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An Ecological Inquiry Into The Taxonomic Diversity And Spatial Distribution Patterns Of Odonata Within The Meenachil And Pampa River Basins In Kerala, India

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ABSTRACT

This study endeavoured to conduct a comparative analysis of Odonate species, within discrete regions along the Meenachil and Pampa rivers, specifically in the Malarikkal and Parumala areas, throughout the period from March 1st to April 30th, 2023. The inquiry encompassed weekly visits to the designated study sites, where meticulous documentation of observations was conducted. A comprehensive analysis unveiled a total of 25 Odonate species in both regions. The Malarikkal region demonstrated heightened diversity with 18 dragonfly and 7 damselfly species, while the Parumala region exhibited comparatively diminished diversity, encompassing 7 dragonfly and 4 damselfly species. Regarding species diversity indices, Malarikkal exhibited values of 0.2022 for dragonflies and 0.25 for damselflies, indicating a moderately diverse Odonate community. Conversely, the Parumala region displayed lower diversity indices, with values of 0.0875 for dragonflies and 0.2857 for damselflies. These observations suggest discernible variations in Odonate species composition and diversity between the two regions. In summary, this study furnishes valuable insights into the Odonate fauna of the Meenachil and Pampa rivers, thereby contributing to the elucidation of regional biodiversity. The discerned distinctions in species composition and diversity underscore the imperative for targeted conservation initiatives in these aquatic ecosystems.

Key Words: Odonata, species diversity index, dragonflies, damselflies, Meenachil River basin, Pampa River basin

Introduction

Odonata possesses a time-honoured evolutionary heritage, with fossils dating back over 300 million years, highlighting their enduring resilience and adaptability through geological time. These organisms are globally distributed, inhabiting a diverse range of environments from pristine freshwater ecosystems to urban areas, showcasing their adaptability and ability to thrive in various ecological niches. Their role as bioindicators of ecosystem health is pivotal, as their sensitivity to changes in water quality and habitat conditions makes them valuable indicators for assessing environmental well-being. The global diversity of odonates is extensive, with

an estimated 6,335 species classified in 693 genera, as reported by Paulson et al. (2021). In India, Subramanian and Babu (2020) identified 493 species and 27 subspecies in 152 genera and 18 families, with 195 species group taxa endemic to the country. The Western Ghats, particularly in the mountains south of Coorg in Karnataka and Kerala, exhibit high endemism. Notably, Southern Western Ghats, Eastern Himalayas, Western Himalayas, and the Andaman and Nicobar Islands in India are recognized for their high diversity and endemism of odonates.

Dragonflies and damselflies, collectively known as Odonata, are intriguing insects found globally in various freshwater and terrestrial habitats (Schorr & Paulson, 2016). Classified under the class Insecta, Odonata are characterized by their elongated bodies, large compound eyes, and four membranous wings capable of independent beating (Corbet, 1999). Extensive research in recent years has shed light on their taxonomy, distribution, and evolutionary history, revealing their remarkable ecological roles, diverse morphologies, and intriguing behaviours. Odonata's ubiquitous presence in ecosystems worldwide underscores their significance as bioindicators of water quality and essential components in food webs, preying on small insects such as mosquitoes and flies (Corbet, 1999; Lencioni, 2005). Additionally, Odonata serves as crucial pollinators, with certain species exhibiting specialized adaptations for flower pollination (Corbet, 1999). Beyond their ecological importance, Odonata has found applications in medical research, with some species producing compounds with antibacterial and antifungal properties, offering potential avenues for drug development (Ware & May, 2013). However, the enchanting world of Odonata faces significant threats, primarily arising from habitat loss, water pollution, and the impacts of climate change (Ware & May, 2013). The conservation status of many Odonata species remains poorly understood, emphasizing the urgent need for comprehensive research to elucidate their population dynamics and distribution (Ware & May, 2013).

Recent studies have delved into the phylogenetic relationships and evolutionary traits of Odonata, leveraging advanced molecular techniques to unravel their intricate biogeographical patterns (Lencioni, 2005; Ware & May, 2013). This paper aims to contribute to the expanding body of knowledge on Odonata by presenting a comprehensive overview of their taxonomy, distribution, and ecological significance. Focusing on the Indian subcontinent, with a particular emphasis on the state of Kerala, we explore the rich diversity of Odonates in this region, which hosts over 500 identified species (Dahanukar et al., 2016).

