat preference	Frequency	Relative abundance	IUCN status	Distribution
1.	*Ischnura aurora*	Golden dartlet	Coenagrionidae	Wetlands, marshes and short grasslands near water bodies	0.625	0.08	LC	Random
2.	*Ischnura senegalensis*	Senegal Golden dartlet	Coenagrionidae	Wet meadows and short grasslands bordering marshes, swamps, weedy lakes, etc.	0.625	0.12	LC	Aggregated
3.	*Pseudagrion rubriceps*	Saffron faced blue sprite	Coenagrionidae	Wetlands, marshes and short grasslands near water bodies	6.25	1.57	LC	Aggregated
4.	*Ceriagrion coromandelianum*	Coromandel marsh dart	Coenagrionidae	Wetlands, marshes and short grasslands near water bodies.	10.62	2.22	LC	Aggregated
5.	*Agriocnemis lacteola*	Milky dartlet	Coenagrionidae	Wetlands, marshes and short grasslands near water bodies	5.31	0.81	LC	Aggregated
6.	*Agriocnemis*	Pigmy dartlet	Coenagrionidae	Wetlands, marshes and short	5.62	0.93	LC	Random

	pygmaea			grasslands near water bodies				
7.	*Ceriagrion cerinorubellum*	Orange-tailed Marsh Dart	Coenagrionidae	Weedy lakes, ponds and marshes.	0.3125	0.04	LC	Random
8.	*Onychargia atrocyana*	Black marsh dart	Coenagrionidae	Wetlands, marshes and short grasslands near water bodies	2.5	0.4	LC	Aggregated
9.	*Copera marginipes*	Yellow bush dart	Platycnemididae	Wetlands, marshes and short grasslands near water bodies	3.12	0.56	LC	Aggregated
10.	*Pseudocopera ciliata*	Pied bush dart	Platycnemididae	Wetlands, marshes and short grasslands near water bodies	5.93	1.13	LC	Aggregated

3.3 Species Dominance and Indicator Value

Rhyothemis variegata emerged as the most abundant and eudominant species, followed by *Pantala flavescens* (Fig. 2). This pattern aligns with findings from neighbouring Assam, where *R. variegata* was also identified as the dominant species (Kalita & Ray, 2015) [18]. The relative abundance profile (Fig. 3) revealed a high proportion of sub-recedent and recedent species, indicating a community structured around a few dominant generalists.

The presence of both pollution-sensitive (*Neurothemis fulvia*, *Ceriagrion coromandelianum*) (Jacob & Manju, 2016) [16] and pollution-tolerant (*Brachythemis contaminata*, *Orthetrum sabina*) (Jacob & Manju, 2016) [16] species suggests the coexistence of microhabitats with varying water quality, possibly influenced by localised anthropogenic disturbances (Jacob & Manju, 2016) [16]. *Brachythemis contaminata*, a recognised bioindicator of degraded aquatic habitats (Ferreras-Romero *et al.*, 2009) [12], was present, indicating potential pollution inputs despite the relatively undisturbed nature of some water bodies. The detection of *Ischnura senegalensis*, a species known to disappear under intense urbanisation (Villalobos-Jiménez *et al.*, 2016) [44], further supports the presence of viable habitats conducive to odonate survival and reproduction.

