Article

Study of dragonfly fauna as bioindicator to assess water quality in District Buner, Khyber Pakhtunkhwa, Pakistan

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Abstract

A systematic odonatological survey was conducted to evaluate dragonfly (Odonata) fauna as bioindicators of water quality across twelve selected localities in District Buner, Khyber Pakhtunkhwa, Pakistan. The study was carried out during the summer seasons from 2021 to 2022. Findings indicate that odonate species exhibit distinct habitat preferences closely linked to specific physicochemical water parameters. The presence of unpolluted aquatic habitats was observed to significantly enhance odonate diversity and persistence by reducing ecological disturbances. A total of 616 dragonfly specimens were collected across the study sites. These were identified as 21 species belonging to 12 genera and 4 families. The family Libellulidae was the most abundant, representing 75.16% of the collected specimens and comprising 15 species across 7 genera. This was followed by Gomphidae (15.25%, 3 species, 3 genera), Aeshnidae (9.41%, 2 species, 1 genus), and Corduliidae (0.16%, 1 species, 1 genus). *Orthetrum coerulescens* subsp. *anceps* (Schneider, 1845) was identified as the most abundant species, whereas *Macromia moorei* (Selys, 1874) was recorded as the rarest.

Keywords Odonata; dragonfly; Libellulidae; bioindicator; water quality; Buner.

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1 Introduction

Dragonflies are an ancient group of insects, that evolved long before dinosaurs (Ahsan et al., 2019). They are strong flyers that spend dual life style, aquatic as naiads and terrestrial as adults (Islam et al., 2024). The life cycle of a dragonfly is completed in three stages – egg, larva, and pupa – all of which take place within aquatic ecosystems (Hayat et al., 2023). Their life cycle is fundamentally amphibiotic, with an aquatic larval stage

followed by a terrestrial adult phase, creating an intrinsic link between freshwater and terrestrial ecosystems. This dual dependency makes them exceptionally sensitive to environmental changes, particularly water quality, temperature fluctuations, and habitat disturbance. Consequently, the presence of odonates is considered a reliable indicator of ecological health across aquatic and riparian-terrestrial ecosystems (Zia et al., 2011). They also deliver diverse benefits to human populations, including preying on pest insects, serving as indicators of drinking water quality, suppressing the larvae of disease-carrying mosquitoes, and acting as biocontrol agents in agriculture (Zia et al., 2018). They also occupy a central role in food webs, serving as prey for various species. Despite their ecological utility and established role in European conservation planning, comprehensive documentation of their diversity and distribution remains inadequate in many regions. This study focuses on employing dragonfly fauna as bioindicators to assess aquatic habitat degradation in District Buner, Khyber Pakhtunkhwa. The region faces severe anthropogenic pressure from over 600 operational marble factories, the highest concentration in the province. These industries discharge untreated effluent—containing suspended solids, heavy metals, minerals, and chemicals—directly into natural waterways, critically threatening aquatic biota, including odonate larvae. Concurrently, particulate and chemical air pollution from these operations impairs the terrestrial adult stage. The primary objectives of this research are to document the dragonfly diversity of District Buner and utilize their community structure as a biological index to evaluate the impact of industrial pollution on local water quality.

2 Materials and Methods

2.1 Study area

Buner is located between 72-10 and 72-47° E longitude; 34-09 and 34-43° N latitude (Naveed Akhtar et al., 2018; Fig. 1). District Buner is a region of Malakand Division, Khyber Pakhtunkhwa which is mostly hilly areas. Buner is bordered by Swabi and Mardan in south, Swat in north, Shangla in east and Malakand agency in west (Saeed et al., 2016). In 2017, the entire population of District Buner is 897,319. The normal temperature is 19 to 30 °C. The assortment of annual rain falls in Buner between 672 and 1198 mm (Anwar et al., 2021). Monsoon rains for the period of summer (July to October) whereas in winter (December to March) snow on the mountain peaks is also very common. The temperature in summertime gradually increases to 44 ˚C and in winter it progressively falls to -2 ˚C (Khan et al., 2015). District Buner is divided into six tehsils (Kumar et al., 2023). Buner comprises of Tehsil Khodokhail, Mandanr, Gadeze, Daggar, Gagra and Chagharzi. The Daggar is the head quarter of the district (Jehangir et al., 2015).

