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Future of reptile research in national parks in Pakistan

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Abstract. Reptiles, the most diverse group of tetrapods with over 12,000 described species, have received less research attention compared to other tetrapod groups worldwide, and this trend also persists in Pakistan. This review aimed to provide a comprehensive overview of reptile research conducted in Pakistan's national parks, identify major knowledge gaps, and propose future research directions. We collected published studies on reptiles from Google Scholar and ResearchGate, extracting relevant data based on the objectives and findings of each study. Our analysis revealed that, to date, only 19 studies have been conducted on reptiles within Pakistan's national parks, with Lal Suhanra National Park having the highest recorded reptile species. Notably, except for one study, all research lacked modern and advanced methodologies. Additionally, we found that reptile studies conducted outside national parks in Pakistan employ significantly more advanced techniques. Baseline data on reptile diversity remains unavailable for many national parks in Pakistan. For future reptile research within these protected areas, we recommend the use of modern techniques, more collaboration with national park authorities, and active involvement of Pakistan's wildlife departments. These approaches will help bridge existing knowledge gaps and contribute to the long-term conservation of reptiles in Pakistan's national parks.

Keywords: reptiles, national parks, *Bungarus caeruleus*, *Nilssonia gangetica*, eDNA, conservation.

Introduction

Reptiles (amphisbaenians, crocodilians, lizards, snakes, tuatara, turtles) play vital roles in ecosystems and are key indicators of environmental health (Miranda 2017, Arana et al. 2023, Farooq et al. 2024). With more than 12,000 species, reptiles are also the most diverse group of tetrapods (Oskyrko et al. 2024, Uetz et al. 2024, Wotherspoon et al. 2024, Cowan et al. 2025). Around 21% reptiles are currently listed as threatened with extinction by the International Union for Conservation of Nature (IUCN) Red List (Dodge et al. 2023, Sparrow et al. 2024). Habitat loss, climate change, pollution, invasive species, diseases, and unsustainable trade are major drivers of reptiles' decline (Marshall et al. 2020, Jarvie et al. 2021, Nordberg et al. 2021, Cox et al. 2022, Farooq et al. 2024).

Compared to other tetrapod groups, reptiles often receive less public attention primarily due to biases and insufficient information (Roll et al. 2016). Worldwide, reptiles are largely neglected in research studies (Böhm et al. 2016, Doherty et al. 2020, Arana et al. 2023, Brum et al. 2023, Guedes et al. 2023). The situation is no different in Pakistan (Rais et al. 2012), which is home to over 190 species of reptiles (Ali et al. 2018). Insufficient research poses serious challenges to species conservation efforts, and reptiles are similarly impacted by this problem (Gibbons et al. 2000, Doherty et al. 2020).

Worldwide, Protected Areas (PAs) play a key role in conserving biodiversity. National Parks fall under Category-II in the PAs classification system (Dudley et al. 2010, Acreman et al. 2020,

Maxwell et al. 2020, Halstead et al. 2022, Zeng et al. 2022, Junaid et al. 2023, Driscoll et al. 2024, Lindenmayer 2024). Lal Suhanra National Park, established in 1972, is the first national park in Pakistan (Khan & Mian 2013). Although many groups of fauna and flora in Pakistan's national parks have been well-studied (Enright et al. 2005, Shafique & Barkati 2010, Qureshi 2012, Rais et al. 2014, Mahmood et al. 2015, Dauda et al. 2016, Shah et al. 2017, Khan et al. 2018, Hameed et al. 2020, Habiba et al. 2021, Nazakat et al. 2021, Saeed et al. 2021, Akram et al. 2022, Saeed et al. 2022, Bashir et al. 2023, Batool et al. 2023, Khan et al. 2023a, Rais et al. 2023), reptiles have been largely overlooked in research (Rais et al. 2012, Junaid et al. 2023). This review provides a comprehensive overview of research conducted to date, identifying existing knowledge gaps and outlining future research directions for reptiles in Pakistan's national parks.

