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Diversity and abundance of odonates in different habitats of Chalisgaon, North Maharashtra region

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Abstract
Odonates diversity was studied during July, 2017 to December, 2019 in Chalisgaon, North Maharashtra region. During the survey, total 3152 adult odonates were recorded from aquatic bodies associated with three different habitats i.e. Urban, Rural and Agro-forest habitat. 52 species including 35 species of Anisoptera and 17 species of Zygoptera which belongs to 29 genera from six families were documented. It was observed that, 51 species were recorded from Agro-forest, followed by rural area (48 species) and least number of species was recorded from then urban area (38 species).
The Agro-forest habitat have highest diversity (H'=3.52), species richness (d=7.046), equitability (J=0.8952) and evenness (E'=0.6624) due to availability of aquatic bodies and healthy breeding environment. The relative abundance of odonates was more in Agro-forest (38.29%), followed by urban area (34.01%) and rural area (27.7%). The relative abundance and diversity indices were highest in the family Libellulidae and Coenagrionidae than other families. In dragonflies, *Pantala flavescens*, *Diplocodes trivialis* and *Orthetrum sabina* and in damselflies, *Ischnura aurora*, *Ischnura senegalensis* and *Ceriagrion coromandelianum* were most abundant and diverse species in all habitats. The diversity and species richness of dragonflies observed in Agro-forest while damselflies in urban habitat.

Keywords: odanata, checklist, diversity, species richness, Chalisgaon, north Maharashtra region

1. Introduction
Odonates are the most ancient and most diverse group of aquatic insects which inhabits all kinds of freshwater habitats. Odonates experiences two different habitats in the life cycle i.e. the egg and larval stages are aquatic whereas the adults are terrestrial which represents amphibiotic nature [1]. The Dragonfly is the vital aerial killer in the insect world. Both larval and adult stages of dragonflies are predatory in nature. They act as pest control agent in agricultural ecosystems [2, 3] and bio-control agents against mosquitoes and flies which spread several epidemic diseases [4, 5]. Dragonfly and damselfly are outstanding insects that can be sensitive to aquatic, terrestrial and environmental changes [6, 7, 8] and provide valuable ecosystem services as intermediate predators in food webs [9], bio-indicators for monitoring the water quality [10, 11].
Recently, about 6321 species and subspecies belonging to 688 genera in 39 families of Odonata are known from all over the world [12]. In India, 492 odonate species belonging to 152 genera and 18 families were taxonomically listed [13]. Recent information on Odonates diversity, species richness and ecological role from different provinces of India was well documented [2, 14-17]. Diversity of odonates was observed by many workers in different geographical area of Maharashtra state [18-20]. In North Maharashtra region, diversity of odonates was recognized and information on 46 species belonging to 26 genera and 7 families collected from Jalgaon [21].
In North Maharashtra Region, there is no proper information available on odonate diversity, species richness and their relation to various ecosystems. Hence, this attempt was to determine occupancy pattern, species richness and diversity status of Odonata fauna in different habitats i.e. urban, rural, agro-forest area of Chalisgaon, North Maharashtra region.

2. Materials and Methods
2.1 Study Area
The present study was carried out in and around Chalisgaon Tehsil, North Maharashtra Region, India. The study area as the south-west part of Jalgaon district located at 20.4619° North Latitude and 75.0063° East Longitude at the elevation of 344 meter from the mean sea level (Fig. 1). The study area is the pilgrim and historical place which covered by 143 villages, ranges from 4 to 30 km away from the city. According the population, around 74% area is covered by rural zone and 26% by urban zone. From the total area (1211 sq. km.), more than 70% (850 sq. km) area is covered by the agriculture field and 5.4% (65 sq. km) area is covered by dry deciduous forest which locally named as Patana forest. Patana forest is substantiality inaccessible forest which is situated in the Satmala hills of Chalisgaon range.

