

Diversity and Distribution of Dragonflies and Damselflies in the Central Karakoram Region of Pakistan

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SUMMARY

Odonates serve as environmental indicators, biological agents against a variety of insect pests and disease vectors, and have certain medical and veterinary applications. The goal of the current study was to document the Odonata species richness and abundance in District Skardu. In 2022–2023, we used aerial nets to gather odonates from fourteen sampling locations. The Odonata survey yielded 372 individuals, representing 16 species, 11 genera, and four subfamilies. Among these, the genus *Orthetrum* exhibited the highest species richness with four species. Among the species, *Orthetrum brunneum* (13.97%) had the highest relative abundance, while *Cordulegaster brevistigma* (0.26%) was the least abundant species. The community analysis revealed a Simpson (1-D) index of 0.81, which represents high Odonata diversity. During the present study, the highest Shannon diversity was recorded at Khushho Chumik (H': 2.28), whereas Chundah (E: 0.94) had the highest evenness. The present manuscript highlights the status of Odonata diversity associated with habitats and seasonal conditions. Further investigations are recommended to address knowledge gaps and support conservation and future Odonata biodiversity planning in Gilgit-Baltistan.

Keywords: Odonata, Anisoptera, Zygoptera, Diversity, Distribution, Skardu, Gilgit Baltistan

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INTRODUCTION

The evolutionary origin of Odonata can be traced back approximately 250 million years ago (Westfall et al., 1996). Odonata are classified into three suborders: Zygoptera (damselflies), Anisoptera (dragonflies), and Anisozygoptera (primitive dragonflies) (Rafique et al., 2022). Odonata are an ancient group of winged insects found today, exhibiting vigorous and highly active behavior (Seyab et al., 2015). Odonata are predatory insects that primarily inhabit a wide range of environments, including fields, meadows, forests, ponds, and river banks (Supanekar et al., 2021). Odonates have a biphasic life cycle, with nymphs inhabiting aquatic environments and adults being terrestrial. Although most species are associated with freshwater

environments, some can tolerate saline waters (Islam et al., 2024). Globally, Odonates are widely distributed across all continents except Antarctica (Koroiva et al., 2022). Odonata comprises a wide range of taxonomic classifications, including 8 superfamilies, 29 families, 58 subfamilies, containing approximately 600 genera and 6,500 species worldwide (Akbar et al., 2017; Mehmood et al., 2020; Nisar et al., 2021; Zia et al., 2009; Zia et al., 2011). The Odonata fauna of Pakistan is currently represented by approximately 128 species (Kalkman et al., 2020). Across the neighboring South Asian region, India harbors 500 species, Sri Lanka has 120 species, and Nepal has 180 species (Rashied et al., 2024).

Odonates are important components of freshwater trophic networks, where they contribute to the proper functioning of the ecosystem (Koroiva et al., 2022). They are predators of several pests and play a significant role in reducing pest populations (Ghahari et al., 2009). Due to their versatile biological properties, they are also used in the treatment of throat ailments and to make ophthalmic remedies (Nur-ul-Islam et al., 2021). The naiads of Odonata are sometimes used by fishermen to attract and catch fish (Rehman et al., 2020). Both adult and larval stages of Odonata act as environmental indicators and play a critical role in the control of many infectious diseases like dengue, filariasis, and malaria (Rehman et al., 2020). Skardu possesses a unique ecology and occupies an important geographic location, characterized by marked seasonal variations. Such environmental heterogeneity provides appropriate breeding and feeding habitats for odonates and likely influences their diversity, species richness, and spatial distribution. Previous studies, such as Khaliq et al. (1994), Jehangir (1997), and Zia et al. (2009), from Gilgit-Baltistan have reported the existence of Odonata in the region. However, despite these contributions, information regarding the diversity and distribution of Odonata in Gilgit-Baltistan remains underexplored. Therefore, the present study aimed to document the diversity and spatial distribution of dragonflies and damselflies in Skardu, Pakistan.