Materials and Methods

We followed the methodology of Doherty et al. (2020) to collect studies conducted on reptiles in national parks of Pakistan. We retrieved published articles from Google Scholar and ResearchGate using key terms i.e., "Reptiles", "Squamates", "Lizards", "Snakes", "Turtles", "Tortoises", "Crocodiles", "National Parks", and "Pakistan", both individually and with "AND" and "OR" combinations. A total of 19 articles were selected and reviewed. For this review, only articles focusing on research conducted on reptile species within the national parks of Pakistan were selected for data extraction. Studies examining reptiles outside the national parks were not included. The required data were extracted by analyzing the objectives and results of each selected article. The extracted data was organized in a spreadsheet. Further analysis was conducted to determine which national parks in Pakistan have been the focus of reptile research and to identify those that remain unexplored. We evaluated the research gaps and shortcomings present in the collected studies. To present the findings of the analysis, a map was created using ArcGIS Desktop 10.8 (ArcGIS Core Team 2020), showing the number of reptile studies conducted in national parks across Pakistan. Data on the total number of species reported from each national park and the number of studies over the years were presented in the form of bar and line graphs, created in R version 4.4.1 (R Core Team 2024), using "ggplot2" and "tidyverse" packages (Wickham 2011, Lee et al. 2020).

Results

The analysis revealed that, to date, 19 studies have been conducted on reptiles within Pakistan's national parks (Figure 1). Lal Suhanra National Park has the most recorded number of reptile species, followed by Kirthar National Park (Figure 2). Yearly trends indicated that the highest number of studies was reported in 2011 and 2021, with three studies reported each year (Figure 3). Except for the phylogenetic analysis of *Bungarus caeruleus* by Ashraf et al. (2019a), all studies have relied on direct sightings, field surveys, and local information, lacking modern molecular and genetic methodologies.

Discussion

Our analysis provided that, compared to other tetrapod groups (amphibians, birds, mammals), reptiles have received significantly less research attention in Pakistan's national parks. For example, in Murree-Kotli Sattian-Kahuta National Park, only one study on reptiles has been conducted to date, compared to extensive research on amphibians and mammals (Figure 4). Similarly, Junaid et al. (2023) reported that Ayubia National Park has a significant lack of reptile research, as most of the research has focused on other fauna.

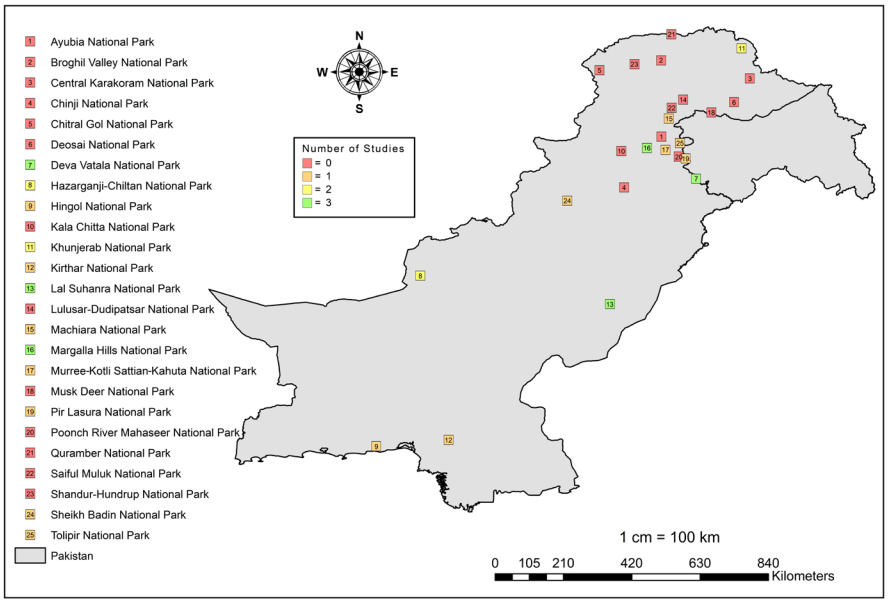

Figure 1. Map showing the locations of national parks and the number of studies conducted on reptiles in each national park in Pakistan.

