

## Species diversity and abundance of Odonata in Sishaghat of Tanahun district, Nepal

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### Abstract

Odonata are one of the most ancient, well studied and fascinating insect orders considered as bio-indicators of aquatic ecosystems. Studies on Odonata have been carried out in many parts of Nepal, but no specific study has been performed in Tanahun. Hence, a study was conducted to determine the species diversity and abundance of Odonata in the Sishaghat of Tanahun district, Nepal from June to August 2020. A transect survey method was used for data collection. A total of six transects (three in each habitat type: agricultural lands and forest streams), each with a length of 200 m were laid out randomly and each transect was surveyed three times. Data were pooled and analyzed with SPSS. A total of 629 individuals of 26 Odonata species from 20 genera and 7 families were recorded. The overall Shannon-Wiener diversity index was  $H=2.25$ , Shannon Equitability was  $E=0.69$  and Margalefs' richness index was  $R=3.88$ . Sub-order Anisoptera was more diverse ( $H=1.94$ ) and more abundant ( $n=545$ ) than Zygoptera ( $H=1.31$ ,  $n=84$ ). However, species richness was higher and evenness lower in Zygoptera ( $R=2.26$ ,  $E=0.55$ ) than Anisoptera ( $R=2.22$ ,  $E=0.72$ ). Anisoptera comprised 15 species within 10 genera from two families and Zygoptera comprised 11 species within seven genera from five families. The family Libellulidae represented the highest species richness ( $R=1.75$ ). *Neurothemis fulvia* and *Orthetrum pruinosum* were the most abundant species ( $RA=23.21$  and  $21.78$  respectively). Of the recorded Odonata, 25 species are included under the least concern and one under the vulnerable category of the IUCN. A higher number of species was found in agricultural lands (nine species); hence, the water bodies around this habitat should be preserved to conserve the Odonata.

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**Key words:** *Calicnemia nipalica*, damselfly, dragonfly, flier, percher, Libellulidae

### Introduction

Odonata is an order of insects, traditionally divided into three sub-orders; Anisoptera (true dragonflies), Zygoptera (damselflies), and Anisozygoptera (mixed characteristics of dragonflies and damselflies) (Kalkman et al., 2008). Odonates are among the most ancient, winged insects having compound eyes and two pairs of wings; and most often found flying over ponds, gardens, lakes, forests and paddy fields (Nair, 2011). Their life history is linked to particular aquatic habitats (Andrew et al., 2008).

Odonates perform hemimetabolous metamorphosis from aquatic nymph to terrestrial adult (Price et al., 2011). They are found on every continent except Antarctica and there are about 6,313 described species of Odonata worldwide (Paulson and Schorr, 2020). There are about 588 taxa of Odonata (including 559 full species) known from South Asian countries (Nepal, Bangladesh, Sri Lanka, India, Bhutan and Pakistan) (Kalkman et al., 2020). About 185 species of Odonata are recorded from Nepal (Conniff, 2020; Sajan and Gurung, 2020).

Odonates are considered as bio-indicators of aquatic ecosystems as their high abundance in freshwater usually indicates good quality of water (Corbet, 1999; Jacob et al., 2017). Odonates are carnivorous predators and they play a significant role in the bio-control of many pests in agro and forest ecosystems (Andrew et al., 2008). They are considered an umbrella species for biodiversity conservation (Noss, 1990; Lambeck, 1997). They are an excellent food for many amphibians, fishes, birds, spiders, bats, and lizards and thus their conservation leads to the conservation of many other aquatic as well as terrestrial organisms.

Odonates are well studied worldwide (Kalkman et al., 2008; Mitra et al., 2012). As far as Nepal is considered, Selys (1854) was the pioneer for dragonfly records from Nepal. Since then, many researchers have contributed to Odonata research in Nepal. Vick (1989) published the first Odonata checklist of Nepal, including 172 species with altitudinal distributions. Thapa (2015) later listed 195 species of Odonata from 87 genera belonging to 18 families, but according to a more modern classification, the species number is now actually 185 for Nepal (Sajan and Gurung, 2020). Local wildlife studies are rare in the context of Nepal. Mahato (1986) had recorded 34 species of Odonata shared between the Dumre of Tanahun district and Khansar of Manang district, but he did not mention how many species of Odonata were found in the Tanahun district only. After this no study has been done on Odonata in the Tanahun district. Hence, this study aims to explore species diversity and abundance of Odonata in Sishaghat, Vyas Municipality-6, Tanahun, Nepal. We provide a checklist, abundance and species richness data of Odonata in the study area.

