

Diversity, Local Distribution and Occurrence of Dragonflies and Damselflies (Odonata: Insecta) In Nalsarovar Bird Sanctuary (Ramsar Site), Gujarat

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Abstract - Dragonflies and damselflies are one of the important aquatic insect groups belonged to Order Odonata. Dragonflies and damselflies immature stage (nymphs) are truly aquatic and adult stage are terrestrial. They sometimes also act as a flagship species group being a top predator and environmentally sensitive group. Nalsarovar is an important wetland in terms of its multiple categories designated such as a Birds Sanctuary, Important Bird and Biodiversity Area, a Ramsar Site of Gujarat State. Total area of Nalsarovar Bird Sanctuary (NBS) area is 120 sq km. A study was carried out from February 2015 to February 2017 at Nalsarovar Bird Sanctuary. A species inventory was carried out by Visual Encounter Survey (VES). Fourteen sites were fixed using GPS for the survey. Survey was carried out including all seasons and covering all major habitats. Adult dragonflies and damselflies encountered were recorded. During the entire survey total 30 species of dragonflies and damselflies were encountered that belonged to 5 different families namely Libellulidae, Gomphidae, Aeshnidae, Coenagrionidae and Lestidae. Total 37 Odonate species including both dragonflies and damselflies were encountered depended especially Nalsarovar Bird Sanctuary area combining the past recorded species and species encountered in current research study. Among species encountered during study almost all species belong to Least Concern (LC) category whereas a dragonfly species *Indothemis carnatica* (Fabricius, 1798) is listed under Near Threatened (NT) category under IUCN category. During entire study 14 species of Odonates were encountered at all sites whereas variations in distribution of 16 Odonate species were encountered at specific sites.

Index terms - Dragonfly, Damselflies, Nalsarovar Bird Sanctuary, Odonates, Ramsar Site

I. INTRODUCTION

The order Odonata includes the dragonflies and damselflies, globally 5,952 species of Odonates under 652 genera have been reported (Schorr and Paulson, 2013) ^[1]. India harbors 474 species and 50 subspecies belonging to 142 genera in 18 families (Subramanian, 2014). Dragonflies and damselflies are an important component of aquatic ecosystems; in which they can often be top predators. They sometimes also act as a flagship species group. Their sensitivity to environmental conditions makes Odonate excellent biological indicators of environmental conditions (Brown 1991 ^[2]; Clark & Samways 1996 ^[3]; Samways, *et al.*, 2010) ^[4]. Being an aquatic insect it is often seen to inhabit and associated with wetlands. Nalsarovar Bird Sanctuary is one of the important wetlands of India and Gujarat. It is internationally recognized as a Ramsar Site of Gujarat. It is also a Bird Sanctuary i.e. protected area and an Important Bird and Biodiversity Area (IBA). The entire study was carried out in Nalsarovar Bird Sanctuary.

The basin of Nalsarovar is of elongate undulating saucer type and its overall shape is very gentle, running from east to northwest and northwest to south. Generally, the depth of water does not exceed 3 metres (Acharya, 1965 ^[5]; Johri *et al.*, 1990) ^[6]. There are more than 300 elevated plateaus in the basin locally called 'Bet' or 'Thalias' meaning islets as they remain above the water surface. The natural and seasonal spread of wetland of Nalsarovar is of irregular shape. It is moreover elliptical in shape. It is shallow and in most parts muddy. This depressed portion had come into existence by a tectonic uplift of an estuary as also by increased sedimentation and aeolian infill (Walsten *et al.*, 1989) ^[7].

Researches on Nalsarovar Bird Sanctuary have been documented in past on various aspects of Nalsarovar Bird Sanctuary. Regular surveys of Birds and other vertebrates are regularly performed in this area. The sanctuary supports more than 216 species of birds that include about 150 species of wetland-dependent species. Apart from these, 72 species of flowering Plants, 48 species of algae, 76 species of zooplanktons and zoo-benthos, 20 species of fish and 13 species of mammals (GEER, 1998) ^[8]. Studies carried out in Nalsarovar so far have mainly focused on the avifauna of the sanctuary and on aspects of diversity of birds in relation to different habitat types. Recently, Oswin D. S. (2004) ^[9] studied on wetland ecosystems and coastal habitat diversity in Gujarat, India including Nalsarovar Lake. Bhavsar *et al.*, (2014) ^[10] studied on Identification of Wetland Vegetation by Supervised Classification of Nalsarovar Area using LISS-III Data. However, limited studies on invertebrates have been performed in Nalsarovar Bird Sanctuary area. Among invertebrates, Odonates (Dragonflies and Damselflies) being an important group it plays an important role both

ecologically by acting as bioindicator of water quality and economically by acting as biocontrol agent of vector borne disease caused by mosquitoes (Chandra *et al.*, 2006^[11], Brown 1991^[2], Clark & Samways 1996^[3], Samways *et al.*, 2010^[4], Tiple 2012^[12], Thomas *et al.*, 1988^[13], Santamarin and Mijares 1986^[14], Sebastian *et al.*, 1990)^[15] are very much required to be studied for regular monitoring wetland in near future.

