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Diversity and abundance of Odonata in parks and gardens of Pune city

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Abstract

Man-made Parks and gardens play a vital role in maintaining urban insect diversity besides controlling pollution. The objective of this study was to find out the diversity and abundance of Odonates and to evaluate the importance of human-managed urban parks and gardens in supporting Odonata diversity. Thirty big and small parks and gardens of Pune city were surveyed during 2012-2013 at regular intervals to record the diversity of Odonates. A total of 1113 individuals were recorded comprising of 33 species under 6 families. The diversity and abundance of species depends on a number of factors like presence or absence of water bodies, size of the water bodies, level of human disturbances, shade cover, presence of emergent aquatic reeds, degree of pollution and garden management practice.

Keywords: Parks, Urban ecology, Odonata, diversity

1. Introduction

Gardens are discrete patches of human-managed habitat that are common in many urban areas [1]. Apart from imparting much needed relief to the tired city souls and enhancing the beauty of the city, the urban green patches like parks and city gardens provide the city dwellers numerous benefits like recreation and environmental education by exposing the urban dwellers to nature. Moreover, parks and gardens help to reduce summer heat and control pollution. Therefore these green spaces are significantly important in improving the quality of urban life. Man-made gardens and parks are inhabited by a variety of insects and other organisms. Insects play an important role in nutrient cycle, organic matter decomposition, pollination and soil aeration in urban ecosystem [2]. Some insects visit parks and gardens for nectar or other resources, others (like Odonates) can reproduce and spend most of their lifespan in the gardens (provided there are some source of water available, where they can lay eggs and larvae can exist). Thus there has been increasing research to show the potential for small scattered habitats like domestic gardens, community gardens, green roofs and parks to support rich biodiversity, even in densely populated urban areas [3].

Pune, Oxford of the East and Cultural capital of Maharashtra, is the seventh largest metropolis and one of the busiest and polluted cities of India [33]. There are a variety of gardens like rose and butterfly garden, Hibiscus Park, Palm Park, Energy Park, Ayurvedic plantations, Lake Park, etc. in the city. Pune Municipal Corporation has already developed 111 big and small gardens and parks measuring up to 475 acres [33]. The present study deals with Odonata diversity in parks and gardens of Pune city which are maintained by Pune Municipal Corporation and also aims to identify the probable factors influencing their abundance and diversity.

The order Odonata is quite big with worldwide distribution of 5,952 species, of which 474 species in 142 genera and 18 families exist in India [4]. Numerous reports have been published in recent years regarding the taxonomic information on Odonata [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. A detailed account of Odonates of Mula-Mutha river basin has been given by Kulkarni and Subramanian [22]. Odonata, being sensitive to habitat structure, constitutes a valuable tool for various types of bio-assessment and bio-monitoring of aquatic habitat like assessment of water quality and ecosystem function, monitoring of management or restoration practices and the detection and prediction of biological impact of climate warming [23]. Against this background, the study is aimed to describe Odonata abundance, diversity and distribution in purely urban parks and gardens in the heart of such a busy, congested and polluted city like Pune and to assess the environmental factors affecting their diversity and abundance.

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2. Materials and Methods

2.1 Study Area

The area under Pune Municipal Corporation (PMC) jurisdiction was selected as the study area. For selection of study sites, the center was geographically located, and the sampling was done from some of the parks and gardens selected from all the four corners (North, South, East and West) and centre of the study area so that almost the total area under Pune Municipal Corporation can be sampled. A total of 30 gardens and parks were sampled during Pre-monsoon and post-monsoon season from March to November 2012-2013. Both, large (like P.L. Deshpanday Udayan, 33 acres) and small

(like Pankunwar Firodia garden, 1/2 acres) parks, and most crowded as well as desolated parks were taken into consideration and sampled extensively for Odonata diversity and abundance.

Data collection was conducted between 09:00 am and 01:00 pm when insects were most active. Odonates were observed in the field and photographed. Identification was done by using identification keys provided by [24, 25, 26, 27]. The one could not be identified in field were only caught by sweeping net and preserved dry. Photographs of the adults were taken either in field or after preservation and spreading.