## Material and Methods

### Study area

The study was conducted in Sishaghat (around 28°05.528'N and 84°13.215'E), Vyas Municipality-6, Tanahun district, Nepal (Fig. 1) from June to August 2020. It covers an area of 3.21 km<sup>2</sup> and an altitudinal range of 438 to 884 m. Agricultural lands and forest streams were the selected habitats for the survey. The agricultural land contains paddy fields, small temporary ditches or water bodies and open areas, which are potential habitat for flier species (species which prefer to fly back and forth along their territory). Mostly maize, soybean and paddy crops are planted on the agricultural lands within the study area but they also include shrubs like *Artemisia vulgaris* and *Chromolaena odorata* and herbs such as *Ageratum conyzoides*, *Imperata cylindrica*, and *Acmela paniculata*. The forest streams are partly, or fully, covered with forest canopy and are more favorable to percher species (species which prefer to sit and wait for their prey). Forest streams have slopes of about 15 to 30 degrees and the forests are dominated by *Schima wallichii*, *Castanopsis indica*, and *Shorea robusta* tree species. The major shrub species include *Artemisia vulgaris*, *Ageratina adenophora*, and *Chlerodendrum*

*infortunatum*, the major herb species are *Ageratum conyzoides*, *Bidens pilosa*, and *Pilea* sp., while the major hydrophytes or aquatic species are *Torenia crustacea*, and *Persicaria* sp.

### Data collection

A transect survey was used for data collection (Sutherland, 1996) with a total of six transects of length 200 m, three in each habitat type (agricultural lands and forest streams) sample. Each transect was surveyed three times (once a month i.e. June, July and August) to detect the maximum number of species which may have been missed in the earlier surveys. The study was carried out from 10:00 am to 4:00 pm on sunny days because Odonata are most active during the daytime (Thomas et al., 2018). Species were photographed with a smartphone "Samsung Galaxy Grand Prime +" and identified with the help of field guides by Emiliyamma et al. (2005) and Nair (2011). When walking the fixed transects, any specimens seen ahead of the observer and within five meters (2.5 meters on either side of the transect) were recorded. Species that were difficult to identify in the field were photographed and later identified with the help of experts and internet reference material (<http://odonatanepal.blogspot.com>).

### Data analysis

Sampling data were pooled and analyzed with SPSS software (Version 26). The local status of Odonata was determined based on the number of individuals of a species encountered during the survey and recorded as: Very rare (< 3), Rare (3–15), Occasional (16–49), Common (50–100), and Very common (> 100) (Das, 2016). The IUCN status is based on IUCN Red List of Threatened Species (2020). Odonata diversity was calculated by using the Shannon-Wiener Diversity Index and the species evenness was calculated by using Shannon Equitability. Species richness was determined based on the total number of species recorded by using Margalefs' richness index, while the species abundance was determined based on the total number of individuals of each species. Relative abundance was calculated to compare with species abundance.

$$\text{Shannon-Wiener diversity index } H = - \sum_{i=1}^n P_i \times \ln p_i$$

$$\text{Shannon Equitability } E = \frac{H}{H_{\max}} \text{ here, } H_{\max} = \ln(S)$$

