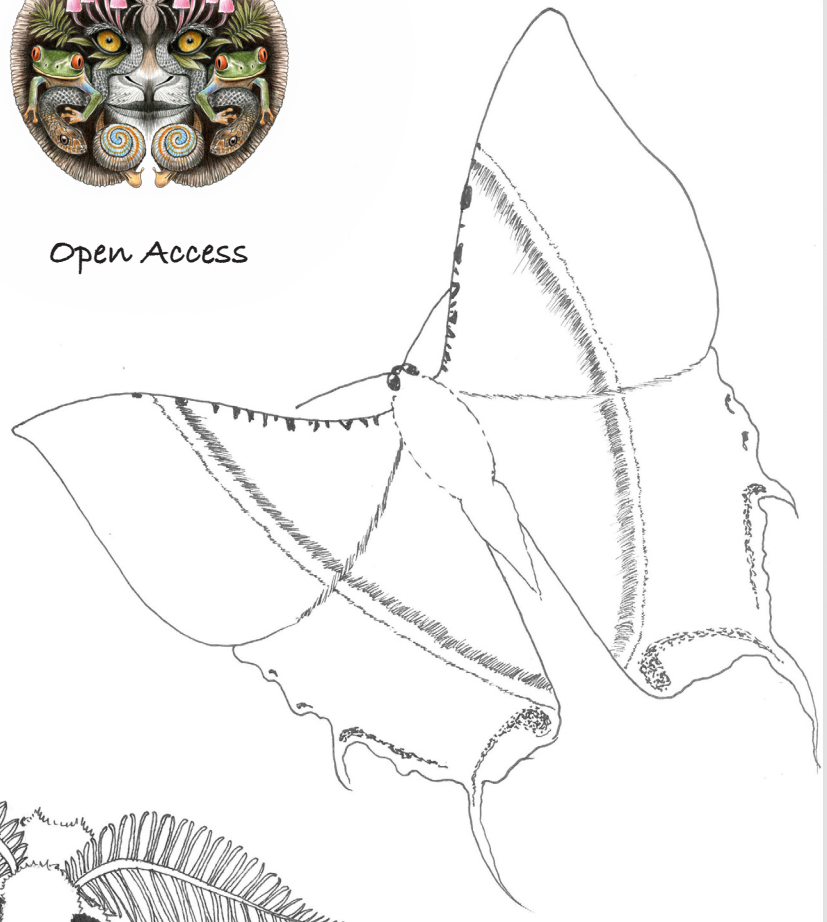
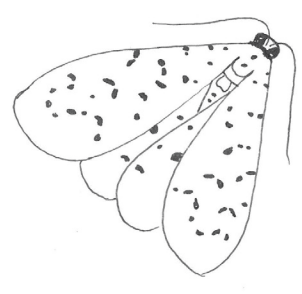


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continued on the back inside cover

Cover: Celebrating the unsung heroes—moths, our nocturnal pollinators. © Priyanka Iyer.



A preliminary assessment of Odonata (dragonflies & damselflies) across an elevation gradient – insights from Shiwaliks to Alpines, northwestern Himalaya, India

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Abstract: Understanding the species distribution and richness along an environmental gradient helps identify hotspots and prioritize conservation efforts at landscape scale. This is more effective for the species that are indicators of environmental change, such as odonates. As the information about the distribution of this group of insects is scarce in Jammu & Kashmir, their documentation assumes a greater significance. Here, we present a checklist of odonate species from 23 sites across diverse landscapes in subtropical, temperate, and alpine ecosystems over an elevational gradient of 3,700 m in Jammu division. We recorded 63 species from 39 genera and 11 families, four Anisoptera and seven Zygoptera. The most represented families were Libellulidae (15 genera & 29 species) and Coenagrionidae (five genera & 10 species). The preliminary surveys resulted in addition of 24 new species to the Odonata fauna of Jammu & Kashmir, including three new to the northwestern Himalaya. The study underlines that even opportunistic records are useful in understanding the distribution range and delineating the potential habitats of odonates. The study calls for intensive odonate surveys to better understand their distribution and ecology in hitherto less explored region in the northwestern Himalaya.

Keywords: Amphibiotic insects, Anisoptera, Greater Himalaya, mountains, Pir-Panjal, puddles, stream off shoots, summer ditches, Zygoptera

अमूर्त: पर्यावरण ढाल दे कन्ने-कन्ने प्रजातिये दे बंड ते समृद्धि गी समझने कन्ने हॉटस्पॉट दी पन्छान ते लैंडस्केप पैमाने पर संरक्षण दे प्रयासें गी प्राथमिकता देने च मदद मिलदी ऐ। एह उने प्रजातिये आसते मता असरदार ऐ जेह डियां पर्यावरण च बदलाव दे संकेतक न, जियां ओडोनेट। चूकि जम्मू-कश्मीर च कीड़े-मकोड़े दे इस समूह दे बंड बारे जानकारी घट्ट ऐ, इस करी उंदे दस्तावेजे दा मता महत्व ऐ। इत्ये, अस उप-उष्णकटिबंधीय, समशीतोष्ण ते अल्पाइन पारिस्थितिकी प्रणाली च बक्ख-बक्ख परिदृश्ये च 23 थाहें थमां ओडोनाटा प्रजातिये दी जांच सूची पेश करदे आं। असें 39 जीनस ते 11 परिवारे थमां 63 प्रजातियां, चार एनिसेप्टेन ते 7 ज़ाइगोप्टेन दर्ज कीतियां। सारे शा मते प्रतिनिधित्व आहले परिवार लिबेलुलिडी हे जिदे च 15 जीनस ते 29 प्रजातियां ते कोएनग्रियोनिडी (5 जीनस ते 10 प्रजातियां) शामिल हे। सर्वेक्षण दे नतीजे च जम्मू-कश्मीर दे ओडोनाटा जीव-जंतुएं च 24 नमी प्रजातियां बी शामिल कीतियां गेड्यां जिदे च उत्तर-पश्चिमी हिमालय च नै नमी प्रजातियां बी शामिल न। अध्ययन इस गल्ले गी रेखांकित करदा ऐ जे अवसरवादी रिकार्ड बी वितरण सीमा गी समझने ते ओडोनेट दे संभावित आवास गी रेखांकित करने च उपयोगी न। इस अध्ययन च उत्तर-पश्चिमी हिमालय च अजे तगर कम खोजे गेदे इलाके च उंदे बंड ते पारिस्थितिकी गी बेहतर तरीके कन्ने समझने लेई गहन ओडोनेट सर्वेक्षण दा आह्वान कीता गेआ ऐ।

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Author contributions: NS, SS and DS conducted the field surveys and drafted the manuscript; NS and SS conceptualized, designed, and executed the surveys and wrote the manuscript; AA analysed the data, while SS communicated with the journal.

