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Morphological evaluation of Gomphidae dragonflies of Hazara region Pakistan through principle component analysis

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Abstract
Current study was conducted on Gomphidae dragonflies in Hazara region of Pakistan. A total 125 specimens were collected and identified in to 8 species and 6 genera. Five morphometric parameters were based to evaluate the variations and similarities among species. The results were obtained using the principle component analysis. Components PC1 and PC2 were observed positive correlated with all variables. Highest Euclidean distance was observed (5.14) between *Platygomphus dolabratus* and *Anormogomphus kiritschenkoi*, while the lowest Euclidean distance was found (0.27) between *Onychogomphus biforceps* and *O. bistrigatus*. Cladogram was showed two groups I and II and result of Line plot highly support the cladogram. Case wise variability showed 6 (75%) and 2 (25%) species were conspired in the same region between (0 to +2.5) and (0 to -2.5) respectively. The component/factors variability plot was observed the cumulative share for PC1 (60.60%) and PC2 (36.82%) respectively. Morphometry and its findings are very important for identification purposes.

Keywords: PCA, Gomphidae, Morphometric parameters, Variability, Hazara

1. Introduction
Fish Gomphidae is family of dragonflies belonging to sub order Anisoptera and order Odonata. They are commonly known as Clubtails, body size is medium to large. Their eyes well separated and body with black and yellow colour. Anal appendages of Gomphids dragonflies have characteristic which help in identification of different genera. They inhabit a wide variety of aquatic habitats, but most dwell in running water like rivers and hill streams in forested habitat [1]. Dragonflies are well known bio-control agents and environmental indicators, they possess slender abdomen, large eyes, short antennae and long wings [2]. They are important predators of serious insect pests of crops, fruits and vegetables [3]. Their larvae are also voracious predators and consume mosquito larvae and other small crustaceans in large numbers [4, 5]. Besides this, Gomphids themselves may also be a significant prey of birds, fishes and few invertebrates thereby playing an important component in food chain of these organisms [6]. Previously 13 species were reported of Gomphidae from Pakistan [6, 7]. While from India 90 species of Gomphidae were recorded [8]. Therefore, purpose of the study was to find variation among species of the same as well as different geographical locations on the basis of morphometric parameters. The study will be helpful in determining the environmental influence on morphological characters.

2. Materials and methods
2.1 Study area
Hazara division was selected as study area. The study area is located between 33º-44' and 35º-35' north latitude and between 72º-33' and 74º-05' east longitude (Fig. 1), having 6 districts including newly established Torghar, with a total area of c.18000 Km2. The region is the joining point of Himalayas with Hindukush range providing unique climatic variations responsible biodiversity. Because of variations in topography and vegetation cover, climate shows marked variations. Even with in the same range inner and outer parts contrastingly differ. Altitude varies from less than 500 meters to 5000 meters. Rain fall has been recorded as 500mm in the foot hills reaching up to 1400mm in subtropical zone. In temperate zone it varies from 1500-1800mm.Winter precipitation in the form snow remains prominent [9].
At its eastern side lies the territory of Azad Jammu and Kashmir (AJ&K), at northern end of

Hazara division is present Gilgit and Baltistan (Northern areas of Pakistan) Western border of Hazara division touches the areas of Malakand division At its Southern end comes the Potohar region of Punjab province (Fig. 1).