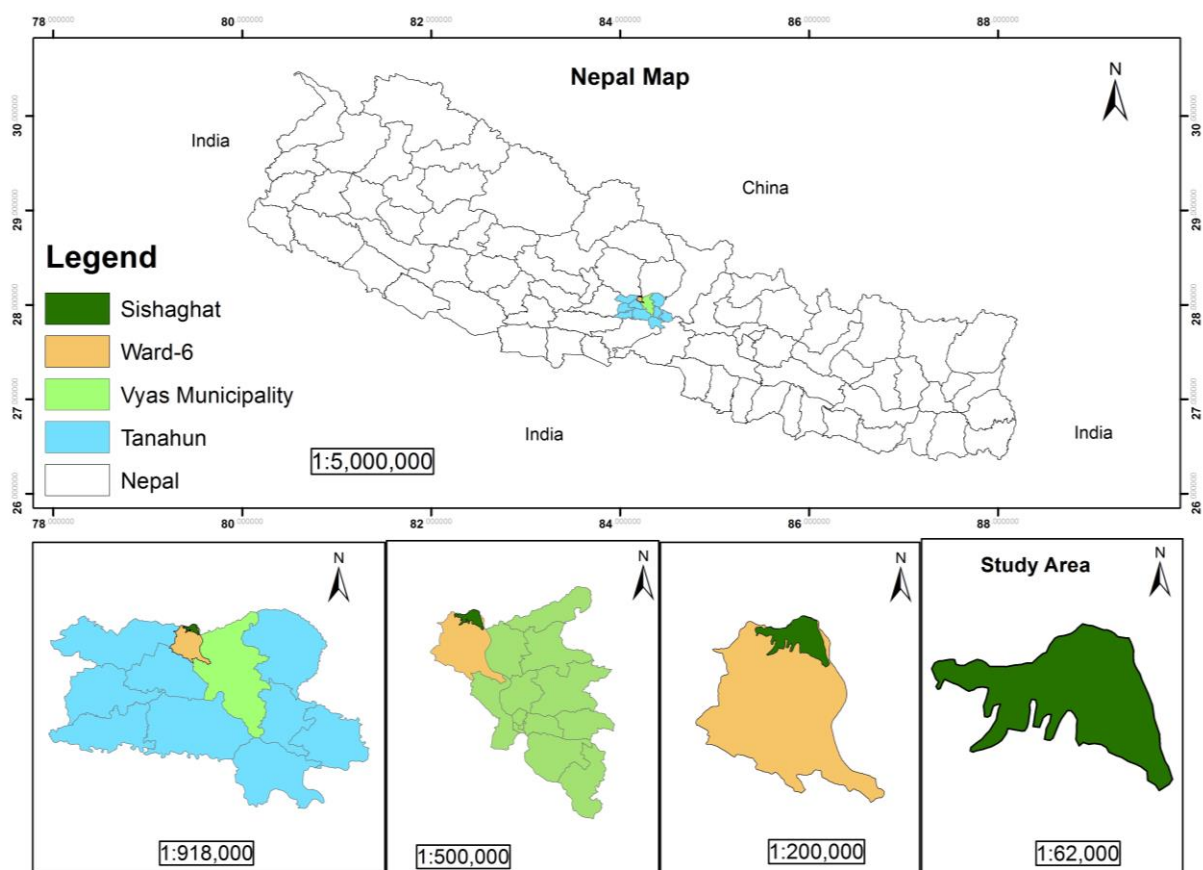
$$\text{Margalefs' richness index } R = \frac{S-1}{\ln(N)}$$

Where,  $P_i$  = Proportion of individuals belonging to the  $i^{\text{th}}$  species,  $N$  = total number of individuals,  $S$  = number of species.