MATERIALS AND METHODS

STUDY AREA

The study was carried out in various localities of Skardu district during 2022-2023 to document Odonata fauna. Skardu district lies in the Baltistan area, which is located at 75°41'10.53" E and 35°17'31.34" N with an elevation of approximately 2,258 m above sea level. Skardu inhabits a significant geographical position, sharing its borders with India, China, Iran, and Afghanistan, and facilitating the migration of many species. Skardu is surrounded by major mountain ranges, i.e., the Himalayas, Karakoram, and Hindukush ranges, which are interspersed by valleys and rivers. Throughout this mountain region, numerous aquatic bodies occur, including glacially fed lakes, marshes, ponds, streams, and rivers. During summer, temperatures approximately reach 35°C, creating favorable conditions for Odonata diversity.

SAMPLING SITES

Data collected from 14 designated localities from Chundah, Gole, Halma Rangah, Hargisa, Katpana, Khushho Chumik, Naghlospang, Narh, Olding, New Rangah, Sermik, Shangrilla, Bain Rangah, and Upper Kachura Lake as shown in (Figure 1).

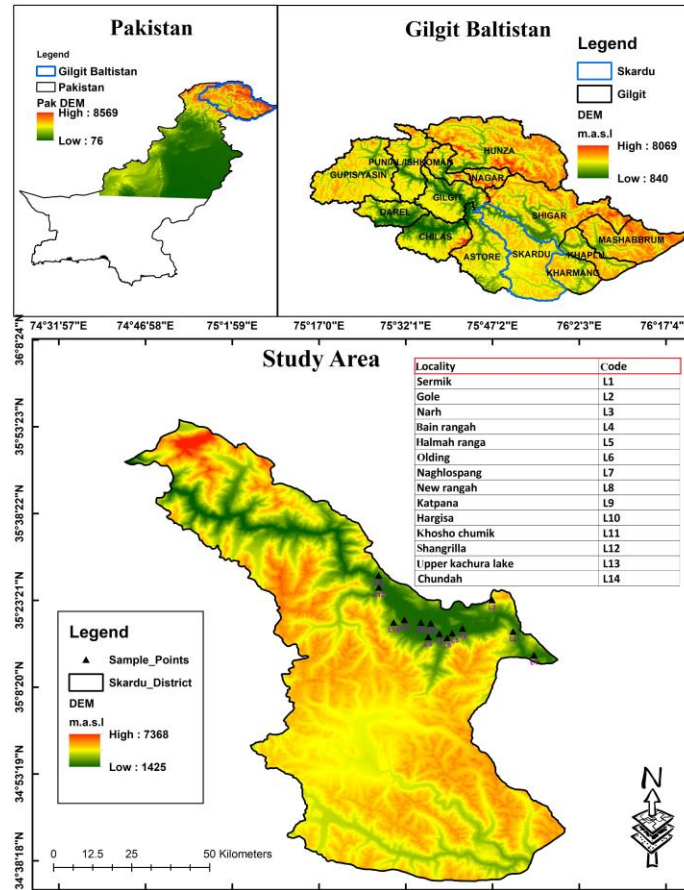


Figure 1. Study area map showing the spatial distribution of Odonata sampling sites in District Skardu, Gilgit-Baltistan, Pakistan.

Collections, identification and preservations

The sampling method for the collection of adult Odonata was adapted from Zia (2011) and Chaudhry (2010), with minor modifications. Adult specimens were captured during clear and sunny days from various surveyed ecological sites with an aerial net. The gathered specimens were euthanized in an ethyl acetate-filled killing jar. To prevent injury to their legs and wings, the dead specimens were wrapped in a triangle of butter paper. Information about the locality, date, and collector was mentioned on the butter paper. The specimens were brought to the University of Baltistan for further identification of species. Using the taxonomic keys of Fraser (1933), Fraser (1934), Zia (2010), and Chaudhry (2010), every specimen was identified to the species level. For future research and reference, the identified species were placed in the Insect Museum of the Biosystematics Laboratory, University of Baltistan, Skardu.

