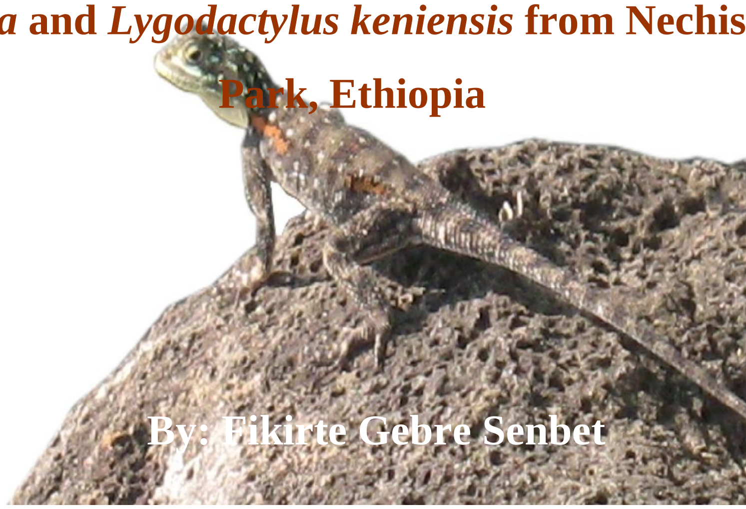
ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

Survey of reptiles and ecological study of two sympatric lizards *Mabuya striata* and *Lygodactylus keniensis* from Nechisar National Park, Ethiopia



By: Fikirte Gebre Senbet

A thesis submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology

(Dryland Biodiversity Stream)

Advisor- Prof. Samy A. Saber

Co-advisor- Prof. Afework Bekele

July 2008

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Addis Ababa

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ABSTRACT

Studies on species composition, diversity, evenness and relative abundance of reptiles in Nechisar National Park were carried out from October 2007 to April 2008. Reptiles were surveyed by using active search, pitfall trapping and cover sheet methods. A total 34 species belonging to 3 orders (Order Squamata, Order Testudines and Order Crocodylia) were recorded. The Order Squamata was the most diverse containing 30 species belonging to 2 Suborders, Sauria which comprises 19 species belonging to 7 Families and 10 Genera and Serpentes comprising 12 species belonging to 4 Families and 13 Genera. The Order Testudines comprised 3 species belonging to 2 Families. The Order Crocodylia comprised only one species. The diversity of reptiles varied among the different habitat types. Bushland habitat had the highest number of reptilian species (29.69% of the collected species). From the total species recorded, 11 (29%) were new records from the area. Detailed observations were made on the lizards *Lygodactylus keniensis* and *Mabuya striata*. These lizards were found to have a very high overlap in their temporal niche dimension, which is compensated by low overlaps in their spatial and food niche dimensions.

Key words: - Competition, niche breadth, niche dimensions, reptiles, resource partitioning, species composition, sympatry

1. INTRODUCTION

One of the first questions that arise in any reflection on the biodiversity of a given environment would be related to identifying the types and numbers of species that are actually present and how this diversity is changing in response to the pressures exerted by human activities. Unfortunately, finding answers to these questions is not an easy task, especially in countries like Ethiopia.

Ethiopia is a country that has long been recognized for its wealth of natural resources, endemic species, and high biodiversity. It used to be a heavily forested country with about 40 percent of its total area covered by dense forests (Sentayehu Tedla and Martha Gebre, 1998). In contrast, at present, only about 2.7 percent is covered by forest. Currently, the deforestation rate is estimated between 100,000 and 200,000 ha a year. Owing to this accelerated loss, the distinctive natural collection of biodiversity will not remain intact for long (Sentayehu Tedla and Martha Gebre, 1998).

The logical first step in the conservation of an area is to identify what species are currently present and explore their structure and function in the ecosystem. Signatory countries of the Convention on Biological Diversity (CBD), like Ethiopia, are obligated to monitor biodiversity. A baseline knowledge is also necessary for monitoring and assessing land-use patterns, pollution, global climate change, and the economic value of natural resources.

Mankind is dependent on a diverse array of products obtained from wild species, on genetic diversity among wild relatives of domesticated species, and on the stability of natural ecosystems. All of these dependencies necessitate the maintenance of biodiversity. Increasing rates of extinction of species, and the loss of knowledge of local species among indigenous people, have stressed the urgent need for scientific exploration to increase man's knowledge of species-level biodiversity across all organisms.

Ethiopia has recently recognized the commercial value of its natural resources and the government has instituted conservation and protected area management programmes. The first priority of these programmes is to establish areas for conservation and protection of a range of species and habitats. Nechisar National Park is one of the National Parks of Ethiopia established in 1967.

In most cases, the available environmental education in different schools, clubs or other environment concerned programmes in the country mainly focus on issues like deforestation, soil erosion, pollution and conservation of the larger mammals and birds. Diverse species of reptiles occur in all types of habitats and many of them live very near to human habitations. But, due to many superstitions, myths and false beliefs, people either avoid them or want solely to kill them. In any case, there is little attempt to study reptiles or understand their ecological significance or protect and conserve them.

Lizards are one of the major groups of reptiles, belonging to the Order Squamata. They are elongated and slender reptiles and use their limbs to anchor and for movement. Lizards have about 300 living genera containing some 3000 species, which make them, by far, one of the most abundant groups of modern reptiles (Webb *et al*., 1978). Because of their high abundance and visibility, lizards are good candidates for the study of functional biodiversity.

Structural biodiversity is a complete survey of the species such as species diversity, species richness, species composition and evenness. Functional biodiversity is concerned with investigation of the functions of the species in the ecosystem. One of these functions is resource partitioning, by which several species coexist in any area through specific functional ecological niches.

Organisms make use of the resources around them effectively. This use of resources leads to competition. Examining the patterns of resource use in coexisting species helps to deduce the minimal differences that are needed for smooth coexistence. Examination of patterns for species that fail to coexist can illuminate what aspects of resource use contributes to apparent competitive exclusion. Such efforts are referred to variously as studies of niche partitioning or resource partitioning (Morin, 1999). Resource partitioning between two or more sympatric species always involves the differential utilization of the existing niche components in that specific area. According to Barbault (1985), communities may not, probably, be organized by species interactions but rather through the specific ecological needs of each species. Understanding the causal mechanisms which determine patterns of habitat use can greatly contribute to the ability and effort to manage natural ecosystems (Cooke *et al*., 2002 and Pyke *et al*., 2002 as cited in Langkilde and Shine, 2004).

In Nechisar National Park, the lizard species *Lygodactylus keniensis* and *Mabuya striata* coexist. Given the fact that these two lizard species are abundant in the Park and coexist in the same habitat in some areas of the Park, investigation was carried on different aspects of niches that they partition.

The present survey of the reptilian fauna of Nechisar National Park was carried out on the structure and function of these taxa as a first step in the conservation of biodiversity of the area.

2. LITERATURE REVIEW

2.1. Reptiles

Reptiles are groups of vertebrates belonging to the Class Reptilia. They are one of the major groups of organisms living in different habitats. These organisms are very diverse depending on the habitat where they exist. Due to their diverse features and climatic tolerance, they have a wide range of adaptation, exceeding mammals and amphibians in number (Bellaris, 1966). There are about 6,500 species of reptiles of 900 genera with 48 families of four Orders based on evolutionary lineages since 200-300 million years (Branch, 1988). These Orders are Order Crocodylia, Order Testudines, Order Squamata, and Order Rhynchocephalia (Branch, 1988).

Their unique evolutionary advancement, in addition to their lack of larval stage in their development, is the presence of amniotic egg. This rendered the aquatic larval phase superfluous, because of abundant reserves of nutritive substances and, above all, contained a special fluid-filled sac, which represented a facsimile in miniature of the watery environment in which the amphibian embryo developed. All reptiles have a dry, horny skin, and in most, it is modified into scales or plates. This feature gives good protection against mechanical injury in addition to preventing rapid water loss. Without their impermeable skins, reptiles might not have been able to colonize deserts or environments that are inhospitable to amphibians (Branch, 1988).

According to Bellairs and Carrington (1966), the characteristic scales are formed from the thickening of the epidermis. These scales are composed of keratin, which is a dead material, and is continually being rubbed off and renewed from below by the deeper, living tissues of the epidermis. The numerous pigment cells are found mainly, though not exclusively, in the deepest region of the skin, the dermis. These cells are responsible for the colouration of the animal and play an important role in colour change, a phenomenon exhibited in many reptiles (Bellairs and Carrington, 1966).

