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Andrea R.M. D'Souza & Irvathur Krishnananda Pai

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A COMPARATIVE STUDY ON DRAGONFLY DIVERSITY ON A PLATEAU AND AN AGRO-ECOSYSTEM IN GOA, INDIA

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Abstract: The present study was carried out to fill the lacuna in the understanding of the diversity of odonates of Goa in general and dragonflies in particular on plateau and paddy fields in coastal villages—agricultural area at Velsao and Taleigao Plateau. Diversity in plateau ecosystem was higher possibly due to a greater plant and insect diversity on the plateau, in comparison with the monoculture paddy agro-ecosystem. Highest number of species recorded belonged to the family Libellulidae. Monthly diversity showed correlation with monthly average rainfall and humidity.

Keywords: Odonates, Taleigao Plateau, Velsao.

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Author details: ANDREA RUNASIA MENEZES D'SOUZA was a post graduate student of Goa University and worked on dragonfly diversity as a part of her MSc dissertation. Presently she is working as Assistant professor in the Department of Zoology at Parvatibai Chowgule College of Arts and Science, Margao, Goa. DR. IRVATHUR KRISHNANANDA PAI is Professor and Head, department of Zoology, Goa University, Goa

Author contribution: ARMD was involved in field work, sample collection, data analysis, and manuscript preparation. IKP was responsible for designing the study, analyzing the data, directing and supervising and preparation of the manuscript.

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INTRODUCTION

Initial work on odonates in the state of Goa was carried out by Prasad (1995), followed by Rangnekar et al. (2010, 2014), and Subramanian et al. (2013), indicating the diversity to be 87 species. Considerable amount of research has been carried out in the Western Ghats and the neighboring state of Maharashtra (Subramanian et al. 2011; Kulkarni & Subramanian 2013; Muthukumaravel et al. 2015; Tiple & Koparde 2015). Despite this, there are several lacunae in understanding the diversity of odonates in general and dragonflies in particular. Hence, this attempt is to study diversity, distribution patterns, specific species abundance and status of dragonflies in plateau and paddy field areas at Taleigao Plateau and paddy fields in a coastal village of Goa, in Velsao. In the present work we have analyzed the odonates from Goa in general and plateau and agro-ecosystem in particular, which has not been attempted previously.

MATERIALS AND METHODS

Study sites

The areas chosen for the study include Velsao (15.354°N & 73.891°E, 11m) (Image 1), which is a coastal village and the Taleigao Plateau (15.457°N & 73.834°E, 50m) (Image 2) which is a lateritic region.

Velsao comprises of several paddy field ponds and streams; four sites were chosen (Image 3a–d) in the village. On the other hand, Taleigao Plateau is a lateritic region comprising several temporary monsoon water pools. Four sites (Image 4a–d) were chosen on Taleigao Plateau, representing the lateritic water pools.

At the plateau study site, the soil is mostly lateritic with vegetation belonging to Asclepiadaceae, Acanthaceae, Leguminosae Mimosaceae, Rubiaceae, Rutaceae families. Paddy fields are composed of loamy-clay mostly with water logging with vegetation comprising of *Tridax* sp., *Gliricidia* spp., *Justicia* spp., and *Centella* spp. seen around the paddy field bunds.

Weather parameters

Table 1 provides meteorological data of the sites under study. The monthly average temperature ranged between 26.86°C to 27.64°C; wind speed from 2.13–6.84 km/h; sunshine was between 97.3–290.1 hr/month; relative humidity was between 78.2–93.7 % and rainfall was from 1–449.5 mm/month (Fig. 1).

METHODS

The study was conducted from August 2016 to February 2017. The sampling is done by monthly direct counts, by following all out opportunistic surveys, at the selected sites from 08.30 to 12.00 hr, which coincides

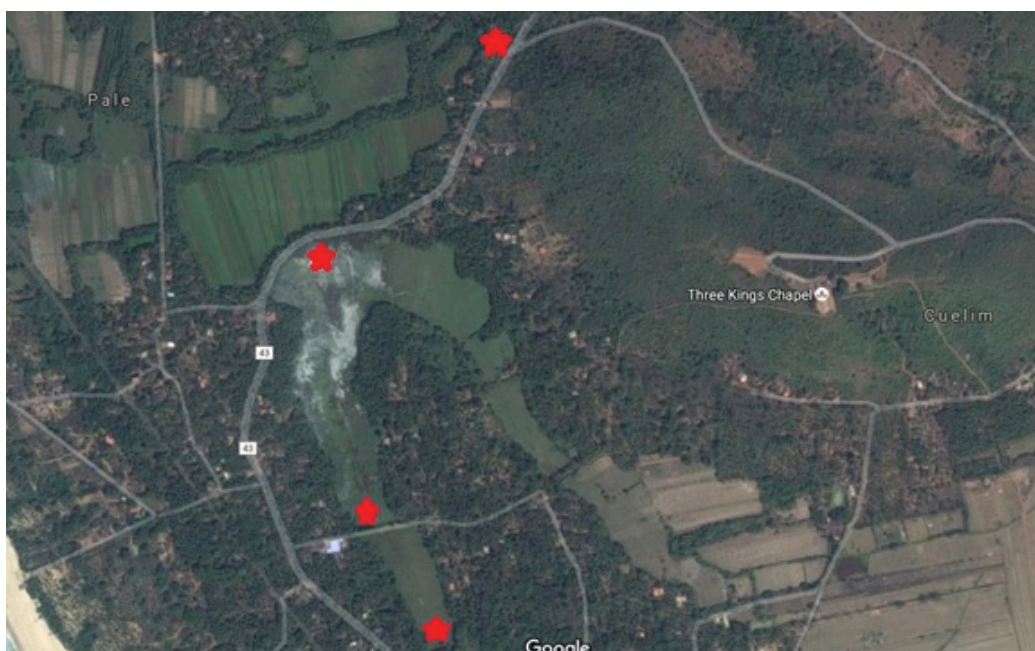


Image 1. Study sites at Velsao. (Courtesy: Google Maps)

