



# Diversity of the Anisoptera and Zygoptera (Odonata: Insecta) of State Biosphere Reserve Neelum of Azad Jammu and Kashmir, Pakistan

Shahida Rashied<sup>1\*</sup>, Ahmed Zia<sup>2</sup>, Riaz Aziz Minhas<sup>1</sup>, Sumera Aslam<sup>3</sup>, Abdul Rauf Bhatti<sup>4</sup> and Ghulam Ali<sup>1</sup>

<sup>1</sup>Department of Zoology, University of Azad Jammu and Kashmir, Muzaffarabad, Azad Jammu and Kashmir, Pakistan

<sup>2</sup>National Insect Museum, National Agriculture Research Centre, Islamabad

<sup>3</sup>Honey Bee Research Institute, National Agriculture Research Centre, Islamabad

<sup>5</sup>Institute of Plants and Environmental Protection, National Agriculture Research Centre Islamabad

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## Authors' Contribution

SR designed the study, collected the specimens and wrote the article in consultation with AZ and RAM. AZ identified the specimens of Odonata. RAM and GA supervised the findings of this work and SA provided the funds to conduct this research. ARB helped in preservation of specimens. All authors discussed the results and contributed to the final manuscript.

## Key words

Biodiversity, Biosphere, Topography, Ecology, Zygoptera and Odonata

## ABSTRACT

State Biosphere Reserve Neelum (SBRN) is located in northern side of state Azad Jammu and Kashmir (AJK) Pakistan. It is a representative region having an important geographical position being located at Line of Control. It shares its border with Indian Occupied Kashmir and due to prevailing of uncertain ground conditions in the past did not allow to get explore this area for the Odonata species complex. In study area first time detailed surveys were conducted for exploring the diversity of both sub orders of Odonata (Anisoptera and Zygoptera) during the summer season of 2018-2019. A total 346 specimens were collected yielding 20 anisopterous species under 13 genera of 5 families and 7 zygopterous species under 4 genera of 3 families. Among these 8 anisopterous species and 7 zygopterous species were first time recorded from the SBRN. According to the results of surveys, the Libellulidae and Coenagrionidae families looked to be the most prominent. For proper identification help was taken from National Insect Museum, NARC, Islamabad, Pakistan.

## INTRODUCTION

Anisoptera and Zygoptera are important groups of biological control agent that comes under order Odonata of class Insecta (Rehman *et al.*, 2020). They go through three stages in their life cycle; egg, larva, and adult and play significant role as flagship species in conservation of biodiversity (Rashied, 2019). They are representative of healthy environment and ecological good conditions (Triplehorn and Johnson, 2005). They play important role as predator of ecologically significant pests that can be found in both aquatic and terrestrial ecosystems. Their larvae also act as a natural biological control agent over mosquito

larvae, assisting in the control of various epidemic diseases like as malaria, dengue fever, and filaria (Din *et al.*, 2013). They also devour noxious insects like aphids, jassids, bollworms, and black flies. They neither sting and nor bite, and even all species are harmless (Subramanian, 2005; Rehman, 2019). Their naiads are crucial food for fish larva, birds, spiders, and other coleopteran insects (Jens and Runyan, 2006). Adults of several species visit major crop fields and helps in crop's protection and pest management (Zia, 2010).

Odonata is one of the few insect orders that have undergone extensive research in the tropics (Woodward, 2001). A total 5740 species of Odonata were known from the world (Subramanian, 2014), and 1669 species from Oriental region (Subramanian, 2009). In comparison, Pakistan stands far behind even from its ecologically similar nearby countries including India 500 species, Sri Lanka 120 species, and Nepal with 180 species (Zia *et al.*, 2011). Across the Pakistan only 128 species has been documented (Kalkman *et al.*, 2020; Nur-ul-Islam *et al.*, 2021). The work on Anisoptera was initiated by Yousaf (1972) who conducted first ever from Pakistan (Ahsan *et al.*, 2019) while the first

\* Corresponding author: zoo2k18@gmail.com  
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most survey for recording Zygoptera complex from country by Khaliq (1990) and Zia (2010). After that Chaudhry (2010) and Zia (2010) conducted countrywise survey for Anisoptera and Zygoptera species of Pakistan.