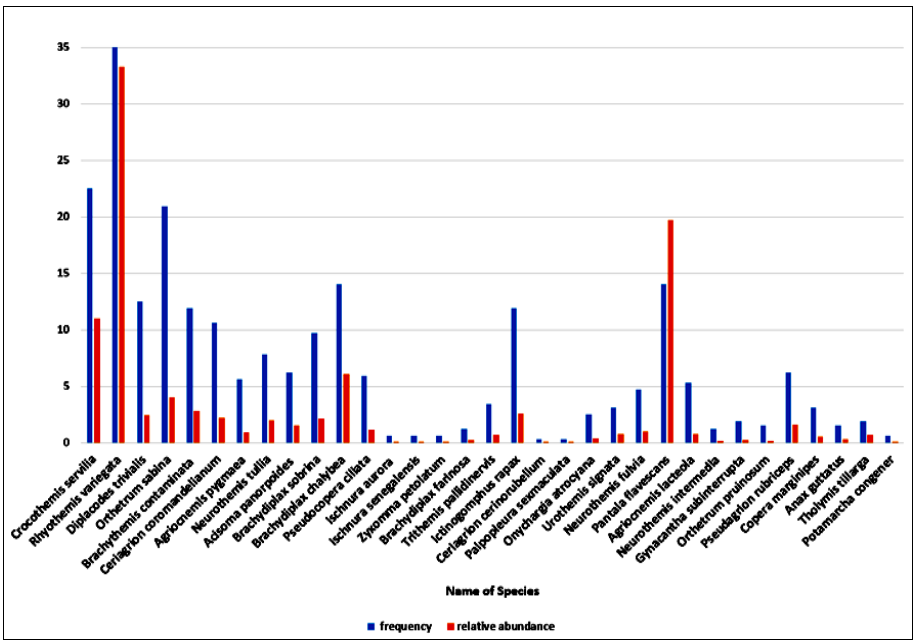

Fig 2: Showing frequency and relative abundance of dragonflies in the study area.

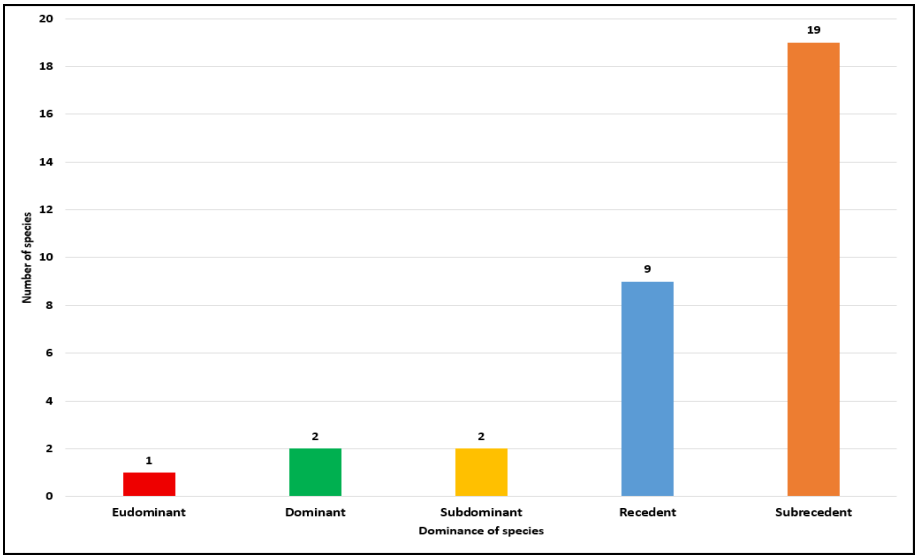

Fig 3: shows species' dominance of the Odonata community in the study area.

3.4 Community Diversity and Structure

The Shannon-Wiener diversity (2.335) and Simpson's dominance index (0.8288) suggest moderate to high diversity of the Odonata community (Table 3). These values fall within the expected range for relatively intact habitats with moderate disturbance (Kemabonta *et al.*, 2019) [21]. However, the Evenness Index (0.3129) was notably low (Table 3), implying that the community is dominated by a few abundant species, while many others occur at low frequencies. Such unevenness may result from interspecific competition, habitat specialisation, or environmental filtering (Tilman, 1982; Smith & Smith, 2018) [42, 35].

The Chao-1 estimator yielded a value of 33.25, nearly identical to the observed species count (Table 3), indicating that the sampling effort was likely sufficient to capture most species present (Magurran, 2004) [25]. Although the sample-based rarefaction curve nearly approaches an asymptote (Fig. 4), suggesting that only a few rare species may have been missed (Wibowo *et al.*, 2019) [45]. The Rényi diversity profile (Fig. 5) further illustrates a steep decline from high species richness (α = 0) to lower Shannon diversity (α = 1), which reflects uneven distribution of species in terms of relative abundances (Andrade *et al.*, 2015) [4].

The rank-abundance curve (Fig. 6) reaffirmed the dominant position of *R. variegata*, highlighting its competitive advantage in resource acquisition and tolerance to environmental variability (Mokaria & Jethva, 2019) [31]. The species distribution curve (Fig. 7) indicated an overall clumped distribution, consistent with odonate behaviour driven by habitat patchiness, mating territories, and larval habitat availability (McPeek, 2008; Lee *et al.*, 2018) [30, 23].

