

THE LAST FLIGHT: SAGA OF VANISHING BIRDS FROM THE HEART OF THAL DESERT

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Abstract

The Thal Desert, located in central and southern Punjab, Pakistan, is a subtropical arid region that supports rich avian biodiversity but is increasingly facing ecological degradation. This study investigates the decline of bird species in the Thal Desert, with a specific focus on District Bhakkar. Using a mixed-methods approach, data were collected through field surveys, direct observations, interviews with local residents and hunters, digital questionnaires, photographic documentation, GPS mapping, and laboratory analysis of soil and water samples. Both resident and migratory bird species were documented, with special attention to species nearing local extinction.

Key bird species recorded include the Green Parakeet, Black and Brown Partridge, Common Quail, Crested Lark, Common Coucal, Desert Warbler, Kite, and Wheat Eater. The findings reveal a significant decline in these species, primarily due to habitat loss, agricultural expansion, climate variability, deforestation, overhunting, water scarcity, and increasing human disturbance. Infrastructure projects such as the Thal Canal, resettlement schemes, road construction, and the spread of Eucalyptus plantations have further reduced nesting and feeding grounds, destabilizing the desert ecosystem.

Fieldwork was conducted at multiple sites including Toba Rawanwala, Rakh Karluwala, Rangpur Baghoor, Nurpur Thal, and Chowk Azam. Environmental assessments showed changes in soil and water quality, indicating increasing ecological stress. Survey results revealed that over 80% of respondents observed a noticeable decline in bird populations, nesting activity, and bird calls. Interviews conducted in the Saraiki language confirmed that several species such as the Houbara Bustard, Demoiselle Crane, Griffon Vulture, and Black Partridge are now extremely rare or extinct in the wild and survive mainly in captivity.

The study highlights that Pakistan hosts approximately 668 bird species, including several endangered and critically endangered species, with Bhakkar contributing significantly to Thal's avian diversity. The results underscore the urgent need for effective conservation strategies, sustainable land-use planning, stronger policy enforcement, and community awareness programs. This research provides valuable baseline data for policymakers, conservationists, and ecologists working to restore ecological balance and protect avian biodiversity in the Thal Desert.

Introduction

The Thal Desert of central Punjab, situated between the Indus and Jhelum rivers, is a fragile arid ecosystem that supports a notable diversity of avian species adapted to extreme climatic conditions. Birds in this desert play critical ecological roles as indicators of environmental change, seed dispersers, and regulators of insect populations. State of the World's Birds. BirdLife International, (2023). In recent years, however, the avifauna of the Thal Desert—particularly in District Bhakkar—has experienced a marked decline due to accelerating anthropogenic pressures such as agricultural expansion, groundwater depletion, habitat degradation, pesticide use, and hunting, compounded by increasing climatic variability. These factors have disrupted breeding habitats and migratory pathways, leading to reduced species richness and abundance. The absence of long-term, systematic avifaunal monitoring in the region has further limited understanding of these trends, highlighting the urgent need for focused scientific assessment (Zahid, M., Abbas, F., & Hussain, I. (2020). This study addresses this gap by evaluating the status of declining bird species in the Thal Desert, with special reference to District Bhakkar, to support evidence-based conservation and sustainable management strategies.

Pakistan's arid and semi-arid deserts occupy more than 11 million hectares of the country's landmass and represent ecologically sensitive systems that are heavily dependent on monsoonal rainfall and humid air inflow (Altaf, 2022). These deserts—Thal, Tharparkar, Cholistan, Kharan, and Nara—are shaped by extreme climatic variability, wind-driven geomorphology, and limited water availability. Among them, the Thal Desert is the third largest and covers approximately 20,000 km² in central Punjab, extending between the Indus and Jhelum river floodplains and adjoining the Salt Range to the north (Traveler Trails, 2024). Its subtropical sandy nature, extensive dune systems, and fluvial-aeolian deposits closely resemble the desert environments of Cholistan and Thar (Garzanti et al., 2020).