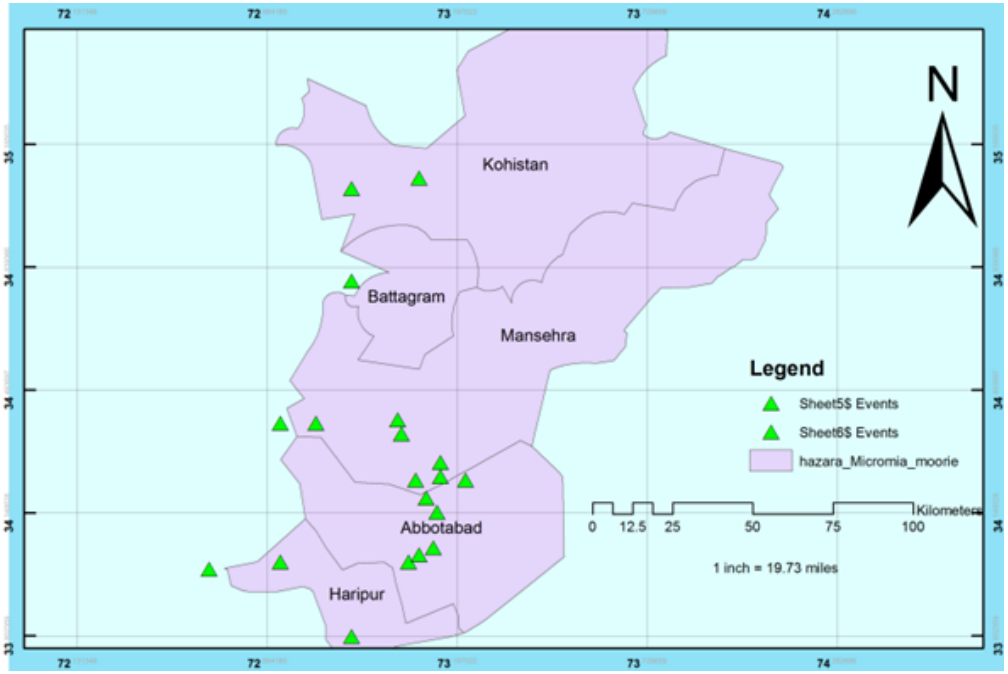

Fig 1: Showing the study area and distribution of species Gomphid dragonflies

2.2 Method of collection and identification

Surveys were conducted during summer season of three consecutive years (2012- 2014) in Hazara region Pakistan. For sampling, methods [10]. With minor additions were followed. Collected specimens were brought to Zoology department, Hazara University Mansehra for pinning and mounting. Preserved specimens were sent to National Insect Museum, National Agriculture Research Centre (NARC) Islamabad for taxonomic identification. Identification was done by Taxonomic keys of [11]. Were followed to identify the collected specimens up to specific level. All identified specimens were deposited in Zoological Museum, department of Zoology, Hazara University Mansehra for future studies.

2.3 Mophometry

Measurements of fore and hind wings, abdomen, superior and inferior anal appendages were done by Divider and Scale method [12].

2.4 Statistical analysis

Statistical analyses of morphometric parameters were done using statistica-7 Ver.7.0 [13] and Past Ver. 1.62 software [14].

3. Results and discussion

The results obtained from the PCA indicated clearly that the increase in the number of factors or components was correlated with the decrease in Eigen values. The values for the different variables were showed that the trend reached its maximum at level of first component (Table1). The percentage contribution of the each factor to the analysis with transformation showed that as in the squared cosines of the factors, it is clear that the first and second factors (PC1 and PC2) have contributed more to the variability and they are indicated by the bold values. Current results as per accordance to the observations of [15]. Basic statistics and correlation values of current studies were significantly agreed with slightly differences to the earlier morphometric analysis as elaborated by [16]. Present findings were similar as previously reported morphometric data of Odonata species by [17, 18].

Table 1: Basic statistics for the morphometric parameters

Traits	PC1	PC2	PC3	PC4	PC5
Eigen value	**3.79**	**0.90**	0.24	0.07	0.00
Cumulative Eigen value	3.79	4.69	4.93	5.00	5.00
%cent of variance	75.87	18.01	4.77	1.30	0.04
Cumulative variance	75.87	93.89	98.66	99.96	100.00

Basic statistics with minimum**,** maximum and standard deviation were presented in (Table 2). It is evident that the first and second factors (FW and AB) were comes up with high variations and were contributed more in PCA analysis, they are indicated by the bold values.

Table 2: Basic statistics for the morphometric parameters

Variable	Valid N	Mean	Minimum	Maximum	Std. Dev.
FW	8	34.75000	25.00000	46.00000	8.908263
ABD	8	38.87500	30.00000	50.00000	9.140764
HW	8	33.12500	24.00000	45.00000	8.773947
SAA	8	3.58750	1.20000	6.00000	1.635706
IAA	8	2.31250	0.50000	6.00000	1.667708

Correlation showed that the factor one (PC1) was positively correlated with the fore wing (FW), hind wing (HW), abdomen (AB) and inferior anal appendages (IAA) while this component has negative correlation with superior anal appendages (SAA). In case of component two (PC2) the correlation with the fore wing (FW), hind wing (HW), abdomen (AB) and inferior anal appendages (IAA) was positive while there was negative correlation of this factor with superior anal appendages (SAA), (Table 3).

