DIVERSITY AND DISTRIBUTION OF LIZARDS IN BENIGHAT RORANG RURAL MUNICIPALITY, DHADING, NEPAL

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Submitted to
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Institute of Science and Technology
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Nepal

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DECLARATION

I, hereby declare that the work presented on the topic entitled **"DIVERSITY AND DISTRIBUTION OF LIZARDS IN BENIGHAT RORANG RURAL MUNICIPALITY, DHADING, NEPAL"** has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of material were explicitly acknowledged with citations to the author(s) and institution(s).

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On the recommendation of supervisor Dr. Bishnu Prasad Bhattarai, Assistant Professor, Central Department of Zoology, Tribhuvan University, this thesis entitled **"DIVERSITY AND DISTRIBUTION OF LIZARDS IN BENIGHAT RORANG RURAL MUNICIPALITY, DHADING, NEPAL"** is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for the Master's Degree of Science in Zoology with special paper Ecology and Environment.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Miss Garima Shrestha entitled **"DIVERSITY AND DISTRIBUTION OF LIZARDS IN BENIGHAT RORANG RURAL MUNICIPALITY, DHADING, NEPAL"** has been accepted as a partial fulfillment of the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Abbreviated form	Details of abbreviations
CITES	Convention on International Trades in Endangered Species
GPS	Global Positioning System
IUCN	International Union for the Conservation of Nature
PCA	Principal Component Analysis
VES	Visual Encounter Survey

ABSTRACT

Lizards are a widespread group of squamate reptiles. This study assessed species diversity and distribution of lizards in Benighat Rorang Rural Municipality, Dhading, Nepal. Using a random transect survey, twenty transects (each of 5 x 100 m) were laid in different habitat types. A visual encounter survey along with an opportunistic survey was adopted to increase the efficacy of the survey. The survey was conducted during the month of October 2022 for 10 days and during the month of April 2023 for 10 days. A total of 119 individuals of 13 species of lizards belonging to six genera and four families (Agamidae, Scincidae, Varanidae, Gekkonidae) were recorded during the study period. The Shannon diversity index (H' = 1.536) showed moderate diversity of lizards and the Evenness index (J = 0.5989) revealed a relatively balanced population with an even distribution of individuals among the lizard species present during the study period. *Laudakia tuberculata* was the most abundant lizard species. Family Agamidae had the highest abundance of lizards. Whereas Gekkonidae was the most dominant family with six species and the least was the family Varanidae (one species). The highest abundance of lizards was found in rocky areas and the highest species richness was in human settlements. *Calotes versicolor* was the only lizard species recorded from all four different habitats. PCA was performed to establish the relationship between lizards and different habitat types and gain insights into the specific habitat preference of lizard species. The study also examined lizard species abundance and richness patterns along an elevation gradient. The study exhibited a hump-shaped pattern for both the species abundance and richness of lizards along an elevation gradient showing a peak at around the elevation of 1,300 m. The decline of species abundance and species richness was observed more towards the higher end of the elevation gradient. Most lizard species were found across a broad range of elevations. *In the study area, Calotes versicolor and Hemidactylus brookii exhibited the widest and narrowest elevation range respectively*. This is the first research on the diversity and distribution of lizards in Dhading, Nepal. So, can serve as the baseline for future studies relating to lizards.

1. INTRODUCTION

1.1 Background

Herpetofauna comprises amphibians and reptiles. Both are ancient groups with fascinating histories and are important individuals that survived the mass extinction. Amphibians and reptiles are grouped under herpetofauna as they share significant physiological, behavioral, and ecological similarities (Vitt & Caldwell 2014). The three orders of amphibians are Caudata (salamanders and newts), Anura (frogs and toads), and Gymnophiona (caecilians) (Shah & Tiwari 2004). Reptiles include their three representative orders of Crocodylia (crocodiles and alligators), Testudines (turtles and tortoises), and Squamata (lizards and snakes) (Schleich & Kastle 2002). Herpetology is zoology's branch concerned with the structure, classification, life history, and distribution of amphibians and reptiles (Smith 1951). Herpetology is crucial for biodiversity research since it is a rapidly evolving field of study, with discoveries being made all the time, and many more are thought to remain unknown to science (WWF 2009). Herpetofauna is considered a beneficial faunal group and plays a crucial role in energy flow, and nutrient recycling in the ecosystem (Chaudhary 1998, Shrestha 2001), and serve as excellent bio-indicators as they are sensitive to environmental changes (Wang & Chan 2008) and are used to gauge the health of riparian ecosystem (Fulton 2013).

Reptiles are a group of creeping or crawling vertebrate species that descended from amphibians more than 200 million years ago (Thapa 2016). All reptiles are tetrapod, meaning they have four limbs (like turtles and crocodiles) or are descended from four-limbed animals (like snakes). Reptile skin is covered by horny structures (scales, plates, granules, tubercles, etc.) that prevent them from losing moisture through their skin and provide them with few glands. Reptiles are influenced by external temperature fluctuations so they are sensitive to environmental changes both in terrestrial and aquatic habitats so they serve as biological indicators of environmental stresses (Zug et al. 2001). Reptiles can be sensitive indicators of the impact of human activities such as intensive grazing, forest cutting, and mining (Read 2002, Thompson & Thompson 2005).

Around the world 11,940 reptilian species have been discovered to date, of which 201 are Amphisbaenia (amphisbaenians), 7,310 are Sauria (lizards), 4,038 are Serpents (snakes), 363 are Testudines (turtles), 27 are Crocodylia (crocodiles) and one is Rhynchocephalia (tuataras) (Uetz et al. 2023). The International Union for the Conservation of Nature (IUCN) examines the status of 6,076 lizard species. Out of which 20 species are already Extinct (Ex) and two are Extinct in the wild (EW), 257 species are Critically Endangered (CR), 510 species are Endangered (EN), 373 species are Vulnerable (VU), 335 species are Near Threatened (NT), 3,809 species are Least Concern (LC), and 770 species are Data Deficient (DD) (IUCN 2023).

Lizards are a diverse group of reptiles that belong to the order Squamata with 7,310 species worldwide (Uetz et al. 2023), found on every continent except Antarctica, and have a wide

range of sizes, shapes, and behaviors. Lizards are found at elevations ranging from sea level to 5,000 meters (16,000 feet). Most lizards are active during the day, while others are nocturnal. Lizards can survive in a wide range of habitats, including the desert, forest floor, scrubland, tunnels, cliffs, rocks, agricultural fields, diverse water bodies, and even houses as macro and microhabitats (Thapa 2016). Lizards, as ectotherms, cannot regulate their body temperature and must seek out and bask in sunlight to become fully active (Pianka et al. 2003).

The Himalayan country of Nepal owes its remarkable diversity of 56 amphibian and 142 reptile species (including both confirmed and most probable occurrences) due to its unique geographic location (Kastle et al. 2013). Due to high habitat diversity, Nepal is home to a diverse range of lizard species (Pokhrel & Thakuri 2016); new species are still being discovered and documented. Lizards can be found in Nepal at altitudes ranging from 80 m to 5490 m (Thapa 2016). *Varanus flavescens* is listed in CITES Appendix I and is protected on a global scale by the National Park and Wildlife Conservation Act of Nepal (GoN 1973), *Varanus bengalensis* is also listed in CITES Appendix I and the *Gekko gecko* is listed in CITES Appendix II (CITES 2023). According to IUCN (2023), lizard species found in Nepal such as *Sitana fusca* is listed as Critically Endangered (CR), *Sitana schleichi* and *Varanus flavescens* are listed as Endangered (EN), *Japalura dasi* is listed as Vulnerable (VU) and *Varanus bengalensis* is listed as Near Threatened (NT).

Lizards play important roles in many ecosystems, serving as predators, prey, and decomposers. Despite the diversity and ecological importance, the lizard population has suffered widespread declines and extinctions (Blaustein & Wake 1995, Kiesecker et al. 2001). Herpetofauna are threatened with extinction due to habitat loss (Marsh & Trenham 2001), climate change (Kiesecker et al. 2001) and hunting for food, forest fire, the presence of invasive and introduced species, pollution, and diseases (Gibbons et al. 2000). Limited dispersal ability of herpetofauna may further increase the vulnerability to changes in climate (Pokhrel et al. 2011). Herpetofaunal conservation efforts are limited in the country (Shah & Tiwari 2004), people consider all reptiles as poisonous and killed at sight. Reptiles are likely to be at a higher risk of going extinct and are experiencing severe range reductions and a decline in abundance (Gibbons et al. 2000, Araujo et al. 2006). Nearly one-fifth of all reptile species (Bohm et al. 2013) are threatened with extinction. In terms of lizards, in some communities, there is a practice of consuming smoked and dried meat of *Varanus* spp (Monitor lizards). The fat of monitor lizards is used for medicinal and cultural purposes (Shah & Tiwari 2004).

Understanding the elevational distribution pattern of species and the factors influencing it might aid in understanding biodiversity and conservation (Hunter & Yonzon 1993). We know little about the factors that influence species richness, particularly along environmental gradients such as the elevational gradient. The richness of species along an elevation gradient may exhibit one of three general patterns: a mid-elevation peak, a monotonic decline, or an increase with elevation (Rahbek 1995). However, increasing research suggests that mid-elevation peaks in species richness are more common for a wide

range of taxa (Rahbek 1995). Although monotonic decline (Hofer et al. 1999) is the most recorded herpetofauna distribution, both linear increase (Naniwadekar & Vasudevan 2007) and mid-elevation peak (Fu et al. 2007) have been described. The mid-domain effect (MDE) has recently been identified as one of the most important drivers of such a pattern (Colwell et al. 2004).

Herpetology has, however, never received the same level of priority as other vertebrates (Bhattarai et al. 2017, Bhattarai et al. 2018). Most of the research work has been carried out on large charismatic mammals and birds, but snakes and lizards are often overlooked (Vasudevan et al. 2006, Chettri et al. 2011). Lizards are the least studied fauna in Nepal and information about lizard species from Nepal is poorly documented, primarily to the cryptic character of many species, behavioral sensitivity to their environments (Munoz et al. 2016), and researcher's lack of interest. Due to their small habitat range lizards are facing strong negative impacts. Anthropogenic activities like deforestation, expansion in agriculture, forest fire, and exploitation of *Varanus* spp by different ethnic groups for different purposes are other major causes for their population decline.