The Thal Desert exhibits pronounced environmental contrasts, where narrow arable tracts and floodplains intersect vast expanses of sand dunes and undulating plains, nearly 50–60% of which are dominated by dunes reaching heights of up to 175 m (Anonymous, 2019). Despite these harsh conditions, the desert sustains specialized vegetation dominated by grasses, thorny shrubs, and drought-resistant trees, along with gram (chickpea) cultivation that forms the backbone of the local agrarian economy, particularly in District Bhakkar (Dawn, 2021).

Ecologically, the Thal Desert supports diverse faunal assemblages, including resident and migratory bird species that rely on its seasonal resources, yet these populations have shown a marked decline over recent decades due to habitat modification, hunting pressure, and large-scale development interventions such as canal irrigation and settlement schemes (Abbas et al., 2020). The cumulative impact of anthropogenic activities has significantly altered the desert's natural structure and functioning, intensifying desertification and biodiversity loss. A comprehensive understanding of the Thal Desert's physical setting, climate, vegetation, and fauna is therefore crucial for informed conservation strategies and sustainable land-use planning in this rapidly transforming arid landscape.

Materials and Methods

The present study was predominantly field-oriented, as implied by its focus on assessing the declining bird species of the Thal Desert in the vicinity of District Bhakkar. Given the ecological nature of the research, laboratory-based (in vitro) experimentation was limited, while emphasis was placed on field surveys, direct observations, community engagement, and environmental sampling, approaches commonly adopted in avian ecological studies. A structured questionnaire survey entitled “Study of Declining Species of Birds in the Thal Desert in the Vicinity of District Bhakkar” was employed as a primary data-collection tool. The survey was developed using Google Forms and comprised both

multiple-choice and short-answer questions, organized into seven sections, including a non-mandatory biodata section to maintain respondent confidentiality. Questionnaire design followed an extensive review of existing literature and regional assessment reports, and it was refined after expert review and approval by the Worthy Prof. Dr. Abdul Haleem Shah. The questions were framed in simple and clear language to ensure comprehension by respondents from varied educational backgrounds, a practice recommended for socio-ecological surveys in rural settings .

The conceptual framework of the survey was informed by the methodology adopted in the PCRWR (2022) groundwater and land-management assessment conducted in the Thal Doab. That study emphasized reconnaissance surveys, stakeholder consultations, and integration of local perceptions related to water, soil, agriculture, and environmental change. Drawing on these principles, the present survey incorporated questions addressing habitat conditions, land-use practices, human disturbances, and observed changes in avifaunal diversity. The survey link was disseminated through social media platforms including WhatsApp, Facebook, email, and text messaging, and responses were collected over a ten-day period.

To complement the survey data, primary information was also gathered through personal interviews and repeated field visits across selected locations in Bhakkar, Mianwali, Layyah, and adjacent Thal regions. Local farmers, hunters, elderly residents, and wildlife observers were engaged to document indigenous knowledge and long-term trends in bird abundance and habitat quality. Interviews were conducted in Urdu and the local Saraiki language to ensure effective communication and reliability of responses. Bird abundance and species presence were assessed using the point count method, a widely accepted technique for avifaunal population studies in open and semi-arid landscapes.

Secondary data were obtained from the District Wildlife Department to verify species records and obtain rough population estimates, which aided

subsequent analysis. In addition, environmental variables influencing bird distribution were evaluated through soil and water sampling. Soil samples were collected from selected habitats exhibiting relatively higher bird activity, while water samples were taken from ponds, canals, and groundwater sources. These samples were analyzed for physicochemical properties, salinity, heavy metals, and pesticide contamination at the Water and Soil Analysis Laboratory, Bhakkar, following standard sampling and analytical protocols . The findings from these analyses are presented and discussed in the subsequent chapters.

Results

Results of Survey

The status of declining bird species in the Thal Desert, particularly within District Bhakkar and its surroundings, was evaluated through a structured survey comprising eight sections. While the survey primarily targeted residents of District Bhakkar, a limited number of respondents from adjacent areas with ecological and social linkages to the region were also included. The survey aimed to assess trends in avian decline, identify underlying causes, and explore public perceptions regarding conservation and habitat restoration.

