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A review on odonate diversity and habitat in India

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Abstract
The current review examines 24 research articles about Odonata Diversity and Habitat, which were previously collected from all over India, and includes an update on their systematic account, sighting period, diagnostic features, measurements, distribution, and perching behavior, conservation status, and threats. If the habitats are saved and safeguarded, this is favorable for their survival.

Keywords: Odonata, diversity of odonata, habitat of odonata, dragonflies, damselflies

Introduction
Odonates, which include dragonflies and damselflies, are one of the most prevalent insects flying over forests, fields, meadows, ponds, and rivers. There are around 6,000 living species on the globe. With over 500 recognized species, India is a fairly diversified country. It first appeared around 250 million years ago, along with mayflies, during the Carboniferous epoch (Ephemeroptera). The Carboniferous era's Odonata includes giants. Dragonflies and mayflies are ancient insect groups that, among other things, were the first to evolve wings and fly.
The order Odonata is separated into three categories based on morphology: damselflies (Zygoptera), Anisozygoptera, and dragonflies (Anisoptera). In the field, dragonflies and damselflies are easily distinguished. Despite their morphological differences, their general life histories are similar.
Dragonflies and damselflies are becoming more widely recognized as valuable environmental indicators. Dragonfly research is also being conducted. Determine what they can tell us about the Diversity and Habitat in India. This review focuses on a few specific dragonfly species and studies on dragonflies in general that are related to Diversity and Habitat. Many of the publications picked provide useful information that will assist our credit for product group in advising Diversity methods for dragonflies discovered in India.

Diversity and Habitat valley
A total of 19 species of dragonfly and damselfly were collected from study locations in the Doon river basin from January to June (2015 and 2016). In compliance with the law, three families of Odonata and Anisoptera (Dragonfly). Two species belong to the group of species that were recorded for the specified sites. Two belong to the Aeshnidae family and two to the Gomphidae family. 1 from the Coenagrionidae family, and the majority of species 14 are members of the Libellulidae family. Apart from Zygoptera, Coenagrionidae is a family of damselflies that includes one species. The findings revealed that out of the total number of species observed in the area, Brachythemis contaminant was the most prevalent in the current study. Trithemis festival is the most abundant species (65%). (62 percent). Orthetrum triangulare is highly prevalent (58%) and Orthetrum pruinosum neglectum and Orthetrum luzonicum are two species of Orthetrum. were the least abundant, accounting for 10% and 9% of the total.
In comparison to other study sites, Sahastradhara has a far greater diversity of odonates. There were 14 species found at Sahastradhara. Eleven species were discovered in the Lachiwala region. In Robbers Cave and Maldevta, nine species were observed. Region. In Rajpur, however, only one species was found. Region. And Anax immaculifrons, which was only found in two places. Crocothemis servilia and Orthetrum pruinosum are two species of Crocothemis. The most common species found at each of the six survey locations Orthetrum *Trithemis aurora*, taeniolatum, and Trithemis festiva spotted in 5 different locations.

(Ashish Uniyal *et al*., 2019) [23].

Wetland

During the investigation, 18 species of odonates from three families were discovered in Randam Puncha, Kulanada. Dragonflies were used to signify by the Libellulidae and Gomphidae family's damselflies, which the family represents. The Coenagrionidae family was discovered. The highest number was recorded in the month of April, their number fell, in May. The dragonflies, in particular, Aethriamanta, Acisoma panorpoides Brachydiplax chalybea, brevipennis Orthetrum sabina and Rhyothemis variegate were the most frequent species seen on the island based on the total number of visitors, Libellulidae was the family with the most individuals recorded. The most powerful family, the majority of them were near the paddy field, it's extremely prevalent. They were also present during the wet season Ceriagrion cerinorubellum and Pseudagrion microcephalum are two common damselflies. Their number was April and May is the busiest month. But their number dramatically plummeted in June. (sreelekshmi. S *et al*., 2019) [19].

