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Research Article

Seasonal Variations in Diversity and Abundance of Odonata at Sawanga-Vithoba Lake, India

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Abstract

Background: Dragonflies and damselflies are one of the most diversified creatures on the earth. **Materials and Methods:** In the present study, Swanga-Vithoba lake was chosen to study Odonata diversity. This study was carried out in three seasons as: monsoon, winter and summer. Lake area was divided in four sites as: East, West, North and South. A total of 33 species representing 6 families were recorded from the multiple transect area of 1 km long and 5 m wide. **Results:** In summer, 88.89% individuals were randomly distributed and 11.11% were aggregated, 89.65% were randomly distributed and 10.35% were aggregated in winter and 93.93% were randomly distributed and 6.06% were aggregated in monsoon. During monsoon, 650 flies were encountered which decreased to 424 individuals in winter and it was only 249 flies in summer. *Brachythemis contaminata* was the most abundant in monsoon. Libellulidae was the dominant family with 19 species while other families were not as much diverse which could be due to their shorter life cycle and widespread distribution. **Conclusion:** Shannon diversity index indicated that winter is relatively diverse (1.357) followed by monsoon (1.342) and summer (1.319).

Key words: Libellulidae, shannon diversity index, random distribution, aggregated

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Odonata belongs to one of the most ancient creatures on earth with fossil records dating back to the Permian era 230-280 million years ago with 5740 species/subspecies of Odonates belonging to 654 genera in 32 families are reported worldwide^{1,2}. Order Odonata which includes dragonflies and damselflies is a small, well known order of insects which is widely distributed all over the world³. Pre-adult stages of Odonates are aquatic in nature and adjust themselves in both stagnant and running water⁴. Odonates may be taken as an indicator of ecosystem quality. In addition to their direct role as predators in ecosystem, they are also indicators of quality of the biotope⁵. They are often used as indicators for environmental health and conservation management⁶. Their sensitivity to structural habitat quality (e.g., forest cover, water chemistry) and amphibious habits make dragonflies well suited for use in evaluating environmental changes in the long term (biogeography, climatology) and in the short term (conservation biology), both above and below the water surface⁷⁻¹¹. Dragonflies are often used in both fundamental and applied research because of the relative ease with which they can be observed and their broad array of behaviours. In many regions reliable identification literature is available, so species can be determined fairly easy.

There is no comprehensive account of Indian odonates after¹² published during 1930's. Large number of endemic odonates are being threatened due to large scale habitat destruction. Large scale habitat alterations such as damming channel diversion, sand mining and pollution are seriously threatening the survival of these species¹³.

Sawanga lake is situated at 20°49' 0" N, 77°53' 0" E, 23 km East to Amravati, Maharashtra; India set in hilly region with good forest cover. At mean water level, the surface area is 6,717 km², the height from riverbed is 19 m, the largest length of the lake is 1,422 m and the volume is 481 m³. The lake is constructed for irrigation purpose and was started to use¹⁴ in 1972.

A seasonal study on Odonata fauna from different locations in Sawanga-Vithoba lake region is carried out. Seasonal diversity and abundance of species are studied. This report also emphasizes season wise family abundance of order Odonata.

MATERIALS AND METHODS

Sawanga-Vithoba lake area was divided into four sites as; East, West, North and South. Each site was surveyed in three

seasons multiple times. For the observations of species, transects of 1 km long and 5 m wide was followed. Bi-weekly random survey carried out from June, 2011 to May, 2012 at Sawanga-Vithoba lake region. Odonates were photographed and identified. Surveys were conducted in all the seasons. All surveys were conducted in the afternoon till 3 pm.

Photography and identification: Odonates were photographed by the digital camera (Make-Sony model No. W-310) and identified using the keys of Andrew *et al.*¹³ and Subramanian¹⁵.

Statistical analysis: Species richness was calculated as:

$$D = \frac{S}{\sqrt{N}}$$

where, D is the species richness, S is the No. of individuals of a particular species and N is the total No. of the individuals in collection.

