

Rainfall intensity impact on biodiversity of benthic macroinvertebrate fauna in stream of Abbottabad district, Pakistan

Wajahat Ali^{1*}, Maria Saba^{2**}, Shumaila Yousef² and Tahir Sarfraz¹

1. Department of Zoology, Government Post Graduate College Mandian, Abbottabad, Pakistan
2. Department of Forestry and Wildlife management, University of Haripur, Khyber Pakhtunkhwa, Pakistan

*Corresponding authors: wajahatalinasir3@gmail.com; mc170201061@gmail.com

ABSTRACT

The present study was designed to observe effect of intensity of rainfall on biodiversity of benthic macroinvertebrate diversity in mountain streams of Abbottabad District, Pakistan. The macroinvertebrates were collected from the River Dorr from March 2019 to April 2019. For sample collection, D-frame kick net and hand search method were used. Standard identification keys, Stereomicroscope and Magnifying glass tools were used for further laboratory analysis. The first three visits were held in March while the last three visits were held in April. A total number of 748 benthic macroinvertebrates belonging to three orders and eight families were recorded. The present study showed that increased rainfall (42.7%) this year in the months of January and February, the river banks were totally eroded due to expansion of river channel as a result of increased flow of water. The flow remained high with changing course of the river Dorr till the end of sampling months. Therefore, there wasn't much diversity encountered.

Keywords: Macroinvertebrate, Rainfall, biodiversity, Ephemeroptera, Mayflies

INTRODUCTION

Biodiversity is 'the variety of life' (Abbasi *et al.*, 2019), high diversity is documented in Pakistan (Roberts, 1991, 1992; Roberts, 1997), while due to anthropogenic impact diversity of flora and fauna is declining gradually (Hussain *et al.*, 2017; Umair, 2018; Fatima *et al.*, 2019; Ali *et al.*, 2020; Altaf *et al.*, 2021a; Altaf, 2021) and every species is bioindicator of ecosystem (Sidra *et al.*, 2019; Khan *et al.*, 2021). Total 1.75 million species of plants, animals and microbes has been estimated so far (Singh *et al.*, 2017). The benthic is utilized to define aquatic insects (Fikri *et al.*, 2016). Microbenthic communities are the livings that present on, or at the bottom of the water body. The benthic fauna are very much diverse and are showed by all phyla from protozoans through large macroinvertebrates to invertebrates (Chowdhary and Sharma, 2013). They are large enough to be seen with naked eye and have no backbone (Meiners, 2016). In an aquatic food chain, benthic macroinvertebrates serve as primary consumers, decomposers and act as a food source for many other invertebrates and vertebrates. Benthos inhabits bottom sediments such as algae, rocks and woody debris for most part of their life. Hyporheic habitats, the area of saturated soil where the mixing of ground water and surface water takes place serve as a source of survival for benthic species during disturbances such as droughts and floods. Benthic habitat is also the source for processing of primary production. Ephemeroptera includes 3000 species of insects and are found everywhere except Artic, Antartic and some oceanic islands (Vilenica *et al.*, 2015). 3500 species of Plecoptera are identified so far (Lancaster and Downes, 2013).

Biodiversity plays an important role in provision of natural services and cultural benefits viz. food (Bale *et al.*, 2008; Aslam and Faiz, 2020; Tariq, 2020), medicine (Khan *et al.*, 2017; Muhammad *et al.*, 2017; Umair *et al.*, 2017; Bashir *et al.*, 2018; Umair and Yaqoob, 2018; Altaf and Umair, 2020; Ijaz *et al.*, 2020; Ijaz and Iftikhar, 2021; Zainab, 2021), entertainment, trade to various human communities (Saleem *et al.*, 2021). It is very important for the sustainability of all life forms on earth. Thousands of plants and animals are edible. Biodiversity also depicts social and cultural values (Abbasi, 2021; Altaf *et al.*, 2021b). Water and energy resource, biological pest control (Saba *et al.*, 2020), genesis of soil, nutrient storage, recycling, climate regulation, photosynthesis, decomposition and pollination through animals among the various services provided by various life forms. Biodiversity also fulfill the purpose of research (Bilal *et al.*, 2021), education and tourism (Aloysius *et al.*, 2020; Khan *et al.*, 2020). Biodiversity also provides food (Ijaz and Faiz, 2021), drugs, ornamental plants and breeding stocks to humans. Most mayfly species are known as sensitive to pollution. Mayflies require high quality water for their existence. Biologists have used their presence or absence in a stream or river, to develop several indices of water quality. Numerous studies demonstrate that mayfly community structure effectively reflects the environmental situation of water courses (Tali *et al.*, 2013; Vijay *et al.*, 2019; Ijaz and Faiz, 2021).