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INTRODUCTION

The Himalayan Odonata fauna comprises of 257 species in 112 genera and 18 families with 34 species endemic to the Himalayas (Subramaniam & Babu 2018). Though well-documented in the neighbouring states of Himachal Pradesh and Uttarakhand, the information on the distribution of Odonata in Jammu & Kashmir is scanty. The earlier accounts of Odonata from Jammu & Kashmir dates back to the records of Abott (Calvert 1899), Fraser (1933, 1934, 1936) followed by a few checklists (Singh & Baijal 1954; Asahina 1978; Kumar & Prasad 1981; Carfi et al. 1983; Kumar 1983; Lahiri & Das 1991; Dar et al. 2002; Mitra 2003). Recently, a few surveys have been conducted to describe the diversity and distribution of odonates of Jammu & Kashmir (Subramaniam & Babu 2018; Sheikh et al. 2020; Riyaz & Sivasankaran 2021; Quereshi et al. 2022; Kumar et al. 2022). Singh (2022) described 65 species from Jammu & Kashmir based on available literature and the online curated website Odonata of India (<https://www.indianodonata.org/>) published until 2022.

Geographically, the union territory of Jammu & Kashmir comprises two regions, Jammu & Kashmir characterized by five distinct physiographic units.

The Jammu region of Jammu & Kashmir offers a wide range of habitats from the alluvial plains of the Ravi and Chenab rivers in the south to the moderately elevated Shiwaliks, Pir-Panjal, and Greater Himalaya northwards, bordering Kashmir in the north and Ladakh in the north-east. Documenting odonate fauna from such regions becomes important as it helps fill the knowledge gap about distribution of species, which may have conservation implications. To gain a better understanding of the spatial distribution of odonates in the region, we conducted preliminary surveys in seasonal and perennial water bodies in parts of alluvial plains, sub-tropics, lesser, and the Greater Himalaya spanning a vast elevational gradient ranging from 260–3,960 m. The baseline information obtained on the abundance and distribution of 63 species of odonates for the region will be useful for monitoring the health of aquatic ecosystems on spatial and temporal scales.

METHODS

We sampled the adult dragonflies in 23 stations: eleven in the subtropics, nine in temperate, and three in alpine habitats in Rajouri, Jammu, Udhampur, Kathua,

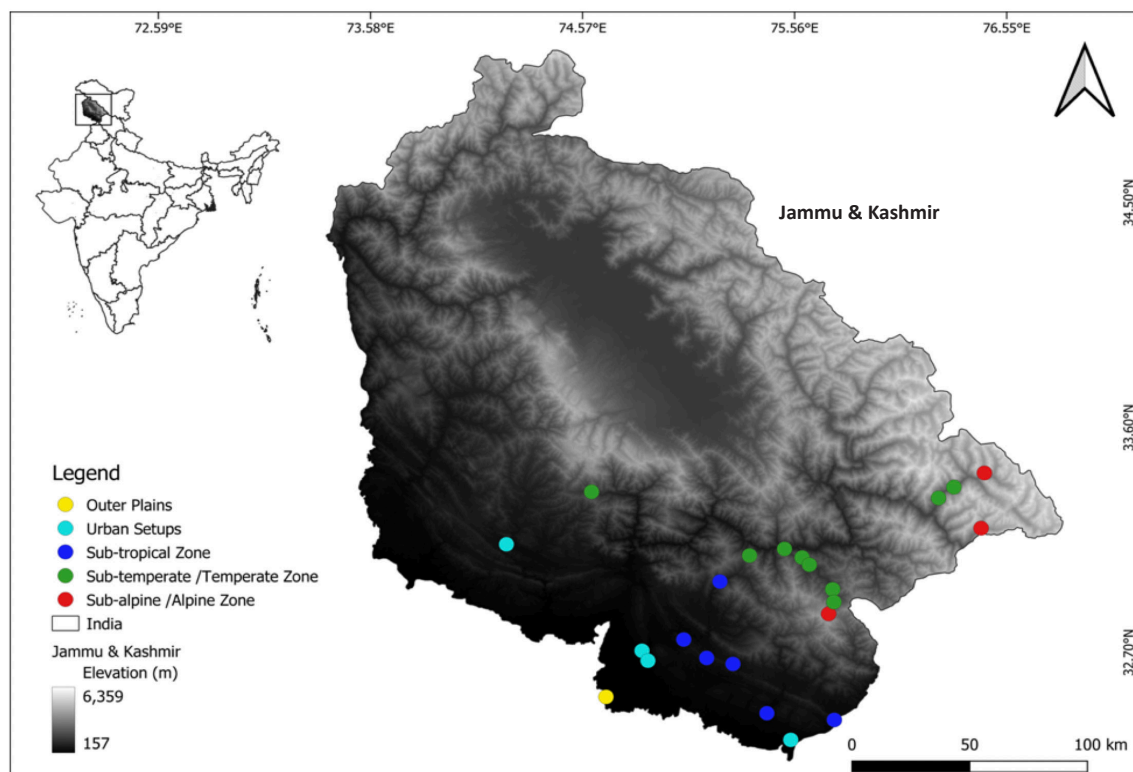


Figure 1. The sampling sites in three climatic zones (subtropical, subtemperate / temperate and alpine) in the study area. The outer plains and urban setups lie in the subtropical zone, a part of Jammu Shiwaliks.