A comprehensive study focusing on aquatic insects with reference to its diversity and ecology in freshwater wetlands of Gujarat is very limited. Few studies done in past are by Prasad (2004)^[16], Sharma (2009)^[17], Prasad and Thakur (1984)[18], Kumar (2009)^[19], V. B. Rohmare *et al.*, (2015)^[20]. Although Nalsarovar Bird Sanctuary being one of the largest natural wetland of Gujarat, internationally important wetland (Ramsar site), Important Bird and Biodiversity Area (IBA), and a protected area (Bird Sanctuary) has inadequate information with respect to insect diversity study. Odonate studies at Nalsarovar Bird Sanctuary are very limited even though it being an important wetland. Research studies on Odonates species specifically dependent on Nalsarovar Bird Sanctuary was lacking. Understanding geographical distribution of a species and species' habitat preferences are two very important approaches necessary for the initiation of conservation planning at the species level (Finch *et al.*, 2006)^[21]. This information would provide baseline information on the current status of the odonates of Nalsarovar Bird Sanctuary that can be a used as a tool by the protected area managers to monitor the health of such an internationally important wetland ecosystem. Considering the same, present study was conducted for developing odonate species inventory specifically dependent on Nalsarovar Bird Sanctuary along with its local distribution of species within Nalsarovar Bird Sanctuary.

II. RESEARCH METHOD

Study area - The entire study was carried out at Nalsarovar wetland. Nalsarovar is located between latitude 22° 78' N to 22° 96' N and longitude 71° 92' E to 72° 64' E. Nalsarovar is located about 65 km from Ahmedabad, Gujarat state. The entire area belongs to two districts - Ahmedabad and Surendranagar. The area includes the semi-arid lands of Ahmedabad and Surendranagar district (Figure 1). Nalsarovar bird Sanctuary is surrounded by 12 villages located at the boundary of the wetland. They are Kayla, Vekaria, Meni, Darji, Digvijaygadh, Shiyal, Paraii, Mulbavla, Ranagadh, Bhagvnpur, Nani-Kathechi and Shahpur village. Biogeographically the area falls in 4B Gujarat-Rajwara biotic Province of semi-arid biogeographical zone, as per the classification zone, as per classification developed by Rodgers & Panwar (1988)^[22] and Rodgers *et al.*, (2000)^[23].

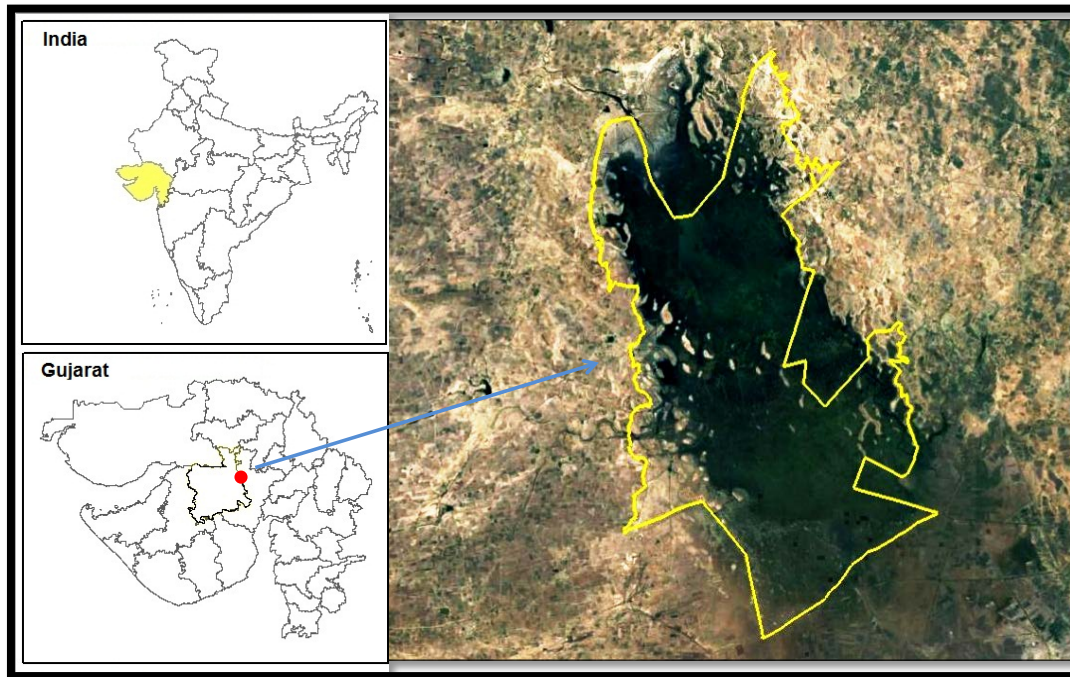


Figure 1: Location of Nalsarovar Bird Sanctuary

Nalsarovar wetland has very unique genesis. Locally, “Nal” is used for canal like protrusion of a creek or river. Prasad *et al.*, (1997)^[24] study the evolution patterns of the Nal Lake. Prasad *et al.*, (1997)^[24] have developed a 3 stage model for the evolution of Nal region during late-Quaternary period. In past, a shallow sea linked the Gulf of Kachchh with Gulf of Khambhat. The sea connection broke up around the beginning of marine isotope due to regression of the sea. Subsequently only a land link remained. Later, fluvial sediments from east were episodically deposited in the Nal region in response to westward migration of depositional front of eastern rivers. Later, due to advance of sedimentation front, tectonics and post glacial sea level rise, the elevation of Nalsarovar came to

