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COLLEGE OF NATURAL SCIENCES

SCHOOL OF BIOSCIENCES

DEPARTMENT OF ZOOLOGY, ENTOMOLOGY AND FISHERIES SCIENCES

OCCURRENCE AND DISTRIBUTION OF HERPETOFAUNA IN MUTUMBA WETLAND, NAMAYINGO DISTRICT, UGANDA

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ZOOLOGY, ENTOMOLOGY & FISHERIES SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTERS OF SCIENCE IN ZOOLOGY, MAKERERE UNIVERSITY

NOVEMBER, 2025

DECLARATION

I, Violet Kantono hereby declare that this research dissertation is original and has never been submitted to any academic institution for an academic award.

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DEDICATION

I dedicate this work to my family, relatives and friends for their outstanding emotional and financial support. Every time I was tempted to quit, you often encouraged me to keep strong and courageous enough to finish this research dissertation.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The study investigated the diversity and distribution of herpetofauna in Mutumba wetland, Namayingo district. The overall objective of this study was to contribute herpetofaunal information that can be used to inform conservation planning and management. Data was collected for 12 days each month for a period of six months (November 2023 to March 2024). Visual encounter surveys, call count and opportunistic encounter techniques were used to accomplish the study objectives. Field surveys were performed around 40 random survey points separated by a distance of 500 meters within Mutumba wetland. Each of these survey points was surveyed 12 times to record the amphibian and reptile species. Six survey points were searched daily (day and night) for three hours per search by a team of three persons; sampling 3 points at night from 18:00 to 21:00 while another 3 points in the early morning hours from 06:00 am to 08:00 am. Data collected were analyzed using a variety of statistical methods namely: species accumulation curve, Simpson index of diversity, agglomerative cluster analysis and canonical correspondence analysis.

The study documented 41 amphibian species from six families and 31 reptile species from twelve families in the Mutumba wetland. Amphibians were found across nine different microhabitats, while reptiles occupied ten. Both groups exhibited significant species diversity in cultivated land microhabitats, with Simpson's index (D) values of 0.87 for amphibians and 0.88 for reptiles. However, amphibians exhibited greater species evenness compared to reptiles. The most abundant amphibian families were *Ptychadenidae* and *Bufonidae* with species Mascarene Grass Frog, Striped Grass Frog and African Common Toad being the most prevalent; while *Scincidae* dominated among reptiles. Amphibians were commoner in rice gardens and papyrus microhabitats, while reptiles were more common in tree canopy and artificial structures. Overlap in microhabitat use was observed, but environmental variables did not fully account for species distributions, suggesting other factors may be important. Species of the *Hyperoliidae* family, typically found in papyrus microhabitats, have become less common, possibly due to changes in the availability of these habitats from human activities. This study emphasizes the need for conservation of these habitats to ensure the sustainability of amphibian and reptile populations Future research should explore multiple environmental influences to enhance understanding of species distribution dynamics.

1.0 CHAPTER ONE: INTRODUCTION

1.1 Background

Amphibians and reptiles are one of the key components of various ecosystems providing a variety of direct and indirect services, including provisioning, regulating, cultural, and supporting. They primarily contribute to biological pest control and bioturbation ecological roles (Valencia-Aguilar et al. 2013). Amphibians also serve as indicators of ecosystem health because of their permeable skin and complex life history which makes them particularly sensitive to environmental disturbance and change (Valentine, 2015). Despite these important roles, studying their ecology in lentic ecosystems remains challenging due to the cryptic nature of their behavior, which makes detecting, capturing, or recapturing individuals difficult (Cecala et al. 2017).

Amphibians and reptiles occupy aquatic, semi-aquatic or terrestrial habitats and are highly vulnerable to habitat degradation and other threats caused by biotic or abiotic factors (Valentine, 2015). As a result, their populations exhibit dramatic natural fluctuations in site occupancy, distribution, abundance and species richness. Globally, 41% of amphibians and 21% of reptiles are experiencing progressive population declines and are listed as facing extinction risk according to the IUCN (Chunrong et al. 2023).

Many of Africa's threatened amphibians and reptiles are restricted to mountain tops and other specific habitats, where expanding agriculture, mining and climate change are becoming threats (Penner et al. 2011). Their vulnerability is partly due to the high habitat specificity of species like *Osteolaemus tetraspis* (dwarf crocodile) and *Arthroleptides dutoiti* (Du Toit's torrent frog). However, information on how amphibians and reptiles respond to habitat disturbances remains limited in Africa, largely due to data deficiency needed to identify areas of high diversity that are crucial for conservation (Tolley et al., 2016); Behangana et al. 2020).

In Uganda, approximately 90 species of amphibians and 174 reptile species have been recorded (Behangana & Hughes, 2025). Most of these species have been categorized as Least Concern by the IUCN because they either have a wide distribution or are tolerant to a broad range of environmental conditions. However, the distribution patterns of amphibians and reptiles has not been documented in some parts of Uganda where little or no research has been conducted.

1.2 Statement of the problem

Amphibians and reptiles represent some of the most rapidly disappearing taxonomic groups in Uganda, yet their conservation status is poorly evaluated (Miller, 2012). This is due to a shortage of data on most species as a result of the limited work conducted to evaluate amphibian and reptile occurrence. In Uganda, few amphibian and reptile species are listed as vulnerable, near-threatened, or critically endangered; while many—25 amphibians and 70 reptiles—are Data Deficient, highlighting gaps in knowledge (NEMA, 2016).

The survival of amphibians and reptiles in the Mutumba wetland is increasingly threatened by climate change, habitat loss and fragmentation, and chemical stressors such as pesticides and fertilizers (Kemigisa, 2022). Climate change disrupts breeding and survival by altering temperature and rainfall patterns. Habitat loss, primarily driven by agriculture and development, reduces available space and isolates populations, thereby limiting genetic diversity. Additionally, chemical runoff from pesticides and fertilizers contaminates water and harms amphibians through skin absorption, resulting in health problems and a loss of biodiversity. These cumulative pressures pose serious risks to wetland species.

Despite these increasing threats, wetlands such as Mutumba remain critical refuges for amphibians and reptiles, offering stable microclimates, breeding grounds, and reliable sources of water and food. However, the absence of species-specific ecological data limits informed conservation action, making it difficult to detect population changes or prioritize habitats that require protection.

Mutumba wetland forms part of the larger Mutumba–Buhemba ecosystem, functioning as an important carbon sink that contributes to local climate regulation. In addition to this ecological role, the wetland provides diverse microhabitats that sustain amphibian and reptile populations and enhance overall biodiversity. Despite the lack of prior studies on herpetofaunal diversity and distribution within this system, the range of habitats present suggests high potential for species richness. Consequently, this study seeks to document the species composition and diversity of amphibians and reptiles inhabiting the Mutumba wetland.

1.3 Main objective

To contribute herpetofaunal information that can be used to inform conservation planning and management.

1.4 Specific objectives

1. To assess amphibian and reptile species diversity within different microhabitat types across the Mutumba wetland.
2. To examine the environmental factors influencing amphibian and reptile diversity and distribution in the Mutumba wetland.

1.5 Research questions

1. What is the species richness, abundance and diversity of amphibians and reptiles in the Mutumba wetland?
2. What are the environmental factors responsible for amphibians and reptiles distribution in Mutumba wetland?

1.6 Justification of the study

Most research on species diversity and distribution in Uganda has concentrated on large vertebrate data for conservation assessments, resulting in limited basic information for many herpetofauna groups, especially in certain regions (Fisher & Robertson, 2002; Wiafe & Agyei, 2013; NEMA, 2016). Although the Mutumba wetland offers suitable habitats for amphibians and reptiles, there is little to no documented information regarding the diversity and occurrence of these species within the wetland.

Although research interest in herpetology in Uganda is increasing, data on amphibians and reptiles in certain areas remain scarce (Smith et al., 2023). Understanding the factors that regulate spatial variation in species richness, abundance and distribution has been a fundamental question in ecology for decades (MacArthur, 1972; Currie, 1991; Wiafe & Agyei, 2013). While numerous studies have explored the relationship between species richness and environmental factors, knowledge about the causes of species richness variation is still limited (Wiafe & Agyei, 2013). This gap is particularly notable for herpetofauna, as global amphibian and reptile species richness is declining (Gibbons et al. 2000; Wiafe & Agyei, 2013).

There is an urgent need to understand the patterns of amphibian and reptile occurrence in the Mutumba wetland and the factors driving their community structures. Documenting species occurrence is essential for understanding and conserving the diversity of amphibians and reptiles, as well as for creating effective conservation strategies. Therefore, this study was aimed to document the diversity and distribution of amphibians and reptiles in the Mutumba wetland, providing critical knowledge to inform sustainable conservation planning and management policies.

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Herpetofauna: Indicators of Ecosystem Health and Biodiversity

Herpetofauna refers to the group of animals that includes amphibians and reptiles which act as bioindicators for climate change and a diversity of species (Ali et al. 2016; Septiadi et al. 2018). Herpetofauna play an important role in taxonomic studies as the key to understanding the existing biodiversity, as well as, ecology in comprehending the balance and sustainability of ecosystems (Indraneil, 2015). They can also be used as an early marker of ecosystem changes (Septiadi et al. 2018). According to Ali et al. (2016) and Ahmed & Khan, (2019), amphibians and reptiles are integral to food webs, controlling insect and pest populations, serving as a food source, and facilitating nutrient transfer between aquatic and terrestrial ecosystems. The absence of herpetofauna can disrupt invertebrate populations, predator dynamics, leaf litter decomposition and nutrient cycling.

Herpetofauna are found in a variety of habitat types throughout the world, including terrestrial, arboreal, aquatic, semi-aquatic and fossorial environments (Septiadi et al. 2018). It has also been reported that their diversity and abundance correlate with some avian and mammalian species (Ali et al. 2016). Though the survival of herpetofauna is under continuous threat due to deforestation, habitat loss, fragmentation, urbanization and pollution (Petrov, 2004; Riyanto, 2011; Ali et al. 2016), leading to significant population declines, especially among habitat specialists. According to Ahmed & Khan, (2019), other causes of global decline in herpetofauna have been reported to include - introduced invasive species, diseases and parasitism, unsustainable and global climate change. As a result, amphibians and reptiles are the most threatened vertebrate taxa globally, with approximately 41% and 25% of all evaluated species threatened with extinction respectively (Butchart & Bird, 2010; Bohm et al. 2013; Faruk et al. 2013; Balaji et al. 2014).

Despite their importance, herpetofauna have not received as much attention from the scientific community in many parts of Uganda. Conservation efforts have often prioritized more conspicuous taxonomic groups like birds and mammals, neglecting amphibians and reptiles (Ahmed & Khan, 2019). Consequently, there is scanty information on the diversity and distribution of herpetofauna in Uganda, underscoring the need for comprehensive surveys and studies on these vital vertebrates.

2.2 Amphibians: Diversity, Distribution and Conservation Status

Amphibians are group of vertebrates characterized by their ability to exploit both aquatic and terrestrial habitats (Duellman & Zug, 2023). This group of vertebrates belong to class Amphibia represented by three orders namely: frogs and toads (Order Anura), newts and salamanders (Order Caudata), and caecilians (Order Gymnophiona). The members of the three orders differ distinctly morphologically. For example, frogs and toads are tailless and slightly squat with long, powerful hind limbs adapted for leaping. In contrast, caecilians are limbless, wormlike and highly modified for burrowing. Salamanders and newts have tails and two pairs of limbs of roughly the same size; however, they are rather less specialized in body form than the other two orders. Anurans are more widespread and diverse than either salamanders or caecilians (Duellman & Zug, 2023).

There are about 7,546 to 8,100 species of living amphibians known worldwide (Wagh et al. 2016; Britannica, 2021); of which 7,131 are frogs and toads, 737 are newts and salamanders, and 213 are caecilians (Frost, 2019; Nepali & Singh, 2022). However, the global statistical estimate of amphibian species varies depending on the different databases and/or authors.