STATISTICAL ANALYSIS

Species diversity was calculated using the Shannon–Wiener diversity index (H'), Simpson diversity index ($1-D$), Simpson dominance index (D), and species evenness (E). All analyses were accomplished using PAST 4.03 version (Hammer et al., 2001). The Shannon–Wiener diversity formula is:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

Simpson's dominance index formula is:

$$D = \sum_{i=1}^S p_i^2$$

Simpson's diversity index formula is: $1 - D$ (Where D is Simpson dominance index)
While

Species evenness formula is:

$$E = \frac{e^{H'}}{S}$$

Where p_i is the ratio of individual member belonging to the i th species and S is the aggregate of recorded species. Diversity indices were analyzed following described ecological procedures by Hussain et al. (2024). The obtained results were compared with earlier published studies on Odonata diversity from Pakistan (Ataullah et al., 2021; Hafeez et al., 2021; Umer et al., 2022; Rashied et al., 2024; Sidra et al., 2022).

RESULTS

The survey yielded a total of 372 adult specimens of Odonata from various localities in the Skardu district during 2022-2023. The collected specimens represented 16 species distributed across 11 genera and four subfamilies. Among the collected Odonata specimens, the genus *Orthetrum* showed the highest relative abundance with four species: *Orthetrum triangulare*, *Orthetrum brunneum*, *Orthetrum anceps*, and *Orthetrum chrysostigma luzonicum*. Nine genera (*Sympetrum*, *Crocothemis*, *Libellula*, *Diplacodes*, *Enallagma*, *Mortonagrion*, *Anax*, *Aeshna*, and *Cordulegaster*) were each represented by a single species from the study area. At the species level, *Orthetrum brunneum* (13.97%) contributed the largest proportion of recorded individuals, while the lowest abundance proportion was shown by *Cordulegaster brevistigma* (0.26%) (Table 1).

In the community with low evenness, the relative abundance of species shows a decreasing tendency in abundance levels. Moderately higher richness and evenness were suggested by the Shannon-Wiener richness (H' : 2.57) and evenness (E : 0.91) indices. Table 2 lists each locality's species distribution. Additionally, Table 3 lists each species' ecological preferences, habitat distributions, and current IUCN status. The diversity indices showed clear spatial variation in the Odonata group among the sampled localities (Figure 2). Species richness varied from 6 to 12 species, with Bain Rangah showing the highest species richness (12 species), followed by Halma Rangah, Olding, and Khushho Chumik (11 species each). In contrast, Chundah revealed the lowest species richness (6 species).

Table 1: Relative Abundance (%) of species of Odonata from District Skardu.

Family	Genus	Species	Abundance (%)
Libellulidae	<i>Orthetrum</i>	<i>Orthetrum brunneum</i>	13.97
		<i>Orthetrum triangulare</i>	11.55
		<i>Orthetrum anceps</i>	9.94
		<i>Orthetrum chrysostigma luzonicum</i>	9.4
	<i>Sympetrum</i>	<i>Sympetrum meridionale</i>	8.6
	<i>Crocothemis</i>	<i>Crocothemis erythraea</i>	7.79
	<i>Libellula</i>	<i>Libellula quadrimaculata</i>	5.1
	<i>Diplacodes</i>	<i>Diplacodes lefebvrei</i>	3.22
Coenagrionidae	<i>Ischnura</i>	<i>Ischnura elegans</i>	6.72
		<i>Ischnura senegalensis</i>	6.18
		<i>Ischnura forcipata</i>	5.37
	<i>Enallagma</i>	<i>Enallagma cyathigerum</i>	4.03
	<i>Mortonagrion</i>	<i>Mortonagrion aborense</i>	1.34
Aeshnidae	<i>Anax</i>	<i>Anax parthenope</i>	4.83
	<i>Aeshna</i>	<i>Aeshna juncea</i>	1.61
Cordulegasteridae	<i>Cordulegaster</i>	<i>Cordulegaster brevistigma</i>	0.26