In this study, 929 individuals from 26 Odonata species from 11 genera and three families were recorded. The families are Coenagrionidae and Calopterygidae. The most dominant family in the present study is Coenagrionidae, which includes 9 genera (81.82% of all genera) and 23 species (88.46% of all species). (Das Bidyut Kumar *et al*., 2015) [5].

Lake and Ponds

The distribution of odonates at different seasons in the study area was determined as 88.89% randomly distributed and 11.11% aggregated in summer, 89.65% randomly distributed and 10.35% aggregated in winter and 93.93% randomly distributed and 6, 06% aggregated in monsoon. The aggregate distribution indicates a seasonal preference, while the random distribution indicates available resource use and the suitability of the season for survival.

In this study, the number of odonates encountered during the monsoon was 650, which decreased to 424 individuals in winter and only 249 individuals in summer. However, 33 species were recorded throughout the year. Some species of Odonates such as Diplacodeslefebvrii, Orthetrum glaucum, Tholymis tillarga, Aethriamanta brevipennis, Aciagrion pallidum and Lesteselatus were not observed in summer. Brachythemiscontaminata was most common in the monsoon, indicating polluted water16. Pantala flavescens were also abundant in the monsoon. A total of 33 species representing 6 families were recorded from the area with multiple transects. Lebellulidae 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 turned out to be the most species-rich gene with 4 species. During the study, Shannon, Simpson and Hills indices were calculated as a measure of diversity in three different seasons of multi-use areas. The Shannon Diversity Index showed that winter is relatively diverse, followed by monsoons and summer. (Manwar Narender *et al*., 2016) [9].

Between December 2016 and February 2017, 19 species were discovered through research employing visual observation methods, direct capture, and sticky traps. The species belong to one of the three families of the genus Anisoptera from the families Aeshidae, Gomphidae, and Libellulidae, as well as two other families Coenagrionidae and Lestidae are two Zygoptera families.

The presence of dragonflies on the University of Sriwijaya campus is a sign of their ability to maintain the generation's sustainability. The presence of adequate habitats and food supplies for dragonflies is a reflection of the environment. In the vicinity of Sriwijaya University Campus, there is a robust environment.

Anax guttatus, Ictinogomphus decoratus, Acisoma panorphoides, Brachythemis contaminata, Diplacodes trivalis, Neurothemis ramburii, Lathrecista asiatica, Trithemis pallidinervis, Orthetrum pruinosum, O. sabina, Orthetrum pruinosum, O. sabina, Orthetrum pruin.

Rhyothemis phyllis, Crocothemis servilia, and Rhodothemis rufa are three species of Rhyothemis. Agriocnemis femina, Agriocnemis pygmaena, Ceriagrion auranticum, Ischnura senegalensis, Pseudagrium microcephalum, and Lestes praemorsus were recognised as Zygoptera species.

R. rufa, A. guttatus, C. auranticum, L. asiatica, and O. pruinosum are the five species with the fewest individuals. The five species with the smallest number of people can be attributed to their bodies' sensitivity, thus they must be tolerated. For relatively small environmental changes, there is a limit. The migration of these animals is thought to be caused by an unfavorable environmental state. Five species to a more favorable location, making these species rare to come across. At research sites, there are five species. (Muhammad Agus *et al*., 2017) [2].

Agricultural area

Three families, namely Libellulidae, Aeshnidae and Gomphidae, have been recorded under Anisoptera (dragonflies), and five families, namely Coenagrionidae, Lestidae, Euphaeidae, Synlestidae and Platycnemididae have been recorded under Zygoptera (miniflies). A total of 29 species of odonate, including 17 species of Anisoptera (dragonflies) and 12 species of Zygoptera (damselflies), were recorded in the study area. Among the Anisoptera, the Libellulidae family dominated with 15 species, followed by Aeshnidae (1) and Gomphidae (1). Among the Zygoptera, Coenagrionidae (7) was the dominant family, followed by Lestidae (2), Euphaeidae (1), Synlestidae (1), and Platycnemididae (1). Diplocodes trivialis (Libellulidae) was the most dominant Anisoptera and Ischnura Aurora (Coenagrionidae) was the most common Zygoptera among the 29 species recorded. (Elanchezhyan K *et al*., 2017) [8].