2.2 Data Sampling
Regular weekly survey was conducted by visiting different aquatic habitats located in and around Chalisgaon region during the period July, 2017 to December, 2019.
During survey, the odonates were observed along the road sides, ponds, lakes, dams, temporary water bodies, drain water canals, open spaces, grasslands and irrigation canals associated with all ecosystems. These observed sampling sites became feeding and breeding ground for odonates during the rainy season. Three different habitats i.e. Urban area, Rural area and agro-forest area were consider to study odonate diversity, their abundance and species richness. It was randomly selected five sites from each ecosystem, at least 4 km apart, by considering the availability and

diversity of the habitat.

Photographic records of different adult odonate species were captured by using 18.1 mega pixels digital camera (Sony cybershot DSC-HX90V) during the survey. Species and number of individuals were documented at each ecosystem. The collected odonates were carried out and identified with the help of taxonomic keys given by [5,13,22-26].

2.3 Data Analysis

The collected data were then analyzed to determine the diversity of species in different ecosystems, species richness using Shannon-Wiener index and evenness, equitability, Fisher-alpha diversity index and Margalef's richness (DMg) index. All analyses were performed using PAST ver. 4.01.

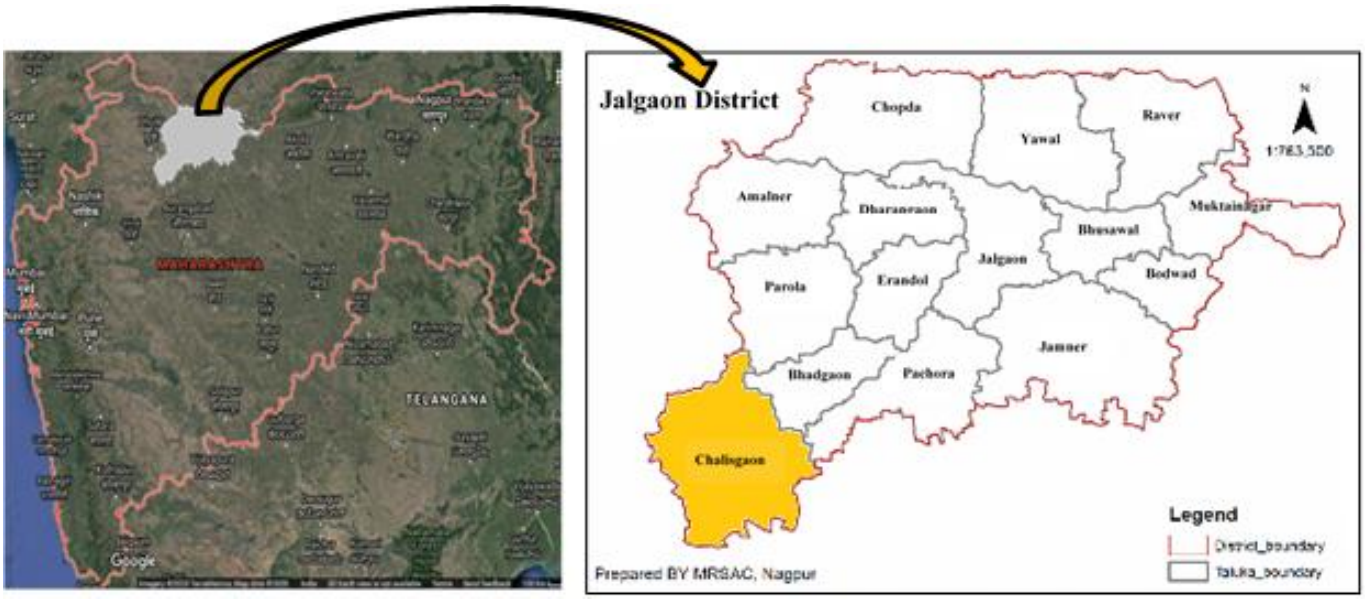

Fig 1: Map of Chalisgaon, North Maharashtra Region (Source- Satelite Map and MRSAC, Nagpur)

3. Results

3.1 Distribution pattern of species in different habitats

During the survey tenure, around 3152 adult odonates were recorded from aquatic bodies associated with three different habitats i.e. Urban area, Rural area, Agro-forest area located in and around the Chalisgaon region. Total 52 species of Odonata including 35 species of Anisoptera and 17 species of Zygoptera which belongs to 29 genera from six families were documented (Table 1). It was observed that, 51 species were recorded from Agro-forest, followed by rural area (48 species) and least number of species was recorded from then urban area (38 species) (Table 1).

