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Efficacy of Odonates as Biological Indicators of Water Quality

Aleena Elizabeth Cyril[1]* and Manju E.K.[2]

[1]PG & Research Department of Zoology, Nirmala College, Muvattupuzha,
aleenaelizabethcyril@gmail.com
[2]Department of Zoology, Alphonsa College, Pala

ABSTRACT

Order Odonata which include dragonflies and damselflies are a group of carnivorous aquatic insects. Their lifecycle is intricately linked to waterbodies in both nymph and adult stages. The study analyses the relationship between water quality and Odonate diversity. Six ponds were studied for a period of six months from September 2015 to April 2016. The study period was divided into Monsoon (Sep - Nov, 2015) and Post monsoon (Feb - Apr, 2016). Nine water quality parameters namely, pH, EC, TDS, hardness, alkalinity, DO, BOD, COD and nitrate were analysed during the study period. Water Quality Index and Simpson's Diversity Index were calculated. 43 species of odonates – 18 damselflies and 25 dragonflies - belonging to seven families were identified. The Water Quality Index value was comparatively higher in the 'Monsoon' season. The Simpson's Diversity Index was also highest (0.95) in the Monsoon. A comparison between Water Quality Index values and Simpson's Diversity Index values showed that Odonate diversity increased with increase in the water quality in both the seasons and in all the six sites.

Keywords: Odonata, Bioindicator, Zygoptera, Anisoptera, WQI, Water quality.

INTRODUCTION

In spite of their fundamental importance to humans, freshwater ecosystems have been severely affected by a multitude of anthropogenic disturbances. Ponds are especially vulnerable to pollution stresses because their small size limits their buffering capacity compared to rivers or larger lakes [1]. Water quality is a measure of the condition of water relative to the requirements of biotic species or to any human need [2]. It is determined by many physical, chemical and biological factors [3]. The complexity associated with analyzing the large number of measured variables makes waterquality analysis tedious [4]. As a solution, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a waterbody with a single number. That number is placed on a relative scale that rates the water quality from very bad to excellent [5].

The traditional water quality monitoring approach has been to collect water samples and analyze them for suspected physical and chemical pollutants [6]. Since concentrations of pollutants vary greatly with time and location, physical and chemical monitoring alone often cannot detect all pollution related problems within watersheds [6]. Because most of the physical and chemical analysis are expensive and labor intensive, biological assessment methods of aquatic environments offer a feasible approach.

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Biomonitoring, incorporates the use of stream organisms like macroinvertebrates, for pollution detection [6]. By monitoring organisms in addition to physical/chemical attributes a temporal aspect is inherently introduced since organisms incorporate past, as well as present, conditions [7]. The life history of odonates is interwoven with water bodies. They depend on waterbodies to survive their nymphal stage and as oviposition sites. Dragonflies and damselflies are collectively called odonates. Based on morphology, the order Odonata are divided into three groups, viz. damselflies (Zygoptera), Anisozygoptera and dragonflies (Anisoptera). Odonates are relatively easy to identify; they are very sensitive to changes in environmental conditions; the monitoring process can be carried out on a regular basis on a very cost-effective budget. All of these advantages indicate that dragonflies, which play many important ecological roles in aquatic ecosystems, may become one of our most important allies in documenting the effects of water pollution.

The study 'Associations of dragonflies (Odonata) to habitat variables within the Maltese Islands: A spatiotemporal approach' [8] investigates how odonate assemblage, structure and diversity are associated with habitat variables of local breeding habitats and the surrounding agricultural landscapes. 'Impact assessment of dragonfly diversity in different wetland ecosystems in Coimbatore with special reference to abiotic factors' [9] reveals that diversity of dragonflies was high during the month of December because water levels where considerably high. Taxonomic study of Odonata [Insecta] in Kolkata and surroundings, West Bengal, India [10] states that urban ponds or lakes where aquatic vegetation is very less or regularly been cleared, showed presence of limited number of species. The study 'Potential of Odonate (Dragonflies and Damselflies) Diversity as a Bioindicator of Water Quality' conducted in Kottayam, Kerala, India on lentic waterbodies has shown that odonate diversities and water quality index of the pond or river is highly related [11].