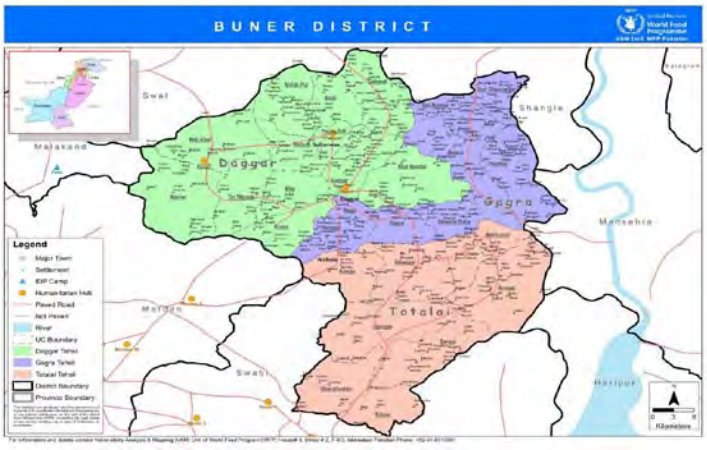

Fig. 1 District Buner (Zahidullah et al., 2016).

2.2 Insect collection

Dragonfly (Anisoptera) specimens were collected from the localities in District Buner, including Chinglai, Mangal Thana, Kawga Camp, Kankowai, Bar Kaly, Tango Pul, Pandair, Gul Bandi, Hisar, Karapa Barandu, Jowar, and Pir Baba using aerial nets between 9:00 am and 5:00 pm. A random field sampling technique was employed to ensure comprehensive coverage of the entire study area. Adults were sampled from a variety of aquatic habitats, including lotic systems (streams, canals, rivers) and lentic environments (pools, wetlands, swamps, marshes, springs), as well as adjacent field crops. Specimen collection followed the methodology described by Orr and Hämäläinen (2003). As noted by Orr (2013), the nets used were strong yet lightweight, featuring a 2-foot (24-inch) grip and an open-mesh net approximately 25 cm in diameter designed to minimize air resistance. This allowed the net to be swung swiftly to capture flying dragonflies.

2.3 Preservation of specimens

Collected dragonfly specimens were individually pinned using odonatological pins, positioned on setting boards to extend appendages, and dehydrated. They were then stored in wooden insect boxes with naphthalene balls and Coopex powder for protection. Specimens are housed in the insect museum of Islamia College Peshawar and the National Insect Museum (NIM), NARC, Islamabad.

2.4 Identification of specimens

Specimens were collected using aerial nets and brought to National Insect Museum for identification. All specimens of dragonflies were observed and documented up to species rank with the assistance of old and up-to-date accessible works by Fraser (1933-36) and Chaudhry (2010) In addition, well-known dragonflies species were also confirmed with the assistance of identified dragonflies species previously housed at NIM, NARC Islamabad, Pakistan.

2.5 Physico-chemical parameters

Water samples were collected in sterilized polyethylene bottles and stored at 4°C. Field measurements included temperature, pH, conductivity, turbidity, and TDS using portable instruments. Additional parameters (alkalinity, hardness, calcium, magnesium, chloride) were analyzed in the laboratory following APHA (1998) standards.

2.6 Data analysis

Biodiversity indices of dragonfly were calculated using Paleontological Statistics Software Package (PAST 3). The species diversity, evenness and an actual number of dragonfly species were calculated and determined using different indices, i.e. Simpson, Shannon, Evenness, Margalef, Dominance, Equitability. These all were used as species diversity index to compare various sampling localities of dragonfly. The entire individuals of dragonfly were manipulated and tabulated at each sampling point.

3 Results

The present odonatological survey of dragonfly fauna as bioindicator to assess water quality from twelve different localities of District Buner, Khyber Pakhtunkhwa province of Pakistan. This survey deliberated the first one. In current study a total of 616 specimens of dragonfly were collected.

3.1 Family wise distribution of dragonfly species and genera of Buner District

During the current exploration study 21 species with 12 genera of 4 families were reported in District Buner which are shown in figure 2. The family Libellulidae was the most prevailing number of 15 species with 7 genera, Gomphidae 3 species with 3 genera, Aeshnidae 2 species with 1 genera and family Corduliidae have only 1 species.