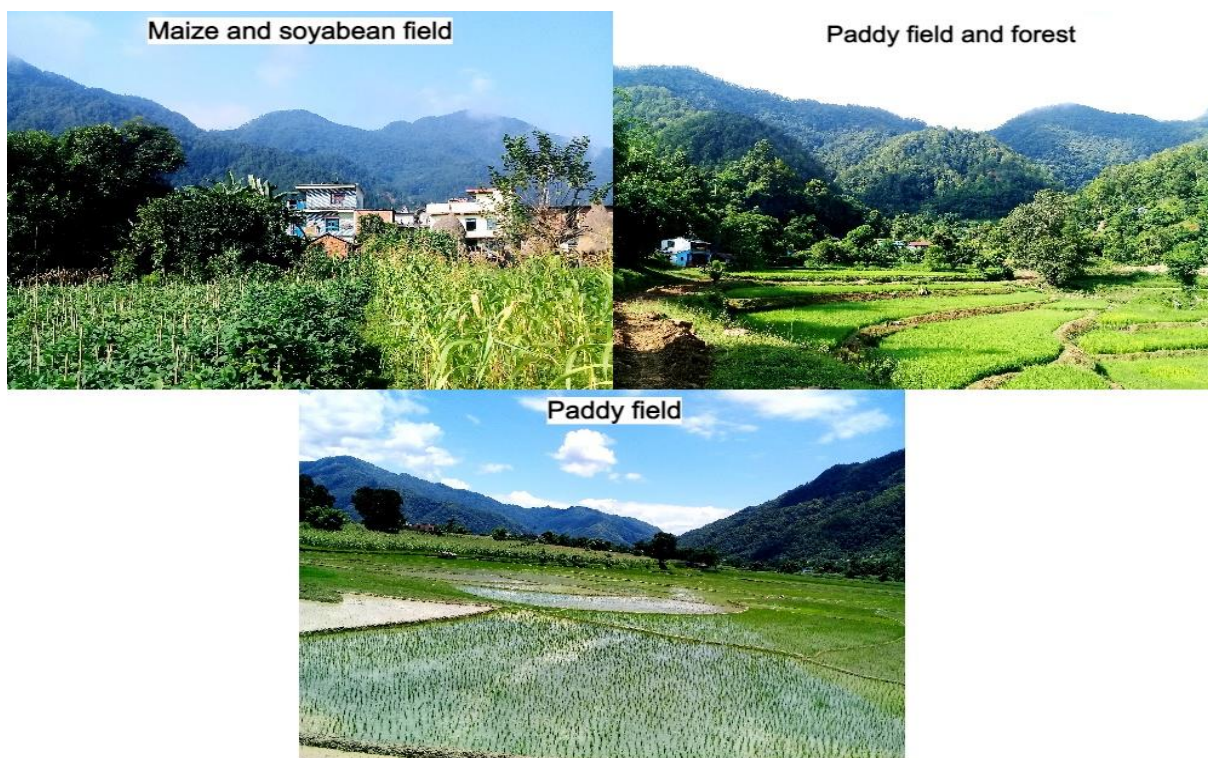
### Relative abundance

$$RA = \frac{\text{Total number of individual of particular species}}{\text{Total number of individual of all Odonata sampled}} \times 100$$

The obtained values were then compared between Odonata families and sub-orders.



**Figure 1:** Map of the study area for Odonata in Sishaghat of Tanahun district, Nepal.



**Figure 2:** Selected habitats of study area for Odonata in Sishaghat of Tanahun district, Nepal.

## Results

A total of 629 individuals of Odonata, 26 species from 20 genera and 7 families, were recorded during the study, including 15 species of dragonfly (Anisoptera) and 11 species of damselfly (Zygoptera). A list of Odonata recorded in the study area is given in Table 1 and Table 2 and photographs are provided in Appendix 1. The overall Shannon-Wiener diversity

index was  $H = 2.25$ , Shannon Equitability was  $E = 0.69$  and Margalefs' richness index was  $R = 3.88$ . The calculated diversity indices for Odonata are mentioned in Table 3. *Neurothemis fulvia* (RA= 23.21) and *Orthetrum pruinosum* (RA= 21.78) were the most abundant species. A total of seven species were recorded from forest streams only, nine species were recorded from agricultural lands only and 10 species were recorded from both habitats.

**Table 1:** List of dragonflies in the study area of Sishaghat of Tanahun district, Nepal.

S. N.	Scientific name	Common name	Habitat type	N	RA	Local status	IUCN status
Family Gomphidae (3)							
1	<i>Ictinogomphus pertinax</i> (Selys, 1854)	Common Flangetail	A	3	0.48	R	LC
2	<i>Lamelligomphus biforceps</i> (Selys, 1878)	-	A	3	0.16	VR	LC
3	<i>Paragomphus lineatus</i> (Selys, 1850)	Common Hooktail	F	3	0.48	R	LC
Family Libellulidae (12)							
4	<i>Brachythemis contaminata</i> (Fabricius, 1793)	Ditch Jewel	B	35	5.56	O	LC
5	<i>Bradinopyga geminata</i> (Rambur, 1842)	Granite Ghost	A	1	0.16	VR	LC
6	<i>Crocothemis servilia</i> (Drury, 1770)	Scarlet Skimmer	B	82	13.04	C	LC
7	<i>Diplacodes trivialis</i> (Rambur, 1842)	Blue Ground Skimmer	B	52	8.27	C	LC
8	<i>Neurothemis fulvia</i> (Drury, 1773)	Fulvous Forest Skimmer	B	146	23.21	VC	LC
9	<i>Neurothemis intermedia</i> (Rambur, 1842)	Paddy Field Parasol	A	1	0.16	VR	LC
10	<i>Orthetrum glaucum</i> (Brauer, 1865)	Blue Marsh Hawk	F	3	0.48	R	LC
11	<i>Orthetrum luzonicum</i> (Brauer, 1868)	Tri-colored Marsh Hawk	B	13	2.07	R	LC
12	<i>Orthetrum pruinosum</i> (Burmeister, 1839)	Crimson-tailed Marsh Hawk	B	137	21.78	VC	LC
13	<i>Orthetrum sabina</i> (Drury, 1770)	Green Marsh Hawk	B	18	2.86	O	LC
14	<i>Palpopleura sexmaculata</i> (Fabricius, 1787)	Blue-tailed Yellow Skimmer	B	48	7.63	O	LC
15	<i>Trithemis festiva</i> (Rambur, 1842)	Black Stream Glider	B	2	0.33	VR	LC

(Abbreviation used: N= Number of individuals, RA= Relative Abundance, F= Forest streams, A= Agricultural lands, B= Both habitats, VC= Very Common, C= Common, O= Occasional, R= Rare, VR= Very Rare, LC= Least Concern and VU= Vulnerable).