The present study analyzes the suitability of using Odonates as biological indicators of water quality by comparing the relationship between water quality index and odonate diversity.

METHODOLOGY

The study period was classified into 'Monsoon' (September- November 2015) and 'Post-monsoon' (February - April 2016) seasons. Six lentic sites were selected. Four sites were located in Elanji Gramapanchayath and two in Pala Municipality, Kerala, India.

Nine important water quality parameters namely, pH, TDS, EC, DO, BOD, COD, Hardness, Alkalinity and Nitrate were analyzed for all water samples. Water Quality Index was calculated as per standard values of ICMR/BIS. The parameter value obtained from the analysis was multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting value were added together to arrive at an overall water quality index (WQI).

$$\mathbf{WQI = \sum Wi \times Vr}$$

Where, $Wi \propto 1/Vi$ or $\mathbf{Wi = k/ Vi}$, k= constant of proportionality, Wi = Unit weight of factor, Vi = maximum permissible limits as recommended by ICMR/ Public health Environmental Engineering Organization.

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Value of k is calculated as:

$$\mathbf{k = \frac{1}{\sum 1/Vi}}$$

The rating scale was prepared for the range of values of each parameter. The rating varies from 0 (polluted) to 100(excellent) and is divided into five intervals. This scale is based on the version of rating scale given by [12]. The Water Quality Index is the sum of the product of rating (Vr) and unit weight (Wi) of all the factors.

i.e. $WQI = Wi_{(pH)} \times Vr_{(pH)} + Wi_{(EC)} \times Vr_{(EC)} + Wi_{(TDS)} \times Vr_{(TDS)} + Wi_{(Alkalinity)} \times Vr_{(Alkalinity)} + Wi_{(Chlorinity)} \times Vr_{(Chlorinity)} + Wi_{(Hardness)} \times Vr_{(Hardness)} + Wi_{(DO)} \times Vr_{(DO)} + Wi_{(BOD)} \times Vr_{(BOD)} + Wi_{(COD)} \times Vr_{(COD)} + Wi_{(Nitrate)} \times Vr_{(Nitrate)}$

Table 1.WQI ranges [12].

Value of WQI	Quality of water
90 - 100	Excellent
70 - 90	Good
50 - 70	Medium
25 - 50	Bad
0 - 25	Very Bad

Odonate diversity was recorded once every month in the morning from 9:30am – 12:00 pm for six months. Observed specimens were photographed, recorded and identified. The species identification was done with the help of ‘Dragonflies and Damselflies of Kerala (Keralathile Thumbikal)’ [13]. The water quality Index and diversity index value were analysed seasonwise and site specifically to reveal their relationship.

RESULTS AND DISCUSSION

Species Diversity:

A Total of 43 species of odonates belonging to seven families were observed from the six sites during the study period. It includes 18 Zygopterans (damselflies) and 25 Anisopterans (dragonflies). The observed damselflies belonged to four different families, namely Calopterygidae, Coenagrionidae, Lestidae, Platycnemididae and Protoneuridae. The two families of dragonflies observed were Gomphidae and Libellulidae. Libellulidae with 24 sps (55% of odonates observed), is the dominant family recorded during the study. Coenagrionidae with 13 sps was the most dominant Zygopteran family. The odonates observed during the study period are listed family wise in the following table

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Table 2. Odonates observed during the study period