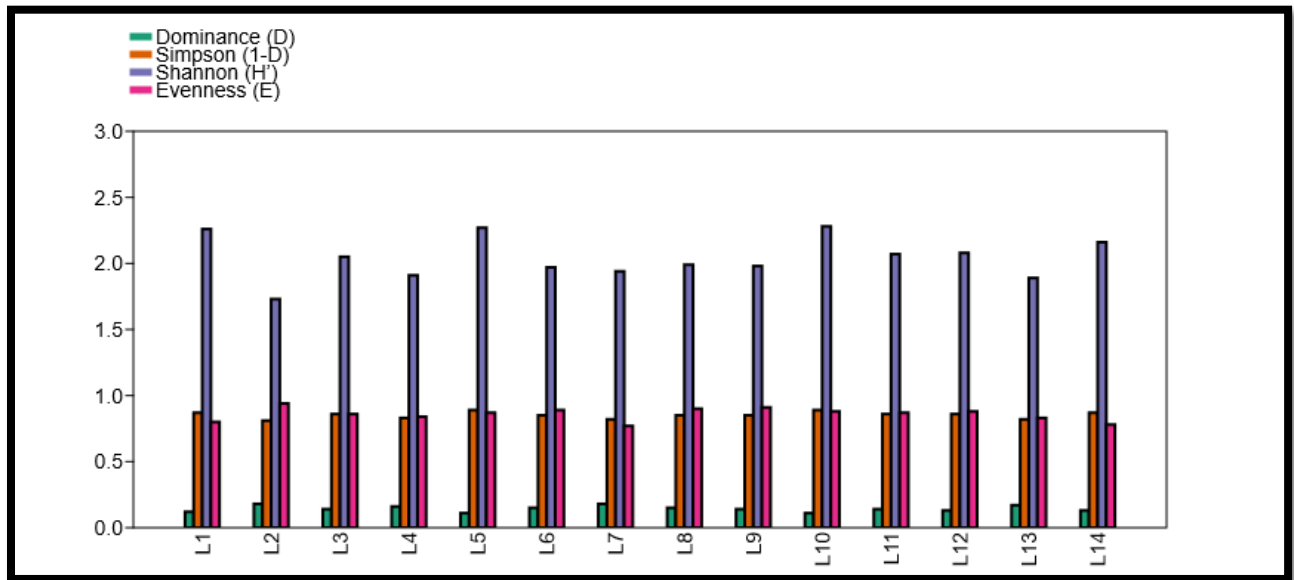


Figure 2: Shannon-wiener diversity index of recorded Odonata species from different localities of Skardu.

The Shannon–Wiener diversity index (H') ranged from 1.73 to 2.28, indicating moderate to high diversity in the study area. The highest diversity was recorded at Khushho Chumik ($H' = 2.28$), followed by Olding ($H' = 2.27$) and Bain Rangah ($H' = 2.26$), whereas the lowest diversity was observed at Chundah ($H' = 1.73$). Additionally, Simpson's diversity index ($1-D$) varied between 0.81 and 0.89, with the highest diversity observed at Olding and Khushho Chumik ($1-D = 0.89$) and

the lowest diversity found at Chundah ($1-D = 0.81$) (Figure 2). Species evenness (E) was relatively high across localities (0.77–0.94), representing a balanced distribution among species. The highest evenness was observed at Chundah (0.94), whereas New Rangah showed the lowest evenness (0.77), representing relatively greater dominance by a few species. Dominance (D) was low across the study area (0.11–0.18), reflecting the balanced species distribution and absence of strong species monopolization among Odonata assemblages (Figure 2). Species dominance varied throughout sampling localities, with some *Orthetrum* species dominating at different specific sites.

