International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Potential of Odonate (Dragonflies and Damselflies) Diversity as a Bioindicator of Water Quality

Sonia Jacob[1], Manju E.K[2]

[1,2] Department of Zoology, Alphonsa College, Pala

Abstract: ***Inorder to determine whether a relationship existed between water quality and odonate fauna, data were collected from four selected sites of Pala Municipality, Kottayam District, Kerala. The Water Quality Index, Simpson's diversity index and Species abundance values were calculated. The area with highest water quality index shows highest species richness and the area with lowest water quality index shows lowest species richness. The abundance of Brachythemis contaminate sp. in the polluted area and Bradinopyga geminate sp. in the non-polluted area shows their indicator efficiency. A potential exists for Odonata species diversity, numbers of individuals and occurrence of particular species to be used as a bioindicator of water quality. Advantages include, data that reflects a time period rather than a point in time and also low costs.***

Keywords: Abundance, Water Quality Index, Simpson's diversity index, Pollution, Odonate,

1. Introduction

Human life is inevitably related to fresh water resources but, they are under severe threat today, thus aquatic ecosystem monitoring and management is important. Even though measuring water quality is a good method, water chemistry is inherently so variable; there are temporal and spatial challenges with data collection; measurements only really provide information on conditions at that moment in time [1], [2]. There is a growing need to identify effective and efficient biological indicators for the assessment of aquatic ecosystems. Biological indicators can provide reliable, quantitative characterizations of ecological condition. A biological indicator (or bioindicator) is a taxon/taxa selected based on its sensitivity to a particular attribute, and then assessed to make inferences about that attribute. They can be evaluated through presence/absence condition, relative abundance, reproductive success, community structure (i.e. composition and diversity), community function (i.e. trophic structure), or any combination thereof [3], [4]. Inference through biological indicators replaces direct measurement when such measurements are not possible, too expensive/difficult, or too direct [5], [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 order Odonata has two suborders namely Zygoptera (damselflies) and Anisoptera (dragonflies). Using Odonata as bioindicators have two obvious advantages over chemical tests: (1) It includes reference to a time period (the larvae living in the pond for at least several weeks) rather than a single chemical sample at one particular point in time that may or may not be representative of conditions over the longer period. (2) It is inexpensive and can be done at most times of year using either mature larvae or adults, or both depending on the time [8]. They are widespread, relatively easy to observe and identify, and they are well dependent on the ecological conditions of the environment [9]. These insects lay their eggs in or near only fresh water and thus, their high abundance in an area is a good indication of the quality of freshwater [10]. Odonata (dragonflies and damselflies) are used as bioindicators for wetland quality in Europe, Japan, the USA, Australia [11] and in South Africa [12].

Although odonatological surveys were conducted in Kottayam District dates back to [13], studies associated to the odonate suitability as indicators or their relationship with the environment have not been conducted. Hence this study sought to: 1) identify the Odonata species occurring in Pala municipality 2) estimate and compare Odonata species diversities in the selected sites 3) examine the suitability of Odonata as indicators of water quality.

2. Materials and Methods

Pala municipality exalted with the Meenachil River, belongs to Kottayam District, Kerala, South India. Four sites were selected for the present study, namely, Oorasala, Lalam, Meenachil and Kaveekunnu. The surveys were conducted during September 2014 to March 2015. The ponds and its adjoining areas present in the sites were visited once in a month from 9.30AM to 2.00 PM. The water samples were collected and analyses once in three month as per the methods of APHA, 1998 [14]. Spot observations were followed by photography and rarely specimens were collected using specially design insect net. The recorded species were identified with the help of members of "Dragonfly group of India" and using a field guide "Dragonflies and Damselflies of Kerala" (KeralathileThumbikal) [15]. The number of species were recorded using tally marking system.

1.1. Simpson's Index (D)

Species diversity of Odonates were computed based on Simpson's Index using the formula,

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species
N = the total number of organisms of all species

1.1.1. Simpson's Diversity Index = 1-D

The value of 1- D ranges from 0 to 1. With this index, 1 represents infinite diversity and, 0 no diversity.

1.2. Species Abundance

The most and least abundant species in each spot and in the area were calculated by using the abundance formula.

$$\text{Abundance} = \frac{\text{Number of individuals of a certain species} * 100}{\text{Total number of individuals}}$$

1.3. Water Quality Index (WQI)

In order to calculate WQI ten important parameters, pH, electrical conductivity (EC), total dissolved solids (TDS), Hardness, Alkalinity, Chlorinity, Dissolved oxygen (DO), Biological oxygen demand (BOD), chemical oxygen demand (COD), and nitrate have been selected. The numerical value obtained from the analysis is then multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting value is added together to arrive at an overall water quality index (WQI).

$WQI = \sum Wi \times Vr$

Where, Wi ∞ 1/Vi or Wi = k/ Vi

K= constant of proportionality

Wi = Unit weight of factor

Vi = maximum permissible limits as recommended by Indian Council of Medical Research / Public health Environmental engineering Organization.