Sl. no	Dragonflies	Scientific name	Sl. no	Damselflies	Scientific name
	Family: Gomphidae			**Family: Calopterygidae**	
1	Common Clubtail	*Ictinogomphus rapax*	1	Black Tipped Forest Glory	*Vestalis apicalis*
	Family: Libellulidae		2	Clear Winged Forest Glory	*Vestalis gracilis*
2	Black Marsh Glider	*Tramea limbata*		**Family: Coenagrionidae**	
3	Brown Backed Red Marsh Hawk	*Orthetrum chrysis*	3	Blue Grass Dart	*Pseudagrion microcephalum*
4	Brown Dusk Hawk	*Zyxomma petiolatum*	4	Coromandel Marsh Dart	*Ceriagrion coromandelianum*
5	Common Picturewing	*Rhyothemis variegata*	5	Golden Dartlet	*Ischnura aurora*
6	Crimson Marsh Glider	*Trithemis aurora*	6	Kerala Dartlet	*Agriocnemis keralensis*
7	Crimson Tailed Marsh Hawk	*Orthetrum pruinosum*	7	Orange Tail Marsh Dart	*Ceriagrion cerinorubellum*
8	Ditch Jewel	*Brachythemis contaminata*	8	Pygmy Dartlet	*Agriocnemis pygmaea*
9	Fulvous Forest Skimmer	*Neurothemis fulvia*	9	Rusty Marsh Dart	*Ceriagrion olivaceum*
10	Granite Ghost	*Bradinopyga geminata*	10	Saffron Faced Grass Dart	*Pseudagrion rubriceps*
11	Greater Crimson Glider	*Urothemis sisgnata*	11	Splendid Dartlet	*Agriocnemis splendidissima*
12	Green Marsh Hawk	*Orthetrum sabina*	12	White Dartlet	*Agriocnemis pieris*
13	Ground Skimmer	*Diplacodes trivialis*	13	Yellow Striped Grass Dart	*Pseudagrion indicum*
14	Little Blue Marsh Hawk	*Brachydiplax sobrina*		**Family: Lestidae**	
15	Pied Paddy Skimmer	*Neurothemis tullia*	14	Davenports False Spreadwing	*Indolestes gracilis*
16	Pigmy Skimmer	*Tetrathemis platyptera*	15	Sapphire Eyed Spreadwing	*Lestes praemorsus*
17	Red Marsh Trotter	*Tramea basilaris*		**Family : Platycnemidae**	
18	Ruddy Marsh Skimmer	*Crocothemis servilia*	16	Blue Bush Dart	*Copera vittata*
19	Rufous Backed Marsh Hawk	*Brachydiplax chalybea*	17	Yellow Bush Dart	*Copera marginipes*
20	Rufous Marsh Glider	*Rhodothemis rufa*		**Family : Protoneuridae**	
21	Sapphire Flutterer	*Rhyothemis triangularis*	18	Coorg Bambootail	*Caconeura ramburi*
22	Scarlet Marsh Hawk	*Aethriamanta brevipennis*			
23	Tricoloured Marsh Hawk	*Orthetrum luzonicum*			
24	Trumpet Tail	*Acisoma panorpoides*			
25	Yellow Tailed Ashy Skimmer	*Potamarcha congener*			

Simpson's Diversity Index value was highest (0.95) for P2 and P4 in the Monsoon season. Hence, these ponds had the highest biodiversity of odonates. P3 and P6 had Diversity index values 0.92 and 0.91 respectively. P5 and P1 had comparatively low index value of 0.88 and 0.87 respectively, pointing to the fact that they hosted low odonate diversity. In the Post-monsoon season also, P4 (0.92) and P2 (0.90) were the most biodiversity rich sites followed by P6 (0.89), P3 (0.85), P5 (0.83) and the least biodiversity rich sites being P1 (0.79). P1 is a shallow artificial pond inside a garden lawn whereas P2 and P4 are natural ponds surrounded by rice fields. This may be attributed to the low diversity in P1 and high biodiversity in P2 and P4 throughout the

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study period. In all the six sites, the simpson's diversity index value was highest in the monsoon season.