Worldwide declines in amphibian populations have caused great concern in the scientific community in recent years. According to IUCN, (2009), over 30% of evaluated amphibians globally are threatened; mainly due to climate change, increased exposure to ultraviolet radiation, acid rain, pathogens, habitat destruction and modification, introduced species, and chemical stressors such as pesticides and fertilizers.

In Uganda, more than 98 amphibian species have been recorded, accounting for 1.65% of global species, with 10% classified as threatened on the IUCN Red List (NEMA, 2016). The majority of these species are categorized as Least Concern by the IUCN due to their wide distribution or tolerance to a variety of habitats. However, this information may not reflect the country because there has been minimal or no research on amphibian diversity in some places of Uganda.

2.3 Reptiles: Diversity, Conservation Status and Knowledge Gap

Reptiles refer to the group of air-breathing vertebrates characterized by internal fertilization, amniotic development, and epidermal scales covering part or the entire body (Dowling et al. 2024). Belonging to the class Reptilia, these species are divided into four major groups: turtles (Order Testudines), tuatara (Order Rhynchocephalia or Sphenodontida), lizards and snakes (Order Squamata), and crocodiles (Order Crocodylia or Crocodilia). Collectively, these groups account for over 8,700 species worldwide (Dowling et al. 2024). Reptiles represent the most diverse assemblage among land vertebrates, significantly contributing to global biodiversity (Pincheira-Donoso et al. 2013; Faiz et al. 2018). However, there are relatively few studies focusing exclusively on reptiles (Tingley et al. 2016). Reptiles are distinguished by their continuous external covering of epidermal scales, which contain beta-keratin. Other defining features include cervical vertebrae, well-developed limbs with two or more sacral vertebrae, and a lower jaw made up of multiple bones but lacking an anterior coronoid bone.

On a global scale, reptiles are underrepresented on the IUCN Red List of threatened species, with only 35% of described species having been evaluated. Moreover, these evaluations have often been conducted in a non-systematic manner (IUCN, 2011; Bohm et al. 2013). According to reports

(IUCN, 2009; Rais et al. 2012), over 28% of evaluated reptiles are considered threatened due to factors such as habitat loss and degradation, invasive species, pollution, unsustainable trade, diseases, and climate change.

In Uganda, approximately 150 reptile species are recorded, representing 1.5% of the global total. Currently, only one species from Uganda is listed as Critically threatened on the IUCN Red List (NEMA, 2016). The available documentation on reptiles in Uganda is sparse, indicating a significant gap in knowledge about this taxon in the region (NEMA, 2016).

2.4 Habitat characteristics

A habitat is a place where an organism makes its home, comprising of all the environmental conditions an organism needs to survive (Stanley, 2023). Amphibians and reptiles live in habitats that provide everything they need to find food, select mates and successfully reproduce. According to Brittingham, (1997) and Stanley, (2023), a habitat is said to be suitable for herpetofauna survival when it comprises four main components including shelter, water, food and space. Although, these components are spatially driven by climate change and human activities among the different microhabitats (Thorpe et al. 2018). Amphibians and reptiles inhabit a variety of habitat types including cultivated land, uncultivated land like inland water, human habitations such as nearby debris materials, and water bodies like wetlands, rivers, lakes, waste disposal ponds, irrigation channels and fisheries ponds (Ali et al. 2016).

Habitat characteristics exert strong influence on herpetofauna behavior, population dynamics, and community composition (Guiden & Orrock, 2017). Amphibians and reptiles distribution has been shown to be highly dependent on habitat characteristics including shrubs, leaf litter, tree canopy, basal area of trees, grassland, papyrus, fallow land, rocky outcrops, snags and dead woods, temporary pools and spring seeps (Brittingham, 1997; Balaji et al. 2014; Lukwago et al. 2017; Thorpe et al. 2018) all reported to variously affect spatial occurrence of their populations. The species may utilize each of these microhabitats for mate advertising, mating, egg deposition, spawning, tadpole, neonate feeding and hibernating from predators (Balaji et al. 2014; Thorpe et al. 2018; Nepali & Singh, 2022).

Amphibians and reptiles are not homogeneously distributed in the world (Nepali & Singh, 2022); hence their species richness, abundance and occurrence are greatly determined by both environmental and human factors (Balaji et al. 2014; Lukwago et al. 2017; Nepali & Singh, 2022). The determining attributes according to these authors may include - elevation, soil condition, temperature, precipitation, humidity, logging, extraction of firewood and leaf-litter respectively. Because studies on herpetofauna are still not very many, their distributions and current status of populations remains poorly known at both local and regional scales.

The current study enhances our knowledge of how amphibians and reptiles respond to habitat characteristics at the species-specific level across various microhabitats. As a result, it provides valuable insights into the status of amphibians and reptiles in a microhabitat that has undergone significant alteration, and aids in assessing the importance of biodiversity conservation at the Mutumba wetland in Namayingo.

2.5 Herpetofauna survey methods

Amphibians and reptiles are a poikilothermic group of animals and are sensitive to the seasonal changes in environment (Mehra et al. 2021). The change in seasonal patterns of temperature and humidity have substantial impacts on the occurrence of amphibians and reptiles; as their biological cycles like reproduction remain consistent with seasonal changes in the environment (De Sousa et al. 2025; Mahra et al. 2021). Because of the behavioral traits of herptiles, it is essential that field surveys are carried out during both wet and dry seasons for assessments of amphibians and reptiles diversity and distribution.

Herpetofauna surveys are conducted through a variety of sampling techniques, including visual encounter surveys, opportunistic observation, pitfall with drift fence trapping, dip-net trapping and call count survey (Balaji et al. 2014; Siqueira et al. 2014; Nepali & Singh, 2022; Behangana et al. 2020; Mehra et al. 2021). Field sampling of amphibian and reptile species is typically conducted at night between 18:00 and 21:00 or from 20:00 to 22:00 hours (Behangana et al. 2009; Shahrudin & Jaafar, 2012) and during the early morning hours from 05:00 to 08:00 (Pankaj & Nath, 2022). This is when the majority of herptiles are most active (Behangana, 2004). For the armature herpetologist, individuals encountered in a survey, may need to be collected as voucher specimens for identification by a senior herpetologist or the use of field guides and identification keys (Ali et al. 2016, Ahmed et al. 2018; Mehra et al. 2021). Individual amphibians and reptiles that are not readily identifiable in the field need to be collected and fixed in 10% formalin, and later preserved in 70% ethanol for later identification and documentation with help of senior herpetologists including Mathias Behangana & Waswa Sadic Babyesiza.

3.0 CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area

This study was conducted in Namayingo district located in the Eastern part of Uganda (Figure 1). The district covers a total land area of 3,041.9 km^2, comprising 1,062 km^2 of dry land with the rest covered by wetlands and water bodies. The land surface is characterized by gently undulating hills with few outstanding features, and a narrow, generally higher relief to the south which constitutes a watershed between Lake Victoria drainage and the northern drainage. Namayingo is endowed with a variety of natural resources which includes water, land, forests, wetlands and minerals (Kemigisa, 2022). Although, these resources are increasingly being depleted due to rapid increase in human population growth.

Mutumba wetland is situated in the Lake Victoria catchment of the Victoria water management zone, located between longitudes 33.657^0E and latitudes 0.174^0N at altitude of 1124m above sea level. Mutumba wetland is largely characterized as a papyrus swamp and lake edge wetland; dominated by both seasonal and permanent landscapes. The wetland ecosystem is classified by land cover classes including cropland, bushland, woodland and water (Namayingo District Local Government, 2023). These land cover classes are associated with potential microhabitats such as rice garden, vegetation litter, star grass, stagnant water, fallow, papyrus, tree canopy, road surface and cultivated land which act as hide-outs for amphibians and reptiles.

The total population associated with Mutumba wetland is estimated at 42,340 people, constituting 20,789 males and 21,551 females (NPA, 2022). The major ethnic groups living in the Mutumba wetland landscapes include -Samya (majority), Jopadhola, Basoga, and Itesot (Namayingo District Local Government, 2017). These ethnic groups derive their livelihoods from Mutumba wetland which is evident by different socio-economic activities carried out in the wetland; including extensive agriculture mostly of rice growing and cassava for home consumption and surplus for sale, cattle grazing, and bush burning for land preparations. These activities have caused gradual decrease in the wetland land cover classes, as well as imposing destructive trails that pose serious threats to herpetofauna biodiversity (Kemigisa, 2022).

