Research Article

# Quantifying Pattern of Recorded Biodiversity Observations in Khyber Pakhtunkhwa from GBIF Database

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**Abstract** | This paper analyzes species occurrence data obtained from multiple sources through the Global Biodiversity Information Facility (GBIF) to understand the distribution and density of recorded biodiversity observations patterns in Khyber Pakhtunkhwa (KP), Pakistan. The dataset includes 4,638 observations with spatial coordinates available. The data was analyzed using MS Excel and ArcGIS. The sources of observations include iNaturalist, the Natural History Museum, United Kingdom, Cornell University Lab of Ornithology, and the Paleobiology Database. The types of observations recorded in the dataset are fossil specimens, human observations, material samples, and preserved specimens. Fossil specimens contribute 3.66% observations, providing insights into past biodiversity and evolutionary history. Human observations comprise 31.86% records, representing direct sightings or visual identifications made by researchers and citizen scientists. Material samples account for 63.20% observations and are collected for genetic, morphological, or ecological analysis. Preserved specimens contribute 1.27% records and undergo preservation techniques for scientific study. The analysis of year-wise observations reveals an increasing trend in recorded observations from the 1980s to the early 2010s. The year 1984 stands out with a significant leap in data collection efforts. The years 2012 and 2013 demonstrate a notable surge in recorded observations, followed by a gradual decrease in subsequent years. However, there are fluctuations and variations in different years, indicating potential variations in data collection intensity or other factors influencing observation counts. Month-wise observations show a seasonal pattern, with higher counts during the summer months (June, July, and August) and a decrease towards the end of the year and the beginning of the following year. June and July exhibit the highest counts, suggesting increased fieldwork and data collection efforts during the warmer seasons. In the spatial analysis Swat, Peshawar, Shangla, Kohistan, Mansehra and Abbottabad were identified as the hotspots in Khyber Pakhtunkhwa. The study acknowledges limitations, including reliance on GBIF data, potential data quality issues, and incomplete coverage of occurrences. To overcome these limitations, future research is recommended to incorporate additional data sources, conduct spatial and temporal analyses, implement data validation protocols, focus on species-specific investigations, and integrate contextual information.

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## Introduction

Khyber Pakhtunkhwa (KP) is a region in Pakistan renowned for its remarkable biodiversity and natural beauty. The province's diverse topography, encompassing high mountains, rolling hills, and fertile plains, provides a multitude of habitats that support a wide range of flora and fauna (CBD, 2022; Marwat *et al*., 2011). The remarkable variety of species found in KP includes several key representatives that contribute to the region's ecological significance and cultural heritage. Among the iconic species in KP, the Himalayan Snowcock, Gray Wolf, Snow Leopards, Common Leopards, Pheasants, and the national animal of Pakistan, the Markhor, hold a prominent place (Ali and Ripley, 1983). These species are not only significant from a conservation perspective but also contribute to the region's natural heritage and ecological balance. Other notable mammalian species found in KP include the Asiatic Black Bear, the Red Fox, the Rhesus Monkey, and the Gray Langur, adding to the province's rich biodiversity (Khan, 1999).

The high-altitude areas of KP provide ideal habitats for numerous avian species. Among these species, the Himalayan Griffon, Golden Eagle, and Lammergeier are particularly noteworthy. These birds of prey contribute to the ecological balance of the region and are indicators of the overall health of the ecosystem. KP also hosts a diverse range of reptiles, including the Monitor Lizard, Indian Cobra, and Saw-Scaled Viper, which are adapted to the region's varied habitats (Khan, 1999). These reptiles play vital roles in the ecosystem, and their presence reflects the ecological diversity and balance within KP. The rivers and streams that flow through KP provide a suitable environment for various freshwater fish species, contributing to the aquatic biodiversity of the region (Rehman *et al*., 2015). The conservation of these aquatic ecosystems is essential to maintaining the health and integrity of KP's water resources.

Recognizing the significance of the region's biodiversity, KP has established a number of protected areas, including Chitral Gol National Park, Broghil National Park, Ayubia National Park, Lulusar Dudipsar National Park, Lake Saif ul Malook National Park, Sheikh Badin National Park, Malakandi National Park, Nizampur National Park, and Kamal Ban National Park (KPK Wildlife Department, 2023). These protected areas serve as important sanctuaries for the conservation of the region's unique flora and fauna, ensuring their long-term survival and contributing to the overall ecological balance of KP. KP, Pakistan is blessed with a diverse array of flora and fauna. Its varied topography and rich ecosystems provide ideal habitats for numerous species, including iconic mammals, birds, reptiles, and freshwater fish. The establishment of protected areas in the region demonstrates a commitment to conserving the unique biodiversity found within KP.