DISCUSSION

The survey resulted in 16 species across 11 genera under 4 families. Among these, Anisoptera accounted for 76.34% and Zygoptera for 23.66%, which indicated higher richness and abundance of Odonates in the study area. Comparable species richness has also been recorded from freshwater ecosystems of northern areas of Pakistan, including Neelum and Swat (Attaullah et al., 2021; Rashied et al., 2024). During the present study, the family Libellulidae was the most prevalent group, with 8 species. The predominance of Libellulidae is consistent with earlier studies from Pakistan, and this pattern may be attributed to the wide ecological tolerance and adaptability of its species (Attaullah et al., 2021; Ali et al., 2025; Khan et al., 2024; Rehman et al., 2020; Rashied et al., 2024). According to Silsby (2001), Libellulidae is the largest family of the suborder Anisoptera, with 1,000 species worldwide. Its predominance in this study illustrates how libellulid species exploit a wide variety of aquatic habitats. Among recorded genera, the genus *Orthetrum* dominated with 4 species. The species of this genus are more easily adjustable and adaptable to diverse environmental conditions (Ali, 2023), which may explain their successful establishment in the freshwater ecosystem of district Skardu.

In addition, *Orthetrum brunneum* exhibited the highest relative abundance among all other recorded species, indicating favorable environmental conditions for this species within Skardu. The dominance of *Orthetrum* has also been reported from different regions of Pakistan (Rashied et al., 2024; Mehmood et al., 2020; Naeem et al., 2022; Khan et al., 2024). The diversity pattern recorded during the current study is influenced by the availability of a variety of freshwater bodies, including ponds, rivers, streams, lakes, and marshes. Odonates require freshwater bodies for larval development and proper vegetation for mating, feeding, and resting (Kalkman et al., 2008). The presence of permanent freshwater bodies, diverse aquatic habitats, and riparian vegetation across gradient elevations of Skardu provides appropriate ecological conditions for Odonata. These ecological conditions might explain the relatively high species richness recorded in the study area.

During the present study, five species (*Ischnura senegalensis*, *Sympetrum meridionale*, *Cordulegaster brevistigma*, *Mortonagrion aborense*, and *Aeshna juncea*) are recorded for the first time from the Skardu district. These records significantly increase the known distribution of Odonata and highlight the importance of further faunal surveys in Gilgit-Baltistan. Among these, *Aeshna juncea* was recorded in low numbers and mostly found in slow-moving water bodies with moderate to dense vegetation. In Pakistan, previous records are available from Gilgit,

Khyber Pakhtunkhwa, and Punjab (Chaudhary et al., 2016; Naeem et al., 2022; Zia et al., 2009). Similarly, *Cordulegaster brevistigma* was represented by a single specimen collected patrolling near marshy vegetation. This species is considered rare in Pakistan and has previously been documented from Khyber Pakhtunkhwa, Punjab, and Gilgit (Bibi et al., 2020; Chaudhary et al., 2016; Din et al., 2013; Perveen et al., 2014).

Mortonagrion aborens was recorded from two localities, specifically reed-dominated ponds and lakes. Previously, this species was reported from Gilgit (Zia et al., 2009); its occurrence in Skardu expands its known dispersal within the northern region of Pakistan. *Sympetrum meridionale* was recorded as a more frequent species and was regularly encountered around ponds, streams, and wetland margins. Previously, this species has been reported from Gilgit and Azad Kashmir (Chaudhary, 2010; Chaudhary et al., 2016; Rafi et al., 2009; Zia et al., 2009). *Ischnura senegalensis* was collected from many localities in moderate numbers, associated with grasslands, ponds, streams, and lake margins. In Pakistan, it was previously reported from Azad Jammu and Kashmir, Sindh, Gilgit, Punjab, and Balochistan (Rashied et al., 2024; Zia et al., 2008; Rafi et al., 2009; Zia et al., 2011; Zia, 2016; Zia, 2010; Khaliq, 1990). Overall, the current study provides useful baseline data on the diversity and distribution of Odonata in Skardu. The five new additional district records highlight the underexplored status of freshwater ecosystems in Gilgit-Baltistan and strongly emphasize the need for further long-term and seasonal surveys to expand understanding of species dispersal, habitat connections, and conservation of Odonata fauna in Gilgit-Baltistan.