The results demonstrate a strong consensus regarding the decline of bird populations in the Thal region. A substantial majority of respondents (84.4%) reported the disappearance of birds from areas where they were previously abundant, while nearly 90% observed reductions in nests, eggs, and bird vocalizations, indicating disruption of breeding activity and overall population health. Similarly, 84.6% confirmed a noticeable decline in both the number and diversity of bird species. Hunting emerged as the leading cause of decline (44.9%), followed by climate variability (30.9%), deforestation (17.6%), and pollution (6.6%). Human interference in natural habitats was identified by 60% of respondents as the greatest threat to avian survival.

Perceptions of the magnitude of decline further highlighted the severity of the problem, with over

80% estimating population reductions exceeding 10%, and approximately 43% reporting declines greater than 30%. Increased migratory behavior associated with climate change was noted by 72.6% of respondents, while 86.8% emphasized that declining water resources are adversely affecting bird habitats. Deforestation and unplanned urbanization were identified as the most damaging anthropogenic activities altering avian environments in the Thal region.

Species-specific responses revealed rapid declines in black and grey partridges, Houbara bustard, quail, ducks, green parrots, vultures, and crested larks, with hunting pressure particularly affecting ducks, parrots, and partridges. More than half of the respondents believed that wildlife protection laws are poorly implemented, and 76.5% recognized that avian decline is negatively influencing other animal species, reflecting ecosystem-level impacts.

Respondents strongly supported conservation interventions, identifying bans on hunting, habitat restoration through plantation, water resource rehabilitation, and community engagement as the most effective measures to reverse population declines. Demographic data showed higher participation by males (71.8%), with the most active age group ranging from 22 to 28 years, indicating growing environmental awareness among the younger literate population.

Results of the Interviews

A total of 15 respondents from different parts of the Thal Desert were interviewed, all of whom had direct or indirect associations with wildlife, agriculture, forestry, or hunting. Several respondents had lived in the desert for decades or maintained agricultural farms, tree plantations, or hunting-related activities. Due to legal and ethical considerations, particularly involving regular or seasonal hunters, the identities of some interviewees were kept confidential, as agreed upon prior to the interviews. Detailed profiles are provided in Appendix II where disclosure was permissible.

Interpretation of interview data, combined with survey results and short feedback questions, revealed a consistent set of major factors

contributing to biodiversity loss in the Thal Desert. Although numerous issues were identified, only the most significant contributors—repeatedly emphasized by respondents—are summarized here. Detailed causal analysis of these factors is presented in Chapter 5 (Discussion and Conclusions).

Key issues identified include rapid industrialization in the Thal region, particularly in District Bhakkar and southern Mianwali, which respondents associated with pollution and accelerated deforestation, especially due to increased demand for wood-based industries. Groundwater depletion was strongly linked to extensive eucalyptus plantation, which has replaced traditional crops such as chickpea and mustard, thereby affecting insect availability and bird-dependent agro-ecosystems.

Climate change was highlighted as a critical driver altering rainfall patterns, seasonal temperatures, and migratory and breeding behavior of birds. Habitat fragmentation and wildlife mortality were frequently attributed to the Mianwali-Multan (MM) road, which bisects the Thal Desert and lacks wildlife crossings, resulting in frequent roadkills of animals and birds.

Additional pressures identified include drying of canals, loss of old native trees essential for cavity-nesting birds such as green parakeets, widespread overhunting (both legal and illegal), direct killing of birds due to human-wildlife conflict, low awareness among local communities, weak enforcement of wildlife laws, and seasonal fires destroying nests and breeding sites. Respondents also emphasized the severe impact of veterinary drugs containing diclofenac sodium, which have nearly eliminated vultures from the region, along with the indirect effects of pesticides through food-chain contamination. Deforestation driven by fuel needs, industrial demand, and unregulated settlement expansion, as well as bird mortality associated with electricity transmission lines, were also recognized as significant contributors to avian decline.

Overall, interview findings strongly corroborate survey results, indicating that cumulative anthropogenic pressures, coupled with climatic

variability, are rapidly degrading avian habitats and threatening the long-term sustainability of biodiversity in the Thal Desert.