A total of 39 species belonging to 25 genera under six families and two suborders were recorded from paddy crops in central Gujarat. A total of 17 species of Zygoptera (damselflies) and 22 species of Anisoptera (dragonflies) were recorded. This list excludes species that are habitat specialists and are found in streams, rivers, forests, and saline wetlands. Three families represented Zygoptera and Anisoptera was represented by three families (V. B. Rohmare *et al*., 2016) [15].

River base

The present study was conducted to monitor dragonfly biodiversity along the banks of the Kallar River in Pathanamthitta District, Kerala. A total of 15 dragonfly species from 14 genera were identified in this study. The maximum number of species belongs to the Libellulidae family, which was represented by 14 species. The Gomphidae family was represented by 1 species. (Cincy Thomas *et al*., 2018) [21].

This study of Lepidoptera and Odonata was too primary to identify the different specimens in different habitats and

different representative fields. Specimens were divided into four groups based on their occurrence during the study period and the frequency of sightings. During the intensive study of insects in the Jabalpur district, 41 species including a total of 10 families belonging to 2 orders Odonata and Lepidoptera were detected during the study from selected sites.

Total 41 species of insects, 22 species of order Odonata, dragonflies have 8 species under 2 families, of which Coenagrionoidae consists of the maximum number of species with 7 species, followed by Chlorocyphidae with 1 species each, while dragonflies have 14 species among 3 families, of which Libellulidae or Skimmers are the most diverse and dominant dragonfly family with 9 species, followed by others such as Aeshnidae with 3 species and Gomphidae with 2 species.

Of 19 species among Lepidoptera belonging to 14 genera of 5 families, namely Nymphalidae, Papillionidae, Piridae, Lycaenidae, and Hesperiidae. In terms of the number of species, the result revealed that out of a total of 5 families, Nymphalidae was the dominant family with 9 species, followed by Pieridae with 4 species, followed by Papilionidae with 3 species, Hesperiidae with 2 species, and Lycaenidae with 1 species. (Dr. Neelima Painkra *et al*., 2016) [13].

During the study period, a total of 20 dragonfly species were discovered. A total of 17 species are included in this family. Libellulidae and Gomphidae, respectively. Cordulidae and Aeshnidae, respectively. Similarly, eight species of damselflies were discovered, six of which belong to the Coenagrionidae family and one each to the Coenagrionidae and Coenagrionidae families. Protoneuridae and Lestidae are two different families. (Veeramani. A *et al*., 2018).

Around the Tons River tributary in Dehradun, Uttarakhand, India, studies on the Odonata fauna found 23 species belonging to 05 families in two suborders of the order Odonata. The study shows that Ceriagrion coromandelianum (Fabricius), Orthetrum Sabina (Drury), Brachythemis contaminata (Fabricius), Crocothemis

Servilia (Drury), and Trithemis festiva (Rambur) was the dominant species in the study area. (Gaurav Sharma., 2020).

In the Tunga riverbank, adjacent fields, and surrounding areas, a total of 29 different odonate species belonging to 7 families and 24 genera were discovered. Land that has been cultivated the species composition of various families is shown. There was no previous research on the odonate diversity of the genus Odonata. Tunga riverbank, adjacent fields, and cultivated lands, as well as thu.

Dragonflies were represented by 14 species among the 29 odonates. There were 13 species of dragonflies in the Libellulidae family, but only one species in the Aeshnidae family.

Damselflies were represented by 15 species among the 29 odonates. The family Coenagrionidae has nine species of damselflies. Three species of the Chlorocyphidae family were present, whereas there were representatives from the Platycnemididae, Lestidae, and Calopterygidae families. Each by a single species as far as the damselflies were concerned, everything was fine. The Coenagrionidae family was found to be the most prevalent in this study. (Naik KL *et al*., 2017) [11].