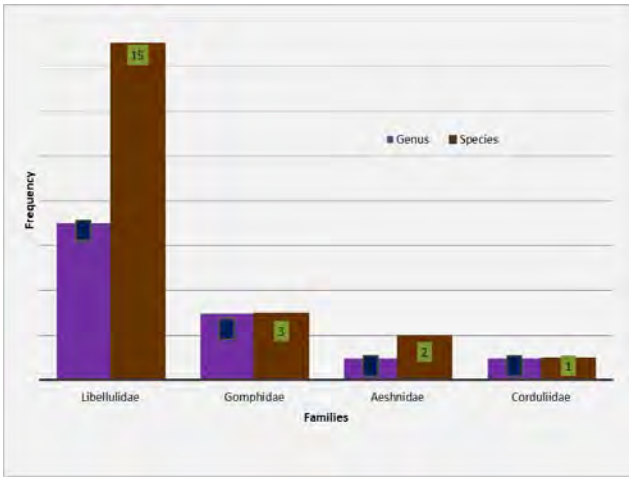

Fig. 2 Family wise distribution of genera and species of dragonfly.

Table 1 Rank list of dragonfly species from different localities of District Buner.

S. No	Name of Species	Chi	Man	Kaw	Kan	Bar	Tan	Pan	Gul	Kar	His	Pir	Jow
1	*Brachythemis contaminata Fabricius* (1793)	2	3	-	4	2	5	5	2	3	6	3	-
2	*Pantala flavescens* Fabricius (1793)	3	-	1	-	-	-	4	3	-	2	2	5
3	*Trithemis aurora* (Burmeister, 1839)	1	4	3	5	3	1	7	2	4	2	-	2
4	*Trithemis festiva* (Rambur, 1842)	3	3	1	1	3	-	6	2	1	3	4	3
5	*Orthetrum purinosum luzonicum* (Brauer, 1868)	4	2	-	3	5	3	4	3	2	1	3	1
6	*Orthetrum cancellatum (*Linnaeus, 1758)	2	3	3	2	4	2	3	1	-	-	3	4
7	*Orthetrum purinosum neglectum* (Rambur, 1842)	4	2	2	1	2	-	3	2	3	3	6	-
8	*Orthetrum coerulescens anceps* (Schneider,1845)	6	5	4	3	1	1	9	1	2	4	2	3
9	*Orthetrum triangulare* (Selys, 1878)	3	3	-	1	4	3	4	2	4	5	-	4
10	*Diplacodes trivialis* (Rambur, 1842)	1	-	3	-	1	1	2	1	5	3	7	2
11	*Diplacodes lefebvrei* (Ramber1842)	-	3	1	4	3	2	3	-	3	3	3	5
12	*Sympetrum hypomelas* (Selys, 1884)	1	2	3	6	1	-	3	1	2	2	2	2
13	*Sympetrum meridionale* (Selys, 1841)	2	4	5	7	-	2	4	2	-	4	4	3
14	*Sympetrum commixtum* (Selys, 1884)	-	6	2	2	3	4	6	2	2	7	3	2
15	*Crocothemis servilia* (Drury, 1770)	2	3	2	2	3	1	3	1	4	3	3	-
16	*Burmagomphus sivalikensis* (Laidlaw, 1922)	1	5	2	1	-	2	4	3	6	6	2	3
17	*Onychomphus bistrigatus* (Selys, 1854)	-	4	-	-	2	-	6	-	2	4	5	6
18	*Mesogomphus lineatus* (Selys, 1850)	1	3	3	1	-	1	7	2	2	4	6	-
19	*Anax Parthenope* (Selys, 1839)	3	6	3	2	2	-	2	2	2	5	1	4
20	*Anax immaculifrons* (Rambur, 1842)	2	5	1	1	3	1	3	1	1	5	2	1
21	*Macromia moorei (*Selys, 1874)	-	-	-	-	-	-	-	-	-	1	-	-
	Sub-total	**41**	**66**	**39**	**46**	**42**	**29**	**88**	**33**	**48**	**73**	**61**	**50**
	Total	**616**											
	Percentage %	6.6	10.7	6.3	7.4	6.8	4.7	14.2	5.3	7.7	11.8	9.9	8.1

Key: Chinglai: Chi; Mangal Thana: Man; Kawga Camp: Kaw; Kankowai: Kan; Bar Kaly: Bar; Tango Pul: Tan; Pandair: Pan; Gul Bandi: Gul; Karapa Barandu: Kar; Hisar: His; Pir Baba: Pir; Jowar: Jow.