within few meters of its present elevation when it became a closed basin. The mudflats, present to South of Nalsarovar, present recent sea transgression in the area.

Nalsarovar is a natural, shallow lake with maximum depth of about 1.5-2.0 meters when flooded. Water level/depth remains almost uniform in the wetland. Being a natural lake, the area under the submerged varies, depending upon the rainfall. During the years of good rainfalls, the total area in and around a sanctuary under the submerged may go beyond 350 sq. km. However, the actual water bodies in normal years is less than the legal area of the sanctuary, as 120 sq. km area is notified as the sanctuary under the Wildlife (Protection) Act, 1972. The area receives water mainly from river viz. the Bhradini and the Bhogavo. It also receives water from the surrounding catchment in North, West and east which area having gentle slopes (Kamboj & Tatu, 2016) ^[25].

The climate of the area is arid to semi-arid type. The temperature rises to a maximum of 45°C in May and minimum of 7°C in January. There appears gentle drainage from north-west to south. The average rainfall in the area is about 580 mm (Kumar 2009) ^[19]. majorly 6 habitats (A) Deeper Open water habitat (depth more than 2 feet), (B) Shallow Openwater habitat (depth more or equal to 2 feet), (C) Emergent hydrophytic cover (depth less than 2 feet), (D) Muddy habitat (Variable depth), (E) Islands ('bet') (F) Other habitats including shoreland area surrounded near to adjoining Scrubland/Grassland/Agriculture (seasonally variable in water depth) (Kamboj & Tatu, 2016) ^[25], Tatu 1995) ^[26] The most unique features of Nalsarovar Bird Sanctuary are presence of islets. The lake has more than 300 islets, most of which are located on the western boundary. They get exposed when water level recedes. Out of this, 36 islets are having sizable plateau like area while the rest are very small. Nalsarovar Bird Sanctuary is a seasonal wetland. During summer months it becomes almost a dry patch of wetland. The substratum of the lakes is undulated and therefore when water occupies the shallow trough, a number of islands appear above the water level. The changes from fresh water to brackish water and again back to fresh water in next monsoon keep the bio-cycles of organisms rotating. After monsoon, the lake gradually becomes brackish as water recedes or evaporates during dry months. (Kamboj & Tatu, 2016) ^[25]

The peripheral and surrounding area of this lake is dominated by cropland, fallow land and wasteland. The trees are mostly *Prosopis juliflora* and also *Salvadora*. Nal Sarovar provides adequate depression over a large area for the existence of submerged aquatic vegetation. Moreover, in an around its shallow water near shores and islets it supports and provides habitat for emergent hydrophytic vegetation. Both the submerged and emergent vegetation as well as algae constitute primary producers of this aquatic ecosystem. Besides they support large epiphytic organisms and also provide cover to a variety of organisms (vegetation). (Kamboj & Tatu, 2016) ^[25]

Materials and Methods - A study of odonates was carried out from February 2015 to February 2017 at Nalsarovar Bird Sanctuary. Nalsarovar Bird Sanctuary area is 120 sq Km. Nalsarovar is the one of the largest inland wetland of Gujarat. Studies on odonate diversity were made by visiting various localities in the study area at monthly intervals during the entire study. Entire study area consists of majorly 6 habitats (A) Deeper Open water habitat (depth more than 2 feet), (B) Shallow Openwater habitat (depth more or equal to 2 feet), (C) Emergent hydrophytic cover (depth less than 2 feet), (D) Muddy habitat (Variable depth), (E) Islands ('bet') (F) Other habitats including shoreland area surrounded near to adjoining Scrubland/Grassland/Agriculture (seasonally variable in water depth) (Kamboj & Tatu, 2016) ^[25]. Survey was carried out covering all seasons and all habitats.

Fourteen sites were fixed using GPS for the survey for the odonate survey within the study area. Survey was carried out including all seasons and covering all major habitats. These sites were named as T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13, and T14 (Table 1). These sites were regularly surveyed. Line transects method was followed for study of odonates (Sutherland, 1996) ^[27]. A species inventory was carried out by Visual Encounter Survey (VES). Observations were made while walking on fixed belt transects of 500 m length and width of 5 m on both side of transect. Each transect was surveyed for half an hour. Adult dragonflies and damselflies encountered were recorded.

