International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 06-10-2024, Accepted: 05-11-2024, Published: 20-11-2024
Volume 9, Issue 11, 2024, Page No. 148-151

Odonates of Vembanad Lake, a Ramsar site in Kerala, India

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Abstract
Besides serving as important prey and predators in the food chain's trophic level balance, odonates are important markers of the health of terrestrial and aquatic ecosystems. The current research endeavors to record and examine the odonate diversity found in Kerala's Vembanad Lake, a Ramsar site. Observations were made for a period from November 2022 to May 2024. A total of 41 species—27 Anisoptera species and 14 Zygoptera species—were identified, spanning two sub-orders, six families, and thirty genera. The families obtained were Gomphidae, Libellulidae, Aeshnidae, Chlorocyphidae, Coenagrionidae and Platycnemididae. Ordre Anisoptera was found to be more diverse and predominant with 27 species under 24 genera belonging to three families Libellulidae, Gomphidae, and Aeshnidae contributing 65%, followed by the order Zygoptera which was less diverse with 14 species under 8 genera belonging to three families Chlorocyphidae, Coenagrionidae and Platycnemididae, contributed 34% of total Odonates recorded from the study area. Libellulidae is the most species-rich family with 25 species, followed by Coenagrionidae, Platycnemididae, Chlorocyphidae, Aeshnidae, and Gomphidae with 10 species, 3 species, and 1 species respectively. The study will provide baseline information on the diversity and composition of odonates in the selected study area.

Keywords: Ecological indicators, ecosystem health, anisoptera, zygoptera, libellulidae, wetland

Introduction
Dragonflies and damselflies, known as odonates, are one of the ancient orders of insects. This group forms the most common insects flying over rivers, lakes, forests, fields, and meadows (Subramanian, 2005) [21]. There are 6324 known species of odonates worldwide. According to the Society for Odonate Studies (2020) [17], there are 497 species and 27 subspecies of odonates in India, distributed across 154 genera and 18 families. Of these, 181 species have been identified in Kerala (Vinayan et. al., 2022) [23]. Odonates are highly specific to their habitat and are very important in their distribution and ecology (Subramanian, 2014) [20]. The dragonfly distribution is directly linked with the climatological zones. When moving from the poles to the equator there is a steep rise in dragonfly diversity. Temperature facilitates this gradation and precipitation makes irregularities as low precipitation areas show decreased diversity. This is also called gaps in diversity. Tropical forests always show a rich diversity of dragonflies, especially in montane regions (Oppel, 2005; Orr, 2006) [12, 13]. The diversity of odonates is higher in the tropics. Both the species diversity and the family level diversity. Out of the 31 families, 12 are confined to streams of tropical forests. (Kalkman *et al*., 2008) [7]. Both adult and larval forms of odonates are predators in nature. Larvae feed on mosquito larvae, tadpoles, aquatic beetles, etc. and adult feeds on small insects and other odonates (Iswandaru, 2018) [4]. The predatory mode of lifestyle makes the odonates a key component in the food chain and ecosystem function. By feeding on harmful pests, odonates also proved their importance in agriculture (Subramanian and Babu, 2018) [19]. In addition to serving as predators in the ecosystem, their significance as markers of habitat quality has gained a lot of attention lately. Certain odonates are habitat-specific, and even small changes have the potential to cause them to vanish (Nair M V, 2011) [10]. According to Sanchez-Payo and Wyckhuys (2019), biological factors such as pathogens, introduced species, pollution, habitat loss, and climate change pose a global threat to insect diversity. Research on insect diversity is desperately needed in tropical nations like India, where there is a dearth of such data (Poorani and Varghese, 2015) [14].