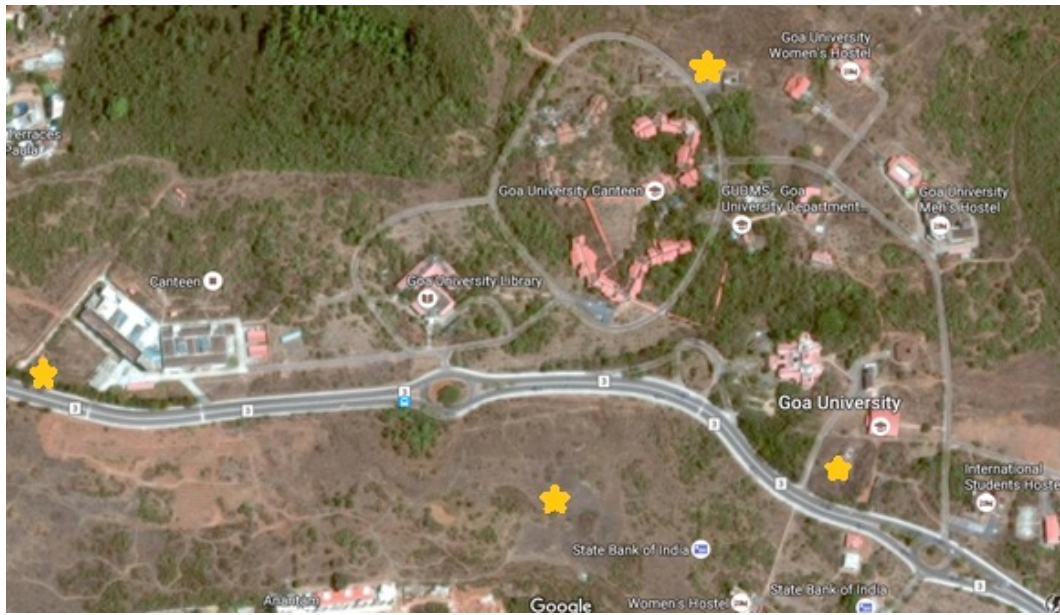


Image 2. Study sites at Taleigao Plateau. (Courtesy: Google Maps)

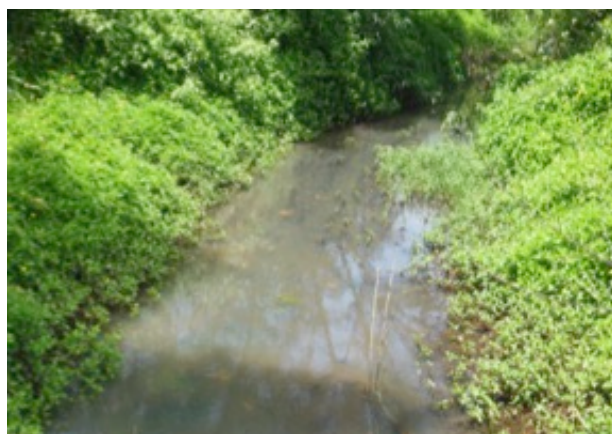


Image 3. Study sites at Velsao (Agro-ecosystem). © Authors.



Image 4. Study sites at Taleigao plateau (plateau ecosystem). © Authors.

Table 1. Weather profile of Goa during the study period (August 2016 to February 2017).

Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Temperature (C°)	27.64	27.3	27.21	27.4	27.11	26.86	27.6
Wind speed (km/hr)	6.84	4.4	3.29	3.2	3.13	3.35	3.96
Sunshine hours	97.3	136	204.2	268.9	273.4	290.1	271.7
Relative humidity	91.5	93.7	92.52	78.2	78.48	79.74	86.14
Rainfall (mm)	449.5	242.9	157.3	1	-	-	-

(Source: Anonymous, Goa Meteorological Department, Panaji, Goa)

with the insect's active period. Species observed were recorded and photographed, using Nikon Coolpix L840 and Nikon Coolpix S6300 cameras. A monthly record of species at the sites was maintained. Species which could not be identified in the field were collected using insect collecting net and maintained by dry preservation (Kapoor 2008) and identified using standard literature such as Fraser (1939), Subramanian (2009) and Nair (2011).

Statistical analysis

From the data obtained of dragonflies species at the sites diversity indices such as shannon diversity index,

evenness index, species richness index and species abundance, were calculated using PAST software and MS-Excel. Correlation between the diversity indices and weather parameters was calculated using correlation coefficient (Fig. 2).

RESULTS

The list of dragonflies encountered at the study sites is given in Table 2. During the study period, a combined total of 28 species of dragonflies belonging to 18 genera and three families were encountered.

Table 2. Dragonfly species observed at the study sites.