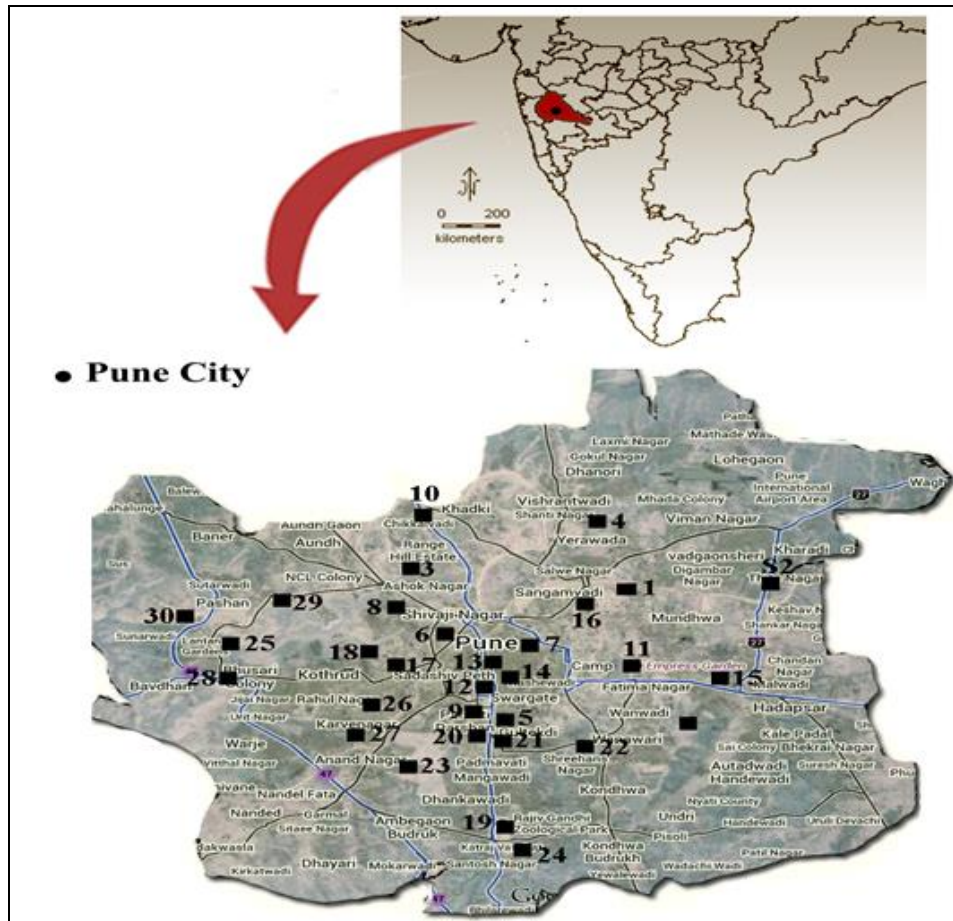


Fig 1: Map depicting collection sites under Pune Municipal Corporation jurisdiction

The habitat, that is the natural environment of the parks and gardens were noted during sampling. The following observations were made for each garden; presence of aquatic body, presence of emergent aquatic vegetations that act as a perching site and shade cover. Water bodies that include mainly small lakes, artificial fountains, pools, puddles, etc. were categorized based on size: large (10m or more), medium (from 5 m but less than 10 m) and small (less than 5 m).

2.3 Data analysis

Diversity indices were calculated using the software PAST [28].

3. Results and Discussion

A total number of 1113 individuals belonging to 33 species of Odonata in 22 genera and 6 families have been reported. Among them were 24 species of Anisoptera under 4 families and 9 species of Zygoptera belonging to 2 families. On the basis of number of identified species, Libellulidae was the most dominant family represented by 20 species followed by family Coenagrionidae represented by 7 species,

Platycnemidae by 2 species, Aeshnidae by 2 species, Macromiidae and Gomphidae by 1 species each. Genera *Orthetrum* and *Trithemis* were represented by maximum number of species i.e. 4 species each. In all, 351 individuals (relative abundance 31.536%) (Table.1) of *Pantala flavescens* (Plate I, D) were recorded from all sampling sites except Site S24 (Fig. 3) which might be due to the mass emergence of the species post monsoon and their yearly aggregation before migration [22]. This was followed by *Diplacodes trivialis*, which recorded 109 individuals (9.793%). However, *Anax immaculifrons* (Plate II, J), *Macromia cingulata* (Plate II, L) and *Zyxomma petiolatum* were represented by only 1 individual each from sites S13, S11 and S19 respectively. Other commonly found species were *Brachythemis contaminata* (Plate I, B) (8.355%), *Orthetrum sabina* (5.750%), *Trithemis aurora* (6.289%), *Ceriagrion coromandelianum* (6.109%) and *Copera marginipes* (3.863%).