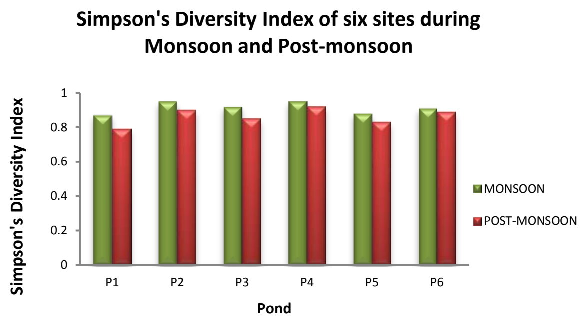

Fig 1. Graph showing Simpson's Diversity Index of six sites during 'Monsoon' and 'Post-monsoon' seasons

Water Quality:

It was found that in all the ponds, WQI was higher in Monsoon as compared to the Post-monsoon. This is attributed to the precipitation during the particular season. According to the WQI in the Post-monsoon, the sites can be grouped as 'Bad', 'Medium' and 'Good'. P1 with WQI value 36.74, had 'bad' water quality index while P3 and P5 with 58.81 and 53.98 respectively have a 'Medium' WQI and the rest of the ponds namely, P2 (72.38), P6 (83.10) and P4 (88.08) have 'Good' WQI. In the Monsoon, the ponds P1 and P5 were grouped into 'Medium' water quality with WQI values, 0.87 and 0.88 respectively. P3 with WQI value 74.43 has 'Good' water quality. Three ponds namely P2, P6 and P4 have 'Excellent' water quality index value 94.20, 94.09, and 94.20 respectively.

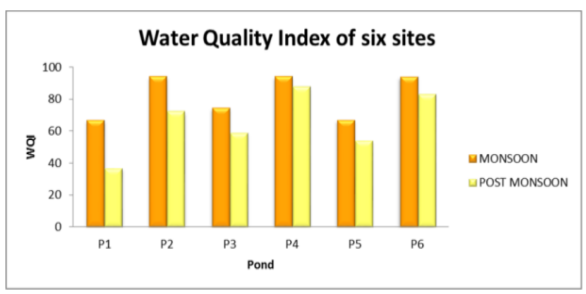

Fig 2. Graph showing Water Quality Index of six sites during 'Monsoon' and 'Post - monsoon' seasons

In the course of the present study, it was observed that among the six sites, more biodiversity was present in sites with comparatively good water quality than others in both the seasons. In monsoon season, all the six sites had high Water Quality Index and Simpson's Diversity Index than the post-monsoon season. Moreover, if we take the case of the selected sites individually, we may observe that in all the sites, Diversity Index value was high when the water quality was high and vice versa.

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Table 3. Comparison of Water Quality Index & Simpson's Diversity Index value of six ponds for the 'Monsoon' season

POND	WQI	WATER QUALITY	SIMPSON'S DIVERSITY INDEX
P1	66.77	Medium	0.87
P2	94.20	Excellent	0.95
P3	74.43	Good	0.92
P4	94.20	Excellent	0.95
P5	67.07	Medium	0.88
P6	94.09	Excellent	0.91

Table 4. Comparison of Water Quality Index & Simpson's Diversity Index value of six ponds for the 'Post-monsoon' season

POND	WQI	WATER QUALITY	SIMPSON'S DIVERSITY INDEX
P1	36.74	Bad	0.79
P2	72.38	Good	0.9
P3	58.81	Medium	0.85
P4	88.08	Good	0.92
P5	53.98	Medium	0.83
P6	83.1	Good	0.89

The post-monsoon period with hot days in February – April had little rainfall and the high temperature. Water level in ponds began decreasing and was finally very low with low water quality. So this might have been a contributing factor in the significant low index value during this period. This result corroborates well with study of [15] which explicitly states that monsoon months with heavy rainfall support maximum odonate diversity when compared to Post-monsoon months. A previous study by [16] also revealed that Odonates are widely distributed in all seasons and especially in Monsoon.

A comparison between Water Quality Index values and Simpson's Diversity Index values showed that Odonate diversity increased with increase in the water quality in both the seasons and in all the six sites. Similar results were obtained in the study of [17, 18]. Thus from the present study, odonates can be suggested as bioindicators of water quality.

CONCLUSION

In the present study, a marked difference was observed in the water quality of the selected sites in the two seasons with high water quality in the Monsoon season. The Odonate diversity was also higher in Monsoon. Moreover, in all the six sites, Odonate diversity increased with increase in the water quality. So it is clear that improvement in water quality in the selected lentic ecosystems was in proportion with increased odonate diversity. Thus Odonates may be suggested as ideal indicators of water quality.

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