Family	Genera	Common name	Scientific name	Plateau	Paddy field
Gomphidae	<i>Ictinogomphus</i>	Common Clubtail	<i>Ictinogomphus rapax</i> Rambur, 1842	+	+
Aeshnidae	<i>Anax</i>	Blue-tailed Green Darter	<i>Anax guttatus</i> Burmeister, 1839	+	-
	<i>Gynacantha</i>	Parakeet Darter	<i>Gynacantha bayadera</i> Selys, 1854	-	+
	<i>Gynacantha</i>	Brown Darter	<i>Gynacantha dravida</i> Lieftinck, 1960	+	-
Libellulidae	<i>Acisoma</i>	Trumpet Tail	<i>Acisoma panorpoides</i> Rambur, 1842	-	+
	<i>Brachythemis</i>	Ditch Jewel	<i>Brachythemis contaminata</i> Fabricius, 1793	+	-
	<i>Bradinopyga</i>	Granite Ghost	<i>Bradinopyga geminata</i> Rambur, 1842	+	+
	<i>Cratilla</i>	Emerald Banded Skimmer	<i>Cratilla lineata</i> Foerster, 1903	+	-
	<i>Crocothemis</i>	Ruddy Marsh Skimmer	<i>Crocothemis servilia</i> Drury, 1770	+	+
	<i>Diplacodes</i>	Ground Skimmer	<i>Diplacodes trivialis</i> Rambur, 1842	+	+
	<i>Indothemis</i>	Blue Ground Skimmer	<i>Indothemis carnatica</i> Fabricius, 1798	+	-
	<i>Lathrecista</i>	Asiatic Blood Tail	<i>Lathrecista asiatica</i> Fabricius, 1798	+	+
	<i>Neurothemis</i>	Fulvous Forest Skimmer	<i>Neurothemis fulvia</i> Drury, 1773	-	+
	<i>Neurothemis</i>	Pied Paddy skimmer	<i>Neurothemis tullia</i> Drury, 1773	+	+
	<i>Orthetrum</i>	Brown-backed Red Marsh Hawk	<i>Orthetrum chrysis</i> Selys, 1891	+	+
	<i>Orthetrum</i>	Tricoloured Marsh Hawk	<i>Orthetrum luzonicum</i> Brauer, 1868	+	-
	<i>Orthetrum</i>	Crimson-tailed Marsh Hawk	<i>Orthetrum pruinosum</i> Rambur, 1842	+	+
	<i>Orthetrum</i>	Green Marsh Hawk	<i>Orthetrum sabina</i> Drury, 1770	+	+
<i>Orthetrum</i>	Small Skimmer	<i>Orthetrum taeniolatum</i> Schneider, 1845	+	-	
<i>Pantala</i>	Wandering glider	<i>Pantala flavescens</i> Fabricius, 1798	+	+	
<i>Rhodothemis</i>	Rufous Marsh Glider	<i>Rhodothemis rufa</i> Rambur, 1842	+	+	
<i>Rhodothemis</i>	Common Picturewing	<i>Rhyothemis variegata</i> Linnaeus, 1763	+	+	
<i>Tholymis</i>	Coral-tailed Cloud Wing	<i>Tholymis tillarga</i> Fabricius, 1798	-	+	
<i>Tamea</i>	Red Marsh Trotter	<i>Tamea basilaris</i> Kirby, 1889	+	-	
<i>Tamea</i>	Black Marsh Trotter	<i>Tamea limbata</i> Rambur, 1842	+	-	
<i>Trithemis</i>	Crimson Marsh Glider	<i>Trithemis aurora</i> Burmeister, 1839	+	-	
<i>Trithemis</i>	Black Stream Glider	<i>Trithemis festiva</i> Rambur, 1842	+	-	
<i>Trithemis</i>	Long-legged Marsh Glider	<i>Trithemis pallidinervis</i> Kirby, 1889	+	-	

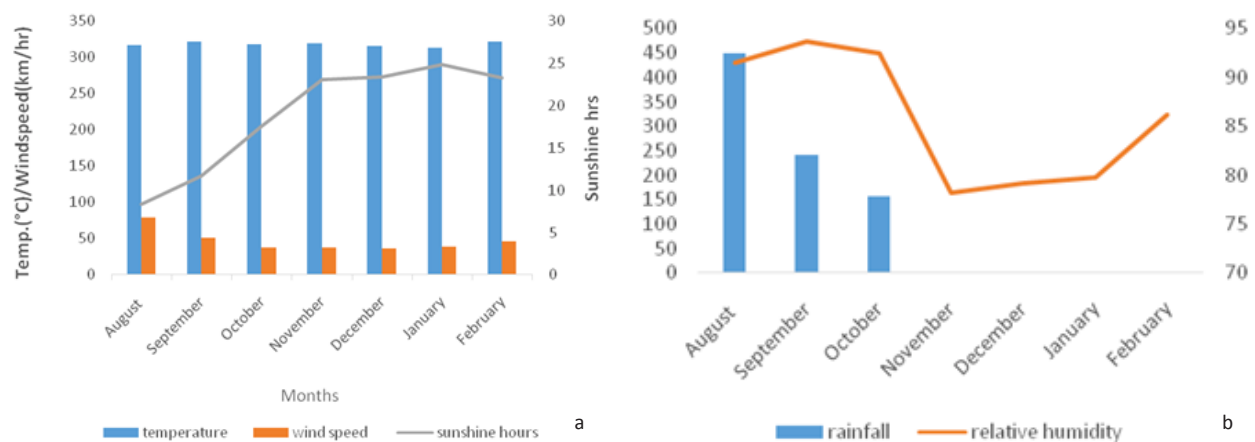
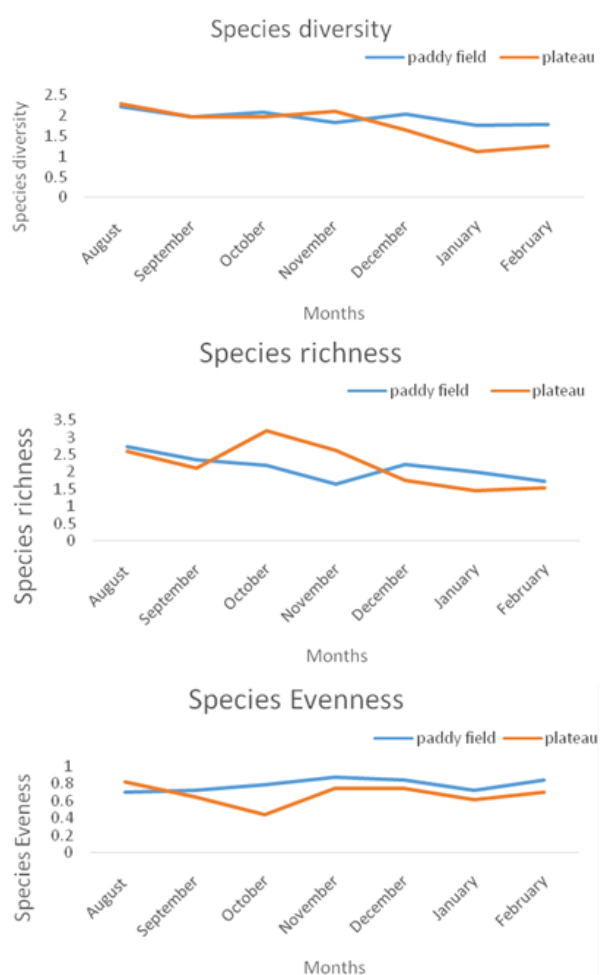