Regional area

As a result of this investigation, up to 60 species of odonate from different habitats of the Thrissur district could be recorded. Of these, 35 species belong to 26 genera and 3 families and fall under the suborder Anisoptera. The remaining 25 species belong to 15 genera and 6 families and fall under the suborder Zygoptera. (Nitha Bose C *et al*., 2019) [3].

Basic knowledge about the diversity and distribution of odonates on a spatio-temporal scale is key to conserving biodiversity. The present work aims to study odonate diversity and distribution at selected sites in Kannur and Wayanad districts such as Madayipara and Mananthavady.

A total of 16 species of odonate from 12 genera and 5 families from the study area were recorded. From the results of the present study, it is clear that the Libellulidae family was dominant among the 5 families with 8 species. Diplacodes trivalis, Neurothemis fulvia, Neurothemis tullia, Orthetrum chrysis, Orthetrum sabina, Rhodothemis rufa, Rhyothemis variegate, and Tholymis tillagra were among the species studied.

Libellulidae and Coenagrionidae were the most frequently sighted groups during the study. The status of all species was categorized based on direct sighting during the study. In the present study, 8 species (Neurothemis fulvia, Neurothemis tullia, Orthetrum chrysis, Orthetrum sabina, Rhodothemis rufa, Rhyothermis variegate, Tholymis tillagra, Ceriagrion cerinorubellum) were frequently sighted, 5 species (Diplacode trivalis, Agriocnemis pygmaea, Ceriagrion coromandelianum, Aciagrion palladium, Agriocnemis pygmaea) were uncommon and 3 species (Vestalis gracilis, Euphaea dispar, Lestes elatus) were rarely sighted. (Athira PM *et al*., 2021) [1].

In the present study, 15 species of the order Odonata, consisting of the 02 suborder, 02 family, and 02 subfamilies, are recorded. The Libellulidae & Coenagrionidae families are identified and the Libellulidae family is dominant in this study area. There are 14 species in this family (95 percent of all species), but just one species in the Coenagrionidae family (05 percent of all species). Under the suborder Anisoptera (dragonflies) there are a total of 12 species of Odonata such as Orthetrum sabina sabina (Drury), Crocothemis servilia servilia (Drury), Pantala flavescens (Fabricious), Aethriamanta brevipennis, Brachydiplax sobrina, Acisoma panorpoides, Orthetrum chrysis, Neurothemis fulvia, Brachythemis contaminata, Rhodothemis rufa, Cratilla lineata and Neurothemis tullia belonging to the family Libellulidae and 03 species such as Ceriagrion coromandelianum (Brewers), Ischnura senegalensis and Paragomphus lineatus belonging to the family Coenagrionidae.

The species dominance of Odonata can be attributed to the presence of swampy areas, shrubs and wetlands. The abundance of the species Brachythemis contaminata indicates that the water quality of the water bodies is poor and it can also be assumed that pollution from the study area could contribute to the spread of this species. (Santosh P. Supanekar *et al*., 2021) [20].

A total of 719 individuals of odonates belonging to 34 species among 06 families were recorded during the study period. Among the Anisoptera, the Libellulidae family was the dominant family with 17 species, followed by Aeshinidae (03 sp.) and Gomphidae (02 sp.). With 09 specthe ies, the Coenagrionidae family was the most dominant among the Zygoptera ahead of the Lestidae family (02 sp.) and the Platycnenididae family (02 sp.). It could be due to mass emergence after crewing and annual accumulation before migration. Among the 10 sites, site S1 (urban area of Vita) recorded the highest species diversity (Shannon Index-2,843), and species richness (Margalefs Index-5,728). However, site S10 (village area of Banurgad) recorded the lowest species

diversity (Shannon Index-1.815), species richness (Margalefs Index-1.800). It was found that the species uniformity was highest at site S9 (Balwadi village area - Pielous flatness index - 0.964) and lowest at site S4 (Pare village area - 0.609). (Rahul Patil *et al*., 2018) [14].