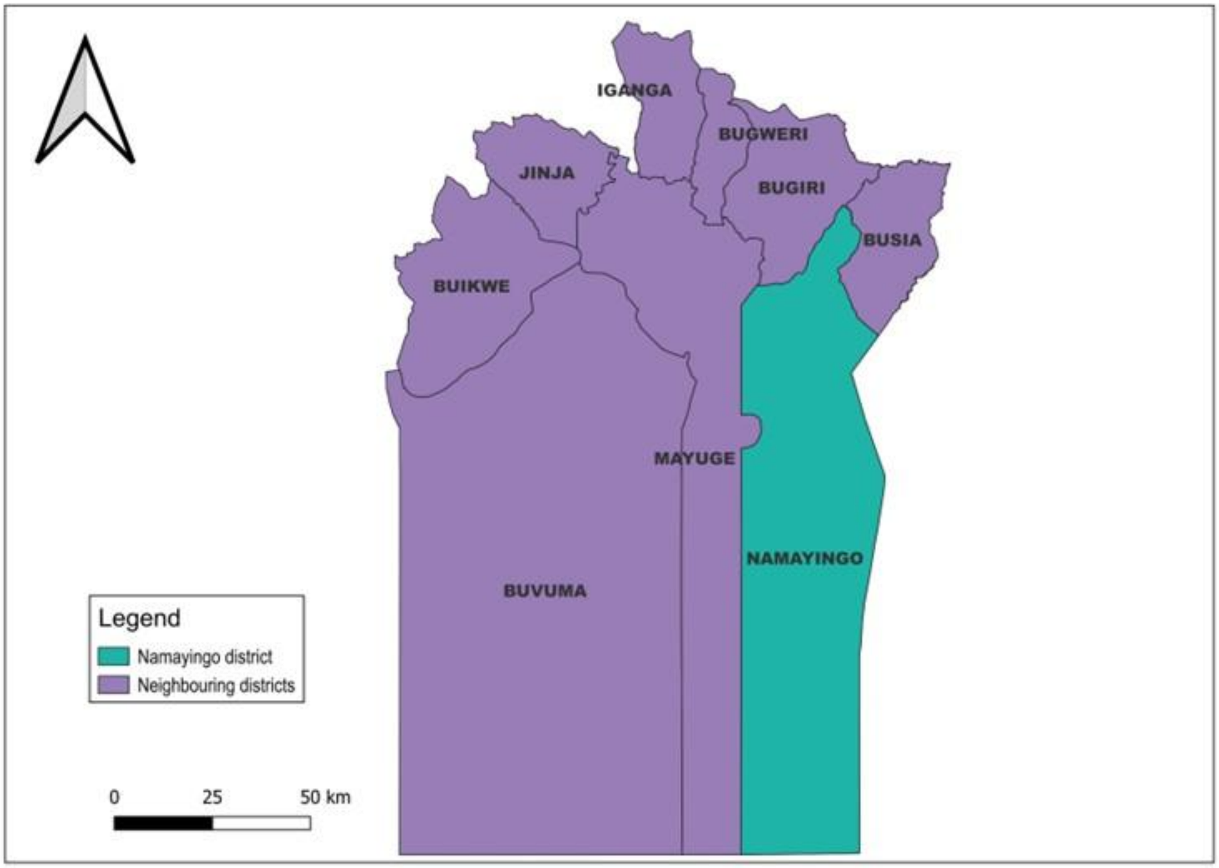

Figure 1: The selected study area (Namayingo district) and neighboring districts

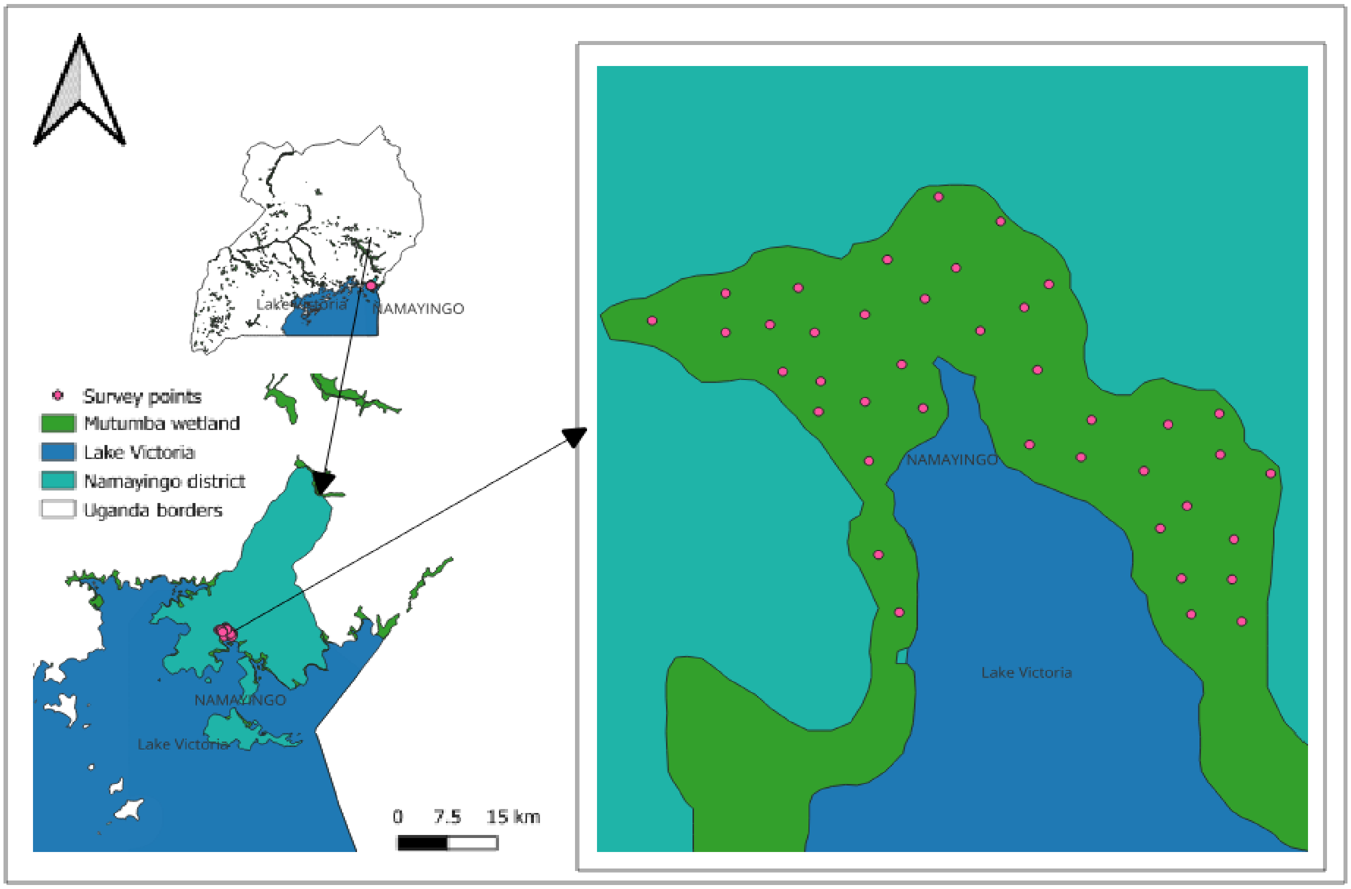

Figure 2: The selected study area and distribution of survey points

3.2 Study design

To ensure comprehensive coverage and accurate data collection, a structured and systematic approach was employed over a six-month period, from November 2023 to March 2024. Field surveys were conducted for 12 days (from day 1 to day 12) each month, totaling 72 days. The study consisted of 40 random survey points separated by at least 500 m (Figure 1b). Each survey point had a radius of 50 m and was surveyed 12 times to record the amphibian and reptile species therein, and each survey point was repeated twice each mouth. A total of six survey points were searched per day, sampling 3 points from 18:00 to 21:00 and another 3 points in the early morning hours from 06:00 am to 08:00 am. This rigorous methodology aimed to capture a comprehensive representation of the herpetofauna diversity within the wetland.

3.3 Microhabitat types

Amphibian and reptile species were observed across eleven distinct microhabitats that are described as follows:

i. **Rice gardens**: These areas offer abundant water sources and shelter, making them ideal for amphibians like frogs and toads, which thrive in the wet conditions. Reptiles, such as snakes, may also use rice fields for hunting or basking along the edges (Grygarová et al., 2023).

ii. **Papyrus**: These wetlands are important habitats for amphibians like frogs, providing shelter, breeding sites, and foraging areas. Reptiles, such as water snakes and lizards, use the dense vegetation for cover and prey, benefiting from both aquatic and terrestrial niches (Ramsar Convention on Wetlands, 2001).

iii. **Tree canopy**: The tree canopy refers to the uppermost layer of evergreen trees, formed by their branches and leaves. This layer creates a continuous cover that shields the ground from direct sunlight and precipitation. It serves as a microhabitat for arboreal amphibians, such as tree frogs, and reptiles like chameleons and geckos, providing shelter and food sources. Additionally, tree-dwelling snakes utilize the canopy for hunting and navigating between trees (McGarigal & McComb, 1995).

iv. **Vegetation litter**: Ground-dwelling amphibians like frogs seek refuge in moist, decaying plant matter, which also provides prey like insects. Reptiles such as skinks and snakes use the litter for hiding, hunting, and regulating body temperature (Semlitsch & Bodie, 2003).

v. **Star grass**: Star grass in open grasslands offers shelter for small reptiles like lizards and snakes, which use it for hiding and hunting. Amphibians, particularly frogs, may also inhabit these areas if there is nearby moisture (Ghosh & Basu, 2020).

vi. **Cultivated land**: Agricultural fields offer foraging opportunities for amphibians and reptiles, especially when water or moisture is present. Amphibians such as toads and frogs may live in fields, while reptiles like snakes and lizards hunt for insects and rodents (Ghosh & Basu, 2020).

vii. **Stagnant water**: Ponds and marshes provide ideal breeding and foraging sites for amphibians like frogs and toads. Reptiles, such as water snakes and some lizards, also rely on stagnant water for hunting, basking and reproduction, benefiting from the calm conditions (Grygarová et al., 2023).

viii. **Fallow**: Abandoned agricultural land offers essential habitat during transitional periods. Amphibians like frogs and toads use the remaining water in fallow fields for breeding, while reptiles such as snakes and lizards find shelter and food in these areas (Ghosh & Basu, 2020).

ix. **Snags**: Dead trees offer shelter and foraging opportunities for both amphibians and reptiles. Tree frogs may hide in the bark, while reptiles like geckos and lizards use snags for hunting and shelter. Some snakes also use snags for resting or nesting (Semlitsch & Bodie, 2003).

x. **Artificial structures**: Human-made structures like buildings, roads and electric poles can provide habitats for amphibians and reptiles adapted to urban environments. Some amphibians breed in artificial ponds, while reptiles such as geckos and snakes find refuge in crevices or stone walls (Semlitsch & Bodie, 2003).

xi. **Ecotone**: Transition zones between ecosystems, such as the edge of a wetland, are often rich in biodiversity. These areas support amphibians like frogs that need moist environments and reptiles like snakes and tortoises that move between habitats for food, shelter and thermoregulation (Ghosh & Basu, 2020).

3.4 Sampling methods

Several methods are commonly used to survey amphibians and reptiles in Uganda, only one of these was employed for the purposes of this study namely: visual encounter surveys. Additionally, I made opportunistic observation outside of designated sampling points when traversing the habitat. The effectiveness of the selected sampling technique depended on weather conditions and time of the day, particularly between 18:00 and 21:00 hours at night and during the early morning hours from 06:00 to 08:00. Upon detection of amphibians and reptiles, I recorded information including - the species, number of individuals encountered, geographic coordinates and habitat type. The study considered eleven weather conditions known to determine the distribution and abundance of reptiles and amphibians (Appendix 1**)**. All environmental variables were recorded using a digital weather app 'AccuWeather' (AccuWeather, 2024), with each variable being logged at the locations where different amphibian and reptile species were encountered within the microhabitats of Mutumba wetland. These records enabled a comprehensive analysis of the environmental conditions associated with amphibian and reptile occurrence and distribution in Mutumba wetland.

3.4.1 Visual Encounter Surveys (VES)

Visual encounter was used across all microhabitat types for amphibians and reptiles in Mutumba wetland. VES involved walking within the area of the selected survey points while visually searching for surface active amphibians and reptiles, turning over logs and other objects under which they could hide like small rocks (Behangana et al. 2017; Lukwago et al. 2017; Nneji et al. 2019). This sampling technique was used to generate encounter rates of species in their microhabitats along the selected survey points in a unit hour (Behangana et al. 2009). The information collected using this method provided records on species richness for each microhabitat within Mutumba wetland. The total sampling effort for 72 days was 432 hours of physical active searching of amphibians and reptiles in Mutumba wetland. Specimens that were captured were identified based on the field guides (Channing & Rodel, 2019; Spawl et al. 2018). Those that could not be identified in the field were preserved in 70% ethanol for subsequent identification with the help of herpetology experts.

3.4.2 Opportunistic observations

Opportunistic encounters were detected in all suitable microhabitats to enhance the reptile species inventory for the Mutumba wetland. This involved casual walks outside of the scheduled sampling periods to increase the chances of encountering a broader variety of reptile species, following the approach also used by Behangana (2004) and Menegon et al. (2011).

3.5 Data analysis

The individual rarefaction method (also known as species accumulation curve) was used to estimate species richness among different microhabitats at selected survey points within the Mutumba wetland. This statistical method was useful in estimating the number of species expected to be present in a random sample of individuals taken from any micro-habitat types (Nneji et al. 2019). The Simpson diversity index was computed to compare species diversity within the different microhabitat types of Mutumba wetland (Septiadi et al. 2018; Nepali & Singh, 2022). To assess the similarity in species composition among the wetland's microhabitats, similarity index and agglomerative cluster analysis were performed using the Jaccard distance method (Lukwago et al. 2017; Nneji et al. 2019).

Canonical Correspondence Analysis (CCA) was conducted to assess how environmental parameters drive the occurrence and distribution of amphibians and reptiles in the Mutumba wetland (Siqueira et al. 2014; Lukwago et al. 2017). Canonical Correspondence Analysis is a multivariate ordination method used for describing the relationships between biotic assemblage of species and their environment through extracting environmental gradients from a given ecological dataset. This comprehensive analysis was used to interrogate how specific environmental factors shape biodiversity within the Mutumba wetland.

4.0 CHAPTER FOUR: RESULTS

4.1 Species diversity of amphibians within different habitat types across the Mutumba wetland

4.1.1 Amphibian species richness

A total of 5318 individuals of 41 amphibian species belonging to 6 families were recorded (Figure 3, Appendix 2). More species were recorded from family *Bufonidae* (n = 11 species) followed by *Hyperoliidae* (n = 10 species) and *Ptychadenidae* (n = 10 species), whereas the families *Dicroglossida*e (n = 1 species) and *Pyxicephalidae* (n = 1 species) had the least number of species recorded. The species accumulation curve for amphibians reached an asymptotic phase (Figure 3). This suggests that amphibian species richness was adequately sampled during the present study; highlighting that further sampling effort may not have added many more species to the study findings.