Figure 1. Monthly profile of weather conditions prevalent in Goa during the study period. a - Temperature, wind speed and sunshine hours | b - Rainfall and humidity.

Table 3. Family-wise percentage composition of dragonflies in ecosystems under study.

	Families	Number of species	
		Agro-ecosystem	Plateau ecosystem
1	Gomphidae	1	1
2	Aeshnidae	1	2
3	Libellulidae	14	21

**Figure 2. Monthly variation in the population indices such as diversity, evenness and richness.**

Of the above, 24 species belonging to 16 genera and three families were sighted in the plateau ecosystem; while 16 species belonging to 12 genera and three families were sighted in the agro-ecosystem. There were 12 species of dragonflies belonging to 12 genera that were common to both the ecosystems (Fig. 3).

a. Agro-ecosystem

A total of 16 species belonging to 12 genera and three families were sighted in the agro-ecosystem. Most number of species noted during post monsoon

Table 4. General composition of dragonfly community and species indices in paddy field and plateau ecosystem.

	Agro-ecosystem	Plateau ecosystem
Affiliations		
Total no. of individuals recorded	308	402
Total no. of species	16	24
Total no. of genera	12	16
Total no. of families	3	3
Species indices		
Species diversity (H')	1.944 ± 0.158	1.762 ± 0.405
Species evenness (J')	0.782 ± 0.066	0.674 ± 0.111
Species richness (SR)	2.113 ± 0.347	2.172 ± 0.603

(October–December) were 13, monsoon (August, September) were 12, and winter (January and February) were nine. Species diversity (H') was found to be 1.944 ± 0.158 , species evenness (J') was 0.782 ± 0.066 , and species richness (SR) recorded was 2.11 ± 0.347 (Table 3).

b. Plateau ecosystem

A total of 24 species belonging to 16 genera and three families were sighted in the plateau ecosystem. Most species were noted in post monsoon (17), followed by monsoon (14) and winter (7).

Species diversity (H') was 1.762 ± 0.405 , species evenness (J') 0.674 ± 0.111 , and species richness (SR) 2.172 ± 0.603 (Table 3).

Weather parameters vs. dragonflies

The monthly diversity of dragonfly species recorded was correlated with the different weather parameters like monthly average rainfall, relative humidity, wind speed, sunshine hours and temperature (Table 1). Monthly diversity of dragonflies showed a significant positive correlation with the monthly average rainfall in the agro-ecosystem ($cr\ cf = 0.765, p < 0.05$) and relative humidity in both the ecosystems (agro-ecosystem- $cr\ cf = 0.759, p < 0.05$ and plateau ecosystem- $cr\ cf = 0.796, p < 0.05$) and a low correlation with temperature and wind speed. Further, it was also found to be strongly negatively correlated with the monthly sunshine hours (agro-ecosystem- $cr\ cf = -0.758, p < 0.05$ and plateau ecosystem- $cr\ cf = -0.731, p = 0.06$).

Table 5. Seasonal variations in species indices of dragonflies in (a) agro-ecosystem and (b) plateau.**a) Agro-ecosystem**

Species indices	Monsoon	Post-monsoon	Winter
Species diversity (H')	2.145	2.138	1.801
Species evenness (J')	0.711	0.652	0.673
Species richness (SR)	2.373	2.435	1.903