3.2 Seasonal variation of dragonfly (Odonata) in District Buner

In present survey a total of 616 specimens were collected in the duration of summer season of 2021-22. The seasonal variation of dragonfly specimens was shown in the Fig. 3.

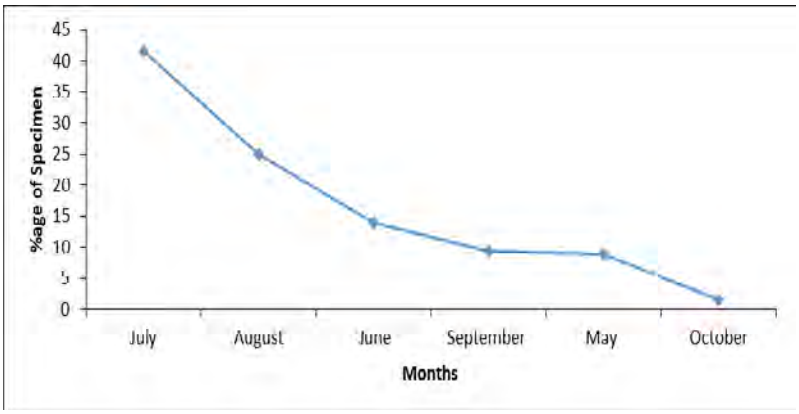

Fig. 3 Seasonal variation of dragonfly specimens.

3.3 Species richness of dragonfly families reported in Buner District

A total of 4 families were recorded. Family Libellulidae showed highest number of samples (463) which was (75.16%), family Gomphidae 94 specimens which was (15.25%), family Aeshnidae 58 specimens which was (9.41%), and Corduliidae with 1 specimens which was (0.16.%). Species richness to each family were presented in Fig. 4.

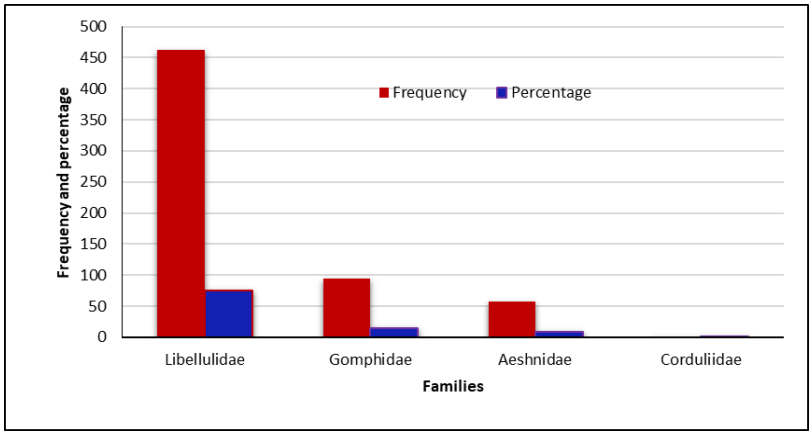

Fig. 4 species richness of dragonfly families.

3.4 Biodiversity and statistical analysis of dragonfly

In order to find out the dragonfly diversity index, different indices were used for diversity of dragonfly i.e. Dominance, Simpson, Shannon, Evenness, Margalef, and Equitability. Overall statistical analysis for diversity of dragonfly is summarized in the Table 2.

Table 2 Dominance, Simpson, Shannon, Evenness, Margalef and Equitability in surveyed localities.