Fresh water ecosystem was considered the most threatened ecosystem. Greater loss in the biodiversity of these ecosystems was recorded during the past few decades. In IUCN red list (2012) about 41% of amphibians, 33 %of coral reefs, 30% of conifers, 25 % of mammals and 13% of birds were considered threatened. Various anthropogenic activities and natural factors are endangering the biodiversity. There are greater threats to biodiversity from degradation, habitat fragmentation, spreading of invasive species, indiscriminate use of natural resources, climate change and aquatic and environmental pollution. About 40% of the world's economy and 80% of needs of the people are being fulfilled by biological resources (Edia *et al.*, 2016; Vijay *et al.*, 2019).

MATERIALS AND METHODS

STUDY AREA

Abbottabad is a district, located in Hazara division of Khyber Pakhtunkhwa (KPK), Pakistan and consist of of 1,967 square kilometers area. The Abbottabad has diverse flora and fauna. Abbottabad is located at the base of Himalayan region and situated between, 73° 35' and 73° 31' East as well as 33° 50' and 34° 23' North. Abbottabad has rocky topography having chiefly of gullies and steep slopes where rocks are divided as metamorphic (Qureshi *et al.*, 2008; Shujahi and Hussain, 2016).

The climate of the city is temperate. The city exists within active monsoon region. It receives 1366.18 mm of rainfall annually with an average relative humidity of 56%. It has higher rate of humidity between the month of July and September. The average minimum temperature is 3 °C and average maximum temperature is 34°C; snowfall is occasional. The average rainfall being 1200 mm/year. Due to heavy snowfall at higher altitudes, winters are comparatively severe resulting in the drop of snowline to 1650m. At the start of 2019, unusual weather conditions have been observed in various parts of the world such as record heat, wild fires, heavy rainfall and snowfall (Qureshi *et al.*, 2008; Raza *et al.*, 2012; NWFC, 2019).

MATERIALS

The materials used for collection of samples were: D –frame kick net (200-500 µm mesh size), Sieves (500 µm mesh size), Forceps, Magnifying lens, Plastic bucket, Big white plastic tray,

70% alcohol for preservation purpose and 100 ml plastic bottles for preserving specimens collected.

The benthic macroinvertebrate collecting by the standard methods of several techniques for monitoring macroinvertebrates but in this research two methods were considered appropriate. Firstly, by kicking in water to disturb bottom substrate and capture dislodged organisms floating downstream with a D Frame net (200-500 μm mesh size), with 500 μm mesh opening size. To standardize the method sampling time (3 minutes), net size, person sampling was kept constant. Along with kick sampling method, 1 min hand search method was also used. Followed the standard procedure specified. Standard identification keys, Stereomicroscope and Magnifying glass tools were used for further laboratory analysis (White *et al.*, 2017).

RESULTS AND DISCUSSIONS

Pakistan has been marked by persistent and unusual weather pattern from January, 2019 to February, 2019. Heavy rainfall and snowfall in the hilly areas has been recorded. During the month of January area weighted rainfall of the country persisted above normal i.e. +20% while during the month of February, it was +61%. On regional basis, area weighted rainfall of the KPK remained above normal i.e. +53% in January while in February it was +22%. KPK has received 45.5mm of the rainfall in January while in February 70.5mm was recorded. On the whole Average minimum temperature was observed all over the Pakistan. Pakistan has experienced five rainy spells during January and four rainy spells in February (NWFC, 2019).

