Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 187 (2024) 47-65 EISSN 2392-2192

Biodiversity and relative abundance preliminary assessment of Odonata (Insecta) fauna in and around Serampore, Jolkol, Hooghly, West Bengal, India

Md. Abu Imran Mallick* and **Narayan Ghorai**

Department of Zoology, West Bengal State University,
Berunanpukuria, North 24 Parganas – 700126, West Bengal, India

*E-mail address: imranmallick708@gmail.com

ABSTRACT

A seasonal study was aimed to examine the diversity and dominance of dragonfly and damselfly in Serampore, Jolkol in Hooghly District, West Bengal was carried out for a period of one year from March 2022 to February 2023, which grouped into monsoon (March to August), post-monsoon (September to November), and winter (December to February) periods. This study emphasizes a checklist of total 29 species of odonata (Dragonflies and Damsepflies). In our study there are two suborders Anisoptera and its family Libellulidae have 19 species, Aeshnidae, Gomphidae, Macromidae have 1 species in each. Other suborder is Zygoptera and it has the family of Coanagrinoidae with 6 species and Platycnenimidae with one species. The two suborder zygoptera and anisoptera the Relative abundance have 75.86% and 24.13% respectively in Serampore, Jolkol. The most abundant species was observed on basis of the results from the abundance formula by using Odonates diversity in the area of Serampore Jolkol. The Shannon diversity index is 2.99 from that result we also conclude evenness index of the odonata in Serampore, Jolkol was 0.103.Simpson diversity index was 0.056 from that result species dominance should be calculated that is 0.944 and the Margalef's richness index was 4.21. It indicates the high diversity of odonates during the monsoon and post-monsoon periods. Major contributing factors observed for biodiversity include water availability, vegetation cover and abundance of predatory species like mosquitoes during monsoon and post-monsoon period. The degradation of the wetland by human activities are the threat to the odonates along with the biodiversity. Finally, increased education on the importance of using native insect species as first-level indicators of

(Received 14 October 2023; Accepted 09 November 2023; Date of Publication 11 November 2023)

environmental health that can save the nation a lot of money if improved is otherwise used for chemical assessments and environmental wetland monitoring.

***Keywords*:** Seasonal study, Odonate, Diversity index, Relative abundance, Serampore, Jolkol

1. INTRODUCTION

Dragonflies and damselflies (Odonata) are among the most recognizable insects which has two sub orders Zygoptera (damselfly) and Anisoptera (dragonfly) [1, 2]. Dragonfly are commonly found near ponds, pools, lake, rivers, streams and marshy places etc [3-5]. They are reported from above sea level is 3,600 M deserts from around the world [4]. Out of 5000 species reported from the world, 500 species belonging to 139 genera of 17 families have been reported from India [3, 6, 7].

They provide valuable information about the present status of diversity, such as information on species richness, distribution patterns and presence of endemic or threatened species etc. [8, 9]. In addition, inventories are essential tools for monitoring diversity, which essential to understanding various impacts, natural or anthropogenic, or its effect effectiveness of different types of management actions among others [10-12]. Since invertebrates are more detailed than vertebrates and in most cases less well-known cases, largely their assessment of conservation status are both challenging and time-consuming [13, 14]. This increases the taxonomic coverage of the Red List by including a representative subset of invertebrates and plants, therefore providing a more representative indicator of the state of biodiversity [8, 15-17]. It is predictable areas that can be evaluated from the point of view of their main biological singularities are elements and then, priorities can be established for the development of conservation policies [3, 8, 18].

Species with complex life cycles such as odonates (dragonfly and damselfly) occupy different ecosystems an aquatic larval stage and a terrestrial adult stage [19]. Adults can actively disperse from one habitat to another; however, the larval stage is usually sedentary, staying at breeding sites [20-22]. Whether assessments of the diversity of such insects should be based on adults or larvae has been debated for decades [22-25]. Adult species are the actual breeding population is believed to be overestimated because individuals can fly into habitats where they do not reproduce [26]. Nevertheless, adults are still commonly used factors in estimating species occurrence and distribution range, compared to larvae and exuvia, they are charismatic and attractive to humans, easily identifiable and easy to identify [27, 28].

Several freshwater system, such as riverine systems have a complex water pumping, geological and ecological structure where a mosaic of patches and habitats is linked by a variety of mechanisms promoting the coexistence of complex communities [29, 30]. Aquatic insects present an additional challenge for large scale biodiversity monitoring because they comprise about 60% of all known freshwater animal species regions and stars require different sampling equipment and special skills [31-33]. These ecosystems support diverse macro-invertebrate communities passive dispersal such as larval drifting, flooding and vector species and more frequently by dispersal of active adults [33-38].

So, lotic species inhabiting rivers and streams and lentic species inhabiting lakes and ponds may coexist in the same area, resulting in high local diversity [38, 39]. Such complex water pumping systems therefore, represent a good system how adults reflect the actual occurrence

of species and how land-landscape complexity affects species richness [40-42]. A lower classification resolution may be sufficient in certain situations, but in many cases, identification is at the family and even genus level to course to serve the purpose of the study [43-48].Occurrence of species inventory useful for large-scale biodiversity monitoring [49-51].

2. METHODOLOGY

Study site

The study area is named as Jolkol [12, William Carey Sarani, Maniktala, Serampore] (22.7495033° N and 88.354230° E) and belongs to the suburban area of Hooghly district of West Bengal, India (Figure 1). The area is just beside River Hooghly and spread over 15.8 acres having shrub and herb vegetation of naturally growing bushy shrebs, herbs, climbers, small grasses and large trees [52-53]. However, several oxidation ponds and reservoir ponds of serampore water treatment plant are located at the study site [54]. Various anthropogenic activities such as sports, fishing, picnicking gathering firewood by locals, grazing livestock are common [55-56].

Figure 1. Map of study area

Method

Odonate survey was conducted in Serampore, Jolkol during March, 2022 to February, 2023. Six surveys were conducted in each seasons as: monsoon (March to August), post-

monsoon (September to November), and winter (December to February) during the morning (8.00 am to 11.00 am) and evening (3.00 pm to 5.00 pm) [57-58]. A line transect method was used to observation the dragonfly and damselfly within 5 m of the transect line were identified [59-60]. Systematic arrangement and scientific name of the species follows Subramanian & Babu (2017) [61].

Data Analysis

Data were arranged to obtain the following parameters:

I) Relative abundance = n/N, where n is the total number of odonates of a particular species and N is the total number of odonats of all species.

The diversity indices were calculated using simpson's diversity index, Shannon wiener diversity index, Margalef's Richness index and Evenness index. The input for the data analysis was a relative abundance matrix of family, genera and species across season.

II) Measurement of diversity

The type of diversity used here is an alpha diversity which is the diversity of species within a community or habitat that diversity index was calculated by using the - Shannon wiener diversity index [62-65].

