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Caption: Malabar Slender Loris *Loris lydekkerianus malabaricus* © Dileep Anthikkad.

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SHORT COMMUNICATION

A preliminary assessment of odonate diversity along the river Tirthan, Great Himalayan National Park Conservation Area, India with reference to the impact of climate change

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Abstract: A total of 19 species of odonates, including eight species of Anisoptera (dragonflies) and 11 species of Zygoptera (damselflies), were recorded along the Tirthan River, Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh. Among these species, 17 were reported from the area for the first time. With the addition of these new records the number of odonates known from the GHNPCA is increased to 23 species representing 18 genera and eight families. *Indothemis carnatica, Agriocnemis femina*, and *Argiocnemis rubescens* are reported for the first time from the western Himalayan region. The study found a significant change in the species composition of odonates over a period of 18 years in the area, which may be due to changes in microhabitat conditions associated with climate change.

Keywords: Dragonfly, damselfly, GHNPCA, Himachal Pradesh, new records, western Himalaya.

Globally, 6,256 species in 686 genera of odonates (order Odonata) are known (Paulson & Schorr 2020) and most of them are restricted to the tropics, especially to forests, where the group has the greatest diversity (Kalkman et al. 2008). The Odonata of India is represented by 488 species and 27 subspecies in 154 genera and 18 families (Kalkman et al. 2020). The suborder Zygoptera (Damselflies) comprise 211 species in 59 genera & nine families; Anisozygoptera one species in one genus & one family; and Anisoptera (Dragonflies) 276 species in 94 genera & eight families (Subramanian & Babu 2017).

The odonates are among the most effective bioindicators of environmental health (Kutcher & Bried 2014; Miguel et al. 2017), and can be used to assess water quality (Kutcher & Bried 2014), changes in the habitat structure (Yang et al. 2017), success of wetland restoration (D'Amico et al. 2004), ecological condition of streams (de Oliveira-Junior et al. 2015), and environmental quality (Júnior et al. 2015). Odonate diversity of Himachal Pradesh has been studied by various authors (Kumar 1982, 2000; Uniyal et al. 2000; Babu & Mehta 2009; Babu & Nandy 2010; Babu & Mitra 2011; Subramanian & Babu 2018). Uniyal et al. (2000) reported six species of dragonflies from the Great Himalayan National Park.

The Great Himalayan National Park Conservation Area (GHNPCA) is a World Heritage site designated by UNESCO, situated in Kullu district of Himachal Pradesh and traversed by three tributaries of river Beas—Tirthan, Parvati, and Sainj. The Park extends from the Himalayan foothills to the alpine zone ranging from 1,300m to 6,000m of altitudinal gradient. The present study was

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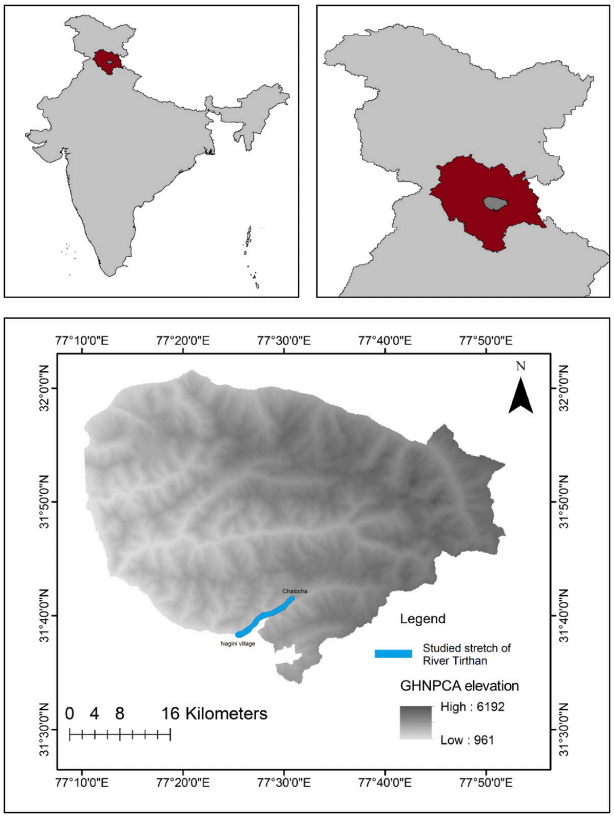

Figure 1. Map represents the studied stretch of Tirthan River, GHNPCA, Himachal Pradesh.

carried out in order to update our understanding of the diversity of odonates in the GHNPCA and to assess the changes of species composition, if any, over the period of 18 years since the previous survey (Uniyal et al. 2000).