Simpson's index (λ): It was calculated by the following equation:

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

where, n is the No. of individuals or amount of each species and N is the total No. of individuals for a site.

Shannon-weiner index (H'): It was calculated as:

$$H = \sum [(n/N) \ln (n/N)]$$

where, n is the No. of individuals or amount of each species and N is the total No. of individuals for a site and ln is natural log of the number.

Similarity index: Similarity index was calculated as:

$$\text{Sim} = \frac{2 \sum n_c}{\sum n_1 + \sum n_2}$$

RESULTS

Distribution of Odonates in different seasons at study area was assessed as 88.89% were randomly distributed and

11.11% were aggregated in summer, 89.65% were randomly distributed and 10.35% were aggregated in winter and 93.93% were randomly distributed and 6.06% were aggregated in monsoon. The aggregated distribution indicates seasonal preference, where random distribution indicates available resource use and suitability of season to survival.

In this study, the number of Odonates encountered during monsoon were 650, which decreased to 424 individuals in winter and it was only 249 individuals in summer. However, 33 species were recorded throughout the year. Few species of Odonates such as *Diplacodes lefebvreii*, *Orthetrum glaucum*, *Tholymis tillarga*, *Aethriamanta brevipennis*, *Aciagrion pallidum* and *Lestes elatus* were not observed in summer. *Brachythemis contaminata* was the most abundant in monsoon indicating polluted water¹⁶. *Pantala flavescens* was also abundant in monsoon. A total of 33 species representing 6 families

were recorded from the multiple transect area. Libellulidae was the dominant family with 19 species, followed by Coenagrionidae (10 species), Gomphidae (1 species), Aeshnidae (1 species), Platycnemididae (1 species) and Lestidae (1 species). *Orthetrum* was found to be the most species rich gen with 4 species. During the study, Shannon, Simpson and Hills indices were calculated as a measure of diversity in three different seasons of multiple use areas. The Shannon diversity index indicated that winter is relatively diverse (1.357) followed by monsoon (1.342) and summer (1.319).

Odonata diversity: Thirty three species of Odonata were observed at Sawanga-Vithoba lake area under six different families. Most of the species were common. Odonata species distribution at four sites at Sawanga-Vithoba lake is documented in Table 1.