Localities	Dominance_D	Simpson_1-D	Shannon_H	Evenness_e^H/S	Margalef	Equitability_J
Chinglai	0.07674	0.9233	2.69	0.8668	4.309	0.9495
Mangal Thana	0.06198	0.938	2.833	0.9447	4.058	0.9803
Kawga Camp	0.07561	0.9244	2.666	0.8987	4.094	0.9615
Kankowai	0.08601	0.914	2.619	0.8071	4.179	0.9244
Bar Kaly	0.0737	0.9263	2.679	0.9108	4.013	0.9663
Tango Pul	0.09631	0.9037	2.48	0.853	3.861	0.9398
Pandair	0.05863	0.9414	2.914	0.9213	4.244	0.9727
Gul Bandi	0.06336	0.9366	2.819	0.9309	4.862	0.9752
Hisar	0.05986	0.9401	2.892	0.9015	4.428	0.9654
Karapa Barandu	0.07205	0.928	2.725	0.8973	4.133	0.9618
Jowar	0.06799	0.932	2.784	0.8987	4.135	0.963
Pir Baba	0.0752	0.9248	2.668	0.9006	3.834	0.9622

3.5 Physicochemical parameters for assessment of water quality

The study found that dragonfly diversity, richness, and community composition are directly influenced by water quality. Habitat variation and disturbance were assessed using standard measurements of key physicochemical parameters: Temperature, pH, Turbidity, Conductivity, Total Dissolved Solids (TDS), Magnesium, Total Alkalinity, Calcium, Total Hardness, and Chloride. All values are provided in Table 3.

Table 3 Physicochemical parameters for assessment of water quality.

Parameters	Units	Chi	Man	Kaw	Kan	Bar	Tan	Pan	Gul	Kar	His	Pir	Jow
Temperature	Degree Celsius	33.8	30.4	29.9	32.9	31.7	31.5	29	27.8	28.1	27.9	29	32.9
Turbidity	NTU	4.54	2.4	8.27	9.5	9.1	12.1	3.1	2.6	11.8	3.86	9.7	4.69
Conductivity	µS/cm	56	49	68	79	64	108	51	45	82	59	63	61
pH		7.58	7.5	6.96	7.67	7.76	6.69	7.5	6.74	7.05	7.27	6.7	7.29
Chloride	mg/L	40	36	41	46	50	53	34	29	56	27	43	50
Total Alkalinity	mg/L	76	69	119	124	104	184	74	63	168	79	121	83
Total Hardness	mg/L	284	243	345	390	352	467	263	231	403	290	362	312
Magnesium	mg/L	57	55	91	93	87	104	65	43	121	65	101	52
Calcium	mg/L	60	53	85	95	89	121	57	55	113	59	98	63
(TDS)	mg/L	180	165	280	321	297	401	174	162	342	190	289	213

Key: Chinglai: Chi; Mangal Thana: Man; Kawga Camp: Kaw; Kankowai: Kan; Bar Kaly: Bar; Tango Pul: Tan; Pandair: Pan; Gul Bandi: Gul; Karapa Barandu: Kar; Hisar: His; Pir Baba: Pir; Jowar: J.

4 Discussion

The present research investigated to study of dragonfly fauna as bioindicator to assess water quality in District Buner, Khyber Pakhtunkhwa Province of Pakistan during summer season of 2021 to 2022. Twelve different localities of District Buner were selected for dragonfly survey and assessment of water quality for their abundance. Physico-chemical water quality variables were measure of Odanata sampling at each point. The physico-chemical parameters such as Turbidity, Temperature, pH, (TDS) Total Dissolved Solids, Total Alkalinity, Conductivity, Magnesium, Calcium, Chloride and Total Hardness were determined for assessment of water pollution in District Buner. Results suggest that species composition of dragonfly was influenced by various water quality parameters. The most abundant specimens of dragonfly were recorded from Pandair and the least number of specimens were recorded from Tango Pul, which water was polluted. In the locality of Tango Pul, water parameters values were not as recommended by WHO standards. Therefore, the dragonfly diversity was badly disturbed in this area. In addition, if we take the situation of the selected localities

individually, it was may observed in all localities that biodiversity of Odonata was richly increased with improvement in water quality. In current research survey a total of 616 individuals of dragonfly were collected from twelve different localities. Odonatological survey showed that 21 species with 12 genera of 4 families were documented. The family Libellulidae was the most dominant Family. The present research also indicated that habitat variation and disturbance of dragonfly diversity as deliberated by standard variation in the water quality parameters such as Temperature, pH, Turbidity, Conductivity, (TDS) Total Dissolved Solids, Magnesium, Total Alkalinity, Calcium, Total Hardness and Chloride. Biodiversity, species richness and community composition of dragonfly (Odonata) increased with respect to physicochemical water quality. Oxygen is essential in evaluation of water quality since dissolved oxygen (DO) promotes the oxidation and reduction of organic and inorganic substances (Suhardono et al., 2025). Outcome also suggests that improvement in aquatic quality was in proportion with increased Odonate biodiversity. Therefore, Odonates may be suggested as good ecological indicators of water quality.