The climate of the Abbottabad city is temperate. The city exists within active monsoon sector. It receives 1366.18mm of rainfall annually with an average relative humidity of 56% (IUCN, 2004). The city has been gripped by heavy rainfall from January, 2019 to February, 2019. The total rainfall recorded in the month of January was 110.11mm with a deviation of 40.3mm from the normal. While in the month of February, total rainfall recorded was 149.52mm with a deviation of 45.1mm from the normal (NWFC, 2019).

IMPACT OF RAINFALL ON BENTHIC MACROINVERTEBRATE ASSEMBLAGES

Intensity of Rainfall has very much impact on the abundance and richness of the benthic macroinvertebrate fauna. During the high rain most individuals could not establish link in their native environment and were flushed out of streams. Due to heavy rain sudden changes in substrate composition were expected to substantially alter FFGs and HTGs (White *et al.*, 2017). Heavy rain influenced substrate composition, and the proportion of large substrate particles. Increased rainfall frequency may lead to a long-term decrease of aquatic organisms. Ephemeroptera is highly sensitive towards any anthropogenic impacts and environmental influence (Fikri *et al.*, 2016).

Table 1: showing the Variations in rainfall patterns from 2019 to April, 2019.

Month	City	Total rainfall	Normal	Deviations
January, 2019	Abbottabad	110.11mm	69.8mm	40.3mm
February, 2019	Abbottabad	149.52mm	104.4mm	45.1mm

Variations in rainfall patterns badly influence the structure and function of aquatic ecosystems such as lakes, rivers, streams and wetlands. Organisms are usually well-habituated to their past weather conditions but abrupt and unusual weather disrupt the structure, distribution and abundance of aquatic communities. Rainfall above 200mm significantly reduces the abundance of the communities and rainfall below 100mm has less impact on the abundance of the communities (Kim *et al.*, 2018) can be seen in table 1.

The water flows from the upper stream (Galliyat) in the lower stream (River Dorr). Water speed is so fast due the heavy rain in upper areas resulting the removal of permanent channels of water, habitat and surface substrates in the down streams. The pressure of water moves the macroinvertebrates from the permanent channel and these organisms shifted to another area along with this water flow. The natural habitat was disturbed and this disturbance provides an opportunity for species to be introduced and survive in new habitats similar effect was observed (Kim *et al.*, 2018).

BENTHIC MACROINVERTEBRATE ASSEMBLAGES

Research work was badly affected by persistent and heavy rainfall during month of January and February, 2019. Samples were planned to be collected from January, 2019 to June, 2019 but the respective task was not accomplished and samples were collected from March, 2019 to April, 2019.

During the study period (March, 2019-April, 2019), total 748 benthic macroinvertebrates belonging to three orders and eight families were recorded. Ephemeroptera was found dominant taxon in terms of both richness and diversity can be seen in table 2. Diptera, hemiptera, coleoptera and plecoptera were not found at all.

Table 2: showing the total number of macroinvertebrate collecting from march, 2019 to April, 2019.

Taxa	Families	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
Trichoptera	Hydropsychidae	4	9	13	2	16	2
	Rhyacophilidae	3	2	5	-	2	-
Diptera		-	-	-	-	-	-
Hemiptera		-	-	-	-	-	-
Odonata	Dragonflies	5	9	24	7	11	2
	Damselflies	-	-	-	-	-	-
Coleptera		-	-	-	-	-	-
Plecoptera		-	-	-	-	-	-
Ephemeroptera	Ephemerellidae	23	30	22	50	53	00
	Baetidae	16	9	22	7	59	19
	Heptageniidae	38	57	74	43	42	13
	Caenidae	9	5	17	7	18	11

Trichoptera, Ephemeroptera and Odonata taxa were in the sampling. Order Ephemeroptera was found dominant taxon in terms of both richness and diversity as compare to other orders same was found (Fikri *et al.*, 2016). Order Ephemeroptera including 4 families i.e, Heptageniidae,

Baetidae, Ephemerellidae and Caenidae has great diversity. Among these four families, Heptageniids and Ephemerellids were found in abundance as compare to other families.