Table 1: Numbers of dragonflies encountered in three different habitats

Sr. No.	Common name	Scientific Name	Urban area	Rural area	Agro- Forest	Total
Family: Aeshnidae						
1	Blue Darner	Anax immaculifrons	2	5	9	16
2	Blue tailed Brown Darner	Anax parthenope	5	7	13	25
3	Blue tailed green Darner	Anax guttatus	9	15	32	56
4	Rusty Darner	Anaciaeschna jaspidea	0	2	8	10
5	Parakeet Darner	Gynacantha bayadera	1	3	11	15
Family: Gomphidae						
6	Common Clubtail	Ictinogomphus rapax	9	13	39	61
7	Lined Hooktail	Paragomphus lineatus	2	7	13	22
Family: Libellulidae						
8	Skimmer	Acisoma panorpoides	2	0	7	9
9	Ditch Jewel	Brachythemis contaminata	5	2	13	20
10	Granite Ghost	Bradinopyga geminata	34	19	16	69
11	Emerald-Banded Skimmer	Cratilla lineata	4	2	7	13
12	Ruddy Marsh Skimmer	Crocothemis servilia	33	39	55	127
13	Blacktipped Ground Skimmer	Diplocodes nebulosa	52	19	38	109
14	Ground Skimmer	Diplocodes trivialis	89	41	86	216
15	Black marsh skimmer	Indothemis carnatica	0	2	3	5
16	Asiatic Blood-Tail	Lathrecista asiatica	0	1	1	2
17	Fulvous Forest Skimmer	Neurothemis fulvia	0	1	2	3
18	Amber-winged Marsh Skimmer	Neurothemis intermedia	1	0	3	4
19	Pied Paddy skimmer	Neurothemis tullia	0	1	3	4
20	Brown-backed Red Marsh Hawk	Orthetrum chrysis	14	23	29	66
21	Blue Marsh Hawk	Orthetrum glaucum	0	5	18	23

22	Tricolored Marsh Hawk	Orthetrum luzonicum	0	7	19	26
23	Crimson-tailed Marsh Hawk	Orthetrum pruinosum	2	11	24	37
24	Green Marsh Hawk	Orthetrum sabina	54	31	62	147
25	Small skimmer	Orthetrum taeniolatum	0	1	3	4
26	Wandering glider	Pantala flavescens	74	66	109	249
27	Common Chaser	Potamarcha congener	0	0	6	6
28	Rufous marsh glider	Rhodothemis rufa	0	1	3	4
29	Common Picture wing	Rhyothemis variegata	0	1	4	5
30	Dusky Cloud Wing	Tholymis tillarga	12	11	29	52
31	Red Marsh Trotter	Tramea basilaris	10	16	31	57
32	Coral Marsh Trotter	Tramea virginia	15	21	39	75
33	Crimson Marsh Skimmer	Trithemis aurora	27	15	21	63
34	Long-legged marsh glider	Trithemis pallidinervis	6	10	18	34
35	Orange-winged dropwing	Trithemis kirbyi	21	18	29	68
Family: Coenagrionidae						
36	Pale slender darlet	Aciagrion pallidum	29	19	14	62
37	Pruinosed darlet	Agriocnemis femina	21	12	9	42
38	Indian hooded darlet	Agriocnemis kalinga	13	8	0	21
39	Pigmy darlet	Agriocnemis pygmaea	55	31	19	105
40	Coromandel Marsh Dart	Ceriagrion coromandelianum	82	78	61	221
41	Western Golden darlet	Ischnura aurora	117	98	79	294
42	blue-tailed damselfly	Ischnura elegans	32	37	26	95
43	Western Golden darlet	Ischnura rubilio	25	17	22	64
44	Senegal Golden Dartlet	Ischnura senegalensis	94	79	63	236
45	Three lined dart	Pseudagrion decorum	27	21	31	79
46	Jungle grass dart	Pseudagrion malbaricum	3	0	3	6
47	Blue grass dart	Pseudagrion microcephalum	21	19	15	55
48	Saffron-faced Blue Dart	Pseudagrion rubriceps	33	29	26	88
49	Pixie Dartlet	Rhodischnura nursei	0	1	2	3
Family: Lestidae						
50	Brown spreadwing	Lestes umbrinus	0	2	8	10
51	Emerald-striped spreadwing	Lestes viridulus	0	3	15	18
Family: Platycnemididae						
52	Yellow bush-dart	Copera marginipes	37	3	11	51
Total number of odonate individuals			1067	873	1207	3152
Total Species richness of odonates			38	48	51	

