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The Odonate fauna (Insecta: Odonata) of agro and riparian ecosystems in Malappuram district, Kerala: A preliminary assessment and comparison

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Abstract
Odonates represent some of the most recognizable insects and are sensitive; it will react immediately to even a small fraction of changes in the habitat. It prefers live freshwater, non-polluted and oxygenated habitats so they may be taken as an indicator of ecosystem quality. The present study investigated to identify and compare the diversity of odonates in agro and riparian ecosystems in Malappuram district, Kerala during June 2021 to April 2022.Total of 689 odonates consisting of 22 different species categorized under 5 different families were observed. In the agro ecosystem a total of 484 odonates categorized under 3 families were observed. Riparian ecosystems total of 205 odonates categorized under 4 different families were observed. The odonata diversity found in this ecosystem shows that the damselfly family ceonagrionidae is the most dominant. Both the ecosystems showed maximum species richness during monsoon and post monsoon season (July to October). It might be due to the fact that it is the harvesting period of many paddy fields and availability of plenty of rain water.

Keywords: Odonates, agro ecosystem, riparian ecosystem, past, species richness, simpson index, shannon index

Introduction

Insects are the abundant invertebrate animals representing the most diverse and largest class of phylum arthropoda. The numbers of insects known have 6-8 million species which represents 90% of total animal life on earth (Chapman, 2006 [4]; Novotny, 2002 [11]; Erwin, 1982) [6]. They are known to have existed in almost all environments with their highest abundance seen in tropics. Odonates (the collective term for dragonflies and damselflies) represent some of the most recognizable insects found in nature. Biologically, the dragonflies (Anisoptera) and damselflies (Zygoptera) represent the two suborders that make up the order ‘odonata': meaning "toothed ones" in Latin. Odonata are an important predatory order, the odonate larvae are in aquatic habitat and the adults are excellent aerial predators. The insect possesses a pair of large compound eyes which helps to capture the prey comfortably. Damselflies tend to be less robust, appearing weak in flight. Most species hold their wings folded back over the abdomen at rest. Dragonfly eyes occupy much of the animal's head, nearly touching each other across the face. The odonate life cycle begins with eggs deposited in water; lakes, ponds, streams, rivers, bogs and woodland seeps all support populations of different species of odonates. Eggs develop into nymphs which typically spend about a year (sometimes more) living and developing as aquatic insects before being ready to emerge as adults. The male odonates have a copulatory organ on the ventral side of abdominal segment 2 in which they store spermatozoa. They mate by holding the female's head (Anisoptera) or thorax (Zygoptera) with claspers located at the tip of the male abdomen. The female odonate bends abdomen forward to touch the male organ and receive sperm. Globally there is an estimate of 6256 species distributed in 39 families under 686 genera (Subramanian and Babu, 2017) [13]. The 39 families fall into 3 distinct suborders consisting of 27 families under Suborder Zygoptera and 11 families under Suborder Anisoptera and only one family in Anisozygoptera. About 488 species and 27 subspecies distributed in 154 genera and 18 families are known to be existing in India. This insect order is said to be abundantly found in Western Ghats, Eastern Himalayas and Andaman Nicobar Island in India. About 154 species spreading in 74 genera and 13 families are distributed in Kerala (Kiran and Raju, 2011) [9]. Odonates are so sensitive and it will react immediately to even a small fraction of changes in the habitation. It prefers live freshwater, non-polluted and oxygenated habitats (Manwar *et al*., 2014) so they may be taken as an indicator of ecosystem quality.