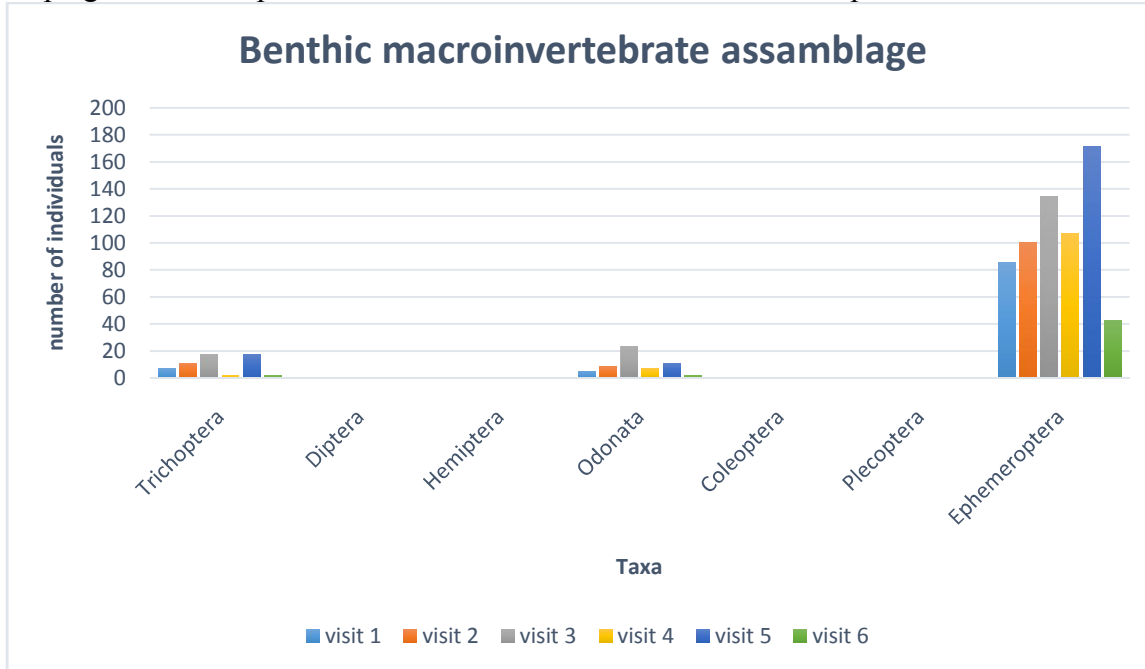


Figure 1: showing the number of benthic macroinvertebrates.

We found insufficient diversity as compare with other studies due to heavy rain in the area. Less number of benthic macroinvertebrate were recorded. During the six visits of this research from March,2019 to April, 2019, total 748 benthic macroinvertebrates belonging to three orders and eight families were recorded, can be seen in figure 1. Ephemeroptera was found dominant taxon in terms of both richness and diversity as compare with other orders, same result was notice in (Fikri *et al.*, 2016).

Increased rainfall has a significant correlation with increased velocity of water in the stream describe in (Kimet al., 2018) which cause the speed of water so fast which cause the removal of many Individual along with water resulting decrease in species diversity. Total 446 Heptageniids and Ephemerellids were recorded in the overall six visits. Disturbance in the habitat affect all the families living in that habitat similar diversity of macroinvertebrate were recorded (Brooks, 2009).

CONCLUSION

The present study showed that increased rainfall (42.7%) this year in the months of January and February, the river banks were totally eroded due to expansion of river channel as a result of increased flow of water. The flow remained high with changing course of the river Dorr till the end of sampling months. Therefore, there wasn't much diversity encountered.