In this context, a brief study of lizards in Benighat Rorang Rural Municipality was conducted to investigate their diversity and distribution. The study area lies near the Chitwan National Park and is expected to have a wide range of lizard species. Additionally, the study of the lizards association with habitats and lizard's distribution pattern along an elevation in the study area is expected to add a new dimension to lizards research in Nepal.

1.2 Rationale

Herpetofaunal research and information in Nepal have long been kept behind closed doors. There are still a lot of unanswered concerns even though herpetological research in Nepal started almost two hundred years ago. Lizards are the least studied fauna in Nepal with very scanty research works, information, and literature, and their present status is also poorly known. So, to analyze the diversity and distribution of lizards, it is necessary to revisit locations that have not been assessed in the last decade and explore unexplored areas. However, little research has addressed herpetofauna distribution patterns in the Nepalese Himalayas, available data is mostly based on checklists and data on altitudinal gradients in species richness are limited. Very few data relating to lizards were extracted from the herpetofauna studies emphasizing that studies of lizards are rarely found. This study will explore the diversity and distribution of lizards along an elevation gradient in Benighat Rorang Rural Municipality, Dhading. Therefore, it is very necessary to develop baseline information about the lizard's diversity and distribution, so this study will be new for Nepal.

1.3 Research Objectives

1.3.1 General objective

The general objective of this study was to explore the diversity and distribution of lizards in Benighat Rorang Rural Municipality, Dhading, Nepal.

1.3.2 Specific objectives

- To determine the species composition and abundance of lizards in Benighat Rorang Rural Municipality, Dhading, Nepal
- To understand the distribution pattern of lizards along an elevation gradient in the study area.

2. LITERATURE REVIEW

2.1 Species composition and abundance of lizards

Globally, herpetofauna is among the least studied vertebrate taxa (Fazey et al. 2005). On a global scale, herpetofauna is declining more rapidly than birds and mammals (Stuart et al. 2004). South Asia is rich in herpetofauna, including endemic species to the region (Das & Van Dijk 2013). This is because the region falls between two biogeographic realms – Palearctic and Oriental. The distribution of the herpetofauna in Nepal covers a large area both horizontally (Mechi to Mahakali) and vertically (60 – 5,490 m). In comparison to other South Asian nations, Nepal has a herpetofauna that is more diverse, with well over 206 species and subspecies. Fourteen species of herpetofauna are endemic to Nepal, seventeen are listed as threatened, of which six are threatened globally (Bhuju et al. 2007). As one of the poorly studied groups in Nepal, the herpetofauna's status is also not well-known (CEPF 2005).

The herpetofauna of India consists of 475 species of reptiles including 186 species of lizards (Dutta: unpublished data). Dutta (1999) provided a record of nine species of lizards belonging to three families namely Agamidae (four species), Scincidae (two species), and Gekkonidae (three species) during the study of assessment of herpetofauna in Great Himalayan National Park and Wildlife Sanctuary.

Khalid et al. (2019) researched the diversity and distribution of lizard fauna in tehsil Samar Bagh, Dir lower, Khyber Pakhtunkhwa, Pakistan, and accounted for a total of 62 specimens of lizards that belonged to four families and five genera. Family Agamidae was the most abundant family followed by Gekkonidae then by Eublepharidae and the least abundant family was Varanidae. The six identified species were: *Laudakia agrorensis*, *Calotes versicolor*, *Eublepharis macularius*, *Hemidactylus frenatus*, *Hemidactylus flaviviridis*, and *Varanus bengalensis*. A preliminary assessment of the diversity and habitat preferences of herpetofauna in the Cholistan desert, Pakistan was carried out by (Ali et al. 2021) and recorded ten lizard species under six families namely Agamidae (two species), Gekkonidae (three species), Lacertoidea (one species), Scincidae (one species), Uromastycidae (two species), and Varanidae (one species). *Uromastyx hardwickii* (Spiny tail lizard) was the most found lizard species followed by *Calotes versicolor* and *Hemidactylus brookii*.

Hodgson's collections between 1826 and 1854 are the earliest source and have provided various information for herpetofauna research in Nepal. A significant contribution was made by (Gunther 1860,1861) to the understanding of Himalayan reptiles and the list of cold-blooded animals compiled by H.B. Hodgson in Nepal.

The foundation for present-day Nepalese herpetology was laid out by Swan & Leviton (1962) establishing the zoogeographic study of the herpetofauna and presenting a checklist of 53 species of reptiles of Nepal along with a sketch of their history.

Nanhoe & Ouboter (1987) prepared the distribution of herpetofauna in the Annapurna Dhaulagiri region of Nepal and reported 11 species of lizards from direct observation whereas two lizard species from unreported collection and literature records belonging to three families namely Gekkonidae (three species), Agamidae (five species), and Scincidae (five species). *Phrynocephalus theobaldi* and *Sphenomorphus maculatus* have not been reported from Nepal before. *Scincella capitanea* was a lizard species described by (Ouboter 1986).

Zug & Mitchell (1995) recorded 10 lizard species from Chitwan National Park under four families i.e., Agamidae (one species), Gekkonidae (four species), Scincidae (three species), and Varanidae (two species). Among all the lizard species, *Calotes versicolor* was mostly found.

Shah (1995) recorded 24 species of lizards in Nepal comprising one endemic species of lizard. An extensive enumeration of the herpetofauna of Nepal had been described by (Shah 1995,1997) and described how they are used for food and medicine in the country.

In this century, the knowledge of herpetology in Nepalese species has greatly increased thanks to publications like "Herpetology of Nepal" by Shrestha (2001) provided the knowledge of 20 herpetofauna and their distribution, "Amphibians and Reptiles of Nepal" by Schleich & Kastle (2002) provided an account of 50 amphibians and 123 reptiles for Nepal, and "Herpetofauna of Nepal, a conservation companion" by Shah & Tiwari (2004). Since then, others have contributed either by describing new species or recording taxa new to the country. Most of the studies were limited to eastern and central Nepal and frequently omitted locality records whereas Nepal's mid-western and far-western regions remain the least explored (Shah & Tiwari 2004). Although that collective work yielded records for 53 species of amphibians and 137 species of reptiles in Nepal, many habitats remain to be explored both within and outside the previously studied areas.

Rai (2003) identified 66 species of reptiles from the Eastern Development Region. Out of the total species of reptiles, the *Gekko gecko* and *Draco* species were new records listed for Nepal.

Bista & Shah (2010) recorded 35 reptiles including 10 species of lizard from Ghodaghodi Lake.

Chhetry (2010) conducted a herpetofauna survey in Koshi Tappu Wildlife Reserve and identified a total of 23 species of herpetofauna belonging to 19 genera and 13 families and recorded the presence of two genera and two families of lizard species.

Shrestha & Dekocha (2011) surveyed herpetofauna from the Banke National Park, Banke, Mid-Western region, Nepal, and recorded six species of lizards within three families namely, Agamidae, Gekkonidae, and Scincidae.

A herpetofauna study was carried out by (Pokhrel et al. 2011) and accounted for a total of eight species of reptiles, four species of lizards within two families namely, Scincidae and

Agamidae while surveying on Nagarjun Forest of Shivapuri National Park. *Calotes versicolor* was found in abundance.

A survey of the herpetofauna in the Manaslu Conservation Area was conducted (Pokhrel & Thakuri 2016) and accounted for four species of lizard: *Laudakia tuberculata, Calotes versicolor, Asymblepharus sikimmensis, and Oriotiaris tricarinata.* The most abundant species were *Laudakia tuberculata, encountered* in agricultural land, settlements, and rocks. Whereas (Shrestha & Shah 2017) and prepared a checklist of six species of lizard belonging to six genera and three families namely Agamidae (three species), Scincidae (two species), and Varanidae (one species). *Laudakia tuberculata* was encountered the most. *Calotes versicolor* was recorded from a higher altitude of 2,512 m.

Bhattarai et al. (2017) conducted research on the herpetofauna of Beeshazar and associated lakes, a Ramsar site in the Chitwan National Park buffer zone and discovered four families and 11 species of lizards.

Bhattarai et al. (2018) have also described the herpetology of Parsa National Park and detected 12 species of lizard within four families; Agamidae (two species), Scincidae (five species), Gekkonidae (three species), and Varanidae (two species). New reports for Parsa National Park include two Gecko species (*Hemidactylus flaviviridis* and *H. frenatus*), two Skink species (*Eutropis carinata* and *Sphenomorphus maculatus*), and one Agamid (*Sitana fusca*).

A study of herpetofauna diversity in the Rupandehi and Arghakhanchi districts was carried out (Nepali & Singh 2018) and 36 species of reptiles were encountered where 11 species of lizard under four different families were represented. Three species were found in the families Gekkonidae, Agamidae, and Scincidae, while two were found in the Varanidae. The most abundant species were *Calotes versicolor, Hemidactylus brookii, H. flaviviridis, and Eutropis carinata.*

Nepali & Singh (2020) again surveyed the herpetofauna of Nawalparasi district, Nepal, and provided an account of 32 species of reptiles where nine species of lizard within four families were recorded. Reptile species richness was higher in the forest. *Calotes versicolor* and *Hemidactylus* spp were the species most encountered.

Gautam et al. (2020) assessed the distribution and diversity of herpetofauna in the Ghandruk region of the Annapurna Conservation Area and recorded four species of lizards namely *Calotes versicolor, Japulara tricarinata, Laudakia tuberculata, and Asymblepharus sikimmensis.* The most abundant species were *Laudakia tuberculata.* Species richness in the study area peaked at the elevation range of 1,500 m – 2,000 m.

Rawat et al. (2020) surveyed the herpetofauna of Shuklaphanta National Park, Nepal, and presented the currently known 56 species of reptiles (16 lizard species under four families). One skink, *Sphenomorphus maculatus*; one agamid, *Laudakia tuberculata* were new records of lizard for ShNP.

A wildlife assessment of the Chandragiri Hills done by (Katuwal et al. 2020) accounted for eight species of lizard belonging to three families namely Agamidae (four species), Scincidae (three species), and Varanidae (one species).

A report on herpetofaunal survey on the entire Chure Range was performed (Bhattarai et al. 2020) by dividing the Chure Range into four survey blocks; namely a) Eastern block: Mechi River to Bagmati River section, b) Central block: Bagmati River to Tinau River section, c) Western block: Tinau River to Karnali River section, and d)- Far western block: Karnali river to Mahakali River section. The report identified 99 species of herpetofauna, accounting for 55.3% of the herpetofauna found in Nepal. In addition, there are 23 lizard species from five families: Agamidae (Five species), Eublepharidae (One species), Gekkonidae (Seven species), Scincidae (Seven species), and Varanidae (Three species). The Chure Range is home to two species of lizards: *Sitana sivalensis* and *Sitana fusca* (endemic to Nepal). For the first time in Nepal, a new lizard species, the water monitor lizard (*Varanus salvator*) was discovered. The survey was conducted between the elevation of 100 m – 1,500 m. The most abundant lizard species during the survey was found to be *Calotes versicolor*.

