INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 25, No. 4, p. 150-156, 2024
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Odonata fauna in adjoining riparian agriland and the riparian urbanland of Muvattupuzha river, Kerala, India

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Article published on October 18, 2024

Key words: Anisoptera, Zygoptera, Urban land, Agriland, Physico-chemical

Abstract

This study, conducted between February and May 2019, coincided with the COVID-19 lockdown period in India. Researchers examined dragonfly (Anisoptera) and damselfly (Zygoptera) assemblages in riparian habitats bordering the Muvattupuzha River, Kerala, India. The investigation revealed a fascinating contrast: odonate diversity was significantly higher in agricultural land than in urban areas. A total of 46 species from nine families were documented across both habitats. The urban zone displayed a community of 19 species, with an even split between dragonflies (19) and damselflies (9). Conversely, the agricultural land teemed with a richer assemblage of 28 species, including a surprising dominance of damselflies (17) compared to dragonflies (11). This finding highlights the potential of agricultural landscapes to support odonate populations, particularly damselflies. Furthermore, the agri-land was a refuge for two endemic Western Ghats species, *Macrogomphus wynaadicus* and *Heliocypha bisignata,* adding to its ecological significance. Researchers conducted a physico-chemical analysis of Muvattupuzha River water samples collected near the study sites to understand potential environmental influences. The analysis revealed variations in 14 measured parameters, which may warrant further investigation to elucidate their role in shaping odonate diversity across these contrasting riparian habitats. The timing of this study, coinciding with the lockdown, offers a unique opportunity to understand how reduced human activity might influence odonate populations. With less traffic and potentially altered land-use patterns during the lockdown, the study provides valuable insights into the potential benefits of reduced anthropogenic pressure on freshwater ecosystems and their biodiversity.

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Introduction

Odonata, which includes dragonflies and damselflies, is an ancient order of insects that first appeared in the Carboniferous period over 300 million years ago (Bora, 2014). They are found on every continent except Antarctica, and their larvae and adults play essential roles in aquatic and terrestrial ecosystems (Samways, 2008). Some species can accept brackish and contaminated water, but most species survive only in freshwater, so they are considered indicators of water quality (Klym, 2003; Harisha, 2018). Both larval and adult stages are predatory for beneficial and harmful insects (Subramanian, 2005). The larval stages of odonates, also known as nymphs, are predators that live in freshwater. They have long, slender bodies with large jaws to catch and eat small aquatic animals like insects, larvae, and even small fish. Nymphs can remain in the larval stage for several years, growing larger and larger until they are ready to metamorphose into adults. Adult odonates are also predators, but they catch their prey in flight. They have large, compound eyes that give them excellent vision, and they can fly at high speeds and make sudden changes in direction. Adult odonates typically eat other insects, such as mosquitoes, flies, and bees. They are also important pollinators, and they help to control populations of pest insects. Odonates are essential members of both aquatic and terrestrial ecosystems. Their larvae help to control populations of aquatic insects, which can be pests of fish and other aquatic organisms. Adult odonates help to control populations of pest insects, and they are also important pollinators. Odonata nymphs usually prey on aquatic insects, diatoms, mosquito larvae, tadpoles, small fishes, etc., and adults feed on other terrestrial and aerial insects in flight, such as grasshoppers, butterflies, bees, moths, mosquitoes, flies, aphids (Subramanian, 2005). They are also cannibalistic (feeding their species).

Materials and methods

The study was conducted from February to May 2019. Opportunistic observations and line transect methods were used to monitor and record the observations systematically. Odonates are mostly seen near water bodies with vegetation. They are active in midday hours, and we observed in the morning, noon and evening hours. Experts identified odonates, in descriptive handbooks such as the common dragonflies and damselflies of Kerala (Emiliyamma *et al.*, 2005), Dragonflies and damselflies of Kerala (Kiran and Raju, 2013) and dragonflies and damselflies of Orissa & eastern India (Nair, 2011). Photographs were taken of all sightings for verification, confirmation, and documentation.