Shannon winner diversity index (H')

$H' = - \{-\sum Pi\ (ln)pi\}$

[Pi = n/N]
S = number of individuals of one species
N = total number of all individuals in the sample
nn = natural logarithm to base e

Measurement of species richness

Margalef's Richness index = [(S-1) /ln(n)]

S = total number of species
N = total number of all individuals in the sample
ln = natural logarithm

Dominance and simpson index = $\sum n*(n-1)/N*(N-1)$

where N is the number of individuals of taxon I
Dominance 1 - Simpson index ranges from 0 to 1
Simpson Index 1-D. Measures evenness of the community from 0 to 1 dominance and Simpson indices are often interchangeably.

Evenness Index (J)

J = H' /H max

3. RESULT

Odonates have a very interested and complex life history with three stages (Larva, Nymph and Adult) and larva stages are aquatic and adult stages is terrestrial [66]. In our study there are two suborders Anisoptera and its family Libellulidae have 19 species, Aeshnidae, Gomphidae, Macromidae have 1 species in each. Other suborder is Zygoptera, and it has the family of Coanagrinoidae with 6 species and Platycnenimidae with one species. In this study there are 25 genera and 29 species of odonata with a total of 770 individuals were observed in and around serampore, Jolkol (**Table 1**). Here we calculate each species Abundance with the bar diagram (**Figure 2**).

Table 1. Checklist of Odonata of Serampore, Jolkol

SCIENTIFIC NAME	FAMILY	Sub order	INDIVIDUAL	STATUS
Crocothemis servilia	Libellulidae	Anisoptera	27	Common
Orthetrum sabina	Libellulidae	Anisoptera	44	Common
Diplacodes trivialis	Libellulidae	Anisoptera	84	Very Common
Macrodiplax cora	Libellulidae	Anisoptera	1	Very Rare
Brachythemis contaminata	Libellulidae	Anisoptera	34	Common
Urothemis signata	Libellulidae	Anisoptera	6	Rare
Pantala flavescens	Libellulidae	Anisoptera	31	Common
Neurothemis tullia	Libellulidae	Anisoptera	24	Common
Acisoma panorpoides	Libellulidae	Anisoptera	42	Common
Rhodothemis rufa	Libellulidae	Anisoptera	7	Rare
Rhyothemis variegata	Libellulidae	Anisoptera	43	Common
Brachydiplax sobrina	Libellulidae	Anisoptera	7	Rare
Aethriamanta brevipennis	Libellulidae	Anisoptera	5	Rare
Tholymis tillarga	Libellulidae	Anisoptera	1	Very Rare
Brachydiplax farinosa	Libellulidae	Anisoptera	5	Rare
Neurothemis fulvia	Libellulidae	Anisoptera	66	Very Common
Potamarcha congener	Libellulidae	Anisoptera	1	Very Rare
Brachydiplax chalybea	Libellulidae	Anisoptera	47	Common
Trithemis pallidinervis	Libellulidae	Anisoptera	8	Rare

Anaciaeschna jaspidea	Aeshnidae	Anisoptera	1	Very Rare
Ictinogomphus rapax	Gomphidae	Anisoptera	41	Common
Epophthalmia vittata	Macromiidae	Anisoptera	5	Rare
Ceriagrion coromandelianum	Coenagrionidae	Zygoptera	58	Very Common
Agriocnemis pygmaea	Coenagrionidae	Zygoptera	44	Common
Ceriagrion cerinorubellum	Coenagrionidae	Zygoptera	32	Common
Ischnura senegalensis	Coenagrionidae	Zygoptera	34	Common
Pseudagrion microcephalum	Coenagrionidae	Zygoptera	24	Common
Paracercion malayanum	Coenagrionidae	Zygoptera	7	Rare
Onychargia atrocyana	Platycnemididae	Zygoptera	41	common