(a1) Abundance and species richness at the agro-ecosystem

Family	Common name	Scientific name	Monsoon	Post-monsoon	Winter
Gomphidae	Common Clubtail	<i>Ictinogomphus rapax</i> Rambur, 1842	4	1	1
Aeshnidae	Blue-tailed Green Darter	<i>Anax guttatus</i> Burmeister, 1839	-	-	-
	Parakeet Darter	<i>Gynacantha bayadera</i> Selys, 1854	-	-	-
	Brown Darter	<i>Gynacantha dravida</i> Lieftinck, 1960	-	1	-
Libellulidae	Trumpet Tail	<i>Acisoma panorpoides</i> Rambur, 1842	4	7	-
	Ditch Jewel	<i>Brachythemis contaminata</i> Fabricius, 1793	-	-	-
	Granite Ghost	<i>Bradinyopyga geminata</i> Rambur, 1842	2	4	-
	Emerald Banded Skimmer	<i>Cratilla lineata</i> Foerster, 1903	-	-	-
	Ruddy Marsh Skimmer	<i>Crocotthemis servilia</i> Drury, 1770	-	-	-
	Ground Skimmer	<i>Diplacodes trivialis</i> Rambur, 1842	11	27	17
	Blue Ground Skimmer	<i>Indothemis carnatica</i> Fabricius, 1798	-	-	-
	Asiatic Blood Tail	<i>Lathrecista asiatica</i> Fabricius, 1798	1	1	1
	Fulvous Forest Skimmer	<i>Neurothemis fulvia</i> Drury, 1773	-	-	1
	Pied Paddy Skimmer	<i>Neurothemis tullia</i> Drury, 1773	30	28	20
	Brown-backed Red Marsh Hawk	<i>Orthetrum chrysis</i> Selys, 1891	-	4	-
	Blue Marsh Hawk	<i>Orthetrum glaucum</i> Brauer, 1865	-	-	-
	Tricoloured Marsh Hawk	<i>Orthetrum luzonicum</i> Brauer, 1868	-	-	-
Crimson-tailed Marsh Hawk	<i>Orthetrum pruinosum</i> Rambur, 1842	5	9	4	
Green Marsh Hawk	<i>Orthetrum sabina</i> Drury, 1770	9	17	6	
Small Skimmer	<i>Orthetrum taeniolatum</i> Schneider, 1845	-	-	-	
Wandering Glider	<i>Pantala flavescens</i> Fabricius, 1798	11	22	10	
Rufous Marsh Glider	<i>Rhodothemis rufa</i> Rambur, 1842	14	15	7	
Common Picturewing	<i>Rhyothemis variegata</i> Linnaeus, 1763	2	2	-	
Coral-tailed Cloud Wing	<i>Tholymis tillarga</i> Fabricius, 1798	10	-	-	
Red Marsh Trotter	<i>Tamea basilaris</i> Kirby, 1889	-	-	-	
Black Marsh Trotter	<i>Tamea limbata</i> Rambur, 1842	-	-	-	
Black Stream Glider	<i>Trithemis festiva</i> Rambur, 1842	-	-	-	
Long-legged Marsh Glider	<i>Trithemis pallidinervis</i> Kirby, 1889	-	-	-	

Table continued on next page

(b) Plateau ecosystem

Species indices	Monsoon	Post-monsoon	Winter
Species diversity (H')	2.203	2.077	1.289
Species evenness (J')	0.646	0.469	0.578
Species richness (SR)	2.49	3.056	1.764

(b1) Abundance and species richness at the Plateau ecosystem

Family	Common name	Scientific name	Monsoon	Post-monsoon	Winter
Gomphidae	Common Clubtail	<i>Ictinogomphus rapax</i> Rambur, 1842	-	3	-
Aeshnidae	Blue-tailed Green Darter	<i>Anax guttatus</i> Burmeister, 1839	-	1	-
	Parakeet Darter	<i>Gynacantha bayadera</i> Selys, 1854	-	-	-
	Brown Darter	<i>Gynacantha dravida</i> Lieftinck, 1960	-	-	-
Libellulidae	Trumpet Tail	<i>Acisoma panorpoides</i> Rambur, 1842	-	-	-
	Ditch Jewel	<i>Brachythemis contaminata</i> Fabricius, 1793	-	1	-
	Granite Ghost	<i>Bradinyopyga geminata</i> Rambur, 1842	9	10	3
	Emerald Banded Skimmer	<i>Cratilla lineata</i> Foerster, 1903	-	-	1
	Ruddy Marsh Skimmer	<i>Crocothemis servilia</i> Drury, 1770	10	6	1
	Ground Skimmer	<i>Diplacodes trivialis</i> Rambur, 1842	19	39	18
	Blue Ground Skimmer	<i>Indothemis carnatica</i> Fabricius, 1798	17	10	-
	Asiatic Blood Tail	<i>Lathrecista asiatica</i> Fabricius, 1798	-	1	-
	Fulvous Forest Skimmer	<i>Neurothemis fulvia</i> Drury, 1773	-	-	-
	Pied Paddy skimmer	<i>Neurothemis tullia</i> Drury, 1773	3	1	-
	Brown-backed Red Marsh Hawk	<i>Orthetrum chrysis</i> Selys, 1891	-	-	-
	Blue Marsh Hawk	<i>Orthetrum glaucum</i> Brauer, 1865	-	1	-
	Tricoloured Marsh Hawk	<i>Orthetrum luzonicum</i> Brauer, 1868	-	-	-
	Crimson-tailed Marsh Hawk	<i>Orthetrum pruinosum</i> Rambur, 1842	2	-	-
	Green Marsh Hawk	<i>Orthetrum sabina</i> Drury, 1770	18	17	
	Small Skimmer	<i>Orthetrum taeniolatum</i> Schneider, 1845			1
	Wandering Glider	<i>Pantala flavescens</i> Fabricius, 1798	59	67	5
	Rufous Marsh Glider	<i>Rhodothemis rufa</i> Rambur, 1842	3	6	
	Common Picturewing	<i>Rhyothemis variegata</i> Linnaeus, 1763	14	2	1
	Coral-tailed Cloud Wing	<i>Tholymis tillarga</i> Fabricius, 1798	-	-	-
	Red Marsh Trotter	<i>Tamea basilaris</i> Kirby, 1889	7	4	-
	Black Marsh Trotter	<i>Tamea limbata</i> Rambur, 1842	18	12	-
	Black Stream Glider	<i>Trithemis festiva</i> Rambur, 1842	5	7	-
	Long-legged Marsh Glider	<i>Trithemis pallidinervis</i> Kirby, 1889	1	-	-

DISCUSSION

A combined total of 28 species of dragonflies recorded at both sites makes about 59.5% of the total dragonflies recorded in the state so far (Rangnekar 2014).