Table 1: Documentation of Odonata species at Sawanga-Vithoba lake

Family	Common name	Scientific name	
Libellulidae	Brown-backed red marsh hawk	<i>Orthetrum chrysis</i> (Selys, 1891)	
	Black stream skimmer	<i>Trithemis festiva</i> (Rambur, 1842)	
	Long-legged marsh skimmer	<i>Trithemis pallidinervis</i> (Kirby, 1889)	
	Crimson marsh skimmer	<i>Trithemis aurora</i> (Burmeister, 1839)	
	Black ground skimmer	<i>Diplacodes lefebvreii</i> (Rambur, 1842)	
	Ground skimmer	<i>Diplacodes trivialis</i> (Rambur, 1842)	
	Scarlet skimmer	<i>Crocothemis servilia</i> (Drury, 1770)	
	Green marsh hawk	<i>Orthetrum sabina</i> (Drury, 1770)	
	Crimson-tailed marsh hawk	<i>Orthetrum pruinosum</i> (Burmeister, 1839)	
	Blue marsh hawk	<i>Orthetrum glaucum</i> (Brauer, 1865)	
	Ditch jewel	<i>Brachythemis contaminata</i> (Fabricius, 1793)	
	Trumpet tail	<i>Acisoma panorpoides</i> (Rambur, 1842)	
	Coral marsh trotter	<i>Tamea virginia</i> (Rambur, 1842)	
	Black marsh trotter	<i>Tamea limbata</i> (Desjardins, 1832)	
	Common picture wing	<i>Rhyothemis variegata</i> (Linnaeus, 1763)	
	Wandering glider	<i>Pantala flavescens</i> (Fabricius, 1798)	
	Coral-tailed cloud wing	<i>Tholymis tillarga</i> (Fabricius, 1798)	
	Yellow-tailed ashy skimmer	<i>Potamarcha congener</i> (Rambur, 1842)	
	Scarlet marsh hawk	<i>Aethriamanta brevipennis</i> (Rambur, 1842)	
Gomphidae	Common club tail	<i>Ictinogomphus rapax</i> (Rambur, 1842)	
Ashnidae	Blue-tailed green darner	<i>Anax guttatus</i> (Burmeister, 1839)	
Coenagrionidae	Saffron-faced blue dart	<i>Pseudagrion rubriceps</i> (Selys, 1876)	
	Blue grass dart	<i>Pseudagrion microcephalum</i> (Rambur, 1842)	
	Pruinosed dartlet	<i>Agriocnemis femina</i> (Brauer, 1868)	
	Splendid dartlet	<i>Agriocnemis splendidissima</i> (Laidlaw, 1919)	
	Pigmy dartlet	<i>Agriocnemis pygemia</i> (Rambur, 1842)	
	Pixie dartlet	<i>Rhodischnura nursei</i> (Morton, 1907)	
	Senegal golden dartlet	<i>Ischnura senegalensis</i> (Rambur, 1842)	
	Golden dartlet	<i>Ischnura aurora</i> (Brauer, 1865)	
	Coromandel marsh dart	<i>Ceragrion coromandelianum</i> (Fabricius, 1798)	
	Pale slender dartlet	<i>Aciagrion pallidum</i> (Selys, 1891)	
	Platycnemididae	Yellow bush dart	<i>Copera marginipes</i> (Rambur, 1842)
	Lestidae	Emerald spreadwing	<i>Lestes elatus</i> (Selys, 1862)

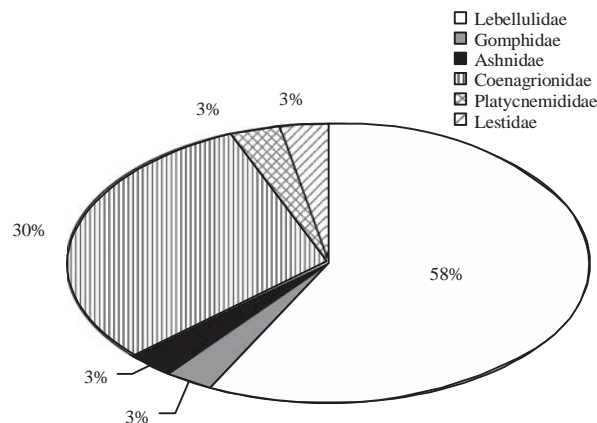


Fig. 1: Family distribution of Odonata at Sawanga-Vithoba lake area

Table 2: Diversity indices of Odonata diversity and distribution at four sites at Sawanga-Vithoba lake area in monsoon

Index	Stations			
	East	West	North	South
Shannon H' Log ₁₀	1.329	1.316	1.342	1.38
Shannon Hmax Log ₁₀	1.519	1.519	1.505	1.519
Shannon J'	0.875	0.867	0.891	0.908
Simpsons diversity (D)	0.07	0.07	0.061	0.050
Simpson's reciprocal index 1/D	14.197	14.224	16.262	20.083

Family diversity of Odonata: Six families of Odonata reside at Sawanga lake region. In the present study, 19 species of odonates belonging to family Libellulidae, 10 species of family Coenagrionidae and one species each of Ghomphidae, Ashnidae, Platycnemididae and Lestidae was found. Libellulidae is the most represented family with 19 species exploring 58% of species, family Coenagrionidae 30% species, families Ghomphidae, Ashnidae, Platycnemididae and Lestidae exhibit 3% of the species (Fig. 1).