Rafi *et al.* (2009) identified 45 species from districts Poonch and Sudhnoti while Luqman (1995) collected 35 species of Odonata from the district Muzaffarabad, Azad Jammu and Kashmir (AJK) (Rafi *et al.*, 2009). In all previous studies few pockets of the country remained unexplored because of uncertain ground conditions and State Biosphere Reserve Neelum (SBRN) in district Neelum is one of them. Previous research has mostly concentrated on the diversity of Odonata found in different districts of AJK like Poonch, Sudhnoti, Muzaffarabad, Mirpur, Bagh, Kotli and Bhimber but no satisfactory work has been done in SBRN (district Neelum valley) with only anisopterous record accessible to date.

## MATERIALS AND METHODS

Field surveys were conducted, during summer season of the years 2018-2019. In present study twelve localities were selected on the basis of altitudes and water resources (Fig. 1). These localities were including as; Kutton (L1),

Salkhala (L2), Athmuqam (3) Nagder (L4), Lawat (L5), Dawarian (L6), Dhodnial (L7), Tehjian (8) Dosath (9), Sharda (L10), Kelseri (11) and Arang Kel (L12).

During survey adult specimens were caught with a light and strong insect collection net having 2ft long handle and a ring of around 25 diameters. Collected specimens were poisoned using potassium cyanide and ethyl acetate and were placed in triangle envelopes with their wings wrapped over the body after being killed. After collection, specimens were arrived in the lab and given water bath to soften them enough for stretching. These softened specimens were spread out on appropriate setting boards, pinned properly, labeled as they became dried and transferred to storage boxes. In order to prevent the specimens from attack of ants and other insectivorous pests, naphthalene balls were installed in these boxes. Specimens were identified one by one up to lowest taxa with the help of Fraser keys (1934-1936) and using Olympus (SZ2-ILST) stereoscope. For further confirmation up to species level, help was also taken from reference collection of National Insect Museum NARC, Islamabad. After complete identification specimens were deposited at Department of Zoology, the University of AJK, Muzaffarabad for future reference and record.

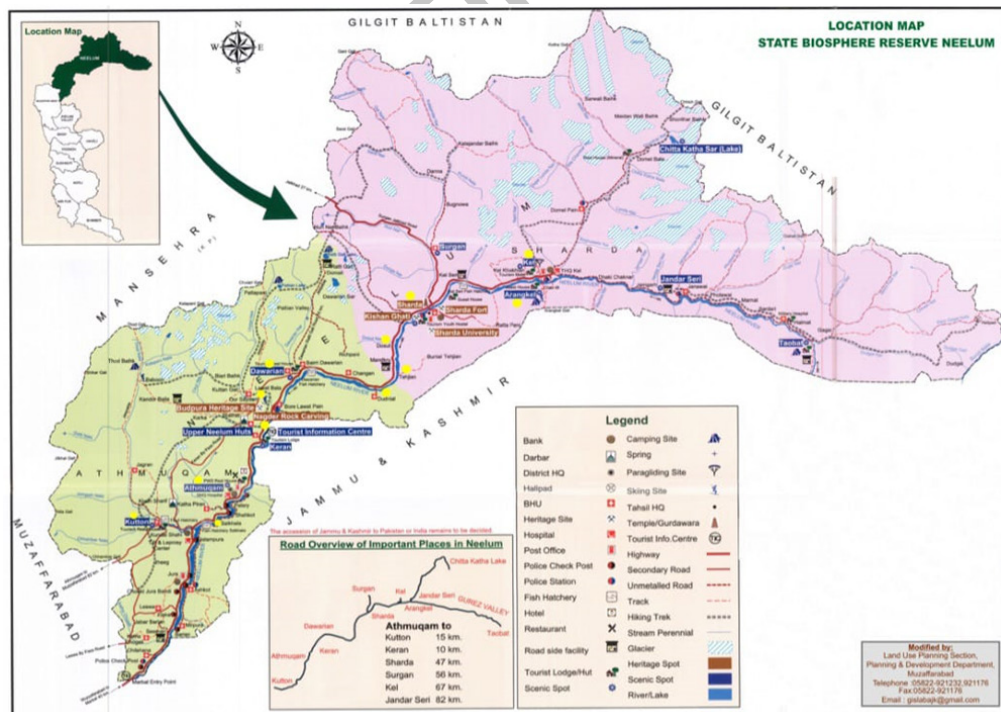


Fig. 1. Location map showing surveyed localities in State Biosphere Reserve Neelum (SBRN), Azad Jammu and Kashmir (AJK), Pakistan.