The highest diversity recorded belonged to family Libellulidae (23) followed by Aeshnidae (3) (in plateau ecosystem) and Gomphidae (1). All over the world,

species belonging to family Libellulidae dominate unshaded habitats with stagnant water, include species with great migratory ability and distributions covering more than one continent including isolated islands (Kalkman et al 2008).

Diversity in plateau ecosystem was more with 24 species while paddy field ecosystem displayed 16 species. This could possibly be due to a greater plant and insect diversity on the plateau, as opposed to the

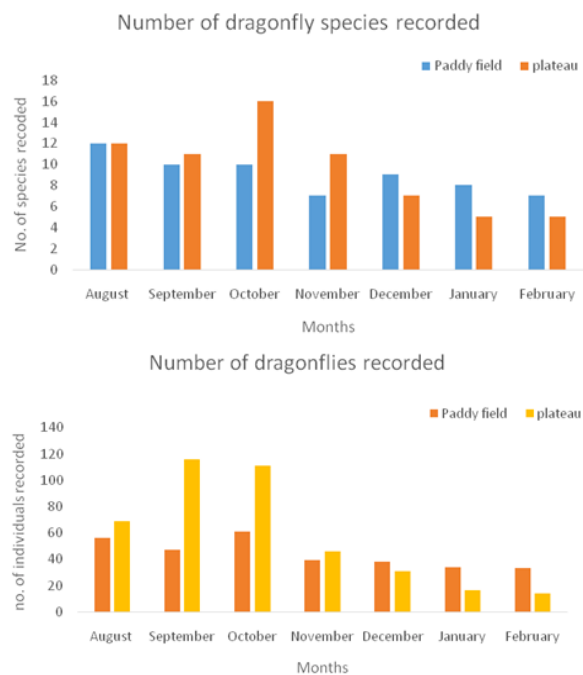


Figure 3. Monthly variation in the number of dragonfly species and number of dragonflies recorded.

monoculture paddy agro-ecosystem, which supports a lesser number of plant species and thus fewer insect species that are the prey base for dragonflies. Aquatic bodies in paddy fields were mostly covered by invasive weed like *Salvinia*, which hampers the growth of other native aquatic plant and animal diversity (Balzan 2012).

In the present study, seasonal variation in dragonfly species was also observed. Highest number of species and individuals were recorded during post monsoon, followed by monsoon and least in winter in both the ecosystems. Species diversity (H') was highest in monsoon followed by post monsoon and winter. Similar studies were carried out by Muthukumaravel et al. (2015). This may be attributed to drying up of the habitats which results in reduction in food resources post monsoon.

Monthly diversity of dragonflies showed a significant positive correlation with the monthly average rainfall in the agroecosystem and relative humidity in both the ecosystems. Similar observations were reported by Kalita et al. (2015) and Muthukumaravel et al. (2015). Weather plays an important role in the survival and activity patterns of adult odonates (Aguilar 2008). These environmental factors, along with vegetation directly affect diversity and distribution of food resources (Morais et al. 1999). The influence of rainfall is seen on density and distribution of vegetation, which leads to

increase in abundance of herbivorous insects (prey for dragonflies).

It was observed that the species diversity (Fig. 2) in both ecosystems continue to be fairly similar in months August to October, however declined in January and February in the plateau ecosystem, along with a decline in the species richness, which can be attributed to the drying up of temporary water bodies following the monsoon season in the plateau ecosystem. Highest number of species was recorded in the month of October on the plateau ecosystem. Many of the species have their flight period during this period and a higher diversity of odonates could be attributed to this (Kulkarni & Subramanian 2013).

Neurothemis tullia shows the highest species abundance, followed by *Diplacodes trivialis* and *Rhodothemis rufa* in the paddy field ecosystem and *Pantala flavescens* in the plateau ecosystem followed by *Diplacodes trivialis*. Similar studies at agricultural areas were also reported by Kulkarni & Subramanian (2013).

Dragonflies are important bio-indicator species (Stewart 1998; Nair 2011). Presence of species like *Brachythemis contaminata*, which is known as a dragonfly of polluted waters (Subramanian 2009), was recorded at some of the sites in the plateau ecosystem, may indicate deterioration of the aquatic body. The presence of *Neurothemis fulvia*, *Neurothemis tullia*, *Bradinopyga geminata* and *Trithemis festiva* at the sites can indicate superior quality water and species *Brachythemis contaminata*, *Orthetrum chrysis*, and *Orthetrum sabina* which are common species at the sites could possible indicate lower water quality.

Most of the species recorded belong to the Least Concern category of the IUCN Red List, while one species *Indothemis carnatica* is Near Threatened.