The Vembanad-Kol wetland complex spans the Malabar coastline in the districts of Ernakulam, Alappuzha, and Thrissur, between latitudes 9° 30' and 10° 12' and longitudes 76° 10' and 76° 29'. Its three main physiographic divisions are the Vembanad Estuary, Kuttanad, and Kol lands. These are connected by a complex network of man-made and natural channels. The rapid development and indiscriminate use of land and water in Kerala puts tremendous strain on the state's wetlands. The main problems Kerala's wetlands face are eutrophication, pollution, reclamation, encroachment, mining, and biodiversity loss (Kokkal *et al*., 2008) [8]. The Vembanad Kole wetland has been recognized as a high-value biodiversity area since 2009 (MoEF, 2009), an important bird area since 2004 (Islam and Rahmani, 2004) [2], and a Ramsar site since 2002 (Islam and Rahmani, 2008) [3]. This agro-ecosystem is rich in biodiversity, as evidenced by the well-documented avifauna (Nameer, 2002) [11], flora (Sujana and Sivaperuman, 2008) [22], herpetofauna (Sreehari 2009) [8], and butterflies (Sarath *et al*., 2017) [16] of the region. Vembanad Kole wetland was a relatively unexplored area as far as odonates were concerned. There are no published papers on the odonate fauna of the Vembanad Lake. There has been no comprehensive study on this insect group from the plains and wetlands of Kerala. The present study attempts to record the odonate fauna of Vembanad-Kol wetland, the largest lake ecosystem in Kerala.

Materials and methods
Study area: Vembanad Lake, a Ramsar site in Kerala
The largest brackish body of water in Kerala is the Vembanad Lake, which stretches 80 km from Kochi to

Alappuzha in a north-south direction. The region stretching between Alleppey and Azhikode (Thrissur District) is actually a land-ward evagination of the Arabian Sea, situated between latitudes 9° 30' and 10° 12' and longitudes 76° 10' and 76° 29' (Figure 1).

- Observations were made from November 2022 to May 2024.
- Adult odonates were sampled using the checklist survey method in twelve randomly selected locations.
- Field observations were carried out monthly during the morning (8.30-11.30 am).
- Odonates were captured on camera, and their identities were confirmed using field guides (Subramanian 2005, 2009; Kiran and Raju 2013) [21] and taxonomic monographs (Fraser 1933, 1934, 1936) [1]. Using a sweep net, species that were difficult to identify in the field were caught, carefully photographed, and then released. Additionally, field notes were taken.