NOVELTY STATEMENT

The present study provides first comprehensive assessment of species richness, distribution and diversity of Odonata in Skardu. Five species, i.e., *Aeshna juncea*, *Sympetrum meridionale*, *Cordulegaster brevistigma*, *Ischnura senegalensis* and *Mortonagrion aborens* are documented for the first time from Skardu district. These extends the known distributions and provides baselines information for future studies Odonata fauna of Gilgit Baltistan.

CONCLUSION AND RECOMMENDATIONS

The present study provides baseline information about substantial diversity and distribution of Odonata in district Skardu, documenting 16 species belonging to 11 genera under 4 subfamilies. The current study also marked variation in species richness, abundance, and evenness among habitats, providing a baseline database for ecological assessment, future Odonata monitoring, and conservation in Gilgit-Baltistan.

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Authors' contributions: Ali designed the study and collected all recorded specimens of Odonata. Ali, Ali, Batool, and Rakha identified all collected specimens to the lowest possible taxa. Muhammad prepared GIS map of Skardu. Usman, Batool, Sania Rubab, Ali and Fatima performed statistical analysis of diversity indices and assisted in the interpretation of diversity indices. Ali, Aziz, and Junaid prepared the initial draft of the manuscript. All authors reviewed, revised, and approved the final version of the manuscript.



Table 2: Distribution of recorded dragonflies and damselfies (Insecta: Odonata) within District Skardu.

Suborder Anisoptera														
Family Libellulidae (Rambur, 1842)														
Genus <i>Orthetrum</i> Newman, 1833														
Species	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14
<i>Orthetrum anceps</i> Schneider, 1845	+	+	+	+	+	+	+	+	+	-	+	+	-	+
<i>Orthetrum triangulare</i> Selys, 1878	+	-	+	+	+	-	+	+	+	+	+	-	-	+
<i>Orthetrum chrysostigma</i> Burmeister, 1839	+	-	+	+	+	+	+	+	-	+	+	-	+	+
<i>Orthetrum brunneum</i> Fonscomlombe, 1837	-	-	+	+	+	+	+	-	-	+	-	+	+	+
Genus <i>Crocothemis</i> Brauer, 1868														
<i>Crocothemis erythraea</i> Brulle, 1832	+	-	+	-	+	+	+	-	+	+	+	+	+	-
Genus <i>Libellula</i> Linnaeus, 1758														
<i>Libellula quadrimaculata</i> Linnaeus, 1758	+	-	+	-	+	+	-	+	+	+	-	-	+	+
Genus <i>Diplacodes</i> Kirby, 1889														
<i>Diplacodes lefebvrei</i> Rambur, 1842	+	+	-	+	+	+	-	+	-	+	+	-	+	-
Genus <i>Sympetrum</i> Newman, 1833														
<i>Sympetrum meridionale</i> Selys, 1841	+	+	-	+	+	+	+	-	+	+	+	+	-	+
Family Aeshnidae, Rambur, 1842														
Genus <i>Aeshna</i> Fabricius, 1775														
<i>Anax parthenope</i> Selys, 1839	+	+	+	+	-	-	-	+	+	-	-	-	-	+
Genus <i>Aeshna</i> Fabricius, 1775														
<i>Aeshna juncea</i> Linnaeus, 1758	-	+	-	-	-	-	-	-	-	+	-	+	-	-
Family Cordulegasteridae Calvert, 1893														
Genus <i>Cordulegaster</i> Leach, 1815														
<i>Cordulegaster brevistigma</i> Selys, 1854	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Suborder Zygoptera														
Family Coenagrionidae Kirby, 1890														
Genus <i>Enallagma</i> Charpentier, 1840														
<i>Enallagma cyathigerum</i> Charpentier, 1840	+	-	-	-	+	-	+	+	+	+	+	+	-	+

Gnus <i>Mortonagrion</i> (Fraser, 1920)														
<i>Mortonagrion aborens</i>	-	-	-	-	-	-	-	-	-	-	-	+	+	-
Fraser,1923														
Genus <i>Ischnura</i> (Charpentier, 1840)														
<i>Ischnura elegans</i> Vander Linden, 1820	+	-	-	-	+	+	+	-	-	-	+	-	+	+
<i>Ischnura forcipata</i> Morton, 1907	+	+	+	+	-	-	+	-	-	+	+	+	+	+
<i>Ischnura senegalensis</i> Rambur, 1842	+	-	-	-	+	-	-	+	+	+	-	+	-	+

Table 3: Ecological preferences and Habitat distribution of Recorded Odonata species in district Skardu.