Table 3: Correlations among the variables on the basis of morphometric parameters at (p< 0.05)

Variable	PC1	PC2	PC3	PC4	PC5
FW	1.00	1.00	0.98	-0.21	0.03
HW	1.00	1.00	0.97	-0.23	0.03
ABD	0.98	0.97	1.00	-0.14	0.03
SAA	-0.21	-0.23	-0.14	1.00	0.88
IAA	0.03	0.03	0.03	0.88	1.00

Euclidean distance was estimated on the basis of 5 morphometric parameters/factors i.e., length of fore and hind wings, abdomen superior and inferior anal appendages. The highest Euclidean distance was observed (5.14) between *Platygomphus dolabratus* Selys, 1854 and *Anormogomphus kiritschenkoi* Bartenef, 1913, followed by *Mesogomphus lineatus* (Selys, 1850) and *Ictinogomphus rapax*, Rambur, 1844 *O. bistrigatus* Selys, 1854 and *Ictinogomphus rapax* (4.85) and (4.74) respectively. While the lowest Euclidean distance was found (0.27) between *Onychogomphus biforceps* (Selys, 1878) and *O. bistrigatus* Selys, 1854.

Table 4: Euclidean distance matrix on the basis of morphometric parameters

	A.k	***G. t-n***	***I. r***	***I. a***	***M. l***	***O. bif.***	***O.bis.***	***P. d***
A. k	0.00							
G. t-n.	3.49	0.00						
I. r	3.88	1.35	0.00					
I. a	3.99	0.72	1.76	0.00				
M. l	2.90	3.70	4.85	3.83	0.00			
O. bif.	2.09	3.57	4.55	3.79	0.93	0.00		
O.bis.	2.10	3.77	4.74	4.00	0.95	0.27	0.00	
P. d	5.14	3.41	4.68	3.26	3.16	3.84	3.96	0.00

A. k =Anormogomphus kiritschenkoi, G. t-n= Gomphidia t-nigram, I. a= Ictinogomphus angulosus, I. r= I. rapax, M. l =Mesogomphus lineatus, O. bif= Onychogomphus biforceps, O. bis= O. bistrigatus, P.d= Platygomphus dolabratus

Cladogram was constructed on the basis of five variables among 8 species of Gomphid dragonflies. All species were clustered in to two groups I and II, group I comes up under three genera with four species i.e., *Anormogomphus kiritschenkoi* Bartenef, 1913, *Mesogomphus lineatus* (Selys, 1850), *Onychogomphus biforceps* (Selys, 1878) and *O. bistrigatus* Selys, 1854**,** in this cluster *M. lineatus* was found to grouped with genus *Onychogomphus*. Group II clustered in to three genera and four species viz., *Gomphidia t-nigram* Selys 1854, *Ictinogomphus angulosus* Selys, 1854, *I. rapax* Rambur, 1844 and *Platygomphus dolabratus* Selys, 1854 (Fig.1). Phylogram/Cladogram was earlier generated by [19] on the basis of geometric morphometrics data to determined differences/similarities among taxa and suggested as a novel method to visualize morphological variations in a type of profile/shape [20]. was constructed phylogram/cladogram on basis of Color variants among the species of damselflies genus Enallagma.