**Table 2:** List of damselflies in the study area of Sishaghat of Tanahun district, Nepal.

S. N.	Scientific name	Common name	Habitat type	N	RA	Local status	IUCN status
Family Calopterygidae (2)							
1	<i>Neurobasis chinensis</i> (Linnaeus, 1758)	Stream Glory	B	6	0.95	R	LC
2	<i>Vestalis gracilis</i> (Rambur, 1842)	Clear-winged Forest Glory	A	1	0.16	VR	LC
Family Chlorocyphidae (2)							
3	<i>Aristocypha trifasciata</i> Selys, 1853	Three-banded Emerald Jewel	F	3	0.48	R	LC
4	<i>Aristocypha quadrimaculata</i> Selys, 1853	Black Emperor	F	2	0.32	VR	LC
Family Coenagrionidae (4)							
5	<i>Aciagrion occidentale</i> Laidlaw, 1919	Green-striped Slender Dartlet	A	2	0.32	VR	LC
6	<i>Aciagrion pallidum</i> Selys, 1891	Pale Slender Dartlet	A	8	1.27	R	LC
7	<i>Ceriagrion coromandelianum</i> (Fabricius, 1798)	Coromandel Marsh Dart	A	2	0.32	VR	LC
8	<i>Ischnura rubilio</i> Selys, 1876	Western Golden Dartlet	A	56	8.90	C	LC
Family Platycnemididae (2)							
9	<i>Calicnemia eximia</i> (Selys, 1863)	Scarlet Open-wing	F	1	0.16	VR	LC
10	<i>Calicnemia nipalica</i> Kimmins, 1958	-	F	2	0.32	VR	VU
Family Platystictidae (1)							
11	<i>Drepanosticta carnichaeli</i> (Laidlaw, 1915)	Indo-Chinese Blue Reedtail	F	1	0.16	VR	LC

(Abbreviation used: N= Number of individuals, RA= Relative Abundance, F= Forest streams, A= Agricultural lands, B= Both habitats, VC= Very Common, C= Common, O= Occasional, R= Rare, VR= Very Rare, LC= Least Concern and VU= Vulnerable).

**Table 3:** Diversity indices of Odonata by family and suborder for the study area of Sishaghat of Tanahun district, Nepal.

S. N.	Family/Order	Total no. of individuals	H	E	R
Suborder Anisoptera			1.94	0.72	2.22
1	Gomphidae	7	1.00	0.91	1.03
2	Libellulidae	538	1.88	0.75	1.75
Suborder Zygoptera			1.31	0.55	2.26
3	Calopterygidae	7	0.41	0.59	0.51
4	Chlorocyphidae	5	0.67	0.97	0.62
5	Coenagrionidae	68	0.62	0.45	0.71
6	Platycnemididae	3	0.64	0.92	0.91
7	Platystictidae	1	0	0	0
<b>Overall</b>		629	2.25	0.69	3.88