The habitat conditions were not suitable in the river Dorr due to heavy rain in the stream. Heavy rainfall during the research changes the conditions of the habitat. Which increased the velocity of water in the stream that divides the permanent channels of the stream into many small channels. It also caused the removal of many larvae from the permanent channel, resulting in habitat destruction and decrease of species diversity.

Environmental conditions for the sampling of these invertebrates are so important. Sampling after heavy rain also created problems in sampling; good number of individuals was collected during dry days and less diversity was found during rainy days. Our current research visits were held after the rainy days, so the assemblage of macroinvertebrate was disrupted and resulted in low biodiversity of benthic macroinvertebrate communities.

REFERENCES

- Abbasi, A.G.M., S. Nazer, A. Awan, N. Khan, N. Hamid, A.R. Abbasi, M. Altaf. 2019. Assessment of diversity of Butterflies in Dhirkot, Azad Jammu and Kashmir, Pakistan. *Journal of Wildlife and Ecology*. 3: 10-17.
- Abbasi, Z. 2021. Diversity and folklore medicinal uses of mammalian species of Harighal, Azad Jammu and Kashmir, Pakistan. *Journal of Wildlife and Ecology*. 5: 60-65.
- Ali, A., M.S.H. Khan, M. Altaf. 2020. Analysis of anthropogenic activities on avian diversity along the coastal landscape of Sindh, Pakistan *Journal of Wildlife and Ecology*. 4: 94-110.
- Aloysius, N., A. Yousaf, Saira, M. Saba. 2020. Challenges and Opportunities for ecotourism in District Jaffna, Sri Lanka. *Journal of Wildlife and Ecology*. 4: 122-129.
- Altaf, M., A.G.M. Abbasi, S. Adil. 2021a. Anthropogenic impacts on the diversity and distribution of amphibian and reptiles in the vicinity of Dhirkot, Azad Jammu and Kashmir, Pakistan. *Journal of Wildlife and Ecology*. 5: 38-46.
- Altaf, M., A.M. Abbasi, M. Umair, M.S. Amjad, N. Muhammad, K.J. Iqbal, A.M. Khan. 2021b. The usage of freshwater fishes in cultural and folklore therapies among the people along river Jhelum, Punjab, Pakistan. *Journal of Wildlife and Ecology*. 5: 79-99.
- Altaf, M., M. Umair. 2020. Diversity, distribution and medicinal importance of Honeybees in the World-A review. *Journal of Wildlife and Ecology*. 4: 130-141.
- Altaf, S. 2021. Diversity of freshwater fishes in Poonch River Mahseer National Park, Azad Jammu and Kashmir, Pakistan. *Journal of Wildlife and Ecology*. 5: 26-31.
- Aslam, H., M. Faiz. 2020. Ethnopharmacological and modern applications of milk of various mammalian species-a review. *Journal of Wildlife and Ecology*. 4: 211-226.
- Bale, J., J. Van Lenteren, F. Bigler. 2008. Biological control and sustainable food production. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 363: 761-776.
- Bashir, S.M., Z. Rashid, B. Mumtaz, M. Altaf, K. Rauf, R. Haider, B. Safeer, S.I. Farooq, L. Safdar, I. Manzoor, S. Yasrub, A. Iftikhar. 2018. Assessment of behavioral ecology, folklore and medicinal uses of Barn Swallow (*Hirundo rustica*) in district Bagh-Pakistan. *Journal of Wildlife and Ecology*. 2: 13-21.
- Bilal, M., A. Naseer, G.N.K. Piebeng. 2021. A comprehensive note on habitat analyses and new record of jungle cat (*Felis chaus*) from Rawalpindi, Pakistan. *Journal of Wildlife and Ecology*. 5: 66-78.
- Brooks, R.T. 2009. Potential impacts of global climate change on the hydrology and ecology of ephemeral freshwater systems of the forests of the northeastern United States. *Climatic Change*. 95: 469-483.
- Chowdhary, S., K. Sharma. 2013. Evaluation of macrobenthic invertebrates in the longitudinal profile of a river (Tawi), originating from Shivalik hills. *Journal of Global Biosciences*. 2: 31-39.
- Edia, O.E., E. Castella, M.K. Konan, J.-L. Gattolliat, A. Ouattara. 2016. Diversity, distribution and habitat requirements of aquatic insect communities in tropical mountain streams