Classification and Global Distribution

The order Odonata encompasses dragonflies and damselflies, divided into two suborders: Anisoptera (dragonflies) and Zygoptera (damselflies) (Schorr & Paulson, 2016). Distinguished by their size, resting wing positions, and eye size, dragonflies and damselflies collectively contribute to the impressive global count of over 6,000 identified species (Clausnitzer et al., 2021). Their distribution spans continents, with tropical regions like Southeast Asia and South America boasting the highest diversity, including numerous endemic species. However, Odonata are also prevalent in temperate regions, such as Europe and North America (Ware & May, 2013).

Odonata in India: A Biodiversity Hotspot

The Indian subcontinent stands out as a biodiversity hotspot for Odonates, with India alone hosting over 330 species, showcasing its significance on a global scale (Subramanian, 2005). The distribution of Odonates in India is diverse, ranging from the high-altitude mountain streams of the Himalayas to the wetlands, ponds, and rivers in the plains and lowlands (Kalkman et al., 2010; Islam & Islam, 2017). Notable species in the region, such as the Himalayan Emerald, Scarlet Skimmer, and Blue-tailed Damselfly, contribute not only to the ecological balance but also hold cultural significance with ties to traditional beliefs and folklore (Samways, 1994; Kalkman, 2018).

Despite their importance, Odonate populations in the Indian subcontinent face numerous threats, including habitat loss, pollution, and the overarching impacts of climate change (Mitra & Saha, 2012). The urgency to understand and conserve these species becomes apparent in light of their integral role in maintaining ecosystem health and their potential contributions to medical research (Ware & May, 2013).

Odonata in Kerala: A Microcosm of Diversity

Zooming into the southwestern coast of India, the state of Kerala emerges as a microcosm of Odonate diversity. Boasting a rich biodiversity, Kerala hosts 141 species of Odonates, making it one of the most diverse regions in the country (Kalesh & Prasad, 2016). The state's varied habitats, including wetlands, paddy fields, and forested areas, provide suitable environments for a plethora of Odonate species.

Several studies conducted in different regions of Kerala emphasize the high diversity and unique composition of Odonates. The Shendurney Wildlife Sanctuary in the southern Western Ghats recorded an impressive 71

species, with several being identified for the first time in the region (Sadasivan et al., 2022). Another comprehensive checklist compiled across various regions of Kerala documented a total of 148 species, highlighting the need for ongoing research to unravel the intricacies of their ecology and conservation needs (Gopalan et al., 2022).

The influence of habitat structure and environmental variables on Odonate diversity was explored in a study conducted in a headwater stream of the Pamba River, revealing 24 species and emphasizing the importance of submerged vegetation and dissolved oxygen concentration (Thomas & Thomas, 2022). Similarly, the Kole Wetlands in central Kerala, despite facing anthropogenic threats, exhibited a remarkable diversity of 58 species, with several rare and threatened species recorded (Chandran et al., 2021).