An updated checklist of amphibians and reptiles in Nepal was provided by (Rai et al. 2022) and listed 143 species of reptilian fauna with only 19 species being endemic to the country. Lizards belonging to 41 species under 16 genera and six families were listed. Out of which 10 species of lizards are endemic to Nepal namely *Japalura dasi*, *Sitana fusca*, *Sitana schleichi*, *Sitana sivalensis*, *Cyrtodactylus markuscombaii*, *Cyrtodactylus martinstolli*, *Cyrtodactylus nepalensis, Asymblepharus mahabharatus*, *Asymblepharus nepalensis*, and *Scincella capitanea*.

Paudel et al. (2022) conducted research on Herpetofauna Diversity in a Threatened Wetland Ecosystem, Ramaroshan Wetland Complex, Western Nepal, and reported four species of lizard belonging to Two families namely, Agamidae (*Calotes versicolor* and *Laudakia tuberculata*) and Scincidae (*Asymblepharus himalayanus* and *Asymblepharus ladacensis*). The most encountered species was *Laudakia tuberculata*. Near human settlements, grassland, and agricultural areas reptiles were most abundantly found.

2.2 Distribution pattern of herpetofauna along an elevation gradient

A study of frog biodiversity along an elevation gradient in the Hengduan Mountains, China conducted by (Fu et al. 2006) observed endemic species richness of frogs followed the mid-domain model predictions, and showed a non-linear relationship with temperature.

Fu et al. (2007) performed a study on elevational gradients of diversity for lizards and snakes in the Hengduan Mountains, China. The study found 42 species of lizards (six families and 38 genera) are distributed between 500m and 3,500m. Among these, eight lizard species were endemic to the mountains. The most species-rich families are the Agamidae (five genera and 16 species, the Scincidae (four genera and 12 species), and the

Gekkonidae (three genera and eight species). The relationship between species richness and elevation for lizards was unimodal. This study shows a diversity peak at low-to-middle elevations for lizards in the Hengduan mountains.

The spatial distribution pattern of reptiles in an eastern Himalayan elevation gradient, in India was studied by (Chettri et al. 2010). Reptiles were surveyed along the elevation gradient (300 m – 4,800 m) of the Teesta Valley in Sikkim. A total of 42 species of reptiles with 14 species of reptiles were observed, and the species richness peaked at 500 m – 1,000 m with no species beyond 3,000 m. The observed species richness of reptiles deviated significantly from that predicted by the mid-domain null model. Reptile species did not peak at mid-elevation but at the lower elevation (500 m – 1,000 m). Lizards showed a linear decline with elevation.

A study on species richness and abundance of anuran along an elevation gradient was conducted by (Khatiwada & Haugaasen 2015) in Chitwan, Nepal. The study examined anuran frog assemblages along an elevation gradient in the range of 200 m – 1,600 m. Regression analysis showed an overall decline trend in frog species richness and abundance with increasing elevation.

A study on amphibian community structure along elevation gradients was performed by (Khatiwada et al. 2019) in eastern Nepal Himalaya, where a survey was done along the elevation gradient 78 m – 4,200 m. Species richness and abundance declined linearly with increasing elevation.

Paudel et al. (2022) also observed a hump-shaped pattern in the distribution of herpetofauna along the elevation gradient with the highest richness and abundance at 2,300 m asl.

To conclude this brief review of related literature, it can be stated that, despite great progress in recent years in this field, many significant regions of the country with a diversity of herpetofauna (especially lizards) have remained unexplored. The previous research mostly focused on collecting and preserving herpetofauna checklists throughout Nepal. However, research on lizard species is limited. In many regions, including presence and absence surveys, a checklist has not been prepared for herpetofauna, particularly lizards. Only a few altitudinal gradient studies have been conducted in Nepal to better understand the distribution pattern of herpetofauna. As a result, this work will serve as a model for future research on lizards. Thus, there is a lot of potential for additional research in this field.

3. MATERIALS AND METHODS

3.1 Study Area

Dhading extends from 27.5556°N latitude to 28.3865°N latitude and 84.2266°E longitude to 85.4587°E longitude. Dhading has been divided into three eco-zones: the high Himalayas, the high mountains, and the mid-mountains. The altitude of the district varies from 300 m to 7,409 m. Dhading is unique in its natural and cultural heritage. The entire area of Dhading is covered by hills and deep slopes. Dhading is the only district of Nepal that ranges from the mountain Ganesh Himal to the Churevawar Pradesh of Terai (Chitwan). The study area, Benighat Rorang, is a rural municipality within Dhading District, Nepal. Benighat Rorang has a total of 10 wards, which are scattered across 29.17 square kilometers (11.26 sq mi) of geographical area. The geographic coordinates of Benighat Rorang Rural Municipality are approximately 27.4829°N and 84.4609°E.

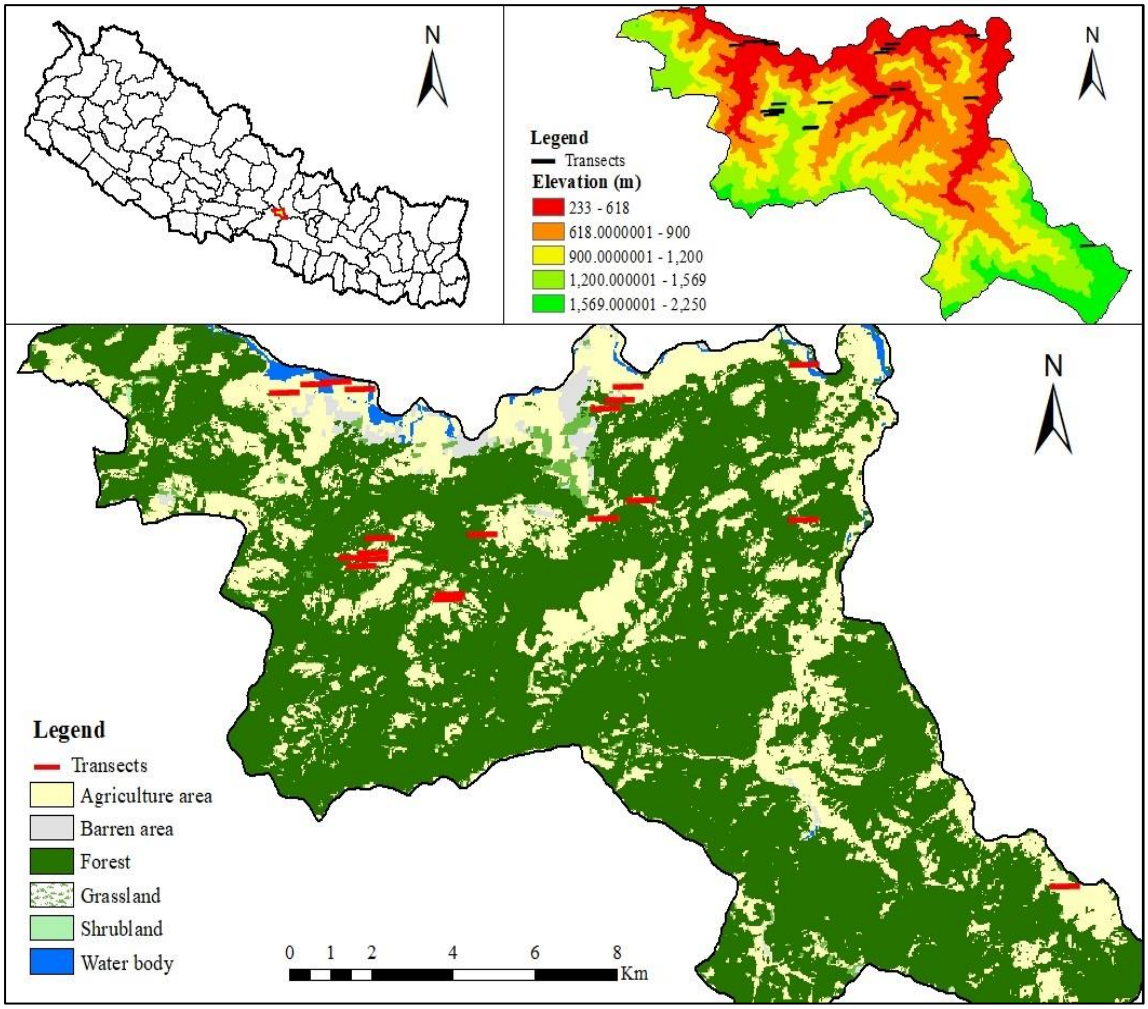

Figure 1. Study area (Benighat Rorang Rural Municipality)

3.2 Methods

3.2.1 Research Design

A preliminary survey was conducted to collect information on possible sites to encounter lizards by interviewing residents of the study area. Before carrying out the field survey, research permission was obtained from the Department of Forest and Soil Conservation and the rural municipality of Dhading, Benighat Rorang. A random transect method was applied for the survey. 500 meters distance in any direction on a possible trail was considered as one transect and species were surveyed along the transects (100 x 5 meters) between 8.00 to 8.00 hr. Data were collected during the month of October 2022 for 10 days and during the month of April 2023 for 10 days. Altogether 20 transects were laid in different habitats, where three transects were laid in agricultural land, five in human settlement, six in forest, and six in rocky areas. A field survey was carried out without disturbing lizard species and its habitat. No collection and preservation of lizard species were performed.

3.2.2 Transect Survey

Visual Encounter Survey (VES) is a popular sampling method for amphibians and reptiles (Scott et al. 1994). Each transect was searched by two people by walking at a slow pace along the transect. Lizard species were extensively examined along the transects in all possible microhabitats such as rocks, boulders, fallen logs, and so on. VES was used to record the presence and absence of lizards (Gillespie 1997). The search lasted from 8:00 a.m. to 8:00 p.m. for about 2-3 hours depending upon the weather conditions. The number of individuals, coordinates, elevation, weather conditions (temperature and humidity), distance to water, distance to settlement, distance to road, and habitat type were all recorded when lizards were sighted.