Table 1: The distribution and abundance of the Odonata in all the 30 sampling sites

Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	Tot	RA%
<i>Anax guttatus</i>																			1	1										2	0.179	
<i>Anax immaculifrons</i>													1																	1	0.089	
<i>Ictinogomphus rapax</i>					1													1												2	0.179	
<i>Macromia cingulata</i>											1																			1	0.089	
<i>Acisoma panorpoides</i>											4																			4	0.359	
<i>Brachythemis contaminata</i>	2		4		3	4	5		2	7	6	2	3	1	2	5	6	5	8	3	2	6	4	1					5	93	8.355	
<i>Bradinyoga geminate</i>					1	2				1	2	1	1			1		1			1								1	13	1.168	
<i>Crocothemis servilia</i>		2		3	9	4	2	2	4	7	4	5	2			4		3	6	2				2				1		2	69	6.109
<i>Diplocodes trivialis</i>	5	3	2	7	4	4	3	2	4	8	6	2	5	2	2	4	4	7	9	4	3	2	2		3	4		2	1	5	109	9.793
<i>Neurothemis fulvia</i>					1								1					1												3	0.269	
<i>Orthetrum luzonicum</i>										2								1												3	0.269	
<i>Orthetrum prunosum</i>	1		1		3	2	2			3	3	1	1			2		3	4	4	2			2	3	2	2		1	3	45	4.043
<i>Orthetrum Sabina</i>	1	2	2	1	4	3	4	2		3	6	4	4	1		4	2	2	4	3	3	4	1		1					3	64	5.750
<i>Orthetrum taeniolatum</i>										3	2		1						1							2				3	12	1.078
<i>Pantala flavescens</i>	2	5	5	2	19	12	9	3	7	3	24	21	11	19	1	1	14	21	19	33	13	12	6		2	9	19	8	24	27	351	31.536
<i>Rhyothemis variegata</i>					2	1				2	1	1				1			1	2					1	1				1	14	1.257
<i>Tramea basilaris</i>							1			2	3	1																		1	8	0.718
<i>Tramea limbata</i>											2		1							1										4	0.359	
<i>Trithemis aurora</i>	2	4	1	4	5	2	1	1	2	5	4	2	4	1	1	3	3	4	6	3	1	2	2	1	1	3			2	70	6.289	
<i>Trithemis festiva</i>	2		1	2	5		2	1		2	3	2	4			2		3	4	1										3	39	3.504
<i>Trithemis kirby</i>					2	2														1										5	0.449	
<i>Trithemis pallidinervis</i>					2	3				3	1							2		1									1	13	1.168	
<i>Urothemis signata</i>																				2										2	0.179	
<i>Zyxomma petiolatum</i>																			1											1	0.089	
<i>Agriocnemis pygmaea</i>		1		2		1				3	1	2						3	2										2	17	1.527	
<i>Ceragrion coromandelianum</i>	2				4	3	4	1		6	5		2	1	3	2	4	2	8	6	2	1	4	3			2		1	2	68	6.109
<i>Ischnura aurora</i>					1					2	1								2	4										10	0.898	
<i>Ischnura senegalensis</i>											4		2				2			4										12	1.078	
<i>Pseudagrion decorum</i>							1				2					2														5	0.449	

<i>Pseudagrion rubriceps</i>					1							1	2															2		11	0.988		
<i>Rhodischnura nursei</i>				1			2				2																			5	0.449		
<i>Copera marginipes</i>	2	1	3	3	1						5	5		2	3			2	3	4	1					2	2		1		3	43	3.863
<i>Copera vittata</i>												3	2	1			2	1	1	3										1	14	1.257	
Total no of individuals	19	18	19	25	68	43	36	12	19	69	94	49	45	28	09	33	38	63	85	79	27	27	19	11	13	36	24	11	29	65	1113		