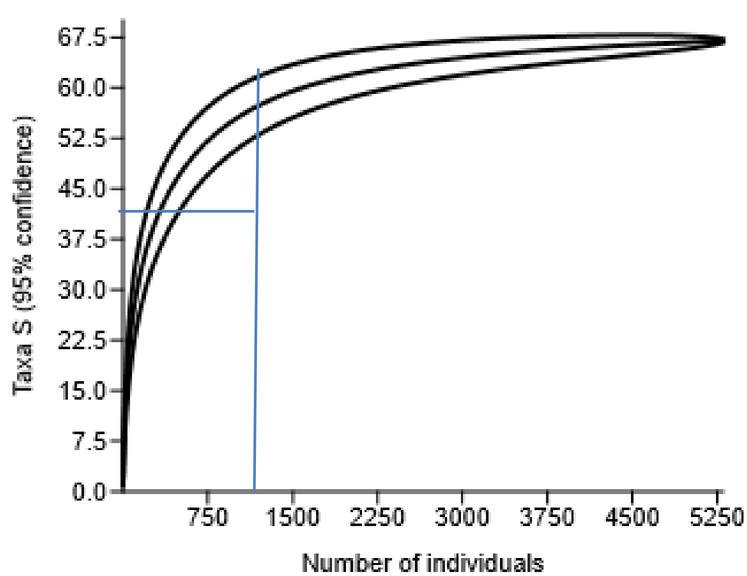

Figure 3: Species accumulation curves comparing sample size and amphibian richness across Mutumba wetland.

4.1.2 Amphibian relative abundance

In this study, observation records show that amphibian abundance varied among different families in the Mutumba wetland. The family *Ptychadenidae* had the highest relative abundance, with species Mascarene Grass Frog (n = 851, 16%), Striped Grass Frog (n = 688, 12.9%) and Southern Dwarf Grass Frog (n = 599, 11.3%) being the most prevalent. This was followed by the families *Bufonidae* and *Phrynobatrachidae,* with species African Common Toad (n = 351, 6.6%) and Scheffler's Puddle Frog (n = 358, 6.7%) being the most abundant (Table 1, Appendix 2).

Additionally, the most frequently encountered species included Scheffler's Puddle Frog, Yellow-Bellied Grass Frog, Sharp-Nosed Grass Frog, Striped Grass Frog, Southern Dwarf Grass Frog, Kerinyaga Toad and African Common Toad; representing the families *Phrynobatrachidae*, *Ptychadenidae* and *Bufonidae* respectively (Appendix 3).

Table 1: Abundance of amphibian species recorded in Mutumba wetland

Species Common Name	Number of Individuals	Relative abundance (%)
African Common Toad	351	6.60
Climbing puddle frog	25	0.47
Crowned Bullfrog	337	6.34
Eastern African Puddle Frog	100	1.88
Garman's Toad	56	1.05
Guttural Toad	29	0.55
Kerinyaga Toad	26	0.49
Kisolo Toad	24	0.45
Mababe Pubble frog	81	1.52
Mahnert’s Grass Frog	11	0.21
Mascarene Grass Frog	851	16.00
Natal Puddle Frog	12	0.23
Nile Grass Frog	316	5.94
Northern Flat-Backed Toad	70	1.32
Rungwe Puddle Frog	85	1.60
Scheffler's Puddle Frog	358	6.73
Sharp-Nosed Grass Frog	95	1.79
Southern Dwarf Grass Frog	599	11.26
Southern Flat-Backed Toad	186	3.50
Steindachner's Toad	17	0.32
Striped Grass Frog	688	12.94
Striped Toad	12	0.23
Yellow-Bellied Grass Frog	36	0.68
Total	**5318**	**100**

4.1.3 Diversity of amphibian species-microhabitat associations

The distribution of amphibians in the Mutumba wetland varied across nine distinct microhabitat types. The highest diversity was found in the papyrus (D = 0.89, n = 18 species) and cultivated land (D = 0.87, n = 13 species) microhabitats. They were followed by fallow and vegetation litter, each with a diversity index of 0.86 and 0.84, supporting 21 and 15 species respectively. In contrast, the road surface (D = 0.55, n = 4 species) had the lowest amphibian diversity (Table 2). The papyrus had 10 species that were not recorded in any of the microhabitats (Appendix 3). This variation in species microhabitat-association highlights the importance of preserving diverse microhabitat types to maintain the overall amphibian diversity in the wetland.

Table 2: Diversity of amphibians recorded in the different microhabitats of Mutumba wetland

	Number of individual species observed per microhabitat								
Species Common Name	**Papyrus**	**Rice garden**	**Cultivated land**	**Star grass**	**Fallow**	**Stagnant water**	**Vegetation litter**	**Ecotone**	**Road surface**
African Bullfrog		2		3	2				
African Common Toad	34	7	6	8	6		1	7	
Bibron's Grass Frog									
Climbing puddle frog		25	4	1	33	1	12		
Garman's Toad									
Green Puddle Frog		12	39	14	195	2	14	1	
Guttural Toad		44	8	6	19		6	4	44
Kerinyaga Toad		8		1	2				
Kisolo Toad		7	19	8	37	11	27		5
Mahnert's Grass Frog		139	18	62	136		4	57	
Mascarene Grass Frog	11	27	7	29	27		2	7	
Narrow-Headed Grass Frog		3		3	5			1	
Nile Grass Frog		21	3	166	231	5	18	26	1
Northern Flat-Backed Toad	1	6					1		
Rungwe Puddle Frog		1	45	10	25		4		
Scheffler's Puddle Frog		3			5	3	2		
Schilluk Grass Frog					1		1		
Sharp-Nosed Grass Frog		11	43	16	138	1	11	2	
Southern Dwarf Grass Frog	19			1	23				
Southern Flat-Backed Toad		1		1	3				
Steindachner's Toad	3	1		3					
Striped Grass Frog									
Striped Toad		185	5	3	52		2	5	26
Yellow-Bellied Grass Frog		223	43	99	36	33	45	69	
Taxa-S	**18**	**22**	**13**	**19**	**21**	**8**	**15**	**11**	**4**
Simpson_1-D	**0.89**	**0.83**	**0.87**	**0.82**	**0.86**	**0.63**	**0.84**	**0.74**	**0.55**

4.1.4 Similarity in amphibian occurrence across the different microhabitat types

The species occurrence data, was used to assess microhabitat similarity in community composition of the recorded amphibian species. Rice gardens and fallow had the highest proportion of closely related occurring species at 72% (Node A), followed by cultivated land and vegetation litter microhabitats with 62% (Node B) (Figure 4). Road surface and stagnant water microhabitats were with the least number of closely related species, with only 32% (Node C). The similarity index also showed that rice gardens and fallow areas had the highest similarity at 63%, while cultivated land and vegetation litter had 40%, and road surface and stagnant water had the lowest (Appendix 4).

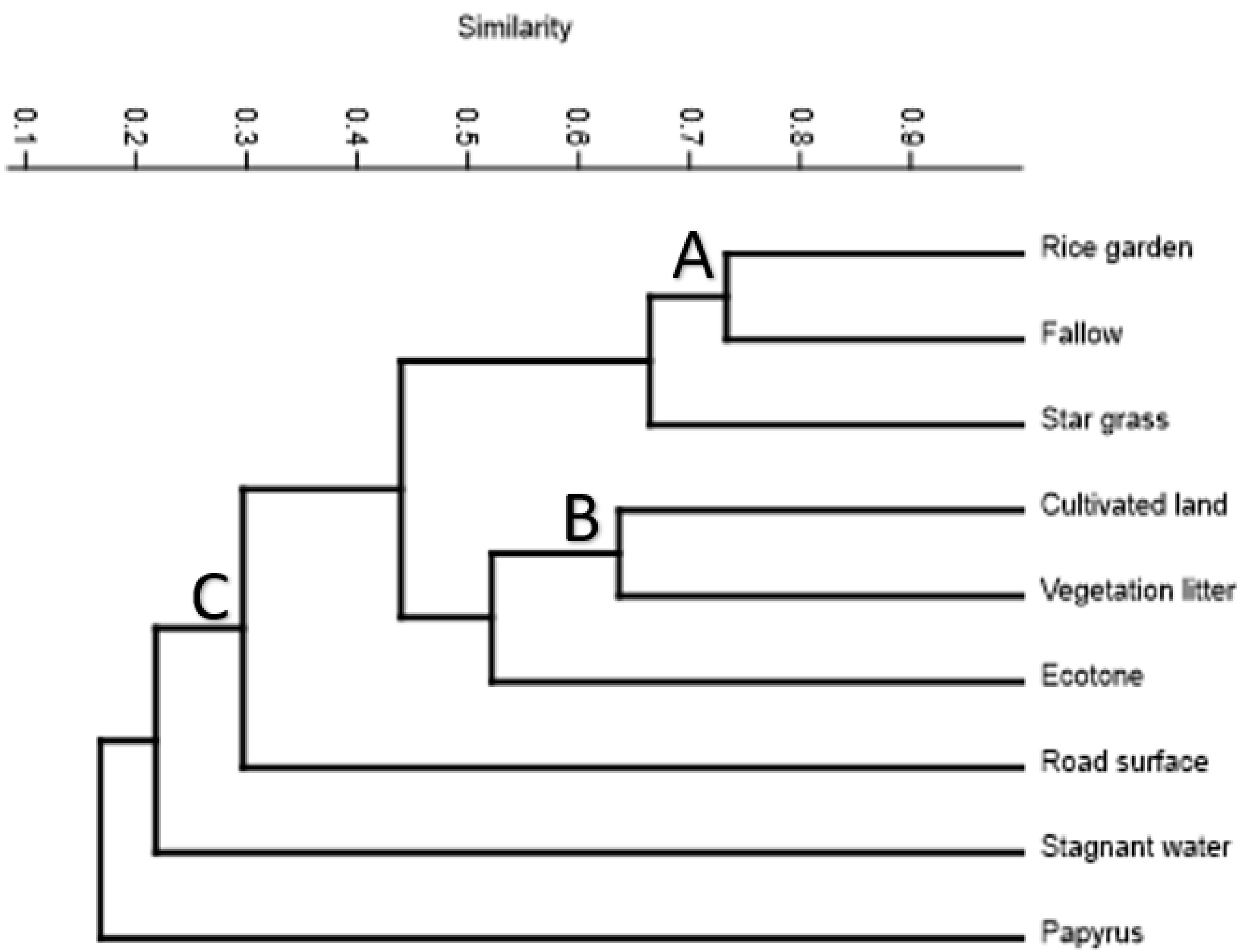

Figure 4: An agglomerative cluster dendrogram for similarity in amphibian *species occurrence in the different microhabitats of Mutumba wetland (Numbers=microhabitat clusters, letters=Nodes)*

4.1.5 Amphibian species-environment associations

Canonical Correspondence Analysis (CAA) was analyzed using five constraining variables including weather conditions, precipitation, temperature, humidity and microhabitat types (Appendix 6). The triplot indicated that a large number of amphibian species were primarily associated with mostly clear (-1.8) and light rain (-1.7) weather conditions in light clay-white mottled loamy soils in the right lower quadrant. The most prevalent species in these conditions were *Hyperolius kivuensis* (Kivu Reed Frog) and *Phrynobatrachus cf. bullans* (Bubbling Puddle Frog) *(*Figure 5). A moderate number of species were linked to fallow microhabitat types (-1.8), with *Phrynobatrachus cf. versicolor* (Green Puddle Frog) and *Ptychadena porosissima* (Striped Grass Frog) being the most common.