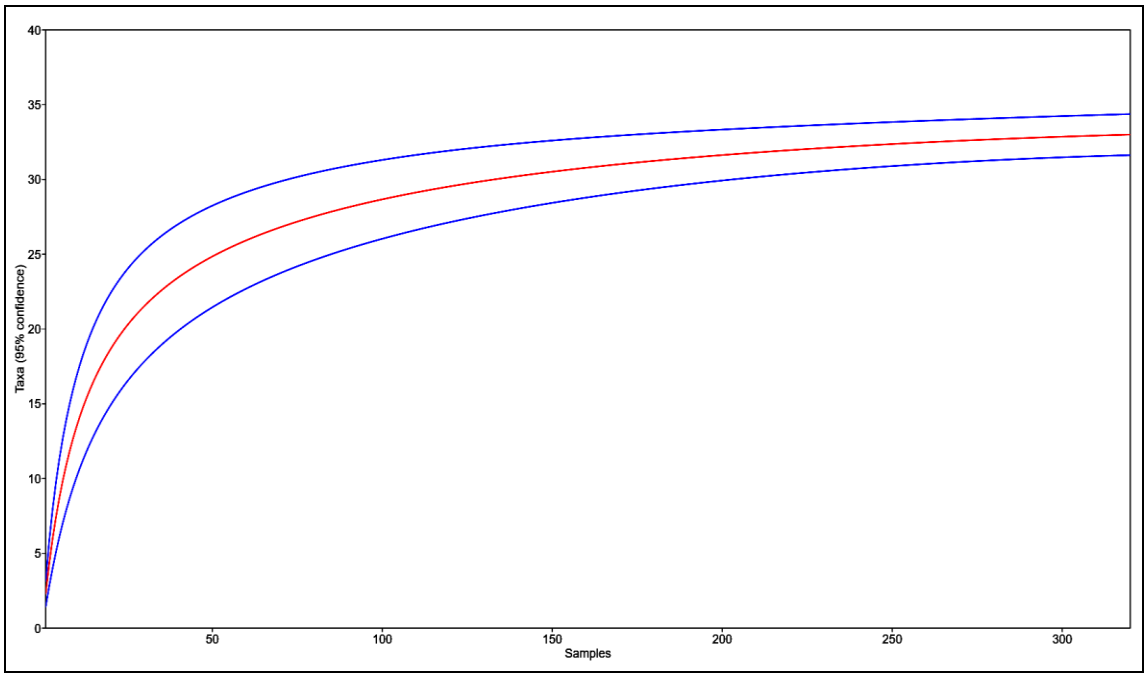

Fig 4: Shows a sample-based rarefaction curve of the Odonata community in the study area.