S1:Valmiki garden; S2: Jogger's park, S3: Shivaji Maharaj garden; S4:Lumbini park; S5: Sarasbag; S6: Sambhaji park; S7: Sahu garden; S8: Chittaranjan park;S9:Bagul garden;S10: Ropevatika;S11: Empress garden; S12:Peshwa Udyan; S13: Jijamata garden; S14: Maharana Pratap garden; S15: Rammohan Lohiya garden;S16: Bund garden;S17: Vartak garden; S18:Kamala Neheru park; S19: Rajiv Gandhi Zoological park; S20: Pu.La Deshpande park; S21: Yashwantrao Chavan park;S22: Gul Poonawala garden;S23: Late Jayantrao Tilak Gulab Pushpa garden; S24:Pragati garden; S25:Pt. Bhimsen Joshi garden; S26: Raja Mantri garden; S27: Rajendra Nagar park; S28: Lakaki garden; S29: Pankunwar Firodia garden; S30: Someshwarwadi garden.; Tot: total; RA%: Relative abundance percent

Table 2: Biodiversity indices in the 30 sampling sites					
Collection sites	No. of Species	Individuals	Simpson(1-D)	Fisher's alpha	Margalef
S1	9	19	0.8587	6.688	2.717
S2	7	18	0.8148	4.208	2.076
S3	8	19	0.831	5.205	2.377
S4	9	25	0.8448	5.043	2.485
S5	18	68	0.8754	7.992	4.029
S6	13	43	0.8718	6.333	3.19
S7	12	36	0.8719	6.303	3.07
S8	7	12	0.8333	7.028	2.415
S9	5	19	0.7535	2.212	1.358
S10	19	69	0.9313	8.662	4.251
S11	24	94	0.9031	10.41	5.062
S12	15	49	0.7855	7.375	3.597
S13	16	45	0.8889	8.869	3.94
S14	7	28	0.5179	2.996	1.801
S15	5	9	0.7654	4.632	1.82
S16	13	33	0.9036	7.912	3.432
S17	9	38	0.8019	3.725	2.199
S18	17	63	0.8506	7.645	3.862
S19	18	85	0.8988	6.981	3.827
S20	19	79	0.8008	7.938	4.12
S21	8	27	0.7243	3.84	2.124
S22	6	27	0.7188	2.392	1.517
S23	6	19	0.7867	3.02	1.698
S24	6	11	0.8099	5.403	2.085
S25	7	13	0.8284	6.182	2.339
S26	10	36	0.8503	4.586	2.511
S27	4	24	0.3576	1.371	0.944
S28	3	11	0.4298	1.359	0.8341
S29	5	29	0.30680	1.742	1.188
S30	17	65	0.8	7.489	3.833