Materials and Methods

The work was carried out along a length of about 28km of the river Tirthan (a tributary of Beas River), from Nagini village (31.640 lat. 77.398 long., 1,475m to Chalocha (31.685 lat., 77.513 long., 2,450m) monthly from June to December, 2018. The area lies near the boundary within the GHNPCA (Figure 1) located in the western Himalaya in the state of Himachal Pradesh. It was declared as a national park in 1999 and a world heritage site by UNESCO in 2014. The area comes under the 'Western Himalayan broadleaf forests' ecoregion (UNESCO 2020).

We surveyed odonate diversity following the methods of Giugliano et al. (2012). Adults were surveyed between 0930 h and 0500 h by walking slowly along the edge of the water body three times a month; and with the help of binoculars notes were made of all species observed. Most species were identified without capture. When necessary, a telescopic sweep net was used to catch odonates for identification. Species were identified using published literature (Andrew et al. 2008; Subramaniam 2009; Nair 2011) and web resources (Joshi et al. 2019).

Results and Discussion

A total of 19 species of odonates representing 16 genera were recorded; these comprised eight species of dragonflies (Anisoptera) and 11 species of damselflies (Zygoptera) (Table 1, Image 1–19). Among the dragonflies, the family Libellulidae was represented by six species in four genera, and the families Aeshnidae and Gomphidae by one species each (Figure 2). Among the damselflies, the family Coenagrionidae was represented by five species in four genera, the families Chlorocyphidae and Platycnemididae by two species each, and the families Lestidae and Calopterygidae by only one species each (Figure 2).

Among these odonates, one dragonfly *Indothemis carnatica* Fabricius, 1798 and two damselflies, namely, *Agriocnemis femina* Brauer, 1868 and *Argiocnemis rubescens* Selys, 1877, are reported for the first time from Himachal Pradesh, these being the westernmost records in the Himalaya. Rank abundance tests revealed that Libellulidae was the dominant family in the river followed by Coenagrionidae and Lestidae was the least dominant family (Figure 3).

Uniyal et al. (2000) reported the presence of six species of odonates from the GHNPCA. The present study reports another 17 species from the area which increases the total number of odonate species from the area to 23 species in 18 genera and eight families. The present study failed to register *Anax guttatus*, *Orthetrum japonicum*, *Pantala flavescens*, and *Sympetrum commixtum*, which were recorded from the area by Uniyal et al. (2000). The present work reported *Indothemis carnatica*, *Agriocnemis femina*, and *Argiocnemis rubescens* for the first time from the western Himalayan region, these species having previously been reported from the east within the Himalayan region (Subramanian & Babu 2018), however, *Indothemis carnatica* was previously reported from Andaman & Nicobar Island, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha, West Bengal (Subramanian et al. 2018; Payra et al. 2020) and has been recently recorded from Punjab (Singh et al. 2021).

Compared with Uniyal et al. (2000) that recorded six species, the present study was conducted more systematically along 28 km of the Tirthan River using standardised methods. Grassy, stagnant water, running water, and rocky habitats were preferred by different species (Image 20 and 21). *Orthetrum triangulare* and *Orthetrum taeniolatum* were the most common species found throughout the stretch from 1,475 m elevation

Table 1. List of odonates recorded from Tirthan River, Great Himalayan National Park Conservation Area.

	Family	Scientific name	Elevation range (m)	No. of individuals observed
	Anisoptera			
1	Aeshnidae	*Anax nigrofasciatus* Oguma, 1915	1475–1700	8
2	Gomphidae	*Paragomphus lineatus* (Selys, 1850)	1475–1600	12
3	Libellulidae	*Crocothemis servilia* (Drury, 1773)	1475–1700	18
4		*Indothemis carnatica* (Fabricius, 1798)	1475–2000	26
5		*Orthetrum pruinosum* (Burmeister, 1839)	1475–1700	22
6		*Orthetrum taeniolatum* (Schneider, 1845)	1475–2450	25
7		*Orthetrum triangulare* (Selys, 1878)	1475–2450	38
8		*Palpopleura sexmaculata* (Fabricius, 1787)	1475–1700	4
	Zygoptera			
9	Coenagrionidae	*Agriocnemis femina* (Brauer, 1868)	1475–1600	2
10		*Amphiallagma parvum* (Selys, 1876)	1475–1700	6
11		*Ceriagrion coromandelianum* (Fabricius, 1798)	1475–1700	35
12		*Ischnura forcipata* Morton, 1907	1475–1700	18
13		*Ischnura rubilio* Selys, 1876	1475–1600	2
14	Chlorocyphidae	*Aristocypha quadrimaculata* (Selys, 1853)	1475–2000	2
15		*Libellago lineata* (Burmeister, 1839)	1475–1700	2
16	Calopterygidae	*Neurobasis chinensis* (Linnaeus, 1758)	1475	4
17	Lestidae	*Indolestes cyaneus* (Selys,1862)	1495	1
18	Platycnemididae	*Calicnemia eximia* (Selys, 1863)	1475–1600	32
19		*Copera vittata* (Selys, 1863)	1475–1700	6