*Issues of biodiversity of KP*

Despite conservation and management efforts, the biodiversity of KP is threatened by human activities such as deforestation, overgrazing, and the construction of dams, which have led to a loss of habitats and a decline in the populations of many species (Khattak *et al*., 2022; NBSAP, 2017). The biodiversity of KP is facing several threats due to human activities such as deforestation, land use changes, and climate change. To address these issues, it is important to have a better understanding of the biodiversity of KP and the factors that are affecting it. In recent years, there has been an increasing focus on the use of digital technologies to collect and share biodiversity data. However, there are still several gaps and lags in the digital accessible knowledge of biodiversity (Compains, 2018).

One of the major issues facing the biodiversity of KP is land use change. Land uses changes can significantly impact ecosystem services and alter the land surface structure (Xu and Xiao, 2022). Deforestation is another major issue that is affecting the biodiversity of KP. The province has lost a significant amount of forest cover over the years due to human activities such as logging and land clearing for agriculture and settlements. Climate change is also having an impact on the biodiversity of KP, with rising temperatures and changing rainfall patterns affecting the distribution and abundance of species (Syariah and Ilmu, 2016). KP is an important region for the conservation of biodiversity in Pakistan, and efforts must be made to protect and preserve its unique flora and fauna for future generations to enjoy (Gohar *et al*., 2021).

*Research gaps*

There are still several gaps in our understanding of the biodiversity of KP despite the increasing use of digital technologies to collect and share biodiversity data.

For example, there is a need for more research on the spatial distribution and hotspot identification issues related to the fitness-for-use of online accessible data (Compains, 2018). Additionally, there is a need for more research on the effects of land use changes on biodiversity in KP, including changes in land use area, pattern, and spatial pattern at different scales (Xu and Xiao, 2022). Finally, there is a need for more research on the effectiveness of conservation policies and programs in protecting the biodiversity of KP.

*Aims and objectives*

This article examines the biodiversity richness distribution of the KP province using the GBIF open-source database of animal biodiversity and recommends areas of conservation prioritization. The following are the aims and objectives.

- To collect and analyze relevant data from GBIF database, focusing on species
- occurrence records in KP, Pakistan.
- To identify biodiversity hotspots in KP, Pakistan using reported data from GBIF
- (Global Biodiversity Information Facility).
- To utilize GIS (Geographic Information System) mapping techniques for the analysis
- and visualization of the identified biodiversity hotspots.
- Provide recommendations for conservation efforts and biodiversity management based
- on the identified hotspots, aiming to support sustainable development in KP, Pakistan.

## Materials and Methods

*Study area*

The Khyber-Pakhtunkhwa Province is supposed to be the total coverage area for the project activities. It is located between 31°4' and 36°57' N. latitude and 69°16' and 74°7' E. longitude. The province's total area, including newly merged areas, is 128,961 sq. km. The region has a diverse landscape with dry, rocky areas, vast barren plains in the South, low hills in the middle and high mountains, and green plains in the north. The area is land to mighty mountain ranges. The lesser Himalayas are situated in the eastern corner, whereas the Hindukush ranges occupy its western borders with Afghanistan and Central Khyber Pakhtunkhwa.

*Data collection and analysis*

The data utilized in this study was obtained by filtering and downloading relevant information from the Global Biodiversity Information Facility (GBIF) (GBIF, 2022). The dataset was subsequently processed and analyzed to investigate various aspects of biodiversity presence. To gain insights into the taxonomic distribution of recorded observations, the data was segregated and visualized based on phylum, class, day, month, year, type, and source of the observations. This allowed for a comprehensive understanding of the taxonomic composition and temporal trends within the dataset. Chi square statistics was applied to all categories of observations to determine whether there is a significant association between categorical variable in the dataset.