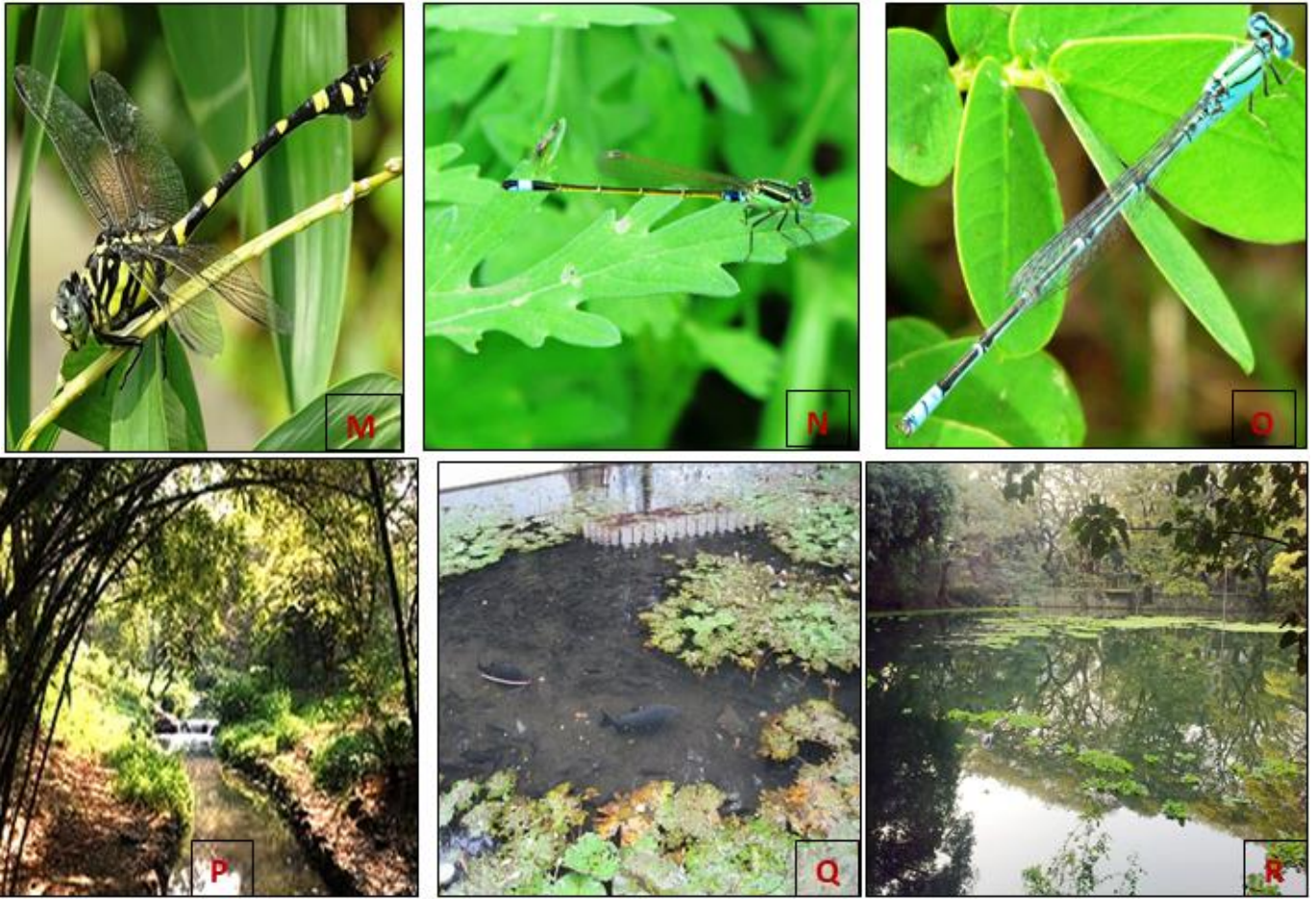
PLATE 1



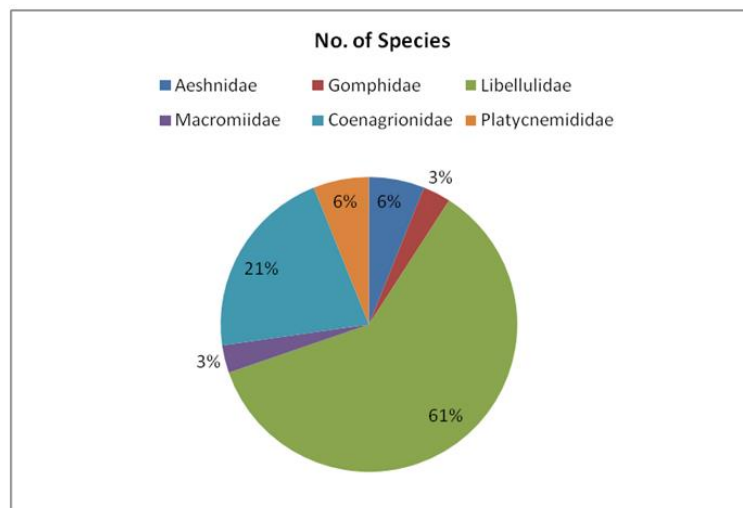
A: *Acisoma panorpoides* Rambur, **B:** *Brachythemis contaminata* (Fabricius), **C:** *Crocothemis servilia* (Drury), **D:** *Pantala flavescens* (Fabricius), **E:** *Orthetrum pruinosum* (Burmeister), **F:** *Orthetrum luzonicum* (Brauer), **G:** *Trithemis pallidinervis* (Kirby), **H:** *Tramea basilaris* (Palisot de Beauvois), **I:** *Urothemis signata* (Rambur)

PLATE 2





J: *Anax immaculifrons* Rambur, **K:** *Anax guttatus* (Burmeister), **L:** *Macromia cingulata* Rambur, **M:** *Ictinogomphus rapax* (Rambur), **N:** *Ischnura senegalensis* (Rambur), **O:** *Pseudagrion decorum* (Rambur), **P,Q, and R:** Different habitats of Odonates in collection sites



Distribution and the relative abundance of Odonates in 30 sites are summarized in Table:1. Among the 30 parks and gardens, Site S11 (Empress Garden) recorded highest species diversity as well as abundance followed by Site S20 (Pu La Deshpande Garden) and Site S10 (Ropvatika). However, Site S28 recorded lowest species diversity and site S15 the least number of individuals (Table: 2).