Table 1: GPS location of each sites for entire survey at Nalsarovar Bird Sanctuary

Sr. No.	Code	GPS of fixed sites at Nalsarovar Bird Sanctuary
1	T1	22 ° 48' 33.1", 72 ° 03' 07.3"
2	T2	22 ° 47' 17.4", 72 ° 03' 48.0"
3	T3	22 ° 45' 18.3", 72 ° 05' 09.1"
4	T4	22 ° 43' 24.4", 72 ° 06' 30.4"
5	T5	22 ° 49' 10.2", 72 ° 02' 39.9"
6	T6	22 ° 50' 55.6", 71 ° 59' 29.0"

7	T7	22 ° 49' 32.0", 71 ° 58' 52.2"
8	T8	22 ° 46' 41.2", 72 ° 59' 58.8"
9	T9	22 ° 43' 39.1", 72 ° 01' 08.9"
10	T10	22 ° 48' 54.4", 72 ° 01' 12.1"
11	T11	22 ° 49' 34.4", 72 ° 01' 47.0"
12	T12	22 ° 48' 12.0", 72 ° 02' 14.7"
13	T13	22 ° 49' 41.5", 72 ° 01' 56.1"
14	T14	22 ° 51' 39.6", 71 ° 59' 15.4"

Opportunistic observations were made within transect for documenting the adults Odonata for species inventory. Species were photographed in the field. All our identifications at NBS were based on digital photos, allowing for later deliberation and confirmation. All photos were taken by Canon Powershot SX60 HS camera with 16.1 mega pixels, ultrasonic, full HD 65X optical zoom. In certain cases, species were difficult to identify, in such case adults were collected using aerial sweep net and after recording morphological details and photography the individuals were released back in field. Identification was carried out with available standard taxonomic literature Fraser (1933)^[28], Fraser (1934)^[29], Fraser (1936)^[30], Subramanian (2005)^[31], Mitra & Babu (2010)^[32], Nair (2011)^[33] and Subramanian (2014)^[34].

III. RESULTS AND DISCUSSIONS

A total of 30 species of dragonflies and damselflies were encountered belonging to 5 families namely Libellulidae, Gomphidae, Aeshnidae, Coenagrionidae and Lestidae were encountered during the entire study (Table 1). Out of these 30 species, 21 species belong to suborder Anisoptera (Dragonflies) and 9 species belong to suborder Zygoptera (Damselflies). Out of total 30 Odonate species encountered during entire study, total 21 species of dragonflies (Suborder – anisoptera) encountered belonged to 16 Genera and 3 families. However, among anisopteras, 18 species are belonged to 13 Genera and family Libellulidae, 1 species belonged to 1 Genera and family Gomphidae, 2 species belonged to 2 Genera and family Aeshnidae. Out of total 30 Odonate species encountered during entire study, total 9 species of zygoptera (damselflies) encountered belonged to 6 Genera and 2 families. However, among zygopterans, 8 species belonged to 6 Genera and family Coenagrionidae, 1 species belongs to 1 Genera and family Lestidae (Table 2). Among Odonates families (5) encountered during studies, the maximum dominance and contribution to the species diversity was accounting to 70% by family Libellulidae followed by Coenagrionidae which contributed 26 % of the total species. Similar observation was also found and recorded by other authors (Adarsh *et al.*, (2015)^[35], Das *et al.*, (2013)^[36], Rathod *et al.*, (2012)^[37], Singh *et al.*, (2017)^[38], Tiple *et al.*, (2008)^[39]. Most of the species are least concern (LC) under the IUCN categories list. A dragonfly species *Indothemis carnatica* (Fabricius, 1798) is listed under Near Threatened (NT) category under IUCN category. These species were encountered during winter seasons within study area majorly observed on/near dry bushes and shrubs.

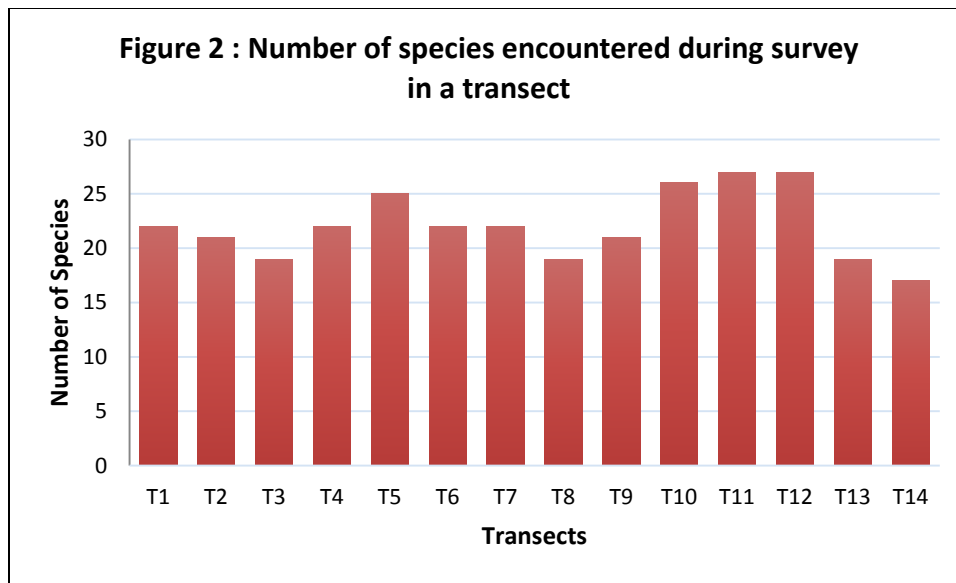
Table 2: Checklist of Odonate encountered within the Nalsarovar Bird Sanctuary during the entire survey