The form and arrangement of the scales are consistent in any given reptile species. This is particularly true for the big scales over the head which are often called shields. Due to this, scales are used as guides for identification. Their arrangement is often shown in the recognition of keys and check-lists (Bellairs and Carrington, 1966).

The sense of hearing does not seem to be very important, among most of the reptiles, at least in the generally understood sense of the perception of air-borne sounds. They are very silent animals as compared with other groups of animals. But, on the other hand, it is possible that in some reptiles, the ear plays an important role in detecting vibrations through the ground (Bellairs and Carrington, 1966). Although better at perceiving moving objects than stationary ones, most reptiles have keen eyesight. Lizards and tortoises are known to have some ability to recognize colours. In some reptiles like the tree snakes and chameleons, the fields of the two eyes overlap giving a degree of binocular vision, which is much needed for judging distances, which is mandatory for the precision needed to capture their prey. The sense of smell is most important in those reptiles that burrow, and have only poor vision (Bellairs and Carrington, 1966).

All reptiles are poikilothermic. They lack fur and feathers, which help other animals, (mammals and birds), to maintain their body temperature (Zug, 1993, Branch, 1988; Spawls *et al.,* 2002). But, this does not mean that they cannot regulate their body temperature. They can decrease their metabolic rate by lowering body temperature or elevate energy for growth and reproduction by consuming and digesting more food during times of prey abundance. Increasing digestive rate to allow frequent meals can be accomplished by increasing body temperature. Compared to endotherms, they eat infrequently, but in snakes as a group, meal intervals may be short, as seen in insectivorous green snakes that eat almost daily

(Plummer, 1981as cited in Sievert *et al.*, 2005) or large, as seen in many Viperids that may go several months between meals (Secor and Diamond, 2000 as cited in Sievert *et al*, 2005). Reptile energy budgets are low and they are able to survive on a relatively lower mass of food than endotherms. It also means that reptiles cannot survive in areas that are constantly cold, and thus they are less restricted at high altitudes (Du *et al.*, 2000; Wang *et al.*, 2003 as cited in Sievert *et al.*, 2005).

All reptiles have a preferred range of temperature in which all their body activities function best. Therefore, the risk of compromised oxygen delivery for an air-breathing ectotherm is increased at temperatures both above and below the preferred range and can lead to lethal hypoxia at extreme temperatures in each case. Sustained environmental temperature change, either warming or cooling, could therefore affect the reptile populations due to compromised oxygen supply and aerobic capacity (Jackson, 2007).

According to Bellairs and Carrington (1966), in many reptiles, the brain weight is less than 0.5% of the total body weight. As in other animals, the proportion of the brain to body size tends to be higher in small species than in big ones.

Reptiles usually have simple pointed teeth, which are not differentiated into incisors, canines and grinding teeth as in mammals. They are more suitable for seizing and holding prey than for cutting it into pieces or chewing it. In addition to this, reptiles are not limited to two sets of teeth, the milk and permanent dentitions. Most of them keep on losing and replacing their teeth as long as they live (Bellairs and Carrington, 1966).

With the exception of some turtles and lizards, the rest of the reptiles are primarily carnivores. They kill large number of insects and rodents. The turtles and tortoises rank first as food for man. Many raptorial birds predate highly upon snakes and lizards. Young turtles and even eggs are readily consumed by birds, fish and mammals (Bellairs and Carrington, 1966).

Reptilian fauna has limited power for dispersion and poor ability to withstand changes in climatic factors. Hence, they are considered as key species for habitat and climate studies. Amphibians and reptiles have recently been recognized as good indicators of ecosystem health. Reptiles undoubtedly play an important role in the functioning of local ecosystems, contributing for regional environmental stability.

Even though reptiles are widely distributed, they are the least known to the public at large and perhaps for that reason, they are widely feared and persecuted, being associated in popular imagination with everything that is most harmful and undesirable. Public knowledge about reptiles is generally full of crap and misconceptions. In most parts of the world, as it is the case in Ethiopia too, they are considered as slimy, cold, slow, and most are thought to be highly venomous. In most places, they are seen as evil animals that are always looking forward to hurting other organisms even though they are not going to benefit anything out of it. As a result, they are seen as inherently inefficient groups, which is quite untrue (Branch, 1988). Their very name is also an indicator of how people used to look at them i.e. in Latin '*repere*' means to creep (Bellairs and Carrington, 1966).

Naturalists have for a long time neglected the reptiles. For instance, the greatest naturalist of all times, Carl Linnaeus has described them as 'foul and loathsome' creatures (Bellairs and Carrington, 1966). At present, though most people agree that the feeling towards reptiles is complicated, they still bring some deep and complicated emotions.

An individual would rather kill a reptile, if it comes across especially snakes, than seeing it reproduce itself and survive in her/his locality. Due to this, children who are brought up with such a mentality, are very likely to think like their parents do and kill reptiles when they come across, especially snakes. The different myths that most societies have towards reptiles are also the major factors affecting their populations.As the public has only little interest in reptiles, research activities on them are only few in number. For instance, the reptile diversity is not studied in Ethiopia, resulting in a huge information gap.

Reptiles have their own advantage to the society and the environment at large. For instance, larger snakes like cobra and rat snakes have a considerable ecological role in keeping the rodent population under control and thereby promote agricultural interests. According to a report by the Chennai Snakes Park Trust (2006/07), it is estimated that 10% to 25% of India's food crop is destroyed every year by rats either in the field or at storage. Snakes and lizards control other pests because they eat mostly insects and other small invertebrates injurious to crops. Thus, reptiles generally play an important role in the environment.

One way to describe distribution of organisms is based on the presence of resources that they need for their existence. Factors that influence the geographic distribution of species include how organisms are related to their environment (i.e. niche requirements) and interspecific interactions such as competition, predation, and parasitism (MacArthur, 1984; Chesson, 2000; Chave *et al*., 2002 as cited in Costa *et al.*, 2008).

Accurate information on distributional patterns of species is important for different activities like using the available resources efficiently, recording and monitoring the biodiversity of the area and identifying hotspot areas. But, in many areas, complete inventories do not exist, which is the case in most parts of Ethiopia; as in most of the developing countries.

History of the Herpetological Survey in Ethiopia

The first herps collected and described from Ethiopia appear to have been those obtained during the period 1839-1841, by a scientific mission under the command of Théophile Lefèvre. In subsequent years, many other travelers explored the country, primarily concerned with surveying or big game hunting, some of whom returned home with odd scraps of herps material (Largen, 2001).

Vincenzo Ragazzi, who was for several years Director of the Italian Station at Let Marefia, included amongst his substantial herpetological collections amphibians that later became the types of *Paracassina obscura* and *Leptopelis ragazzii*, obtained in 1885 and 1892, respectively. During 1891-1893, Eugenio Ruspoli traveled extensively in eastern and southern Ethiopia; two visits to the Ogaden Region, followed by a journey from Dolo to Lake Abaya and his fatal meeting with an elephant in December 1893. Meanwhile, Vittorio Bttego was independently involved with exploration of much of the same region. In 1892-1893, he traveled from Berbera on the Somali coast through the Ogaden region to conduct a detailed investigation of the drainage systems of the Ganale and Dawa Rivers, before returning to Somalia through Dolo. By 1895, Bttego was again in Ethiopia, journeying from Dolo to Lake Abaya, the Omo River and Lake Rudolf (now Lake Turkana) before his unfortunate death in 1897 (Largen, 2001).

During 1894-1895, Arthur Donaldson Smith undertook the first of his two great expeditions to Lake Rudolf. Starting from Berbera, his itinerary involved a survey of previously unexplored areas in northern Bale Province and visits to Lakes Abaya, Chamo and Stephanie, before extending southwards into Kenya (Largen, 2001).

A German expedition during the years 1899-1901 led by Carlo von Erlanger and Oscar Neumann, engaged in zoological research in central and southern Ethiopia. Their route extended from the Somali coast at Zeila to Harar and then onwards through the northern foothills of the Arussi Mountains to Addis Ababa. From here the expedition moved southwards along the Rift Valley to Lake Chamo. The former journeyed northeast into the Bale Mountains, but yet again missed the opportunity for rewarding exploration at high altitude, before once more turning south and following the Ganale River into Somalia. Neumann worked his way westwards, by way of Kaffa Province, into the Sudan and eventually back to Europe through Khartoum (Largen, 2001).

During 1901-1902, Edward Degen collected a long a route that extended from Zeila, by way of Harar and Lake Zwai to Addis Ababa, and from there northwards through Gojjam Province to Lake Tana. The return journey more or less retraced the outward course, but terminated at Djibouti (Largen, 2001).