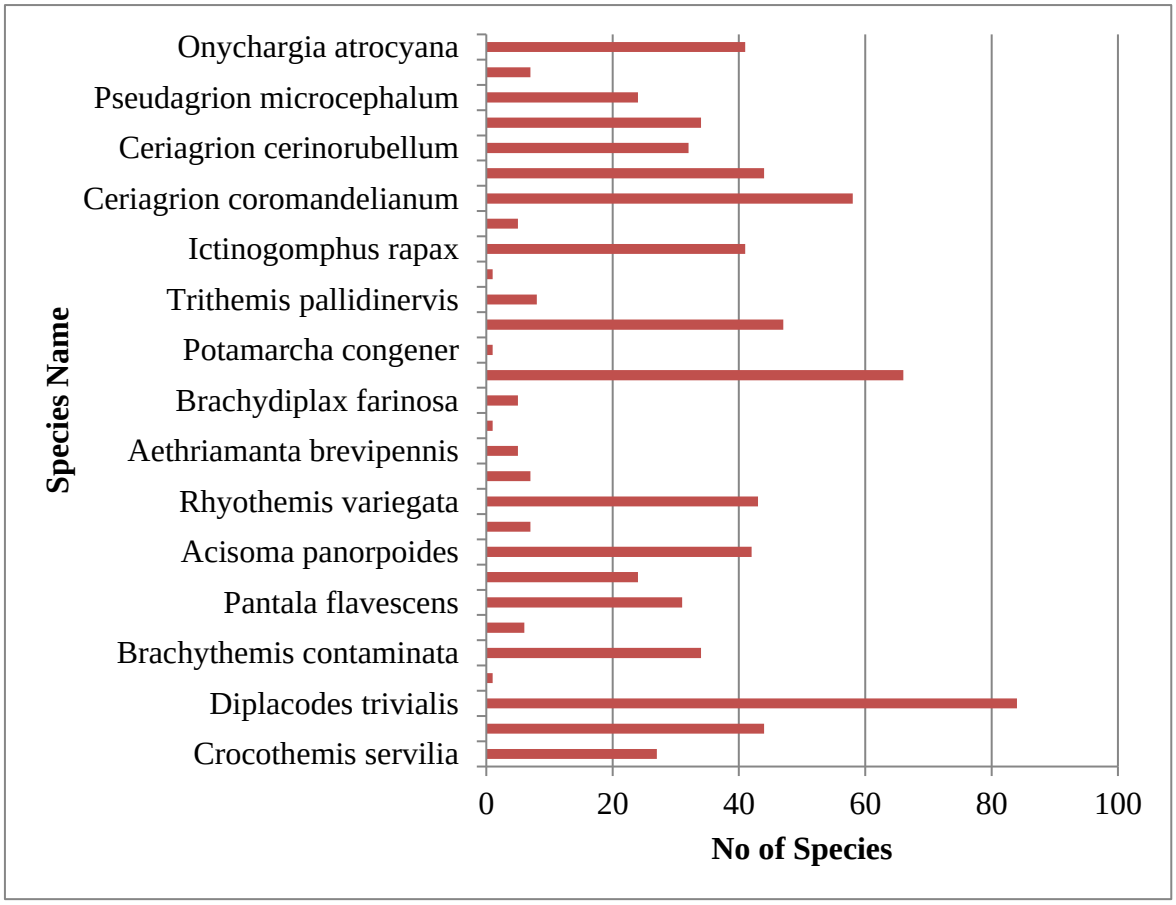

Figure 2. Abundance for different species of odonates in study area

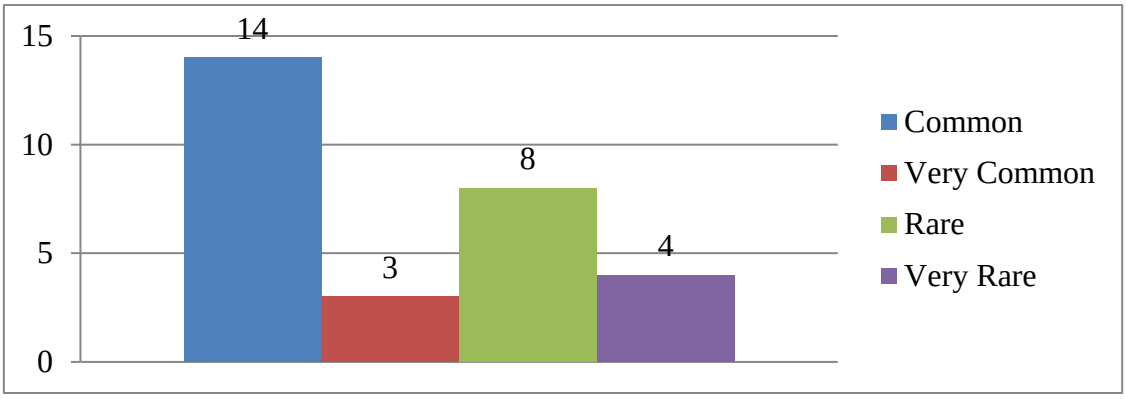

Figure 3. Abundance status of Odonata in Serampore, Jolkol

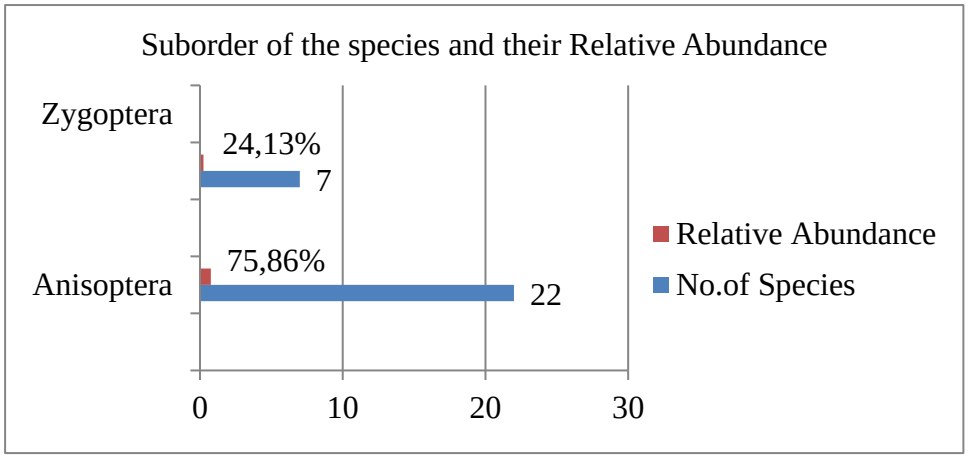

Figure 4. Percentage Relative Abundance Odonata species in two sub order in study area

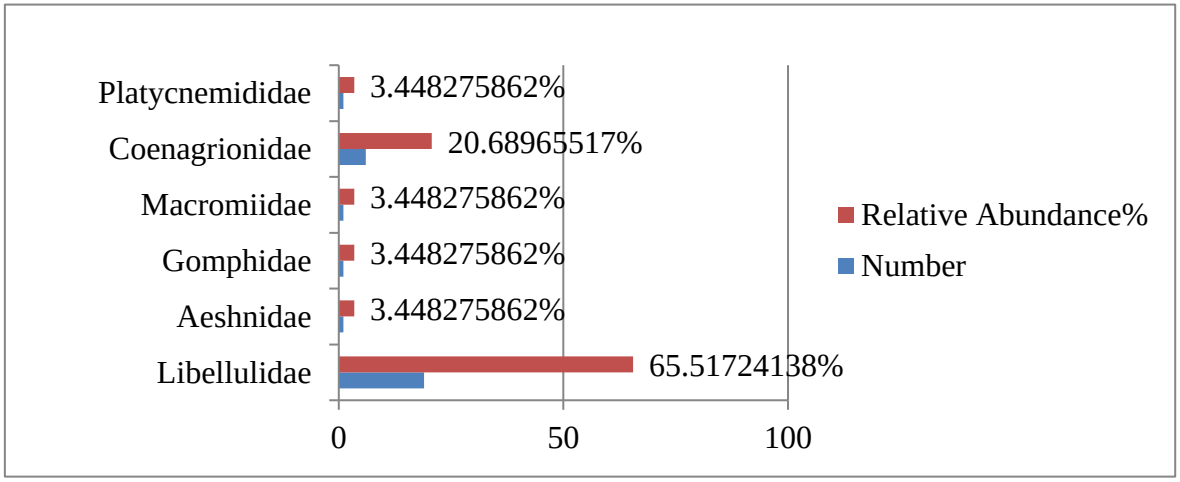

Figure 5. Percentage Relative Abundance Odonata species in different families in study area

Table 2. Percentage Relative Abundance Odonata species in two sub orders in study area

Sub Order	Number	Relative Abundance
Anisoptera	22	75.86%
Zygoptera	7	24.13%

Table 3. Species diversity indices of Odonata recorded in study area

Individuals (n)	770
Taxa (s)	29
ShnnonWeaner Index (H')	2.99
Evenness Index (J)	0.103
Margalef's Richness Index [(S-1) /ln(n)]	4.21
Simpson Index (1-D)	0.056
Species Dominance (∑n*(n-1)/N*(N-1))	0.944

In this study the species are divided by their four status rare, very rare, common, and very common (**Figure 3**). The two suborder zygoptera and anisoptera have the different percentage composition (Relative abundance) 75.86% and 24.13% respectively in serampore jolkol (**Figure 4, Table 2**). Species composition was highest in the family Libellulidae (19) 65.51% followed by the family of Coanagrinoidae (06) 20.68%, Gomphidae (01) 3.44%, Aeshnidae (01) 3.44%, Macromidae (01) 3.44% and Platycnenimidae (01) 3.44% (**Figure 5**).

In our observation three most seen species are Diplacodest rivialis belongs to family Libellulidae found in highest amount 84 number of individuals and it's status is very common the next one is Neurothemis fulvia which belongs to family Libellulidae 66 number of individuals and its status is also very common and the other one is Ceriagrion coromandelianum it belongs to family Coenagrionidae 58 number of individuals and it's status is also very common.