Doda, and Kishtwar districts of Jammu division in the union territory of Jammu & Kashmir. The subtropical habitats included the alluvial plains and hills and ridges of Jammu Shiwaliks (250–1,150 m). Characterized by dry climate and soils with low water retention capacity, most of the sampled habitats included seasonal ponds, roadside ditches, and streams. The subtemperate and temperate ecosystems in the lesser Himalayas were scanned for forested perennial channels, rivulets, and

streams in an elevation range of 1,150 to 3,000 m, while sub alpinos and alpinos included springs, minor streams, summer ditches, and swamps (3,200–4,200 m) in parts of the Greater Himalaya bordering the Zaskar region of Ladakh (Table 1, Image 1). During a two-year sampling period, we followed an opportunistic sampling strategy and visited all stations twice during summer to monsoon (end of May to mid-September) except for the alpinos which were too far apart. The individuals were not

Table 1. Spatial attributes of sampling locations, including geomorphological features and the degree of disturbance.

Climate zones	Sampling sites / District	Geo co-ordinates *	Elevation (in m) *	Habitat description	Disturbance
Subtropical zone	1.Gharana and associated wetlands in agricultural landscape, Jammu	32.540°N, 74.690° E	260	A vast agriculture landscape comprised of a protected wetland, marshlands, ditches, channels, and paddy fields	High
	2.GGM Science College, Jammu	32.724° N, 74.851° E	302	Botanical Garden and college lawns	Moderate
	3. Kathua town, Kathua	32.367° N, 75.525° E	318	Urban drain dissecting the town	High
	4.Trikutanagar, Jammu	32.685° N, 74.879° E	320	Urban storm water drain	High
	5. Nowshera, Rajouri	33.149° N, 74.234° E	543	Urban drain at the confluence with a perennial stream	High
	6. Jasrota WLS / Ujh Barrage, Kathua	32.474° N, 75.417° E	382	A lacustrine ecosystem surrounded with plantations, farmlands and habitations.	Low
	7. Thein Conservation Reserve, Kathua	32.446° N, 75.721° E	518	A terrestrial protected area bounded by a reservoir eastward.	Low
	8. Surinsar, Jammu	32.770° N, 75.041° E	605	Medium sized lake, seasonal ponds and channels	Moderate
	9. Battal, Udhampur	32.672° N, 75.264° E	630	Streams, roadside water channels and ditches	Low
	10. Mansar, Udhampur	32.696° N, 75.145° E	662	Large water body, ponds, and ditches	Moderate
	11. Samroli, Udhampur	33.002° N, 75.206° E	845	Seasonal and perennial streams, ditches, and roadside drains	Moderate
Subtemperate / Temperate zone	12. Pranoo, Doda	33.097° N, 75.580° E	1210	Neeru stream, main channel	Low
	13. Bhalla, Doda	33.068° N, 75.613° E	1270	Neeru stream and tributaries	Low
	14. Khellani, Doda	33.132° N, 75.500° E	1350	Streams, roadside water channels, and springs	Low
	15. Batote, Doda	33.106° N, 75.341° E	1430	Roadside springs, water channels and rivulets	Moderate
	16. Phalni, Rajouri	33.361°N, 74.621° E	1440	A fish farm housing Indian Major Carps adjacent to trout raceways of state fisheries department.	Low
	17. Bhaderwah, Doda	32.969° N, 75.718° E	1714	Springs, water channels and ditches in Bhaderwah Campus, seasonal channels	Low
	18. Kundail, Kishtwar	33.331° N, 76.204° E	2075	Bhot stream and springs	Low
	19. Thanthera, Doda	32.918° N, 75.723° E	2155	Basti stream and roadside springs	Low
	20. Chasoti, Kishtwar	33.374° N, 76.275° E	2356	A typical mountain village with terrace farmlands	Low
Subalpine / Alpine zone	21. Suncham, Kishtwar	32.429° N, 76.410° E	3260	Bhot stream, its tributary Hagshu, springs and channels.	Low
	22. Tun, Kishtwar	33.208° N, 76.396° E	3345	Sansari stream, seasonal ditches, and springs	Low
	23. Kailash Lake, Doda	32.871° N, 75.699° E	3960	Natural springs and rivulets	Low

* Geo co-ordinates and elevation taken as the centre point of each 1.5–2 km² grids sampled.

counted for abundance and density estimates, however, the frequency of sightings was taken into account for computing the relative frequency. The odonates were categorized as very common (sighted during 75–100 % of the sampling), common (sighted between 50–75 % times), occasional (observed between 25–50 %), and rare (sighted below 25% times) following Adarsh et al. (2014). All the field visits were conducted between 1000 h to 1200 h, when the adult odonates are most active. The individual odonates were photographed and identified to the species level referring to the field guides (Subramanian 2005, 2009; Kiran & Raju 2013; Singh 2022) and curated online platforms like Odonata of India website (<https://www.indianodonata.org/>). No specimens were, however, collected during the surveys. The species have been enlisted following the systematic arrangement and taxonomy of Subramanian et al. (2018) and Kalkman et al (2020).

RESULTS

A total of 63 odonates (40 dragonflies and 23 damselflies) were recorded from the study area. These belonged to 39 genera and 11 families, four anisopterans and seven zygopterans (Table 2, Figure 2, Images 1–63). In terms of habitat sharing, 50 species were exclusively found to be associated with one of the three ecosystems studied, indicating their limited geographical distribution. The sub-tropical ecosystems

harboured high richness (SR = 46) accounting for 73% of the total, followed by temperate (SR = 28, 43%) and alpine (SR = 5, 8%). Fourteen species were found to be common across subtropical and temperate ecosystems, whereas temperate and alpine shared only two species, *Cordulegaster brevistigma* and *Orthetrum internum*. Families Calopterygidae, Chlorocyphidae, Chlorocyphidae, and Platycnemididae were confined to subtropical habitats, while Gomphidae, Libellulidae, Coenagrionidae, Euphaeidae, Lestidae, and Synlestidae exhibited affinities for both sub-tropical and temperate climate (Figure 3).