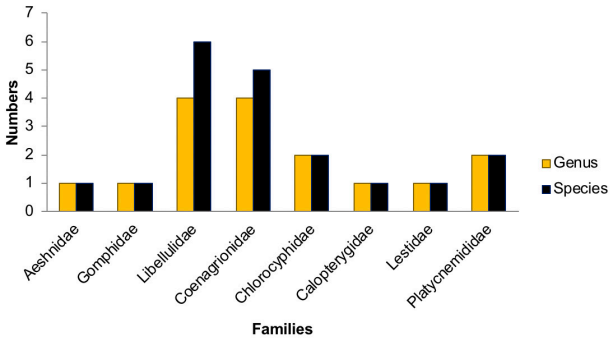

Figure 2. Comparative numbers of genera and species of odonates under eight families recorded from Tirthan River, Great Himalayan National Park Conservation Area.

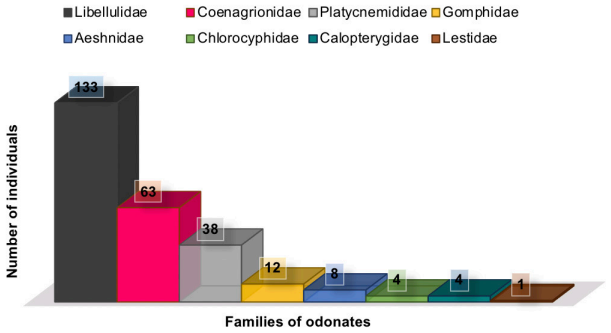

Figure 3. Rank abundance of odonate families along the Tirthan River of Great Himalayan National Park Conservation Area.

up to 2,450 m. There was higher species richness at lower elevations. *Calicnemia eximia, Ischnura rubilio*, and *Agriocnemis femina* preferred grassy habitat near the banks of stagnant ponds at a lower elevation range from 1,475–1,600 m. *Anax nigrofasciatus, Crocothemis servilia, Orthetrum pruinosum*, *Orthetrum triangulae, Amphiallagma parvum, Ceriagrion coromandelianum, Ischnura forcipate, Palpopleura sexmaculata, Libellago lineata*, and *Copera vittata* were found at stagnant or slow running grassy water channels from 1,475–1,700 m. *Indolestes cyaneus* was very rare in the region and was found away from the river under forest canopy cover at an elevation of 1,495 m. *Aristocypha quadrimaculata* and *Indothemis carnatica* preferred rocky water channels from 1,475–2,000 m. However, *Paragomphus lineatus* was found in agricultural areas near the river from 1,475–1,600 m and *Neurobasis chinensis* was collected from fast running water at 1,475 m.

The Himalayan ecosystem is a sensitive and fragile ecosystem with rich biodiversity that provides major ecosystem services (Kumar et al. 2019). As climate change phenomena become a threat to this ecosystem, monitoring climatic indicator species helps us understand the change of ecosystem functions caused by climate change. Odonates have for some time been used successfully as model organisms to study climate change (Hassall & Thompson 2008; Parr 2010; Jaeschke et al. 2013; Bush et al. 2014; Hassall 2015; Termaat et al. 2019). Studies by Flenner & Sahlén (2008) has shown that species composition and abundance may change over as short a time span as 10 years due to environmental changes as dragonflies react rapidly to climate change. The present study found significant changes in the odonate species composition relative to that found by Uniyal et al. (2000), as only two species were re-recorded with the addition of 17 new species to the region. These changes in species

Images 1–19: 1—*Anax nigrofasciatus* | 2—*Paragomphus lineatus* | 3—*Crocothemis servilia* | 4—*Indothemis carnatica* | 5—*Orthetrum pruinosum* | 6—*Orthetrum taeniolatum* | 7—*Orthetrum triangulare* | 8—*Palpopleura sexmaculata* | 9—*Agriocnemis femina* | 10—*Amphiallagma parvum* | 11—*Ceriagrion coromandelianum* | 12—*Ischnura forcipata* | 13—*Ischnura rubilio* | 14—*Aristocypha quadrimaculata* | 15—*Libellago lineata* | 16—*Neurobasis chinensis* | 17—*Indolestes cyaneus* | 18—*Calicnemia eximia* | 19—*Copera vittata.* © Amar Paul Singh

Image 20. *Anax nigrofasciatus* in stagnant and grassy water habitat.

Image 21. Rocky, grassy, and fast running water habitat.

composition may have occurred because of changes in microhabitat factors due to climate changes in the Himalayan region or due to the sampling efforts in the region.

Dragonflies have been shown to be useful for ecosystem monitoring and conservation, and recently an increased effort is being made to make information on dragonflies available to both scientists and policymakers (Kalkman et al. 2008). So, it is indispensable to document the status of diversity and ecology of odonates as well as other entomofauna from the Great Himalayan National Park Conservation Area to understand changing ecological conditions in the context of climate change.

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