The least found species are Macrodiplax cora belongs to family Libellulidae its status is very rare. Next one is Anaciaeschna jaspidea it belongs to Aeshnidae, it is also very rare in status. The last two species were Tholymis tillarga and Potamarcha congener belongs to Libellulidae and there status are very rare. We have calculated the total Odonates diversity in the area of Serampore Jolkol. The Shannon diversity index is 2.99. From that result we also conclude evenness index of the odonata in Serampore, Jolkol was 0.103. Simpson diversity index was 0.056 from that result species dominance should be calculated that is 0.944 and the margalef's richness index was 4.21 (**Table 3**).

Seasonal Distribution of Odonata

Brachithemis contaminata was present throughout the season (summer, monsoon, post-monsoon and winter). Single species of Macrodiplax cora was found only in the post monsoon. Majority of the species did not find in the summer season. During the summer only nine species are found and 73 species individuals are collected. Agriocnemis pygmaea found in the highest amount. In the monsoon total 22 species are collected and the total species of individuals are 367 species within this 68 individuals of Diplacodes trivialis found. After monsoon post monsoon came and there are 25 species with total 299 number of individuals found. Neurothemia fulvia (58 species of individuals) found in highest amount. At last winter came 5 species are collected with 31 individual of species. Neurothermiciple we are found 8 species of individuals in highest number (**Figure 6**).

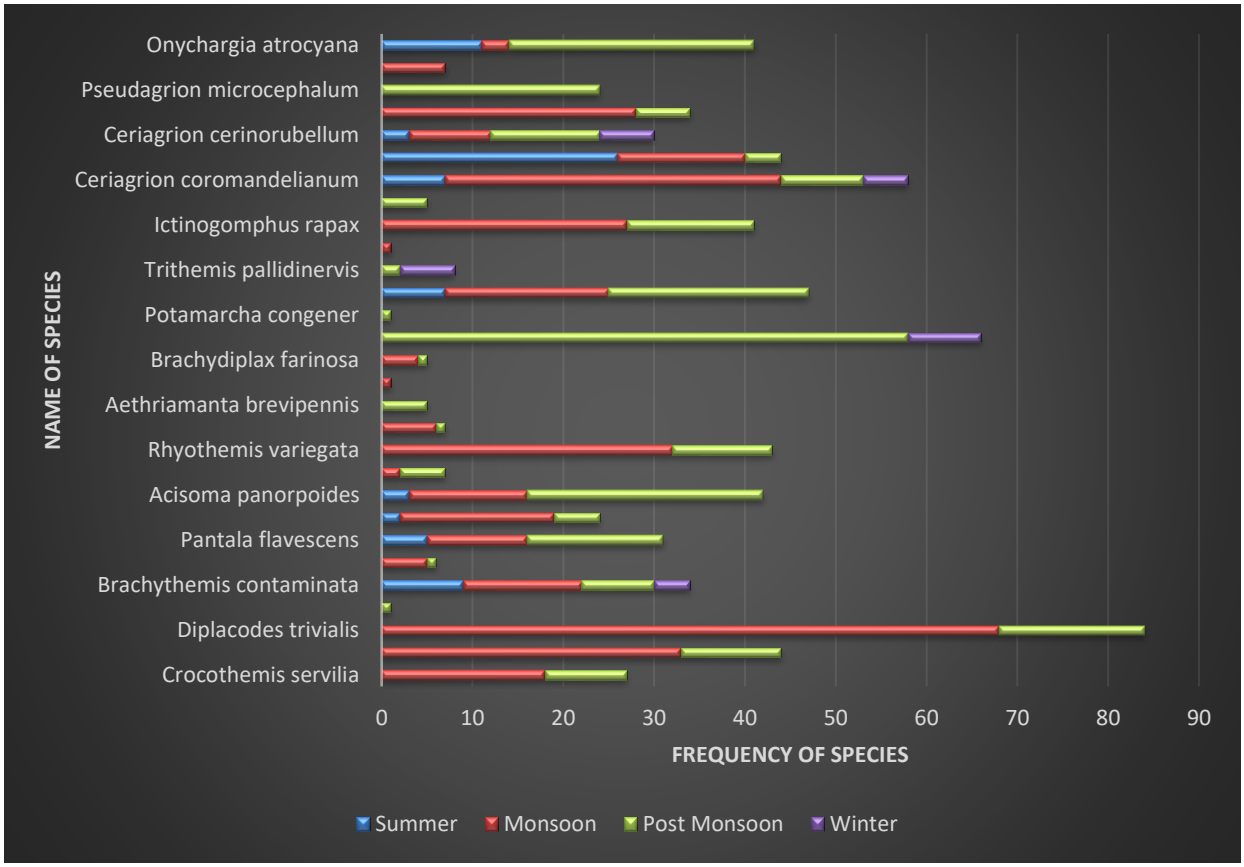

Figure 6. Seasonal variation of Abundance for different species of odonates in study area

We have calculated throughout the season wise diversity, richness, evenness, dominance indices of Odonates (Dragonflies and Damselflies) (**Table 4**). The Shanon diversity index shows that in the summer the species diversity was 0.284, Then we calculated evenness index which are 0.031 in summer, Then the margalef's index of species richness calculated and the result in summer is 1.86. Simpson index is also calculated during the whole season in summer it was 0.18. The species Dominance throughout the season in summer 0.82. During the monsoon

Shanon diversity index 0.1 in monsoon. Species Evenness index is 0.1. Margalef's index of species richness calculated and the result is 3.44. Simpson index is also calculated during the Monsoon is 0.082 species Dominance throughout the season in monsoon is 0.91. In post monsoon Shanon diversity index is 2.81 and species evenness is 0.1 and margalef's index of species richness calculated and the result is 4.38. Simpson index is 0.078, also calculated during the Post Monsoon is 0.078. The species Dominance throughout the season is 0.92. Last season was winter here the Shannon diversity index is 1.57. Species evenness is 0.31. Margalef's index of species richness calculated and the result is 1.16. Simpson Index is 0.187. The species Dominance index throughout the season is 0.82 (**Table 5**, **Figure 7**).