Observations also showed that species richness is higher in the post-monsoon period (September - October) and their number in the census gradually decreases from November to January and is lower in the winter season (December - March).

The present study, conducted at four study sites by Pt. Ravishankar Shukla University Raipur C.G. (India) led to the listing of the 28 odonatan species, which account for more than 5.9% of the Indian odonatan species.

Among these 28 Odonatan species belong three families and 19 genera. The family Libellulidae is numerically the most dominant family with 17 species, the family Coenagrionidae is the second dominant family with 8 species, the family Gomphidae with 2 species, and Aeshnidae with only one species. The family Libellulidae comprises 60.71%, the family Coenagrionidae 28, 57% and the family Gomphidae 7.14 and Aeshnidae 3.57% of all observed Odonatan species.

The Libellulidae are the most common and Aeshnidae are the least common family in the campus area. The Pseudagrion rubriceps show a particularly simple aggressive courtship behavior.

The Odonata showed seasonal variations acc in relation to seasonal changes according to their occurrence Sahu R *et al*., 2019) [16].

During the study period, a total of 30 species were identified. Two families and 17 species make up the Anisoptera suborder, whereas two families and two species make up the Zygoptera suborder. 13 species and 13 families. There were 26 different species in total. 25 were found in habitats near the Mordhana dam, while 25 were found in Amirthi. Pulliyanthangal has streams and 16 different species. With 345 individuals (175 Anisopteran and 170 Zygopteran), Mordhana Dam is the most abundant environment, followed by Amirthi.

Streams with 288 individuals (151 Anisopteran). Pulliyanthangal Lake (containing 184 Zygopteran and 137 Zygopteran) is the least abundant (104 Anisopteran and 80 Zygopteran) the Libelullidae family was dominating (40 percent) from the start. In the Vellore areas, the five families were discovered Coenagrionidae (27 percent), Gomphidae, and Coenagrionidae are the next most popular families (2 percent), only 3 percent of the Lestidae family and 28% of the Platycnemididae family are found in the United States.

Brachythemis contaminating, Trithemis festiva, Crocothe misservilia, Orthetrum Sabina, and others are among the nine species. Bradinopyga geminate, Pantala flavescens Orthetrumpruino, Diplacode strivialis All of the Trithemis aurora were verified to be present habitats. Neurothemis tullia, Neurothemis tullia, and Neurothemis tullia fulvia and Brachidiplax sobrina were discovered in two distinct locations. Rhyothemis variegata, Brachidiplax chalybea, and Palpopleurasexmaculata were the only three species detected in one location. Kind of habitat the most common Anisopteran species in the world Diplacodes trivialis and Pantala were the Amirthi streams. In Mordhana Dam and Pulliyanthangal Lake, flavescens were found. The most common species is Brachythemis. Their ascension is due to the existence of huge marshy areas, bushes, etc. as well as wetlands. (Selvarasu.P *et al*., 2019) [17].

Wildlife sanctuary

A total of 58 species representing 37 genera from 9 families were recorded from the multi-use area of the reserve. Coenagrionidae [11], Calopterygidae [3], Platycnemididae [3], Protoneuridae [2], Lestidae [2], Chlorocyphidae [2], Gomphidae [2], and Aeshnidae [2]. Orthetrum was the most species-rich genus with 7 species? (Sunit KR. DAS *et al*., 2012) [6].

The study region yielded a total of 57 species, divided into 39 genera and eight families. Three families, 25 genera, and 37 species were found in the suborder Anisoptera (64 percent), while five families, 14 genera, and 20 species were found in the suborder Zygoptera (36 percent).

Libellulidae (52%) had the most species, followed by Coenagrionidae (14%), Gomphidae (9%), Aeshnidae, Platycnemididae, Calopterygidae, and Chlorocyphidae (4%), while Euphaeidae (1%) had the fewest.