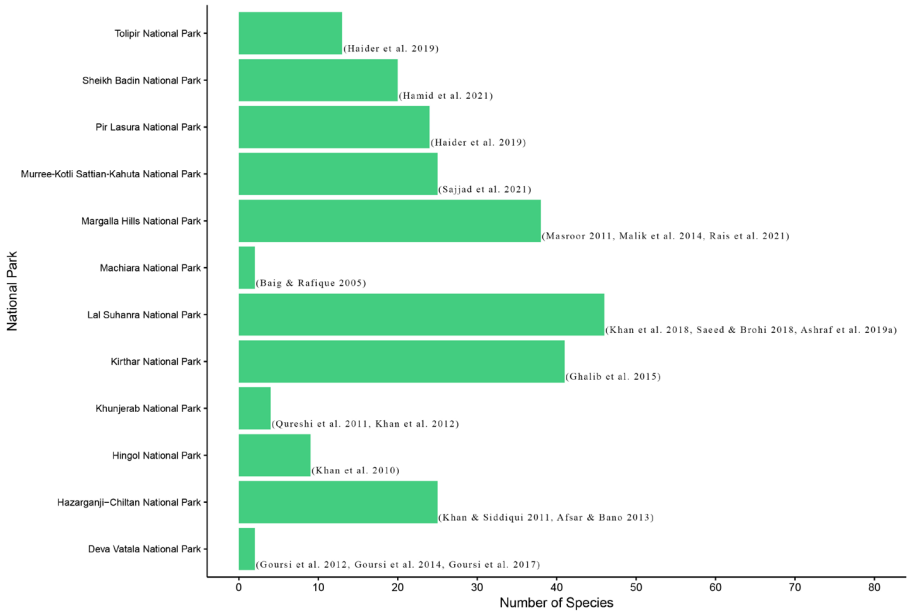

Figure 2. Number of species recorded from each national park studied (see Supplementary Material for more details).

Numerous studies on reptiles outside of national parks are available in Pakistan, and the use of advanced methodologies is significantly higher in these studies compared to those within national parks. Snakes have been the focus of molecular research in Pakistan among reptiles. Phylogenetic analysis and venom properties of *Bungarus caeruleus*, *Daboia russelii*, *Echis carinatus*, *Eristicophis macmahoni*, *Naja naja*, and *Platyceps rhodorachis* have been studied across different regions of the country (Feroze et al. 2010, Modahl et al. 2010, Wong et al. 2018, Asad et al. 2019, Ashraf et al. 2019b, 2020, Hashmi et al. 2020, Khan et al. 2023b, Malik et al. 2023). Genetic studies on *Lissemys punctata*, *Nilssonia gangetica*, and *Pangshura smithii* have been conducted in Pakistan (Kayani et al. 2015 a, b, c, Khan et al. 2021a). In case of lizards, genus *Eremias* and

Uromastyx have been studied at the genetic level (Khan et al. 2021b, Malik et al. 2024). Balouch et al. (2022) documented the movement and habitat use of *Calotes versicolor* using radio telemetry in agricultural landscapes.

The baseline data on reptiles in many of Pakistan's national parks is currently unavailable. Future studies should aim to integrate modern approaches with field surveys to assess reptile diversity across different national parks. The use of genetic techniques to understand the reptilian diversity in the national parks of Pakistan is essential. The Environmental DNA (eDNA) method, which has gained considerable global acceptance in reptile studies due to its non-invasive nature and ease of application (Akre et al. 2019, Katz et al. 2021, Kyle et al. 2022, Nordstrom et al. 2022, Mousavi-Derazmahalleh et al. 2023, Pérez-Fleitas et al. 2023), is recommended.