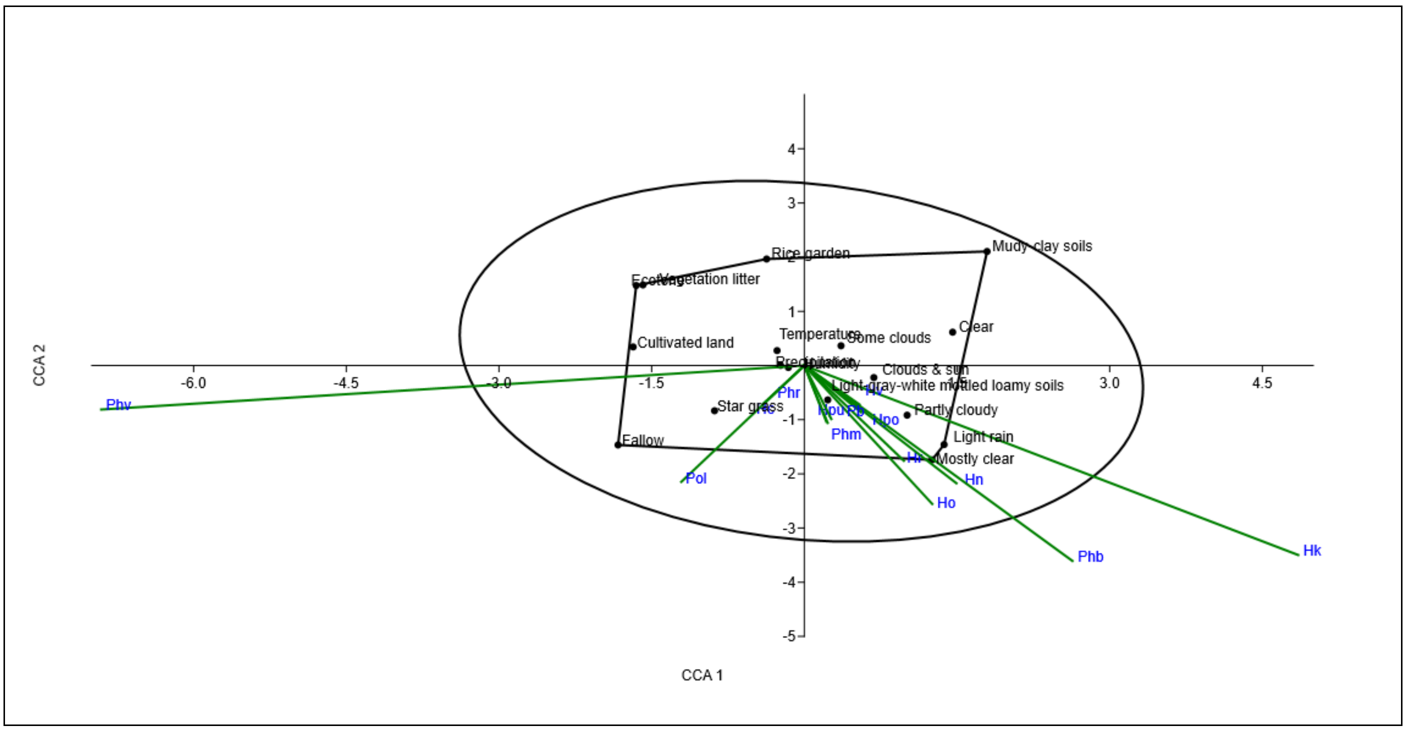

Figure 5: Triplot for amphibian occurrence in Mutumba wetland (blue dots/texts=species, green arrows=gradients and black dots/text=environmental variables). Af = Afrixalus fulvovittatus, Aq = Hyperolius viridiflavus bituberculatus, Ho = Haplobatrachus occipitalis, Hb = Hperolius balfouri, Hr = Hyperlius rwandae, Hc = Hyperolius cinnamomeoventris, Hk = Hyperolius kivuensis, Hn = Hyperolius nasutus, Hpo = Hyperolius poweri, Hpu = Hyperolius pusillus, Hv = Hyperolius viridiflavus, Pha = Phrynobatrachus acridiodes, Phb = Phrynobatrachus cf. bullans, Phm = Phrynobatrachus mababiensis, Phn = Phrynobatrachus natalensis, Phr = Phrynobatrachus cf. rungwensis, Phs = Phrynobatrachus scheffleri, Phd = Phrynobatrachus cf. dendrobates, Phv = Phrynobatrachus cf. versicolor, Pol = Tomopterna cf. cryptotis, Pc = Ptychadena chrysogaster, Pmt = Ptychadena cf. mahnerti, Pm = Ptychadena mascareniensis, Pn = Ptychadena nilotica, Pox = Ptychadena oxyrhynchus, Pb = Ptychadena cf. bibroni, Po = Ptychadena porosissima, Psc = Ptychadena schillukorum, Pst =Ptychadena cf. stenocephala, Pt = Ptychadena taenioscelis, Pye = Pyxicephalus cf. edulis, Sb = Sclerophrys cf. brauni, Sg = Sclerophrys garmani, Sk = Sclerophrys kerinyagae, Sm = Sclerophrys maculata, Sp = Sclerophrys pusilla, Sr = Sclerophrys regularis, Ss = Sclerophrys steindachneri, Sv = Sclerophrys vittata, Sg = Sclerophrys gutturalis, Ski = Sclerophrys kisoloensis

4.2 Species diversity of reptiles within different habitat types across the Mutumba wetland

4.2.1 Reptile species richness

A total of 221 individuals of 31 species across 12 families were recorded (Appendix 5). The family *Lamprophiidae* (n = 5 species) had the highest species richness. This was followed by families *Agamidae, Chamaeleonidae, Elapidae, Gekkonidae* and *Pelomedusidae,* each with 3 species. In contrast, the families *Psammophidae* and *Typhlopidae* had the fewest, each with only 1 species. The species accumulation curve did not plateau, representing that additional surveys may turn up more species (Figure 6).

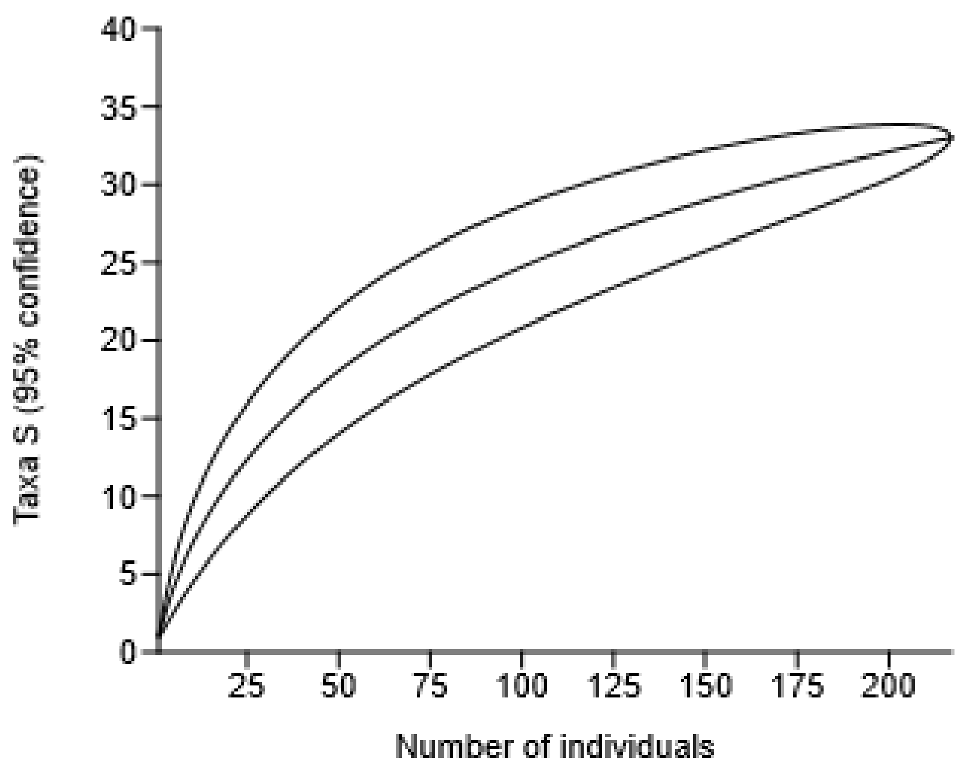

Figure 6: Species accumulation curves comparing sample size and reptiles richness across Mutumba wetland.

4.2.2 Reptile relative abundance

The reptile community in the Mutumba wetland displays variation in species abundance across different families. The family *Scincidae* had the highest abundance, with species Speckle-lipped Skink (n = 52, 23.5%) being the most prevalent (Table 3, Appendix 5). This was followed by the family *Agamidae*, with Kivu Blue-headed Tree Agama (n = 31, 14%) being the most abundant. In contrast, the family *Psammophidae* had the lowest abundances, with species Olive Whip Snake contributing just 0.5% of the total (n =1).

The most commonly occurring reptile species included Speckle-lipped Skink, African Striped Skink, Kivu Blue-headed Tree Agama, and Lake Tanganyika Blind Snake; representing the families *Scincidae, Agamidae* and *Lamprophiidae* respectively. In contrast, species Olive Whip Snake and Angolan Blind Snake from the families *Psammophidae* and *Typhlopidae*, were less frequently encountered compared to other species (Appendix 6).

Table 3: Abundance of reptile species recorded in Mutumba wetland

Species Common Name	Number of Individuals	Relative abundance (%)
African Striped Skink	23	10.41
Battersby's Green Snake	2	0.90
Bayon's Skink	6	2.71
Bibron's Burrowing ASP	10	4.52
Black-necked Agama	8	3.62
Black-necked Spitting Cobra	4	1.81
Christy's Snake-Eater	3	1.36
Egyptian Cobra	2	0.90
Elliot's Chameleon	2	0.90
Emerald Snake	1	0.45
Flap-necked Chameleon	6	2.71
Graceful Chameleon	4	1.81
Highland Grass Lizard	3	1.36
Kivu Blue-headed Tree Agama	31	14.03
Lake Tanganyika Blind Snake	14	6.33
Lake Turkana Hinged Terrapin	5	2.26
Lolui island Skink	3	1.36
Olive House Snake	1	0.45
Olive Whip Snake	1	0.45
Speckle-lipped Skink	52	23.53
Sternfeld's Gecko	8	3.62
Tropical House Gecko	2	0.90
Uganda Blue-headed Tree	2	0.45
Werner's Garter Snake	1	0.45
William's Hinged Terrapin	7	3.17
Yellow-Flanked Snake	6	2.71
Zambian Hinged Terrapin	3	1.36
Total	**221**	**100**

4.2.3 Diversity of reptile species-microhabitat associations

The distribution of reptiles in the Mutumba wetland varied across ten distinct microhabitat types. Simpson's index was used to evaluate reptile diversity in these habitats. The highest diversity was found in fallow (D = 0.95, n = 6 species), followed by cultivated land (D = 0.88, n = 13species). Conversely, the road surface (D = 1, n = 3 species) had the fewest reptile species (Table 4). Overall, this variation in reptile diversity highlights the ecological significance of different microhabitats in the wetland.

Table 4: Diversity of reptiles recorded in the different microhabitats of Mutumba wetland

	Number of individuals species observed per microhabitat									
Species Name	**Snags**	**Tree canopy**	**Artificial structures**	**Papyrus**	**Rice garden**	**Cultivated land**	**Star grass**	**Fallow**	**Vegetation litter**	**Road surface**
African Striped Skink										1
Battersby's Green Snake					1	1				
Bayon's Skink									1	
Bibron's Burrowing ASP						1				
Black-necked Agama		7				1				
Black-necked Spitting Cobra					1	1				
Cape Wolf Snake	1									
Christy's Snake-Eater								1		
Egyptian Cobra	35	8	4					1		
Elliot's Chameleon	3	10	10			1				
Emerald Snake						2				
Flap-necked Chameleon		1								
Graceful Chameleon						1				
Grass Snakes						2				1
Highland Grass Lizard	3	5								
Karamoja Dwarf Gecko				1		3				
Kivu Blue-headed Tree Agama	1	26		1		9				
Lake Tanganyika Blind Snake					1					
Lake Turkana Hinged Terrapin							1			
Lolui island Skink							1		1	
Olive House Snake		2				3				
Olive Whip Snake		1								
Speckle-lipped Skink		5				1				
Sternfeld's Gecko					4		1	1		
Tropical House Gecko					6			1	6	
Uganda Blue-headed Tree					1		1			
Werner's Garter Snake		1	1							
William's Hinged Terrapin		1		1				1		
Yellow-Flanked Snake										1
Zambian Hinged Terrapin				3			4			
Taxa_S	**5**	**11**	**3**	**4**	**7**	**13**	**5**	**6**	**4**	**3**
Simpson_1-D	**0.28**	**0.80**	**0.51**	**0.80**	**0.80**	**0.88**	**0.79**	**0.95**	**0.68**	**1.00**

4.2.4 Similarity in reptile occurrence across the different microhabitat types

The species occurrence data, was used to assess microhabitat similarity in community composition of the recorded reptile species. Tree canopy and artificial structure microhabitats had the highest proportion of closely related occurring species at 32% (Node A), followed by Fallow and vegetation litter microhabitats with 20% (Node C) (Figure 7). The similarity index also showed that Tree canopy and artificial structure microhabitats had the highest similarity at 33% (Appendix 4).