- (South-eastern Guinea, West Africa). In: Annales de limnologie-international journal of limnology. p 285-300.
- Fatima, S.A., M. Altaf, S. Nazer, A.R. Abbasi. 2019. Study of anthropogenic impacts on snow leopards in district Neelum, Azad Jammu and Kashmir-Pakistan. *Journal of Wildlife and Ecology*. 3: 21-27.
- Fikri, A.H., A.A.C. Shian, S. Harun, K.B. Hee. 2016. Biomonitoring of streams: using Ephemeroptera, Plecoptera and Trichoptera (EPT) in responses to the different types of land use at Tabin Wildlife Reserve (TWR), Lahad Datu, Sabah, Malaysia. *Borneo Science*. 31: 23-36.
- Hussain, A., S. Ali, M. Altaf, A. Hussain, J.I. Qazi. 2017. Length-weight relationships of native Indian major carps from anthropogenically affected segment of the Ravi, Pakistan. *Journal of Wildlife and Ecology*. 1: 1-7.
- Ijaz, S., S. Adil, H. Aslam, R. Kanwal, S. Afsheen. 2020. Human interaction, conflict, threats and role of mammals-A review. *Journal of Ethnomedicine and Ethnoecology*. 1: 1-11.
- Ijaz, S., M. Faiz. 2021. Chemical composition, folk and modern uses of Fats and oil-a review. *Journal of Wildlife and Ecology*. 5: 104-110.
- Ijaz, S., A. Iftikhar. 2021. Chemical composition, ethnomedicinal and industrial uses of bones-a review *Journal of Wildlife and Ecology*. 5: 56-59.
- Khan, A., S. Mehmood, R.A. Khan. 2017. Ethnobotanical study of some wild herb medicinal Xerophytes of district Bannu, Khyber Pakhtunkhwa, Pakistan. *Journal of Wildlife and Ecology*. 1: 37-51.
- Khan, M.S.H., U. Khalid, N.A. Raja, S. Ullah, F. Anjum. 2020. Tourists' prospective about recreation at daman-e-koh and linked hiking trails in Margalla Hills National Park, Islamabad. *Journal of Wildlife and Ecology*. 4: 1-14.
- Khan, R.U., W.A. Panhwar, K.H. Memon, S.A. Larik. 2021. Effects of lead on feathers of grey francolin *Francolinus pondicerianus*. *Journal of Wildlife and Ecology*. 5: 7-12.
- Kim, D.G., T.J. Yoon, M.J. Baek, Y.J. Bae. 2018. Impact of rainfall intensity on benthic macroinvertebrate communities in a mountain stream under the East Asian monsoon climate. *Journal of Freshwater Ecology*. 33: 489-501.
- Lancaster, J., B.J. Downes. 2013. *Aquatic entomology*. OUP Oxford.
- Meiners, J.M. 2016. Biodiversity, community dynamics, and novel foraging behaviors of a rich native bee fauna across habitats at Pinnacles National Park, California. Utah State University.
- Muhammad, N., M. Umair, A.M. Khan, A.R. Abbasi, Q. Khan, A. Khan, M.Z. Awan. 2017. Assessment of the diversity and ethno-medicinal uses of the carps in Punjab, Pakistan. *Journal of Wildlife and Ecology*. 1: 52-60.
- NWFC. 2019. National Weather Forecasting Center Islamabad. Pakistan Meteorological Department. Islamabad.
- Qureshi, S., M. Khan, M. Ahmad. 2008. A survey of useful medicinal plants of Abbottabad in northern Pakistan. *Trakia Journal of Sciences*. 6: 39-51.
- Raza, A., I.A. Raja, S. Raza. 2012. Land-use change analysis of district Abbottabad, Pakistan: Taking advantage of GIS and remote sensing analysis. *Sci. Vis*. 18: 43-49.
- Roberts, T.J. 1991. *The Birds of Pakistan* Oxford University Press. Karachi
- Roberts, T.J. 1992. *The Birds of Pakistan*. Oxford University Press. Karachi.
- Roberts, T.J. 1997. *The Mammals of Pakistan*. Oxford University Press. New York.