Results of Fieldwork

Fieldwork was conducted from May 2024 onwards across District Bhakkar and adjacent areas. Bird sightings were recorded and photographed at marked sites, despite challenges due to migratory behavior and wide territories. Observed species were categorized as: most common, less common, rare, and those now only in captivity.

Most Common Birds: Common Sparrow (*Passer domesticus*), Rock Pigeon (*Columba livia*), Asian Green Bee-eater (*Merops orientalis*), Black Kite (*Milvus migrans*), Sunbirds (*Cyanomitra olivacea*, *Cinnyris asiaticus*), Pied Bushchat (*Saxicola caprata*), Brown Rockchat (*Oenanthe fusca*), Black Drongo (*Dicrurus macrocercus*), Oriental Magpie Robin (*Copsychus saularis*), Hoopoe (*Upupa epops*), Common Myna (*Acridotheres tristis*). These species showed stable populations with minimal hunting pressure.

Less Common Birds: Spotted Rock Pigeon, Spotted Dove, Kestrel, Common Eagle, Kingfisher, Red-vented Bulbul (*Pycnonotus cafer*), Black Phoebe (*Sayornis nigricans*), Large Grey Babbler (*Turdoides malcolmi*). These species are declining due to hunting, habitat loss, and human disturbance.

Rare/Declining Birds: Indian Roller (*Coracias benghalensis*), Demoiselle Crane (*Grus virgo*), Indian Ringneck Parakeet (*Psittacula krameri*), Houbara Bustard (*Chlamydotis undulata*), Greater Coucal (*Centropus sinensis*), Jack Snipe (*Lymnocyptes minimus*), Spotted Owlet (*Athene brama*), Asian Koel (*Eudynamis scolopaceus*), Grey Partridge (*Perdix perdix*), Common Quail (*Coturnix coturnix*), Common Teal (*Anas crecca*). Populations are threatened by hunting, poaching, and habitat fragmentation.

Species Only in Captivity: Budgerigar (*Melopsittacus undulatus*) and Peacocks (*Pavo*

cristatus) previously abundant in the wild, now mainly maintained domestically.

Environmental Assessments:

Water Analysis: Samples from Kalorkot (pH 6.1, polluted), Mankera, and Branga Garbi indicated presence of arsenic and heavy metals, unsafe for birds and livestock (Appendix II, Figs. 4.59–4.61).

Soil Analysis: Samples from Awanawala and Fazil showed high salinity and pollutants, unsuitable for bird breeding or burrowing (Appendix II, Figs. 4.62–4.63).

Spatial Arsenic Distribution: Data from Rehman et al., 2020 (Kuwait J. Sci.) was used to corroborate contamination patterns in Bhakkar (Fig. 4.58).

Overall, field observations confirm a clear decline in rare and threatened bird species, with environmental degradation, hunting, and human activity as major contributing factors.

Discussion

The entire thesis focused on the theme of “The Declining Species of Birds in Desrt Thal, in the vicinity of District Bhakkar.” To this end, a variety of methods were employed to gather data, access existing material, and analyze what was novel. The websites of regional wildlife offices and organizations, including the IUCN, WWF P, Punjab Wildlife Department, and district-by-district profiles created by the province government, were the primary sources of data. Chapter No. 4 discusses the results of the survey that was conducted after the data and raw material were accessed. The survey’s findings are alarming since they show that the Thal Desert is severely stressed in terms of bird species. The most common result from the survey was consensus that species such as Plack patridge, green parakeet, Houbara bustard, Demosille cran, Spotted Dove, common quail, Grey partridge, crested lark etc are constantly decreasing and some have touched the level that gone from wild and only available in captivity. Seasonal fires, overhunting, deforestation, mm roads, industry