An opportunistic survey was also carried out to gather additional information and insights to ensure the record of species that are extremely rare and may not be detected using standard methods such as VES (Durkin et al. 2011). Such records of species were combined with those from the Virtual Encounter Survey method to contribute to total species richness data.

3.2.3 Species Identification

Species were identified based on the photograph elicitation method with the help of standard literature and the keys used (Shah & Tiwari 2004, Schleich & Rai 2012, Kastle et al. 2013). An online database of http://www.reptile-database.org was also used to identify lizard species.

3.3 Data Analysis

The primary data was obtained during the field visit and the data was organized, structured, and processed using Microsoft Excel 2011 for further analysis. Arc GIS 10.8 (Esri 2011) was used to create a map of the study region.

Other analyses were:

3.3.1 Species diversity

Shannon-Wiener diversity index is a dominance index as it provides more weight to common or dominant species and a few rare species with fewer numbers will not affect diversity (Simpson 1949). Higher index values indicate greater diversity, whereas lower values indicate lower diversity.

It can be calculated by using the formula:

$H' = - \sum (pi \, ln \, pi)$

Where, H' = Shannon's index of diversity

pi = the proportion of individuals in the ith species

ln = Logarithm to base e

ni = Number of individuals

N = Total number of individuals

Pielou's evenness (J) was calculated to compare the actual diversity value (the Shannon index, H') to the maximum possible diversity value (when all species are equally common, $H_{max} = lnS$).

$J = \frac{H'}{Hmax}$ or $J = \frac{H'}{lnS}$

Where, H' = Shannon's index of diversity

H_{max} = Maximum possible diversity value

S = Total number of species

3.3.2 Kruskal-Wallis Test

The Kruskal-Wallis test was used to test significant differences in lizard species abundance and species richness along different habitat types using PAST software (Hammer et al. 2009) as the data obtained during the study were not normally distributed.

3.3.3 Principal Component Analysis (PCA)

In data analysis, Principal Component Analysis (PCA) is a popular dimensionality reduction technique. PCA was performed using R studio (version 4.2.2) with dplyer, ggplot2 and FactominerR and factoextra packages (Team 2021) to help identify and visualize the distribution and understand how the lizard species are associated with different habitats and their specific habitat preferences.

3.3.4 Polynomial Regression

Polynomial regression was used to understand the relationship between elevation and the response variable such as lizard species abundance and species richness. It allows us to capture the potential curvature in the data and provide a more accurate fit as the data has a non-linear relationship between the variables. Polynomial regression was performed in Ms-Excel.

4. RESULTS

4.1 Species composition and abundance of lizards

The Shannon-Wiener diversity index (H' = 1.5361) shows a moderate level of diversity of lizard species which indicated a reasonable number of different lizard species present in the study area. This could indicate a healthy and ecologically stable lizard population. The evenness index (J = 0.5989) shows a moderate degree of evenness, indicating there is some degree of variation in the abundance or presence of lizard species within the study area. This could suggest a relatively balanced population with an even distribution of individuals among the lizard species present in Benighat Rorang Rural Municipality, Dhading (Table 1).

Table 1. Shannon-Wiener diversity index of lizards in Benighat Rorang Rural Municipality, Dhading.

Name of species	**No. of individuals**	**pi**	**ln (pi)**	**pi*ln (pi)**
Laudakia tuberculata	54	0.453782	-0.7901394	-0.3585507
Calotes versicolor	39	0.327731	-1.1155618	-0.3656043
Japalura tricarinata	1	0.008403	-4.7791235	-0.0401607
Japalura sp	2	0.016807	-4.0859763	-0.0686719
Eutropis macularia	2	0.016807	-4.0859763	-0.0686719
Eutropis carinata	1	0.008403	-4.7791235	-0.0401607
Varanus bengalensis	1	0.008403	-4.7791235	-0.0401607
Hemidactylus flaviviridis	6	0.05042	-2.987364	-0.1506234
Hemidactylus frenatus	5	0.042017	-3.1696856	-0.1331801
Hemidactylus granotii	2	0.016807	-4.0859763	-0.0686719
Hemidactylus bowringii	2	0.016807	-4.0859763	-0.0686719
Hemidactylus brookii	3	0.02521	-3.6805112	-0.092786
Hemidactylus sp	1	0.008403	-4.7791235	-0.0401607
			Diversity (H')	1.536074725
			Evenness (J)	0.59888122

Table 2. Key identifying features of lizards species recorded during the study (Photo elicitation method was used).

Species	**Identifying features**
Laudakia tuberculata (Gray, 1827)	It has a flattened body of dark-olive brown. Juveniles have black spots on their body. Adults have dark-brown and yellowish coloration; the upper side of the head is light brown; the ventral part is yellowish white.
Calotes versicolor (Daudin, 1802)	Color light brown or gray, sometimes with dark brown transverse spots or bars upon the back and lateral parts. It has a swollen head with spines extending from the head along its body. During the breeding season, the male's head and shoulders turn red color. The juveniles have diamond-shaped markings on their back.
Japalura tricarinata (Blyth, 1853)	Body size small and long tail. V-shaped ridges present along the body midline from neck to pelvis, formed by enlarged keeled scales. Body coloration in life is mostly uniform grass green or pale brownish, below yellowish white uniform or with small black dots.
Eutropis carinata (Schneider, 1801)	It is a large skink with shiny brown or olive color. The ventral part is smooth white. The dorsal scales have 3-8 keels. A well-defined lateral strip (white) runs from above the eye to the base of the tail.
Eutropis macularia (Blyth, 1853)	The dorsal surface is bronze-brown with or without small dark spots forming longitudinal lines. A white strip is present on the upper lip extending backward to the shoulder; a dorsolateral light line extends from the eye to midway on the body; the side of the neck and flank is dark brown, usually with white spots.
Varanus bengalensis (Daudin, 1802)	It has a large triangular, flat head. Brownish or grayish body with dark spots and bands, and lower parts yellowish. They have strong, long, and slender tails.
Hemidactylus brookii (Gray, 1845)	Dorsally light brown or gray with dark brown spots, usually more or less regularly arranged, a dark streak along the side of the head. It has tails with spines.

Hemidactylus flaviviridis (Ruppell, 1835)	The basic color is light gray, yellowish gray or greenish gray. It can change color: by day brown to olive with wavy dark cross bands, at night pale gray without any markings.
Hemidactylus frenatus (Dumeril & Bibron, 1836)	It has a larger head with a smooth body surface but the side of the tail is denticulated. The dorsal part is gray to medium brown, uniform or with indistinct darker markings sometimes arranged as longitudinal stripes, a dark line along the side of the head and a light one above it; the underside of the body is cream-colored.
Hemidactylus garnotii (Dumeril & Bibron, 1836)	Dorsal grayish brown speckled or indistinctly marbled with darker brown. A darker postorbital strip on the head; trunk with 5 longitudinal rows of light spots. The tail has a sharp denticulated lateral edge, with a uniform small scale above, not swollen at the base.
Hemidactylus bowringii (Gray, 1845)	Snout obtusely pointed; ear opening small; dorsal light brown and whitish below.
Hemidactylus sp	Body color is yellowish gray; flattened body and adhesive toe pads; nocturnal.

One hundred and nineteen individuals of thirteen species of lizards belonging to four families Agamidae, Scincidae, Varanidae, and Gekkonidae and six genera (Table 3) were recorded of the order Squamata.

Laudakia tuberculata (45.38%) was the most abundant lizard species followed by *Calotes versicolor* (32.77%), *Hemidactylus flaviviridis* (5.04%), *Hemidactylus frenatus* (4.20%), *Hemidactylus brookii* (2.52%), *Japalura* sp (1.68%), *Eutropis macularia* (1.68%), *Hemidactylus bowringii* (1.68%), *Hemidactylus garnotii* (1.68%), *Japalura tricarinata* (0.84%), *Eutropis carinata* (0.84%), *Varanus bengalensis* (0.84%), and *Hemidactylus* sp (0.84%) (Table 3). *V. bengalensis* listed as Near Threatened (NT) in IUCN and also listed in CITES Appendix I was encountered during the study period (Table 3).

Table 3. Species of lizards recorded from Benighat Rorang Rural Municipality, Dhading (A- Agricultural land, S- Human Settlement, F- Forest, R- Rocky area).

Name of the species	**Family**	**Common name**	**Habitat types**	**Relative abundance (%)**	**IUCN status**
Laudakia tuberculata	Agamidae	Rock lizard	R	45.38	LC
Calotes versicolor	Agamidae	Common Garden Lizard	A, S, F, R	32.77	LC
Japalura sp	Agamidae	-	F, R	1.68	-
Japalura tricarinata	Agamidae	Three-keeled Garden Lizard	F	0.84	LC
Eutropis macularia	Scincidae	Bronze Grass Skink	F, R	1.68	LC
Eutropis carinata	Scincidae	Common Grass Skink	F	0.84	LC
Varanus bengalensis	Varanidae	Bengal Monitor Lizard	R	0.84	NT
Hemidactylus flaviviridis	Gekkonidae	Yellow-bellied Gecko	S	5.04	LC
Hemidactylus frenatus	Gekkonidae	Common House Gecko	S	4.20	LC
Hemidactylus brookii	Gekkonidae	Brook's Gecko	A, S	2.52	LC
Hemidactylus bowringii	Gekkonidae	Bowring's Gecko	S	1.68	LC
Hemidactylus garnotii	Gekkonidae	Indo-pacific Gecko	S	1.68	LC
Hemidactylus sp	Gekkonidae	-	S	0.84	-

The lizards species belonging to four families were recorded namely Agamidae, Scincidae, Varanidae, and Gekkonidae. The abundance of the family Agamidae (81%) was the highest followed by Gekkonidae (16%), Scincidae (2%), and Varanidae (1%) (Figure 2).

Whereas Gekkonidae was the most dominant family consisting of six species followed by Agamidae (four species), Scincidae (two species) and Varanidae (one species).