3.2 Richness and diversity of odonates in different habitats

The relative abundance of odonates observed in three different habitats where species abundance was more in Agro-forest (38.29%) followed by urban area (34.01%) and then rural area (27.7%). The rural area has the least evenness (E'=0.5661) and equitability (J=0.853) than other two habitats. However, the Agro-forest have highest diversity (H'=3.52), species richness (d=7.046), equitability (J=0.8952) and evenness (E'=0.6624). The Fisher-alpha diversity indices shows that the rural area has the highest index of diversity (10.93), followed by Agro-forest (10.79) and urban area has the least (7.684) (Table 2).

As per the observation, in most of the water bodies, Anisopteran population is abundant as compare to Zygopteran. The diversity and species richness of odonates is totally depends on the water availability in aquatic bodies chiefly observed during rainy to winter season. Hence, aquatic bodies with vegetation i.e. temporary and permanent were observed more in Agro-forest followed by Rural and urban habitat.

The highest relative abundance in odonates was shown in the family Libellulidae (28 species, 47.49%), followed by Coenagrionidae (14 species, 43.50%) while least abundance in Lestidae (2, 0.89). The diversity indices shows that family Libellulidae have the highest diversity index (H'= 2.336) and species richness (d = 3.693) followed by family Coenagrionidae with diversity index (H'=2.27) and species richness (d=1.8). Family Platycnemididae was noted to have the highest evenness index (E'= 1), the least (H'= 0) and (d = 0). However, highest evenness after family Platycnemididae was observed in family Lestidae with (E'=0.9595) (Figure 2).

In order Anisoptera, *Pantala flavescens* was the most dominant species and constituted (249, 14.63%) of the total individuals followed by *Diplocodes trivialis* (216, 12.69%), *Orthetrum sabina* (147, 8.64%), *Crocothemis servilia* (127, 7.46%) and *Diplocodes nebulosa* (109, 6.40%). The diversity and species richness of dragonflies is more in Agro-forest followed by rural area and then urban area. In order Zygoptera, the most dominant species was *Ischnura aurora* which constituted (294, 20.28%) of the total individuals followed by, *Ischnura senegalensis* (256, 17.66%), *Ceriagrion coromandelianum* (221, 15.24%), *Agriocnemis pygmaea* (105, 7.24%) and *Ischnura elegans* (95, 6.55%). The diversity and species richness of damselflies is more in urban area followed by rural area and then Agro-Forest (Table 1).

Table 2: Relative abundance, diversity indices, evenness and species richness from the selected habitats

Family	Relative Abundance	Shannon index (H^1)	Evenness (E^1)	Fisher-alpha (α)	Margalef (d)	Equitability (J)
Urban area	34.01	3.16	0.6201	7.684	5.303	0.8686
Rural area	27.697	3.30	0.5661	10.93	6.94	0.853
Agro-forest	38.29	3.52	0.6624	10.79	7.046	0.8952