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References

Ahsan H, Zia A, Abdul Ghaffar SM, Ahmed S, Bhatti AR, Mehmood SA, Saleem R, Iqbal J. 2019. Anisopterous dragonflies of district neelum, azad Jammu and Kashmir Pakistan. Pakistan Entomologist, 41(1): 7-12

Anwar F, Khan M, Salman M, Ahmad S, Ullah F, Khan J, Haq I, Abbas M. 2021. Seroprevalence of hepatitis B virus in human population of district Buner Khyber Pakhtunkhwa Pakistan. Clinical Epidemiology and Global Health, 10: 100688

Chaudhry M. 2010. Systematics of Dragonflies (Anisoptera: Odonata) of Pakistan. Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. Pakistan

Fraser F. 1933-36. The Fauna of British India including Ceylon and Burma (Vols. 1-3). Today and Tomorrow’s Printers And Publishers. Tayler and Francis Ltd, London, UK

Hayat D, Tariq N, Zia SA, Makai G, Wali S, Shahwani F, Hakeem A. 2023. Guardians of Quetta's Skies: Aeshnidae dragonflies explored. Pak-Euro Journal of Medical and Life Sciences, 6(3): 295-302

Islam I, Ullah R, Zia A, Bhatti A, Ilyas M, et al. 2024. Species complexity of order Odonata in district Dir Upper, Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Agricultural Research, 37(1): 56-61

Jehangir K, Zeshan A, Bakht T, Faiz U. 2015. Burden of marble factories and health risk assessment of kidney (renal) stones development in district Buner, Khyber Pakhtunkhwa, Pakistan. Expert Opin. Environ. Biology, 2: 2

Khan J, Shah M, Khan BT, Naeem M, Ismail M, Abbasi A, Khan SA. 2015. A survey of adult and larval mosquito fauna in Tehsil Daggar and Gagra of District Buner, Khyber Pakhtunkhwa, Pakistan. International Journal of Mosq Research, 2(3): 170-174

Kumar L, Kumari R, Kumar A, Tunio IA, Sassanelli C. 2023. Water quality assessment and monitoring in Pakistan: A comprehensive review. Sustainability, 15(7): 6246

Naveed Akhtar NA, Riaz Muhammad RM, Kausar Saeed KS, Khan MF, Muzaffar Shah MS, Jehan Zeb JZ, et al. 2018. Distribution of wild mammalian fauna of Mahaban and Malka valley district Buner. Pakistan. Pakistan Journal of Zoology. DOI: 10.17582/journal.pjz/2018.50.2.sc4

Saeed K, Khattak MNK, Khan F, Naz F, Akhtar N. 2016. Morphological characteristics of ladybird beetles (Coccinellidae: Coleoptera) of district buner, khyber pakhtunkhwa, Pakistan. Pakistan Journal of Zoology, 48(5): 1367-1272

Suhardono S, Sunarhadi MA, Septiariva IY, Rachman HT, Suryawan IWK. 2025. Biomonitoring of Bedog River water quality using dragonfly diversity as bioindicators in Yogyakarta, Indonesia. Nature Environment and Pollution Technology, 24(2): 1-8

Zia A, Din A, Azam I, Munir A, Afsheen S. 2018. Effect of salinity gradients on species composition of Odonata naiads. Arthropods, 7(1): 11-25

Zia A, Naeem M, Rafi MA, Naz F, Afsheen S, Ilyas M. 2011. Damselflies (Zygoptera: Odonata) of Pakistan: Part 1. Journal of Insect Science, 11(1): 102

Zia A, Shabnem B, Mastoi MI, Shehzad A, Ahmed S. 2024. *Aeshna mixta* (Latreille, 1805), a new record for the Odonata (Anisoptera: Aeshnidae) fauna of Pakistan. Arthropods, 13(2): 87-93