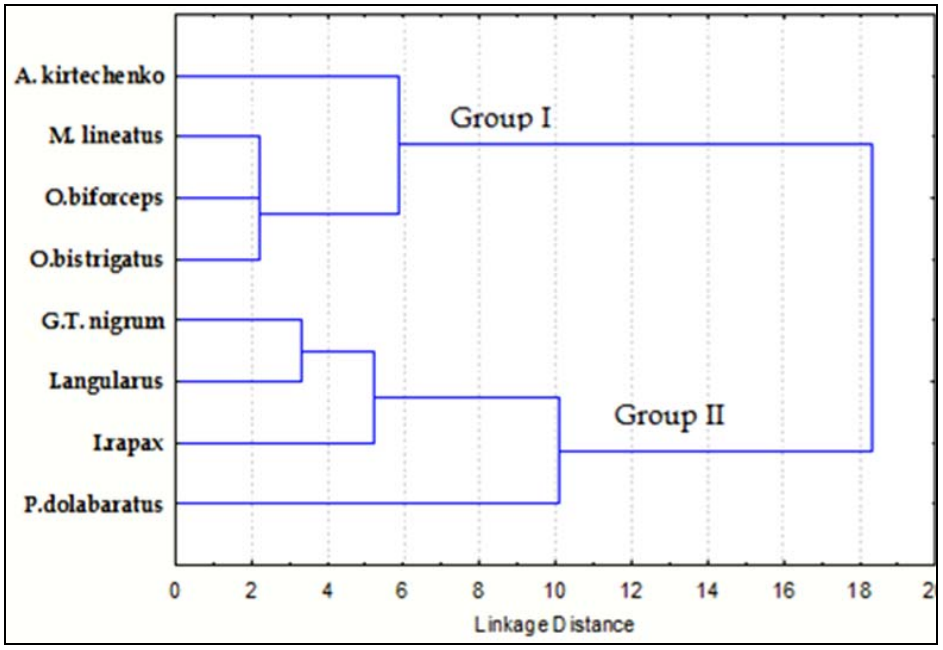

Fig 1: Cladogram constructed on the basis of morphometric variables

Line plot was constructed on basis of five morphometric components i.e., wing (FW), hind wing (HW), abdomen (AB) and inferior anal appendages (IAA) and superior anal appendages (SAA). Four Gomphids dragonflies' species i.e., were observed align in the same line and having similar node at all variables. While remaining four species viz., were observed align in the same line and having similar node at all variables. The result of Line plot highly supported the observations of cladogram (Fig.2). On the basis of variables [21, 22] were evaluated the difference in the population of genus *Ischnura*. The current findings from Line plot as per accordance to the studies of [23], who determined the hybridization of different morphometric variables along with wing spot *Cerigrion splendens.*

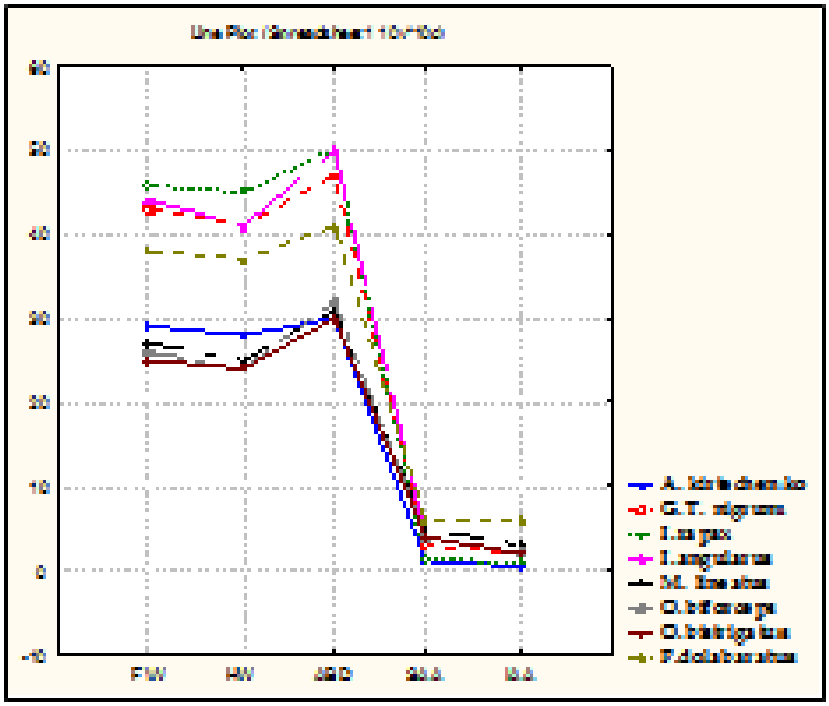

Fig 2: Line plot on the basis of morphometric variables among species.