in the Thal desert, ignorance, poverty, absence of canals, medicine of domestic life stock, pollution of air, water, and soil, etc. are all factors that contributed to these results. Zaman A. Et al. Show comparable results. The most prevalent bird species in the Thal desert, according to a 2023 study published in the Journal of Zoological Systematics and Evolutionary Research, were the Indian roller, common quail, cattle egret, little egret, red vented bulbul, common myna, Indian house crow, and Indian/pariah kite. In order to determine the diversity of birds in the Thal desert in district Jhang, Mahboob et al. Carried out a study there between December 2008 and November 2009. A total of 2,550,219 birds from 55 species were recorded throughout the year-round study. Out of these bird species, one was an ordinary migratory, six were summer breeders, thirteen were winter visitors, and thirty-six were residents. With 26 species, Passeri formes was the most prevalent order. The most prevalent species were the house sparrow and common myna. Since the midwinter season (December and January) was the most prominent time for the richness of bird fauna, the results of both research are comparable. The abundance of bird fauna is the most notable difference between the two studies. Only 12,905 individuals of 45 species were spotted in the current survey, compared to 2,550,219 individual birds in the previous study. The most recent study shows that the diversity and richness of bird fauna in district Jhang have been decreasing as compared to previous studies. After successfully conducting the survey, Interviews session was held time and again by different peoples in the areas such as , Jhammat Shumali, Anarshah, Hastiwala, Rakh karluwala, Hussain shah nurpur , Jandanwala, Barkat wala, Rangpur bagoor...etc and their observations and data were collected by directly accessing these people or on phone. The data collected from them was very helpful in furthering the research work, It enhanced not only the knowledge about the field work but also increased the basic wildlife know how. These interviews showed Thal Area was rich in biodiversity but now facing the decrease due to many reasons like, the lack of government

policies, the weak writ of law enforcement in this area, the government policies of allowing hunting in non breeding seasons for the sake of money , lack of rains as it is desert, scarcity of water except moonsoon, lack of awareness, wild human conflict and wild life consciousness. The similar results are also depicted in Mehboib et al. (2013) said that they had identified 55 different species of birds. Thirteen of these species were winter visitors, five were summer breeders, one was an ordinary migratory, and thirty-six were local (endemic) residents. Common swallows, yellow wagtails, black redstarts, desert wheatears, mustached and arabian warblers, brown chiffchaff, rosy starlings, eurasian kestrels, peregrine falcons, and Houbara bustards (sky larks) were among the winter visitors. These birds spend the winter in Pakistan after breeding in western Siberia. These findings are consistent with Khan's (1997) study of the avifauna of Lal Suhanra National Park in Bahawalpur, Pakistan, where he identified 117 bird species belonging to 81 taxa, 43 families, and 16 orders.

The density of resident birds was higher as compared to migratory birds. Most of the migratory birds were observed during winter season. Another highly significant study by Akbar et al. (2003) This is a survey conducted in the desert regions of Thal, Dera Ghazi Khan, and Cholistan (Punjab). They used various methods to estimate the number of Houbara bustards in Thal to be 138. Houbara bustards constituted up only 0.03% of the total estimated population throughout the current investigation, and their graph is still declining. Seasonal variations in bird species abundance were thoroughly examined by Wardmana and Warrington (1997). The approximate densities of birds were 157 per km (15 species) in the spring and 187 per km (19 species) in the winter. They noted that the most prevalent species were *Lanius excubitor*, *Turdoides squamiceps*, and *Eremopterix nigriceps*. *Lanius excubitor* was a resident species in the current study, accounting for just 0.52% of the total population. The results are matching to this survey and thus enhancing the preciseness of the results.