Family Libellulidae was the most abundant (61%) and widely distributed in different sampling sites (Fig.2). Out of 33 species recorded, 20 species belonged to family Libellulidae and 7 species to family Coenagrionidae (21%). Keize & Kalkman^[29] reported that Coenagrionidae and Libellulidae are the two worldwide largest families which dominated the Odonata fauna of standing water in every continent.

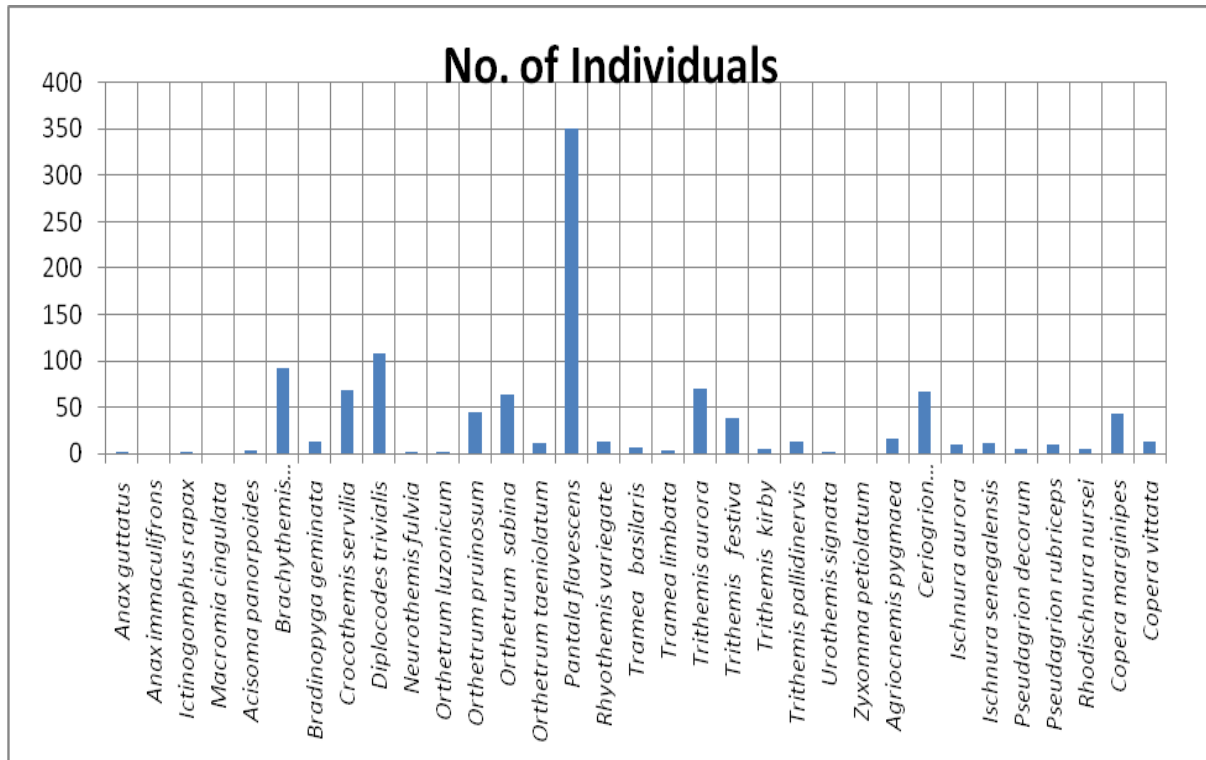


Fig 3: Species abundance in study area

The biodiversity indices in the 30 sampling sites (Table: 2) indicate that most of the sampling sites were found to have moderate diversity. Fig.4 shows the similarity between the study sites based on different ecological factors. The most similar pairs of samples are first joined into clusters. The most similar clusters are then joined into superclusters, and the process continues until all clusters are joined. The sites S5, S11, S19, S18, S30, S12, S20 and S10 form one cluster. All these parks have some common characteristics like large size of the garden with variety of tree species, presence of large

water body (10 meter or more) with diverse habitat, presence of floating and submerged macrophytes, and proper scientific maintenance. The sites S3 and S23; S15 and S24; S4 and S1, S2, S8 and S25 formed small clusters and are similar in having small water bodies, less diverse habitats and small garden area. Therefore, they exhibited less species diversity and abundance. Similarly, sites S6, S7, S17, S21, S13 and S22 forms a cluster where moderate abundance is noted due to its medium sized water bodies and more or less similar type of aquatic vegetation.