- Saba, M., D.S. Awan, S. Yousaf. 2020. Spider as a biological agent in pest control-A Review. *Journal of Wildlife and Ecology*. 4: 27-34.
- Saleem, R., M. Altaf, M. Umair, M.S. Amjad, A.M. Abbasi. 2021. Ethnopharmacological applications of the amphibians and reptiles among the people in the vicinity of Margalla Hill National Park, Islamabad, Pakistan. *Journal of Wildlife and Ecology*. 5: 13-25.
- Shujahi, A.H., A. Hussain. 2016. Economic and Environmental Costs of Tourism: Evidence from District Abbottabad. Islamabad: Pakistan Institute of Development Economics (PIDE).
- Sidra, S., R. Saleem, S. Ghafoor, H. Azeem, I. Imtiaz, Z. Parveen. 2019. Fecal matter as a bio-indicator tool for heavy metal pollution. *Journal of Wildlife and Ecology*. 3: 1-7.
- Singh, R.K., H.-W. Chang, D. Yan, K.M. Lee, D. Ucmak, K. Wong, M. Abrouk, B. Farahnik, M. Nakamura, T.H. Zhu. 2017. Influence of diet on the gut microbiome and implications for human health. *Journal of translational medicine*. 15: 1-17.
- Tali, I., Z. Pir, A. Siddiqui, S. Sharma. 2013. RESEARCH ARTICLE ANALYSIS OF MAYFLIES (INSECTA: EPHEMEROPTERA) AND PHYSICO-CHEMICAL PROPERTIES OF RIVER NARMADA MADHYA PRADESH INDIA.
- Tariq, S. 2020. Chemical composition and traditional uses of eggs of different avian species-A review. *Journal of Wildlife and Ecology*. 4: 45-50.
- Umair, M. 2018. Anthropogenic impacts on the coastal wetland and wildlife-A review. *Journal of Wildlife and Ecology*. 2: 30-36.
- Umair, M., Z. Rashid, N. Muhammad, A. Khan. 2017. Study of diversity and ethnomedicinal plants of head Khanki, Pakistan. *Journal of Wildlife and Ecology*. 1: 25-36.
- Umair, M., M. Yaqoob. 2018. Traditional medicinal uses of honey in the district Gujranwala, Punjab, Pakistan. *Journal of Wildlife and Ecology*. 2: 11-19.
- Vijay, S., S.A. Khan, A. Kusk, A.M. Solgaard, T. Moon, A.A. Bjørk. 2019. Resolving seasonal ice velocity of 45 Greenlandic glaciers with very high temporal details. *Geophysical Research Letters*. 46: 1485-1495.
- Vilenica, M., J.-L. Gattolliat, Z. Mihaljević, M. Sartori. 2015. Croatian mayflies (Insecta, Ephemeroptera): species diversity and distribution patterns. *ZooKeys*. 99.
- White, J.C., D.M. Hannah, A. House, S.J. Beatson, A. Martin, P.J. Wood. 2017. Macroinvertebrate responses to flow and stream temperature variability across regulated and non-regulated rivers. *Ecohydrology*. 10: e1773.
- Zainab, S. 2021. Antibacterial and antibiofilm activity of Bull frog *Hoplobatrachus tigerinus* skin extract. *Journal of Wildlife and Ecology*. 5: 32-37.