Table 4. Seasonal variation in Species diversity indices of Odonata recorded in study area

	Summer	Monsoon	Post Monsoon	Winter
Individuals (n)	73	367	299	31
Taxa (s)	9	22	26	5
ShnnonWeaner Index (H')	0.284	2.37	2.81	1.57
Evenness Index (J)	0.031	0.1	0.1	0.31
Margalef's Richness Index [(S-1) /ln(n)]	1.86	3.44	4.38	1.16
Simpson Index (1-D)	0.18	0.082	0.078	0.187

Table 5. Relative abundance of Odonates for Seasonal Variations in study area

Species Name	Summer	Relative abundance	monsoon	Relative abundance	Post monsoon	RA	Winter	RA
Crocothemis servilia	0	0	18	4.904632153	9	3.01	0	0
Orthetrum sabina	0	0	33	8.991825613	11	3.67893	0	0
Diplacodes trivialis	0	0	68	18.52861035	16	5.351171	0	0
Macrodiplax cora	0	0	0	0	1	0.334448	0	0
Brachythemis contaminata	9	12.32876712	13	3.542234332	8	2.675585	4	13.7931
Urothemis signata	0		5	1.36239782	1	0.334448	0	0
Pantala flavescens	5	6.84	11	2.997275204	15	5.016722	0	0
Neurothemis tullia	2	2.73	17	4.632152589	5	1.672241	0	0
Acisoma panorpoides	3	4.1	13	3.542234332	26	8.695652	0	0
Rhodothemis rufa	0	0	2	0.544959128	5	1.672241	0	0

Rhyothemis variegata	0	0	32	8.719346049	11	3.67893	0	0
Brachydiplax sobrina	0		6	1.634877384	1	0.334448	0	0
Aethriamanta brevipennis	0		0	0	5	1.672241	0	0
Tholymis tillarga	0		1	0.272479564	0	0	0	0
Brachydiplax farinosa	0		4	1.089918256	1	0.334448	0	0
Neurothemis fulvia	0		0	0	58	19.39799	8	27.58621
Potamarcha congener	0		0	0	1	0.334448	0	0
Brachydiplax chalybea	7	9.58	18	4.904632153	22	7.35786	0	0
Trithemis pallidinervis	0		0	0	2	0.668896	6	20.68966
Anaciaeschna jaspidea	0		1	0.272479564	0	0	0	0
Ictinogomphus rapax	0		27	7.356948229	14	4.682274	0	0
Epophthalmia vittata	0		0	0	5	1.672241	0	0
Ceriagrion coromandelianum	7	9.58	37	10.08174387	9	3.010033	5	17.24138
Agriocnemis pygmaea	26	35.61	14	3.814713896	4	1.337793	0	0
Ceriagrion cerinorubellum	3	4.1	9	2.452316076	12	4.013378	8	25.80645
Ischnura senegalensis	0		28	7.629427793	6	2.006689	0	0
Pseudagrion microcephalum	0		0	0	24	8.026756	0	0
Paracercion malayanum	0		7	1.907356948	0	0	0	0
Onychargia atrocyana	11	15.06	3	0.817438692	27	9.0301	0	0
Total	73	99.92876712	367	100	299	99.99997	31	105.1168

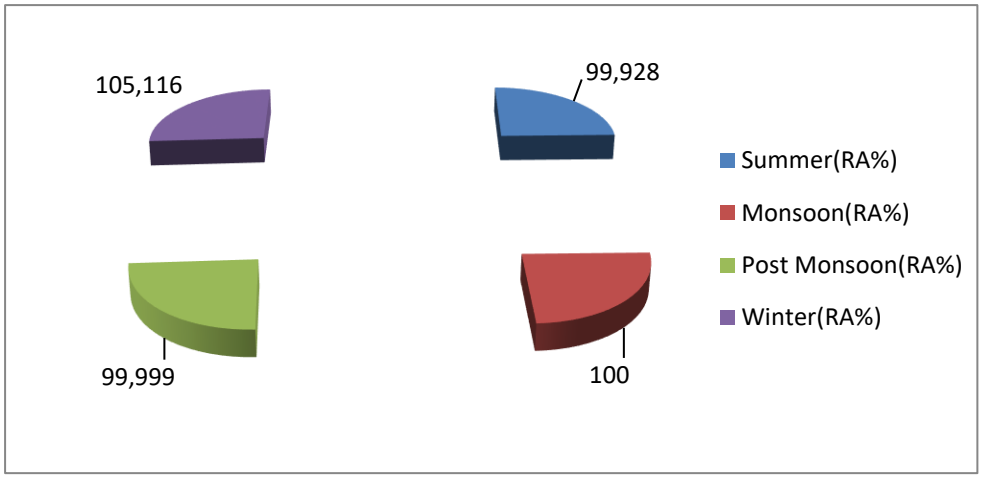

Figure 7. Total Relative Abundance of Seasonal Diversity of species

4. DISCUSSION

In our observation the relative abundance of the Anisoptera is fairely high (75.86%) than the Zygoptera (24.13%). This may be due to their wider distributional pattern and their body size [67]. In our study the most abundant family was Libellulidae followed by family Coenagrionidae represents 19 and 6 species respectively. Libellulidae is the largest family carrying maximum number of species during the study period. This same trend declared by Arulprakash and Gunathilagaraj (2010), Tijare & Patil (2012) [68, 69]. In our observation three most seen species are Diplacodes trivialis belongs to family Libellulidae found in highest amount (84 species of individuals) and it's status is very common. The next one is Neurothemis fulvia which belongs to family Libellulidae (66 species) of individuals and its status is also very common and the other one is Ceriagrion coromandelianum it belongs to family Coenagrionidae (58 number of individuals) and it's status is also very common. The least found species are Macrodiplax cora belongs to family Libellulidae its status is very rare. Next one is Anaciaeschna jaspidea, it belongs to Aeshnidae, it is also very rare in status. The last two species were Tholymis tillarga and Potamarcha congener belongs to Libellulidae and their status are very rare.

In our observed result we can conclude that in the area of serampore Jolkol, the number of odonata species are quite good and their diversity, richness and evenness is properly notice in this place. Total 29 species are observed here with 770 individuals. The Shannon diversity index is 2.99 in this place which indicate very good diversity and it also maintain a certain diversity range which helps maintain the balance in the environment. In the stable environment the evenness index should maintain a range which is from 0 to 1. In our calculation the evenness index is 0.1 03 so, it maintains the ranges of the stable environment for that reason we can say that the species evenness also maintain in this place. In this place species richness index that is Margalef's index is 4.21. This index ranges from 0 to 8. In our calculation it was 4.21 so we can conclude that species richness of serampore, Jolkol area is medium, which also indicate that this place is medium in species richness. In normal stable environment simpson's index ranges from 0 to 1, in our calculation this index value is 0.056, close to the value of zero meaning that in this place, there are infinite diversity and close to 1 meaning no diversity. So, here our value is very close to zero that means this place is highly diversified. Here the Simpson dominance index is 0.944.

The value of this index also ranges between 0 and 1, the greater the value greater the sample diversity, which also means that here our dominance value is very close to one which indicates species dominance with diversity found in this place very properly.

During the season wise distribution of odonata species we also conclude the seasonal diversity, richness, evenness and dominance. In summer 9 species with 73 total species of individuals are collected. The Shannon diversity index of summer, monsoon, post monsoon and winter are 0.284 2.37 2.81 and 1.57 respectively. That means post monsoon and monsoon season are the most diversified season and the least diversified season is summer. From this calculation we also conclude the evenness index of summer, monsoon, post monsoon and winter and the value are 0.031, 0.1, 0.1 and 0.31 respectively. Here monsoon and post monsoon are medium in evenness most even species are found in the winter and the least event species are found in the summer. Margalef's index of species richness in Summer, Monsoon, Post Monsoon and Winter are 1.86, 3.44, 4.38, 1.16 respectively. So, the species richness are high in the Post monsoon and Monsoon mostly.