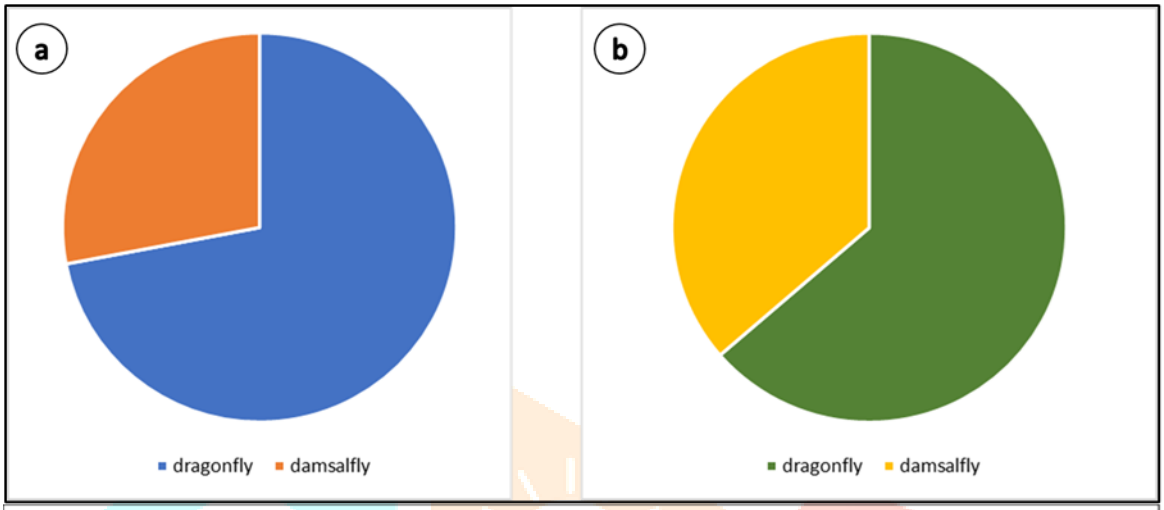

Fig.1 Comparison of dragonfly and damselfly observed from both sites. a-from Malarikkal region, b-from Parumal region

Morphology, Behavior, and Migration: Unraveling the Odonate Mystique

The unique morphology and anatomy of Odonates contribute to their distinctive ecological roles and behaviors. Characterized by three main body parts – head, thorax, and abdomen – and intricate wing venation, Odonates exhibit remarkable flight capabilities and specialized structures for mating and reproduction (Córdoba-Aguilar & González-Soriano, 2010). Their courtship rituals, involving elaborate displays and copulation, add a layer of complexity to their life cycle, which includes an aquatic larval stage marked by molts and eclosion (Polhemus, 1991).

Beyond their terrestrial lives, Odonata engages in migratory behaviors, although less documented than some insects. Influenced by factors like temperature, photoperiod, and resource availability, Odonata migration patterns have been observed globally, including regions in India such as the Western Ghats and the Himalayas (May, 2013; Sivaperuman et al., 2014). Notable migratory events, such as the annual migration of the common green darner in North America, underscore the importance of understanding these movements in maintaining genetic diversity and colonizing new habitats (Chapman et al., 2019).

Ecological Importance and Conservation Imperatives

The ecological significance of Odonata cannot be overstated. As voracious predators, they regulate insect populations, including disease vectors like mosquitoes, while their larvae contribute to nutrient recycling in aquatic ecosystems (Corbet, 1999; Buchwald et al., 2018). Their role as pollinators and bioindicators of water quality further solidifies their importance in maintaining the health and integrity of freshwater ecosystems, both in India and globally (Sharma et al., 2013; Potts et al., 2010).

Despite their vital contributions, Odonate populations face an array of threats, necessitating urgent conservation efforts. Habitat loss and degradation, pollution, and the overarching impacts of climate change pose significant risks to their survival (Mitra & Saha, 2012). Ongoing research, monitoring, and conservation initiatives are imperative to safeguard the diverse and unique Odonate fauna, especially in regions like Kerala, where anthropogenic pressures intersect with high biodiversity.

In conclusion, Odonata, encompassing dragonflies and damselflies, stand as captivating insects with a global presence and diverse ecological roles. The Indian subcontinent, particularly the state of Kerala, emerges as a hotspot for Odonate diversity, offering a rich tapestry of species across varied habitats. As we navigate the

intricate realms of their morphology, behaviours, migration patterns, and ecological importance, it becomes evident that Odonates play a crucial role in maintaining the delicate balance of freshwater ecosystems.

However, the enchanting world of Odonata faces unprecedented challenges. Habitat loss, pollution, and climate change threaten their existence, demanding concerted conservation efforts. The studies conducted in different regions of Kerala underscore the urgent need for continued research and monitoring to unravel the complexities of Odonate ecology and devise effective conservation strategies.

This comprehensive overview sets the stage for a deeper exploration of Odonates, urging researchers, policymakers, and conservationists to work collaboratively in preserving the diverse and invaluable insect group that is Odonata.

Methodology

This study encompassed the temporal interval from March 1, 2023, to April 30, 2023, and concentrated on two discrete locations adjacent to the Pampa River in the Parumal region within the Pathanamthitta district and the Meenachil River in the Malarikkal region situated in the Kottayam district of Kerala. The data acquisition process involved recurrent visits to the designated observation sites on a weekly basis throughout the stipulated timeframe. Specimen identification adhered to the protocols elucidated in "Introduction to Odonata with Identification Keys for Dragonflies & Damselflies Found in Kerala" authored by Jose, Jeevan, et al. (2020). Detailed records were meticulously documented during each visit, encompassing both the enumeration of observed species and the quantification of individual abundances within each species.To assess the ecological diversity of the study areas, the species diversity index was calculated utilizing the formula:

Species diversity index = species richness/species evenness.