Study area

Muvattupuzha is a prominent old town in the midlands, around 35 km east of downtown Kochi. The city is a growing urban centre in central Kerala and an aspiring new district headquarters. The town is also famous as the starting point of the Muvattupuzha River, which happens by the merging of three rivers – namely Thodupuzhayar (Thodupuzha River), Kaliyar (Kali River) and Kothayar (Kothamangalam River) – to form Muvattupuzha river. The confluence of three rivers, known as the Thriveni Sangama in the local language, translates to Muvattupuzha (Fig. 1&2).

The study was conducted on riparian urban and agricultural land along the Muvattupuzha River (Fig. 3&4). The metropolitan land is located in and around Muvattupuzha town, including buildings, parks, grasslands, and other human-altered habitats. The agricultural land is located in the Vallikadavu locality of Nadukkara village, which is characterised by grasslands and farming plantations. The study aimed to compare the ecological characteristics of the two land types and to identify any potential impacts of urbanisation on the riparian ecosystem. The study found that the urban land had lower levels of biodiversity than the agricultural land and that it was more susceptible to pollution and other environmental stressors. The study also found that the urban land could have been more effective at filtering stormwater runoff, which can lead to water quality problems downstream.

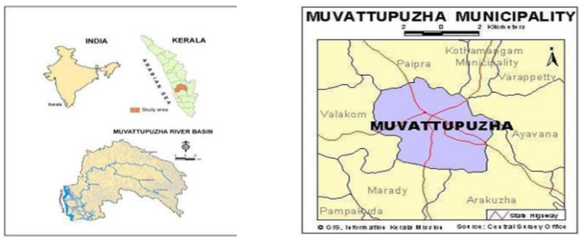

Fig. 1. Map of Muvattupuzha region

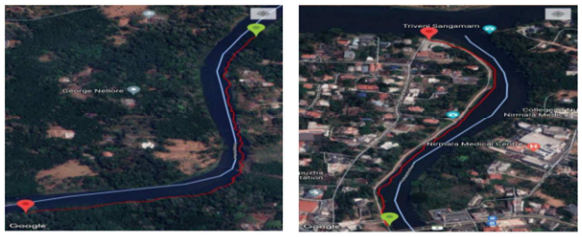

Fig. 2. Transect route of (1) agriland and (2) urban land

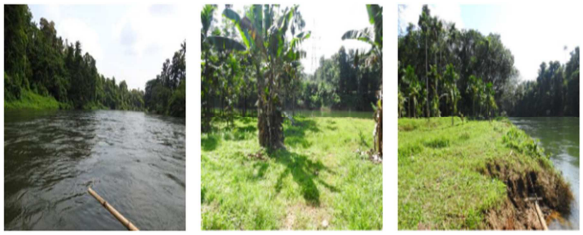

Fig. 3. Muvattupuzha river in agriland region showing the habitat

Fig. 4. Muvattupuzha river in urbanland showing the habitat

The study's findings suggest that urbanisation can harm riparian ecosystems. These findings are essential for policymakers and land managers, who need to be aware of the potential effects of urbanisation on riparian ecosystems and take steps to mitigate these impacts.

Behaviour and habitat

The dragonflies are beautiful and fascinating insects found near water bodies worldwide. Their hovering is mainly for feeding and breeding purposes. They complete their life cycle in the air as adults and in water as nymphs or larvae. The adult and the nymphs are highly predacious in nature and carnivorous, too. Their unique life cycle includes egg, nymph, and adult stages. The lifecycle of damselflies and dragonflies go through incomplete metamorphosis or hemimetabolous metamorphosis, where they lack the pupal stage. Instead, they go through several nymphal stages called instars before they undergo a final moult into their adult form consisting of three stages of the life cycle starting with the laying of the eggs in water bodies, to the underwater nymph life as voracious predators, and the final emergence into adult dragonflies or damselflies as predators of the sky (Bybee, 2016). The odonates can be found in streams, rivers, ponds, lakes, and wetlands. They live where water is slow-moving or still and are mostly found in shallow freshwater habitats. Adult dragonflies often stay near water but sometimes travel away from water while hunting or on migration. Some dragonflies are more tolerant of shade than others, and very few prefer it. Still, most dragonflies could be described as flying solar panels – without direct sunlight, they can't drift themselves and fly (Corbet, 1999).