Hear the Simpson's index of summer , monsoon , post monsoon and winter season are 0.18, 0.082, 0.078, and 0.187 respectively it indicates that post monsoon and monsoon season value are close to zero that means this two season are highly diversified than other two season. Monsoon and post monsoon seasonal dominance are 0.92 and 0.91 respectively and it is highest and summer and winter 0.82 and 0.81 is lowest.

In my predicted analysis this place is situated nearly a wetland and in summer season(March-May) this pond kind of water land is less in water and the temperature was very dry in that place. So the species growth and species abundance are not so found like monsoon and post monsoon. So, the species richness and diversity of Odonata also modified or influenced by the size of the water bodies. During the month from March to May or summer season some of species are totally absent.

They are spreading enormously in late May and fully come out in monsoon (June-August). Finding their mate in this time the high number of species can be attributed to the high rainfall and the proper humidity 80 to 90% with temperature range 22 degree Celsius to 28 degree Celsius. Favorable green vegetation, breeding condition, parching sites conditions during monsoon make this species growth very profoundly. After monsoon, Post monsoon (September-November) came, during this time Odonates diversity are also found very abundantly because of their breeding time and green weather. In the winter (December – February) this species are not fully active and they are not freely moved, they are little bit in resting mode. So there abundance are decreased abruptly from post monsoon to winter. So the abundance of odonata species counted during summer is 73 and increase to 367 in monsoon decreased a little bit to 299 and lastly in the winter it's abundance came to 31. This kind of observation is more or less similar with the earlier studies by the authors [70-72].

Threats to this Species

A global assessment shows that more than 6000 dragonfly and damselflies of 16% are risk of extinction main traits are human destruction of their wetland habitats, water pollution and climate change [73]. Odonates are an indicator group and conservation activities like work can be done by odonates [13]. To conserve the suitable habitat of this ecologically important insects, public awareness is required [22]. Anthropogenic activities, filtration and eutrophication are among the major cause for increasing deterioration rate of the suitable habitats of odonates [4, 43]. So, the most dominant and abundant family was libellulidae of Anisoptera are lost day by day and also the rare and very rare species are fully disappear very soon [74]. In our study libellulidae of Anisoptera are abundantly found and most of the species found in Monsoon and Post monsoon [75]. Further investigation is necessary for utilizing this group of insects as bio indicators for managing various water bodies and also used for monitoring environmental changes [76, 77]. Present study is a small contribution of listing Odonates diversity in serampore, jolkol area with its seasonal variation.

5. CONCLUSIONS

Odonates are characterized as Predator as well as prey in nature so this pieces are very important in sect in our food chain and food web [78]. Dragonfly nymphs are beneficial to human because they can be used as baits and to assist in the control of aquatic insect pest they are connecting link between aquatic and terrestrial ecosystem [66].

In our observation most dominant species is *Diplacodes trivialis* belongs to family Libellulidae. Most least species are *Macrodiplax cora*, *Tholymis tillarga* and belongs to the family Libellulidae, Potamarcha congener and Anaciaeschna jaspidea belongs to Aeshnidae and there status are very rare. Monsoon season is the most diversified season for Odonates and least diversified season is winter. *Brachithemis contaminata* was present throughout the season. *Macrodiplax cora, Tholymis tillarga*, *Potamarcha congener* are found least in number (one species of individual) in monsoon and post monsoon respectively.

In our study we conclude that serampore, Jolkol was moderately diversified by this insects and the species richness are found properly species evenness is also found in this place but the wavelength system needs to be monitored as well as maintained here [17,24]. The water system is not very clear in this place it should take care properly, many species found in this place are rare and very rare, and this should be very beneficial and increase the ecological diversity of this place. Odonata diversity is much more profound in the water land (pond like).

Therefore, public awareness is necessary to conserve the suitable habitats of these ecologically important invertebrate insect organism.

Acknowledgements

The authors are thankful to the H.O.D., Department of Zoology, West Bengal State University, Barasat, West Bengal, India for necessary permission to perform the initial observations. The authors are grateful to Dr. Narayan Ghorai, Department of Zoology, WBSU and Dr. Kuladeep Roy, Assistant Manager, WWF-India, WBSO for their kind support throughout the study. Authors are also thankful to Annesha Lahiri, Uttam Gupta, Sayok Dolui and Loknath Saha for giving constant encouragement.

Reference

[1] He, F.; Bremerich, V.; Zarfl, C.; Geldmann, J.; Langhans, S.D.; David, J.N.W; Darwall, W.; Tockner, K.; Jähnig, S.C., Freshwater Megafauna Diversity: Patterns, Status and Threats. *Divers. Distrib.* 24 (2018) 1395–1404

[2] Corbet P.S., Dragon flies: Behaviour and ecology of odonates, Corn. Uni. Press New and Harley Books, Greathoretesty, UK. 1 (1999) 829.

[3] Lahiri, A.R., Studies on odonate fauna of Megalaya. *Rec. Zool. Survey of India Misc.* 99 (1987) 402

[4] Prasad, M. and Kulkarni, P.P., Insecta: OdonataZoolSurv.India: Fauna of Eravikulam National Park. *Conservation Area Series,* 13 (2002) 7.

[5] Kulkarni, P.P., and M. Prasad 2002. Insecta: Odonata Zool. *Survey India: Wetland Ecosystem* Series No. 3. Fauna of Ujani. 91–104.

[6] Noss, R.F., Indicators for Monitoring Biodiversity: A Hierarchical Approach. *Conserv. Biol.* 4 (1990) 355–364

[7] Lozano, F.; del Palacio, A.; Ramos, L.; Muzón, J., The Odonata of Argentina: State of knowledge and updated checklist. *Int. J. Odonatol.* 23 (2020) 113–153

[8] Muzón, J.; Pessacq, P.; Lozano, F., The Odonata (Insecta) of Patagonia: A Synopsis of their current status with illustrated keys for their identification. *Zootaxa* 3784 (2014) 346–388

[9] Bailey, R.G., Identifying Ecoregion Boundaries. *Environ. Manage.* 34 (2004) 14–26

[10] Coscarón, M.C.; Melo, M.C.; Coddington, J.; Corronca, J., Estimating Biodiversity: A Case Study on True Bugs in Argentinian Wetlands. *Biodivers. Conserv.* 18 (2009) 1491–1507

[11] Baillie, J.E.M., Hilton-Taylor, C., Stuart, S.N., IUCN Red List of Threatened Species: A Global Species Assessment. IUCN, Gland Switzerland 1 (2004) 1.