Seasonal distribution of Odonata: In monsoon, total 650 individuals were observed at the lake region, 132 individuals at East site, 189 at West, 176 at North and 153 South sites. *Trithemis festiva* was not observed at site third (North). *Brachythemis contaminata* and *Pantala flavescens* were prevalent.

In winter, total 424 individuals of the Odonata were observed. One hundred and eleven at East site, 107 individuals at West site, 111 at North site and 95 at South site. Species *Diplacodes lefebvrii*, *Rhyothemis variegata*, *Potamarcha congener*, *Aethriamanta brevipennis* were not observed in winter.

In summer, total 249 individuals of the Odonata were observed, 66 at East site, 65 individuals at West site, 58 at North site and 60 individuals at South site were observed. Few species of Odonata such as *Diplacodes lefebvrii*, *Orthetrum glaucum*, *Tholymis tillarga*, *Aethriamanta*

brevipennis, *Aciagrion pallidum* and *Lestes elatus* were not observed in summer. Most of the species were less in number in summer (Fig. 2).

Diversity indices in monsoon: Diversity indices show that the distribution and diversity of Odonata at four sites of Sawanga-Vithoba lake area are in good range. Similarity index (J) is in the range of 0.9 stating much similar species of Odonata at four sites of Sawanga-Vithoba lake area. Various indices of Odonata diversity are shown in Table 2 and 3.

Diversity indices for winter season: Diversity indices show that the distribution and diversity of Odonata at four sites of Sawanga-Vithoba lake area are in good range. Similarity index (J) in the range of 0.9 stating much similar species of Odonata at four sites of Sawanga-Vithoba lake area. Various indices of Odonata diversity are shown in Table 4 and Fig. 3.

Diversity indices for summer season: Diversity indices show that the distribution and diversity of Odonata at four sites of Sawanga-Vithoba lake area is less as compared to winter and monsoon. Similarity index (J) is the range of 0.9 stating much similar species of Odonata at four sites of Sawanga-Vithoba lake area. Various indices of Odonata diversity are shown in Fig. 4.

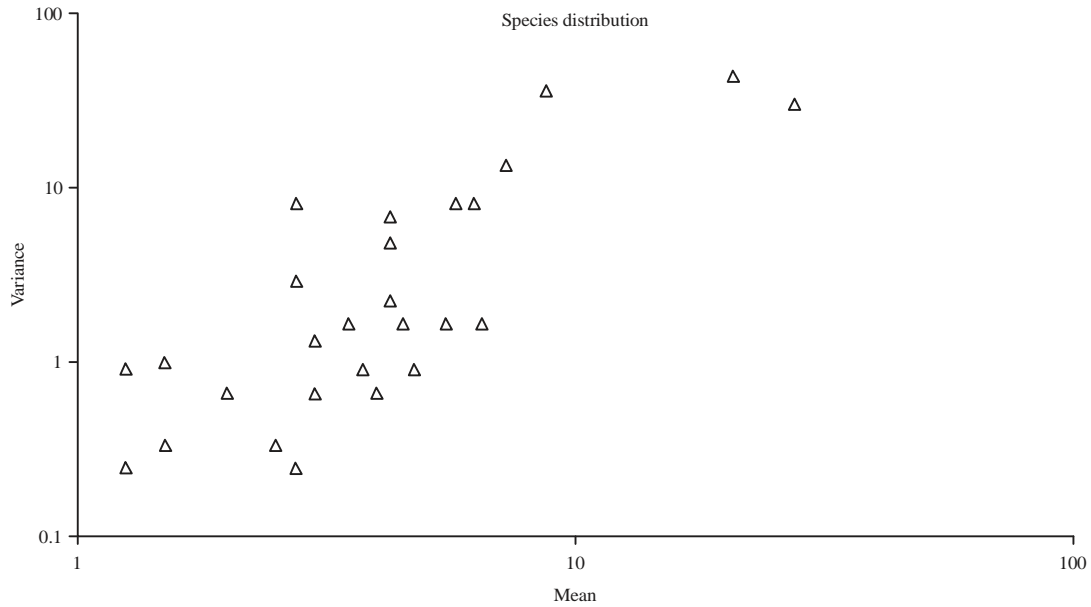


Fig. 2: Pattern of species distribution of Odonata at Sawanga-Vithoba lake area in monsoon