Sr. No.	Species listed	Common name
	Suborder: Anisoptera	
	Family : Libellulidae	
1	<i>Diplacodes lefebvrii</i> (Rambur, 1842)	Black Ground Skimmer
2	<i>Tramea limbata</i> (Desjardins, 1832)	Black Marsh trotter
3	<i>Trithemis festiva</i> (Rambur, 1842)	Black Stream Glider
4	<i>Orthetrum glaucaum</i> (Drury, 1770)	Blue Marsh Hawk
5	<i>Indothemis carnatica</i> (Fabricius, 1798)	Bush skimmer
6	<i>Macrodiplax cora</i> (Brauer, 1867)	Coastal glider /Estuaries skimmer
7	<i>Rhyothemis variegata</i> (Linnaeus, 1763)	Common Picture Wing
8	<i>Brachythemis contaminata</i> (Fabricius, 1793)	Ditch jewels
9	<i>Bradinyopyga geminata</i> (Rambur, 1842)	Granite Ghost
10	<i>Orthetrum sabina</i> (Drury, 1770)	Green Marsh hawk
11	<i>Diplacodes trivialis</i> (Rambur, 1842)	Ground Skimmer

12	<i>Brachydiplax sobrina</i> (Rambur, 1842)	Little blue Marsh Hawk
13	<i>Trithemis pallidinervis</i> (Kirby, 1889)	Long-legged Marsh Glider
14	<i>Trithemis kirbyi</i> (Kirby, 1889)	Orange-Winged Dropwing
15	<i>Tramea basilaris</i> (Rambur, 1842)	Red Marsh Trotter
16	<i>Crocothemis servilia</i> (Drury, 1770)	Ruddy Marsh Skimmer
17	<i>Acisoma panorpoides</i> (Rambur, 1842)	Trumpet tail
18	<i>Pantala flavescens</i> (Fabricius, 1798)	Wandering Glider
	Family: Gomphidae	
19	<i>Ictinogomphus rapax</i> (Rambur, 1842)	Common Clubtail
	Family: Aeshnidae	
20	<i>Hemianax ephippiger</i> (Burmeister, 1839)	Vagrant emperor
21	<i>Anax guttatus</i> (Burmeister, 1839)	Blue-Tailed Green Darner
	Suborder: Zygoptera	
	Family: Coenagrionidae	
22	<i>Pseudagrion microcephalum</i> (Rambur, 1842)	Blue Grass Dartlet
23	<i>Enallagma cyathigerum</i> (Charpentier, 1840)	Common Blue Damselfly
24	<i>Ceriagrion coromandelianum</i> (Fabricius, 1798)	Coromandel marsh dart
25	<i>Ischnura aurora</i> (Brauer, 1865)	Golden Dartlet
26	<i>Rhodischnura nursei</i> (Morton, 1907)	Pixie Dartlet
27	<i>Agriocnemis pygmaea</i> (Rambur, 1842)	Pygmy dartlet
28	<i>Ischnura senegalensis</i> (Rambur, 1842)	Senegal Golden Dartlet
29	<i>Pseudagrion decorum</i> (Rambur, 1842)	Three striped blue dart
	Family: Lestidae	
30	<i>Lestes species</i>	Spread wings

About 13 species were recorded in past (Prasad and Thakur, 1984) ^[18] within/ around sanand District out of which 7 species of Odonata are recorded in Nalsarovar Bird Sanctuary viz. *Pseudagrion decorum* (Rambur), *Ischnura senegalensis* (Rambur), *Rhodischnura nursei* (Morton), *Enallagma cyathigerum cyathigerum* Charpentier, *Agriocnemis pygmaea pygmaea* (Rambur), *Orthetrum sabina sabina* (Drury), *Crocothemis servilia servilia* (Drury). Later, odonate study was reported in Fauna of Nalsarovar, Gujarat, Wetland Ecosystem Series with unidentified odonates (Kumar 2009) ^[19]. Recently, 20 species of Odonates were recorded from entire Ahmedabad District at various selected sites including Nalsarovar as one of the site (V. B. Rohmare *et al.*, 2015) ^[20]. However, compiling the past record of Odonates (dragonflies and damselflies), around 26 species of odonates was recorded in and around Nalsarovar wetland (Table 2). Nalsarovar Bird Sanctuary being a nationally and internationally important wetland. During present study 30 species were encountered depended specifically on Nalsarovar Bird Sanctuary. Combining the past recorded species from Nalsarovar and species encountered in current research study checklist has risen to 37 odonate species including both dragonflies and damselflies depended mainly on the Nalsarovar Bird Sanctuary - Ramsar site and Important Bird Area.