[12] Baillie, J.E.M., Collen, B., Amin, R., Akcakaya, H.R., Butchart, S.H.M., Brummitt, N., Meagher, T.R., Ram, M., Hilton-Taylor, C., Mace, G.M., Towards monitoringglobal biodiversity. *Conservation Letters* 1 (2008) 18–26

[13] Thomas, C.D., Cameron, A., Green, R.E., Bakkenes, M., Beaumont, L.J., Collingham, Y.C., Erasmus, B.F.N., de Siqueira, M.F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A.S., Midgley, G.F., Miles, L., Ortega-Huerta, M.A., Peterson, A.T., Phillips, O.L., Williams, S.E., Extinction risk from climate Change. *Nature* 427 (2004) 145–148

[14] Lehner, B.; Grill, G. Global River Hydrography and Network Routing: Baseline Data and New Approaches to Study the World's Large River Systems. *Hydrol. Process.* 27 (2013) 2171–2186.

[15] Stoks, R., Córdoba-Aguilar, A., Evolutionary ecology of Odonata: a complex life cycle perspective. *Annu. Rev. Entomol.* 57 (2012) 249–265

[16] Ellingsen, K., Clarke, K., Somerfield, P., Warwick, R., Taxonomic distinctness as aMeasure of diversity applied over a large scale: the benthos of the Norwegian conti-Nental shelf. *J. Anim. Ecol.* 74 (2005), 1069–1079

[17] Grainger, T.N., Gilbert, B., Dispersal and diversity in experimental metacommuni-ties: linking theory and practice. *Oikos* 125 (2016) 1213–1223

[18] Benard, M.F., McCauley, S.J., Integrating across life-history stages: consequences of natal habitat effects on dispersal. *Am. Nat.* 171 (2008) 553–567

[19] Hardersen, S., Dragonfly (Odonata) communities at three lotic sites with different hydrological characteristics. *Italian Journal of Zoology* 75 (2008) 271–283

[20] Bried, J.T., D'Amico, F., Samways, M.J., A critique of the dragonfly delusion hypoth-esis: why sampling exuviae does not avoid bias. *Insect Conservation and Diversity* 5 (2012) 398–402

[21] Raebel, E.M., Merckx, T., Riordan, P., Macdonald, D.W., Thompson, D.J., The drag-onfly delusion: why it is essential to sample exuviae to avoid biased surveys. *J. Insect Conserv*. 14 (2010) 523–533.

[22] Malmqvist, B., Aquatic invertebrates in riverine landscapes. *Freshw. Biol.* 47 (2002) 679–694.

[23] Cordero-Rivera, A., Stoks, R., Mark-recapture studies and demography. In:Córdoba-Aguilar, A. (Ed.), Dragonflies and Damselflies: Model Organisms for Ecologi-cal and Evolutionary Research. Oxford University Press, Oxford, pp. (2008) 7–20.

[24] Dijkstra, K.-D.B., Lewington, R., Field Guide to the Dragonflies of Britain and Europe: Including Western Turkey and North-Western Africa. British Wildlife Publishing dorset (2006).

[25] Mellal, M.K., Bensouilah, M., Houhamd, M., Khelifa, R., Reproductive habitat pro-visioning promotes survival and reproduction of the endangered endemic damselfly Calopteryx exul. *J. Insect Conserv.* 22(2018) 563–570.

[26] Dijkstra, K.-D.B., Monaghan, M.T. &Pauls, S.U., Fresh-Water biodiversity and aquatic insect diversification. *Annual Review of Entomology*, 59 (2014) 143–163.

[27] Bonada, N., Prat, N., Resh, V.H. &Statzner, B., Developments in aquatic insect biomonitoring: a comparative analysis of recent approaches. *Annual Review of Entomology*, 51 (2006) 495–523

[28] Bilton, D.T., Freeland, J.R., Okamura, B., Dispersal in freshwater invertebrates. *Annu. Rev. Ecol. Syst. 32* (2001) 159–181

[29] Bohonak, A.J., Jenkins, D.G., Ecological and evolutionary significance of dispersal by freshwater invertebrates. Ecol. Lett. 6 (2003) 783–796

[30] Carter, J.L. &Resh, V.H. After site selection and before Data analysis: sampling, sorting, and laboratory procedures Used in stream benthic macroinvertebrate monitoring programs By USA state agencies. *Journal of the North American Bentho-Logical Society*, 20 (2001) 658–682

[31] Ward, J., Tockner, K., Schiemer, F., Biodiversity of floodplain river ecosystems: eco Tones and connectivity1. *River Res. Appl.* 15 (1999) 125–139.

[32] Heino, J., Biodiversity of aquatic insects: spatial gradients and environmental corre-Lates of assemblage-level measures at large scales. *Fr. Rev.* 2 (2009) 1–29.

[33] Bailey, R.C., Norris, R.H. &Reynoldson, T.B. Taxonomic Resolution of benthic macroinvertebrate communities in Bioassessments. *Journal of the North American Benthological Society*, 20 (2001) 280–286

[34] Landeiro, V.L., Bini, L.M., Costa, F.R.C., Franklin, E.,Nogueira, A., de Souza, J.L.P., Moraes, J. &Magnusson,W.E. How far can we go in simplifying biomonitoring assessments? An integrated analysis of taxonomic surrogacy,taxonomic sufficiency and numerical resolution in a megadi-Verse region. *Ecological Indicators*, 23 (2012) 366–373

[35] Batzer, D.P. &Wissinger, S.A. Ecology of insect commu-nities in nontidal wetlands. *Annual Review of Entomology*, 41 (1996) 75–100

[36] Lenat, D.R. &Resh, V.H. Taxonomy and stream ecology– The benefits of genus- and species-level identifications. *Jour-Nal of the North American Benthological Society*, 20 (2001) 287–298

[37] King, R.S. & Richardson, C.J. Evaluating subsampling approaches and macroinvertebrate taxonomic resolution forWetlandbioassessment. *Journal of the North American Benthological Society,* 21 (2002) 150–171

[38] Greffard, M.-H., Saulnier-Talbot, E. & Gregory-Eaves, I. A comparative analysis of fine versus coarse taxonomic resolution in benthic chironomid community analyses. *Ecological Indicators,* 11 (2011) 1541–1551

[39] Droege, S., Cyr, A. &Larivee, J., Checklists: an under-used tool for the inventory and monitoring of plants and animals. *Conservation Biology,* 12 (1998) 1134–1138

[40] Nielsen, S.E., Haughland, D.L., Bayne, E. &Schieck, J., Capacity of large-scale, long-term biodiversity monitoring pro-Grammes to detect trends in species prevalence. *Biodiversity and Conservation,* 18 (2009) 2961–2978

[41] Packer, L., Monckton, S.K., Onuferko, T.M. & Ferrari, R.R., Validating taxonomic identifications in entomological research. *Insect Conservation and Diversity*, 11 (2018) 1–12

[42] Manju E.K., Cyril A.E., and Jacob s.,Seasonal variation of Odonate diversity in selected areas of ElanjiGrampanchayath. *Aureole,* 7 (2015) 7-16

[43] Kulkarni A.S, & Subramanian K.A., Habitat and Seasonal distribution of Odonata (Insecta) ofMula and Mutha river basine, Maharashtra, India. *Journal of Threatened Taxa* 5 (2013) 4084-4095