Table 3: Species distribution of Odonata at Sawanga-Vithoba lake region in monsoon

Species	Mean	Variance	Chi-sq	Degree of freedom	Probability	Aggregation
<i>Orthetrum chrysis</i>	6.25	8.25	3.96	3	0.264863	Random
<i>Trithemis festiva</i>	1.25	0.9167	2.2	3	0.5353473	Random
<i>Trithemis pallidinervis</i>	8.75	36.25	12.4286	3	0.0062265	Aggregated
<i>Trithemis aurora</i>	1.25	0.25	0.6	3	0.8966206	Random
<i>Diplacodes lefebvrii</i>	3.00	0.6667	0.6667	3	0.881643	Random
<i>Diplacodes trivialis</i>	4.50	1.6667	1.1111	3	0.7776275	Random
<i>Crocothemis servilia</i>	2.75	8.25	9	3	0.0289077	Random
<i>Orthetrum sabina</i>	4.25	6.9167	4.8824	3	0.178844	Random
<i>Orthetrum prunosum</i>	2.50	0.3333	0.4	3	0.9393621	Random
<i>Orthetrum glaucum</i>	3.00	1.3333	1.3333	3	0.7251902	Random
<i>Brachythemis contaminata</i>	27.50	30.3333	3.3091	3	0.3466983	Random
<i>Acisoma panorpoides</i>	3.75	0.9167	0.7333	3	0.8664132	Random
<i>Tramea virginia</i>	4.25	4.9167	3.4706	3	0.3245437	Random
<i>Tramea limbata</i>	5.50	1.6667	0.9091	3	0.8254327	Random
<i>Rhyothemis variegata</i>	3.75	0.9167	0.7333	3	0.8664132	Random
<i>Pantala flavescens</i>	20.75	44.25	6.3976	3	0.0922131	Random
<i>Tholymis tillarga</i>	1.50	1	2	3	0.5762582	Random
<i>Potamarcha congener</i>	1.50	0.3333	0.6667	3	0.881643	Random
<i>Aethriamanta brevipennis</i>	1.00	0	0	3	0	Aggregated
<i>Ictinogomphus rapax</i>	7.25	13.5833	5.6207	3	0.1297668	Random
<i>Anax guttatus</i>	5.75	8.25	4.3043	3	0.229038	Random
<i>Pseudagrion rubriceps</i>	4.25	2.25	1.5882	3	0.6663203	Random
<i>Pseudagrion microcephalum</i>	4.75	0.9167	0.5789	3	0.9012883	Random
<i>Agriocnemis femina</i>	4.00	0.6667	0.5	3	0.9184757	Random
<i>Agriocnemis splendidissima</i>	3.75	0.9167	0.7333	3	0.8664132	Random
<i>Agriocnemis pygemia</i>	2.75	2.9167	3.1818	3	0.3650693	Random
<i>Rhodischnura nursei</i>	4.50	1.6667	1.1111	3	0.7776275	Random
<i>Ischnura senegalensis</i>	3.50	1.6667	1.4286	3	0.7029828	Random
<i>Ischnura aurora</i>	2.75	0.25	0.2727	3	0.9639589	Random
<i>Ceragrion coromandelianum</i>	6.50	1.6667	0.7692	3	0.8581274	Random
<i>Aciagrion pallidum</i>	1.25	0.25	0.6	3	0.8966206	Random
<i>Copera marginipes</i>	2.00	0.6667	1	3	0.8039588	Random
<i>Lestes elatus</i>	2.50	0.3333	0.4	3	0.9393621	Random