This methodological approach facilitated a comprehensive and systematic scrutiny of dragonfly and damselfly populations within the designated regions, yielding valuable insights into the biodiversity and ecological dynamics inherent in these aquatic habitats.

Result

The results derived from the systematic observations conducted in the Malarikkal region of the Meenachil River and the Parumala region of the Pampa River yield significant insights into the Odonata populations thriving in these discrete ecosystems. Initial observations indicate a prevalence of dragonflies over damselflies at both sites, with the Parumala region exhibiting a higher dragonfly to damselfly ratio. Subsequent taxonomic analysis, focusing on the family level of Odonata members, identifies the presence of three major dragonfly families—Aeshnidae, Gomphidae, and Libellulidae—with Libellulidae emerging as the most dominant family in both regions.

On a species-specific level, the Malarikkal region showcases a remarkable diversity, hosting a total of 25 Odonata species, including 18 dragonfly and 7 damselfly species. Notably, Neothemis tullia emerges as the most frequently recorded species, followed by Gomphus vulgatissimus and Brachythemis contaminata. In the Parumala region, seven dragonfly species are observed, with Neothemis tullia taking the lead, closely followed by Brachythemis contaminata. Damselfly diversity in the Parumala region is comparatively lower, with only four observed species, and Pseudagrion microcephalum being the most frequently recorded.

These findings, encompassing comparative analyses across various taxonomic levels, provide a comprehensive overview of the Odonata populations inhabiting the studied regions. The discerned abundance and distribution patterns of both dragonflies and damselflies, examined at broad and species-specific scales, furnish invaluable data conducive to further research and scientific exploration. The outcomes obtained establish a robust foundation for an in-depth research paper, elucidating the ecological dynamics and species composition of Odonata in the designated riverine habitats of Kerala.