## Discussion

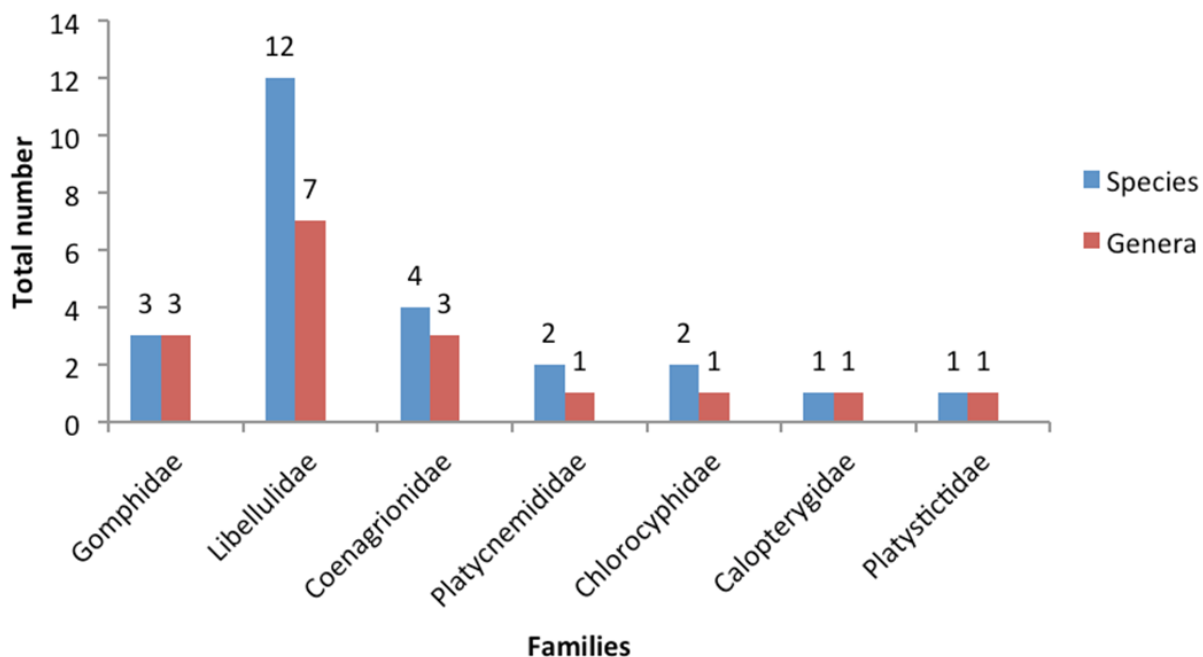
A total of 26 species of Odonata were recorded during the study, which is about 14% of total Odonata species (N= 185) recorded from Nepal. Mahato (1986) had recorded 34 species of Odonata in both Dumre of Tanahun district and Khansar of Manang district. However, this study did not mention the exact number of Odonata species found in Tanahun district alone. Therefore, we cannot compare this to the present species number, but 12 species from the present study (*Calicnemia eximia*, *Ceragrion coromandelianum*, *Crocothemis servilia*, *Diplacodes trivialis*, *Neurothemis fulvia*, *Neurothemis intermedia*, *Orthetrum glaucum*, *Orthetrum luzonicum*, *Orthetrum pruinosum*, *Orthetrum sabina*, *Palpopleura sexmaculata* and *Trithemis festiva*) overlap with the past study of Mahato (1986). Sharma et al. (2018) have recorded 61 species of Odonata in Western Nepal, which includes a wide area from tropical to temperate regions (the six districts: Rukum, Dang, Surkhet, Kailali, Kanchanpur and Mugu). In contrast to this, the small area selected for our study might be the reason for the lower species number. In the study by Sajjan and Gurung (2020) during April and May of 2019 in Dipang Lake, Kaski (catchment area of 2.39 km<sup>2</sup> and water body area of 0.14 km<sup>2</sup>), they recorded 28 species. This area presents an altitude range of 670–700 m, which is close to the altitude range of our study area, but our area contains less, and discontinuous, water bodies, with a similar number of species within it.

Table 3 indicates that suborder Anisoptera is more diverse (H= 1.94) and more abundant (n= 545) than Zygoptera (H= 1.31, n= 84). Species richness is higher and evenness lower in Zygoptera (R= 2.26, E= 0.55) than Anisoptera (R= 2.22, E= 0.72). In the study Anisoptera comprises 15 species from 10 genera in two families and Zygoptera comprises 11 species from seven genera in five families (Fig. 3). Libellulidae is the most diverse (H= 1.88), most abundant (n= 438) and most species richness (R= 1.75) among all families. The tolerance to a wide range of habitats (Hodgkin and Watson, 1958) and higher dispersal ability (Kayoda et al., 2004) of

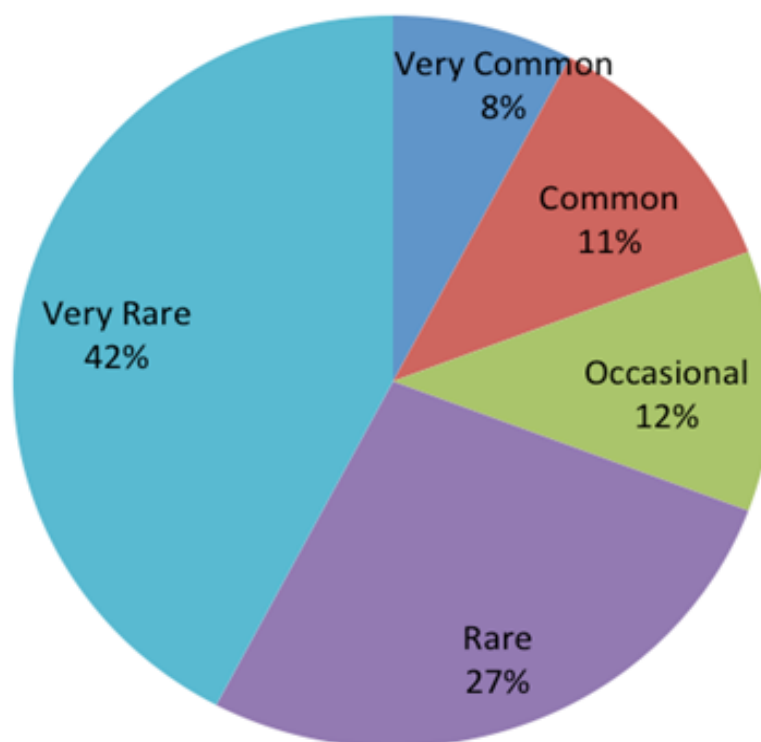
Libellulidae might be the reason behind higher diversity, abundance and richness. Similarly, Zygoptera having less species abundance might be due to their restricted dispersal ability (Kayoda et al., 2004). Sharma et al. (2018) observed the Libellulidae as the dominant family in Western Nepal, where 28 species were Libellulidae among 61 species from 11 families of Odonata. Similarly, Sajjan and Gurung (2020) recorded 17 species of Libellulidae among the 28 species from six families of Odonata in Dipang Lake, Kaski. The large and bulky body size of Libellulidae might facilitate access to a wide distribution (Dalzochio et al., 2011). Outside of Nepal, Dayakrishna (2015) recorded a total of 19 species from four families in the Corbett Tiger Reserve, Uttarakhand, India, of which Libellulidae was the most dominant family. Other studies by Vashishth et al. (2002), Asaithambi and Manickavasagam (2002), and Uniyal et al. (2000) also documented Libellulidae as a dominant family.