Entomologist, Hugh Scott visited Ethiopia on several occasions in order to undertake ecological research at high altitude. During 1926, he was accompanied by Joseph Omer-Cooper, a Freshwater Biologist, whose collection of 11 amphibian species included the endemic *Ptychadena cooperi*. In 1926-1927, a major expedition on behalf of the Field Museum of Natural History in Chicago explored a wide area in central and northern Ethiopia. The team included Wilfred H. Osgood, who, though best known as a Mammalogist, appears to have assumed responsibility for the collection of amphibians and reptiles (Largen, 2001).

The only period (1936-1941) during which Ethiopia has ever been subjected to occupation by a foreign power saw two particularly important Italian expeditions in the southern region of the country. The Missione Biologica nel Paese dei Borana in 1937 and the Missione Biologica Sagan-Omo in 1939, both led by Edoardo Zavattari, explored the Borana Region from Dolo westwards to Lake Stephanie and the Omo River. There collections are now housed in Milan at the Museo Civico di Storia Naturale (Largen, 2001).

This flurry of activity was immediately followed by a remarkable hiatus in the advancement of Ethiopian herpetology, lasting for almost 30 years. The resurgence of interest dates from 1968, when John Blashford-Snell led an expedition to explore the valley of the Great Abbai (Blue Nile) River. Although composed mainly of British army personnel, the party included as zoologists, Patrick Morris and Derek Yalden from England, and Malcolm Largen, who was a member of the staff of the Biology Department, Addis Ababa University during 1966 - 1977. Largen, Morris and Yalden made three further joint excursions in Ethiopia during 1970-1971, 1971-1972 and 1975, working primarily at high elevations in the Bale Mountains, but including trips to the southwestern forests, the Awash National Park and Sidamo Province. Many other biologists were also encouraged to accumulate specimens on our behalf and, apart from representative series deposited at the Natural History Museum in Addis Ababa. Unfortunately, most of these materials eventually passed, either directly or indirectly, into the possession of the Natural History Museum, London. As a result, this institution now has by far the largest collection of Ethiopian herps available anywhere in the world. Other significant samples of the Ethiopian herpetofauna that dates from this period are those acquired by the Germans Gerhard Nikolaus and Hans Rüpp in 1972-1976 and donated to the Museum Koenig in Bonn (Largen, 2001).

Finally, during three weeks in August 1986, the Harenna Forest Expedition, led by Jesse C. Hillman of the then Ethiopian Wildlife Conservation Organisation, conducted a transect survey on the southern slopes of the Bale Mountains. The resulting collections, now preserved in the Liverpool Museum, include the type specimens of *Balebreviceps hillmani, Ptychadena harenna* and *Ericabatrachus baleensis* (Largen, 2001).
In terms of rewards obtained relative to time and effort invested, this expedition must surely rank as one of the most successful ever undertaken in Ethiopia, and

provides a very clear indication of how much biological organisms still remain to be learned from this region of Africa (Largen, 2001).

Herpetological work in Ethiopia became rather slow during the subsequent 20 years, with only few publications dealing directly with distribution and taxonomy depending mainly on specimens deposited in museums outside Ethiopia (Largen and Rasmussen, 1993; Largen and Spawls, 2006)

Several publications dealing with the herpetofauna of adjacent countries often cover parts of Ethiopia. There are some herpetological works done in Ethiopia which in general added valuable information about the herpetofauna of the area (Welch, 1982; Spawls *et al.*, 2002).

Ongoing herpetological research, started from September-October 2006, by a joint expedition between Addis University and British Natural History Museum to Bale Mountain and southwestern region. Several amphibian and reptile specimens were collected and are still under publication. The present study is considered as one of the studies of the ongoing herpetological research, by the developing Ethiopian Scientific community.

2.2 Resource partitioning

According to Schoener (1965 as cited in Toft, 1985), the expression "resource partitioning" was coined in the 1960s to mean, simply, how species differ in their use of resources. This term is usually used in ecology in a synonymous fashion with the words 'niche differentiation', 'niche segregation', 'niche separation' and 'niche partitioning', referring to the process by which natural selection drives competing species into different patterns of resource use or to occupy different niches (Wikipedia online http://en.wikipedia.org/wiki/Niche_differentiation accessed in April, 2008). The niches of a species are defined as the set of environmental conditions required for the species to maintain a viable population in order to persist through time (Hutchinson, 1957; Chase and Leibold, 2003as cited Costa *et al.*, 2008). According to Morin (1999), examining patterns of resource use in coexisting species helps to deduce the minimal differences that are compatible with coexistence. Examination of patterns of species that fail to coexist can illuminate what aspects of the resource use contribute to apparent competitive exclusion, which is studied as niche partitioning or resource partitioning.

Niche differentiation is a process, which occurs through several different modes and multiple temporal and spatial scales. In most cases, niche differentiation has created a relationship between two species, where current competition is small or non-existent. It is important to keep in mind that niche differentiation and inter-specific competition cannot always be linked.

According to Morin (1999), organisms that exist in sympatry should adapt to a mechanism in which they are able to consume the resources that are available in their surrounding in the most efficient and convincing way so that one species does not out-compete the other as dictated by the competitive exclusion principle; thus, coexistence is obtained through the differentiation of their realized ecological niches. As an example of resource partitioning, seven *Anolis* lizards in tropical rainforest share common food needs, mainly insects. They avoid competition by occupying different sections of the rainforest. Some live on the leaf litter floor, while others live on shady branches, thereby avoiding competition over food in those sections of the forest. All resources are subject to partitioning, for example; space, food and nesting sites. This minimizes competition between similar species (Wikipedia, 2008).

2.2.1. Temporal partitioning

Temporal resource partitioning takes place when two species eliminate direct competition by utilizing the same resource at different times. The assumption is that competition among species that are active at different times would be less intense than if the same set of species all attempted to use the same resources at the same time (Morin, 1999). This can be on a daily scale in a way that one species feeds on a prey during the day time and the other species feeds on the same prey at night. It can also be on a longer, seasonal scale. A good example will be the reproductive asynchrony, or the division of resources by the separation of breeding periods. According to Morin (1999), this scenario of temporal partitioning is plausible merely in situations where the resource levels rapidly recover from utilization; otherwise, the second species would not be able to get anything once the first species has depleted the available resource.

Temporal partitioning on daily basis may facilitate coexistence through avoidance of direct confrontation or through the reduction of resource overlap (resource competition). Resource overlap may be reduced if the shared limited resources differ between activity times (particularly for predatory species whose prey populations have activity patterns) or if they are renewed or depleted within the time frame involved in the separation (Schoener, 1974).

2.2.2. Spatial partitioning

Spatial distribution of species can have important implications for interactions of the species. According to Atkison and Shorrocks (1981) and Ives and May (1985), as cited in Morin (1999), a tendency for individuals of a species to aggregate within spatially isolated habitats can promote coexistence of competition within a mosaic of habitat patches.

Spatial resource partitioning occurs when two competing species use the same resource by occupying different areas or habitats within the range of occurrence of the specific resource that they are partitioning. According to Wikipedia online http://en.wikipedia.org/wiki/Niche_differentiation, (accessed on April, 2008), spatial partitioning can occur at small scales (microhabitat differentiation) or at large scales (geographical differentiation). Microhabitat differentiation occurs when two competing species with overlapping home ranges partition a resource. An example to this kind of resource partitioning would be different species of monkeys feeding at different heights of the same tree. Geographical differentiation is when two competing species have non-overlapping home ranges, and thus partition resources. An example might again be given with monkeys; two competing monkey species using the same species of fruit trees, which are found in different parts of the forest.

2.2.3. Food niche partitioning

This type of resource partitioning deals with dividing up the food material in the locality. Competing species can be feeding upon the same or different types of food items. If species are feeding upon the same kind of food items then their competition would be fierce and there should be a mechanism to withstand the competition. For instance, if one of the species is active during the day time and the other at night and both feed upon the same food item, as long as the food resource is not depleted, there will not be much problem.

Lizards can differ in the type of prey they consume, in their feeding strategy and/or in the size of food they consume. According to Rouag *et al.*, (2007), sympatric lizards are well known to usually partition the spatial resources in a wide variety of habitats and climatic conditions.

3. OBJECTIVES OF THE STUDY

3.1. General objectives

- To get information on the diversity of reptiles from Nechisar National Park and conduct ecological study on *Mabuya striata* and *Lygodactylus keniensis.*

3.2. Specific objectives

- To gather information on the species composition of reptiles in Nechisar National Park.