Species Diversity Index

1.Malarikkal region of Meenachil river

Table 1 : Species Diversity Index of Malarikkal region of Meenachil river

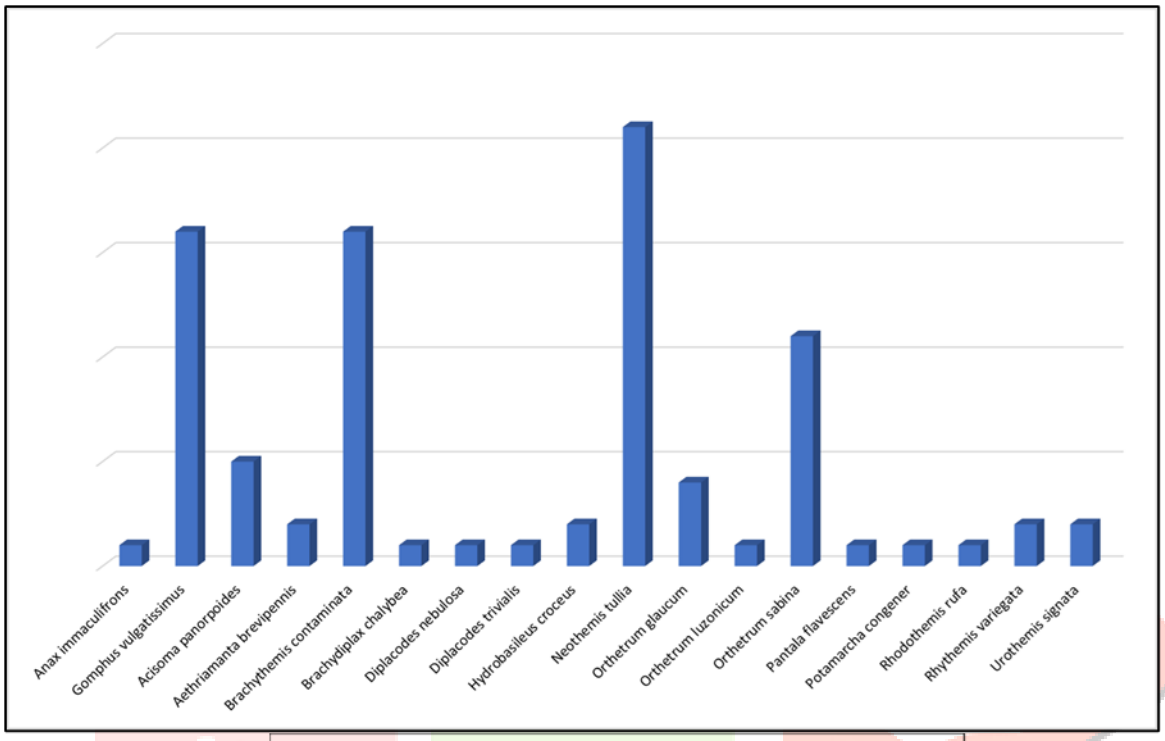

Fig.4 Species wise analysis of dragonfly in Malarikkal region

	No. Of species	No. Of individuals	Diversity index
Dragonfly	18	89	0.2022
Damselfly	7	28	0.25

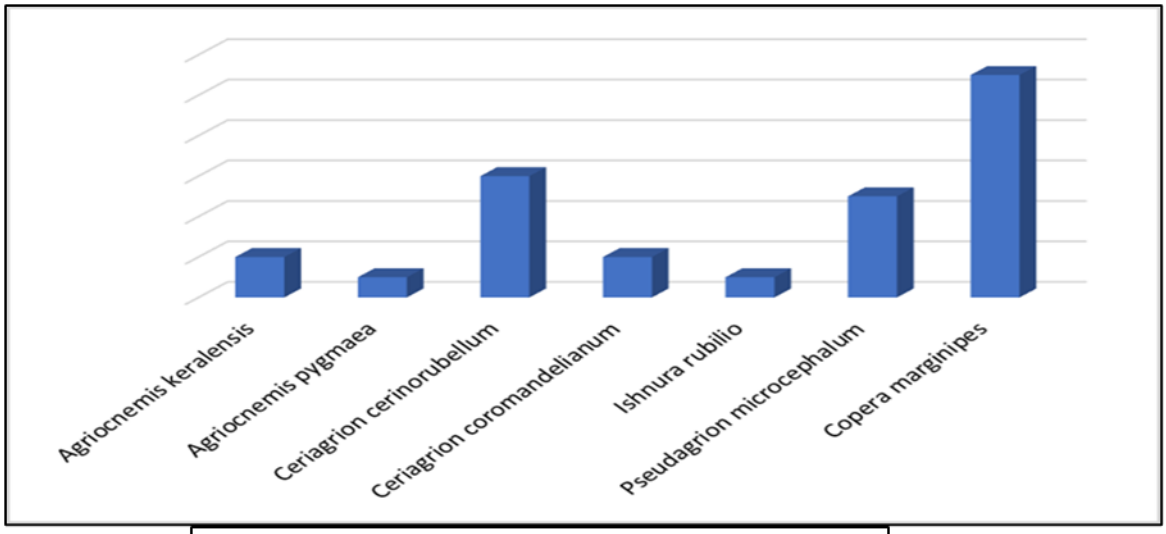

Fig.5 Species wise analysis of damselfly in Malarikkal region

2. Parumala region of Pampa River

Table 2 : Species Diversity Index of Parumala region of Pampa River

	No. Of species	No. Of individuals	Diversity index
Dragonfly	7	80	0.0875
Damselfly	4	14	0.2857