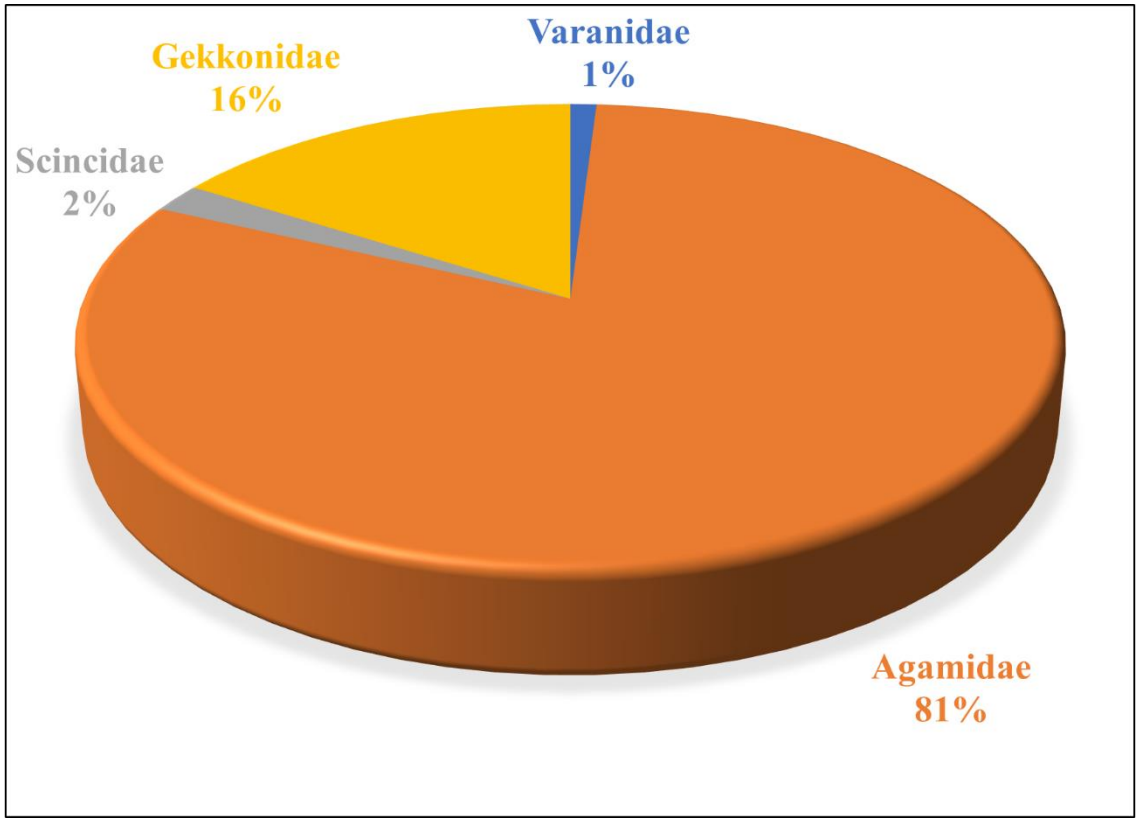

Figure 2. The family-wise abundance of lizards in the study area.

4.1.1 Species abundance and richness of lizards in different habitat types

Lizard abundance was found to be highest in the rocky area (53%) followed by human settlement (29%), agricultural land (10%) and least in forest (8%). The lizard species richness was found to be highest at human settlement (37%) whereas forest and rocky areas had the same species richness (26%) and the least was found in agricultural land (11%) (Figure 3).

C. versicolor (Appendix I. Photograph 2) was found in all four different habitats. Lizard species like *Japalura* sp*, E. macularia,* and *H. brookii* were recorded from two different habitats. *J. tricarinata*, *E. carinata*, *L. tuberculata* (Photograph 1), *V. bengalensis*, *H. bowringii*, *H. flaviviridis*, *H. frenatus*, *H. garnotii*, and *Hemidactylus* sp were observed only from single habitat type.

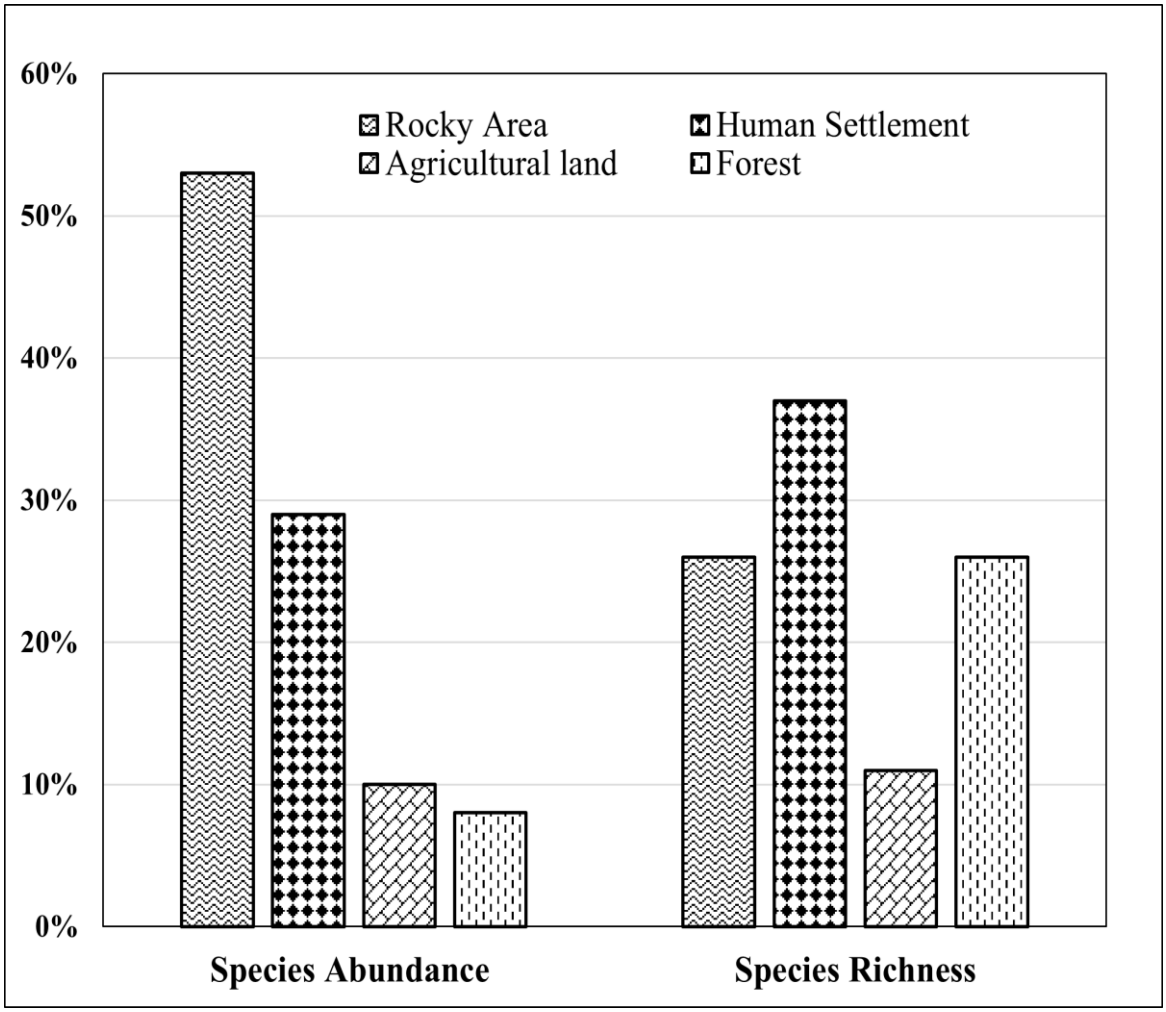

Figure 3. Species abundance and richness of lizards in different habitat types.

Here, the Kruskal-Wallis test was performed, and the result suggested that no strong evidence supports the idea that species abundance and species richness of lizards differs significantly among different habitat types. The test revealed that the p-value ($p > 0.05$) was not significant, suggesting that there is no significant variation in species abundance and species richness across the different habitats.

4.1.2 Assessment of the relationship between lizard species and habitat types

The Principal Component Analysis reveals that the lizard's presence was found to be associated with all four different habitat types. *L. tuberculata* showed a close association with the rocky areas. Whereas all the species of the Gekkonidae family (*H. bowringii*, *H. flaviviridis*, H. *brookii*, *H. frenatus*, *H. granotii* and *Hemidactylus* sp) showed a close association with human settlement. *C. versicolor* and *H. brookii* showed a close association with agricultural land. *V. bengalensis*, *Japalura* sp, *E. carinata,* and *J. carinata* showed a close association with the forest (Figure 4).