Materials and Methods

The present study investigated the diversity of Odonates in 2 different ecosystems of Kalpakanchery (station-1) and Valavannur (station-2) Panchayath of Malappuram district during June 2021 to April 2022. The agro and riparian ecosystems respectively seen in Station 1 and station 2 were selected for the comparative study. The selection of adopting these 2 ecosystems is mainly due to the high occurrence of this particular insect fauna for various reasons such as pest management strategies, food source availability and role in nutrient recycling. This ecosystem generally depends upon various climatic, hydrological and ecological environments and hence the biodiversity of each area will also change. Aquatic ecosystems situated in Kalpakanchery and Valavannur have been selected for the study. It is located between latitude – 10.9445 and longitude – 75.9821 (Kalpakanchery) and latitude-11.9207 and longitude-79.5800 (Valavannur). The major vegetation found here are paddy, banana plantations, crop varieties etc.

The collection of odonata specimens was carried out four times in a month and mean value is taken as final. Sampling exercise was usually done between 9:00am and 4:00pm. Odonates collected by using sweep nets and direct hand collection methods. A killing jar is used to kill captured insects quickly and with minimum damage. Collected specimens dried as such and the water content was removed and decaying activity was stopped. Before displaying, posture should be maintained and pinning is important to avoid breakage and to demonstrate each part clearly and

make collection neat and clean. The spreading board is used to spread the wings for taxonomic study. The collected odonates are pinned with a minute, fine entomological pin through the thorax. The specimens were identified on the basis of the external morphology and available keys.
The analyses were done using paleontological statistics software (PAST) (version 4.03).

Results and Discussion
The Present study investigated the pattern of diversity of odonata in agro and riparian ecosystems of Station 1 and Station 2 respectively. Total of 689 odonates consisting of 22 different species were observed during the study period of June 2021 to April 2022. Both agro and riparian ecosystems showed differences in the pattern of distribution during the season (June to April). In agro-ecosystem a total of 484 odonates are categorized. The odonata diversity found in this ecosystem shows that the Anisopteran family Libellulidae was the most dominant and followed by Ceonagrionidae and Aeshnidae. From these 484 individuals 344 were collected from station-1and 140 were collected from station-2. As this study was conducted during June to April, maximum abundance was seen from July to October. The seasonal variation of the representing members and their Family distribution are tabulated (Table 1 & 2). In riparian ecosystems a total of 205 odonates were reported; generally depending upon various climatic, hydrological and ecological environments. The odonata diversity found in this ecosystem shows that the damselfly family ceonagrionidae is the most dominant and species rich family followed by Plactinemida, Libellulidae and calopterygidae. From these 205 individuals 168 were collected from station-1 and 37 were collected from station-2. As the odonates are strictly confined to live in an unpolluted environment, reduction in the number of individuals in station2 revealed that the water in this ecosystem is somewhat polluted. The seasonal variation of the representing members and their family distribution are tabulated in (Table 1 & 2). It is relevant in ecology to understand the distribution pattern of the organisms and the pressures that determine them (Apodaca and Chapman, 2004) [2]. The occurrence of different species completely depends on the prevailing season (Akshad, M. A. 2021) [1]. There occurs a significant seasonal variation in all the biotopes or transect (agro and riparian system) taken under study. In the current study high density and species richness of odonates were found in the dragonfly family libellulidae (Anisoptera) consisting of 12 species (Table 1 & 2). This is according to the study of Shelton and Edwards (1983). Which include *Acisoma panorpoides, Agriocnemis pygmea, Brachythemis contaminate, Bradinopyga geminate, Diplocodes trivialis, Neurothemis fulvia, Neurothemis intermedia, Nerothemis tullia, Orthetrum pruinosm, Orthetrum Sabina, Pantala flavescence, Rhyothemis veriegata, Thylomis tillarga, Trithemis aurora*. High species richness of this family has been attributed to its tolerance to a wide range of habitats (Sam ways, 1989) [12], shorter life cycle and also being predators of various crop pests. In general, like Libellulidae (Anisoptera), Coenagrionidae is also most common family (Arulprakash and Gunathilagaraj, 2010) [3] on the basis of its abundance and richness due to shorter life cycle, widespread distribution and tolerant to wide range of habitats.