## RESULTS AND DISCUSSION

A total of 346 adult specimens of Anisoptera and Zygoptera were collected. As a result of surveys, a total 27 species of Odonates, representing 17 genera under 8 families were recorded from the study area (Table I). In case of sub order Anisoptera 20 species having family Libellulidae is the dominant by 15 species followed by Aeshnidae (2), Corduliidae (1), Gomphidae (1), and Cordulegasteridae (1) and among Zygoptera 7 species having family Coenagrionidae is the dominant by 4 species followed by Euphaeidae (2) and Platynemididae (1). Among Anisoptera, 8 species including *Anax immaculifrons* (Rambur, 1842), *Anax parthenope* (Selys, 1839), *Orthetrum glaucum* (Brauer, 1865), *Acisma panorpoides panorpoides* (Rambur, 1842), *Rhodothemis rufa* (Rambur, 1842), *Trithemis aurora* (Burmeister, 1839), *Bradinopyga geminata* (Rambur, 1842) and *Macromia moorei* (Selys, 1874) while in case of Zygoptera 7 species including *Calicnemia eximia*, (Selys, 1863), *Ischnura forcipata* (Morton, 1907), *Ischnura aurora rubilio* (Selys, 1876), *Ischnura senegalensis* (Rambur, 1842), *Agriocnemis pygmaea* (Rambur, 1842), *Bayadera indica* (Selys, 1853) and *Bayadera longicauda* (Fraser, 1928) were first time reported from from SBRN.

Distribution of Anisoptera and Zygoptera species complex was also studied in study area (Fig. 2). In case of sub order Anisoptera *Crocothemis servillia* (Drury, 1770), *Crocothemis erythraea* (Brulle, 1832), *Orthetrum triangulare triangulare* (Selys, 1878) and *Cordulegaster brevistigma* (Selys, 1854) were found to be most common and widely distributed species of the area being recorded from ten out of twelve surveyed localities. These were followed by *Orthetrum chrysostigma luzonicum* (Brauer, 1868), *Orthetrum pruinosum neglectum* (Rambur, 1842), *Rhodothemis rufa* (Rambur, 1842), *Sympetrum commixtum* (Selys, 1884) and *Trithemis aurora* (Burmeister, 1839) that were found at seven localities. Certain species were observed to be rare and were seen only in few localities. These includes; *Anax immaculifrons* (Rambur, 1842), *Anax parthenope* (Selys, 1839), *Orthetrum anceps* (Schneider, 1845), *Pantala flavescens* (Fabricius, 1798) and *Onychogamphus bistrigatus* (Selys, 1854) followed by *Bradinopyga geminata* (Rambur, 1842), *Orthetrum sabina* (Drury, 1770), *Palpopleura sexmaculata sexmaculata* (Fabricius, 1787), *Acisoma panorpoides panorpoides* (Rambur, 1842), and *Bradinopyga geminata* (Rambur, 1842) which were recorded from two localities only.

In case of sub order Zygoptera *Calicnemia eximia*, (Selys, 1863), *Ischnura forcipata* (Morton, 1907) and *Ischnura senegalensis* (Rambur, 1842) were found as most common species and recorded from six out of twelve

selected localities followed by *Agriocnemis pygmaea* (Rambur, 1842), *Bayadera indica* (Selys, 1853) and *Bayadera longicauda* (Fraser, 1928) from five localities while *Ischnura aurora rubilio* (Selys, 1876) was recorded from one locality only.

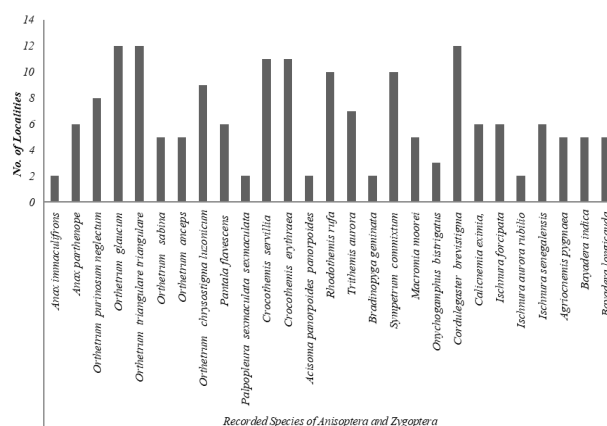


Fig. 2. Distribution of Anisoptera and Zygoptera species complex observed in State Biosphere Reserve Neelum, Azad Jammu and Kashmir Pakistan (SBRN, AJK).