- To identify the diversity and evenness of reptiles in Nechisar National Park.

- To identify resource partitioning pattern between two lizard species, *Lygodactylus keniensis* and *Mabuya striata*, together with their mechanisms of coexistence.

4. MATERIALS AND METHODS

4.1. The study area

4.1.1. Topography

Nechisar National Park (NNP) is located about 505 km south of Addis Ababa, in the Amaro Special Woreda and Arbaminch Zuria Woreda of the Southern Nations Nationalities and Peoples National Regional State (SNNP), between 5˚ 51' N and 6˚50'N longitude and 37˚32' E and 37˚48' E latitude (Fig. 1). The Park is bounded by the Amaro Mountains in the east, by Arbaminch town in the west and by Lakes Abaya and Chamo in the north and south respectively (Kirubel Tesfaye, 1985).

The park has an area of 514 km^2 (SNNPRS BOA, 1996). The Nechsar plain of the park is bounded by the Amaro hills in the Southeast, Harre Mountain in the East, undulated Degabulle terrain in the weste and Lake Abaya and Lake Chamo to the north and south respectively (Bolton, 1970).

4.1.2. Climate

According to the Ethiopian climatic classification, the Abaya Chamo basin is characterizing hot semiarid, warm temperate and tropical climate (EPA, 2005).

As no temperature or rainfall records of the Park exist, the data consisting of the Park's temperature and rainfall were collected from Arbaminch State Farm Meteorology Station located 5 km to the northwest of the Park and Arbaminch University.

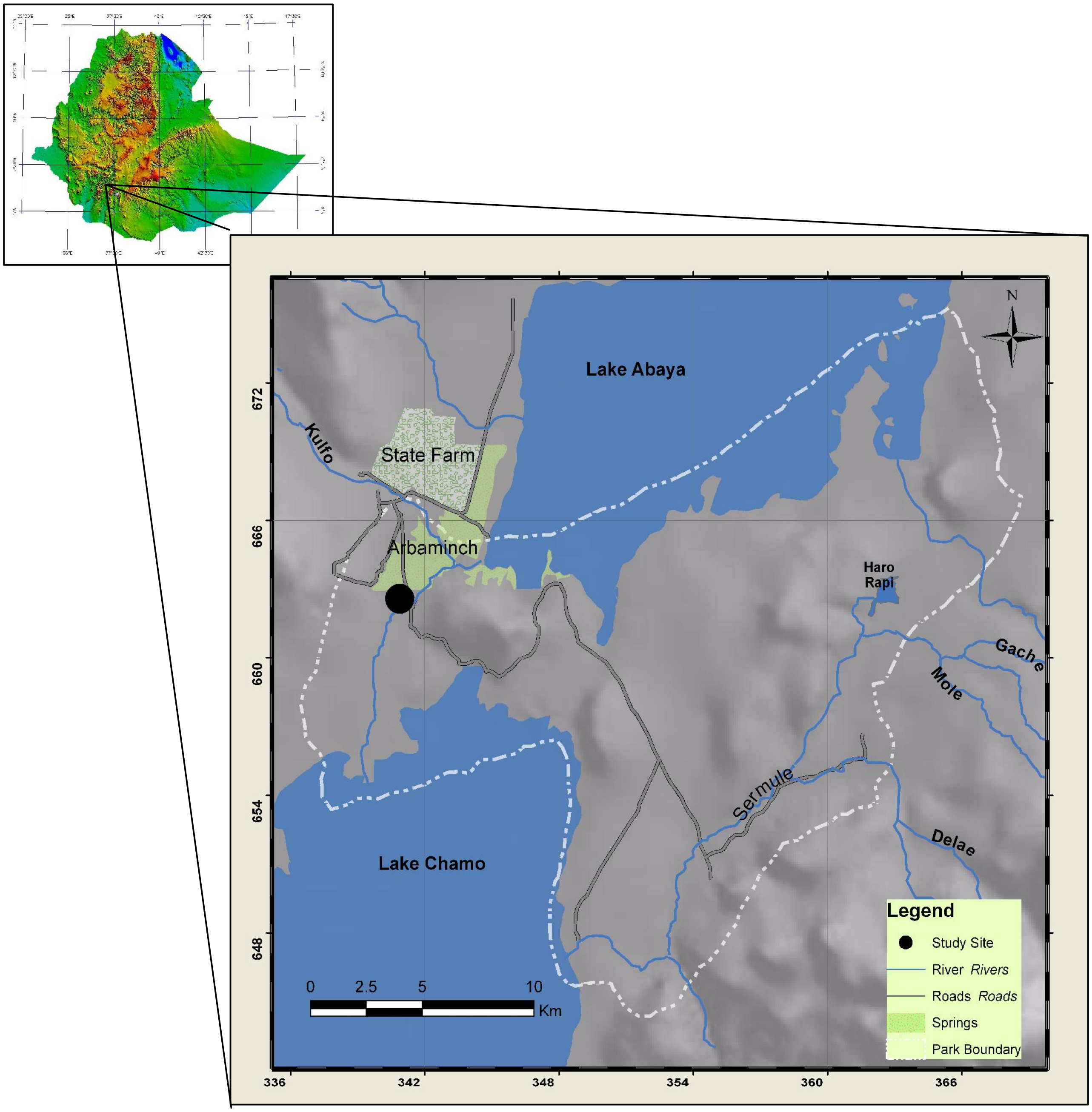


Figure 1. Map of Nechisar National Park with the study site.

The climate of NNP is generally characterized by higher temperature with unreliable and unevenly distributed rainfall. The hottest time of the year is between January and March with mean maximum temperature 32.7 ^{o}C (Kirubel Tesfaye 1985). The cooler months are November and December with mean minimum temperature of 15.3^{o}C. The mean annual temperature of the area is 23.8 ^{o}C and the mean daily maximum temperature of the warmest months is 26.1 ^{o}C. The mean daily maximum temperature of the coldest months is 23.5 ^{o}C. The rainfall regime is made up of two distinct rainy seasons with the long rain season occurring in April, May and June and the short rainy season occurring in September, October and November. The total annual of rainfall of the area is between 500 mm and 1200 mm.

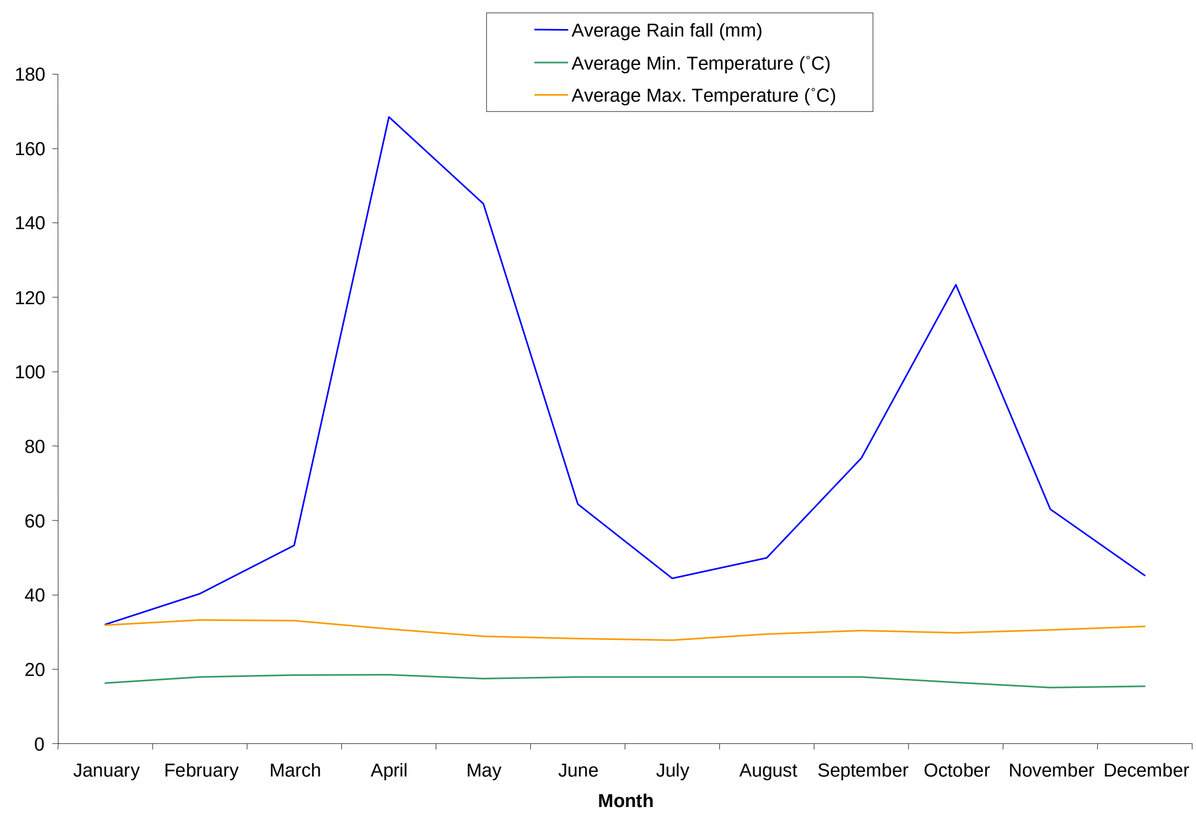


Figure 2. The average temperature and rainfall distribution of the area based on a 21 years data (from 1987-2007) (Source- Arbaminch State Farm and Arbaminch University Metrological Station).