The case wise (species) based variability plot was also generated on the bases of two principal component (PC1 and PC2). The 8 species of from different geographical location were chosen to generate this plot. The observation plot showed that almost 6 (75%) of the species were plotted in the same region (0 to +2.5) while the remaining 2 (25%) in the same region (0 to -2.5) (Fig. 3A).While alternately this process was repeated on the bases of another two principal component (PC2 and PC3) to constructed plot. The observation plot showed that 5 (62.5%) of the species were plotted in the same region (0 to +2.0) while the remaining 3 (37.5%) in the same region (0 to -2.5) (Fig. 3B). This is clear that component/factors 1 and 2 are more important for such type of elaborations. Present case wise (species) findings based on variability plot as per similar to the observations were reported by [24], while [25]. Elaborated the positive relationships between different variables/parameters of arthropods such as aphids and copepod crustaceans [26]. Studied the morphologically different species Odonata, especially their wing differences [27]. And [28]. Measured different geometric and morphometric sighns of dragonflies species.

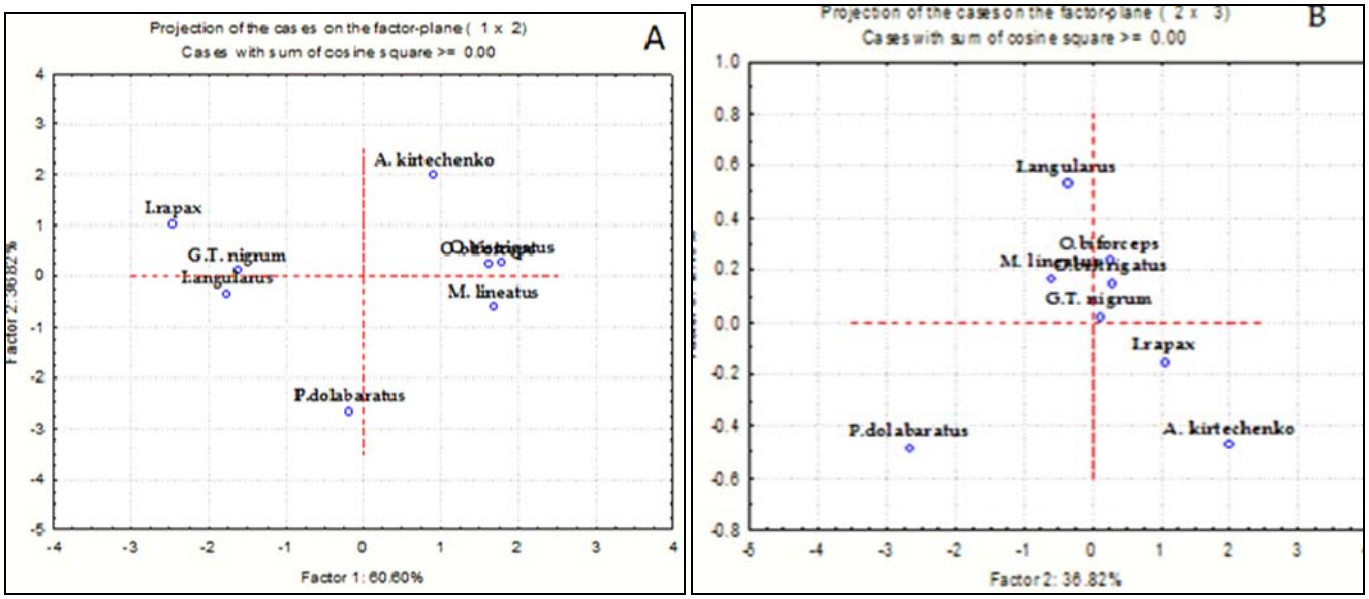

Fig 3(A-B): Species (observations) variability plot on the basis of morphometric variables.

On the basis of variables (Morphometric parameters) the variability plot was generated among the variables. This bi-plot was determined the degree of resembles among the species from different geographical locations. It is evident that PC1 and PC2 factors based graph between the variables were showed the cumulative share of these variables was 97.42% while the PC1 was contributed 60.60% and PC2 was shared 36.82%. It is recorded from the variables plot that on the basis of morphometric parameters all the species were plotted in the same area (0 to +1.0) with slightly differences (Fig. 4A).Present morphometric analysis on basis of PCA as per accordance to the earlier recorded data of [29-32].