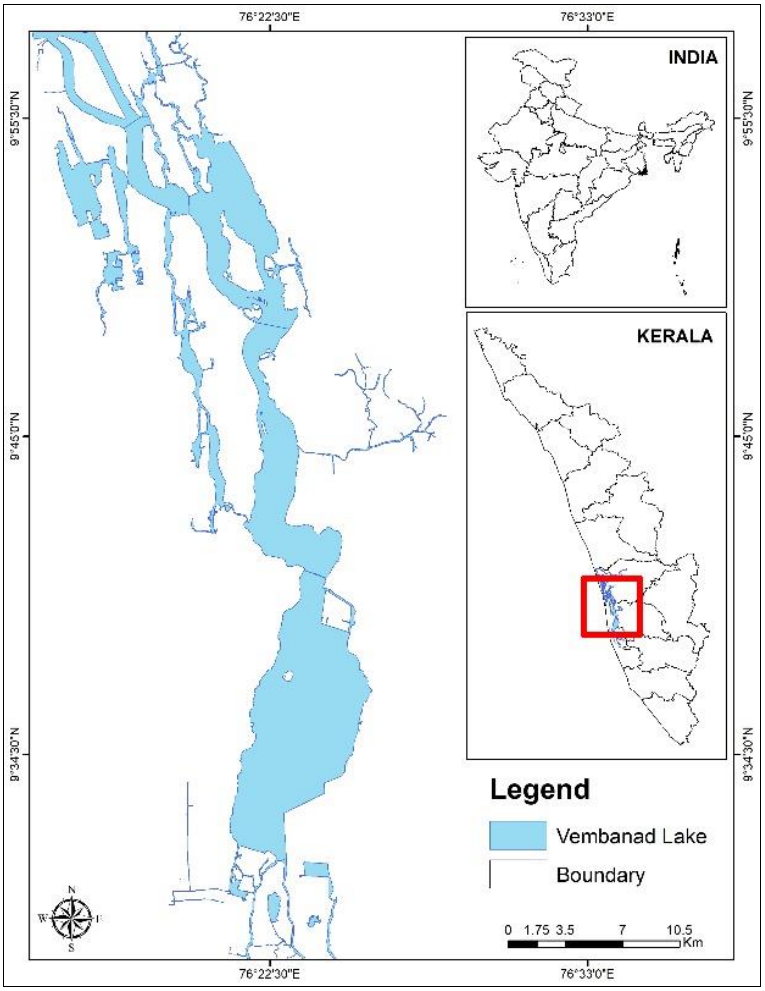

Fig 1: Location map, Vembanad Lake

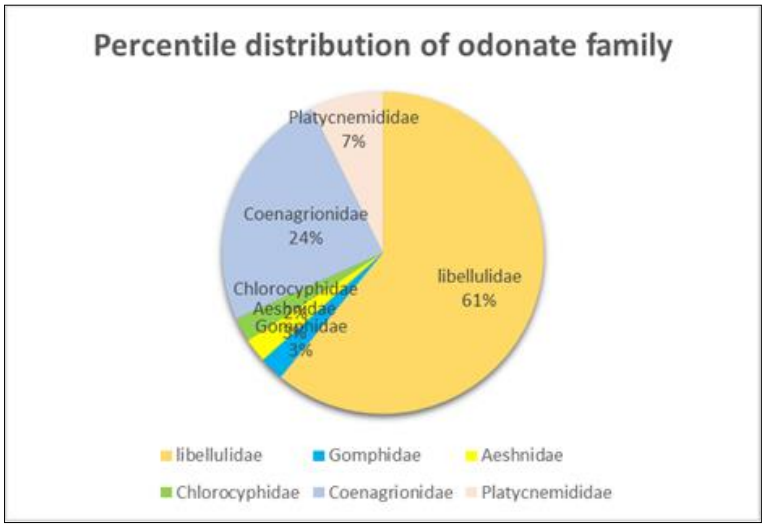

Fig 2: Percentile distribution of Odonate family in the study area

Table 1: Checklist of Odonata recorded from Vembanad-Kole wetlands, a Ramsar site in Kerala, India.

	Name of the species	Common English Name	IUCN Red List Status
	Class: Insecta		
	Order: Odonata		
	Suborder: Anisoptera		
	Family: Aeshnidae		
1	*Gynacantha Dravida*	Brown Darner	DD
	Family: Gomphidae		
2	*Ictinogomphas rapax*	Indian Common Clubtail	LC
	Family: Libellulidae		
3	*Acisoma panorpoides*	Trumpet-Tail	LC
4	*Aethriomanta brevipennis*	Scarlet Marsh Hawk	LC
5	*Brachidiplax chalybea*	Rufous-Backed Marsh Hawk	LC
6	*Brachythemis contaminate*	Ditch Jewel	LC
7	*Bradinopyga germinate*	Granite Ghost	LC
8	*Crocothemis serevilia*	Scarlet Skimmer	LC
9	*Diplacode trivialis*	Blue Ground Skimmer	LC
10	*Hydrobasileus croceus*	Amber winged marsh Glider	LC
11	*Latherecista asiatica*	Asiatic blood tail	LC
11	*Macrodiplax cora*	Estuarine Skimmer	LC
12	*Neurothemis fulvia*	Fulvous Forest Skimmer	LC
13	*Neurothemis tulia*	Pied Paddy Skimmer	LC
14	*Orthetrum Chrysis*	Brown-Backed Marsh Hawk	LC
15	*Orthetrum glaucum*	Blue Marsh Hawk	LC
16	*Orthetrum pruinosm*	Crimson-tailed Marsh Hawk	LC
17	*Orthetrum sabina*	Green Marsh Hawk	LC
18	*Palpopleura sexmaculata*	Blue-tailed Yellow Skimmer	LC
19	*Pantala flavescens*	Globe skimmer	LC
20	*Potamarcha cogner*	Yellow-tailed Ashy Skimmer	LC
21	*Rhodothemis rufa*	Rufous marsh glider	LC
22	*Rhyothemis variegata*	Common picture wing	LC
23	*Tholymis tyllagra*	Coral tailed cloud-wing	LC
24	*Tramea limbate*	Black marsh trotter	LC
25	*Trithemis aurora*	Crimson marsh glider	LC
26	*Urothemis signata*	Scarlet basker	LC
27	*Zyxoma petiolatum*	Brown dusk hawk	
	Suborder: Zygoptera		
	Family: Chlorocyphidae		
28	*Libellago lineata*	River Heliodor	LC
	Family: Coenagrionidae		
29	*Agriocnemis keralensis*	Kerala dartlet	LC
30	*Agriocnemis pieris*	White dartlet	LC
31	*Agriocnemis pygmea*	Pygmy dartlet	LC
32	*Ceriagrion cerenorubellum*	Orange tailed marsh dart	LC
33	*Ceriagrion coromandelianum*	Coromandel marsh dart	LC
34	*Ischnura rubilio*	Western golden dartlet	NE
35	*Ischnura senegalensis*	Common blue tail	LC
36	*Mortonagrion varalli*	Brown dartlet	
37	*Pseudagrion microcephalum*	Blue grass dart	LC
38	*Pseudagrion rubriceps*	Saffron faced grass dart	LC
	Family: Platycnemididae		
39	*Copera marginipes*	Yellow bush dart	LC
40	*Copera vitata*	Blue bush dart	LC
41	*Prodasineura verticalis*	Black bamboo tail	LC