REFERENCES

- Aguilar, A.C. (2008). *Dragonflies and Damselflies: Model Organisms for Ecological and Evolutionary Research*. New York: Oxford University Press, 8pp
- Anonymous (2016). Weather charts. Retrieved from Meteorological Centre: <http://www.imdgoa.gov.in/>. Accessed on 1st February 2017
- Balzan, M.V. (2012). Associations of Dragonflies (Odonata) to Habitat Variables within the Maltese Islands: A Spatio-Temporal Approach. *Journal of Insect Science* 12: 87. <https://doi.org/10.1673/031.012.8701>
- Fraser, F. (1939). *The Fauna of British India (Vol. III)*, pp420–427. Taylor and Francis, London.
- Kalkman, V.E., V. Clausnitzer, K.D.B. Dijkstra., G.O. Albert, R.P. Dennis & J.V. Tol (2008). Global diversity of dragonflies (Odonata) in freshwater. *Hydrobiologia* 595(1): 351–363.
- Kapoor, V.C. (2008). *Theory and Practice of Animal Taxonomy* (6th ed.). Oxford & IBH Publishers, New Delhi, 83pp.

Table 6. Species abundance from most abundant to least abundant.

Scientific name	Agro-ecosystem	Scientific name	Plateau ecosystem
<i>Neurothemis tullia</i> Drury, 1773	25.324	<i>Pantala flavescens</i> Fabricius, 1798	32.506
<i>Diplacodes trivialis</i> Rambur, 1842	17.857	<i>Diplacodes trivialis</i> Rambur,1842	18.858
<i>Pantala flavescens</i> Fabricius, 1798	13.961	<i>Orthetrum sabina</i> Drury, 1770	8.684
<i>Rhodothemis rufa</i> Rambur, 1842	11.688	<i>Tramea limbata</i> Rambur,1842	7.444
<i>Orthetrum sabina</i> Drury, 1770	10.389	<i>Indothemis carnatica</i> Fabricius, 1798	6.699
<i>Orthetrum pruinum</i> Rambur, 1842	5.8441	<i>Bradinopyga geminata</i> Rambur, 1842	5.459
<i>Acisoma panorpoides</i> Rambur, 1842	3.5714	<i>Crocothemis servilia</i> Drury, 1770	4.218
<i>Tholymis tillarga</i> Fabricius, 1798	3.246	<i>Rhyothemis variegata</i> Linnaeus, 1763	4.218
<i>Ictinogomphus rapax</i> Rambur, 1842	1.948	<i>Trithemis festiva</i> Rambur, 1842	2.977
<i>Bradinopyga geminata</i> Rambur, 1842	1.948	<i>Tramea basilaris</i> Kirby,1889	2.729
<i>Orthetrum chrysis</i> Selys, 1891	1.298	<i>Rhodothemis rufa</i> Rambur, 1842	2.233
<i>Rhyothemis variegata</i> Linnaeus, 1763	1.298	<i>Neurothemis tullia</i> Drury, 1773	0.992
<i>Lathrecista asiatica</i> Fabricius, 1798	0.974	<i>Ictinogomphus rapax</i> Rambur, 1842	0.744
<i>Gynacantha bayadera</i> Selys, 1854	0.324	<i>Orthetrum pruinum</i> Rambur, 1842	0.496
<i>Neurothemis fulvia</i> Drury, 1773	0.324	<i>Anax guttatus</i> Burmeister, 1839	0.248
<i>Anax guttatus</i> Burmeister, 1839	0	<i>Brachythemis contaminata</i> Fabricius, 1793	0.248
<i>Gynacantha dravida</i> Lieftinck, 1960	0	<i>Cratilla lineata</i> Foerster,1903	0.248
<i>Brachythemis contaminata</i> Fabricius, 1793	0	<i>Lathrecista asiatica</i> Fabricius, 1798	0.248
<i>Cratilla lineata</i> Foerster, 1903	0	<i>Orthetrum glaucum</i> Brauer, 1865	0.248
<i>Crocothemis servilia</i> Drury, 1770	0	<i>Orthetrum taeniolatum</i> Schneider, 1845	0.248
<i>Indothemis carnatica</i> Fabricius, 1798	0	<i>Trithemis pallidinervis</i> Kirby, 1889	0.248
<i>Orthetrum glaucum</i> Brauer, 1865	0	<i>Gynacantha bayadera</i> Selys,1854	0
<i>Orthetrum luzonicum</i> Brauer, 1868	0	<i>Gynacantha dravida</i> Lieftinck,1960	0
<i>Orthetrum taeniolatum</i> Schneider, 1845	0	<i>Acisoma panorpoides</i> Rambur, 1842	0
<i>Tramea basilaris</i> Kirby, 1889	0	<i>Neurothemis fulvia</i> Drury, 1773	0
<i>Tramea limbata</i> Rambur, 1842	0	<i>Orthetrum chrysis</i> Selys, 1891	0
<i>Trithemis festiva</i> Rambur, 1842	0	<i>Orthetrum luzonicum</i> Brauer, 1868	0
<i>Trithemis pallidinervis</i> Kirby, 1889	0	<i>Tholymis tillarga</i> Fabricius, 1798	0