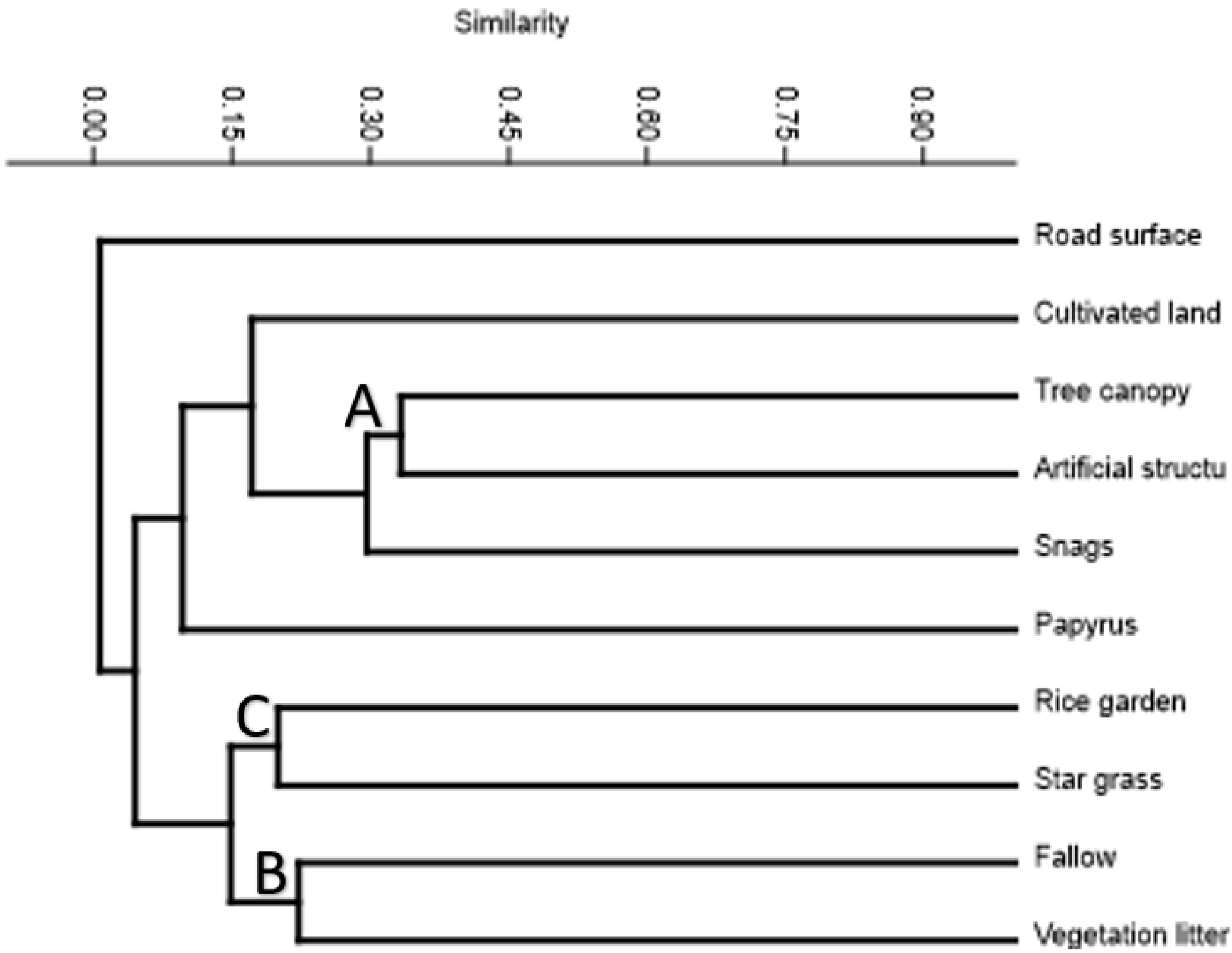

Figure 7: An agglomerative cluster dendrogram for similarity in reptile species occurrence in the different microhabitats of Mutumba wetland (Numbers=microhabitat clusters, letters=Nodes)

4.2.5 Reptile species-environment associations

Canonical Correspondence Analysis (CCA) revealed that a large number of reptile species were primarily associated with tree canopy (2.2) and cultivated land (-2.2) under favorable humidity and precipitation in the right quadrants. The common species included *Acanthocercus cf. gregorii* (Black-necked Agama), *Boaedon olivaceus* (Olive House Snake) *and Crotaphopeltis degeni* (Yellow-Flanked Snake) (Figure 8). Whereas *Afrotyphlops angolensis* (Angolan Blind Snake) and *Lygodactylus karamoja* (Karamoja Dwarf

Gecko) were more prevalent under clouds and sun conditions especially in structure-less loamy sand soils in the left quadrants.

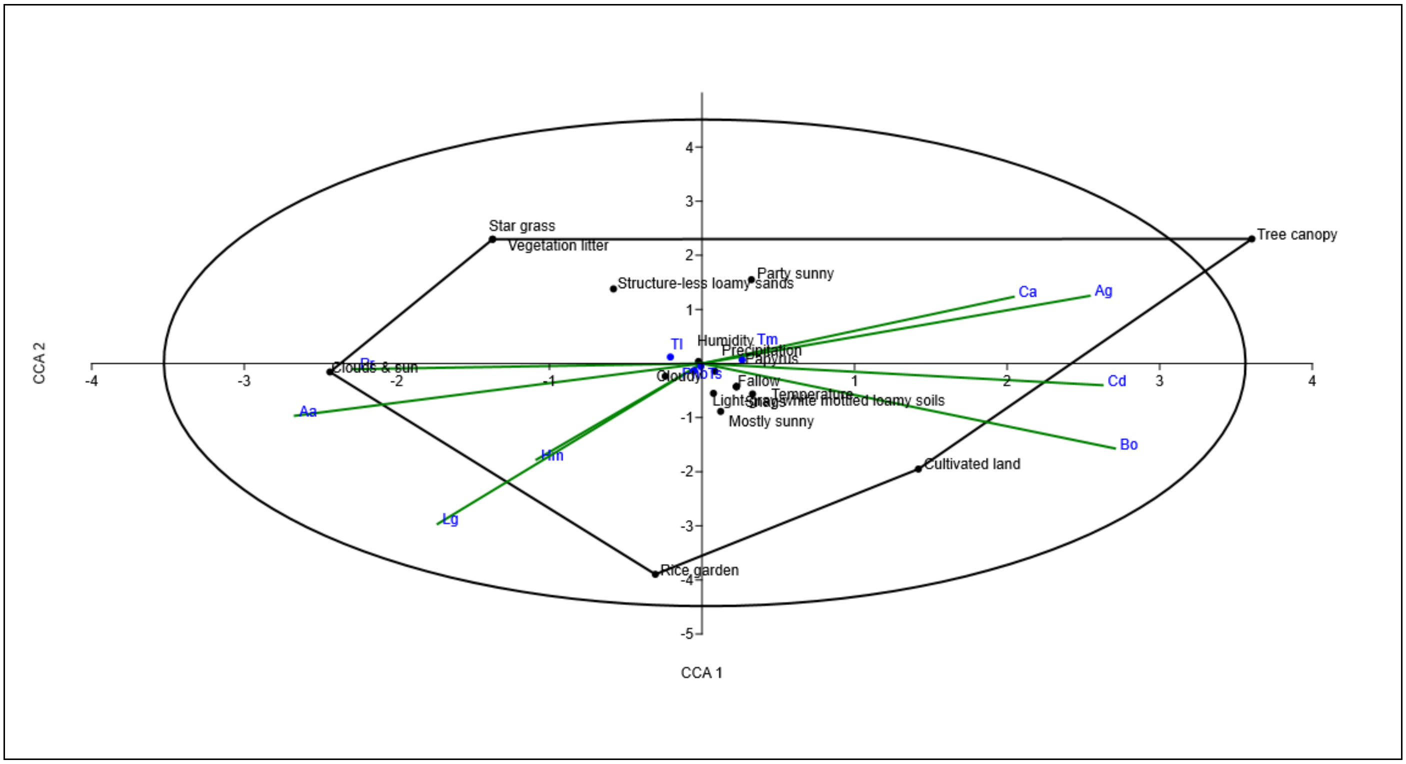

*Figure 8: Triplot for reptile occurrence in Mutumba wetland (blue dots/texts=species, green arrows=gradients and black dots/text=environmental variables). **Ag** = Acanthocercus cf. gregorii, Ak = Acanthocercus kiwuensis, Au = Acanthocercus atricollis, **Aa** = Afrotyphlops angolensis, Ab = Atractaspis bibronii, **Bo** = Boaedon olivaceus, Dd = Chamaeleo dilepis, Cg = Chamaeleo gracilis, Ca = Chamaesaura anguina, Cq = Cnemaspis cf. quattuorseriata, **Cd** = Crotaphopeltis degeni, El = Elapsoidea laticincta, Hs = Hapsidophrys smaragdina, **Hma** = Hemidactylus mabouia, Leg = Letheobia cf. graueri, **Lg** = Lygodactylus karamoja, Ld = Lycophidion capense, Nni = Naja nigricollis, Nh = Naje haje, Pr = Pelusios rhodesianus, Pw = Pelusios williamsi, Pbr = Pelusos broadleyi, Phb = Philothamnus battersbyi, Pc = Polemon christyi, Pm = Psammophis mossambicus, Pv = Psammophis sudanensis, Tb = Trachylepis cf. bayonii, Tl = Trachylepis cf. loluiensis, Tm = Trachylepis maculilabris, Ts = Trachylepis striata, Tsh = Trioceros ellioti*

5.0 CHAPTER FIVE: DISCUSSION

5.1 Amphibian species diversity within different habitat types

This study presents the first record on the diversity and distribution of amphibians in Mutumba wetland. The richness of amphibians found was 41 species belonging to 6 families. The higher species count in families *Bufonidae, Ptychadenidae* and *Hyperoliidae* could be attributed to more favorable microhabitats with natural or semi-natural vegetation, which are influenced by local weather conditions and soil types. This pattern aligns with recent studies indicating that habitat quality and environmental factors significantly affect amphibian diversity (Smith et al. 2023; Johnson & Lee, 2022; Martinez et al. 2024). Additionally, studies have shown that specific weather conditions, such as humidity and precipitation fluctuations, are critical factors in amphibian distribution and abundance (Carter & Nguyen, 2024).