Local distribution in each site within study area during the entire survey: During the entire survey, out of total 30 species, 22 species of Odonates were recorded in Transect T1, 21 species were recorded in Transect T2, 19 species were recorded in Transect T3, 22 species were recorded in Transect T4, 25 species were recorded in Transect T5, 22 species were recorded in Transect T6, 22 species were recorded in Transect T7, 19 species were recorded in Transect T8, 21 species were recorded in Transect T9, 26 species were recorded in Transect T10, 27 species were recorded in Transect T11, 27 species were recorded in Transect T12, 19 species were recorded in Transect T13 and 17 species were recorded in Transect T14. During the entire survey highest number of Odonates was observed in T11 and T12 whereas lowest number of species was encountered in T14. This indicates that frequency of occurrence of species was high in T12 and T11 were as lowest in T14 (Figure 2).



Occurrence of dragonfly and damselfly species at each site: During the entire study variation in occurrence of odonate species is recorded among different sites during entire study. Out of all 30 species, 21 species of dragonfly and 9 species of damselflies was encountered. Adult odonates presence and their distribution area generally are on the bases of their requirements. They are associated with aquatic habitats, terrestrial landscapes and their associated habitat required for selection of egg laying sites which further leads to future associated process for larval life stage and its characteristic habitat (Corbet 1993, 1999) ^[40,41]. This makes Odonata susceptible to specific types of habitat changes (Corbet 1993 ^[40], Clark and Samways 1996 ^[3], Schindler, Fesl, and Chovanec 2003 ^[42], Foote & Rice Hornung 2005) ^[43].

Distribution and occurrence of odonates are linked to its associated habitat and landscape different odonate groups are known to associate with different vegetation life-forms and height categories (Balzan 2012) ^[44]. Certain dragonflies and damselflies are encountered at all sites including T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13 and T14 whereas certain species are observed in lesser sites compared to other. Among suborder Anisoptera (Dragonflies), total 9 species of dragonfly such as *Trithemis festiva* (Rambur, 1842), *Macrodiplax cora* (Brauer, 1867), *Rhyothemis variegata* (Linnaeus, 1763), *Brachythemis contaminata* (Fabricius, 1793), *Orthetrum sabina* (Drury, 1770), *Diplacodes trivialis* (Rambur, 1842), *Trithemis pallidinervis* (Kirby, 1889), *Crocothemis servilia* (Drury, 1770), *Pantala flavescens* (Fabricius, 1798) belonging to Libellulidae and *Hemianax ephippiger* (Burmeister, 1839) belonging to Aeshnidae were encountered at all the 14 sites (T1 to T14). However, among suborder Zygoptera (Damsselflies), total 5 species of damselfly such as *Ischnura aurora* (Brauer, 1865), *Pseudagrion decorum* (Rambur, 1842), *Rhodischnura nursei* (Morton, 1907), *Agriocnemis pygmaea* (Rambur, 1842) and *Ischnura senegalensis* (Rambur, 1842) belonging to family Coenagrionidae were encountered at all the 14 sites (T1 to T14) (Table 3).

Among suborder Anisoptera (Dragonflies), certain species were distributed at selected sites such as *Diplacodes lefebvrii* (Rambur, 1842) were encountered at 7 sites (T2 T6 T7 T8 T9 T10 T11), *Tramea limbata* (Desjardins, 1832) were encountered at 9 sites (T4 T6 T7 T9 T10 T11 T12 T13 T14), *Orthetrum glaucaum* (Drury, 1770) were encountered at 4 sites (T1 T5 T10 T12). *Indothemis carnatica* (Fabricius, 1798) were encountered at 3 sites (T3 T6 T7 T11 T12), *Bradinopyga geminata* (Rambur, 1842) were encountered at 2 sites (T2 T5), *Brachydiplax sobrina* (Rambur, 1842) were encountered at 2 sites (T1 T3), *Trithemis kirbyi* (Kirby, 1889) were encountered at 10 sites (T1 T2 T4 T5 T6 T7 T8 T10 T11 T12), *Tramea basilaris* (Rambur, 1842) were encountered at 12 sites (T1 T2 T4 T5 T6 T7 T9 T10 T11 T12 T13 T14), *Acisoma panorpoides* (Rambur, 1842) were encountered at 8 sites (T1 T2 T3 T4 T5 T10 T11 T12) belonging to family Libellulidae, *Ictinogomphus rapax* (Rambur, 1842) were encountered at 6 sites (T1 T4 T5 T10 T11 T12) belonging to family Gomphidae and *Anax guttatus* (Burmeister, 1839) were encountered at 6 sites (T6 T7 T8 T9 T11 T12) belonging to family Aeshnidae. Among suborder Zygoptera (Damsselflies), certain species were distributed at selected sites such as *Pseudagrion microcephalum* (Rambur, 1842) were encountered at 12 sites (T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13). *Ceriagrion coromandelianum* (Fabricius, 1798) were encountered at 5 sites (T4 T5 T10 T11 T12), *Enallagma cyathigerum* (Charpentier, 1840) were encountered at 6 sites (T1 T5 T9 T10 T11 T12) belonging to family Coenagrionidae and *Lestes* species were encountered at 5 sites (T5 T10 T11 T12 T13) belonging to family Lestidae (Table 3).