The occurrence data (relative frequency) during the study period shows that 48 species (76%) belonged to occasional and rare (n = 24, each) category. Eleven species were found common and four very common. *Orthetrum pruinosum*, *O. triangulare*, and *Sympetrum commixtum* among the Anisoptera and *Amphiallagma parvum* among the Zygoptera were the most commonly encountered species during the current sampling. In all, 60 species are classified as ‘Least Concern’ by the IUCN, while three species have not yet been evaluated for their threat status (Table 2). Families Aeshnidae and Libellulidae are found in all three climatic zones, occupying a greater elevational range than other Anisoptera families (Figure 3). Family Cordulegastridae comprising a solitary taxon *Cordulegaster brevistigma* was restricted to temperate and alpine zones, whilst members of the family Gomphidae were restricted to subtropical and temperate regions. Most of

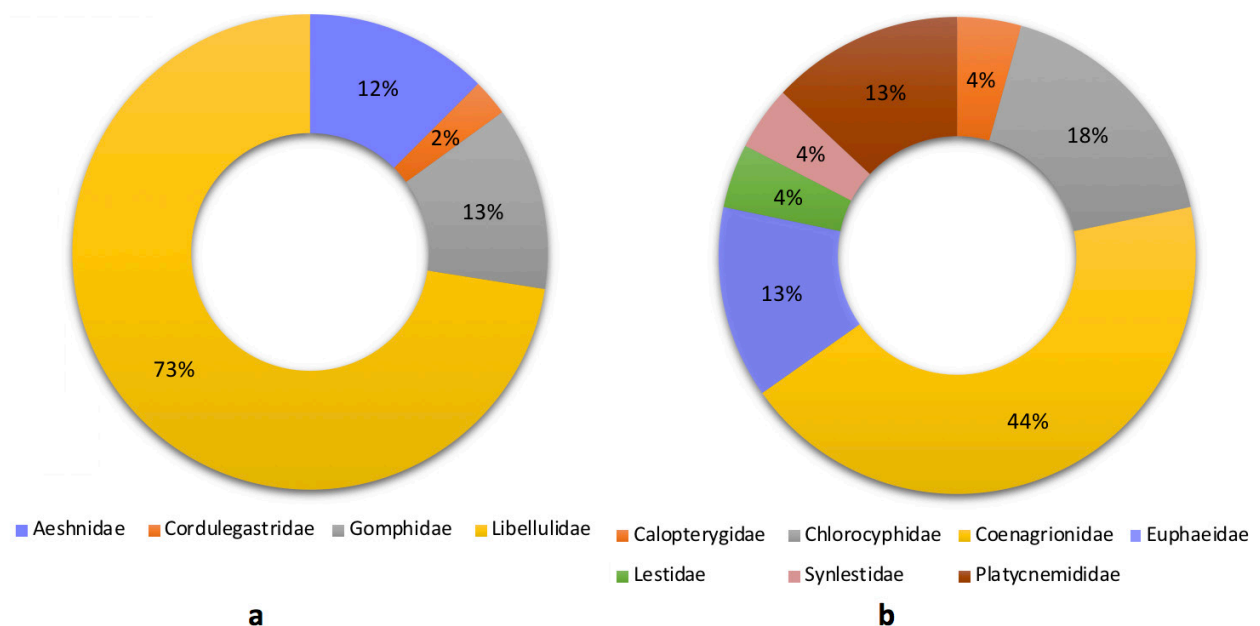


Figure 2. The species observed in different families: a—Anisoptera | b—Zygoptera.

Table 2. Checklist of odonates in the three distinct ecosystems in Jammu division of Jammu & Kashmir depicting distribution, relative frequency and threat status.