The high species diversity in papyrus and cultivated land is likely attributed to the consistent availability of water especially in papyrus, marshes and regenerating vegetation, all of which are essential for feeding, breeding and burrowing, and thus crucial for amphibian survival. This aligns with findings by Nneji et al. (2019), who noted that wetland ecosystems including microhabitats such as ponds, swamps and lowland forests support greater amphibian species richness due to the presence of water which is a critical need for amphibian breeding (Ghose et al. 2017). In contrast, amphibians showed little association with road surfaces and stagnant water, likely because the sporadic availability of water in these areas is insufficient for the metamorphosis of tadpoles (Pankaj & Nath 2023). Additionally, many amphibian species tend to avoid road surfaces, likely due to the risk of road kills from passing motorcycles and vehicles. Amphibians are often victims of accidental road kills while migrating to breeding sites (Thorpe et al. 2018).

Mascarene Grass Frog, Striped Grass Frog and Southern Dwarf Grass Frog were identified as the most prevalent species across all microhabitat types. Notably, species from the *Hyperoliidae* family were observed only in papyrus microhabitats. This variation may be due to species preferences for different microhabitats and their tolerance to microhabitat modification. Such patterns have been documented in other studies, such as Johnson & Lee (2022) and Smith et al. (2023), which emphasize the role of habitat preferences and adaptability in shaping amphibian distribution. Additionally, Ghose et al. (2017) reported that dominant amphibian species across all habitat types demonstrate a strong tolerance for habitat modification; unlike species confined to specific microhabitats due to their narrow survival requirements.

5.2 Reptile species diversity within different habitat types

The reptile diversity comprised 31 species from 12 families. The high number of species in *Lamprophiidae* can be attributed to the presence of suitable microhabitats, including vegetation litter, rice gardens and fallow, coupled with favourable weather conditions, humidity and temperature in the local soil types (Table 4, Figure 7). High humidity and stable temperatures support reptile reproductive behaviors (Marsh, 1997). Additionally, species of family *Lamprophiidae* such as Yellow-Flanked Snake and Lake Tanganyika Blind Snake are known to exploit a variety of microhabitats including rice gardens, fallow, vegetation litter and star gras, which contributes to their species richness (Platt, 2012). In contrast, fewer species (such as Olive Whip Snake and Angolan Blind Snake) were observed in *Psammophida* and *Typhlopidae* families respectively. These species primarily inhabited habitats like rice gardens and star grass. This restriction is likely due to habitat modification from agricultural activities in Mutumba wetland. *Psammophidae* and *Typhlopidae* have specialized habitat requirements, often preferring rocky and arid environments, which are relatively scarce in the Mutumba wetland (Lamb, 2020). Additionally, habitat transformation from agricultural expansion, deforestation and urbanization diminishes the availability of suitable habitats for these reptile families, contributing to their lower species richness (Murray, 2021).

Fallow microhabitats supported 95% of the total 31 species, this distribution suggests these microhabitats offer more favorable conditions for reptiles compared to the more exposed or less complex environments of road surfaces. The relative scarcity of species in these latter habitats may be attributed to their limited shelter, food availability, or other ecological factors that affect reptile habitation and survival. Recent studies have highlighted the importance of habitat complexity and resource availability for reptile diversity. For instance, Smith et al. (2023) found that diverse vegetative cover in agricultural landscapes significantly enhances reptile species richness and abundance. Similarly, Miller & Nadeau (2023) reported that tree canopies provide critical microhabitats that support a greater diversity of reptiles than open habitats. On the other hand, Smith & Roberts (2022) indicate that road surfaces generally support fewer reptile species due to limited shelter and food resources. These findings underscore the need to consider habitat complexity and resource availability when planning reptile conservation strategies.

Species from family *Scincidae* were identified as the most common across all microhabitat types. This suggests that these species may be better adapted to the prevailing local environmental conditions compared to the less abundant families like *Cordylidae* and *Psammophidae*. Müller (2022) found that species such as Speckle-lipped Skink (*Scincidae*) and Kivu Blue-headed Tree Agama (*Agamidae*) showed higher abundance and diversity in specific microhabitats, suggesting their better adaptation to local conditions. Similarly, Kate & Blackburn (2007) observed that species of the family *Scincidae* were widespread across various microhabitats, highlighting their adaptability to diverse environmental conditions.

5.3 Amphibian and reptile species microhabitat associations

The cluster diagram for species occurrence similarity showed that rice gardens and fallow had the highest proportion of closely related amphibian species, whereas tree canopy and artificial structure had more reptiles. This suggests a substantial similarity in the amphibian and reptile communities within these microhabitats, highlighting their unique role in supporting amphibian and reptile species. It indicates that fallow and tree canopy may offer more conducive environments for species with similar ecological needs such as shelter and food than other microhabitat types. Additionally, the presence of closely related species in these habitats indicates that they may offer specialized resources or conditions that facilitate their coexistence. Such habitats are likely essential for maintaining biodiversity in these habitats. Zainudin et al. (2017) observed that closely related amphibian and reptile species tend to partition their microhabitats to coexist, highlighting the importance of understanding microhabitat features and species interactions in shaping biodiversity. However, the study's reliance on species occurrence data alone may not fully capture the complexities of species interactions and habitat use. Further research incorporating behavioral and ecological data would provide a more comprehensive understanding of these dynamics.

5.4 Implications for conservation and management

The conservation status of 41 amphibian and 31 reptile species in Mutumba wetland was evaluated (Appendices 1 & 3). Notably, all these species are categorized as 'Least Concerned' according to the IUCN Red List of Threatened Species in Africa. This is likely due to their wide distribution, ability to thrive in a variety of microhabitats and presumed large populations, as reported by IUCN (2016) and Smith et al., (2023). However, these species are not expected to experience rapid declines that would qualify them for listing in a more threatened category. The study findings indicate that most amphibian and reptile species in Mutumba wetland are closely associated with papyrus, cultivated land and fallow microhabitats, which are under threat from slash-and-burn agriculture, papyrus harvesting, livestock grazing and habitat conversion. As a result, any damage to these essential microhabitats could severely impact the survival and conservation status of these species. It is therefore crucial to implement more focused conservation and management measures to ensure their long-term sustainability.

6.0 CONCLUSION

The study documented 41 amphibian species from six families and 31 reptile species from twelve families in the Mutumba wetland. Both groups exhibited substantial species diversity in fallow and cultivated land, with amphibians showing higher species evenness. The most abundant amphibian family was *Ptychadenidae*, with Mascarene Grass Frog, Striped Grass Frog and Southern Dwarf Grass Frog being the most prevalent.

While *Scincidae* dominated among reptiles, with Speckle-lipped Skink being the most abundant species. Amphibians preferred papyrus and rice garden microhabitats, while reptiles were more common in cultivated land and fallow. In contrast, papyrus microhabitat had 10 amphibian species that were not recorded in any of the microhabitats. This suggests that species are adapting to new ecological niches and expanding into human-altered habitats. Additionally, the ability of these species to thrive in altered environments likely indicates their resilience and potential for coexistence with human activities. However, continued habitat changes may pose future challenges to their long-term survival if not properly managed.

7.0 RECOMMENDATIONS

1. This study on amphibian and reptile occurrence and distribution in the Mutumba wetland of Namayingo district indicates that further research is needed to fully explore the diversity of herpetofauna in the area. In particular, additional studies should focus on identifying new reptile species, as the species accumulation curves did not plateau, suggesting that our current understanding of species diversity is incomplete.
2. The gradual loss of key microhabitats for amphibians and reptiles, particularly papyrus and tree canopies, due to slash-and-burn agriculture, papyrus harvesting, livestock grazing and habitat conversion, is increasing the vulnerability of species with limited distribution ranges and low tolerance to human disturbances, especially those from the family *Hyperoliidae.* This heightened vulnerability puts these species at greater risk of being lost out locally. Consequently, it is critical to prioritize the conservation of these essential microhabitats to ensure the long-term sustainability of amphibian and reptile populations in the wetland.
3. Further research should investigate multiple environmental factors simultaneously to better assess and understand their influences on amphibian and reptile distribution in Mutumba wetland. This approach will provide a more comprehensive understanding of the complex interactions affecting their microhabitats and distribution patterns.

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9.0 APPENDICES

Appendix 1: Overview of factors influencing the occurrence and distribution of amphibians and reptiles in the Mutumba wetland

Environmental variables	**Description**	**References**
A. Weather conditions **i. Clear**	The sky is fully unobstructed, resulting in maximum sun exposure. Amphibians may be less active due to higher temperatures and direct sunlight, preferring shaded or moist areas. In contrast, reptiles may be more active, basking in the sun to regulate their body temperature.	Wyman & Salsbury, 2023
ii. Clouds and Sun	This condition features a mix of clouds and sunshine. Amphibians may be more active during cloud cover as temperatures are milder, while reptiles might alternate between basking in sunny periods and seeking shelter or hunting during cloudier times.	Heller & Tilszer, 2022
iii. **Cloudy**	Extensive cloud cover leads to cooler temperatures and higher humidity. Amphibians are likely to be more active due to favorable conditions for skin moisture and breeding, whereas reptiles might be less active because of the cooler temperatures but may emerge during warmer intervals.	Brunke & Howard, 2023

iv.	**Hazy Sunshine**	The sun's light is diffused by haze, leading to warmer temperatures with reduced UV intensity. Amphibians might be moderately active, though less so compared to clear conditions. Reptiles may use the diffused sunlight to bask without the intensity of direct sun, aiding in temperature regulation.	Smith & Roberts, 2022
v.	**Light Rain**	Light rain increases humidity and provides moisture, stimulating amphibian activity, particularly for breeding and feeding. Reptiles may be less active but could benefit from the increased humidity, making them more likely to emerge from shelters.	White & Patton, 2021
vi.	**Mostly Clear**	Predominantly clear skies with minimal cloud cover result in more direct sunlight. Amphibians might be less active due to higher temperatures and lower humidity, while reptiles are likely to be more active, using the sun for thermoregulation and foraging.	Li & Zhang, 2023
vii.	**Mostly Cloudy**	A mostly cloudy sky with occasional breaks creates a moderate environment. Amphibians are likely to be active due to favorable humidity levels, while reptiles may be intermittently active, utilizing breaks in the clouds for basking.	Stevens & Jacobsen, 2022
viii.	**Mostly Sunny**	Mostly sunny conditions imply high temperatures and direct sunlight. Amphibians may be less active to avoid overheating, seeking shade or moisture. Reptiles are likely to be highly active, taking advantage of sunny conditions for basking and hunting.	Thompson & Lopez, 2024

ix. **Partly Sunny**	This condition features a balance of sun and clouds. Amphibians may be actively foraging and breeding during sunny intervals but seek shelter during cloud cover to avoid drying out. Reptiles may bask during sunny periods and seek cover when it is cloudy.	(Miller & Nadeau, 2023
x. **Partly Cloudy**	The sky is partially covered with clouds, with significant periods of sunshine and cloud cover. Amphibians are likely to be moderately active, benefiting from stable conditions that prevent excessive drying. Reptiles will take advantage of sunny periods for basking and use cloudy periods to avoid overheating.	Newman & Millar, 2022
xi. **Thunderstorm**	Thunderstorms bring heavy rain, high winds, and potential flooding. Amphibians are likely to be very active during and immediately after thunderstorms due to the increased moisture stimulating their activity and breeding. Reptiles might seek shelter during storms but could emerge afterward for foraging or basking in the increased humidity.	Ford & Henderson, 2024
B. Temperature	As ectothermic animals, both groups rely on external temperatures for their metabolic processes. Amphibians prefer cooler, moist habitats, while reptiles thrive in a wider temperature range, often favoring warmer areas.	Sinervo & Heulin, 2023

C. Humidity	High humidity is critical for amphibians to prevent dehydration due to their permeable skin, making them more likely to inhabit wet environments. Reptiles can tolerate lower humidity but still benefit from adequate moisture.	McElroy & Benner, 2021
D. Precipitation	Rainfall affects water availability, which is essential for amphibians during breeding. Increased precipitation can create temporary water bodies, while reptiles may rely on moisture for prey abundance.	Müller et al., 2022
E. Soil Types	The composition of soil affects vegetation and microhabitat availability. Certain soils retain moisture better, supporting amphibians, while others create favorable conditions for burrowing reptiles.	Bury & Corn, 2023
F. Microhabitat	Specific microhabitats, such as vegetation litter, star grass, papyrus or cultivated land, are crucial for survival. Amphibians seek moist areas for protection, while reptiles prefer environments that provide warmth and cover.	Pike et al. 2022