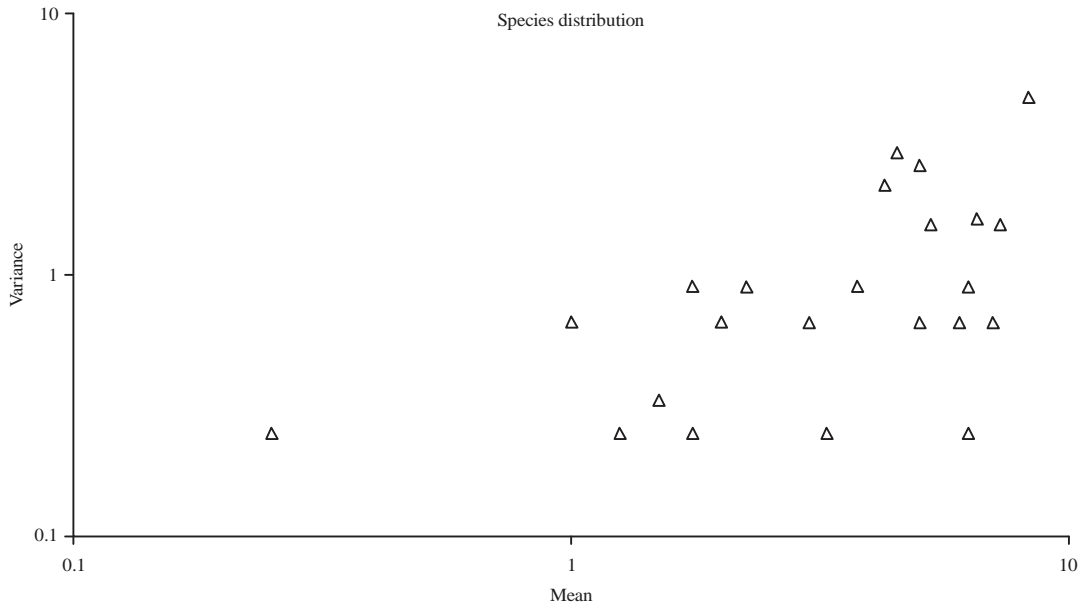


Fig. 3: Pattern of species distribution of Odonata at Sawanga-Vithoba lake area in winter