Table 3: Occurrence (Presence/Absence) of odonate species at different site during entire study at Nalsarovar Bird Sanctuary

Sr.	Scientific name	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
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No.															
1	<i>Diplacodes lefebvrii</i> (Rambur, 1842)		+					+	+	+	+	+			
2	<i>Tramea limbata</i> (Desjardins, 1832)				+			+	+		+	+	+	+	+
3	<i>Trithemis festiva</i> (Rambur, 1842)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
4	<i>Orthetrum glaucaum</i> (Drury, 1770)	+				+					+		+		
5	<i>Indothemis carnatica</i> (Fabricius, 1798)			+				+	+						
6	<i>Macrodiplax cora</i> (Brauer, 1867)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
7	<i>Rhyothemis variegata</i> (Linnaeus, 1763)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
8	<i>Brachythemis contaminata</i> (Fabricius, 1793)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
9	<i>Bradinopyga geminata</i> (Rambur, 1842)		+			+									
10	<i>Orthetrum sabina</i> (Drury, 1770)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
11	<i>Diplacodes trivialis</i> (Rambur, 1842)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
12	<i>Brachydiplax sobrina</i> (Rambur, 1842)	+		+											
13	<i>Trithemis pallidinervis</i> (Kirby, 1889)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
14	<i>Trithemis kirbyi</i> (Kirby, 1889)	+	+		+	+	+	+	+		+	+	+		
15	<i>Tramea basilaris</i> (Rambur, 1842)	+	+		+	+	+	+	+		+	+	+	+	+
16	<i>Crocothemis servilia</i> (Drury, 1770)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
17	<i>Acisoma panorpoides</i> (Rambur, 1842)	+	+	+	+	+					+	+	+		
18	<i>Pantala flavescens</i> (Fabricius, 1798)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
19	<i>Anax guttatus</i> (Burmeister, 1839)							+	+	+	+		+	+	
20	<i>Hemianax ephippiger</i> (Burmeister, 1839)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
21	<i>Ictinogomphus rapax</i> (Rambur, 1842)	+			+	+					+	+	+		
22	<i>Enallagma cyathigerum</i> (Charpentier, 1840)	+				+					+	+	+	+	
23	<i>Ischnura aurora</i> (Brauer, 1865)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
24	<i>Pseudagrion decorum</i> (Rambur, 1842)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
25	<i>Rhodischnura nursei</i> (Morton, 1907)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
26	<i>Agricnemis pygmaea</i> (Rambur, 1842)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
27	<i>Ischnura senegalensis</i> (Rambur, 1842)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
28	<i>Pseudagrion microcephalum</i> (Rambur, 1842)		+	+	+	+	+	+	+	+	+	+	+	+	

29	<i>Ceriagrion coromandelianum</i> (Fabricius, 1798)				+	+						+	+	+		
30	<i>Lestes</i> species					+						+	+	+	+	

* Presence of species - '+'



Figure 3 - 1. *Trithemis festiva* (Rambur, 1842), 2. *Crocothemis servilia* (Drury, 1770), 3. *Brachythemis contaminata* (Fabricius, 1793), 4. *Macrodiplax cora* (Brauer, 1867), 5. *Diplacodes trivialis* (Rambur, 1842), 6. *Bradinopyga geminata* (Rambur, 1842), 7. *Trithemis pallidinervis* (Kirby, 1889), 8. *Orthetrum sabina* (Drury, 1770), 9. *Pantala flavescens* (Fabricius, 1798), 10. *Rhyothemis variegata* (Linnaeus, 1763), 11. *Tramea limbata* (Desjardins, 1832), 12. *Tramea basilaris* (Rambur, 1842), 13. *Acisoma panorpoides* (Rambur, 1842), 14. *Orthetrum glaucaum* (Drury, 1770), 15. *Brachydiplax sobrina* (Rambur, 1842)