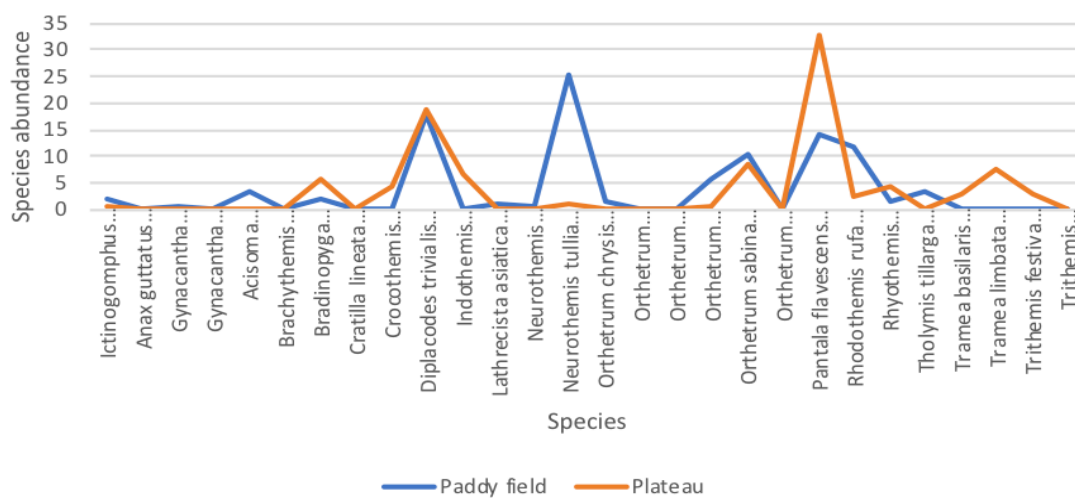


Figure 4. Species abundance of the dragonfly species recorded.



Image 5. Common Clubtail *Ictinogomphus rapax* Rambur, 1842.



Image 6. Ditch Jewel *Brachythemis contaminata* Fabricius, 1793.



Image 7. Granite Ghost *Bradinopyga geminata* Rambur, 1842.



Image 8. Ruddy Marsh Skimmer *Crocothemis servilia* Drury, 1770.



Image 9. Ground Skimmer *Diplacodes trivialis* Rambur, 1842 (male and female).



Image 11. Pied Paddy skimmer *Neurothemis tullia* Drury, 1773 (male and female).



Image 10. Blue Ground Skimmer *Indothemis carnatica* Fabricius, 1798.

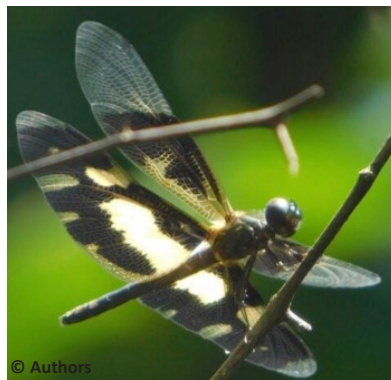


Image 13. Common Picturewing *Rhyothemis variegata* Linnaeus, 1763.



Image 14. Coral-tailed Cloud Wing *Tholymis tillarga* Fabricius, 1798.



Image 12. Rufous Marsh Glider *Rhodothemis rufa* Rambur, 1842 (male and female).



Image 15. Long-legged Marsh Glider *Trithemis pallidinervis* Kirby, 1889.

- Kalita, H., R.K. Avasthe & K. Ramesh (2015).** Effect of weather parameters on population buildup of different Insect pests and their natural enemies. *Indian Journal of Hill Farming* 28(1): 69–72.
- Kulkarni, A.S. & K.A. Subramanian (2013).** Habitat and seasonal distribution of Odonata (Insecta) of Mula and Mutha river basins, Maharashtra, India. *Journal of Threatened Taxa* 5(7): 4084–4095. <https://doi.org/10.11609/JoTT.o3253.4084-95>
- Morais, H.C., I.R. Diniz & D.M.S. Silva (1999).** Caterpillar seasonality in a central Brazilian Cerrado. *Revista de Biologia Tropical* 47: 1025–1033.
- Muthukumaravel, K., R. B. Raja, A. Amsath, S. Prabakaran & Y. Chezian (2015).** Seasonal variation of dragonflies diversity in Muthupet mangrove forest, Tamilnadu, India. *International Journal of Pure and Applied Zoology*, 3(2): 188-192.
- Nair, M.V. (2011).** *Dragonflies & Damselflies of Orissa and Eastern India*, pp13–24. Wildlife Organization, Forest & Environment Department, Government of Orissa.
- Prasad, M. (1995).** On a collection of Odonata from Goa. *Fraseria* (N.S.) 2(1/2): 7-8.
- Rangnekar, P. (2014).** Further additions to Odonata fauna in Goa. *Journal of Threatened Taxa* 6(3): 5585–5589. <https://doi.org/10.11609/JoTT.o3641.5585-9>
- Rangnekar, P., M. Borkar & O. Dharwadkar (2010).** Additions to The Odonata (Insecta) of Goa. *Journal of Threatened Taxa* 2(4): 805–814. <https://doi.org/10.11609/JoTT.o2286.805-14>
- Stewart, D.S. (1998).** Conserving Dragonfly assemblages relative to river dynamics in an African savanna game reserve. *Conservation Biology* 12(3): 683–692.
- Subramanian, K. (2009).** *Dragonflies of India, a Field Guide*. Vigyan Prasar, Noida, New Delhi, 86pp.
- Subramanian K.A., F. Kakkassery & M.V. Nair (2011).** The status and distribution of dragonflies and damselflies (Odonata) of the Western Ghats, pp. 63–72. In: Molur S., K.G. Smith, B.A. Daniel, W.R.T. Darwall (eds.). The status and distribution of freshwater biodiversity in the Western Ghats, India. International Union for Conservation of Nature and Zoo Outreach Organization, Coimbatore, Tamil Nadu, 63pp+CD-Rom.
- Subramanian, K.A., P. Rangnekar & D. Naik (2013).** *Idionyx* (Odonata: Corduliidae) of the Western Ghats with a description of a new species. *Zootaxa* 3652(2): 277–288
- Tiple, A.D., & P. Koparde (2015).** Odonata of Maharashtra, India with Notes on Species Distribution. *Journal of Insect Science* 15(1): 47. <https://doi.org/10.1093/jisesa/iev028>





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