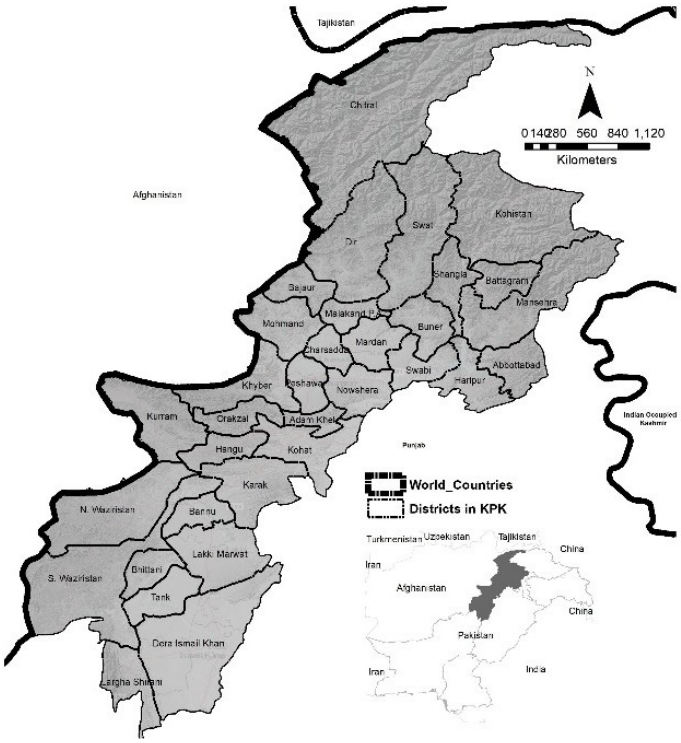


**Figure 1:** *Study area.*

In order to map the spatial patterns of the recorded observations, spatial data was generated in an Excel sheet by incorporating the latitude and longitude coordinates of each observation. The spatial data was then plotted in the WGS 1980 coordinate system using ArcGIS 10.8, a widely used geographic information system (GIS) software (ESRI, 2001). To quantify and visualize the density of the biodiversity patterns across the study area, the Point Density tool within the Spatial Analyst extension of ArcGIS 10.8 was employed. This tool facilitated the creation of a raster layer representing the densities of the biodiversity patterns, enabling the identification of areas with higher concentrations of recorded observations.

## Results and Discussion

*Sources of observations*

The GBIF dataset utilized a total of 4638 observations with spatial coordinates, focusing on biodiversity presence points within KP. These observations were contributed by several reputable sources including iNaturalist (2014), the Natural History Museum in the United Kingdom, Cornell University Lab of Ornithology (2022), and the Paleobiology Database (Alroy, 2014).

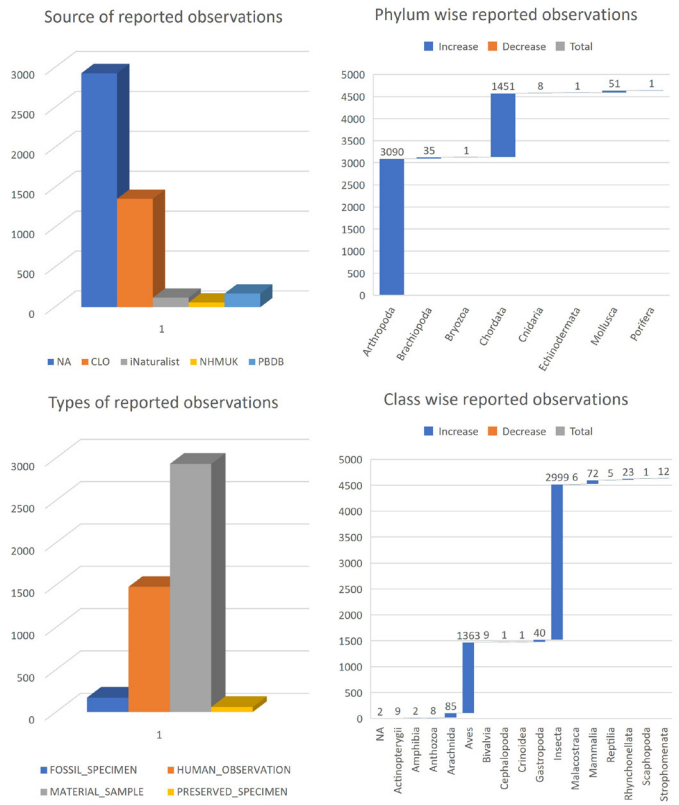


**Figure 2:** *Source, Phylum, Type and class wise cases respectively*

*Types of observations*

The dataset classified observations into four distinct types. Fossil specimens, totaling 170 observations, were derived from preserved remains or traces of ancient life, offering insights into historical biodiversity and evolutionary trends. Human observations, comprising 1478 instances, involved direct sightings or visual identifications by researchers or citizen scientists. Material samples accounted for 2931 observations, involving biological specimens collected for analysis or study, crucial for genetic, morphological, or ecological research. Lastly, preserved specimens included 59 observations of organisms preserved through various techniques for scientific examination.