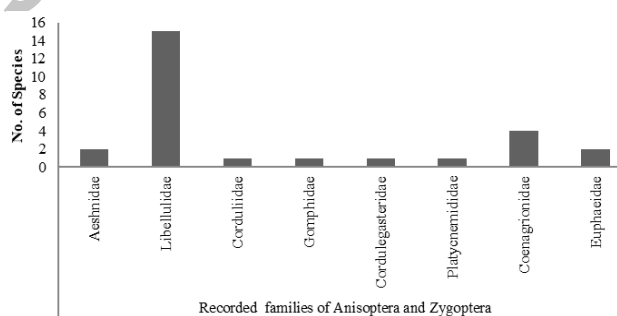


Fig. 3. Dominance observed in Anisoptera and Zygoptera families.

Dominance of species with respect to family was also studied (Fig. 3). Among Anisoptera and Zygoptera family Libellulidae with its fifteen out of total twenty-seven species appeared as a dominant group among all recorded families followed by family Coenagrionidae with four species out of seven. As in many other studies Libellulidae family is most dominant group and widely represented in surveys elsewhere locally and internationally documented by Silsby (2001), Din *et al.* (2013), Zada *et al.* (2016), Rashied (2019), and Zia *et al.* (2019). The findings of present study further authenticated to these results by declaring family Libellulidae as a dominant group among Odonata (Anisoptera and Zygoptera) of SBRN as well.

**Table I. List of Anisoptera and Zygoptera species studied in State Biosphere Reserve Neelum (SBRN), Azad Jammu and Kashmir (AJK).**

Family/Genus	Species name	Localities										
		Kut-ton	Salkh-ala	Ath-muqam	Nag-der	La-wat	Dawar-ian	Dudh-nial	Dos-ath	Teh-jian	Shar-da	Kel Arang Kel
<b>Family: Aeshnidae</b>												
<i>Anax</i> Leach, 1815	<i>A. immaculifrons</i> (Rambur, 1842)	-	+	+	-	+	-	+	-	-	-	-
	<i>A. parthenope</i> (Selys, 1839)	-	-	-	+	-	-	+	-	+	+	+
<b>Family: Libellulidae</b>												
<i>Orthetrum</i> Newman, 1833	<i>O. pruinatum neglectum</i> (Rambur, 1842)	-	+	+	+	+	+	+	-	+	+	-
	<i>O. glaucum</i> (Brauer, 1865)	+	+	+	+	+	+	+	+	+	+	+
	<i>O. triangulare triangulare</i> (Selys, 1878)	+	+	+	+	+	+	+	+	+	+	+
	<i>O. sabina</i> (Drury, 1770)	+	+	+	-	-	-	+	-	+	-	-
	<i>O. anceps</i> (Schneider, 1845)	-	+	-	-	-	+	+	-	+	+	-
	<i>O. chrysostigma luzonicum</i> (Brauer, 1868)	+	+	+	+	+	+	+	-	+	+	-
<i>Pantala</i> Hagen, 1861	<i>P. flavescens</i> (Fabricius, 1798)	+	+	+	-	-	+	+	-	+	-	-
<i>Palpopleura</i> Rambur, 1842	<i>P. sexmaculata sexmaculata</i> (Fabricius, 1787)	-	+	+	-	-	-	-	-	-	-	-
<i>Crocothemis</i> Brauer, 1868	<i>C. servillia</i> (Drury, 1770)	-	+	+	+	+	+	+	+	+	+	+
	<i>C. erythraea</i> (Brulle, 1832)	-	+	+	+	+	+	+	+	+	+	+
<i>Acisoma</i> Rambur, 1842	<i>A. panorpoides panorpoides</i> (Rambur, 1842)	-	+	-	-	-	-	+	-	-	-	-
<i>Rhodothemis</i> Ris, 1909	<i>R. rufa</i> (Rambur, 1842)	-	+	+	+	+	+	+	+	+	+	-
<i>Trithemis</i> Brauer, 1868	<i>T. aurora</i> (Burmeister, 1839)	+	+	+	+	+	+	-	+	-	-	-
<i>Bradinopyga</i> Kirby, 1893	<i>B. geminata</i> (Rambur, 1842)	-	+	-	+	-	-	-	-	-	-	-
<i>Sympetrum</i> Newman, 1833	<i>S. commixtum</i> (Selys, 1884)	-	+	+	+	+	+	+	-	+	+	+
<b>Family: Corduliidae</b>												
<i>Macromia</i> Rambur, 1842	<i>M. moorei</i> (Selys, 1874)	-	+	-	-	-	-	+	-	+	+	-
<b>Family: Gomphidae</b>												
<i>Onychogomphus</i> Selys, 1854	<i>O. bistrigatus</i> (Selys, 1854)	-	+	-	+	-	+	-	-	-	-	-
<b>Family: Cordulegasteridae</b>												
<i>Cordulegaster</i> Leach, 1815	<i>C. brevistigma</i> (Selys, 1854)	+	+	+	+	+	+	+	+	+	+	+
<b>Family: Platycnemididae</b>												
<i>Calicnemia</i> Strand 1928	<i>C. eximia</i> , (Selys, 1863)	-	+	+	+	+	-	+	-	+	-	-
<b>Family: Coenagrionidae</b>												
<i>Ischnura</i> , Charpentier 1840	<i>I. forcipata</i> (Morton, 1907)	+	+	+	+	+	-	-	-	+	-	-
	<i>I. aurora rubilio</i> (Selys, 1876)	-	+	-	-	+	-	-	-	-	-	-
	<i>I. senegalensis</i> (Rambur, 1842)	+	+	+	+	+	-	-	-	+	-	-
<i>Agriocnemis</i> Selys, 1877	<i>A. pygmaea</i> (Rambur, 1842)	-	+	+	+	+	-	-	-	+	-	-
<b>Family: Euphaeidae</b>												
<i>Bayadera</i> Selys, 1853	<i>B. indica</i> (Selys, 1853)	-	+	+	+	+	-	-	-	+	-	-
	<i>B. longicauda</i> (Fraser, 1928)	+	+	-	+	+	-	-	-	+	-	-