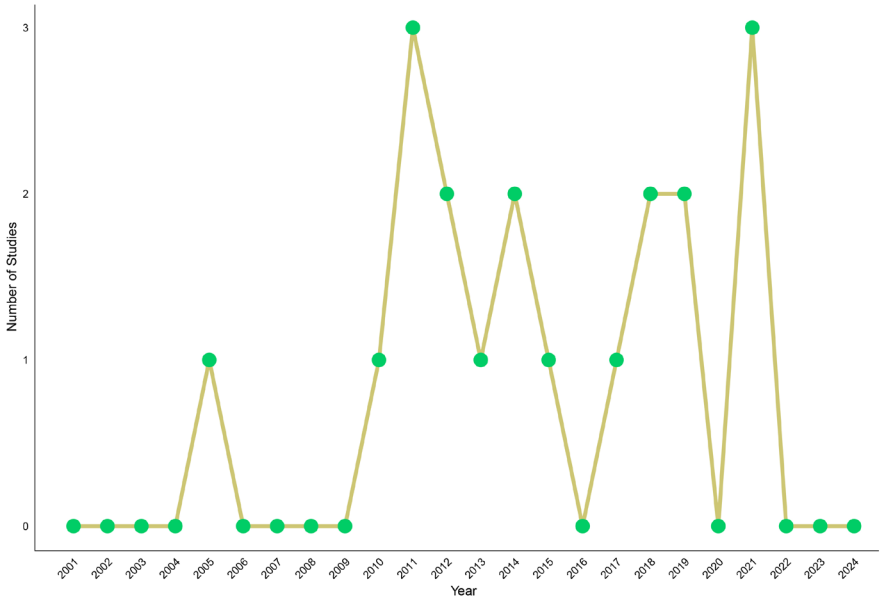

Figure 3. Number of reptile studies reported each year, since 2001, from national parks in Pakistan.

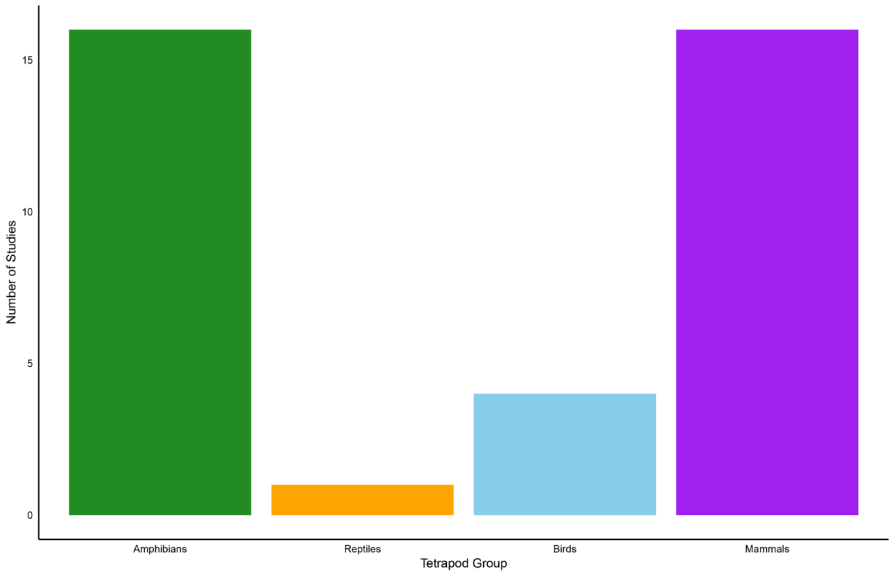

Figure 4. Number of studies conducted on each tetrapod group in Murree-Kotli Sattian-Kahuta National Park, Punjab Province, Pakistan.

Collecting data on how climatic and topographic factors - such as temperature, precipitation, elevation, and habitat characteristics - affect reptiles will help make effective conservation planning. Collaboration with national park authorities is crucial for evaluating reptile diversity and improving conservation strategies. Engaging with park staff will facilitate access to key habitats and foster a better understanding of the ecological needs of reptiles. Additionally, the involvement of Pakistan's wildlife departments will play a pivotal role in the protection of reptilian fauna. Their support in implementing management plans, enforcing protection measures, and promoting awareness will be vital in addressing conservation challenges for reptile populations in national parks. The combined effects of these approaches will help close existing knowledge gaps and ensure the long-term survival of reptiles in Pakistan's national parks.

In conclusion, addressing the current knowledge gaps in reptile diversity within Pakistan's national parks requires a multidisciplinary approach combining ecological, genetic, and conservation-focused research. Future research should prioritize long-term monitoring programs, species distribution modeling, and conservation action plans tailored to the specific environmental conditions of each national park. Strengthening collaboration among researchers, conservationists, and government departments will be essential to ensure the long-term survival of reptilian fauna in national parks.

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