*Year wise observations*

Analysis of observations from the early 1960s to 2019 showed variable annual data collection trends. The early years (1960s-1970s) recorded low activity, with sporadic observations. A notable increase began in the 1980s, with 1984 marking a significant peak of 273 observations. The trend continued with fluctuations; the early 2010s saw a surge, peaking in 2013 with 1301 observations. Post-2013, a gradual decline in observation frequency was noted, concluding with 94 observations in 2019.

*Month wise observations*

Seasonal analysis revealed a pattern in data collection, with low activity at the year's start and end, and a peak during summer months. June and July recorded the highest observations, indicating intensified fieldwork likely due to favorable weather conditions. The other months showed varying levels of activity, with the lowest in March (6 observations) and significant peaks in April (183) and May (249).

*Day wise observations*

Day-to-day data showed highest activity on Days 17, 18, and 19 each month, suggesting targeted data collection periods. Other days, like day 3 and day 4, showed considerably lower counts. The overall daily data exhibited irregularities, with no consistent trend across the month, indicating sporadic data collection events rather than a steady daily effort.

*Species diversity in recorded observations*

At the phylum level, Arthropoda recorded the highest observations, indicating a focus on this diverse group, including insects and crustaceans. Chordata, including vertebrates like birds and mammals, also had substantial observations. Lesser attention was given to other phyla like Mollusca and Echinodermata, suggesting potential areas for further research. At the class level, Insecta and Aves were prominently observed, reflecting specific interests in insects and birds, respectively.

*Spatial pattern of recorded observations*

Spatial analysis highlighted Balakot as a significant hotspot with the highest occurrences, suggesting its ecological or geographical importance. Other areas like Shogran and Manglawer also showed high density, indicating key locations for biodiversity data. Conversely, regions like Bahrain and D.I. Khan showed minimal occurrences, highlighting the uneven

spatial distribution of data collection across KP.

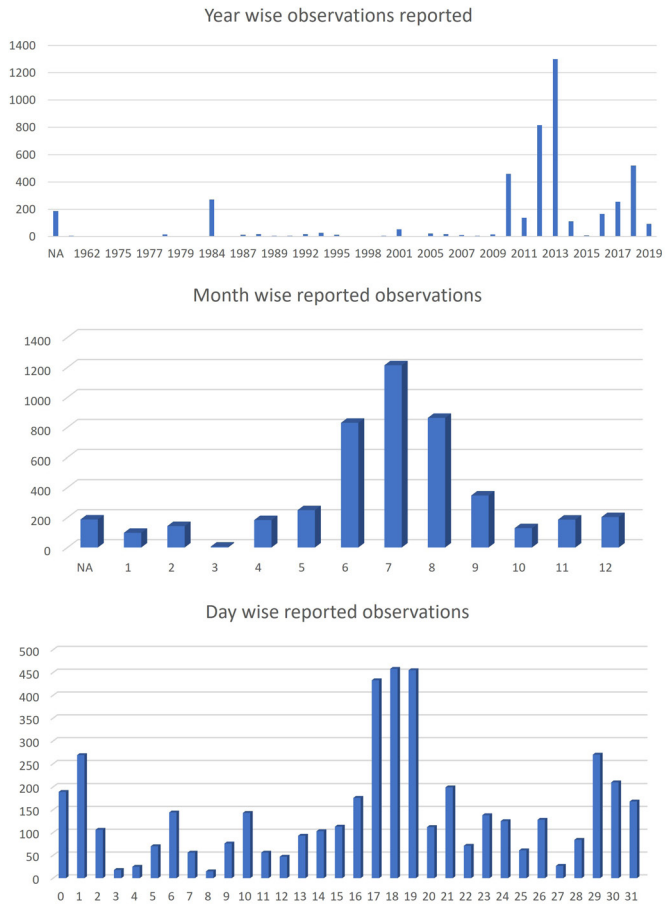


**Figure 3:** *A, B and C Year, Month and Day wise observations, respectively.*

**Table 1:** *Chi square test results.*

| Dataset | Chi- Sq value | P-value |
|---|---|---|
| class | 32,867.87 | 0 |
| day | 3,057.91 | 0 |
| month | 4,300.02 | 0 |
| phylum | 15,469.62 | 0 |
| source | 6,661.81 | 0 |
| type | 4,682.94 | 0 |
| year | 21,683.87 | 0 |

Table 1 presents the outcomes of Chi-square tests for various categorical variables in a species dataset, with each showing highly significant results (p-value = 0) across categories like class, day, month, phylum, source, type, and year. The large Chi-square values (ranging from 3,057.91 for 'day' to 32,867.87 for 'class') indicate that these variables are strongly associated with the distribution or characteristics of species within the dataset.