4.1.3 Soils

The soils of the Nechisar grassland plains and wooded grasslands which are usually derived from sedimentary rocks have a high clay content and are cottony with a black colour. On the contrary, the soils of the rugged mountainous parts of the Park are derived from volcanic rocks also known as igneous rocks and are brown in colour with calcareous loams having some amount of humus (Bolton, 1970 as cited in Kirubel Tesfaye, 1985).

4.1.4. Water Bodies

The Park has a number of water bodies.

4.1.4.1. Lakes

The Park incorporates the lakes and shores of Lakes Abaya and Chamo. These two lakes belong to the Ethiopian Rift Valley lake system.

Lake Chamo has an area of 551 km^2 and is located at an altitude of 1108 m asl (Bolton, 1970 as cited in Kiribel Tesfaye, 1985). It is a tectonic southern Rift Valley lake, which is fed by a perennial river, Kulfo. Kulfo enters the lake from the north with a number of small but non-perennial rivers including Rivers Sile and Sego. This lake is the second largest of the African Rift Valley Lakes and the third in the country.

Lake Abaya is the largest Rift Valley lake in Ethiopia. Lake Abaya is bigger than Lake Chamo with a height of 1169 m asl, an area of 1200 km^2 (Bolton, 1970 as cited in Kirubel Tesfaye, 1985), a volume of $8.25x10^9$ m^3, a mean depth of 7.1 m and a maximum depth of 13.1 m.

Lake Abaya has a red colour resulting from the colloidal suspended ferric oxide particles introduced by most of its tributaries which empty into it, particularly the largest river entering it, River Bilate which drains areas of red clay soil rich in iron from Wolaita and Kambata regions. The lake contains 420mg/m³ dissolved phosphorus, 390 mg/m³ nitrogen and 260 mg/m³ ammonia. The conductivity of the water is found to be 698 μs (Kirubel Tesfaye, 1985).

4.1.4.2. Rivers and Streams

There are a few rivers in the NNP. The two major rivers are Sarmelle and Kulfo. River Sermale is one of the permanent sources of water for the wildlife of the Park and livestock of the surrounding Guji people. It flows in the southerly direction along the eastern most corner of the Park. It joins the Meo River which flows out from Lake Chamo to form the Segen River which drains into Lake Stephanie (Kirubel Tesfaye, 1985).

Another important river in the Park is River Kulfo which has its sources from Gentha Mountain and Lake Abaya. It got its name from the confluence of the outflow of Lake Abaya with the river from Gentha Mountain. This river is also joined by the outflow from the Arbaminch below the town of the Park. Bilate River is the largest of all the rivers joining Lake Abaya and is important in providing water for the wildlife in the Park (Kirubel Tesfaye, 1985).

In addition, the park also possesses what is commonly known as the 'Arbaminch' or literally meaning, Forty Springs, which outflows from the high underground water table water located at the western border side of the Park. The springs flow into the Kulfo River. A small, but, unique groundwater forest has flourished along the course of the same stream. The different water sources of the Park are also known to provide vital support to the different species of wildlife (Matewos Ersado, 1984as cited Kirubel Tesfaye, 1985).

4.1.4.3. Hot spring

The hot springs occur along the eastern border of the Park. The hot spring area is known as 'Tsebel' (or Holy Water) and is believed to have a healing power. People come from near by and far places and camp around the hot springs for days. It is one of the potential tourist attraction sites in the Park.

4.1. 5. Biotic Elements of Nechisar National Park

A. Flora

The Park vegetation is commonly divided into five vegetation types: savanna grassland, grassland with scattered trees and bushes, dense thickets, riverine forest association and Groundwater forest, and aquatic vegetation (Bolton, 1970as cited Kirubel Tesfaye, 1985).

The savanna grassland is the largest habitat of the Park covering an area of 270 km^2. It is found about 30 km east of Arbaminch, where it is situated at an altitude of 1200 m asl. The second largest habitat in the Park is the grassland with scattered trees and bushes and is found evenly distributed throughout the Park. The dense thicket vegetation type is not as extensive as the previous two vegetation types and it is found on the escarpment, steep, rocky slopes and in gullies (Bolton, 1970as cited Kirubel Tesfaye' 1985).

The name Nechisar came from the high dominance of grass species especially by *Ischaemum afrum* which confers the impression of white colour when looked from a distance.

B. Fauna

Because of its geographical isolation and wide variety of ecological environments, the Park harbors a variety of mammalian, avian, amphibian, reptilian and fish fauna

(African Parks Conservation 2006 report, 2006). The mammalian fauna of the Park belongs to 10 orders, 27 families and 84 species of which 4 species are endemic. One of the endemic mammalian sub-species of the park is the Swayne's hartebeest, *Alcelaphus buselaphus swaynei*. NNP is also known for its large population of Burchellis Zebra, *Equus burchellii*, which is now named as plains zebra (Kirubel Tesfaye, 1985, Yisehak Doku *et al.*, 2006).

The high population of crocodiles and the Nile perch are unique to the waters of Lake Abaya and Chamo. The Species diversity of mammals is very impressive. Mammalian diversity is next to the Mago National Park (EPA, 2005). Large mammals currently present are the common Zebra, Swayne`s Hartebeest, Grant`s gazelle, Greater kudu, Guenther`s dikdik, Anubis baboon, Colobus monkey, and Hippopotamus. Spotted hyaena, Mountain reedbuck, Black-backed jackal, Side-striped jackal, Golden jackal, Defassa waterbuck, Bushbuck, Klipspringer, Warthog, Bush pig and Lions occur. Nechisar is particularly important as a sanctuary for Swayne`s Hartebeest, that is endemic to the country and survives in three isolated populations in Ethiopia, with a total population not exceeding 250 individuals (African Parks Conservation, 2006).

The diversity of the rest of the vertebrate fauna of the Park is not very well known. Most of the vertebrate species of the Park are believed to be under threat due to habitat loss and human disturbance.

4.1.6. Socioeconomics

According to the report of the Netherlands Development Organization SNV (2006), ‘Arbaminch Zuria Woreda’ covers an estimated area of 168,172 ha with estimated population of 232,000 of which 50.8% are males and 49.2% are females. The major crops that grow in the area are maize, sorghum, teff and beans. The area is very famous for its fish productivity and fruits like banana, mango, avocado and highland fruits like apples and pears. It is also an important tourist route from Addis Ababa to the southern parts of Ethiopia like Konso, Jinka, Hamer and Omo.

From February 2005, the Park was under the formal management of African Parks (AP) until the end of June 2008, up to the contract got terminated due to some disagreement.

4.2. Materials

The materials that were used for the study are listed below:-

- A stick to catch snakes
- Cotton bags to handle reptiles
- Plastic buckets for pitafalls
- Pieces of metal sheets for cover sheet method
- Flash lamps to search reptiles during night
- Canon digital camera
- Garmin e-trex GPS
- Calipers and spring balances to measure the snout vent length and weight of lizards, respectively
- A thermometer and a hygrometer
- Field guide books
- Books with reptile and insect identification keys
- Microscope

4.3. The study animals

The two species of lizards that were selected to carry out the resource partitioning study in this study were *Lygodactylus keniensis* Parker 1936 and *Mabuya striata* (W. Peters 1844), which occur in sympatry around the Fourty Springs in NNP.