Value of k is calculated as, $K = \frac{1}{\sum 1/Vi}$

The rating scale was prepared for range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating Vr= 0 implies that the parameter present in the water exceeds the standard maximum permissible limits and water is severely polluted. Vr =100 implies that the parameter present in water has the most desirable value. The other ratings fall between these two extremes and are Vr =40, Vr =60 and Vr =80 standing for excessively polluted, moderately polluted and slightly less polluted respectively. This scale is based on the version of rating scale given by [16].

The Water Quality Index is equal to the product of rating (Vr) and unit weight (Wi) of all the factors.

$WQI = \sum Wi \times Vr = Wi_{(pH)} \times Vr_{(pH)} + Wi_{(EC)} \times Vr_{(EC)} + Wi_{(TDS)} \times Vr_{(TDS)} + Wi_{(Alkalinity)} \times Vr_{(Alkalinity)} + Wi_{(Chlorinity)} \times Vr_{(Chlorinity)} + Wi_{(Hardness)} \times Vr_{(Hardness)} + Wi_{(DO)} \times Vr_{(DO)} + Wi_{(BOD)} \times Vr_{(BOD)} + Wi_{(COD)} \times Vr_{(COD)} + Wi_{(Nitrate)} \times Vr_{(Nitrate)}$

WQI ranges as follows:

Value of WQI Quality of water

90-100 Excellent
70-90 Good
50-70 Medium
25-50 Bad
0-25 Very Bad

3. Result and Discussion

In the present study a total of 49 species of odonates belonging to ten families were recorded from the sampling sites. 26 sps. of dragonflies of three families, Aeshnidae, Libellulidae and Gomphidae and 23 sps of damselflies of 7 families such as Protoneuridae, Platycnemididae, Lestidae, Euphaeidae, Coenagrionidae, Calopterygidae and Chlorociphidae were identified. Libellulidae (23 sps.) was the most dominant family observed, which is followed by Coenagrionidae (11sps). The highest numbers of species 37 with 382 individuals were exhibited in the sampling site II. 28 species with 299 individuals at site I, 20 species with 228 individuals at site III and 7 species with 28 individuals at site IV were observed respectively in the sampling sites. The Simpson's diversity index classified the sites in the same order: Site II as the most species rich habitat (0.961) followed by site I (0.952), site III (0.939) and Site IV (0.85) (Table 1). *Ceriagrion cerinorubellum* was the most abundant species observed at site I; *Ceriagrion cerinorubellum* and *Bradinopyga geminata* at site II; and *Brachythemis contaminata* at Site III and site IV.

A summary of the estimated species per site as well as the observed species abundance values along with the water quality index and the status of the ecosystem selected for study is given in table 1.

Table 1: List of Odonates observed and abundance values

SI.NO	Scientific Name	Site I	Site II	Site III	Site IV
		Abundance	Abundance	Abundance	Abundance
	DAMSELFLIES (ZYGOPTERA)				
I	**CALOPTERYGIDAE**				
1	*Neurobasis chinensis*	-	-	5.15	-
2	*Vestalis apicalis*	-	3.40	-	7.14
3	*Vestalis gracilis*	-	2.62	-	-
II	**CHLOROCIPHIDAE**				
4	*Libellago lineata*	-	-	9.44	-
5	*Rhinocyphabi signata*	-	-	3.43	-
III	**COENAGRIONIDAE**	-	-	-	-
6	*Aciagrion occidentalae*	-	0.79	-	-
7	*Agriocnemis pygmaea*	0.67	0.79	-	-
8	*Agriocnemis pieris*	-	2.62	-	-
9	*Agriocnemis splendidissima*	5.02	4.45	4.29	-
10	*Ceriagrion cerinorubellum*	**9.36**	**6.54**	-	-
11	*Criagrion coromandelianum*	7.36	4.45	-	-
12	*Ceriagrion olivaceum*	2.34	1.83	-	-