Khyber Pakhtunkhwa has rich wildlife and some of the most unique and worldwide important as well as endangered species of birds and mammals (Khan *et al.*, 2016). According to Rahman *et al.* (2023) the diverse landscape of Khyber Pakhtunkhwa contributes significantly to the wildlife of the country. one of the reasons of biodiversity's richness of this province is The Western Himalayas, a global conservation priority. This region includes the Himalayan subtropical pine forests, Northwestern Himalayan alpine shrubs, Western Himalayan broadleaf forests, and subalpine conifer forests. Hosting 285 bird species, with nine endemic, including the Himalayan quail and the endangered Himalayan griffon vulture, these eco-zones are biodiversity-rich due to their varied climates, altitudes, and relative isolation, underscoring their importance for ecological preservation.

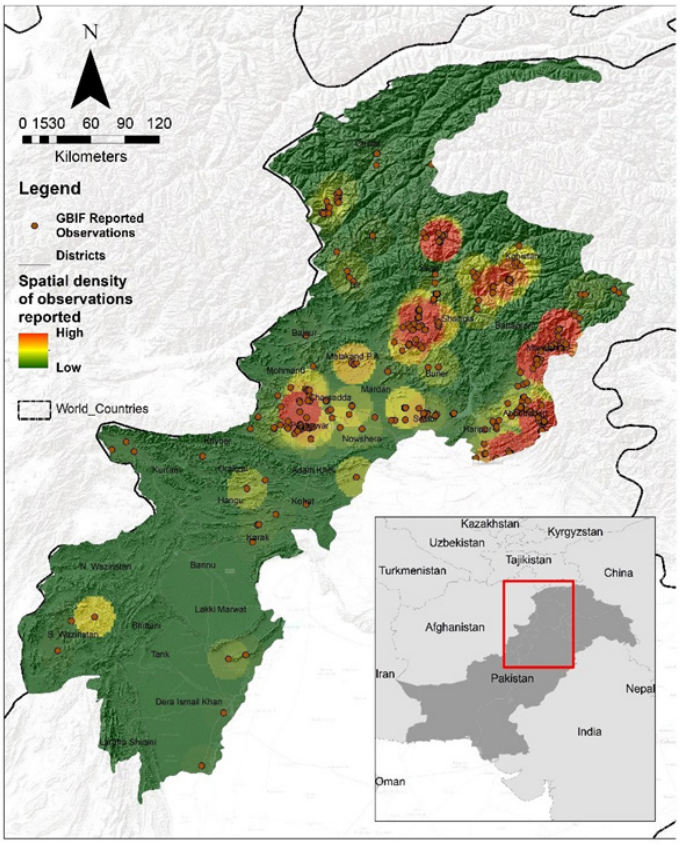


**Figure 4:** *Point density map of recorded observations in KP.*

The analysis of GBIF recorded observations in Khyber Pakhtunkhwa reveals intriguing patterns and trends in biodiversity data collection, aligning with findings from regions sharing comparable ecological characteristics. The identified biodiversity hotspots, including Swat, Peshawar, Shangla, Kohistan, Mansehra, and Abbottabad, are consistent with studies highlighting the region's rich wildlife and unique species (Khan *et al.*, 2016; Rahman, 2023).

The data spanned several decades, with a noticeable increase in recorded observations from the 1980s onwards. The year 2010 marks a substantial increase, with a significant chi square test result indicating intensified data collection efforts. Changes in environmental conditions, such as climate change, habitat destruction, and human activities, affect species populations and distribution over time. This leads to variations in recorded observations between years (Barange *et al*., 2018). However, there are fluctuations and variations in different years, suggesting potential variations in data collection intensity or other factors influencing the number of recorded observations.

The month wise data revealed a seasonal pattern, with higher counts during the summer months (June, July, August) and a decrease towards the end of the year and the beginning of the following year (September to February). This suggests increased observations and data recorded during the warmer seasons. Seasonal changes influence species activity, migration, and breeding patterns, making them more or less observable. For example, some species may be more active during summer months, while others may be more active during winter months leading to significant numbers of recorded observations (Auteri, 2022).