According to the identification on Spawls *et al*., (2002) and the field observation, *L. keniensis* (which belongs to the family Gekkonidae) is a small dwarf gecko with a short head, rounded snout and fairly large eyes with round pupils and distinct eyelids. The body is cylindrical and the toes have a large retractile claw. The tail which can be shed very easily is about half the total length. Its colour is ground grey with a striking black head pattern (Plates 1 and 2).

Plate 1. *Lygodactylus keniensis* (Photo by Fikirte G.S., Oct, 2007.)

 **(a)**  **(b)**

Plate 2. (a) *Lygodactylus keniensis* on a wall about 2 m. above the ground
(b) *L. keniensis* on a tree at 1 m. height
(Photo by Fikirte G.S., Jan., 2008 and April, 2008)

On the other hand, *M. striata* (which belongs to the family Scincidae) is a skink which is usually seen in towns and usually around houses and fences. According to the identification given on Spawls *et al*., (2002) and the observation in the field, it is a medium sized, robust (full-bodied) striped skink with slightly depressed head and body. The tail is just over half the total body length and their colour is brown, olive, or dull green with two cream, yellow or light greenish stripes on its dorsal side, which might fade in some animals. The tip of the snout and the head are reddish; the flanks usually speckled white or yellow, underside cream or white with some grey or black speckling (Plate 3).

Plate 3. *Mabuya striata* lying on the ground (Photo by Fikirte G.S, Oct., 2007)

4.4. Methodology

Four trips were made to the study site, two during the wet (October and April) and two during the dry seasons (January and March) in order to carry out the reptile survey and ecological study.

4.4.1. Survey of Reptiles

Reptiles were surveyed using ‘active search’ (searching under rocks, fallen logs, or any cover material), ‘pitfall trapping’ (setting traps of buckets for the reptiles to get in to) and ‘cover sheet’ (putting pieces of metal sheets in early morning so that reptiles can come and bask on them) methods in order to collect animals representing all the available microhabitats and different patterns of habitat utilization. To maximize detection, surveys targeted appropriate weather conditions and times of days.

All habitat types in the Park were surveyed paying more attention to those most preferred by reptiles. The areas which were considered as ideal places (most preferred habitats) for reptiles were identified through communicating with the local people and then by visiting the areas.

A total of 290 km (on average 9.67 km per day) with an average width of 9m was surveyed out of which 230 km was in the grassland and rocky habitats while the remaining 60 km was in the ground water forest and along the lake shores.

While searching actively, the area was searched thoroughly by turning up fallen logs and rocks or any material under which reptiles might take refuge. Pictures of the reptiles that were encountered were taken whenever possible and effort was made to collect more.

If snakes were encountered, a stick was placed on their head (Plate 4) which was then carefully replaced by fingers and then they were placed in a cotton sac. If chameleons, tortoises, skinks and geckos were encountered, they were collected directly by hand and put in the cotton sacs. For all collected and pictured reptiles, the location and coordinates were taken by GPS. In addition to this, local names of all possible species were collected together with the different myths (if they have any).

Plate 4. A juvenile puff adder (*Bitis arientans*) being collected in the Park. (Photo by Fikirte G.S. March, 2008.)

For the pitfall traps, the researcher used medium sized buckets and they were checked every 6 or 7 hours. If there were any reptiles inside, they were transferred into a sac carefully. Snakes were handled with maximum care.

In the case of cover sheet method a small metal sheet was used as an attractant to reptiles and it was checked three times a day, in early mornings, at mid-days and in late afternoons.

4.4.2. Ecological Study

For the ecological study, the selected site was around the Forty Springs in NNP at N 05° 58.9' longitude and E 037° 33.2' latitude, which was 70 m by 120 m (8,400 m^2). Two sympatrical lizard species (*Lygodactylus keniensis*- a gecko and *Mabuya striata* – a skink) were chosen to carry out resource partitioning study.

Herpetological data sheet (Appendix I) was used to be filled whenever one of the two species were encountered. When a lizard was sighted during a search, the weather condition (sunny, windy, cloudy or rainy) and the habitat type in which they were encountered were recorded. In addition to this, measurements of the structural microhabitat from the point where the lizard was initially sighted were recorded. These measurements included the distance to the nearest vegetation, the height from the ground, the distance to their refuge site and its type.

The temperature and humidity of the area were recorded every hour and every observation was carried out for 150-180 minutes at a time to prevent bias. The time left from the observation was used for the survey.

Individuals from both species (25 from *L. keniensis* and 11 from *M. striata*) were collected and injected with 10% formalin, after being anesthetized by ethanol, in order to identify their stomach contents, at later stages, to reveal the food. In addition to the food niche, temporal and spatial niches were also taken into account. In the laboratory, the following measurements were taken for all individual lizards:

- SVL (snout-vent length):- measured as the length from the snout up to the vent in mm.

- TL (tail length):- measured as the length from the vent up to the tip of the tail in mm.

- HL (head length):- measured as the length from the anterior edge of the ear opening to the tip of the snout in mm (Schoener, 1968 as cited in Sadek, 1992).

- HW (head width):- measured as the horizontal line joining the angles of the jaws in mm.

- HD (head depth):- measured from the vertical plane whose upper edge is measured by the posterior margin of the frontal bones in mm (Schoener, 1969 as cited in Sadek, 1992).

- BW (Body weight): - measured in grams.

In addition to these lizards that were being kept in 10% formalin solution were dissected in order to reveal their stomach contents. Then the prey lengths (in mm) and prey volumes (in ml^3) were measured and the sex of the lizard was also recorded.

4.5. Data analysis

4.5.1. Survey of Reptiles

The collected reptile species were identified by using keys from Largen and Spawls (2006) for lizards and Largen and Rasmussen (1993) for snakes. Websites of IUCN (2007) and Spawls *et al.*, (2002) were used for tortoises, terrapins and crocodiles. In addition to identification, the current status of the reptiles was also assessed by using information from IUCN (2007) and CITES (2008).

Shannon-Weaver Index (Shannon and Weaver, 1949) and Simpson's Index (Simpson, 1949) were used to compute the diversity of the reptiles.

$$H' = \sum P_i \ln P_i$$, Where

H'= Shannon-Weaver index

P_i = the proportion of individuals

ln= natural logarithm

$$D = \frac{\sum n(n-1)}{N(N-1)}$$, Where

D= Simpson's index

N = the total number of organisms of all species

n = total number of organisms of a particular species

Simpson's index (D) (Simpson, 1949) was used to calculate the dominance.

$$D = 1 - \lambda \quad ; \lambda = \sum p_{i^2}$$, Where

D = Simpson's index of dominance

P_i = the proportion of individuals

The evenness was calculated by using the formula:-

$$E = \frac{H'}{H_{max}} \quad ; H_{max} = \ln S$$, where

ln = natural logarithm

S= number of species

The habit of all the reptiles which was recorded was checked with earlier literature. Collections of the Addis Ababa University Zoological Museum were also referred.

The common english names of all the reptiles are referred from Spawls *et al.*, (2002) and the common names in different Ethiopian languages are the ones that are being used in the study area by the local ethnic groups.

The sites where the reptiles were collected (observed) were located on the map of the Park using the co-ordinate readings from the GPS. These maps were done by using ARC-GIS software version 9.1. These maps are given after the respective reptiles. Chi-square test (χ^2) was done, using SPSS (version 13), for comparing the significance in habitat preferences of the different reptiles.

4.5.2. Ecological Study

Data recorded by observation were further analyzed for activity patterns, microhabitats, refuge sites, refuge behaviours and food item selections by both species. The niche breadths (diversity of resource categories used) were estimated using the formula

$$B=\frac{1}{\sum_{i=1}^{n} P_i^2}$$, where P_i is the proportional use of resource category i

This index renders values between 1 (when only one category is used) and n (when n categories are evenly used) (Levins' 1968as cited Njunez *et al.,* 1989).

The niche overlap (similarity in resource use) is estimated by using the formula

$$Ojk=\frac{\sum p_{ij}\, p_{ik}}{\sqrt{\sum P_{ij}^2 \times \sum P_{ik}^2}}$$; where P_{ij} and P_{ik} are the proportion uses of a resource by species j and k. This index renders values between 0 and 1 (between complete dissimilarity and complete similarity in resources used, respectively), and was computed separately for the niche dimensions of microhabitat, time and food (Pianka, 1973 as cited in Núñez *et al.*, 1989, Pianka, 1986 as cited in Rouag *et al*., 2007).

To compare the sizes of the two lizard species, mean comparison of their SNV and BW were computed using SPSS (version 13). The identification of food items to order level was carried out using keys from Elzinga (1978).

