Study on the abundance and diversity of dragonflies and damselflies (Insecta: Odonata) of Corbett Tiger Reserve, Uttarakhand, India

Dayakrishna, Manoj Kumar Arya

Abstract
A study on the abundance, species richness and diversity of Odonate fauna in and around Corbett Tiger Reserve was conducted during 2013-2015. A total of 420 individuals of Odonates belonging to 4 families and 19 species under two suborders were recorded during the entire study period. Suborder Anisoptera was represented by family Libellulidae and suborder Zygoptera was represented by the families Coenagrionidae, Chlorocyphidae and Calopterygidae. Libellulidae was the most dominant family with 15 species constituting 92.14% of the total recorded individuals of Odonates followed by Coenagrionidae with 2 species and constituting 6.19% of the total recorded individuals, Calopterygidae and Chlorocyphidae (1 species each), respectively. Orthetrum pruinosum neglectum Rambur was the most abundant species constituting 29.76% of the total number of individuals of Odonates followed by Aethriamanta brevipennis Rambur (14.52%), Orthetrum glaucum (Brauer) (12.62%) and Crocothemis s. servilia (Drury) (8.80%), respectively. On the other hand, Rhinocypha f. fenestrella Rambur, Palpopleura s. sexmaculata (Fabricius) and Palpopleura sp. were recorded less abundant species during the entire study period. Maximum number of species and individuals of Odonates were recorded during rainy season followed by summer and winter. Similarly, maximum values of species diversity were recorded during the rainy season followed by summer and winter.

Keywords: Abundance, Corbett Tiger Reserve (CTR), diversity, Odonates, richness, species

1. Introduction
The order Odonata (dragonflies and damselflies), comprising three suborders Anisoptera, Anisozygoptera and Zygoptera are one of ancient group of Insects [1] and considered as an important link in the food chain of any forest ecosystem [3]. Generally, they are known as “guardians of the watershed” [3] and their rich diversity and habitat specificity make them ideal tools for assessing freshwater ecosystem health [4]. Globally, 5,740 species of Odonates are known of this 470 species representing 139 genera and 19 families have been reported from India [5]. Corbett Tiger Reserve (CTR), endowed with unique and exceptionally rich biodiversity, is one of the best suitable habitats for tiger in the world. However, different vertebrates of CTR have been studied for many occasions but a little information is available regarding invertebrates particularly Odonates of CTR [18-20]. Apart from the CTR, various studies have been conducted on Odonates from different parts of the world [1, 2, 4, 6-17]. Therefore, the present study was conducted to explore the abundance, species richness and diversity of Odonates in and around CTR, Uttarakhand, India.

2. Materials and Methods
2.1 Study area
Corbett Tiger Reserve (29°13’-29°35’ N and 78°33’-78°46’ E) is located in the hilly districts of Nainital and Pauri Garhwal in the southern part of Uttarakhand, India (Figure 1). With 1318 sq. km, Corbett Tiger Reserve (CTR) covers a large area including Corbett National Park, Sonanadi Wildlife Sanctuary and an additional reserve forest. The elevation ranges from 400-1200m. CTR falls in the subtropical climate zone with annual rainfall varying from 1400-2800 mm. Temperature of the area varies between 11°C to 41°C. Climatically, the area is unique and has three distinct seasons i.e. winter (November to February), summer (March-June) and rainy (July-October). The CTR mainly supports northern dry deciduous vegetation dominated by Shorea robusta along with its associate species. River Ramganga coursing sinuously through CTR and with its subsidiary streams is only source of water to the wildlife of the reserve. To carry out the present study four sites with varied habitat type were selected in and around CTR (Table 1).
Fig 1: Map showing different study sites in and around Corbett Tiger Reserve

Table 1: Characteristic features of different study sites in the landscape of Corbett Tiger Reserve

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Study Sites</th>
<th>Division</th>
<th>Elevation</th>
<th>Coordinates</th>
<th>Habitat status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Jhirna (Site-1)</td>
<td>Corbett</td>
<td>330 m</td>
<td>N 29°25.332”E 79°59.943”</td>
<td>Open, dry and scrubby</td>
</tr>
<tr>
<td>2.</td>
<td>Bijrani (Site-2)</td>
<td>Corbett</td>
<td>393 m</td>
<td>N 29°33.096” E 79°06.576”</td>
<td>Moist and riverine</td>
</tr>
<tr>
<td>3.</td>
<td>Garjia (Site-3)</td>
<td>Ramnagar</td>
<td>433 m</td>
<td>N29°29.708” E 79°08.159”</td>
<td>Open, dry and scrubby</td>
</tr>
<tr>
<td>4.</td>
<td>Mohaan (Site-4)</td>
<td>Ramnagar</td>
<td>508 m</td>
<td>N 29°58.472” E 79°08.461”</td>
<td>Moist and riverine</td>
</tr>
</tbody>
</table>

2.2 Sampling of Odonates

Sampling of Odonates was carried out from July 2013 to June 2015 in different study sites selected in and around Corbett Tiger Reserve (CTR). Random sampling was carried out by direct searching methods following Sutherland [21] at a thirty days interval during the period of 10:00 to 16:00 hours, because Odonates are found mostly active during midday due to their dependence on sunlight directly to regulate their body temperature [16]. Identification of Odonates was carried out with the help of Odonates identification guide [5, 22-24].