The day-wise analysis shows an irregular distribution of recorded observations, with some days exhibiting higher data collection activity than others. Days 17, 18, and 19 have the highest counts, indicating a concentrated period of data collection.

At the phylum level, Arthropoda and Chordata are the most frequently recorded, reflecting attention towards diverse animal groups and vertebrates. At the class level, Insecta, Aves, and Arachnida receive significant attention, indicating a focus on insects, birds, and spiders. Different phyla have distinct characteristics, habits, and habitats, making some more observable than others. For example, insects are more abundant and diverse than vertebrates, making them more likely to be recorded (Thomas, 2005).

The Chi-square test results indicate significant associations between the variables and species distribution, highlighting the importance of considering these factors in biodiversity documentation and conservation efforts. The ecological rationale behind these associations lies in the interactions between species and their environments, as well as the influence of human activities and data recorded observations. Understanding these patterns and trends is crucial for effective conservation and management of biodiversity in Khyber Pakhtunkhwa (Taylor-Brown *et al*., 2019).

In spatial analysis, the dataset revealed a non-uniform distribution of recorded occurrences across different cities and areas. Balakot, Shogran, Manglawer in Swat, Gara Tajik in Khyber Pakhtunkhwa, and Ayubia NP emerge as significant locations with high occurrence density, while other areas have lower to moderate density.

The temporal analysis revealed significant fluctuations in biodiversity recordings over the decades, mirroring the findings of (Khan and Zaman, 2015) in the Buner area. The seasonal pattern, with higher counts during summer months (June, July, August), is consistent with the activity patterns of spider fauna reported by (Khan and Zaman, 2015) and Perveen (2012).

Spider fauna is most active during daytime and in the summer season, as observed in our study and supported by literature. For instance, Khan and Zaman (2015) reported 23% of the total specimens belonged to the Pholcidae family, while (Perveen, 2012) identified 18 species under 13 genera and 8 families of spiders.

The species diversity analysis revealed a focus on Arthropoda, Chordata, and Mollusca at the phylum level, with Insecta, Aves, and Arachnida being prominent at the class level. This aligns with studies on spider fauna (Khan and Zaman, 2015) and Perveen (2012), scorpions (Jawad and Zahid, 2024) and butterflies (Bibi *et al*., 2022) in the region. For example, Bibi *et al*. (2022).

Bibi *et al*. (2022) identified nine distinct species of butterflies spanning three families and seven genera, while Jawad and Zahid (2024) reported five different species of scorpions from four districts of KP.

The literature highlighted the importance of Khyber Pakhtunkhwa's diverse landscape, including the Western Himalayas, for biodiversity conservation (Faiz et al., 2023). The region's rich fauna and flora are supported by studies on freshwater turtles (Khan *et al*., 2016; Safi and Khan, 2014), fish fauna (Ishaq *et al*., 2014) and bats (Perveen and Rahman, 2015). For

instance, Khan *et al.* (2016) reported all freshwater turtle species are found in Peshawar except spotted pond turtle, while Ishaq *et al.* (2014) identified 94 species of fishes from the whole province of KP.

The climate of Khyber Pakhtunkhwa, characterized by hot summers and mild winters (Shah *et al.*, 2015), likely influences the biodiversity patterns in the region. Temperature variations affect biodiversity, with bats entering hibernation in temperate zones during winter months (Perveen and Rahman, 2015). Rain intensity also impacts macroinvertebrate fauna, with sudden changes disturbing aquatic communities (Ali *et al.*, 2021).

*Study limitations*

The current study was limited by several factors. The analysis was limited to the data obtained from GBIF (Global Biodiversity Information Facility). The conclusions drawn are based on the available dataset, which may not encompass the entire range of occurrences or areas of interest. Other sources of data could provide a more comprehensive understanding of the distribution and density of recorded incidents. The accuracy and reliability of the data rely on the quality of the records within the GBIF database. Issues such as incomplete or erroneous entries, misidentification, or sampling biases may affect the validity of the results. Care should be taken to address and mitigate these potential data quality concerns. The following recommendations are made for future research on the biodiversity of KP.

Future studies should aim to collect and incorporate additional data sources beyond GBIF to obtain a more comprehensive understanding of the occurrence patterns. This could include data from local biodiversity surveys, research publications, or citizen science initiatives, which can provide valuable insights into specific areas or species of interest. To improve the accuracy and reliability of the data, future research should focus on implementing rigorous data validation and quality assurance protocols. This may involve cross-referencing data from multiple sources, verifying species identifications, and ensuring comprehensive metadata documentation. Conducting species-specific analyses can provide a deeper understanding of the distribution patterns and ecological preferences of individual species. Focusing on specific taxa or groups of interest can help uncover more detailed information and facilitate targeted conservation efforts.