Odonata as water quality indicators

The correlation between odonata diversity and water quality is now well-established through various studies (Jacob *et al.*, 2017). For the present work, the present study used the inverse correlation to estimate the water quality in the study areas by observing the population of observed odonates in those regions. The method is followed since odonates spend a long period of their life cycle in aquatic habitats and can thus give more reliable estimates of the ecosystem's health in contrast to local and temporal chemical tests.

It is to be noted that *Brachythemis contaminata* is found only in very bad conditions and is thus a sure indicator of contaminated water. Most other species have varying adaptability, though they are seen only marginally in similar circumstances. The most probable reason for this could be their inability to

breed and survive in polluted environments. Also, it proves that the species *Brachythemis contaminata* is more resistant to contaminated waters.

Water samples were collected from both the regions, agriland and urban land of Muvattupuzha River by the end of May-June months, and the physicochemical parameters were analysed. The samples of the agriland region were analysed at the Central Inland Fisheries Research Centre (CIFRC), Kochi and of the urban land in Albio Biotechnology Lab, Muvattupuzha.

The Physicochemical parameters measured are Total alkalinity, Calcium, Ammonia, Total hardness, Conductivity, Phosphate, Nitrate, COD, Salinity, TDS, Nitrite, Dissolved oxygen, pH, and BOD.

Results and discussion

The most important finding of this study was that the number of dragonfly species occurring in riparian urban land was not significantly different than that of riparian agriland. However, riparian agri-land collectively had a numerically greater representation of total species (Table 1).

Table 1. Checklist of odonate species from study areas, indicates the species-wise classification of odonates collected from both areas

Suborder	Family	No.	Common name	Scientific name	Area 1-agriland	Area 2-urbanland	IUCN status
Anisoptera	Gomphidae	1.		*Macrogomphus wynaadicus* (Fraser,1924)	+	-	VU
		2.	Lined hooktail	*Paragomphus lineatus* (Selys,1850)	+	-	LC
		3.	Indian common clubtail	*Ictinogomphus rapax* (Rambur, 1842)	-	+	LC
	Libellulidae	4.	Trumpet tail	*Acisoma panorpoides* (Rambur, 1842)	-	+	LC
		5.	Scarlet marsh hawk	*Aethriamanta brevipennis* (Rambur, 1842)	-	+	LC
		6.	Rufous-Backed Marsh Hawk	*Brachydiplax chalybea* (Brauer, 1868)	-	+	LC
		7.	Ditch jewel	*Brachythemis contaminata* (Fabricius,1793)	-	+	LC
		8.	Granite ghost	*Bradinopyga geminata* (Rambur,1842)	-	+	LC
		9.	Ground skimmer	*Diplacodes trivialis* (Rambur,1842)	-	+	LC
		10.	Asiatic blood tail	*Lathrecista asiatica* (Fabricius,1798)	+	-	LC
		11.	Fulvous forest skimmer	*Neurothemis fulvia* (Drury, 1773)	-	+	LC
		12.	Pied paddy skimmer	*Neurothemis tullia* (Drury,1773)	+	+	LC
		13.	Stellate river hawk	*Onychothemis testacea* (Laidlaw, 1902)	+	-	LC
		14.	Brown-backed red marsh hawk	*Orthetrum chrysis* (Selys,1891)	-	+	LC
		15.	Green marsh hawk	*Orthetrum sabina* (Drury,1770)	+	+	LC
		16.	Marsh skimmer	*Orthetrum luzonicum* (Brauer,1868)	+	+	LC
		17.	Crimson-tailed marsh hawk	*Orthetrum pruinosum* (Burmeister,1839)	-	+	LC
		18.	Small skimmer	*Orthetrum taeniolatum* (Schneider, 1845)	-	+	LC
		19.	Yellow-tailed ashy skimmer	*Potamarcha congener* (Rambur, 1842)	-	+	LC
		20.	Common picture wing	*Rhyothemis variegata* (Linnaeus, 1763)	+	+	LC
		21.	Voyaging glider	*Tramea limbata* (Desjardins, 1832)	-	+	LC