13	*Ischnura aurora*	2.01	1.83	1.72	-
14	*Pseudagrion indicum*	-	-	5.15	-
15	*Pseudagrion microcephalum*	3.68	3.66	4.29	-
16	*Pseudagrion rubriceps*	-	1.31	-	-
IV	**EUPHAEIDAE**				
17	*Euphaea dispar*	-	-	1.29	-
18	*Euphaea fraseri*	-	-	0.86	-
V	**LESTIDAE**	-	-	-	-
19	*Lestes praemorsus*	2.01	1.31	-	-
20	*Lestes umbrinus*	4.01	1.83	11.16	**21.43**
VI	**PLATY CNEMIDIDAE**	-	-	-	-
21	*Copera marginipes*	3.01	2.36	2.15	-
22	*Copera vittata*	2.34	2.09	1.29	-
VII	**PROTONEURIDAE**				
23	*Prodasineura verticalis*	1.00	0.79	1.29	-
	DRAGONFLIES (ANISOPTERA)				
VIII	**AESHNIDAE**				
24	*Gynacantha bayadera*	1.67	0.79	-	-
25	*Gynacantha dravida*	1.67	1.83	-	-
IX	**LIBELLULIDAE**				
26	*Acisoma panorpoides*	3.01	2.62	3.43	-
27	*Aethriamanta brevipennis*	1.67	1.83	-	-
28	*Brachythemis contaminate*	-	-	**13.30**	**25**
29	*Brachydiplax chalybea*	2.01	-	-	-
30	*Bradinopyga geminata*	5.35	**6.54**	-	-
31	*Crocothemis servilia*	2.01	1.31	-	-
32	*Diplacodes trivialis*	-	1.05	-	-
33	*Lathrecista asiatica*	-	0.52	-	-
34	*Neurothemis fulvia*	5.69	6.28	-	-
35	*Neurothemis tullia*	6.69	5.49	3	-
36	*Orthetrum chrysis*	5.02	3.66	5.15	10.71
37	*Orthetrum luzonicum*	0.67	-	-	-
38	*Orthetrum Sabina*	3.68	4.19	8.15	-
39	*Orthetrum glaucum*	-	1.57	-	-
40	*Pantala flavescens*	-	1.57	-	7.14
41	*Rhyothemis variegata*	6.35	3.40	9.87	7.14
42	*Rhodothemis rufa*	-	0.52	-	-
43	*Tetrathemis platyptera*	2.34	-	-	-
44	*Trithemis aurora*	8.69	5.24	3.43	-
45	*Trithemis festiva*	-	5.76	-	-
46	*Tholymis tillarga*	0.67	-	-	-
47	*Urothemis signata*	-	1.83	-	-
48	*Zyxomma petiolatum*	-	-	-	**21.43**
X	**GOMPHIDAE**				
49	*Ictinogomphus rapax*	-	1.31	-	-
	Simpson's Index (D)	**0.048**	**0.039**	**0.061**	**0.15**
	Simpson's Diversity Index	**0.952**	**0.961**	**0.939**	**0.85**
	Water Quality Index	**59.07**	**78.72**	**32.54**	**6.97**
	Status	**Medium**	**Good**	**Bad**	**Very Bad**

Table 2: Vi and Wi values used for the calculation of WQI

Parameters	Vi	Wi
pH	6.5-8.5	0.19
EC	300	0.01
TDS	500	0.00
Hardness	300	0.01
Alkalinity	120	0.01
Chloride	250	0.01
D.O	5	0.33
B.O.D	5	0.33
C.O.D	20	0.08
Nitrate	45	0.04

WQI is calculated using the Vi and Wi values presented in the Table 2. The site II has the highest water quality index (78.72) with status as good, followed by site I (59.07) with status medium, site III (32.54) as status bad and Site IV (6.97) with status very bad. The comparison of the water quality index with respect to the Simpson's index of the selected sites (Fig.1) reveals that the highest species richness is observed in site II which has good quality followed by medium, bad and very bad qualities i.e. associated with the increase in water quality increase in the number of individuals and also number of species of odonates were increased. The increase in diversity of species and numbers of individuals with improving water quality supports similar findings in studies comparing polluted and non-polluted waters [17], [18], [19], [20].

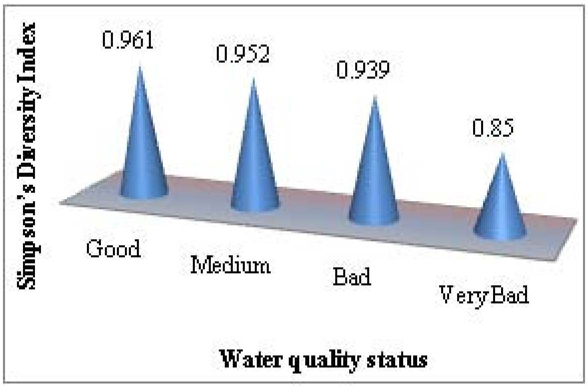

Figure 1: The relationship between the water quality status and Simpsons Diversity Index

The most abundant species in the polluted area was *Brachythemis contaminate and in the non-polluted area was Bradinopyga geminata* (Table 1) which lay egg only in the fresh water. *Trithemis aurora*, *Neurothemis fulvia*, *Neurothemis tullia*, *Bradinopyga geminata*, *Agriocnemis splendidissima*, *Ceriagrion cerinorubellum*, *Ceriagrion coromandelianum*, and *Trithemis festiva* were the common species in the sites with superior water quality. *Libellago lineata*, *Pseudagrion indicum*, *Lestes umbrinus*, *Brachythemis contaminate*, *Orthetrum chrysis*, and *Orthetrum Sabina* were the most common species of the sites with inferior water quality. The species *Zyxomma petiolatum* was found only in the highly polluted site.

4. Conclusion

This study has shown that odonate diversities and water quality index of the pond or river is highly related. Any small change in the ecosystem rigorously affects the diversity of these small creatures. Thus these populations can be monitored, and used as indicators of the water quality and its related ecotones. Especially the abundance of *Brachythemis contaminate* indicates the polluted water and the abundance of *Bradinopyga geminate* indicates the non-polluted water.

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