## Conclusions and Recommendation

This research analyzed the recorded observation from Khyber Pakhtunkhwa sourcing GBIF data. Analysis revealed intriguing patterns, including a noticeable increase in recorded observations from the 1980s, a seasonal pattern with higher counts during summer months, and an irregular distribution of recorded observations across days. The data showed a focus on Arthropoda, Chordata, and Mollusca at the phylum level, and Insecta, Aves, and Arachnida at the class level, with significant associations between variables and species distribution. Spatial analysis revealed non-uniform distribution of recorded occurrences across cities and areas, with Swat, Peshawar, Shangla, Kohistan, Mansehra and Abbottabad emerging as significant locations. Temporal analysis showed significant fluctuations in biodiversity recordings over decades, mirroring findings from the Buner area. The study highlights the importance of considering these factors in biodiversity documentation and conservation efforts, and underscores the importance of Khyber Pakhtunkhwa's diverse landscape for biodiversity conservation.

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## Novelty Statement

This study presents the first comprehensive analysis of biodiversity patterns in Khyber Pakhtunkhwa using GBIF data, identifying key hotspots and seasonal trends which will significantly aid in targeted conservation efforts and ecological management within the region.

## Author's Contribution

**Barkat Ullah Khan:** Contributed to the concept development, data collection, data analysis, manuscript drafting, and review process.

**Ayaz Ahmad:** Participated in conceptualizing the

study, drafting the manuscript, and reviewing the final version.

**Ashar Farooq:** Contributed to the study concept and supervised the project.

**Muhammad Bilal Zia:** Involved in the development of the study concept.

**Muhammad Atif Majeed:** Assisted in conceptualizing the study.

**Hammad-ud-din:** Contributed to the development of the research concept.

*Conflict of interest*

The authors have declared no conflict of interest.

## References


Ali, S. and Ripley, S.D., 1983. Handbook of the birds of India and Pakistan.

Ali, W., Saba, M., Yousef, S. and Sarfraz, T., 2021. Rainfall intensity impact on biodiversity of benthic macroinvertebrate fauna in stream of Abbottabad district, Pakistan. J. Wildlife Ecol., 2(1): 1–8.

Alroy, J., 2014. Paleobiology Database. In Fossilworks.

Auteri, G.G., 2022. A conceptual framework to integrate cold-survival strategies: Torpor, resistance and seasonal migration. Biol. Lett., 18(5). https://doi.org/10.1098/rsbl.2022.0050

Barange, M., Merino, G., Blanchard, J.L., Scholtens, J., Harle, J., Allison, E.H., Allen, J.I., Holt, J. and Jennings, S., 2018. Climate change impacts, vulnerabilities and adaptations: North Pacific and Pacific Arctic marine fisheries. In Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options (Vol. 12).

Bibi, M., Bibi, S., Akhtar, N., Ullah, Z., Fiaz Khan, M. and Qureshi, I.Z., 2022. Butterfly (Order: Lepidoptera) species Richness, diversity and distribution in different localities of Battagram, Pakistan. Saudi J. Biol. Sci., 29(3): 1853–1857. https://doi.org/10.1016/j.sjbs.2021.10.039

CBD, 2022. Pakistan: Main Biodiversity Details.

Compains, N.E., 2018. Gaps, lags and other shortfalls besetting the digital accessible knowledge of biodiversity.

ESRI, 2001. What is ArcGIS? Environmental systems research institute.

Faiz-ur-Rahman, Y. K., Rauf, T., Javid, A., Zulkamal, I. U., Salim, M., Shah, M., Ali, H., Ullah, R., Ullah, I., and Jamal, M. 2023. Recent records of wildlife regarding their habitat and threats in northern Khyber Pakhtunkhwa, Pakistan. Pure Appl. Biol., 12(1): 517–522.

GBIF, 2022. GBIF home page. Available from: https://Www.Gbif.Org.

Gohar, Al, I.K., Saleem, M.M. and Ali, A., 2021. View of comparative review of Khyber Pakhtunkhwa and Federal Environmental Protection Laws in Pakistan. Palarch's J. Archaeol. Egypt Egyptol., 18(5): 22–31. https://archives.palarch.nl/index.php/jae/article/view/7566/7144

iNaturalist. 2014. Reference Reviews. https://doi.org/10.1108/rr-07-2014-0203

Ishaq, M., Khan, S., Khan, J., Akhtar, N. and Saeed, K., 2014. Study on Ichthyofaunal Biodiversity of River Swat. World J. Fish Mar. Sci., 6(4): 313–318.