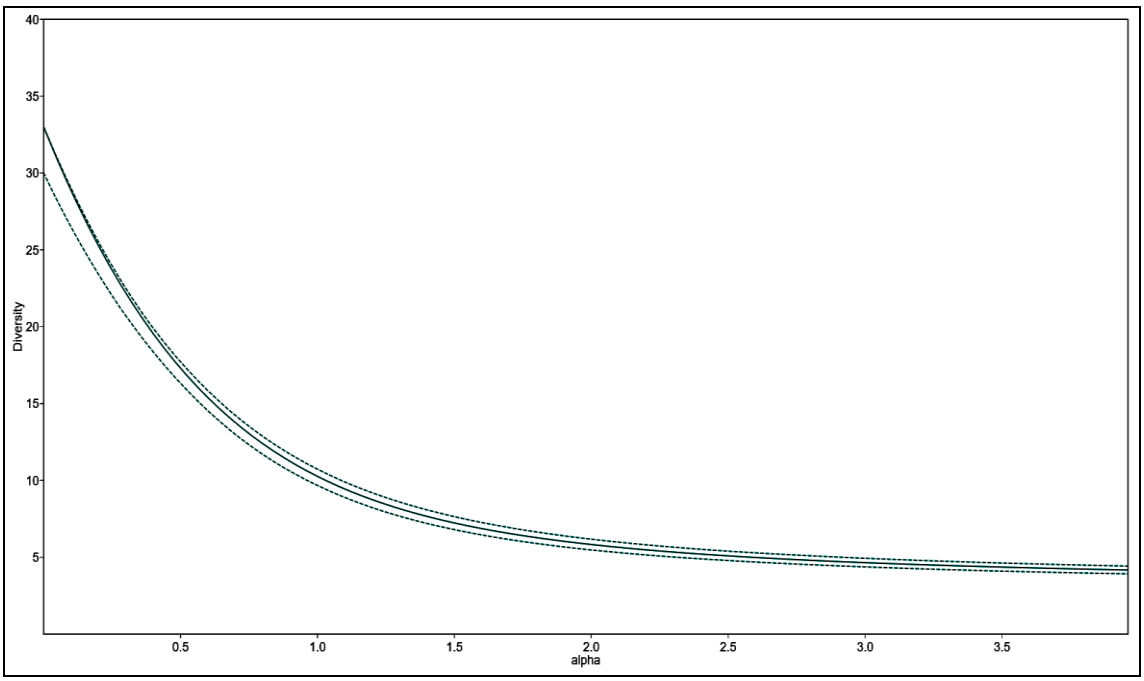

Fig 5: Showing diversity profile curve of the Odonata community on the Tripura University campus.

Plate 1: List of odonate species recorded on the TU campus

i. *Crocothemis servilia* ♀, ii. *Crocothemis servilia* ♂, iii. *Rhyothemis variegata* ♀, iv. *Rhyothemis variegata* ♂, v. *Diplacodes trivialis* ♂, vi. *Neurothemis fulvia* ♂, vii. *Neurothemis tullia* ♀, viii. *Neurothemis tullia* ♂, ix. *Neurothemis intermedia* ♀, x. *Acisoma panorpoides* ♀, xi. *Acisoma panorpoides* ♂, xii. *Pantala flavescans* ♂, xiii. *Brachythemis contaminata* ♂, xiv. *Brachythemis contaminata* ♀, xv. *Brachydiplax sobrina* ♀, xvi. *Brachydiplax sobrina* ♂, xvii. *Brachydiplax chalybea* ♂, xviii. *Orthetrum sabina* ♂, xix. *Orthetrum pruinosum* ♂, xx. *Trithemis pallidinervis* ♂, xxi. *Potamarcha congener* ♂, xxii. *Urothemis signata* ♂, xxiii. *Tholymis tillarga* ♂, xxiv. *Zyxomma petiolatum* ♀, xxv. *Brachydiplax farinosa* ♀, xxvi. *Palpopleura sexmaculata* ♀, xxvii. *Gynacantha subinterrupta* ♂, xxviii. *Anax guttatus* ♂, xxix. *Ictinogomphus rapax* ♂, xxx. *Ischnura aurora* ♂, xxxi. *Ischnura senegalensis* ♂, xxxii. *Pseudagrion rubriceps top* ♂ *bottom* ♀, xxxiii. *Ceriagrion coromandelianum* ♂, xxxiv. *Agriocnemis lacteola* ♂, xxxv. *Agriocnemis pygmaea - top* ♂ *bottom* ♀, xxxvi. *Ceriagrion cerinorubellum* ♂, xxxvii. *Onychargia atrocyana*, xxxviii. *Copera marginipes* ♂, xxxix. *Pseudocopera ciliata* ♀, xL. *Pseudocopera ciliata* ♂.

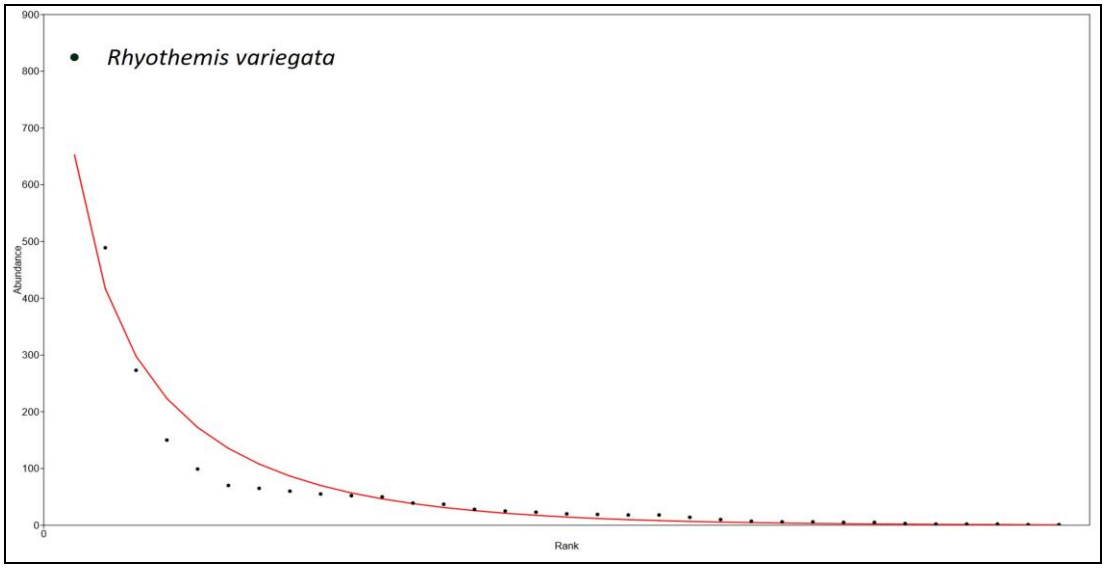

Fig 6: showing the rank abundance curve of the Odonata community in the study area.