	Suborder / Family / Species	Distribution			Relative frequency	IUCN Red List status	Image number
		ST	TM	AL			
Suborder : Anisoptera (Dragonflies)							
Family : Aeshnidae							
1.	<i>Aeshna juncea</i> (Bartenev, 1929)	-	-	+	RA	LC	1
2.	<i>Anax immaculifrons</i> (Rambur, 1842)	+	-	-	OC	LC	2
3.	<i>Anax indicus</i> (Lieftinck, 1942)*	+	-	-	RA	LC	3
4.	<i>Anax nigrolineatus</i> (Fraser, 1935)*	-	+	-	OC	LC	4
5.	<i>Anax parthenope</i> (Selys, 1839)	-	+	-	RA	LC	5
Family : Cordulegastridae							
6.	<i>Cordulegaster brevistigma</i> (Selys, 1854)	-	+	+	OC	LC	6
Family : Gomphidae							
7.	<i>Anisogomphus bivittatus</i> (Selys, 1854)*	-	+	-	OC	LC	7
8.	<i>Davidius davidii</i> (Selys, 1878)**	-	+	-	RA	LC	8
9.	<i>Ictinogomphus rapax</i> (Rambur, 1842)*	+	-	-	OC	LC	9
10.	<i>Ophiogomphus reductus</i> (Calvert, 1898)	-	+	-	OC	LC	10
11.	<i>Paragomphus lineatus</i> (Selys, 1850)	+	+	-	OC	LC	11
Family : Libellulidae							
12.	<i>Acisoma panorpoides</i> (Rambur, 1842)	+	-	-	RA	LC	12
13.	<i>Brachythemis contaminata</i> (Fabricius, 1793)	+	-	-	OC	LC	13
14.	<i>Brachydiplax sobrina</i> (Rambur, 1842)*	+	-	-	RA	LC	14
15.	<i>Bradynopyga geminata</i> (Rambur, 1842)	+	-	-	OC	LC	15
16.	<i>Crocothemis erythraea</i> (Brullé, 1832)	+	-	-	OC	LC	16
17.	<i>Crocothemis servilia</i> (Drury, 1770)	+	+	-	CO	LC	17
18.	<i>Diplacodes lefebvrei</i> (Rambur, 1842)	+	-	-	OC	LC	18
19.	<i>Diplacodes nebulosa</i> (Fabricius, 1793)*	+	-	-	RA	LC	19
20.	<i>Libellula quadrimaculata</i> (Linnaeus, 1758)	-	+	-	RA	LC	20
21.	<i>Neurothemis tullia</i> (Drury, 1773)	+	-	-	RA	LC	21
22.	<i>Orthetrum cancellatum</i> (Linnaeus, 1758)	-	+	-	RA	LC	22
23.	<i>Orthetrum glaucum</i> (Brauer, 1865)	-	+	-	OC	LC	23
24.	<i>Orthetrum internum</i> (McLachlan, 1894)	-	+	+	CO	NE	24
25.	<i>Orthetrum luzonicum</i> (Brauer, 1868)	-	+	-	CO	LC	25
26.	<i>Orthetrum pruinosum</i> (Burmeister, 1839)	+	+	-	VC	LC	26
27.	<i>Orthetrum sabina</i> (Drury, 1770)	+	-	-	CO	LC	27
28.	<i>Orthetrum taeniolatum</i> (Schneider, 1845)*	+	-	-	RA	LC	28
29.	<i>Orthetrum triangulare</i> (Selys, 1878)	+	+	-	VC	LC	29
30.	<i>Palpopleura sexmaculata</i> (Fabricius, 1787)	+	+	-	CO	LC	30
31.	<i>Pantala flavescens</i> (Fabricius, 1798)	+	-	-	OC	LC	31
32.	<i>Rhyothemis triangularis</i> (Kirby, 1889)	+	-	-	RA	LC	32
33.	<i>Rhyothemis variegata</i> (Linnaeus, 1763)	+	-	-	OC	LC	33
34.	<i>Sympetrum commixtum</i> (Selys, 1884)	-	-	+	VC	LC	34
35.	<i>Sympetrum fonscolombii</i> (Selys, 1840)	-	+	-	RA	LC	35
36.	<i>Sympetrum speciosum</i> (Oguma, 1915)*	-	-	+	CO	NE	36
37.	<i>Tramea transmarina</i> (Selys, 1878)**	-	+	-	OC	LC	37

	Suborder / Family / Species	Distribution			Relative frequency	IUCN Red List status	Image number
		ST	TM	AL			
38	<i>Tramea virginia</i> (Rambur, 1842)	+	+	-	OC	LC	38
39	<i>Trithemis aurora</i> (Burmeister, 1839)	+	-	-	OC	LC	39
40	<i>Trithemis festiva</i> (Rambur, 1842)	+	+	-	CO	LC	40
Suborder : Zygoptera (Damselflies)							
Family : Calopterygidae							
41	<i>Neurobasis chinensis</i> (Linnaeus, 1758)	+	-	-	RA	LC	41
Family : Chlorocyphidae							
42	<i>Aristocypha trifasciata</i> (Selys, 1853)*	+	-	-	OC	LC	42
43	<i>Aristocypha quadrimaculata</i> (Selys, 1853)	+	-	-	CO	LC	43
44	<i>Paracypha unimaculata</i> (Selys, 1853)	+	-	-	RA	LC	44
45	<i>Libellago lineata</i> (Burmeister, 1839)	+	-	-	OC	LC	45
Family : Coenagrionidae							
46	<i>Amphiallagma parvum</i> (Selys, 1876)*	+	+	-	VC	LC	46
47	<i>Agriocnemis pygmaea</i> (Rambur, 1842)*	+	-	-	RA	LC	47
48	<i>Ceragrion coromandelianum</i> (Fabricius, 1798)	+	-	-	CO	LC	48
49	<i>Ischnura forcipata</i> (Morton, 1907)	+	+	-	CO	LC	49
50	<i>Ischnura rubilio</i> (Selys, 1876)	+	+	-	OC	NE	50
51	<i>Pseudagrion decorum</i> (Rambur, 1842)*	+	-	-	RA	LC	51
52	<i>Pseudagrion hypermelas</i> (Selys, 1876)*	+	-	-	RA	LC	52
53	<i>Pseudagrion microcephalum</i> (Rambur, 1842)*	+	-	-	RA	LC	53
54	<i>Pseudagrion rubriceps</i> (Selys, 1876)	+	+	-	OC	LC	54
55	<i>Pseudagrion spencei</i> (Fraser, 1922)*	+	-	-	OC	LC	55
Family : Euphaeidae							
56	<i>Anisopleura comes</i> (Hagen, 1880)*	+	+	-	RA	LC	56
57	<i>Anisopleura lestoides</i> (Selys, 1853)*	-	+	-	OC	LC	57
58	<i>Bayadera indica</i> (Selys, 1853)*	+	-	-	RA	LC	58
Family : Lestidae							
59	<i>Lestes dorothea</i> (Fraser, 1924)*	+	+	-	OC	LC	59
Family : Synlestidae							
60	<i>Megalestes major</i> (Selys, 1862)*	+	+	-	CO	LC	60
Family : Platycnemididae							
61	<i>Calicnemia imitans</i> (Lieftinck, 1948)**	+	-	-	RA	LC	61
62	<i>Copera marginipes</i> (Rambur, 1842)	+	-	-	RA	LC	62
63	<i>Drepanosticta carmichaeli</i> (Laidlaw, 1915)*	+	-	-	RA	LC	63