Sr.	Species Name	Remarks	IUCN Status
1	<i>Orthetrum brunneum</i>	This species was recorded from wetlands having dense grasses, the banks of slowly moving streams, and the boundaries of small ponds. They prefer semi aquatic environments for proper perching and foraging sites.	Least Concern
2	<i>Orthetrum triangulare</i>	This species was collected from small ponds, lakes and marshy areas which have well established vegetation. They prefer lentic environments for territorial activities and foraging.	Least Concern
3	<i>Orthetrum anceps</i>	This species was found in many freshwater habitats, including ponds, slow moving streams, rivers bank having dense grasses and running water having moderate vegetations. This species prefer both lentic and lotic environments for its survival.	Least Concern
4	<i>Orthetrum chrysostigma luzonicum</i>	This species was mainly collected from slow moving streams and flying along the margins of ponds with moderate vegetation and grasses. These shows that species prefer semi open freshwater environments which emergent vegetation for its perching and open places for foregng.	Least Concern
5	<i>Sympetrum meridionale</i>	This species was collected from small ponds, slow moving streams with established vegetation and bank of lakes. They prefer both lentic and lotic environments for its breeding and hunting.	Least Concern
6	<i>Crocothemis erythraea</i>	This species was recorded from slow moving streams having large grassland, banks of lake and small ponds. These observation indicated that they prefer vegetated aquatic environments which provide space for perching, breeding grounds and foraging sites.	Least Concern
7	<i>Libellula quadrimaculata</i>	Found in open valley grasses having slow moving water. They were also found from stagnant water pond and also found on standing over wheats fields. They prefer freshwater environments closest to nearer vegetation for proper perching and foraging.	Least Concern
8	<i>Diplacodes lefebvrei</i>	This dragonfly was recorded from resting on weedy plants and rocks nearer to water bodies, indicating preference for open sunlit habitats nearer to freshwater.	Least Concern

9	<i>Ischnura elegans</i>	This species was recorded from small ponds within grassland and slow moving streams, canals, lakes with grasses and minute vegetation. They both lentic and lotic environments for their daily territorial activities and breeding.	Least Concern
10	<i>Ischnura senegalensis</i>	This species was recorded from marshy areas and sides of ponds having grasses and minute vegetation. They prefer freshwater bodies with ample vegetation for its perching, foraging and breeding.	Least Concern
11	<i>Ischnura forcipata</i>	This species was collected from shores of Lake, ponds and slowly moving streams. They prefer freshwater bodies that offer aquatic vegetation for its breeding and foraging.	Least Concern
12	<i>Enallagma cyathigerum</i>	This species was recorded from freshwater habitats small marshy area, slow moving water and small ponds. They prefer both lentic and lotic environments for its daily territorial activities and breeding.	Least Concern
13	<i>Mortonagrion aborens</i>	This species was found only from Shangrilla Lake and upper kachura lake. This species was collected while flying over banks of lake, suggesting key habitat for its daily territorial activity and breeding.	Data Deficient
14	<i>Anax parthenope</i>	This species was recorded from fast flowing streams, canals, stagnant water bodies and slow moving streams. They are also observed mating in grassy areas. They prefer both aquatic and semi aquatic environments for their breeding and foraging.	Least Concern
15	<i>Aeshna juncea</i>	This species was collected from slow moving streams and stagnant freshwater environment having dense vegetation. They prefer both lentic and lotic environments for their daily territorial activities and breeding.	Least Concern
16	<i>Cordulegaster brevistigma</i>	Generally this species was found in fast flowing freshwater streams and canals. In District it is collected from single point while flying over large grass nearer to streams. This species prefer lotic freshwater habitat for its daily territorial activities and breeding.	Least Concern