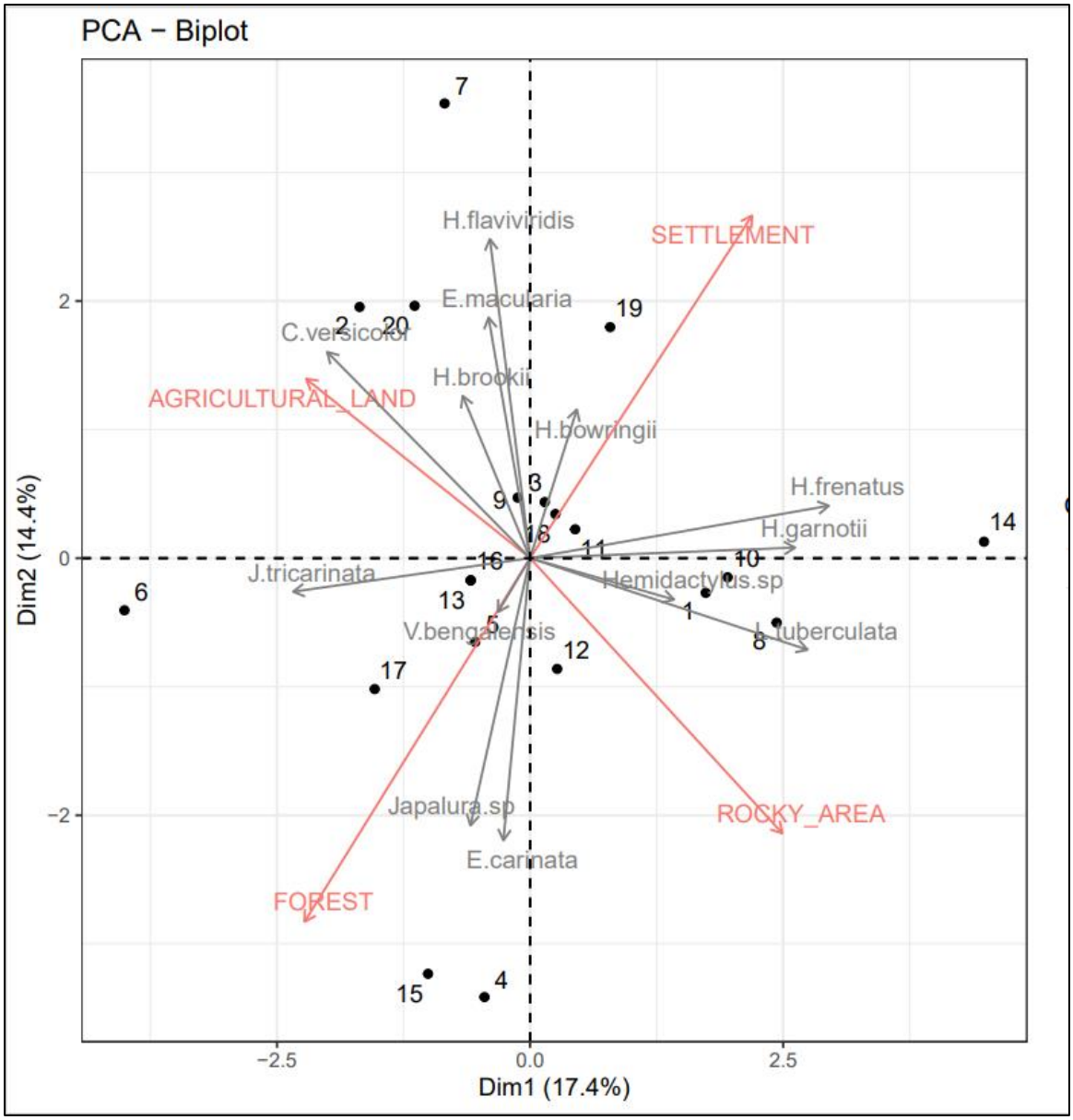

Figure 4. Principal Component Analysis (PCA) illustrating the relationship between lizard species and the habitat types in the study area. Habitats and lizard species are shown as solid red and grey arrows, respectively.

4.2 Distribution pattern of lizards along an elevation gradient

A survey was conducted from the elevation range of 300 m to 2,100 m and species were classified under 200 m in each band in the study area. Lizards were recorded abundantly in between the elevation range of 300 m – 500 m (45 individuals) followed by an elevation range of 1,300 m – 1,500 m (35 individuals) (Figure 5). The elevation range of 1,300 m – 1,500 m had the highest species richness, seven species namely *C. versicolor*, *L. tuberculata*, *E. macularia*, *H. bowringii*, *H. flaviviridis*, *H. frenatus*, and *Hemidactylus* sp, followed by the elevation range of 300 m – 500 m (Figure 5). *Japalura* sp was the only lizard species found above the 1,300 m – 1,500 m elevation range.

There was an irregular distribution pattern of lizards along an elevation gradient. Both lizard species abundance and richness dropped to zero at the elevation ranges of 1,500 m – 1,700 m and 1,700 m – 1,900 m. And a slight increase above the elevation from 1,900 m was observed.

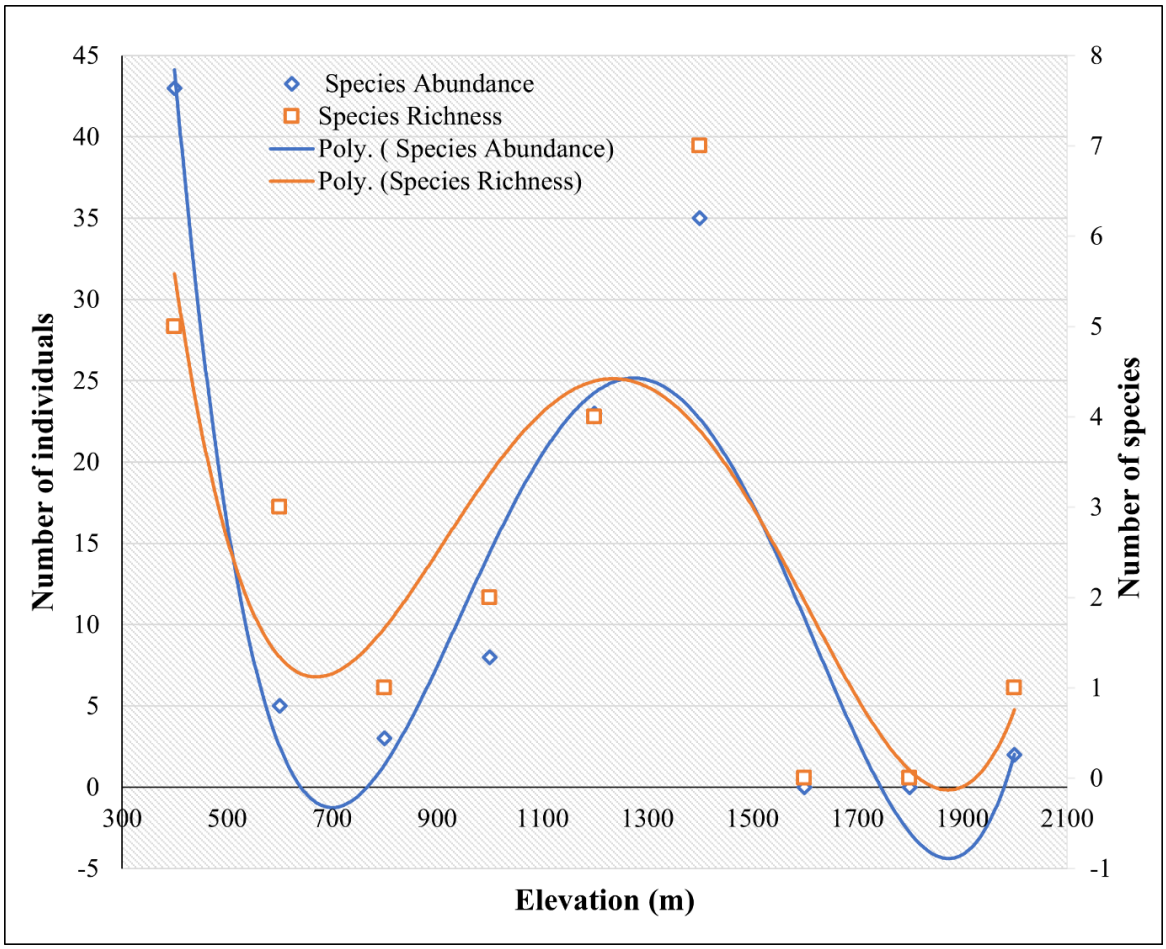

Figure 5. Polynomial regression model showing the relationship between both lizard species abundance and richness along an elevation gradient.

The above study showed both the abundance and richness of lizards followed a hump-shaped relationship with elevation showing a peak at around 1,300 m. The decline of species abundance and species richness was observed more towards the higher end of the elevation gradient meaning species richness and abundance followed the declining trend with an increase in elevation after a mid-elevation peak.

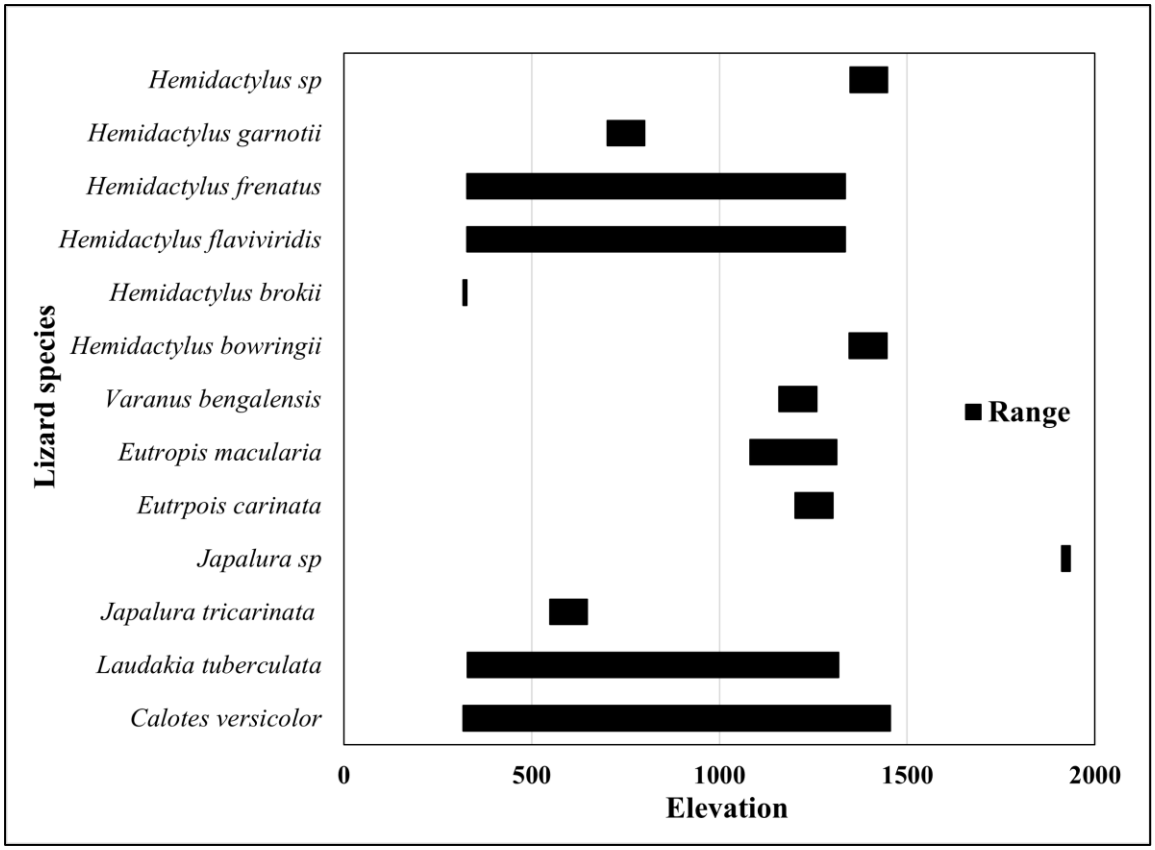

Figure 6. Elevation range profiles for lizard species in Benighat Rorang Rural Municipality, Dhading, Nepal. The range profile is based on the lowest and highest elevation at which a species was observed.

Most lizard species were found across a broad range of elevations. *C. versicolor* showed a high elevation range followed by *H. flaviviridis* and *H. frenatus*. However, *H. brookii* exhibited a narrow elevation range. Among the lizard species, *Japalura* sp was discovered at the highest elevation (1,934 m) whereas *C. versicolor* and *H. brookii* were discovered at the lowest elevation each at 317 m (Figure 6).