Appendix 2: Number of amphibian species recorded in Mutumba wetland

Family	Scientific Name	Common Name	Number of Individuals
	Afrixalus fulvovittatus	Banded Spiny Reed Frog	11
	Hyperolius viridiflavus bituberculatus	Variable Reed Frog	3
	Hperolius balfouri	Balfour's Reed Frog	6
	Hyperlius rwandae	Rwanda Reed Frog	95
Hyperoliidae	*Hyperolius cinnamomeoventris*	Cinnamon-Bellied Reed Frog	211
	Hyperolius kivuensis	Kivu Reed Frog	77
	Hyperolius nasutus	Large-Nosed Reed Frog	107
	Hyperolius cf. poweri	Power's Reed Frog	25
	Hyperolius pusillus	Water Lily Reed Frog	118
	Hyperolius viridiflavus	Common Reed Frog	89
Dicroglossidae	*Haplobatrachus occipitalis*	Crowned Bullfrog	337
	Phrynobatrachus acridiodes	Eastern African Puddle Frog	100
	Phrynobatrachus cf. bullans	Bubbling Puddle Frog	2
	Phrynobatrachus mababiensis	Mababe Pubble frog	81
Phrynobatrachidae	*Phrynobatrachus natalensis*	Natal Puddle Frog	12
	Phrynobatrachus cf. rungwensis	Rungwe Puddle Frog	85
	Phrynobatrachus scheffleri	Scheffler's Puddle Frog	358
	Phrynobatrachus cf. dendrobates	Climbing puddle frog	25
	Phrynobatrachus cf. versicolor	Green Puddle Frog	8
	Ptychadena cf. bibroni	Bibron's Grass Frog	4
	Ptychadena chrysogaster	Yellow-Bellied Grass Frog	36
	Ptychadena cf. mahnerti	Mahnert’s Grass Frog	11
	Ptychadena mascareniensis	Mascarene Grass Frog	851
Ptychadenidae	*Ptychadena nilotica*	Nile Grass Frog	316
	Ptychadena oxyrhynchus	Sharp-Nosed Grass Frog	95
	Ptychadena porosissima	Striped Grass Frog	688
	Ptychadena schillukorum	Schilluk Grass Frog	5
	Ptychadena cf. stenocephala	Narrow-Headed Grass Frog	7
	Ptychadena taenioscelis	Southern Dwarf Grass Frog	599
Pyxicephalidae	*Pyxicephalus cf. edulis*	African Bullfrog	7

	Tomopterna cf. cryptotis	Catequero Bullfrog	4
	Sclerophrys cf. brauni	Braun's Toad	174
	Sclerophrys garmani	Garman's Toad	56
	Sclerophrys kerinyagae	Kerinyaga Toad	26
	Sclerophrys maculata	Northern Flat-Backed Toad	70
	Sclerophrys pusilla	Southern Flat-Backed Toad	186
Bufonidae	*Sclerophrys regularis*	African Common Toad	351
	Sclerophrys steindachneri	Steindachner's Toad	17
	Sclerophrys vittata	Striped Toad	12
	Sclerophrys gutturalis	Guttural Toad	29
	Sclerophrys kisoloensis	Kisolo Toad	24

Note: All species were recorded as LC (Least Concern) according to IUCN RedList

Appendix 3: Amphibians encountered in the different microhabitats of Mutumba wetland (x=species recorded)

Species name	Papyrus	Rice garden	Cultivated land	Star grass	Fallow	Stagnant water	Vegetation litter	Ecotone	Road surface
Afrixalus fulvovittatus	x								
Hyperolius viridiflavus bituberculatus	x								
Haplobatrachus occipitalis	x	x	x	x	x				
Hperolius balfouri	x								
Hyperlius rwandae	x								
Hyperolius cinnamomeoventris	x								
Hyperolius kivuensis	x								
Hyperolius nasutus	x								
Hyperolius cf. poweri	x								
Hyperolius puillus	x								
Hyperolius viridiflavus	x								
Phrynobatrachus acridiodes	x	x		x	x			x	
Phrynobatrachus cf. bullans	x				x		x		
Phrynobatrachus mababiensis	x	x			x			x	
Phrynobatrachus natalensis		x			x	x	x		
Phrynobatrachus cf. rungwensis		x	x	x	x	x	x		
Phrynobatrachus scheffleri		x	x	x	x	x	x	x	
Phrynobatrachus cf. dendrobates	x			x	x				
Phrynobatrachus cf. versicolor	x				x	x			
Tomopterna cf. cryptotis		x							
Ptychadena chrysogaster	x	x	x	x	x		x	x	
Ptychadena cf. mahnerti		x		x	x				
Ptychadena mascareniensis	x	x	x	x	x	x	x	x	

Ptychadena nilotica	x	x	x	x	x		x	x	
Ptychadena oxyrhynchus		x	x	x	x		x	x	
Ptychadena cf. bibroni		x		x					
Ptychadena porosissima	x	x	x	x	x	x	x	x	x
Ptychadena schillukorum		x		x	x				
Ptychadena cf. stenocephala		x		x	x				
Ptychadena taenioscelis	x	x	x	x	x	x	x	x	
Pyxicephalus edulis		X					x		
Sclerophrys cf. brauni		X	x	x	x		x	x	x
Sclerophrys garmani		X	x		x		x	x	x
Sclerophrys kerinyagae		X	x	x	x		x	x	x
Sclerophrys maculata	x	X	x	x	x				x
Sclerophrys pusilla		X	x	x	x	x	x		x
Sclerophrys regularis	x	X	x	x	x		x	x	x
Sclerophrys steindachneri	x	X			x				
Sclerophrys vittata		X							
Sclerophrys gutturalis		X		x	x			x	x
Sclerophrys kisoloensis		X	x	x	x				x

Appendix 4: Similarity index of amphibians and reptiles encountered in the different microhabitats of Mutumba wetland

	Snags	Tree canopy	Artificial structures	Papyr us	Rice garden	Cultivated land	Star grass	Fallow	Stagnant water	Vegetation litter	Ecotone	Road surface
Snags	**1.00**	0.31	0.29	0.02	0.00	0.06	0.00	0.02	0.00	0.00	0.00	0.00
Tree canopy	0.31	**1.00**	0.33	0.04	0.00	0.15	0.00	0.04	0.00	0.00	0.00	0.00
Artificial structures	0.29	0.33	**1.00**	0.00	0.00	0.06	0.00	0.02	0.00	0.00	0.00	0.00
Papyrus	0.02	0.04	0.00	**1.00**	0.20	0.15	0.18	0.22	0.09	0.12	0.20	0.05
Rice garden	0.00	0.00	0.00	0.20	**1.00**	0.34	0.56	0.63	0.14	0.36	0.35	0.29
Cultivated land	0.06	0.15	0.06	0.15	0.34	**1.00**	0.31	0.32	0.17	0.40	0.32	0.19
Star grass	0.00	0.00	0.00	0.18	0.56	0.31	**1.00**	0.57	0.16	0.35	0.37	0.26
Fallow	0.02	0.04	0.02	0.22	0.63	0.32	0.57	**1.00**	0.19	0.41	0.40	0.30
Stagnant water	0.00	0.00	0.00	0.09	0.14	0.17	0.16	0.19	**1.00**	0.29	0.19	0.08
Vegetation litter	0.00	0.00	0.00	0.12	0.36	0.40	0.35	0.41	0.29	**1.00**	0.43	0.17
Ecotone	0.00	0.00	0.00	0.20	0.35	0.32	0.37	0.40	0.19	0.43	**1.00**	0.21
Road surface	0.00	0.00	0.00	0.05	0.29	0.19	0.26	0.30	0.08	0.17	0.21	**1.00**

Appendix 5: Number of reptile species recorded in Mutumba wetland

Family	Scientific Name	Common Name	Number of Individuals
Agamidae	*Acanthocercus kiwuensis*	Kivu Blue-headed Tree Agama	31
	Acanthocercus cf. gregorii	Black-necked Agama	8
	Acanthocercus atricollis	Uganda Blue-headed Tree	2
Atractaspididae	*Atractaspis bibronii*	Bibron's Burrowing ASP	10
	Polemon christyi	Christy's Snake-Eater	3
Chamaeleonidae	*Chamaeleo dilepis*	Flap-necked Chameleon	5
	Chamaeleo gracilis	Graceful Chameleon	1
	Trioceros ellioti	Elliot's Chameleon	2
Colubridae	*Philothamnus battersbyi*	Battersby's Green Snake	2
	Hapsidophrys smaragdina	Emerald Snake	1
Psammophidae	*Psammophis mossambicus*	Olive Whip Snake	1
Elapidae	*Elapsoidea laticincta*	Werner's Garter Snake	1
	Naja nigricollis	Black-necked Spitting Cobra	4
	Naje haje	Egyptian Cobra	2
Gekkonidae	*Cnemaspis sp. cf. quattuorseriata*	Sternfeld's Gecko	8
	Hemidactylus mabouia	Tropical House Gecko	2
	Lygodactylus karamoja	Karamoja Dwarf Gecko	1
Lamprophiidae	*Crotaphopeltis degeni*	Yellow-Flanked Snake	6
	Letheobia cf. graueri	Lake Tanganyika Blind Snake	14
	Lycophidion capense	Cape Wolf Snake	1
	Boaedon olivaceus	Olive House Snake	1
	Psammophis sudanensis	Grass Snakes	2
Pelomedusidae	*Pelusios williamsi*	William's Hinged Terrapin	7
	Pelusios rhodesianus	Zambian Hinged Terrapin	3
	Pelusos broadleyi	Lake Turkana Hinged Terrapin	1

	Chamaesaura anguina	Highland Grass Lizard	3
Scincidae	*Trachylepis maculilabris*	Speckle-lipped Skink	62
	Trachylepis cf. bayonii	Bayon's Skink	6
	Trachylepis cf. loluiensis	Lolui island Skink	1
	Trachylepis striata	African Striped Skink	23
Typhlopidae	*Afrotyphlops angolensis*	Angolan Blind Snake	2

Note: All species were recorded as LC (Least Concern) according to IUCN RedList

Appendix 6: Reptiles encountered in the different microhabitats of Mutumba wetland (x=species recorded)

Species name	Snags	Tree canopy	Artificial structures	Papyrus	Rice garden	Cultivated land	Star grass	Fallow	Stagnant water	Vegetation litter	Ecotone	Road surface
Acanthocercus cf. gregorii		x				x						
Acanthocercus kiwuensis	X	x		x		x						
Acanthocercus atricollis		x										
Afrotyphlops angolensis					x		x					
Atractaspis bibronii					x	x		x		x		
Boaedon olivaceus						x						
Chamaeleo dilepis		x				x						
Chamaeleo gracilis		x										
Chamaesaura anguina						x						
Cnemaspis cf. quattuorseriata	X	x										
Crotaphopeltis degeni					x		x	x				
Elapsoidea laticincta												x
Hapsidophrys smaragdina								x				
Hemidactylus mabouia		x	x									
Letheobia cf. graueri					x			x		x		
Lycophidion capense					x							
Lygodactylus karamoja	X											
Naja nigricollis				x		x						
Naje haje					x	x						
Pelusios rhodesianus		x		x				x				
Pelusios williamsi				x			x					
Pelusos broadleyi							x					
Philothamnus battersbyi					x	x						
Polemon christyi						x						x
Psammophis mossambicus										x		
Psammophylax sudanensis							x			x		
Trachylepis cf. bayonii		x				x						
Trachylepis cf. loluiensis												x

Trachylepis maculilabris	x	x	x	x	x
Trachylepis striata	x	x	x	x	
Trioceros ellioti				x	