IUCN status: LC—Least Concern | NE—Not Evaluated l DD- Data Deficient

Results and discussion

A total of 41 species belonging to 2 sub-orders, 6 families, and 30 genera were recorded, which include 27 species of Anisoptera and 14 species of Zygoptera (Table 1). The families obtained were Gomphidae, Libellulidae, Aeshnidae, Chlorocyphidae, Coenagrionidae, and Platycnemididae. The order Anisoptera was found to be more diverse and predominant with 27 species, contributing 65%, followed by the order Zygoptera which was less diverse with 14 species and contributed 35% of total odonates recorded from the study area. With 25 species, the Libellulidae family showed the highest species richness and widest distribution. Coenagrionidae (10), Platycnemididae (3), Aeshnidae (1), Gomphidae(1) and Chlorocyphidae(1) were the next families in order of size. The family Libellulidae was found to be dominant in the Indian subcontinent by numerous earlier researchers. The family-wise distribution of odonates is given in Figure. 2. Previous studies on odonates of Kerala also reported Libellulidae as the dominant family (Emiliyamma and Radhakrishnan, 2002; Emiliyamma, 2005; Emiliyamma *et al*., 2005). Damsel fly distribution is lesser than dragonflies recorded

during the study. It might be due to the lesser shade cover. Spread of aquatic vegetation and shade favor damselflies (Fraser, 1933; Subramanian, 2005) [1, 21].

In conclusion, the current study area, the Vembanad wetland system seems to be an important source of support for insects like odonates, with this investigation which records 41 species belonging to 30 genera and six families. The abundance and species richness tends to increase with an increase in the presence of perennial water bodies, good aquatic vegetation, etc. The lower shade levels may be the cause of the comparatively lower number of damselfly species found in the Vembanad. Damselflies are more favored than dragonflies by shade and the expansion of aquatic vegetation (Fraser, 1933; Subramanian, 2005) [1]. It should be noted that all but two of the odonate species identified in the study are classified as Least Concern species by the International Union for the Conservation of Nature and Natural Resources (IUCN, 2020) [5], and none of them are protected under the Wildlife Protection Act of 1972 (MoEF, 2019) [9]. The present investigation on the diversity of odonates will serve as the baseline data for future researchers and investigators for the conservation of odonate species. The wetland faces two main challenges: pesticide use in agriculture without proper control and pollution from untreated sewage inflow (Sujana and Sivaperuman, 2008; Jayson, 2018) [6, 22]. Therefore, researching the odonates in these wetlands will be a great way to learn how they react to different levels of pollution.

Acknowledgments

The authors are grateful to Mahatma Gandhi University for the financial assistance provided in the form of a research fellowship. The authors are also thankful to CMS College, Kottayam for providing the facilities needed to carry out the work.

Declaration of competing interest

The authors affirm that there is no conflict of interest associated with this research

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