5. RESULT

5.1. Survey of Reptiles

During the study period 36 reptilian species were recorded through the present study in Nechisar National Park, out of which 34 species were confirmed and two species were not confirmed (*Typhlops lineolatus* and *Varanus albigularis*). The list of reptilian species with their habitat types is given in Table 1.

The recorded species belonged to three orders (Order: Squamata, Order: Testudines, and Order: Crocodylia). Order Squamata was the most diverse order with 30 species belonging to two suborders. The first suborder, Sauria, comprised 19 species belonging to seven Families and 10 Genera and the second suborder, Serpentes, had 10 species belonging to three Families and 10 Genera. Order Testudines comprised three species belonging to two Families and two Genera. Order Crocodylia comprised only one species. No endemic species was recorded from the study area in the study period.

Table 1. The list of species and their distribution in different habitat types.

Species	Habitat						
	B.L	G.L	R.A	A.E	S.A	GWF	B&T
1. *Coluber florulentus*	+						
2. *Crotaphopeltis hotamboeia*	+	+		+			
3. *Lycophidion capense*	+		+				
4. *Meizodon regularis*	+		+				
5. *Psamophis sibilans*		+	+			+	
6. *Psamophis* sp.	+		+				
7. *Scaphiophis albopunctatus*		+					
8. *Telescopus dhara*							+
9. *Dendroaspis polylepsis*	+						
10. *Naja nigricollis*	+	+					
11. *Bitis arietans*	+	+	+				
12. *Agama agama*			+				+
13. *Agama doriae*			+				
14. *Chameleo gracilis*	+					+	
15. *Gerrhosaurus flavigularis*	+					+	
16. *Hemidactylus brooki*			+				+
17. *Hemidactylus isolepis*							+

Continued . . .

18. *Hemidactylus ruspoli*							+
19. *Hemidactylus somalicus*							+
20. *Lygodactylus keniensis*	+					+	+
21. *Heliabolus spekii*					+		
22. *Latastia longicaudata*					+		
23. *Lygosoma afrum*	+					+	
24. *Mabuya brevicollis*	+		+			+	+
25. *Mabuya maculilabris*	+		+				
26. *Mabuya planifrons*	+			+		+	
27. *Mabuya quinquetaniata*			+				
28. *Mabuya striata*	+		+			+	+
29. Mabuya varia	+		+			+	
30. Varanus niloticus				+		+	
31. Crocodylus *niloticus*				+			
32. *Geochelone paradalis*	+	+					
33. *Geochelone sulcata*	+	+					
34. *Pelomedusa subrufa*				+			

(B.L= Bushland, G.L= Grassland, R.A= Rocky Area, A.E= Aquatic Environment, SA= Sandy Area, GWF= Ground Water Forest and B&T= Buildings and Tents)

The following list is the species of reptiles observed in the study area. The two species marked (*) are not confirmed and need more clarification. The number of encountered specimens and their frequencies are shown in bracket following each species.

A. Snakes

Order Squamata

Family Colubridae

Genus *Coluber* Linnaeus 1758

1. *Coluber florulentus* Geoffroy 1827 (1, 0.19%)

Genus *Crotaphopeltis* Fitzinger 1843

2. *Crotaphopeltis hotamboeia* (Laurenti 1768) (4, 0.76%)

Genus *Lycophidion* Fitzinger 1843

3. *Lycophidion capense* (Smith 1831) (2, 0.38%)

Genus *Meizodon* Fischer 1856

4. *Meizodon regularis* Fischer 1856 (3, 0.57%)

Genus *Psamophis* Boie 1826

5. *Psamophis sibilans* (Linnaeus 1758) (3, 0.57%)
6. *Psamophis* sp. (1, 0.19%)

Genus *Scaphiophis* Peters 1870

7. *Scaphiophis albopunctatus* Peters 1870 (2, 0.38%)

Genus *Telescopus* Wagler 1830

8. *Telescopus dhara* (Forsskal 1775) (3, 0.57%)

Family Elapidae

Genus *Dendroaspis* Schlegel 1848

9. *Dendroaspis polylepsis* Gunther 1864 (3, 0.57%)

Genus *Naja* Laurenti 1768

10. *Naja nigricollis* Reinhardt 1843 (3, 0.57%)

Continued . . .

Family Typhloidae

Genus *Typhlops* Oppel 1811

* 11. *Typhlops lineolatus* Jan 1864

Family Viperidae

Genus *Bitis* Gray 1842

12. *Bitis arietans* (Merrem 1820) (3, 0.57%)

B. Lizards

Order Squamata

Family Agamidae

Genus *Agama* Daudin 1802

13. *Agama agama* (Linnaeus 1758) (42, 8.03%)

14. *Agama doriae* Boulenger 1885 (26, 4.97%)

Family Chamaeleonidae

Genus *Chamaeleo* Laurenti 1768

15. *Chameleo gracilis* Hallowell 1842 (2, 0.38%)

Family Cordylidae

Genus *Gerrhosaurus* Wiegmann 1828

16. *Gerrhosaurus flavigularis* Wiegmann 1828 (2, 0.38%)

Family Gekkonidae

Genus *Hemidactylus* Oken 1817

17. *Hemidactylus brooki* Gray 1845 (28, 5.35%)

18. *Hemidactylus isolepis* Boulenger 1895 (20, 3.82%)

19. *Hemidactylus ruspoli* Boulenger 1896 (26, 4.97%)

20. *Hemidactylus somalicus* Parker 1896 (18, 3.44%)

Genus *Lygodactylus* Gray 1864

21. *Lygodactylus keniensis* Parker 1936 (106, 20.27%)

Continued . . .

Family Lacertidae

Genus *Heliabolus* Fitzinger 1843

22. *Heliabolus spekii* (Gunther 1872) (7, 1.34%)

Genus *Latastia* (Bedriaga 1884)

23. *Latastia longicaudata* (Reuss 1834) (8, 1.53%)

Family Scincidae

Genus *Lygosoma* Hardwicke and Gray 1827

24. *Lygosoma afrum* (W. Peters 1854) (4, 0.76%)

Genus *Mabuya* Fitzinger 1826

25. *Mabuya brevicollis* (Wiegmann 1837) (15, 2.87%)

26. *Mabuya maculilabris* (Gray 1845) (2, 0.38%)

27. *Mabuya planifrons* (W.Peters 1878) (3, 0.57%)

28. *Mabuya quinquetaniata* (Lichtenstein 1823) (20, 3.82%)

29. *Mabuya striata* (W. Peters 1844) (98, 18.74%)

30. *Mabuya varia* (W. Peters 1867) (26, 4.97%)

Family Varanidae

Genus *Varanus* Merrem 1820

* 31. *Varanus albigularis* (Daudin 1802)

32. *Varanus niloticus* (Linnaeus 1766) (15, 2.87%)

C. Crocodiles, Tortoises and terrapins

Order Crocodylia

Family Crocodylidae

Genus Crocodylus

33. Crocodylus *niloticus* (20, 3.82%)

Continued . . .

Order Testudines

Family Testudinidae

Genus *Geochelone* Fitzinger, 1835

34. *Geochelone pardalis* (2, 0.38%)

35. *Geochelone sulcata* (Miller 1779) (2, 0.38%)

Family *Pelomedusidae*- African mud terrapins

Genus *Pelomedusa* Wagler, 1830

36. *Pelomedusa subrufa* Lacépède 1788 (3, 0.57%)

The list of reptilian species with their ecological preference is given in Table 2.

Table 2. List of species and their ecological preference

Species	Food			Habits				Activities		
	I	C	H	SA	A&R	F	A	D	N	C
1. C. florulentus		+		+				+		
2. *C. hotamboeia*		+		+		+		+	+	
3. *L. capense*		+				+		+		
4. M. regularis		+		+				+		
5. *P. sibilans*		+			+	+		+		+
6. *Psamophis* sp.		+		+	+					
7. *S. albopunctatus*		+		+	+				+	
8. *T. dhara*		+			+				+	
9. *D. polylepsis*		+		+	+			+		
10. *N. nigricollis*		+		+	+			+		
11. *B. arietans*		+		+	+	+		+		
12. *A. agama*	+			+	+					
13. *A. doriae*	+			+	+			+		
14. *C. gracilis*	+				+			+		+
15. *G. flavigularis*	+					+		+		
16. *H. brooki*	+			+	+			+	+	

Continued . . .