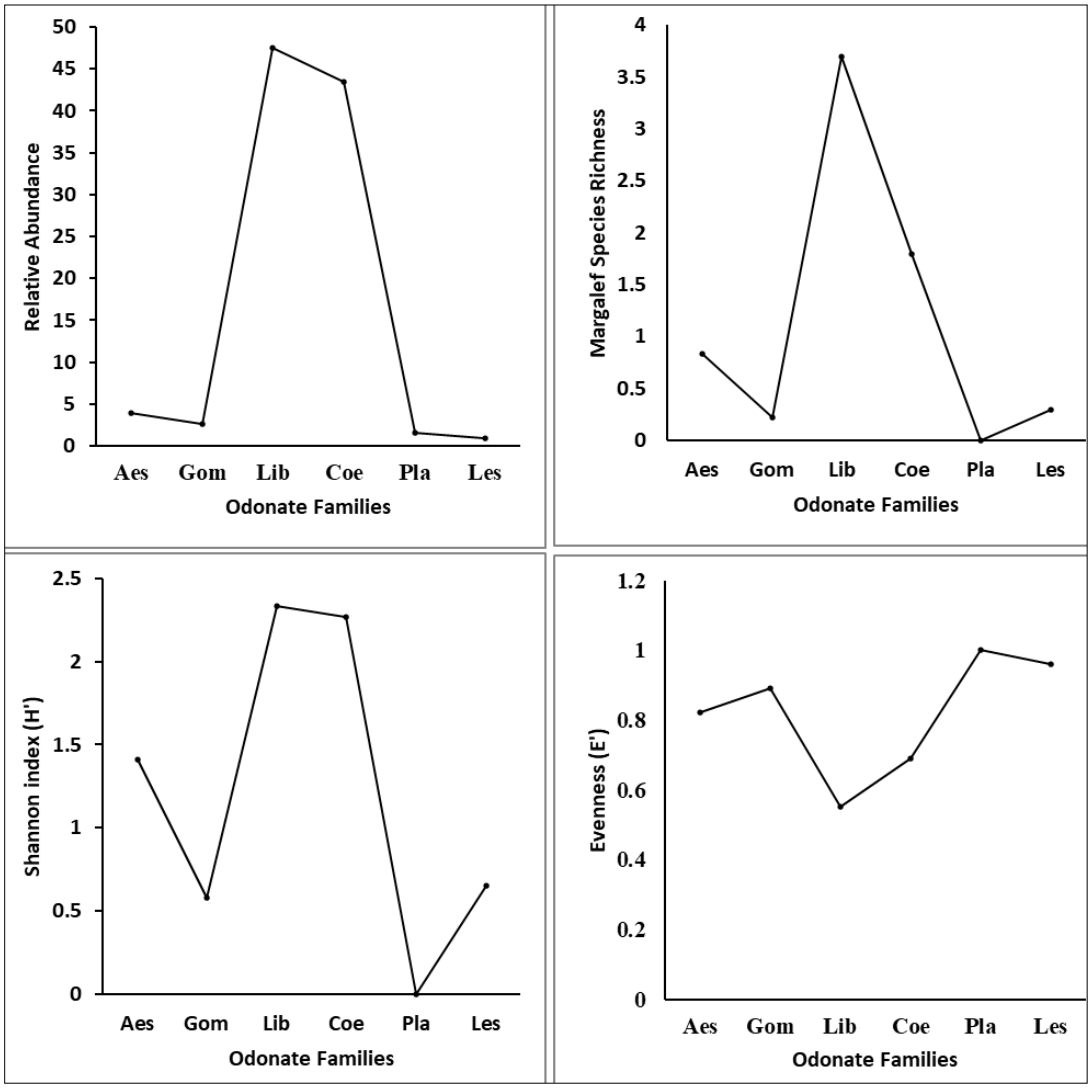

Fig 2: Family wise differences in diversity indices a) Relative abundance (Number of individuals) b) species richness (Number of Species) c) Shannon index d) evenness. Odonate family's abbr. Aes-Aeshnidae; Gom-Gomphidae; Lib-Libellulidae; Coe-Coenagrionidae; Pla-Platycnemidae; Les-Lestidae.