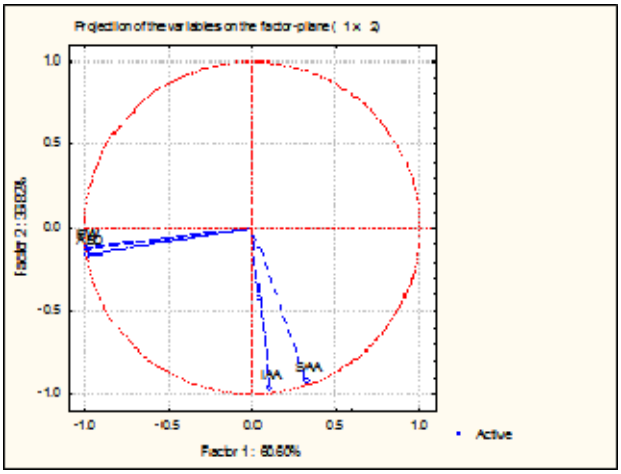

Fig 4A: Morphometric parameters (variables) variability plot

Variability plot was repeated on the bases of another two principal components (PC2 and PC3) to determine the validity of component. It is observed that the cumulative share of these variables was 39.31% while the PC1 was contributed 36.82% and PC2 was shared 02.49% (Fig. 4B). It is strongly clear that component/factors PC1 and PC2 are more valid than PC2 and PC3 for such type of elaborations.

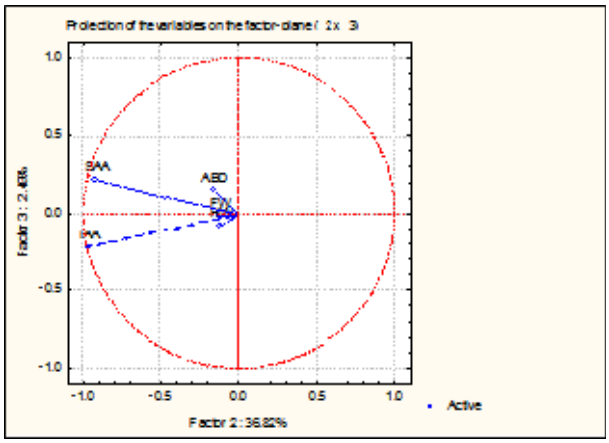

Fig 4B: Morphometric parameters (variables) variability plot

4. Conclusion

These morphometric characteristics may be used in as a determination tools. They make primary imputs into other analysis, e. g. impact of various habitats and environmental variables on phenotype of any taxa such as means in future for monitoring of changing environmental variables.