Hence the high species richness of this ecosystem showed dragonflies selected agricultural landscapes for getting sufficient shelter or forage. The riparian ecosystem, unlike agro-ecosystem, showed the existence of 4 different families. Here irrespective of agro-ecosystems damselflies of the coenagrionidae family were more dominant (Table 1 & 2). The existence of damselflies in this habitat is mainly due to the presence of macrophytes and also for doing several key activities like foraging, roosting / sheltering, predator avoidance, oviposition, etc. The studies revealed that riparian vegetation promotes the occurrence of invertebrates including insects and facilitates suitable habitat for insects by providing food, resting and hiding places for emergent adults and substratum for egg laying. The damselfly species richness in the riparian ecosystem can be considered as valuable biological indicators of freshwater ecosystem integrity. The diversity indices of odonates are maximum in the rainy season (Table 1 & 2), when humidity and temperature were favourable for growth and development (1-D≥0.85 & H ≥2.01) (Table 3 & 4). The seasonal variation probably due to availability of bushes was high during monsoon months and they are flying from sub marginal plants as well as some water plants. The minimum number of odonates reported in pre monsoon season in both agro (1-D≥0.812 & H ≥1.96) and riparian (1-D≥0.72 & H ≥1.33) ecosystems (Table 3 & 4). The average number of odonates were reported in post-monsoon season reported from both agro (1-D≥0.824 & H ≥2.012) and riparian (1-D≥0.765 & H ≥1.52) ecosystem (Table 3 & 4)

Conclusion
The odonata diversity investigated in both agro and riparian ecosystems showed marked differences in the concerned study period. Total of 689 odonates consisting of 22 different species were observed during the study period of June 2021 to April 2022. In agro-ecosystem a total of 484 odonates and in riparian ecosystems a total of 205 odonates were reported. Both agro and riparian ecosystems showed differences in the pattern of distribution during the season (June to April). Both the ecosystem showed maximum species richness during Monsoon and Post monsoon season (July to October). It might be due to the fact that it is the harvesting period of many paddy fields and availability of plenty of rain water. The comparative study showed that the agro-ecosystem was found to be the most diverse and species rich study area compared with the riparian ecosystem due to favourable environmental conditions. The agro-ecosystem showed maximum number of dragonfly members while riparian ecosystem by damselfly species due to the high availability of pest species for dragonflies and low dispersal ability of damselflies. As they can be used to control pest populations in agro-ecosystem and confined to live in unpolluted environments, this particular fauna can be used as an indicator of a healthy ecosystem.

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Table 1: Seasonal variation of Odonata in Station 1 (June 2021-April 2022)

Sl No	Species	Agro- Ecosystem			Riparian Ecosystem		
		Premonsoon	Monsoon	Postmonsoon	Premonsoon	Monsoon	postmonsoon
Sub-order: Zygoptera							
1	*Vestalis apicalis*	0	0	0	0	6	5
2	*Aciagrion occidentale*	2	9	1	1	4	0
3	*Ceriagrion cerinorubellum*	0	0	0	0	3	3
4	*Ceriagrion coromandelianum*	0	0	0	0	2	0
5	*Ischnura aurora*	0	2	0	1	0	0
6	*Copera marginipes*	0	0	0	0	4	3
7	*Copera vittata*	0	0	0	0	6	4
Sub-order: Anisoptera							
8	*Aeshna grandis*	0	1	0	0	0	0
9	*Acisoma panorpoides*	0	0	0	1	4	3
10	*Agriocnemis pygmaea*	0	1	0	0	0	0
11	*Brachythemis contaminate*	15	29	18	0	0	0
12	*Bradinopyga geminate*	0	0	0	2	5	3
13	*Diplacodes trivialis*	2	3	3	3	8	4
14	*Neurothemis fulvia*	1	2	2	0	0	0
15	*Neurothemis intermedia*	2	15	8	2	20	3
16	*Neurothemis tullia*	9	30	11	2	18	10
17	*Orthetrum pruinosum*	0	5	0	0	0	0
18	*Orthetrum sabina*	3	5	4	2	8	5
19	*Pantala flavescens*	22	49	28	0	0	0
20	*Rhyothemis variegate*	2	12	4	4	5	4
21	*Thylomis tillarga*	5	6	4	0	0	0
22	*Trithemis aurora*	5	18	6	1	5	4