Single specimens of *Ictinogomphus pertinax*, *Neurothemis intermedia*, *Calicnemia eximia*, and *Drepanosticta carmichaeli* were recorded in our study area. The genus *Orthetrum* is the most species rich with 4 species (viz. *Orthetrum glaucum*, *Orthetrum luzonicum*, *Orthetrum pruinosum* and *Orthetrum sabina*). The fact that *Neurothemis fulvia* and *Orthetrum pruinosum* show greater abundance might be explained by common species surviving in greater numbers than rare species under the existing environmental conditions (Shelton and Edward, 1983).

Among the total recorded Odonata in this study, *Calicnemia nipalica* is the only species categorized as Vulnerable by the IUCN, whereas the other 25 species are categorized as Least Concern. On a local scale, 11 species (42%) were very rare, seven species (27%) were rare, three species were occasional (12%), three species were common (11%), and two species were very common (8%) (Fig. 4). The local status though is only representative of the studied months, as their status could change throughout the year and other new species could be recorded during other months.



**Figure 3:** Diversity composition of the families of Odonata from the study area of Sishaghat, Tanahun district, Nepal.



**Figure 4:** Local status of recorded Odonata from the study area of Sishaghat of Tanahun district, Nepal.

A higher number of species was recorded from agricultural lands compared to forest streams, but, 10 species were recorded from both habitats (Table 1). Most of the species found in both habitats were from Libellulidae. This family contains larger flier dragonflies which require more open habitats to

thermoregulate (Corbet, 2005; Corbet and May, 2008; Seidu et al., 2017). Agricultural lands reduce the opportunities for some endemic species, but provide favorable habitat for generalist species (Kietzka et al., 2018). A higher number of species in agricultural lands (mostly dragonflies) might be due to the presence of

temporary, discontinuous, and patchy water bodies, as well as open lands as favorable habitat for generalist species (Samways, 1989). Even though the studied agricultural area has agricultural activities with use of a wide range of fertilizers, herbicides, and various pesticides, it has more dragonfly diversity compared to forest streams. This could mean that disturbed artificial areas create favorable environments for opportunistic, or least concern dragonflies, but threats for rare and endemic species. A higher number of Odonata species in agricultural lands than in forests was also reported by Ferreira-Peruquetti and Fonseca-Gessner (2003) and Hofhansl and Schneeweih (2008). The forest covering the streams provides important habitat for the forest specialist damselflies and dragonflies (Seidu et al., 2017). Some damselflies need vegetated ovipositor substrates for their reproduction, require lower thermoregulation and use the forest structure as perching substrate (Seidu et al., 2017). This might be the reason for higher numbers of damselfly species (five species) localized only in forest streams (Table 2).

## Conclusion

A total of 26 species of Odonata comprising 15 dragonflies (Anisoptera) and 11 damselflies (Zygoptera) were recorded. Suborder Anisoptera was more diverse and more abundant than Zygoptera. However, species richness was higher and evenness lower in Zygoptera than Anisoptera. Libellulidae family was the most diverse and represented the highest species richness and abundance in the study area. Agricultural lands comprised more species of Odonata than forest streams, but only supported generalist species of least concern. *Neurothemis fulvia* and *Orthetrum pruinosum* were the most abundant species. Our findings could be used as a baseline for further research on Odonata in Tanahun district and these results could be used to make local or regional conservation plans.

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## Conflict of interest

The authors declare that there are no conflicting issues related to this research article.