[44] O. N. Kaul, and D. C. Sharma, Forest type Statistics. *Indian Forester.* 97 (1971) 432-436

[45] Remsburg AJ and Turner MG. Aquatic and terrestrial drivers of dragonfly (Odonata) assemblages within and among north temperate lakes. *Journal of the North American Benthological Society*, 28(1) (2009) 44-56

[46] A. C. Benke. Dragonfly production and prey turnover. *Ecology* 57 (1976) 915–927

[47] G. Sharma, R. Sundararaj& L. R. Karibasvaraja., Species diversity of Odonata in the selected provenances of Sandal in southern India. *Zoo's Print Journal* 22 (7) (2007) 2765–2767

[48] Tiple, A.D., Odonata (Damselfly and Dragonfly) fauna of Tadoba National Park and surroundings, Chandrapur, Mahrashtra (Central India). *Bionano Frontier*, 5 (2012) 149-152

[49] Kalita, G. J., Boruah, B., Das, G.N., An observation on odonata (damselflies and dragonflies) fauna of Manchabandha reserve forest, Baripada, Odisha. *Pelagia Research Library*, 5(1) (2014) 77-83

[50] Das, S.K. et al., Diversity, distribution and species composition of odonates in buffer areas of Similipal Tiger Reserve, Eastern Ghat, India. *Academic Journal of Entomology,* 5(1) (2012) 54-61

[51] Andrew, R.J., Thaokar, N., Verma, P., Odonate diversity at Wena Dam of Nagpur District (Ms), India. *International Journal of Scientific Research*, 2(10) (2013) 1-3

[52] Adarsh CK, Aneesh KS, Nameer PO., A preliminary checklist of Odonates in /kerala agricultural university (KAU) campus, Thrissur district, Kerala, Southern India. *Journal of Threatened Taxa. 6*(8) (2014) 6127-6137

[53] Rathod PP, Manwar NA, Pawar SS, Raja Ia., Diversity and abundance of dragonflies and damselflies (Order- Odonata) in Agro ecosystems around the Amravati City (M.S), India in Monsoon season, *International Journal of Advanced and Innovative Research.* 1(7) (2012) 174-182

[54] Ghosh A, Mukherjee T., Butterfly diversity at suburban green patch: A sustainable approach towards conservation. *Journal of Entomology and Zoology Studies.* 4(2) (2016) 34-39

[55] Malagrino GG, Lagunas MM, Rubio AO., Environmental impact reduction through ecological planning at Bahia Magdalena, Mexico. *J. Environ. Biol.* 29 (2008) 79-82

[56] Sudheendrakumar VV, Binoy CF, Suresh PV, Mathew G., Habitat associations of butterflies in the Parambikulam Wildlife Sanctuary, Kerala, India. *J. Bombay Nat. Hist. Soci*. 97 (2000) 193-201

[57] Subramanian KA., A checklist of odonata of India. *Zoological Survey of India.* 36 (2009).

[58] Subramanian Ka., &Babu, R., Checklist of odonata (Insecta) of India. Version 3.0. www.zsi.gov.in . (2017) 1-54

[59] Magurran AF. Ecological diversity and its measurements. University Press, Cambridge, (1988) 192

[60] Sargent, R. D., & Ackerly, D. D., Plant-pollinator interactions and the assembly of plant communities. Trends in Ecology & Evolution, 23(3) (2008) 123-130

[61] Andrew RJ, Subramaniam KA, Tiple AD., A handbook on common odonates of central India. South Asian Council of Odonatology. (2009). ISBN: 978-81-910409-0-6

[62] Shannon CE, Weaver W., The mathematical theory of communication, University of Illinois Press, Urbana (1949).

[63] Simpson EH, Measurement of diversity, *Nature* 163 (1949) 688

[64] Margalef, R., Temporal succession and spatial heterogeneity in phytoplankton. In A. A. Buzzati-Traverso (Ed.), Perspectives in marine biology University of California Press, (1989) 323-349

[65] Pielou EC., An Introduction to mathametical ecology. John Wiley, New York, (1969) 286

[66] Furlan, Nicole Emilie. Life histories, Diets and Secondary production of Odonata along a temperature gradient on the Copper River Delta, Alaska. Master' Theses. (2014) 2621

[67] Norma-Rashid Y., Mohd-Sofian A., & Zakaria-Ismail M. Diversity and distribution of Odonata (dragonflies and damselflies) in the fresh water swamp lake Tasek Bera, Malaysia. *Hydrobiologia* 459 (2001) 135-146

[68] Tijare, R. V., and K.G. Patil., Diversity of Odonets in and around Gorewada National Park, Nagpur, MS (India). *Bionano Frontoer.* 9 (2012) 182-183

[69] Arulprakash R. & Kandasamy G. Abundance and diversity of Odonata in temporary water bodies of Coimbatore and Salem districts in tamil Nadu. *Journal of Threatened Taxa* 2(8) (2010) 1099-1102

[70] Tuhin MSH, Khan MK. Species richness, habitat association and odonata diversity of the south-western region of Bangladesh. *Bio Rxiv,* (2018) 1-28

[71]] Oppel S., Habitat association of an Odonata community in a lower montane rainforest in Papua New Guinea. *International Journal of Odonatology.* 8(2) (2005) 243-257

[72] Kalkman VJ, Boudot JP, Bernard R, Knijf DG, Suhling F, Termaat T. Diversity and conservation of European dragonflies and damselflies (Odonata). *Hydrobiologia.* 811(1) (2018) 269-282

[73] Collen B, Whitton F, Dyer EE, Baillie JE, Cumberlidge N, Darwall WR et al. Global patterns of freshwater species diversity, threat and endemism. *Global Ecology and Biogeography.* 23(1) (2014) 40-51

[74] Watson JAL, Arthington AH, Conrick DL. Effect of sewage effluent on dragonflies (Odonata) of Bulimba Creek, Brisbane. *Marine and Freshwater Research.* 33(3) (1982) 517-528

[75] Narebder M, Ahmad SA, Pandit RS & Wankhade. Seasonal variation in diversity and abundance of Odonata at Sawanga-Vithoba Lake, India. *Journal of Entomology.* 13(5-6) (2016) 170-178

[76] Ram R., VD. Srivastava and M. Prasad., Odonata (Insecta) fauna of Calcutta and surroundings. *Records Zool. Sur. India.* 80 (1982) 169-196

[77] Tarak Samanta, Lina Chatterjee, Arjan Basu Roy, Saswati Sinha, Sumana Besra, Importance of Ecopark, Kolkata in the context of sustainability, compare to Rajarhat grassland, as a habitat for Odonata (Dragonflies and Damselflies) diversity. *World News of Natural Sciences* 44 (2022) 165-175

[78] Benke, AC, Crowley, PH and Johnson, DM. Interactions among coexisisting larval Odonata: an insitu experiment using small enclosures. *Hydrobiol.* 94 (1982) 121-130