The distribution of lizards ranged from 27.704826°N to 27.817306°N and 84.687064°E to 84.88737°E (Figure 7).

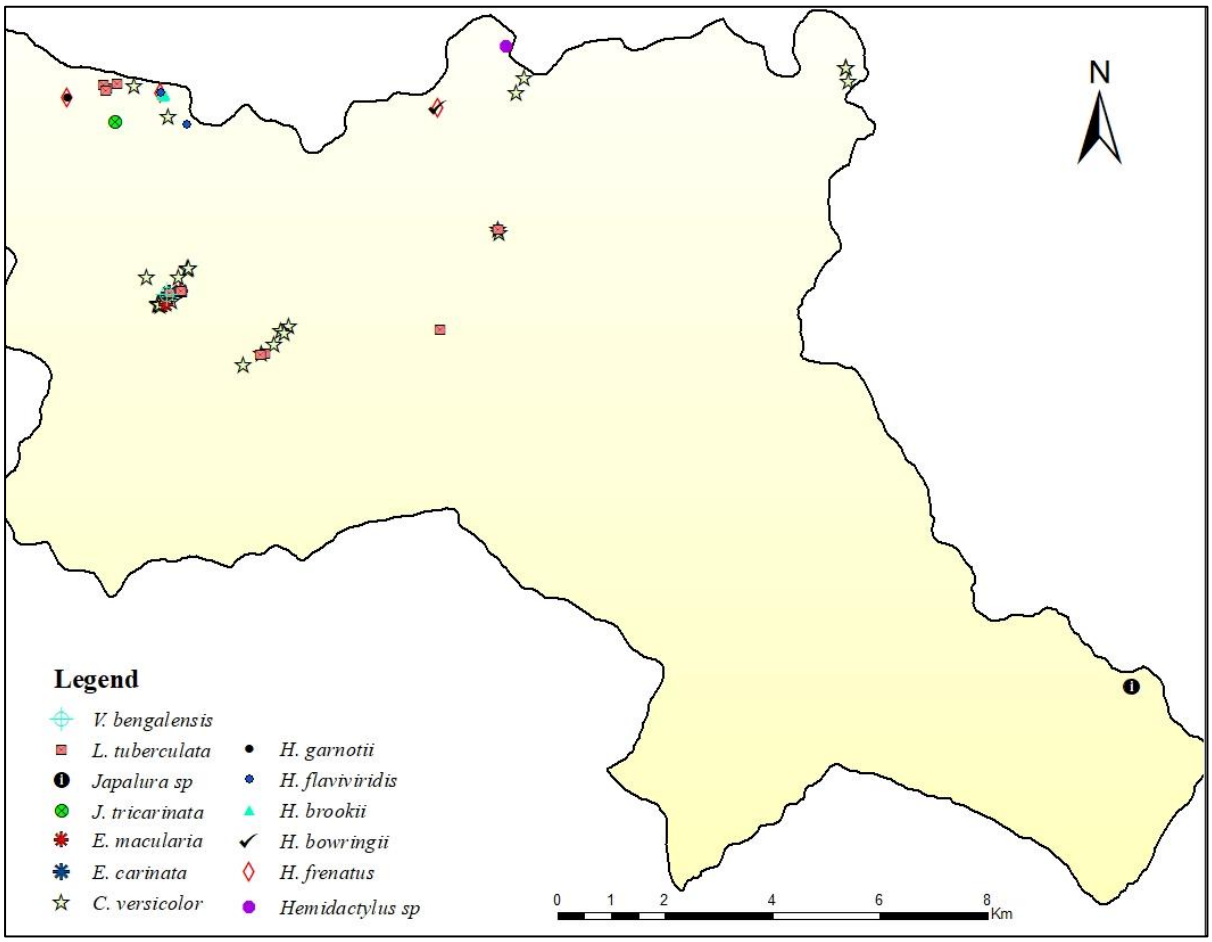

Figure 7. Distribution map of lizard species in the study area

5. DISCUSSION

A total of thirteen species of lizards from six genera and within four families were recorded during the study. Shannon diversity index and evenness index showed a relatively balanced and diverse population with an even distribution of individuals among the lizard species present, making the area an important site for lizard species. The four families namely, Agamidae (four species), Scincidae (two species), Gekkonidae (six species), and Varanidae (one species) were observed during the study. Family Agamidae was the most abundant family and such generalist lizards have been reported to thrive well in different habitats whereas the least abundant family was Varanidae. According to the available literature on the survey of herpetofauna, (Zug & Mitchell 1995, Pokhrel et al. 2011, Bhattarai et al. 2017, Bhattarai et al. 2018, Nepali & Singh 2018, Nepali & Singh 2020, Rawat et al. 2020) recorded four families of lizards namely, Agamidae, Scincidae, Varanidae, and Gekkonidae which aligns with this study.

Whereas the herpetofaunal research performed (Nanhoe & Ouboter 1987, Shrestha & Dekocha 2011) recorded three families of lizards (Agamidae, Scincidae, and Gekkonidae). But the study (Shrestha & Shah 2017, Katuwal et al. 2020) reported three families of lizards (Agamidae, Scincidae, and Varanidae). Bhattarai et al. (2020) reported twenty-three lizard species from five families: Agamidae, Eublepharidae (One species), Gekkonidae (Seven species), Scincidae (Seven species), and Varanidae (Three species). A new lizard species, the water monitor lizard (*Varanus salvator*) was discovered for the first time in Nepal. An updated checklist of amphibians and reptiles in Nepal was provided by (Rai et al. 2022) and listed 41 lizard species belonging to six families Agamidae (11 species), Anguidae (one species), Eublepharidae (one species), Gekkonidae (11 species), Scincidae (14 species) and Varanidae (three species).

In this study, the most abundant lizard species was *Laudakia tuberculata.* A similar result was found in the study (Pokhrel & Thakuri 2016, Shrestha & Shah 2017, Gautam et al. 2020). But the study (Zug & Mitchell 1995, Pokhrel et al. 2011, Nepali & Singh 2018, Bhattarai et al. 2020, Nepali & Singh 2020) reported *Calotes versicolor* as the most abundant lizard species.

Habitat types also help to determine lizard species abundance and diversity. The highest abundance of lizards was found in the rocky area followed by settlement, agricultural land, and forest. As most of the individuals recorded in the rocky habitat were *Laudakia tuberculata*. Similar findings were observed by (Thapa 2016, Nepali & Singh 2020, Paudel et al. 2022) where the highest abundance of reptilian species was observed in the settlement areas which might be explained by the availability of higher structural diversity, food and water sources, opportunity for more insolation, and easy escape. These studies did not consider the rocky areas as different habitat types. Whereas lizards were found to be least abundant in the forests which may be due to the destruction of forests for road construction and forest fire during the study period. But on the contrary (Pokhrel & Thakuri 2016) discovered that lizards were found abundant in agricultural land followed by settlements,

and rocky areas. During the study, the species richness of lizards was found higher at human settlements and the least on agricultural land. All the *Hemidactylus* spp were recorded from the roof of houses and holes in the houses and were encountered at night near the light area, possibly due to a greater availability of prey around the light. But (Thapa 2016) explained a different scenario and reported the highest richness of herpetofauna was from agricultural land and the least from the forest. Whereas (Nepali & Singh 2020) observed higher reptile species richness in the forest. Most of the lizards were recorded from more than one habitat. The study showed no significant difference in lizard species richness and abundance across different habitat types. *C. versicolor* was found in all four different habitats.

Lizard species like *Calotes versicolor*, *Laudakia tuberculata, Eutropis carinata*, and *Japalura tricarinata* were recorded during this study. Several studies by (Nanhoe & Ouboter 1987, Shah 2001, Pokhrel et al. 2011, Shrestha & Dekocha 2011, Schleich & Rai 2012, Pokhrel & Thakuri 2016, Shrestha & Shah 2017, Gautam et al. 2020, Paudel et al. 2022) also supported the presence of these lizard species in their studies. *Asymblepharus sikimmensis* was found in many studies (Pokhrel et al. 2011, Pokhrel & Thakuri 2016, Bhattarai et al. 2020, Gautam et al. 2020, Rawat et al. 2020) but was unable to sight during this study. *Varanus* spp was encountered in almost all the herpetofaunal studies conducted except (Pokhrel & Thakuri 2016, Paudel et al. 2022). *Varanus bengalensis* listed as near threatened globally was encountered but *V. flavescens* was not sighted during the study period. But according to the residents, *V. flavescens* are also found in the study area. Both species are used for food as well as medicinal purposes. Monitor lizards are only the lizard species hunted in Nepal (Shah & Tiwari 2004). The skin of *Varanus* spp is removed and kept in the sun for drying (Appendix I. Photograph 7) and is used to make drum-like musical instruments (eg. Khaijedi).

There was a decreasing trend of species richness and abundance of lizards with an increase in elevation. Declining species richness with increasing elevation was observed in many taxa and this relation is widely accepted as a general pattern (Rahbek 1995). Khatiwada & Haugaasen (2015) and (Kastle et al. 2013) also support a decrease in Nepalese herpetofauna with an increase in altitude. A study by (Navas 2006) also documented a decline in herpetofaunal species richness with increasing elevation.

In this study species richness and abundance of lizards followed a mid-elevation peak (hump-shaped) relationship with elevation showing a peak at around 1,300 m. The higher end of the elevation gradient observed more decline in species number. A similar hump-shaped pattern of species richness along the elevation gradient was presented by (Sander 2002, Fu et al. 2006, Fu et al. 2007, McCain 2010, Pandey et al. 2020, Paudel et al. 2022). Although a monotonic decline in species richness with increasing elevation was observed in the study of (Naniwadekar & Vasudevan 2007, Chettri et al. 2010, Khatiwada et al. 2019). Hump-shaped patterns or mid-elevation peaks are the most recognized pattern in the study of the relationship between species richness and elevation (Rahbek 1995, Colwell et al. 2004). Multiple factors like Climatic, biological, and historical factors cause variation in species richness along the elevation gradients (Rahbek 1995, Whittaker et al. 2001).

McCain (2010) and Navas (2006) consider temperature as the strongest single factor influencing the elevation richness patterns of reptiles. Chettri et al. (2010) believe rainfall and temperature an important limiting factors in the distribution of snakes in the Himalayas.