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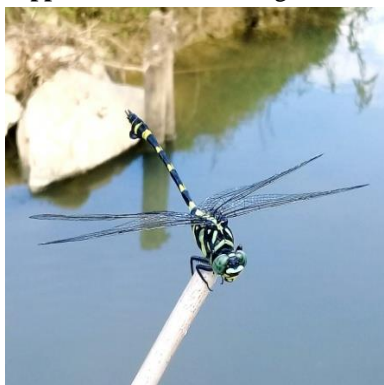
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**Appendix 1:** Photos of dragonflies and damselflies recorded from the study area of Sishaghat of Tanahun district, Nepal.



1. *Ictinogomphus pertinax* ♂  
© MS Miya



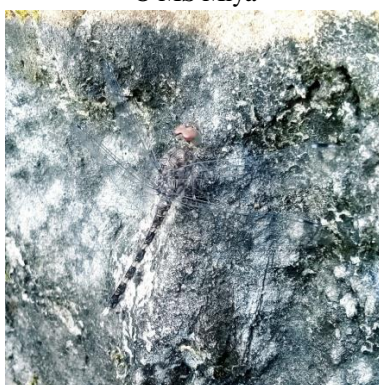
2. *Lamelligomphus biforceps* ♂  
© MS Miya



3. *Brachythemis contaminata* ♂  
© MS Miya



4. *Brachythemis contaminata* ♀  
© MS Miya



5. *Bradinopyga geminata* ♀  
© MS Miya



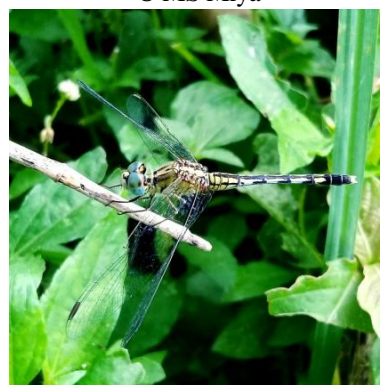
6. *Crocothemis servilia* ♂  
© MS Miya



7. *Crocothemis servilia* ♀  
© MS Miya



8. *Diplacodes trivialis* ♂  
© MS Miya



9. *Diplacodes trivialis* ♀  
© MS Miya



10. *Neurothemis fulvia* ♂  
© MS Miya



11. *Neurothemis fulvia* ♀  
© MS Miya



12. *Neurothemis intermedia* ♂  
© MS Miya



13. *Orthetrum glaucum* ♂  
© MS Miya



14. *Orthetrum glaucum* ♀  
© MS Miya



15. *Orthetrum luzonicum* ♀  
© MS Miya



16. *Orthetrum pruinosum* ♂  
© MS Miya



17. *Orthetrum pruinosum* ♀  
© MS Miya



18. *Orthetrum sabina* ♂  
© MS Miya



19. *Palpopleura sexmaculata* ♂  
© MS Miya



20. *Palpopleura sexmaculata* ♀  
© MS Miya



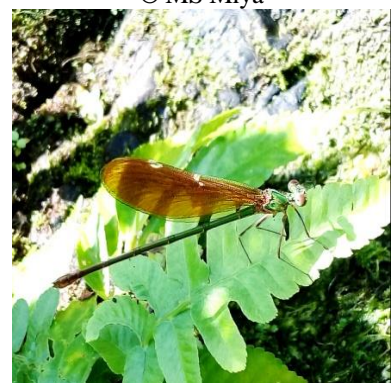
21. *Trithemis festiva* ♂  
© MS Miya



22. *Trithemis festiva* ♀  
© MS Miya



23. *Neurobasis chinensis* ♂  
© MS Miya



24. *Neurobasis chinensis* ♀  
© MS Miya



25. *Vestalis gracilis* ♂  
© MS Miya



26. *Aristocypha trifasciata* ♂  
© MS Miya



27. *Aristocypha quadrimaculata* ♂  
© MS Miya



28. *Aciagrion pallidum* ♂  
© MS Miya



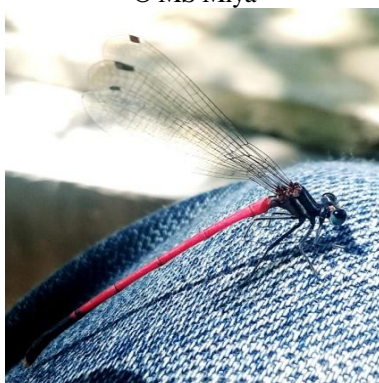
29. *Ceriagrion coromandelianum* ♂  
© MS Miya



30. *Ischnura rubilio* ♂  
© MS Miya



31. *Calicnemia eximia* ♂  
© MS Miya



32. *Calicnemia nipalica* ♂  
© MS Miya



33. *Calicnemia nipalica* ♀  
© MS Miya



34. *Drepanosticta carmichaeli* ♀  
© MS Miya