- indicates absence and + indicates presence

During surveys genera wise richness and abundance of species was also studied (Fig. 4). Among Anisoptera genus *Orthetrum* Newman, (1833) having family Libellulidae was observed to be one of most rich genus among all recorded genera by representing six species out of twenty species while in case of Zygoptera genus *Ischnura* Charpentier, (1840) having family Coenagrionidae was recorded to be rich genus among all recorded genera by representing three species out of seven. This finding is also in accordance to the observations made by various other researchers like Ahsan *et al.* (2019), and Zia *et al.* (2019).

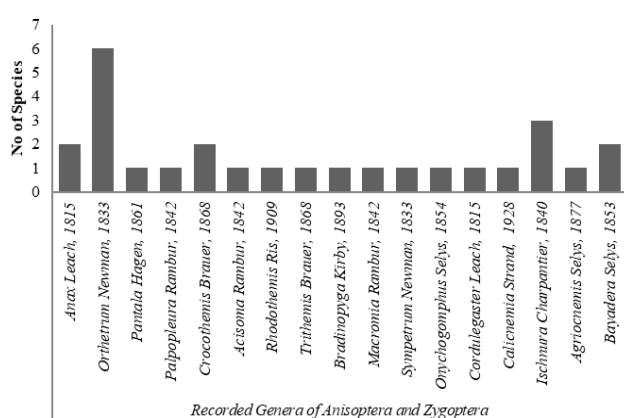


Fig. 4. Recorded genera of Anisoptera and Zygoptera in different localities of State Biosphere Reserve Neelum.

In previous studies, only anisopterous species were recorded by Ahsan *et al.* (2019), from district Neelum. However zygopterous species were recorded first time from SBRN. Also, Dow *et al.* (2014) reported a new to science record of Odonata from Nusery valley (near district Neelum) of AJK that highlights potential of a rich Odonata fauna in valleys of AJK. Odonates are prefers to unpolluted and less disturbed environments. According to Zia *et al.* (2011), Odonata population is decreasing as a result of the recent sharp rise in air and water pollution. In Pakistan AJK generally and area under SBRN (Neelum valley) specially have an abundance of seasonal streams, rivers, tiny lakes, ponds and natural springs as well. The study area is also providing an ecological less disturbed ecosystem that can display a richness of Odonata species if properly and thoroughly get surveyed. The biology and population of Odonata are ultimately supported by the hundreds of streams and rivers that are fed by the winter snowfall that covers the whole valley in the summer.