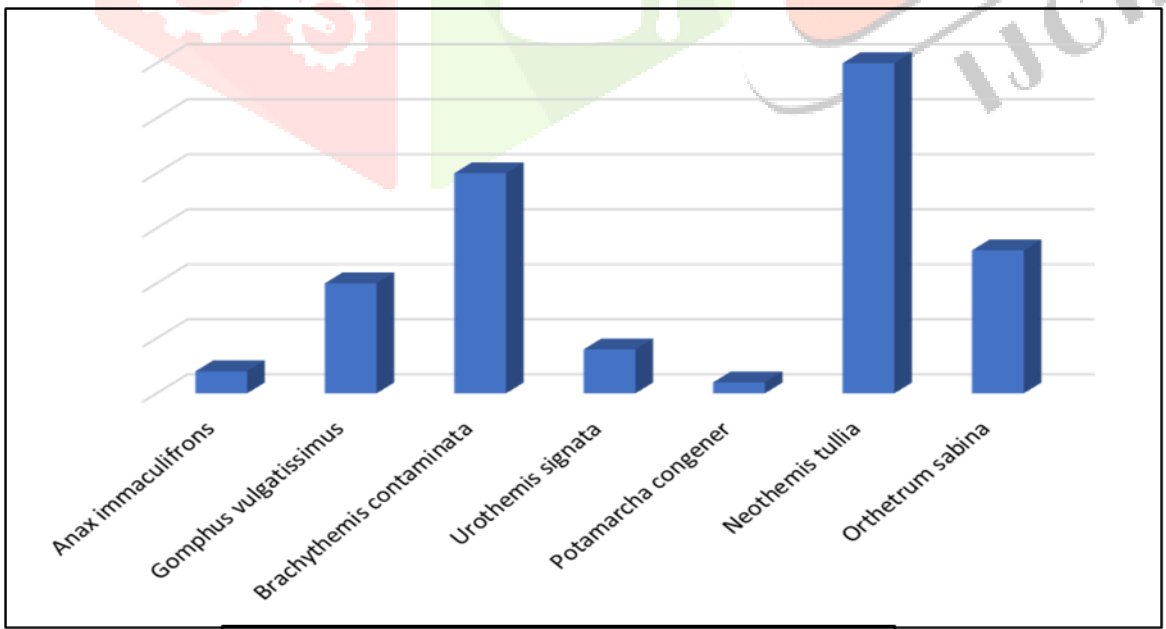

Fig.6 Species wise analysis of dragonfly in Parumal region

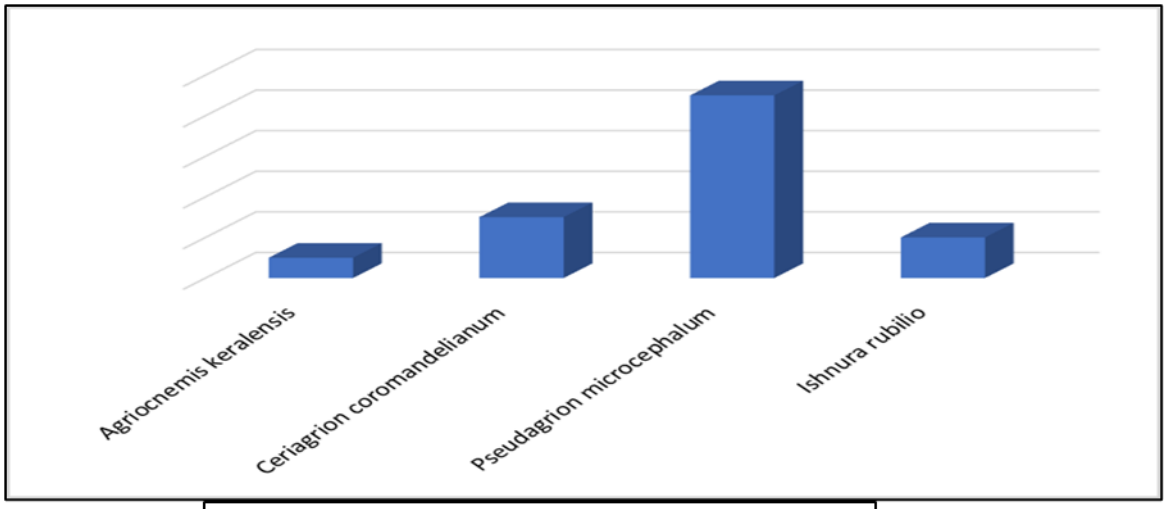

Fig.7 Species wise analysis of damselfly in Parumal region

Table 3 : Species description

Sl. No.	TYPE	FAMILY	SCIENTIFIC NAME	COMMON NAME
1	Dragonfly	*Aeshnidae*	*Anax immaculifrons*	Blue Darner
2		*Gomphidae*	*Gomphus vulgatissimus*	Common Clubtail
3		*Libellulidae*	*Acisoma panorpoides*	Trumpet Tail
4			*Aethriamanta brevipennis*	Scarlet Marsh Hawk
5			*Brachythemis contaminata*	Ditch Jewel
5			*Brachydiplax chalybea*	Rufous-Backed Marsh Hawk
6			*Diplacodes nebulosa*	Black Tipped Percher
7			*Diplacodes trivialis*	Chalky Percher
8			*Hydrobasileus croceus*	Amber Winged Marsh Glider
9			*Neothemis tullia*	Pied Paddy Skimmer
10			*Orthetrum glaucum*	Blue Marsh Hawk
11			*Orthetrum luzonicum*	Marsh Skimmer
12			*Orthetrum sabina*	Green Marsh Hawk
13			*Pantala flavescens*	Wandering Glider
14			*Potamarcha congener*	Yellow Tailed Ashy Skimmer
15			*Rhodothemis rufa*	Rufous Marsh Glider

16			***Rhythemis variegata***	**Common Picture Wing**
17			***Urothemis signata***	**Scarlet Basker**
18	**Damselfly**	***Coenagrionidae***	***Agriocnemis keralensis***	**Kerala Dartlet**
19			***Agriocnemis pygmaea***	**Pygmy Darlet**
20			***Ceriagrion cerinorubellum***	**Orange Tailed Marsh Dart**
21			***Ceriagrion coromandelianum***	**Coromandel Marsh Dart**
22			***Ishnura rubilio***	**Golden Darlet**
23			***Pseudagrion microcephalum***	**Blue Grass Dartlet**
24		***Platycnemididae***	***Copera marginipes***	**Yellow Bush Dart**

Species description Discussion

The investigation into Odonata diversity in the distinct locales of Malarikkal and Parumala yielded the identification of 25 species, comprising 18 dragonflies and 7 damselflies. A meticulous scrutiny of the gathered data vis-à-vis referenced scholarly works elucidates that the ascertained spectrum of Odonata species in the study area harmonizes with the findings of analogous studies