5. References

1. Rafi MA, Khan MR, Zia A, Shehzad A. Diversity of Odonata in district Poonch and Sudhnoti of Kashmir Valley-Pakistan, with a new record for the country. Halteres. 2009; 1(1):28-35.
2. Dijkstra KDB, Lewington R. Field guide to the dragonflies of Britain and Europe. British Wildlife Publishing. 2006; 3(6):22-29.
3. Zia A, Naeem M, Rafi MA, Hassan SA. A list of damselflies (Zygoptera: Odonata) recorded from Azad Jammu and Kashmir (AJ&K). Pakistan. J of Scientific and Industrial Research. 2008; 51(1):329-332.
4. Din A, Zia A, Bhatti AR, Khan MN. Odonata Naiads of Potohar Plateau, Punjab, Pakistan. Pakistan Journa of Zoology. 2013; 45(3):695-700.
5. Bhatti AR, Zia A, Mastoi MI, Din A, Ashfaque M, Zahid RA. Fenland naiads of Odonata from Tehsil Shakargarh, Punjab, Pakistan. Pakistan Entomologist. 2013; 36(1):35-38.
6. Chaudhry MT. Systematics of dragonflies (Anisoptera: Odonata) of Pakistan. PhD Thesis, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan, 2010.
7. Raza KA. Altitudinal distribution of dragonflies of sub-Himalayan hill tracts of Pakistan. M. Phil Thesis Quaid-e –Azam University Islamabad, 2016.
8. Nair MV. Dragonflies and damselflies of Orissa and Eastern India. Wildlife Organisation Forest and environment department, Government of Orissa, 2011.
9. Majid A, Ahmad H, Saqib Z, Ali H. Potential distribution of endemic Scutellaria chamaedrifolia; Geographic Information System and statistical model approach, Pakistan. Journal of Botany. 2015; 47(SI):51-56.
10. Wahizatul-Afzan Jullia AJ, Amirrudin A. Diversity and distribution of dragonflies (Insecta: Odonata) in Sekayu recreational forest, Terengganu. Journal of Sustainable Watershed Science and Management. 2006; 1(2):97-106.
11. Fraser FC. The Fauna of British India Including Ceylon and Burma. Today and tomorrow's Printers and Publishers. New Dehli-5, 1936, 1-3.
12. Zia A. Biosystematics of damselflies (Zygoptera: Odonata) of Pakistan. Ph.D. Thesis, Deptt. Agric. Entomol, Pir Mehr Ali Shah Arid Agric, Univ, Rawalpindi, Pakistan, 2010.
13. StatSoft Inc. STATISTICA Ver. 7 Software system and data analyzer, www.StatSoft.Com, 2004.
14. Hammer, Harper DAT, Ryan PD. PAST: Paleontological Statistics Software Package for Education and Data Analysis, Palaeontologia Electronica. 2001, 2007; 4(1):9. http://palaeoelectronica.org/2001_1/past/issue1_01.htm.
15. Kaiser HF. The varimax criterion for analytic rotation in factor analysis. Psychometrika. 1958; 23:187-200.
16. Trueman JWH. A preliminary cladistic analysis of odonate wing venation. Odonatologica. 1996; 25:59-72.
17. Westfall MJ, May ML. Damselflies of North America. Gainsville: Scientific Publishers, 1996.
18. Needham JD, Westfall MJ, May ML. Dragonflies of North America (Revised edition). Gainsville: Scientific Publishers, 2000.
19. Mutanen M, Pretorius E. Subjective visual evaluation vs. traditional and geometric morphometics in species delimitation: a comparison of moth genitalia. Systematic Entomology. 2007; 32:371-386.
20. Turgeon JR, Stoks RA, Thum JM, Brown MA, McPeek. Simulataneous Quaternary radiations of three damselfly clades across the Holarctic. American Naturalist. 2005; 165:78-107.
21. Schneider W. Description of Calopteryx waterstoni spec. nov. From northeastern Turkey (Zygoptera: Calopterygidae). Odonatologica. 1984; 13:281-286.
22. Dumont HJ, Demirsoy A, Verschuren D. Breaking the Calopteryx-bottleneck: taxonomy and range of Calopteryx splendens waterstoni Schneider, 1984 and C. splendens tschaldirica Bartenef, 1909 (Zygoptera: Calopterygidae). Odonatologica. 1987; 16:239-247.
23. Heidari H, Dumont HJ. An annotated check-list of the Odonata of Iran. Zool. Middle East. 2002; 26:133-

150.
24. May ML. Allometric analysis of body and wing dimensions of male Anisoptera. Odonatologica. 1981; 10:279-292.
25. Gregory TR, Hebert PDN, Kolasa J. Evolutionary implications of the relationship between genome size and body size in flatworms and copepods. Heredity. 2000; 84:201-208.
26. Dumont HJ. The taxonomic status of *Calopteryx xanthostoma* (Charpentier, (1825) (Zygoptera: Calopterygidae). Odonatologica. 1972; 1:21-29.
27. Giacomini HC, De marco P. Larvae ecomorphology of 13 Libelluliade (Anisoptera, Odonata) of the Middle Rio Doce Valley, Minas Gerais, Brasil. Brazilian. Journal of Biology. 2008; 68(1):211-219.
28. Goretti E, Ceccagnoli D, Laporta D, Giovanni MV. Larval development of Aeshna cyanea (Muller, 1764) (Odonata: Aeshnidae) in Central Italy. Hydrobiologia, Kluwer Academic Publishers. 2001; 457:149-154.
29. Dumont HJ. A note on some dragonflies from Afghanistan. Odonatologica. 1975; 4:243-248.
30. Mayr E. Animal species and evolution. Harvard Univ. Press, Cambridge/MA, 1963.
31. Ricklefs RE, Miles DB. Ecological and evolutionary inferences from morphology: an ecological perspective. In: P.C. Wainwright and S.M. Reilly (Eds.) morphology: integrative organismal biology, Chicago University Press, 1994, 13-41.
32. McPeek MA. Behavioral differences between Enallagma species (Odonata) Influencing differential vulnerability to predators. Ecology. 1990; 71:1714-1726.