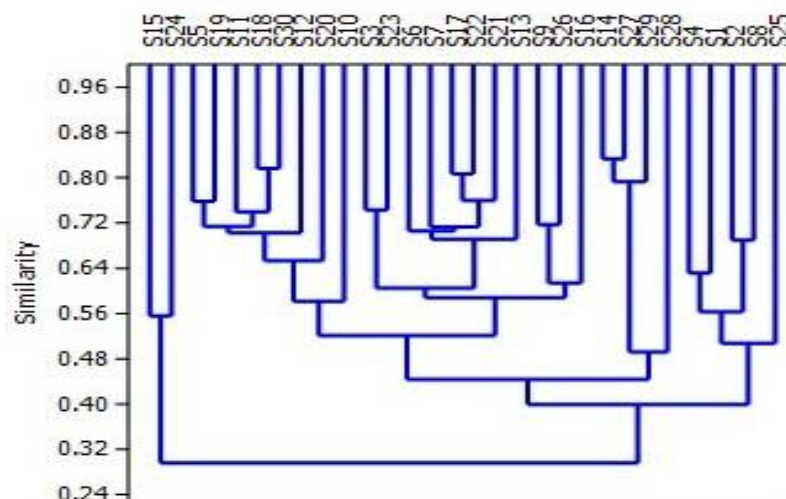


Fig 4: Cluster analysis of study sites based on disturbance gradient

From this study it is more or less clear that to some extent Odonata abundance is not much affected by human interference and disturbances. Since, being a very famous park situated in the heart of the city and visited by thousands of people every day, Site S11 (Empress Garden) recorded maximum species diversity as well as abundance. Credit can thus be given to the Park authority which has maintained the garden well and kept it free from the anthropogenic actions.

Similarly, site S19 (Rajiv Gandhi Zoological Park), S20 (Pu La Deshpande park), S5 (Sarasbag), etc. have rich diversity and abundance though being much crowded park. Again some other factors like presence of a large number of predators like fish, ducks and water birds sometime cause decline in Odonate abundance as Odonate larvae act as a prey to these organisms. So parks with lakes stacked with fishes and water birds have less diversity of Odonates. Thus it is clear that Odonate

diversity mostly depends on the habitat and environmental attributes like presence of water bodies, aquatic plants, shade cover, etc. and most species can tolerate habitat disturbances and are able to survive in human settlements.

Vegetation type affects Odonata diversity and abundance [30]. The other factors which determine the presence and diversity of Odonate species are shoreline structures, reeds and shade cover [31]. Odonates use reeds as oviposition sites and as a shelter for protection from predators and wind [32]. Despite being ectothermic, they can regulate their body temperature to some extent by stretching out in sun and by adjusting their orientation. Therefore, shade affects thermoregulation and consequently their abundance and distribution. Zygoptera species were recorded at sites with higher percentage shade; however, Anisoptera species were mostly recorded in sunny biotopes [33, 34]. Pictures depicting different habitats of Odonates in the collection sites has been given in Plate II (P,Q, R).

4. Conclusion

Urban ecology, being a relatively new field of research in most developing countries has a predominant focus on plants. Yet, it is also important to understand the factors affecting the diversity and abundance of insects, which provides a range of supporting ecosystem functions in urban ecosystem [3, 32]. Urban parks and gardens in Pune city seem to be an important source of support for insects like Odonates with this investigation which records 1113 individuals belonging to 33 species. The abundance and species richness tends to increase with increase in size of the park, presence of large and perennial water sources, good aquatic vegetations, etc. Again park management practices play a vital role in influencing the species diversity and richness. Our observation indicates that along with accelerated rate of urbanization, simple steps can be taken to increase the insect diversity of these parks such as 1. Afforestation 2. Periodically cleaning and keeping the water bodies pollution free and 3. Checking the population of fishes, ducks, etc. as they are the main predators of naiads.

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