	22.	Crimson marsh glider	*Trithemis aurora* (Burmeister, 1839)	+	+	LC
	23.	Black stream glider	*Trithemis festiva* (Rambur, 1842)	+	-	LC
	24.	Long-legged marsh glider	*Trithemis pallidinervis* (Kirby, 1889)	-	+	LC
Synthemistidae	25.		*Macromidia donaldi* (Fraser, 1924)	+	-	LC
	26.	Stream ruby	*Heliocypha bisignata* (Hagen in Selys, 1853)	+	-	LC
Chlorocyphidae	27.	River heliodor	Libellago lineata (Burmeister,1839)	+	-	LC
Calopterygidae	28.	Stream glory	*Neurobasis chinensis* (Linnaeus,1758)	+	-	LC
	29.	Black tipped forest glory	*Vestalis apicalis* (Selys,1873)	+	-	LC
	30.	Clear winged forest glory	*Vestalis gracilis* (Rambur,1842)	+	-	NT
Coenagrionidae	31.	Green striped slender dartlet	*Aciagrion occidentale* (Laidlaw,1919)	+	-	LC
	32.	White dartlet	*Agriocnemis pieris* (Laidlaw,1919)	-	+	LC
	33.	Pygmy dartlet	*Agriocnemis pygmaea* (Rambur,1842)	+	+	LC
	34.	Orange tailed marsh dart	*Ceriagrion cerinorubellum* (Brauer,1865)	+	+	LC
	35.	Coromandel marsh dart	*Ceriagrion coromandelianum* (Fabricius,1798)	-	+	LC
	36.	Rusty marsh dart	*Ceriagrion olivaceum* (Fraser,1924)	-	+	LC
	37.	Golden dartlet	*Ischnura rubilio* (Braner, 1865)	+	+	LC
	38.	Common bluetail	*Ischnura senegalensis* (Rambur,1842)	+	+	LC
	39.	Three striped blue dart	*Pseudagrion decorum* (Rambur,1842)	+	-	LC
	40.	Yellow striped blue dart	*Pseudagrion indicum* (Fraser, 1924)	+	-	LC
	41.	Blue grass dart	*Pseudagrion microcephalum* (Rambur, 1842)	+	-	LC
	42.	Saffron faced blue dart	*Pseudagrion rubriceps* (Selys, 1876)	+	-	LC
Euphaeidae	43.	Black torrent dart	*Dysphaea ethela* (Fraser, 1924)	+	-	LC
Lestidae	44.	Sapphire eyed spreadwing	*Lestes praemorsus* (Hagen in Selys, 1862)	-	+	LC
Platycnemididae	45.	Yellow bush dart	*Copera marginipes* (Rambur,1842)	+	+	LC
	46.	Red striped black bamboo tail	*Prodasineura verticalis* (Selys, 1860)	+	-	LC

Zygoptera

A total of 46 species from 9 families were observed, in which 30 species belong to Anisoptera and 26 belong to Zygoptera. The families observed are Gomphidae, Libellulidae and Synthemistidae under Anisoptera and Calopterygidae, Chlorocyphidae, Coenagriondidae, Euphaeidae, Lestidae, Platycnemididae under Zygoptera. Highest number of species found in Libellulidae (n=21) followed by Coenagriondidae (n=12), Gomphidae (n=3), Calopterygidae (n=3), Platycnemididae (n=2), Chlorocyphidae (n=2), Euphaeidae (n=1), Lestidae (n=1), Synthemistidae (n=1). The most abundant species seen in urban land was *Neurothemis tullia, Orthetrum chrysis* in Anisoptera and *Agriocnemis pieris* in Zygoptera. And from agri land, *Rhyothemis variegate* in Anisoptera and *Libellago lineate*, *Prodasineura verticalis, and Dysphaea ethela* in Zygoptera. The least observed species in riparian urban land were *Ictinogomphus rapax* and *Brachydiplax chalybea* in Anisoptera and *Ischnura*

senegalensis and *Copera marginipes* in Zygoptera. And from riparian agri land *Lathrecista asiatica* and *Paragomphus lineatus* in Anisoptera and *Aciagrion occidentale, Ceriagrion cerenorubellum, Ischnura rubilio, Vestalis gracilis* in Zygoptera.