Jawad, S.M. and Zahid, M., 2024. Exploring species diversity and abundance of scorpions (Arachnida: Scorpiones) in certain regions of Khyber Pakhtunkhwa, Pakistan. Braz. J. Biol., 84: 1–11. https://doi.org/10.1590/1519-6984.264291

Khan, J., and Zaman, A. 2015. Biodiversity of spider fauna in Pir Baba, district Buner, Khyber Pakhtunkhwa, Pakistan. Entomol. J. Com., 3(1): 69–74.

Khan, M.A., 1999. Wildlife of Pakistan. Oxford University Press.

Khan, M.Z., Safi, A., Ghalib, S.A. and Kanwal, R., 2016. Population status, distribution and conservation of freshwater turtles of Peshawar valley, Khyber Pakhtunkhwa, Pakistan. Can. J. Pure, 10(1): 3732–3750. http://www.cjpas.net/wp-content/uploads/pdfs/10/1/7-Imtiaz-3732-3750.pdf

Khattak, R.H., Liu, Z., Teng, L. and ur Rehman, E., 2022. The wild mammalian fauna of Nowshera District Khyber Pakhtunkhwa, Pakistan. Pak. J. Zool., https://doi.org/10.17582/journal.pjz/20200519200539

KPK Wildlife Department, 2023. Total National Parks In Province.

Marwat, S.K., Khan, M.A., Rehman, F., Ahmad, M. and Zafar, M., 2011. Biodiversity and importance of floating weeds of Dara Ismail, Khan District of KPK, Pakistan. Afr. J. Trad. Complement. Altern. Med., 8(5S). https://doi.org/10.4314/ajtcam.v8i5S.17

NBSAP, 2017. Pakistan National Biodiversity

Strategy and Action Plan 2017-2030. Government of Pakistan, 2017, 57. http://www.mangrovesforthefuture.org/assets/Repository/Documents/MFF-NSAP.pdf

Perveen, F., 2012. Checklist of spider fauna of FR Peshawar, FATA, Pakistan. Arthropods, 1(1): 35–39.

Perveen, F., and Rahman, F.U., 2015. Characteristics of the first record of bat (Mammalia: Chiroptera) fauna from Peshawar and adjacent areas, Khyber Pakhtunkhwa, Pakistan. Glob. J. Anim. Sci. Res., 3(1): 148–160.

Rahman, F., 2023. Recent records of wildlife regarding their habitat and threats in northern Khyber Pakhtunkhwa, Pakistan. Pure and Appl. Biol., 12(1): 517–522. https://doi.org/10.19045/bspab.2023.120053

Rehman, H.U., Ullah, A., Rehman, F.U., Khattak, B., Ullah, S., Atlas, A., Rehman, J.U. and Ullah, W., 2015. Biodiversity of Fish Fauna of Ghandiali Dam, District Kohat, Khyber Pakhtunkhwa, Pakistan. World Appl. Sci. J., 33(9): 1511–1513.

Safi, A. and Khan, M.Z., 2014. Distribution and current population status of freshwater turtles of District Charsadda of Khyber Pakhtunkhwa, Pakistan. 1(4): 31–38.

Shah, A., Rahimullah S.S., Ather R.M., Shah, M. and Mitra, A., 2015. Identification of the prevalent ticks (Ixodid) in goats and sheep in Peshawar, Pakistan. J. Entomol. Zool. Stud., 3(2): 11–14.

Syariah, K.B. and Ilmu, G., 2016. Sarhad Provincial Conservation Strategy (Issue september 2016).

Taylor-Brown, A., Booth, R., Gillett, A., Mealy, E., Ogbourne, S.M., Polkinghorne, A. and Conroy, G.C., 2019. The impact of human activities on Australian wildlife. PLoS One, 14(1): 1–28. https://doi.org/10.1371/journal.pone.0206958

Thomas, J.A., 2005. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philos. Trans. R. Soc. B Biol. Sci., 360(1454): 339–357. https://doi.org/10.1098/rstb.2004.1585

Xu, J. and Xiao, P., 2022. A bibliometric analysis on the effects of land use change on ecosystem services: Current status, progress, and future directions. Sustainability. https://doi.org/10.3390/su14053079