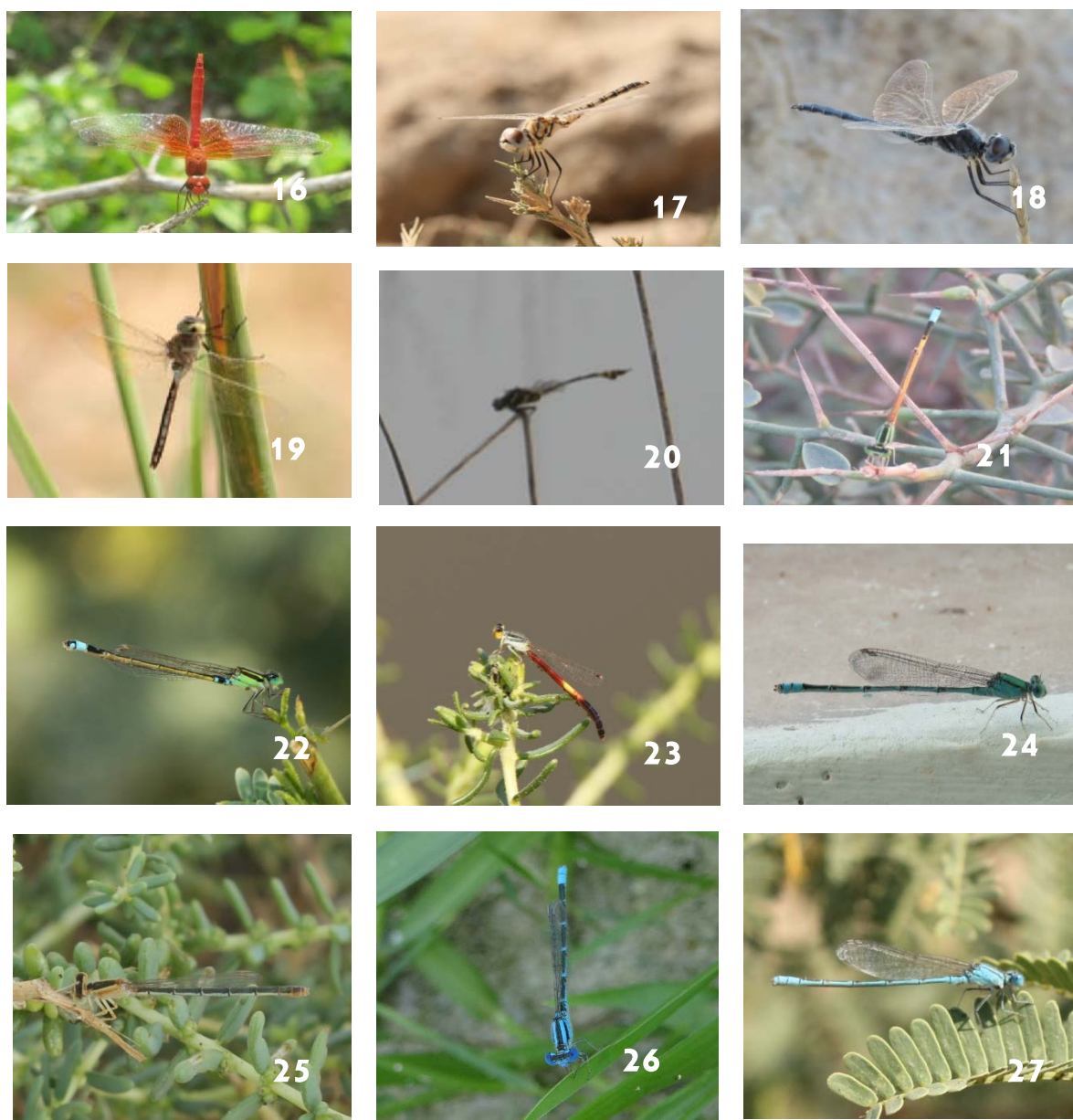


Figure 3 - 16. *Trithemis kirbyi* (Kirby, 1889), 17. *Diplacodes lefebvrii* (Rambur, 1842), 18. *Indothemis carnatica* (Fabricius, 1798), 19. *Hemianax ephippiger* (Burmeister, 1839), 20. *Ictinogomphus rapax* (Rambur, 1842), 21. *Ischnura aurora* (Brauer, 1865), 22. *Ischnura senegalensis* (Rambur, 1842), 23. *Rhodischnura nursei* (Morton, 1907), 24. *Pseudagrion decorum* (Rambur, 1842), 25. *Agriocnemis pygmaea* (Rambur, 1842), 26. *Enallagma cyathigerum* (Charpentier, 1840), 27. *Pseudagrion microcephalum* (Rambur, 1842)

IV. CONCLUSION

Dragonflies and damselflies both being an aquatic insect and playing an important role of environmental bio-indicator of water quality this study can be used to evaluate physical and biological conditions in wetlands. Odonates also play very important role as a bio-control agent of mosquitoes i.e. Vector of various vector borne diseases including malaria and dengue. Various studies on mosquito vorous dragonflies include *Bradinopyga geminata*, *Brachythemis contaminata* and *Pantala flavescens*. These three dragonfly species are encountered during this study. This Study can be used for controlling various vectorborne diseases including malaria and dengue in future. The studies can also be used for better management of these species within a protected area like Nalsarovar Bird Sanctuary.

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