Most of the lizard species showed a wide elevation distribution range. *C. versicolor* showed a high elevation range followed by *H. flaviviridis* and *H. frenatus*. However, *H. brookii* and *Japalura* sp showed a narrow elevation range whereas *H. brookii* was reported from the lowest elevation 317 m and *Japalura* sp was discovered at the highest elevation (1,934 m).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study indicated that Benighat Rorang Rural Municipality has a moderately diverse and relatively balanced population with an even distribution of individuals among the lizard species present. Thirteen species of lizards belong to four families with *Laudakia tuberculata* being the most abundant lizard species. Gekkonidae was the most dominant family with six species followed by Agamidae. The abundance of lizards was found to be highest in the rocky area and least in the forest. Lizards were evenly distributed in different habitat types. No significant differences were found in lizard species richness and abundance across different habitat types. *Calotes versicolor* was the only species found in all four different habitat types. Regression analysis showed an overall declining trend in lizard species richness and abundance with the increase in elevation gradient. The hump-shaped pattern was observed in both the abundance and richness of lizards with elevation showing a peak at around 1,300 m.

6.2 Recommendations

Based on this study following recommendations have been made

- An extensive survey should be conducted covering all the seasons to get better data and understanding of the diversity and distribution of lizards.
- As lizards are neglected in comparison to other species, research work and projects related to lizards should be encouraged.

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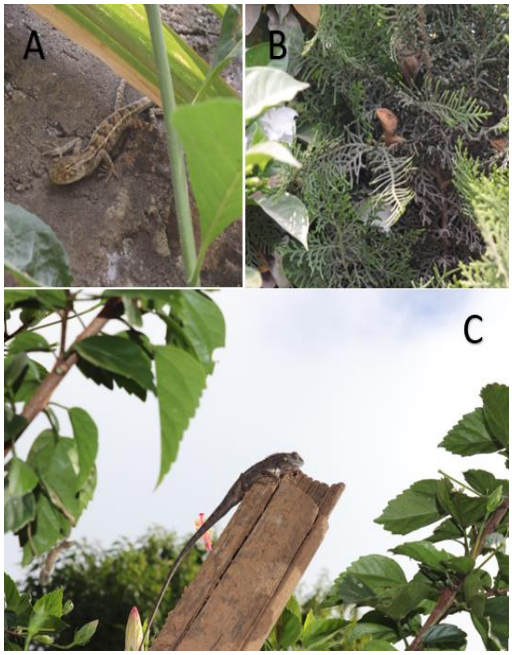
APPENDICES

Appendix I. List of Photographs

Photograph 1. *Laudakia tuberculata*
(A-Juvenile; B-Adult)



Photograph 2. *Calotes versicolor*
(A-Juvenile; B-Breeding male C-Adult)

Photograph 3. *Eutropis carinata*

Photograph 4. *Eutropis macularia*

Photograph 5. Skin of *Varanus bengalensis*

Photograph 6. *Hemidactylus brookii*

Photograph 7. *Hemidactylus flaviviridis*

Photograph 8. *Hemidactylus frenatus*

Photograph 9. *Hemidactylus granotii*

Photograph 10. *Hemidactylus bowringii*

Appendix II. Permission letters

Research permission letter from the Department of Soil and Environment and Benighat Rorang Rural Municipality, Dhading

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वन तथा भू-संरक्षण विभाग

४-२२७५७४
४-२२०३०३
४-२२१२३१
४-२१६३७९
४-२२१७४४
फ्याक्स: ४-२२७३७४

प्राप्त पत्र संख्या र मितिः
पत्र संख्याः ०६८/६९
च. नं.: ९९३६

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला ।)
बबरमहल
काठमाडौं, नेपाल
मिति : २०७९/०१/२६

विषयः अनुसन्धान अनुमति सम्बन्धमा ।

श्री गरिमा श्रेष्ठ
धादिङ्ग, नेपाल ।

प्रस्तुत विषयमा त्रिभुवन विश्वविद्यालय, प्राणी शास्त्र केन्द्रीय विभाग, कीर्तिपुर मार्फत स्नातकोत्तर तह तेस्रो सेमेष्टरमा अध्ययनरत तपाईले **" Diversity and Distribution of lizard in the different landscape of Dhading, Nepal"** को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०७९/०१/०८ गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो । सो सम्बन्धमा कारवाही हुँदा उक्त प्रपोजलमा उल्लेखित Methodology (Field survey, transect walk method) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि सन् २०२३, अप्रिल सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

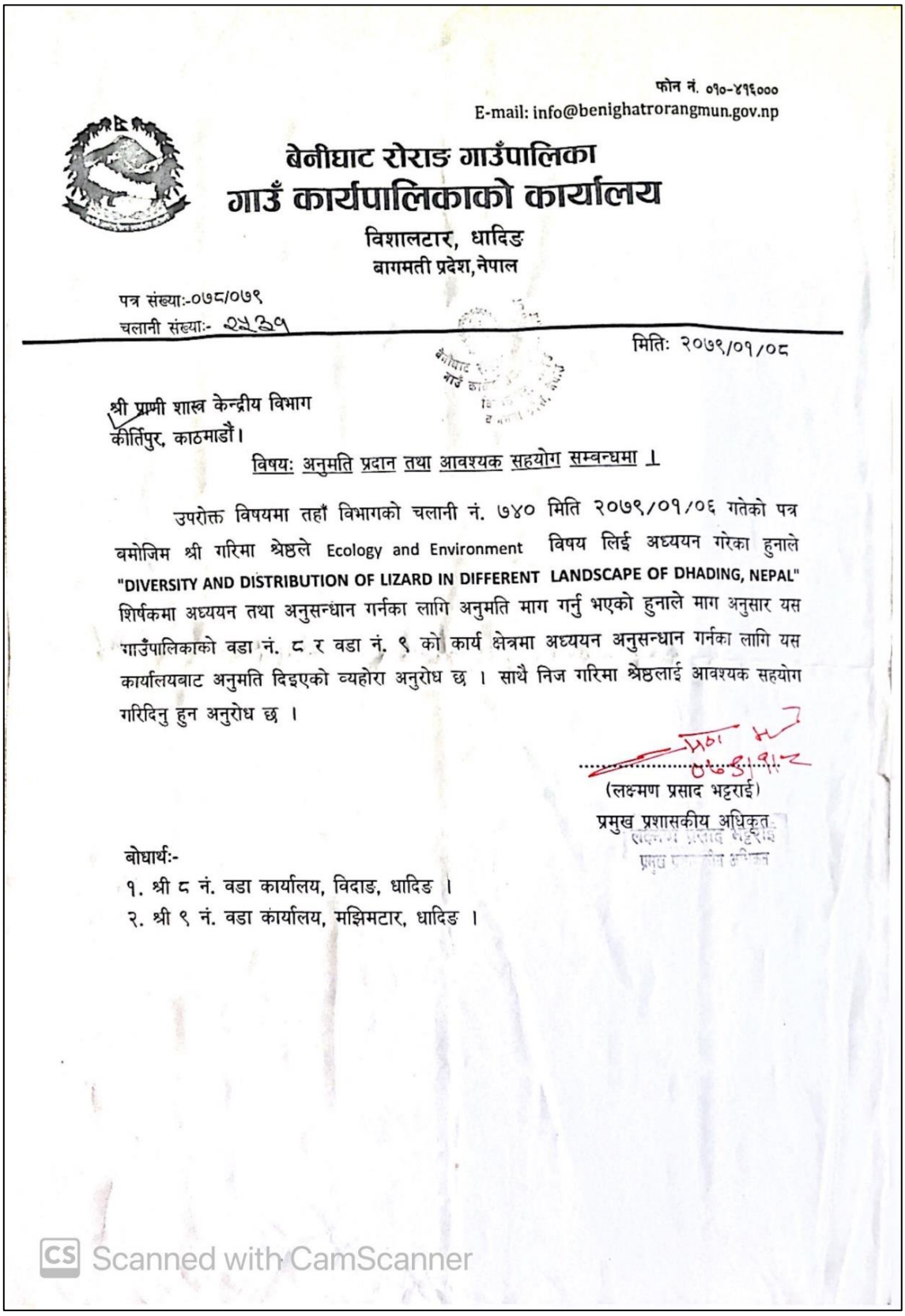
शर्तहरु

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०५१, राष्टिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. नमुना संकलन गर्न पाईने छैन ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ । अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतिय) यस विभागमा अनिवार्य रुपमा बुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

२०७९।०१।२६
(सवनम पाठक)
सहायक वन अधिकृत

बोधार्थ
श्री डिभिजन वन कार्यालय, धादिङ्ग । : जानकारी तथा आवश्यक सहयोगका लागि अनुरोध छ ।

Research permission letter from Benighat Rorang Rural Municipality, Dhading



फोन नं. ०१०-४१६०००
E-mail: info@benighatrorangmun.gov.np

बेनीघाट रोराङ गाउँपालिका
गाउँ कार्यपालिकाको कार्यालय

विशालटार, धादिङ
बागमती प्रदेश, नेपाल

पत्र संख्या:-०७८/०७९
चलानी संख्या:- २५३७

मितिः २०७९/०१/०८

श्री प्राणी शास्त्र केन्द्रीय विभाग
कीर्तिपुर, काठमाडौं।

विषयः अनुमति प्रदान तथा आवश्यक सहयोग सम्बन्धमा ।

उपरोक्त विषयमा तहाँ विभागको चलानी नं. ७४० मिति २०७९/०१/०६ गतेको पत्र बमोजिम श्री गरिमा श्रेष्ठले Ecology and Environment विषय लिई अध्ययन गरेका हुनाले "DIVERSITY AND DISTRIBUTION OF LIZARD IN DIFFERENT LANDSCAPE OF DHADING, NEPAL" शिर्षकमा अध्ययन तथा अनुसन्धान गर्नका लागि अनुमति माग गर्नु भएको हुनाले माग अनुसार यस गाउँपालिकाको वडा नं. ८ र वडा नं. ९ को कार्य क्षेत्रमा अध्ययन अनुसन्धान गर्नका लागि यस कार्यालयबाट अनुमति दिइएको व्यहोरा अनुरोध छ । साथै निज गरिमा श्रेष्ठलाई आवश्यक सहयोग गरिदिनु हुन अनुरोध छ ।

(लक्ष्मण प्रसाद भट्टराई)
प्रमुख प्रशासकीय अधिकृत

बोधार्थः-
१. श्री ८ नं. वडा कार्यालय, विदाङ, धादिङ ।
२. श्री ९ नं. वडा कार्यालय, मझिमटार, धादिङ ।