In the agri land region, Zygoptera (n=17) was more than Anisoptera (n=11), whereas in the urban land, Anisoptera (n=19) was more than Zygoptera (n=9). Urban land has buildings, and small grass-covered land has artificial ponds and parks. *Lestes praemorsus* (Hagen in Selys, 1862) is a damselfly in the family Lestidae, commonly called spread wing was observed in urban land. Agri land is a site that has river banks with vegetation areas, so there were females as well as males. The natural ponds in the agri land are active with Zygopterans rather than Anisopterans. We could observe *Macrogomphus wynaadicus* (Fraser, 1924), which is a threatened species endemic to the Western Ghats, and *Macromidia donaldi* which is only found in India and Sri Lanka, was reported in the agri land,. All other species are least concerned. The females were seen in the vegetative areas and reached the water bodies only for mating and egg-laying. The males were seen hovering near the water bodies. In agri land, we could observe most of the behavioural activities like mating-courtship behaviour from simple postures to display occurs and a favourable female pair with a potential male followed by tandem position and wheel position (Subramanian, 2005), Egg laying or oviposition occurs soon after mating, and a female lays hundreds to thousands of eggs per batch (Nair, 2011). Congregation & roosting is the assemblage of more than two individuals at one spot. At night, some odonates roost among vegetation or up in the canopy of large trees (Joseph and Lahiri, 1989).

Obelisk posture is the handstand-like position in odonates to maintain thermoregulation during sunny days. Territorial fight -Mature males hold their territory but other males try to enter, and the inhabited male shows aggressiveness from simple wing warning to fight in flight, etc. All the above said behavioural phenomena are indications of undisturbed agriland concerning the polluted and disturbed urban land. Also, the abundance of *Brachythemis contaminata* species in urban land irrespective of agriland proclaims *Brachythemis contaminata* as water pollution indicators. Also, we could observe *Neurobasis chinensis*, *Vestalis apicalis*, *Vestalis gracilis*, and species of damselflies (Zygoptera) in agriland, which is also an indication of pollution-free water. We tested the quality of water of both urban land and agriland with the help of analysing the physicochemical as well as the biological parameters concerning the normal standard range.

Table 2. Physico-chemical properties of water in urban land and agriland regions

SL	Parameters of water analysis	Normal range	Sample results	
			Urbanland region	Agriland region
1.	Total alkalinity (mg/l)	25-100	20	28.0
2.	Calcium (mg/l))	4-160	8.0	9.6
3.	Ammonia (mg/l)	-	BDL	Nil
4.	Total hardness (mg/l)	>20	30	100
5.	Conductivity (µS/cm)	150-600	143.5	88.2
6.	Phosphate (mg/l)	0.01-3	BDL	Traces
7.	Nitrate (mg/l)	0-100	8.0	4.0
8.	COD (mg/l)	-	9.9	92
9.	Salinity (ppm)	-	0.01	Nil
10.	TDS (ppm)	-	70.24	56.4
11.	Nitrite (mg/l)	-	0.2	Traces
12.	Dissolved oxygen (mg/l)	3-5	1.8	4.5
13.	pH	6.5-8.5	5.25	6.59
14.	BOD (mg/l)	>4.0	0.8	3.6

The Physicochemical parameters of water greatly influence the species richness (Table 2). A total of 14 parameters were taken. An important parameter is pH, which can make changes in the biological activities (Susmita, 2016) of the species. The normal pH range is 6.5 to 8.5. Agri land has a 6.59,

and urban land has a 5.25 pH range. TDS level was 56.4 mg/l in agri land and 70.24 mg/l in urban land. The usual range of total alkalinity is 25 – 100 mg/l, agri land has 28 mg/l, and urban land has 20 mg/l. The total hardness of water in agri land was 100 mg/l, and in urban land was 30 mg/l. The dissolved oxygen level in agri land was 4.5, and in urban land was 1.8, the normal range is 3-5 mg/l. The normal BOD level is >4 mg/l. But in agri land, it was 3.6 mg/l which is close to the normal level, and in urban land it was 0.8 mg/l.

Macrogomphus wynaadicus- A medium-sized dragonfly from the family Gomphidae was found in the agri land stream. *Heliocypha bisignata*- Endemic to South India were also found in the small irrigation channels of agri land. *Macromidia donaldi*- a species from the Synthemistidae family was seen near streams with vegetation and mostly perched on twigs of tree branches above 3 m from the ground (Payra *et al.,* 2022).

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