2.3 Data analysis

In order to compare the diversity of Odonates across the different sites as well as different seasons various measures of diversity were calculated by using the program Past 3.4 [25].

3. Results and Discussion

3.1 Species composition and abundance: A total of 420 individuals of Odonates belonging to 19 species under 4 families were recorded during the entire study period (Table 2). On the basis of total number of species Libellulidae was the most dominant family with 15 species followed by Coenagrionidae (2 species), Chlorocyphidae and Calopterygidae (1 species each).

On the basis of total number of individuals recorded, Libellulidae was the most dominant family constituting 29.76% of the total number of recorded Odonates. Orthetrum pruinum neglectum (Rambur) was the most abundant species of this family followed by Aethriomanta brevipennis (Ram)ber (14.52%), Orthetrum glaucum (Brauer) (13.30%) and Crocothemis s. servilia (Drury) (8.80%), respectively. Family Coenagrionidae was the second most dominant family and constituted 6.19% of the total individuals of Odonates recorded during the study period. Pseudagrion r. rubriceps Selys was the most abundant species and accounted for 61.54% of the total individuals of this family. Family Chlorocyphidae and Calopterygidae, both were represented by a single species constituting 0.24% and 1.43% of the total number of individuals of the Odonates, respectively.

Across the entire study period, Orthetrum pruinum neglectum Rambur was the most abundant species constituting 29.76% of the total number of individuals of Odonates recorded followed by Aethriomanta brevipennis Rambur (14.52%), Orthetrum glaucum (Brauer) (12.62%) and Crocothemis s. servilia (Drury) (8.80%), respectively. Whereas, Rhinocypha f. fenestrella Rambur (0.24% of the total Odonates), along with Palpopleura s. sexmaculata (Fabricius) and Palpopleura sp. (both accounted for 0.47% of the total Odonates), was the least abundant species during the entire study period.
In the present study, site no. 4 supported the maximum number of Odonates species (19) followed by site no. 1 (12 species) and site no. 3 (12 species), respectively. Five species were common in all the four study sites, while site no. 1 and 3 had one common species. On the other hand, site no. 3 and 4 supported 2 common species. During the entire study period *Rhinocycpha f. fenestrella* Rambar was recorded from site-Only. Among the 19 species of Odonates *Ceriagrion coromandelianum* (Fabricius) and *Tholymis tillarga* (Fabricius) were reported first time from the CTR during the present study period.

A total of 420 individuals belonging to 19 species of Odonates were recorded from different sites of CTR during the present study period. In comparison, 37 species of Odonates belonging to eight families have been reported from Corbett Tiger Reserve [18-20]. Similarly, six species belonging to 4 families of Odonates have been reported from Nanda Devi Biosphere Reserve, India. Platycnemididae was the most dominant family with 3 species, followed by Synlestidae, Aeshnidae and Cordulegasteridae (1 each) [6]. In addition, 42 species of Odonates with their habitat ecology have been reported from Sahastradhara (Sulphur springs) of Dehradun [7]. Clausnitzer [8] has documented 194 species of Odonates belonging to 11 families from Kenya. Libellulidae, with 75 species, was the dominant family followed by Coenagrionidae (43), Gomphidae (25), Aeshnidae (15), Lestidae (9), Cordulidae (7), Chlorocyphidae (7), Protoneuridae (5), Platycnemididae (5), Calopterygidae (2) and Megapodagrionidae (1). Few workers have reported 6 species of Odonates under 2 families from Great Himalayan National Park, Western Himalaya. Libellulidae was the most dominant family with 4 species while aeshnidae was represented by only 2 species [9]. Similarly, 23 species of Odonates under 4 families have been listed from Annamalai University of Tamilnadu. Libellulidae (13) was the most dominant family followed by Coenagrionidae (5), Aeshnidae (4) and Gomphidae (1) [10]. Some workers have reported 17 species belonging to 4 families of Odonates from Rajaji National Park, India. Libellulidae was the most dominant family with 9 species, followed by Coenagrionidae (5), Chlorocyphidae (2) and Gomphidae (1) [2]. Few workers have reported 27 species of Odonates representing 8 families from a wetland area in Hanwella, Sri Lanka. With 11 species Libellulidae was the most dominant family followed by Coenagrionidae (7 species), Gomphidae (3 species), Protoneuridae (2 species), Chlorocyphidae, Platycnemididae, Aeshnidae and Cordulidae (1 species each) [11]. Some workers have reported 58 species of Odonates representing 37 genera from 9 families in buffer area of Similipal Tiger Reserve, Eastern Ghat, India. Libellulidae was the dominant family with 31 species, followed by Coenagrionidae (11), Calopterygidae (3), Platycnemididae (3), Protoneuridae (2), Lestidae (2), Chlorocyphidae (2), Gomphidae (2) and Aeshnidae (2) [12]. Moreover, 58 species of Odonates under 37 genera and 9 families have been reported from buffer areas of Similipal Tiger Reserve, Eastern Ghat, India [13]. Similarly, 41 species of Odonate fauna belonging to 7 families and 31 genera have documented from three tiger reserves of Madhya Pradesh, Central India [14]. On the other hand, 46 species of dragonflies and damselflies have recorded from Mula and Mutha river basins at Maharashtra India [4]. More recently, 68 species of Odonates belonging to 44 genera and 10 families Chhattisgarh, India [14] whereas, 33 species of dragonflies and damselflies representing 4 families have been reported from Umiam, Meghalaya, India [13].