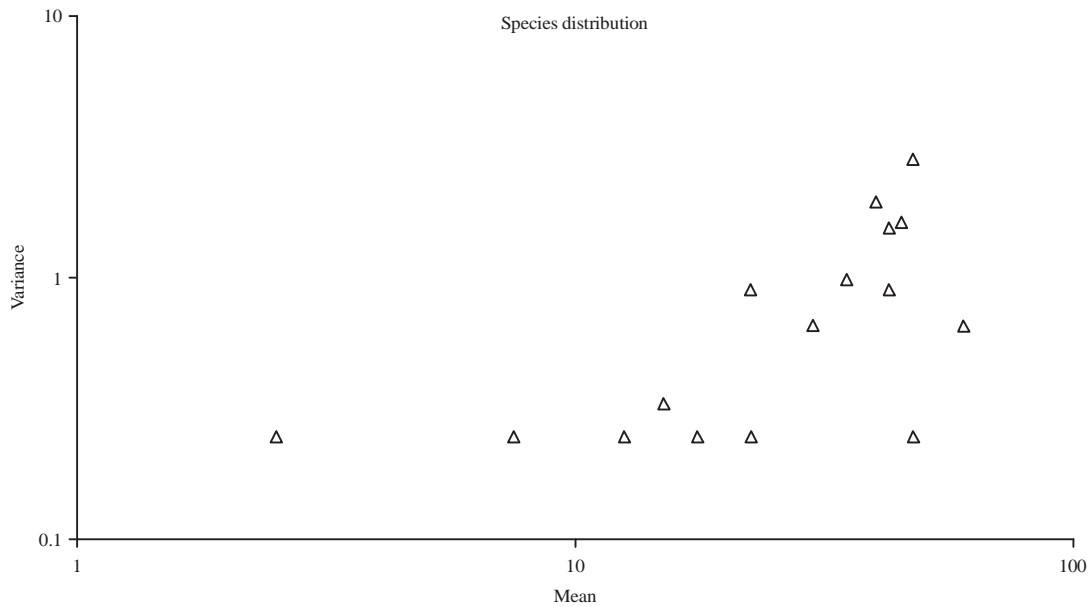


Fig. 4: Pattern of species distribution of Odonata at Sawanga-Vithoba lake area in summer

Table 4: Diversity indices for Odonata diversity and distribution at four sites of Sawanga-Vithoba lake area in winter

Index	Stations			
	East	West	North	South
Shannon H' Log ₁₀	1.37	1.364	1.363	1.331
Shannon Hmax Log ₁₀	1.462	1.447	1.447	1.431
Shannon J'	0.937	0.942	0.942	0.93
Simpsons diversity (D)	0.041	0.039	0.04	0.044
Simpson's reciprocal index 1/D	24.617	25.317	24.717	22.781

Table 5: Seasonal variation of Odonata interms of species richness at Sawanga-Vithoba lake area

Family	Scientific name	Season wise species richness			
		Monsoon	Winter	Summer	Total
Lebellulidae	<i>Orthetrum chrysis</i>	0.980	0.38	0.31	1.67
	<i>Trithemis festiva</i>	0.196	0.24	0.38	0.816
	<i>Trithemis aurora</i>	0.196	1.40	1.07	2.666
	<i>Diplacodes lefebvrei</i>	0.470	0.00	0.00	0.470
	<i>Diplacodes trivialis</i>	0.706	0.43	0.31	1.446
	<i>Crocothemis servilia</i>	0.431	0.33	0.25	1.011
	<i>Orthetrum Sabina</i>	0.666	0.97	0.57	2.206
	<i>Orthetrum pruinosum</i>	0.392	0.33	0.25	0.972
	<i>Acisoma panorpoides</i>	0.588	0.29	0.25	1.128
	<i>Tramea virginia</i>	0.666	0.19	0.06	0.916
	<i>Tramea limbata</i>	0.863	0.33	0.31	1.503
	<i>Rhyothemis variegata</i>	0.588	0.00	0.38	0.968
	<i>Pantala flavescens</i>	3.256	0.63	0.31	4.196
	<i>Tholymis tillarga</i>	0.235	0.82	0.00	1.065
	<i>Potamarcha congener</i>	0.235	0.00	0.19	0.425
		<i>Aethriamanta brevipennis</i>	0.156	0.00	0.00
Gomphidae	<i>Ictinogomphus rapax</i>	1.137	0.17	0.443	1.75
Ashnidae	<i>Anax guttatus</i>	0.902	0.38	0.190	1.472
Coenagrionidae	<i>Pseudagrion rubriceps</i>	0.666	1.21	0.380	2.256
	<i>Pseudagrion microcephalum</i>	0.745	1.60	1.141	3.486
	<i>Agriocnemis femin</i>	0.627	1.16	0.380	2.167
	<i>Agriocnemis splendidissima</i>	0.588	0.72	0.317	1.625
	<i>Agriocnemis pygemia</i>	0.431	1.35	0.887	2.668
	<i>Rhodischnura nursei</i>	0.706	1.21	1.077	2.993
	<i>Ischnura senegalensis</i>	0.549	0.19	1.487	2.226
	<i>Ischnura aurora</i>	0.431	0.87	0.570	1.871
	<i>Ceriagrion coromandelianum</i>	1.020	1.01	0.760	2.79
	<i>Aciagrion pallidum</i>	0.196	0.19	0.00	0.386
Platycnemididae	<i>Copera marginipes</i>	0.313	1.26	1.014	2.587
Lestidae	<i>Lestes elatus</i>	0.392	0.19	0.00	0.582