4. Discussion

A total 52 species of Odonata including 35 species of Anisoptera and 17 species of Zygoptera were recognized from three different habitats i.e. Urban, Rural and Agro-forest area located in and around the Chalisgaon region. During the survey, around 3152 adult odonates were recorded. In Maharashtra, Tiple and Koparde [20]. recorded 135 species of odonata belonging to 70 genera and 11 families. Saha and Marathe[21] documented 46 species belonging to 26 genera and 7 families from Jalgaon city in North Maharashtra region.

The species diversity of odonates was significantly higher in agro-forest area and least in urban area. However, in Agro-forest, the diversity index (relative abundance, species richness, evenness and equitability) has highest value than other two habitats (Table 2). This might be due to dragonfly's high dispersal ability, strong musculature and wide range of landscape habitats would have no problem to take long flights in the forest area [7, 27-30]. In contrary, species diversity and abundance of damselflies noted more in urban while minimum in agro-forest area. This may be considering that damselflies more sensitive to local habitats (urban and rural) where water bodies located in close vicinity than in the agro-forest area. According to De Marco & Resende [31], damselflies unable to take long flights in open fields due to their small size, weak musculature and high risks of thermoregulation. A similar result was described in another study where the Zygopteran diversity significantly decline with the increasing forest area in relation to the surrounding habitat [7, 30].

The abundance of damselflies was mainly observed in shady places around the water bodies. It may be due to presence of bushes, small trees and even aquatic vegetation. It means that shady and aquatic vegetation could favour to the Zygoptera more than Anisoptera [22, 26]. In another study, Carvalho *et al*. [32]. was noticed that the Zygoptera would

have trouble surviving in open spaces exposed to light and heat.

The diversity indices shows that family Libellulidae (28 species) have the highest diversity index (H'=2.336) and species richness (d=3.693) followed by family Coenagrionidae (14 species) with diversity index (H'=2.27) and species richness (d=1.8). It may consider that the member of these families was very common in all habitats and hence most diverse. In the odonates, family Libellulidae and Coenagrionidae were represent a large proportion of species distributed in every continent due to their great flight ability and preference of open habitats [33].

More than 72% (37 members) of *Copera marginipes* (Family- Platycnemididae) was observed in two marshy and shady places of small water canal located in urban area. Family Platycnemididae was noted to have the highest evenness index (E'= 1) than other noted odonate families. The members of family Platycnemididae are very sensitive to habitat and confined in small areas [34].

This study showed that species diversity in three habitats had similar communities. Around 65% odonate species can occupy all sites with different aquatic habitats. Among dragonflies, *Pantala flavescens*, *Diplocodes trivialis* and *Orthetrum sabina* were the most dominant species. Meanwhile in damselflies, the most dominant species were *Ischnura aurora*, *Ischnura senegalensis* and *Ceriagrion coromandelianum*. It might be due to their abundance and high dispersal ability in different aquatic habitats [35].

Notified total 52 species of odonates from all the three different habitats in Chalisgaon region were rich in odonates diversity. The findings suggest that this region comprises with small forest area and several water bodies located in selected habitats became an ideal environment for odonates. Though the study provides baseline data on diversity and species richness of odonates in different habitat of Chalisgaon region, which might be beneficial to understand their valuable ecosystem services as well as ecological role in this region.

5. Conclusion

The distribution patterns of odonate species was investigated from three different habitats i.e. urban, rural and agro-forest observed in Chalisgaon region. A total of 52 odonate species belonging to six families, comprising 35 species in order Anisoptera and 17 species in order Zygoptera were recorded. Agro-forest habitat bears bloom of vegetation with many breeding grounds for odonates in the form of water canals, river, irrigation, dams and small ponds confirmed that the diversity and species richness was significantly higher as compare to urban and rural habitats. It was conclude that the species abundance of damselflies more in urban than the agro-forest habitat, due to presence of permanent, small but many water bodies covered by shady places in urban habitat.

Different diversity index applied during study were indicated that all three different habitats has different but moderate species diversity, abundance and species richness should be helpful for further research study.

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