### 3.2 Species richness and diversity of Odonates

During the study period Simpson, Shannon, Margalef, Fisher-alpha and Berger-Parker indices were calculated as a measure of diversity of Odonates in different study sites as well as different seasons. Maximum species richness was recorded during the rainy season (18 species), followed by winter (14 species) and summer (11 species). Eight species were common during all the three season. Among the total species of Odonates 3 species were common during the summer and
rainy season, while 9 species were common in rainy and winter. Across the different study sites species richness was higher in site-4 (17 species) which was characterized by marshy riverine habitat and dense sal forest. However, during the second year of study, this site was represented by only 13 species of Odonates. Decline of species richness in this site during the second year of the study was possibly due to habitat destruction by various development activities. Site-1 (Jhirna) was represented by 12 and 7 species only during 2013-14 and 2014-15, respectively. Thus lower species richness of Odonates in this site (Jhirna) indicates that Odonates profoundly rely on aquatic habitat for survival. Similarly, across the study sites, maximum values of species diversity was recorded from site-4 (Mohaan) followed by site-3 (Bijrani), site-2 (Garjia) and site-1(Jhirna), respectively (Figure-2). During both the years of study and across the different season, maximum values of species richness, abundance and different diversity indices of Odonates was observed during the rainy season followed by winter and summer, respectively (Table 3).

During the present study, maximum value of species richness and diversity of Odonates were recorded during the rainy season supporting the earlier observation [2]. On the other hand, species diversity declined with increase in dryness of environmental conditions, as in summer season. It is believed that scarcity of water during the summer season creates a challenge to the survival of Odonates because their life cycle mainly depends upon aquatic environment [16]. Thus the present study reveals that the CTR with its adjacent landscape harbours rich diversity of Odonates. However, inside the CTR various anthropogenic activities have been restricted except eco-tourism but destruction of suitable habitats of Odonate fauna around CTR by local villagers is a matter of concern. Therefore, public awareness is necessary to conserve the suitable habitats of these economically important invertebrate organisms.

<table>
<thead>
<tr>
<th>Diversity Indices</th>
<th>2013-14</th>
<th>2014-15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer</td>
<td>Rainy</td>
</tr>
<tr>
<td>Species Richness</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Individuals</td>
<td>36</td>
<td>120</td>
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<tr>
<td>Dominance- D</td>
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<td>0.12</td>
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<tr>
<td>Simpson 1-D</td>
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<td>0.87</td>
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<tr>
<td>Shannon –H</td>
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<td>2.41</td>
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<tr>
<td>Margalef</td>
<td>2.79</td>
<td>3.55</td>
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<tr>
<td>Fisher-alpha</td>
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<td>5.87</td>
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<tr>
<td>Berger-Parker</td>
<td>0.22</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Fig 2: Diversity indices calculated for the Odonates in different study sites in and around CTR during 2013-14 and 2014-15.

Figure 4. Photographs of Odonates (M-R). M. *Orthetrum a. triangulare* N. *Pulicaria s. sexmaculata* O. *Pantala flavescens* P. *Thriamis tillarga* Q. *Prathecus festiva* R. *Prathecus pallidinervis* (Photo by Dayakrishna).
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5. References