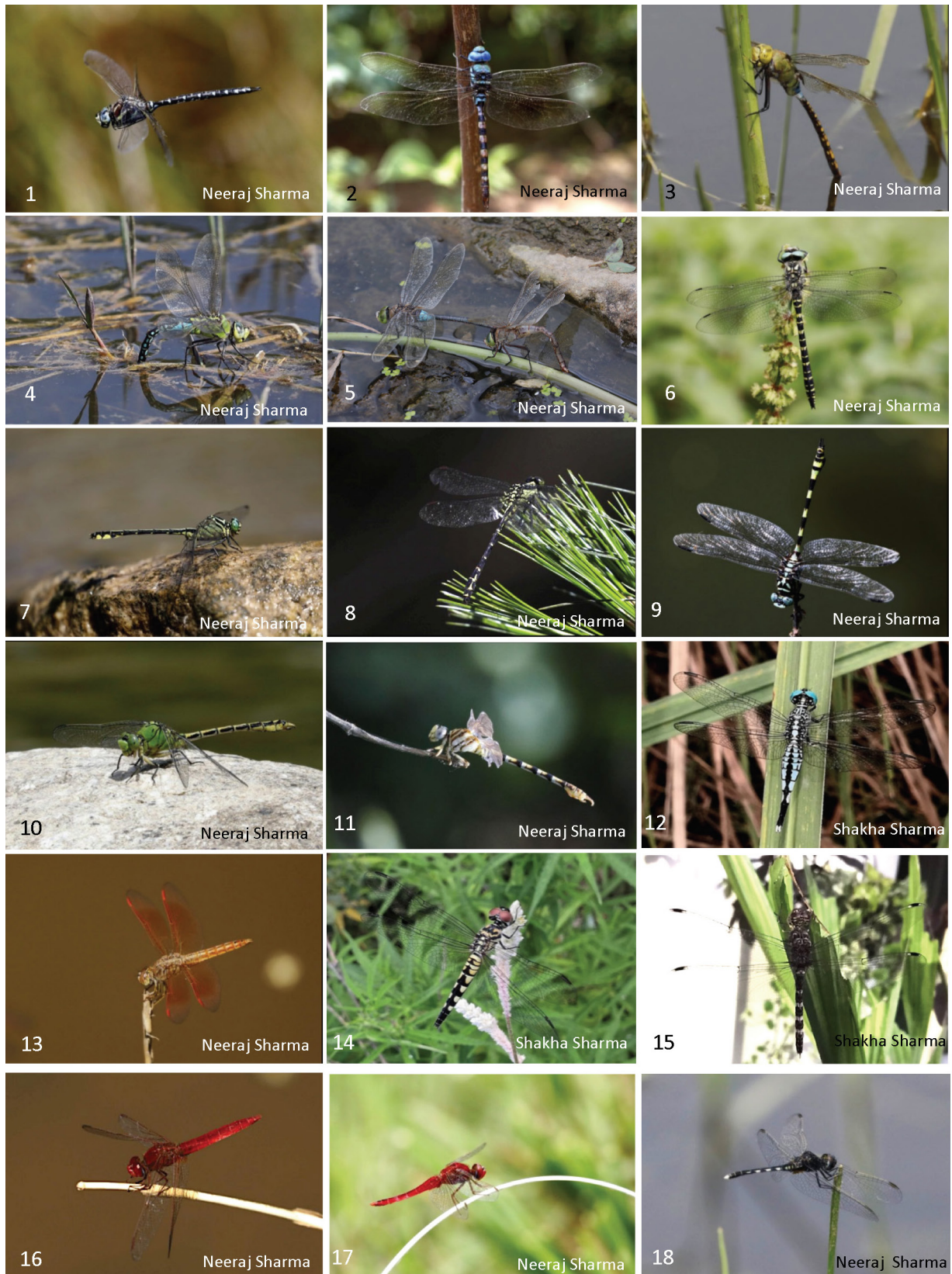
+—presence | —absence | ST—Sub-tropical | TM—Subtemperate / Temperate zone | AL—Alpine zone |

OC—Occasional | CO—Common | VC—Very Common | RA—Rare | LC—Least Concern | NE—Not Evaluated | *—Addition to the Odonata fauna of Jammu & Kashmir | **—Addition to the Odonata fauna of northwestern Himalaya, India.

the Zygoptera families occupied subtropical regions, although a few extended their range into sub-temperate and temperate zones (Figure 3).

Twenty-four (10 Anisoptera and 14 Zygoptera) among the 63 species encountered during the surveys are reported for the first time in Jammu & Kashmir, including three new to the northwestern Himalaya. These include