In previous studies, a total of 76 species of Odonates have been reported among which 45 anisopterous species have been reported by Kanth (1985), Khaliq (1990), Khaliq

and Yousuf (1994), Khaliq and Siddique (1995), Luqman (1995), Rafi *et al.* (2009) and Chaudhry *et al.* (2015), and 31 zygopterous species bought forward by Zia *et al.* (2008) from AJK. The current study resulted 27 Odonata species complex which is 1/3<sup>rd</sup> part of the AJK while the country's known Anisoptera and Zygoptera fauna is 128 species was recorded up to the date by Kallkman *et al.* (2020) and Nurul-Islam *et al.* (2021) (Fig. 5).

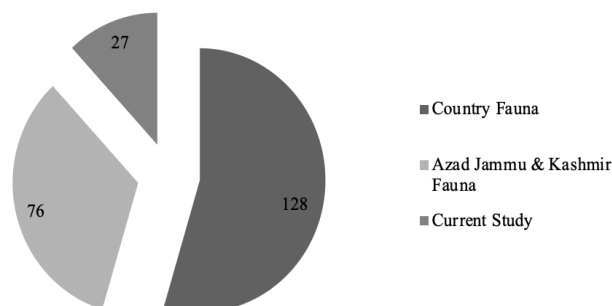


Fig. 5. Comparison of current study with previous known Anisoptera and Zygoptera fauna.

SBRN is located in northern end of State AJK Pakistan between 73°–75° E longitude and 32°–35° N latitude (Fig. 1). It's covering an area of 3737 km<sup>2</sup> and present at an altitude of 900-6325 meters above sea level. Its topography is mainly hilly with an average annual precipitation of 1511mm. It is an enrich area of water resources and supportive to moist temperate forest, dry temperate forest, sub-alpine scrub, alpine pastures, high peaks and cold deserts (Champion *et al.*, 1965) as well. On the basis of scenic beauty, globally significant biodiversity and unparalleled habitats, the entire district Neelum valley of state AJK has been notified as SBRN on August 31, 2020 (GoAJK, 2020).

In summer season, temperature ranges are from 20 to 30 degrees Celsius, while in winter season from 0 to 4 degrees Celsius (Dar, 2003). Main crops and fruits grown in this area are including maize, rice, potato, pulses, apple, walnut, pear, plum, apricot and variety of vegetables (Ahsan, 2015). Odonates are known to feed on pests of these crops as a main predator (Rafi *et al.*, 2010). SBRN is one of hard to reach area and ground conditions of the area make its less favorable for research surveys being located at the border of disputed territory i.e. Indian Occupied Kashmir. In light of unexplored status of the study area it was decided to get thoroughly explore the diversity of Odonates (Zygoptera and Anisoptera) of SBRN. Present manuscript is based over a study that was under taken to record the diversity of both sub orders (Anisoptera and Zygoptera) of Odonata of SBRN and Zygoptera fauna for the first time since 1947. SBRN is located on the Line of

Control (LOC) that separates India from Pakistan. Another country China is also sharing its border with this area being located to the north of study area. All these countries possess a special geographic position by reflecting Oriental, Palearctic as well as Ethiopian fauna. Anisoptera and Zygoptera are migratory insects and known to travel great distances in search of ideal climatic conditions and their food (Zia *et al.*, 2019). Many migratory species of Anisoptera and Zygoptera can migrate from Pakistan, India and China to the study area as home. Moreover, the study area needs to be properly examined in order to investigate new and significant records of migrating anisopterous and zygopterous species. The current study provides a good picture of the inhabiting Odonates by describing 27 species of Anisoptera and Zygoptera from SBRN in its initial and baseline survey and by describing more than 1/3<sup>rd</sup> part of the entire AJK fauna (Fig. 5). For exploring the new important records of Anisoptera and Zygoptera species from this area, more thoroughly surveys and proper investigation are proposed.

### CONCLUSION

On completion of study, a total of 27 species of Anisopterous and Zygoptera has explored from SBRN that is one of significant geographical region being located at Line of Control and shares its border with Indian Occupied Kashmir. Among these reported species 8 anisopterous species and 7 zygopterous species were first time recorded from study area presenting a strong potential to come up with more important and new records if explored thoroughly and hectically.

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#### Statement of conflict of interest

The authors have declared no conflict of interest.

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