Table 2: Seasonal variation of Odonata in Station 2 (June 2021-April 2022)

Sl no	Species	Agro- Ecosystem			Riparian Ecosystem		
		Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Sub-order: Zygoptera							
1	*Vestalis apicalis*	0	0	0	0	4	2
2	*Aciagrion occidentale*	1	2	1	1	3	2
3	*Ceriagrion cerinorubellum*	2	4	1	2	5	3
4	*Ceriagrioncoromandelianum*	0	3	1	0	2	0
5	*Ischnura aurora*	0	0	0	0	0	0
6	*Copera marginipes*	0	0	0	1	3	1
7	*Copera vittata*	0	0	0	0	0	0
Sub-order: Anisoptera							
8	*Aeshna grandis*	0	0	0	0	0	0
9	*Acisoma panorpoides*	2	4	2	0	0	0
10	*Agriocnemis pygmaea*	0	0	0	0	0	0
11	*Brachythemis contaminate*	0	0	0	0	0	0
12	*Bradinopyga geminate*	2	7	1	0	0	0
13	*Diplacodes trivialis*	3	10	2	0	0	0
14	*Neurothemis fulvia*	0	0	0	0	0	0
15	*Neurothemis intermedia*	4	16	5	0	0	0
16	*Neurothemis tullia*	6	15	9	0	2	0
17	*Orthetrum pruinosum*	0	0	0	0	0	0
18	*Orthetrum sabina*	2	8	5	0	0	0
19	*Pantala flavescens*	0	0	0	0	0	0
20	*Rhyothemis variegate*	2	6	4	1	2	1
21	*Thylomis tillarga*	0	0	0	0	2	0
22	*Trithemis aurora*	2	6	2	0	0	0

Table 3: Showing the seasonal diversity index of Odonates in Station 1.

Indices	Agro ecosystem			Riparian ecosystem		
	Pre	Monsoon	Post	Pre	Monsoon	Post
Dominance_D	0.1873	0.1464	0.1756	0.1247	0.1104	0.09958
Simpson_1-D	0.8127	0.8536	0.8244	0.8753	0.8896	0.9004
Shannon_H	1.965	2.181	2.012	2.187	2.42	2.407
Margalef	2.37	2.485	2.228	3.057	2.835	2.798

Table 4: Showing the seasonal diversity index of Odonates in Station 2.

Indices	Agro ecosystem			Riparian ecosystem		
	Pre	Monsoon	Post	Pre	Monsoon	Post
Dominance_D	0.1272	0.1236	0.1497	0.28	0.1418	0.2346
Simpson_1-D	0.8728	0.8764	0.8503	0.72	0.8582	0.7654
Shannon_H	2.185	2.227	2.115	1.332	2.017	1.523
Margalef	2.762	2.276	2.86	1.864	2.233	1.82

Odonates collected from the Station 1and 2

Ceriagrion coromandelianum

Ceriagrion cerinorubellum

Agriocnemis pygmaea

Ischnura aurora

Aciagrion occidentale

Copera marginipes

Coperavittata

Vestalisapicalis

OrthetrumSabina

Neurothemis intermedia

Trithemis aurora

Brachythemis contaminate

Diplacodestrivalis

Bradinopygageminate

Rhyothemisvariegate

Pantala flavescence

Acisoma panorpoides

Neurothemis tullia, male

Neurothemistullia, Female

Neurothemis fulvia, male

Neurothemis fulvia, Female

Orthetrum pruinosum

Thylomis tillarga

Aeshna grandis

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