conducted in the Kerala region. Gopalan et al.'s (2022) comprehensive enumeration of dragonflies and damselflies in Kerala chronicled a total of 108 species, encompassing 58 dragonfly and 50 damselfly species. The Shendurney Wildlife Sanctuary, situated in the southern expanse of the Western Ghats, documented a total of 72 species, featuring 41 dragonfly and 31 damselfly species (Sadasivan et al., 2022).The exploration of the Kattampally wetland unearthed a total of 48 species, embracing 30 dragonfly and 18 damselfly species (Rodrigues et al., 2022). The observed Odonata species richness in the study area appears to exhibit a relatively diminished profile compared to other wetlands within the Kerala region, exemplified by the Palakkal Kole wetland, which documented a total of 62 species (PK and Bijoy, 2019). Correspondingly, the study on the Odonata diversity of the Vakkom Grama Panchayath delineated 30 species, encompassing 20 dragonfly and 10 damselfly species (Arunima and Nameer, 2021).

The inquiry into the ramifications of habitat structure and physico-chemical variables on entomofaunal diversity in a headwater stream of the Pamba River unveiled a total of 31 species, inclusive of 21 dragonfly and 10 damselfly species (Thomas and Thomas, 2022). Furthermore, the examination of Odonata diversity in the Kole Wetlands documented a total of 65 species, featuring 42 dragonfly and 23 damselfly species (Chandran et al., 2021).In summation, the study on Odonata diversity in the demarcated regions of Malarikkal and Parumala contributes nuanced insights into the intricacies of species diversity and distribution of Odonata within the broader context of the Kerala region. The comparative analysis of findings with existing literature underscores the exigency for additional research endeavors dedicated to Odonata diversity across diverse habitats and regions within Kerala, thereby advancing the imperatives of efficacious conservation and management of these ecologically pivotal insect taxa.