The soil and water analysis tests were conducted whose reports are attached in the thesis and according to these reports the water and soil is unsafe for birds and other animals in drinking or habitat formation. The main causes of these water and soil unfit reports were pollution either air, water or soil which was disturbing the salinity, pH and texture. Two samples one for water and one for soil were taken from Fazil and Branga and it is common concept that these factories apparently pollute here the all spheres of life. The pictures taken are attached with report. The other samples from Klorkot, Nurpur and Shahi Shomali are also indicating pollution as well as heavy metal, arsenic. At the belt from north east to south west including, Sargodha, Khushab, Bhakkar, Jhung, Mianwali, Layyah and Muzafargarh arsenic either more or very less exists in the water along with salts. The research article posted in Kuwait Journal of Science by Rehman F et al in 2024 shows that arsenic concentrations in the Indus River's lateral distribution and upstream to downstream sites were found to be variable in a study. The Health Risk Assessment (HRA) found that samples from Bhakkar tehsil (73.3%), Darya Khan tehsil (60%), and Kalur Kot tehsil (13.3%) all exceeded the hazard quotient threshold of "1," but all samples from Mankera tehsil were within acceptable limits. With an average of 1.149, the hazard quotient numbers ranged from 0.038 to 5.127, indicating that a large percentage of people who drink water with high arsenic content may experience non-cancerous health issues. Furthermore, the arsenic contaminated water resulted in carcinogenic risk values of 2.31×10^{-3} , suggesting an increased long-term cancer risk. The groundwater in the Bhakkar tehsil was found to be unsafe for human consumption since it had the highest amount of arsenic of any tehsil in the Bhakkar district. Arsenic is generally attributed to groundwater by natural means like weathering/erosion of arsenic-bearing rocks and deposits and the electronic industrial process as the primary anthropogenic source (Naujokas et al., 2013; Chakraborti et al., 2017). According to Rehman et al., 2020 research article the water and soil of district Bhakkar has arsenic in a varying amount in all four tehsils. The graphical

representation of their report is as shown as under.

Conclusion

The gist of the research done by different ways including physical and online interviews, survey, soil and water analysis reports and secondary data platforms, is that some species of birds in district Bhakkar and all over the Thal area are declining sharply and if unchecked the Thal would forever be lost of these species and future repercussions without certain birds species would be alarming and great biodiversity loss for all of us. The species that are decreasing and have extreme entanglement issues are green parrot, grey Partridge, Crested Lark, Common quail, Small spotted dove, the Vultures, Black partridge, Demosille crane, common Teal and Houbara bustard. The study is calling for dire need of allocating Thal national park including areas of districts Mianwali, Khushab, Bhakkar, Layyah, Jhung and Muzafargarh. This study also recommends and looking for more and more agencies presence in the area that till now is not appreciable. Completely keeping the Industrial setup on the sides of Thal rather than in the desert's heart or at least applying strict laws and penalties in case of misuse would be big hand for nature's rejuvenation. Banning completely the hunting in the area and law in action against the plunders would be great effort there for revival and growth of species. Keeping in check the rate of deforestation to certain limit in general and banning deforestation of government's older forests for fire and other purposes would also be appreciated. In short, this study is helping for policy makers as primary data source and policy decisions.