The preferences of odonates for each of the five habitats reveal a wide range of results. The wetland (n=35, 63 percent) has the most species, followed by paddy field (n=29, 52 percent), degraded forest (n=26, 46 percent), hill stream (n=25, 44 percent), and dense forest (n=23, 41 percent). According to the findings, a total of 20 species have been identified. 7 species were identified as habitat specialists in various habitats, while 7 species were identified as habitat generalists. Depicts the in the research region, the ratio of habitat generalist and habitat specialist species. (Kushal Choudhury *et al*., 2020) [4].

A total of 30 dragonfly and damselfly species were found, divided into five families: Libellulidae, Gomphidae, Aeshnidae, Coenagrionidae, and Coenagrionidae. Throughout the research, Lestidae was present. A total of 21 species of dragonflies (Suborder - Anisoptera) were found among the total of 30 Odonate species seen throughout the investigation. (Kalavanti Mokaria *et al*., 2019) [10].

During the survey, 54 odonate species were discovered, comprising 37 Anisoptera (dragonflies) and 17 Zygoptera (damselflies). KWS was used to record this. Anisoptera is a family of insects. The Libellulidae family was well represented, with 31 species. Aeshnidae and Gomphidae are two families of Aeshnidae (3 species each). Likewise, seven species of Zygoptera Coenagrionidae dominated the Zygoptera Coenagrionidae. Calopterygidae and Protoneuridae are the next two families. Chlorocyphidae (2 species), and Chlorocyphidae (3 species each). (Subrat Debata *et al*., 2018) [7].

During the study, 72 species of odonate from eight families were recorded, three of which were new records for the Vidarbha region. Most odonates belonged to the family Libellulidae (31 species), followed by Coenagrionidae (15 species), Aeshnidae (six species), Gomphidae (seven species), Platycenemididae (four species), Lestidae (five species), Macromiidae (three species) and Chlorocyphidae (one species). Of these, 30 species were very common, 18 common, 7 common, 11 rare and 6 very rare. Asterisks indicate species that have been recorded for the first time in the Vidarbha region: Gomphidia t-nigrum, Macromia cingulata, and Elattoneura nigerrima.

Of the 72 odonates recorded at the Bor Wildlife Sanctuary, only Indothemis carnatica is classified as Near Threatened, 65 as Least Concern, and the rest as data deficient. The Gomphidae family is represented by the highest number of data-insufficient species for which information is not available in the IUCN Red List of Threatened Species.

(Ashish Tiple. 2020) [22].

A total of 21 species of odonates in 19 genera belonging to 5 families have been reported. During the study, the order Anisoptera, which includes dragonflies with 17 species belonging to three families, was predominant and contributed 76%, followed by the order Zygoptera, which includes dragonflies with 5 species belonging to two families and 24% of totalodonates collected contributed.

Among the order Anisoptera, the family Libellulidae was widespread and dominant with a high percentage composition, ie 74% (n=12), while the families Aeshnidae and Gomphidae were both equal with a percentage composition, ie 13% each (n=2). were distributed. Whereas in the order Zygoptera, the family Coenagrionidae dominated with the highest percentage composition, ie 60% (n=3), followed by the family Platycnemididae with 40% (n=2). The status of odonates based on frequency of occurrence shows that 33% (n=7) occurred frequently, 24% (n=5) very frequently, 14% (n=3) occasionally and 19% (n=4) occurred rare and 10% (n=2) were very rare. According to the IUCN categorization, all odonate species recorded from the study area fall into the Least Concern (LC) category. (Harisha m. Nijjavalli *et al*., 2017) [12].

Conclusion

The majority of India's uncommon or vulnerable dragonfly species are little understood. What is known about habitat requirements varies greatly depending on the species. Dragonflies can be found in a variety of places. Others live in bogs, streams, and standing ponds.

Habitat modification is the principal danger to almost all dragonfly species studied. Damming/rerouting streams and rivers, clear cutting of nearby woodlots, road runoff, and other concerns are some of the threats.

Habitat preservation, limited development of upland areas away from streams, and restoration of various types of wetlands are all possible management options.

Dragonflies and damselflies are excellent markers of ecosystem health, and habitats must be preservto to maintain stable populations of these invertebrates.

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