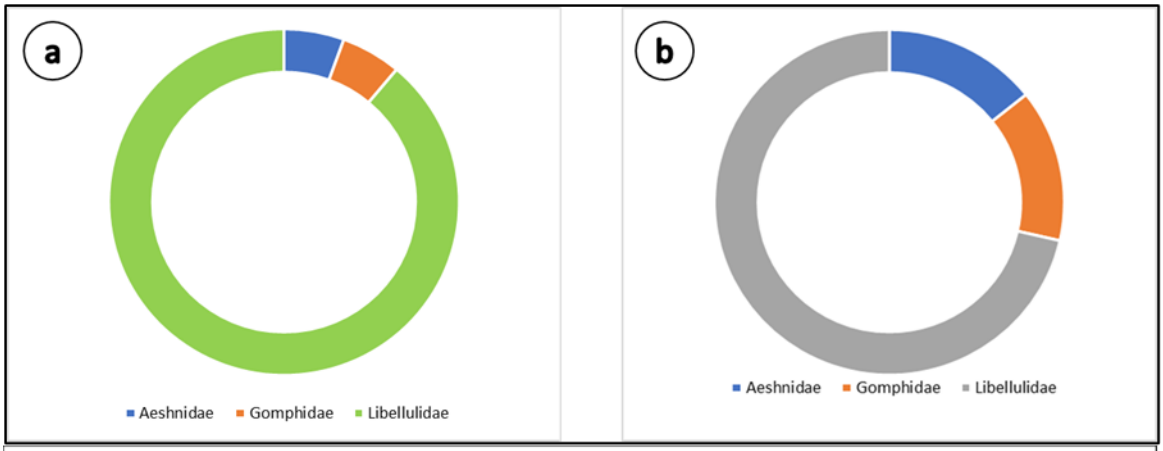

Fig.2 Comparison of dragonfly observed from both sites based on the family. a-from Malarikkal region, b-from Parumal region

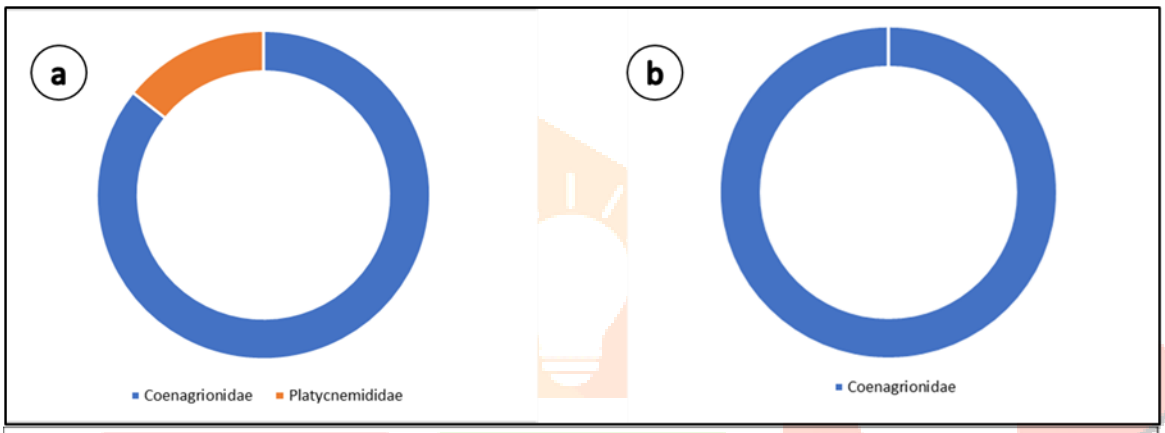

Fig.3 Comparison of damsalfly observed from both sites based on the family. a-from Malarikkal region, b-from Parumal region

Conclusion

The present investigation was undertaken to assess and juxtapose the Odonata diversity within the Malarikkal vicinity of the Meenachil River and the Parumala region of the Pampa River. The data obtained revealed the presence of 25 odonate species across five families in the Malarikkal region, whereas the Parumala region exhibited 11 species spanning four families. Neothemis tullia emerged as the preponderant dragonfly species in both locales. *Copera marginipes* was identified as the most prevalent damselfly in Malarikkal, whereas *Pseudagrion microcephalum* dominated in the Parumala region. The notably elevated abundance of *Brachythemis contaminatea* in both sites suggests a significant degree of environmental pollution, as this species thrives in polluted aquatic environments and serves as an indicator species for assessing pollution levels.

In terms of species diversity indices, the dragonflies in the Malarikkal region of the Meenachil River yielded a value of 0.2022, while the Parumala region of the Pampa River recorded a lower index of 0.0875. This discernible contrast in diversity indices underscores a greater richness of dragonfly species in the Malarikkal region compared to the Parumala region. Furthermore, the species index for damselflies was calculated at 0.25 for the Malarikkal region and 0.2857 for the Parumala region, indicating a relatively higher prominence of damselfly species in the latter locale as opposed to the former.

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