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REFERENCES

- Abbas, M., W. Gillani, A. Ahmad. (2020). A Study of Settlement of Refugees in the Thal Desert (1947-1969). *Pakistan Social Sciences Review*, 4(2), 164-176.
- Abd El Ghani, M.M., F.M. Huerta Martinez, L. Hongyan, R. Qureshi. (2017). *Plant Responses to Hyperarid Desert Environments*. Springer.
- Ahmad, Rafiq. (2017). "Indo Pakistani Deserts". In A. Mares (Ed.), *Encyclopedia of Deserts*. University of Oklahoma Press, pp. 291-293. ISBN 978-0-8061-7229-3.
- Akbar, M., Junjua, A.S., Akhtar, M.M. (2003). Comparison of Different Techniques for Houbara (*Chlamydotis undulata macqueenii*) Population Estimates. *Pakistan Journal of Life and Social Sciences*, 1, 144-146.
- Akram, M., M.A. Kahlowan, Z.A. Soomro. (2008). *Desertification Control for Water Use in the Cholistan Desert, Pakistan. The Future of Drylands*, pp. 483-492. Springer.
- IUCN Pakistan. (2015). *Red List of Threatened Species of Pakistan*. International Union for Conservation of Nature, Pakistan.
- BirdLife International. (2023). *State of the World's Birds*. BirdLife International.
- Zahid, M., Abbas, F., & Hussain, I. (2020). Impact of habitat degradation on bird diversity in desert ecosystems of Pakistan. *Journal of Arid Environments*, 173, 104-113.
- Altaf, M. (2022). The Major Deserts of Pakistan: A Review. *Journal of Wildlife and Ecology*, 6, 78-92.
- Anonymous. *Bor. Punjab Gazette, Bhakkar*. (2024).
- Anonymous. (2018). *Wikipedia: Thal_desert*.
- Anonymous. (2008). "Annual Rainfall, Relative Humidity and Temperature of Thal Desert Punjab, Pakistan, 2006-2008". Pakistan Meteorological Department.
- Basir, N.H. (2017). *Ecological Report of Tehsil Mankera (Bhakkar), Punjab, Pakistan*. ResearchGate.
- Dasti, A., Agnew, A.D.Q. (1994). "The Vegetation of Cholistan and Thal Deserts, Pakistan". *Journal of Arid Environments*, 27(3), 193-208.
- Dawn, *The Business and Finance Weekly*, May 10th, 2021.
- Faisal Rehman, Munir H. Shah, Tahir Azeem, Jamil Siddique, Asfandyar Shahab, Omar Riaz, Faisal Rehman. (2024). *Groundwater Contamination & Health Risk Assessment with Special Reference to Arsenic in Bhakkar District*. *Kuwait Journal of Science*, 51(2), 100158.
- Funk, et al. (2008). Pollen and the Evolution of Arctotideae (Compositae). *The Botanical Review*, 76, 438.
- Garzanti, E., Liang, W., Andò, S., Clift, P.D., Resentini, A., Vermeesch, P., Vezzoli, G. (2020). Provenance of Thal Desert Sand: Erosion and quaternary Climate Change. *Earth Science Reviews*, 207.
- Khan, M.H., Alam, M., Fozia, A.U., Rehman, Y., Ihtesham, S.I., Hassan, W., Ullah, M.Z.M., Naz, S. (2020). Seasonal Variations in Diversity and Distribution of Avian Fauna in Trimmu Barrage, District Jhang, Punjab, Pakistan. *International Journal on Emerging Technologies*, 11(5), 647-651.
- Khan, W.A. (1997). *Biodiversity of Avifauna of Lal Suhanra National Park, Bahawalpur, Pakistan*. Biodiversity of Pakistan, Pakistan Museum of Natural History, Islamabad, pp. 429-436.
- Kudaisya, G. (1995). The Demographic Upheaval of Partition: Refugees and Agricultural Resettlement in India, 1947-67. *South Asia Journal of South Asian Studies*, 18(sup001), 73-94.
- Lok Sanjh Foundation. (2013). *Thal Desert: A Research Study on Understanding Desert Ecology and Livelihood Patterns [Ebook]*.
- Mahboob, S., Zaib U. Nisa, Ahmad, Z., Sultana, S. (2013). Study on Avian Diversity of Thal Desert (District Jhang), Punjab, Pakistan. *Life Science Journal*, 10(11), 1-8.

- Munir, M.U., Ahmad, A., Khan, M.A., Ashraf, M. (2022). Improved Land and Water Conservation Practices to Enhance Wasteland Productivity in Thal Desert. Islamabad: Pakistan Council of Research in Water Resources.
- Overton, W.S. (1971). Estimating the Numbers of Animals in Wildlife Populations. In R.H. Giles, Jr. (Ed.), *Wildlife Management Techniques*, 3rd ed., pp. 403-455. Wildlife Society, Washington.
- Punjab Bhakkar. (2022, October 26). <https://pakistanalmanac.com/punjab-bhakkar/#1633497144852f0a014d6aded>
- Shaheen, H., et al. (2015). A Preliminary Floristic Checklist of Thal Desert, Punjab, Pakistan. *ResearchGate*, 46(1), 13-18.
- Shaheen, H. (2015). Floristic and Ethnobotanical Enumeration of Thal Desert, Punjab, Pakistan (Ph.D). Arid Agriculture University, Rawalpindi.
- Shaheen, H., R. Qureshi, M.F. Qaseem, P. Bruschi. (2020). The Fodder Grass Resources for Ruminants: An Indigenous Treasure of Local Communities of Thal Desert, Punjab, Pakistan.
- Traveler Trails. (2023, May 24). Thal Desert: The Third Largest Desert in Pakistan.
- Zaman, A., et al. (2023). Diversity, Abundance, and Distribution of Avifauna in District Jhang, Pakistan. *Journal of Zoological Systematics and Evolutionary Research*.