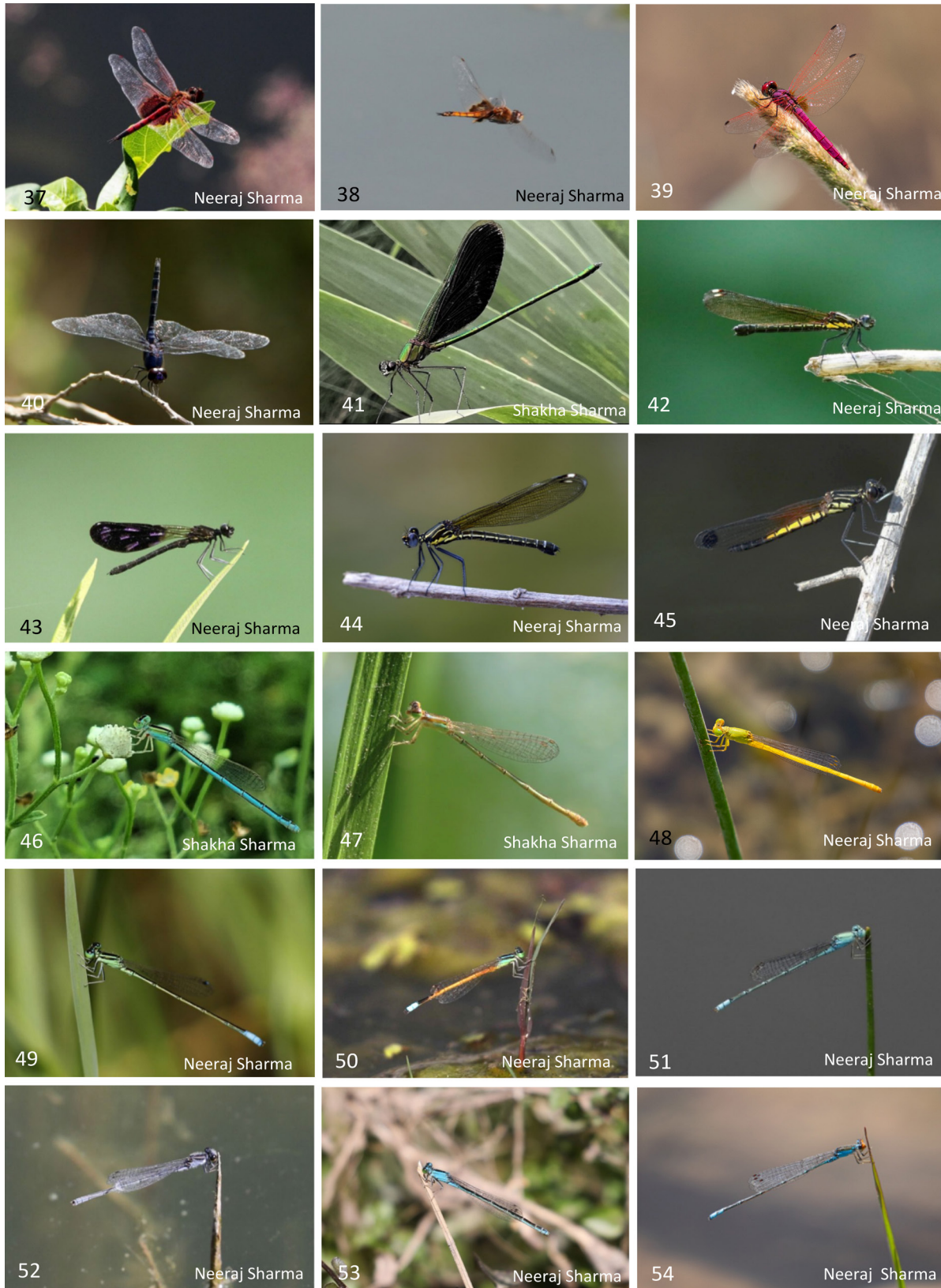
Anax indicus, *A. nigrolineatus*, *Anisogomphus bivittatus*, *Ictinogomphus rapax*, *Brachydiplax sobrina*, *Diplacodes nebulosa*, *Orthetrum taeniolum*, *Sympetrum speciosum*, *Aristocypha trifasciata*, *Amphiallagma parvum*, *Agriocnemis pygmaea*, *Pseudagrion decorum*, *P. hypermelas*, *P. microcephalum*, *P. spencei*, *Anisopleura comes*, *A. lestoides*, *Bayadera indica*,



Images 1–18. 1—*Aeshna juncea* | 2—*Anax immaculifrons* | 3—*Anax indicus* | 4—*Anax nigrolineatus* | 5—*Anax parthenope* | 6—*Cordulegaster brevistigma* | 7—*Anisogomphus bivittatus* | 8—*Davidius davidii* | 9—*Ictinogomphus rapax* | 10—*Ophiogomphus reductus* | 11—*Paragomphus lineatus* | 12—*Acisoma panorpoides* | 13—*Brachythemis contaminata* | 14—*Brachydiplax sobrina* | 15—*Bradinyopyga geminata* | 16—*Crocothemis erythraea* | 17—*Crocothemis servilia* | 18—*Diplacodes lefebvrei*.



Images 19–36. 19—*Diplacodes nebulosa* | 20—*Libellula quadrimaculata* | 21—*Neurothemis tullia* | 22—*Orthetrum cancellatum* | 23—*Orthetrum glaucum* | 24—*Orthetrum internum* | 25—*Orthetrum luzonicum* | 26—*Orthetrum pruinosum* | 27—*Orthetrum sabina* | 28—*Orthetrum taeniolatum* | 29—*Orthetrum triangulare* | 30—*Palpopleura sexmaculata* | 31—*Pantala flavescens* | 32—*Rhyothemis triangularis* | 33—*Rhyothemis variegata* | 34—*Sympetrum commixtum* | 35—*Sympetrum foncolombii* | 36—*Sympetrum speciosum*.



Images 37–54. 37—*Tamea transmarina* | 38—*Tamea virginia* | 39—*Trithemis aurora* | 40—*Trithemis festiva* | 41—*Neurobasis chinensis* | 42—*Aristocypha trifasciata* | 43—*Aristocypha quadrimaculata* | 44—*Paracypha unimaculata* | 45—*Libellago lineata* | 46—*Amphialagma parvum* | 47—*Agriocnemis pygmaea* | 48—*Ceriagrion coromandelianum* | 49—*Ischnura rubilio* | 50—*Pseudagrion decorum* | 52—*Pseudagrion hypermelas* | 53—*Pseudagrion microcephalum* | 54—*Pseudagrion rubriceps*.



Images 55–63. 55—*Pseudagrion spencei* | 56—*Anisopleura comes* | 57—*Anisopleura lestoides* | 58—*Bayadera indica* | 59—*Lestes dorothea* | 60—*Megalestes major* | 61—*Calicnemia imitans* | 62—*Copera marginipes* | 63—*Drepanosticta carmichaeli*.