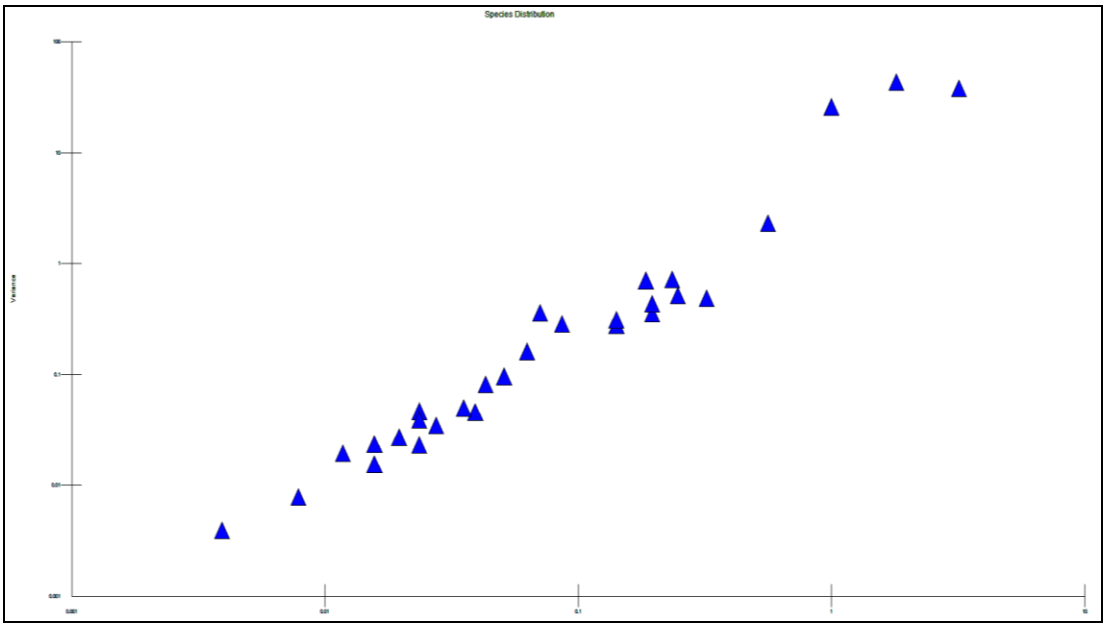

Fig 7: showing species distribution pattern of the Odonata community in the study area.

Table 3: Diversity indices of the TU campus as a habitat concerning the order Odonata.

Parameters	Observed value
Taxa	33
Individuals	2479
Dominance	0.1712
Simpson	0.8288
Shannon	2.335
Evenness	0.3129
Brillouin	2.298
Menhinick	0.6628
Margalef	4.094
Fisher's alpha	5.379
Chao-1	33.25

4. Conclusion

The present study recorded 33 Odonata species, comprising 23 Anisoptera and 10 Zygoptera, from the Tripura University campus. The family *Libellulidae* was the most speciose, and *Rhyothemis variegata* was identified as the eudominant species in the community. Diversity indices indicated moderate to high overall diversity, while low evenness suggested dominance by generalist taxa. The presence of both sensitive and tolerant species implies a mosaic of habitat quality, likely influenced by localised anthropogenic pressures.

These findings underscore the ecological value of semi-urban landscapes like the TU campus in supporting odonate diversity and highlight their utility in environmental monitoring. Continued habitat disturbances and an overrepresentation of generalists point to the need for management strategies that preserve microhabitat heterogeneity and minimise anthropogenic impacts. The present dataset provides a baseline reference for future ecological assessments and can inform local and regional conservation planning. Further studies should focus on temporal dynamics, larval stage ecology, and physicochemical correlates to better understand drivers of community composition in urban green spaces.

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