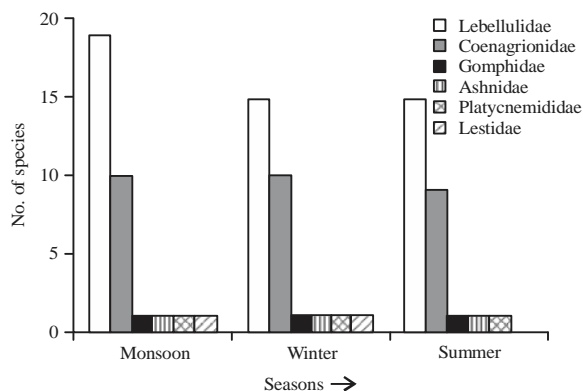


Fig. 5: Seasonal variation in family abundance of Odonata at Sawanga-Vithoba lake area, y-axis represents number of species

Seasonal variation and family abundance: In all the three seasons family Lebellulidae and Coenagrionidae are the most represented families. The most abundant family is Lebellulidae with more number of species. Other four families Gomphidae, Ashnidae, Platycnemididae and Lestidae are distributed equally (Fig. 5, Table 5).

DISCUSSION

Distribution range of Odonata is from temporary to permanent water bodies^{6,17}. Earlier 54 species of Odonata: Anisoptera (33) and Zygoptera (21) belonging to temporary water bodies were recorded from different parts of India^{12,18-24}. Odonata are sensitive to the changes in the habitat and climate, which influence their distribution and abundance.

In the present study, Anisoptera (Dragonfly) were abundant than the Zygoptera (damselfly). However, Fraser¹² and Subramanian¹⁵ stated that shade and aquatic vegetation could favour Zygoptera more than Anisoptera. Anisoptera are abundant in most of the water bodies might be due to their high dispersal ability²⁵⁻²⁸ and their adaptability to wide range of habitats²⁹⁻³¹. Damselflies are less abundant might be due to their limited dispersal ability³², unstable and changing environment in the temporary water bodies^{26,28} and partial or absence of shade cover⁷. Species richness and diversity of Odonata also influenced by the size of the temporary water bodies^{7,28,33-37}. Satisfactory species richness and abundance at Sawanga-Vithoba lake could be attributed to the size of the lake and less pollution.

Human disturbances (modification of habitat structure)^{9,34,38-43} contamination of water bodies⁴⁴ and the presence of predators^{45,46} affect assemblage of Odonata species. The abundance of Libellulidae (Anisoptera) and Coenagrionidae (Zygoptera) in the present study could be due to their shorter life cycle and widespread distribution⁴⁰ and tolerant to wide range of habitats^{47,48}. Species richness was found to be similar for all the sites. In summer few species were totally absent. Patterns of species richness and community composition are found to be similar.

In odonates showing highly significant univariate relationships between community composition and locally measured habitat/vegetation structure variables. The importance of environmental variables in predicting the community similarity and odonates may be largely attributable to substantial similarity in the physical environment (e.g., vegetation structure) between various sites.

CONCLUSION

Thirty three species of Odonata under six different families were observed at Sawanga-Vithoba lake. Most of the species are evenly distributed at four sites of Sawanga-Vithoba lake area. Species richness of few species such as *Trithemis pallidinervis*, *Brachythemis contaminata*, *Pantala flavescens*, *Ictinogomphus rapax* and *Ceriagrion coromandelianum* is higher in all the seasons. Odonata season wise preference and available resources use was almost same at four sites. Diversity as determined by Shannon index was higher in winter as compared to summer due to reducing the level of water in summer and partial drying of lake at some places causing loss of feeding resources. Some families such as Libellulidae and Coenagrionidae were highly represented due to their shorter life span and wider distribution. Most of species were common at four station as determined by similarity index (J).

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