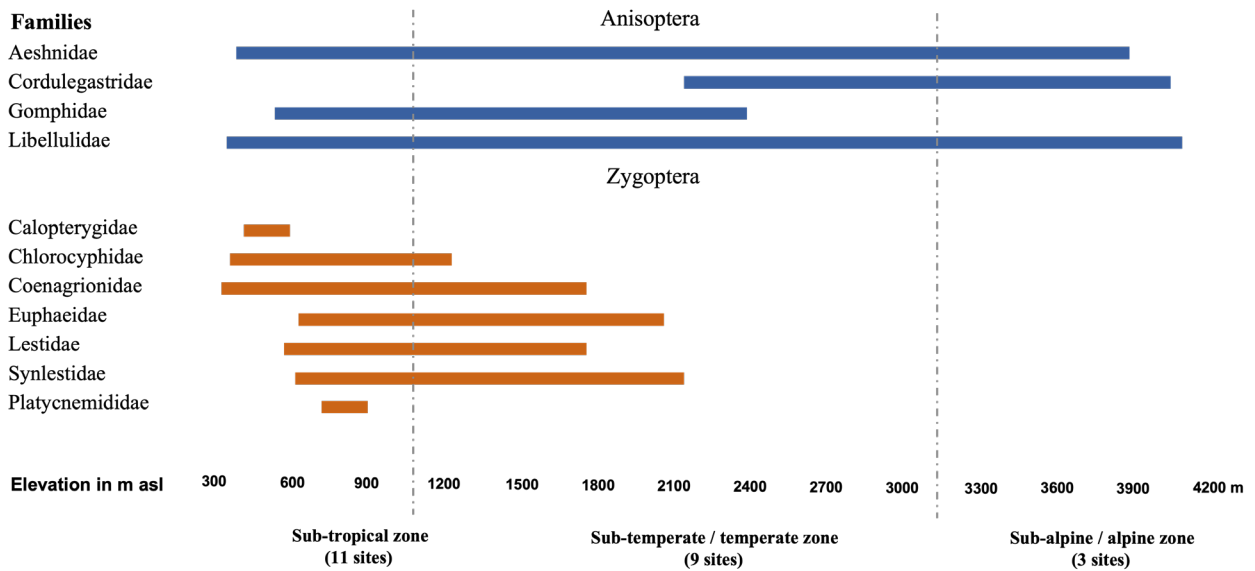


Figure 3. The elevational distribution of odonatan families in the study area. The blue bars represent Anisoptera, while the red bars represent Zygoptera. The dashed lines separate the three climatic zones, the subtropical (11 sites), subtemperate / temperate (9 sites) and alpine (3 sites).

Lestes dorothea, *Megalestes major*, and *Drepanosticta carmichaeli*. Among these *Sympetrum speciosum* and *Aristocypha trifasciata* reported by Singh (2022) are based on the media records of the first author already published in Odonata of India website (<https://www.indianodonata.org/>). The newly added Odonata fauna to the northwestern Himalaya include *Davidius davidii*, *Tramea transmarina*, and *Calicnemia imitans* (Table 2).

DISCUSSION

The Anisoptera families Libellulidae (29 species) and Aeshnidae & Gomphidae (5 species, each) accounted for nearly 62% of all species observed during the current sampling. Four families (Cordulegastridae, Calopterygidae, Lestidae, and Synlestidae) and 24 genera were monotypic indicating their restricted distribution in the region. Libellulidae and Gomphidae are well-distributed (Subramanian 2005) Anisoptera across the Indian subcontinent. The widespread dispersal and distribution may be attributed to the larger body size of species in these families (Dalzochio et al. 2011). The habitat heterogeneity and varying microclimatic regime sustain a high species richness and diversity (Cramer & Willig 2005; Storch et al. 2023) among different groups of animals. High species richness has been recorded from the small water bodies like rivulets, and streams as they create conducive microhabitats suitable for their survival as observed by Arunima & Nameer (2021), Chandran & Chandran (2021) Chandran et al. (2021), and Thakuria & Kalita (2021) as well. Key conditions for many species include shading around water bodies, specific vegetation structure for breeding and oviposition or nymphal microhabitat availability (Rantala et al. 2004; Cheri & Finn 2023). Subtropical ecosystems supported more odonates than temperate and alpine habitats, indicating a declining trend in species richness with increasing elevation as reported in other insect groups (Vetaas et al. 2019, Fontana et al. 2020; Dewan et al. 2022). No damselfly was found above 2,200 m in the current sampling effort (Figure 3). This does not, however, elude their presence in sub-alpine and alpine climate zones, as these landscapes were not visited as frequently as subtropical and temperate ones were.

Singh (2022) described 184 odonate species from north-western region of India, including 65 from the Union Territory of Jammu & Kashmir. During their explorations in selected localities of the Jammu division, Kumar et al. (2022) observed 32 odonate species, 25 of which are new to Jammu & Kashmir. This communication adds 24 more species to odonate

fauna of Jammu & Kashmir, including three new to the northwestern Himalaya. This trend may be explained by the fact that the area has been less explored for Odonata. Recent studies conducted in the Himalaya reveals that Odonata fauna of the region is threatened due to habitat destruction, agricultural expansion, pesticides, tourism, urban and industrial pollution (Subramanian & Babu 2018; De et al. 2021) and this holds true for the study area. Aquatic ecosystems are spatially and temporally constrained (De et al. 2021), and the sites of current explorations are found in close proximity to human settlements, roads and highways making them vulnerable to management activities that threaten the existence of aquatic biodiversity including odonates. Most roadside ditches are being destroyed by road expansions, ponds are being encroached upon for land reclamation, and rivers and streams are being exposed to sand extraction and increased pollutant loads.

In terms of the occurrence data, 48 species belonged to occasional and rare categories. Arunima & Nameer (2021) in their observations recorded a moderately high number of occasional and rare species. Interestingly, all taxa found during the sampling figure in the least concern category of conservation (IUCN 2023) indicating a stable worldwide population. The study though preliminary with limited area coverage and ecological scope has unveiled vital information regarding the distribution of the observed odonate species in the heterogenous landscapes of northwestern Himalaya. Though the current observations on the Odonata do not necessarily provide a complete checklist for the region, they do add to the knowledge of the insect fauna of the Union Territory of Jammu & Kashmir. More systematic research on odonate assemblages and seasonality is needed to describe the ecology and biomonitoring of their habitats in the region as macroinvertebrates are standard bioindicators of freshwater ecosystems (Barbour et al. 1999).

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