17. *H. isolepis*	+			+	+				+	
18. *H. ruspoli*	+			+	+			+	+	
19. *H. somalicus*	+			+	+				+	
20. *L. keniensis*	+			+	+			+	+	+
21. *H. spekii*	+			+				+		
22. *L. longicaudata*	+			+				+		
23. *L. afrum*	+					+		+		
24. *M. brevicollis*	+			+	+	+		+	+	
25. *M. maculilabris*	+			+				+		
26. *M. planiforons*	+				+			+		
27. *M. quinquetaniata*	+			+	+			+		
28. *M. striata*	+			+				+		
29. *M. varia*	+			+	+			+		
30. *V. niloticus*		+			+		+	+		
31. *C. niloticus*		+					+	+	+	
32. *G. paradalis*			+	+	+			+		
33. *G. sulcata*			+	+	+			+		
34. *P. subrufa*		+					+	+		

[Food (I= Insectivorous, C= Carnivorous and H= Herbivorous), habits (SA= Surface Active, A&E= Arboreal and Rocky places, F= Fossorial and A= Aquatic) and time of activity (D= diurnal, N= nocturnal and C= crepuscular)].

Thirty species from the order Squamata (498 individuals), three species from Order Testudines (seven individuals) and one species of Order Crocodylia (20 individuals) were observed in the study area. The order Squamata is the highest in species richness and diversity followed by the orders Testudines and Crocodylia while its evenness is computed to be lower than all. Order Crocodylia appeared to have the highest evenness value owing it to the fact that it has only one species member (Table 3).

Table 3. Diversity indices for the orders of the reptiles encountered in the study area.

Parameters	Snakes and lizards (Squamata)	Tortoises and terrapins (Testudines)	Crocodiles (Crocodylia)
No. of species	30	3	1
Individuals	496	7	20
Dominance (D)	0.11	0.35	1
Shannon- Weaver (H’)	2.65	1.08	0
Simpson’s index	0.89	0.65	0
Evenness (E)	0.46	0.98	1

The relative abundance is for Order Squamata is 94.84% (for Suborder 5.7% Serpentes and for Suborder Sauria 89.14%); 1.34% for Testudines and 3.82% for Crocodylia.

All the available data that were witnessed while observing the reptiles, their available pictures, the different myths about the reptiles in the study area and the distribution map of the respective reptile are given below.

A. Snakes

1. *Coluber florulentus*(Flowered Racer)

Local names in different Ethiopian languages- Amharic- እባብ ('*Ebab*'); Gamo-ሾሻ ('*Shosha*'); Kore- ሾሼ ('*Shoshe*'); Oromifa- ቦፋ ('*Bofa*') [These local names in different Ethiopian languages are the same for the species listed upto no. 12].

The distribution of this species recorded during the present study is shown in Fig. 3.

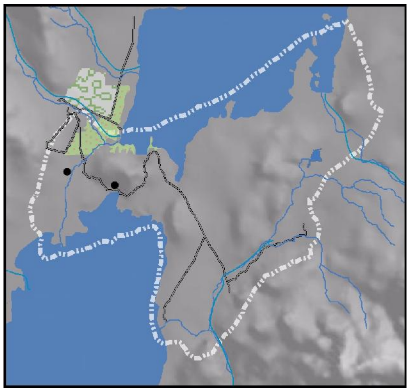


Figure 3. Distribution map of C. florulentus in the present study area.

2. *Crotaphopeltis hotamboeia* (White-lipped snake; Herald snake – in South Africa) (Plate 5).

The distribution of this species recorded during the present study is shown in Fig. 4.

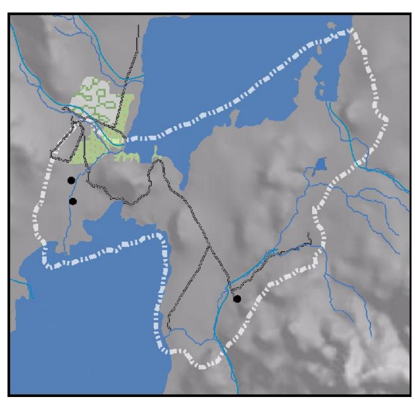


Plate 5. *C. hotamboea* (Photo by Fikirte G.S. Oct., 2007)

Figure 4. Distribution map of C. hotamboeia in the present study area.

This species was always encountered during the night around water bodies (around Lake Chamo and the Forty Springs). It was also observed feeding on amphibians. During the day time, it hides under rocks or any cover material. The species was seen moving away from people quickly but when there was no way out, it tried to strike but missed.

3. *Lycophidion capense* (Cape Wolf snake)

The distribution of this species recorded during the present study is shown in Fig. 5.

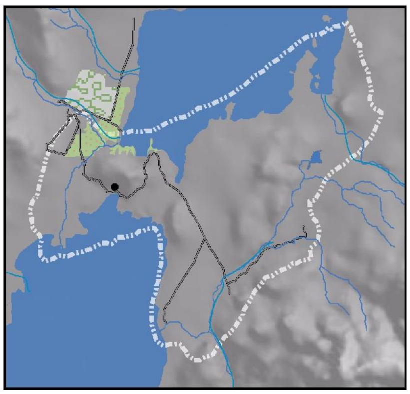
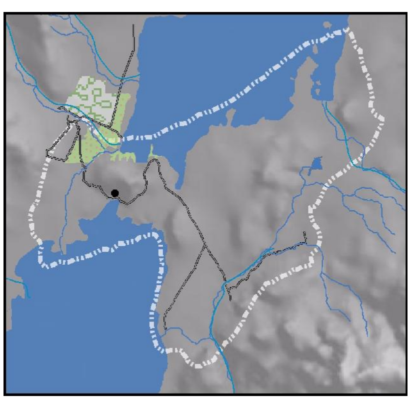


Figure 5. Distribution map of *L. capense* in the present study area.

4. *Meizodon regularis* (Eastern crowned snake)

The distribution of this species recorded during the present study is shown in Fig. 6.



This species was collected from a rocky area in a bushland habitat in the current study.

Figure 6. Distribution map of *M. regularis* in the present study area.

5. *Psamophis* sp.

The distribution of this species recorded during the present study is shown in Fig. 7.

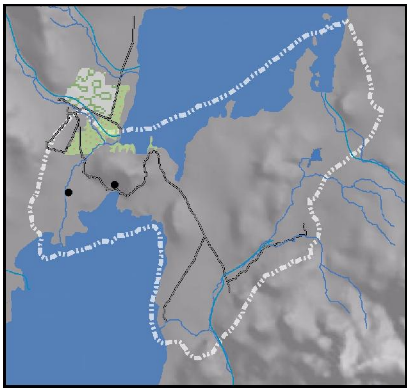


Figure 7. Distribution map of *Psamophis* sp. in the present study area.

6. *Psamophis sibilans* (Short snouted grass snake) (Plate 6).

The distribution of this species recorded during the present study is shown in Fig. 8.

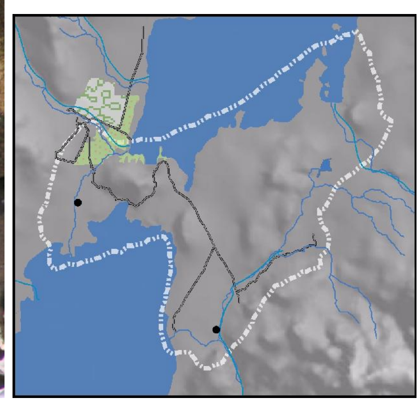


Plate 6. *P.sibilans* (Photo by Fikirte G.S. March 2008.)

Figure 8. Distribution map of *P. sibilans* in the present study area.

7. *Scaphiophis albopunctatus* (Grey beaked snake)

The distribution of this species recorded during the present study is shown in Fig. 9.

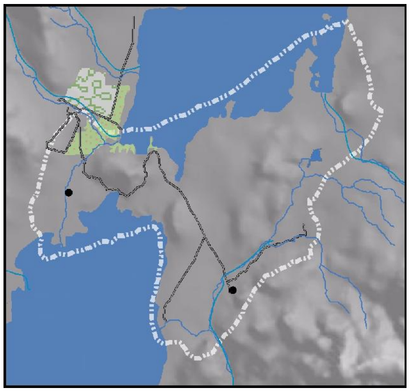


Figure 9. Distribution map of *S. albopunctatus* in the present study area.

8. *Telescopus dhara* (Large eyed cat snake)

It was collected in the ground water forest at night on a building at about 1.5m. It was also observed inside a building resting on the roof (about 4 m from the ground) during day time.

The distribution of this species recorded during the present study is shown in Fig. 10.

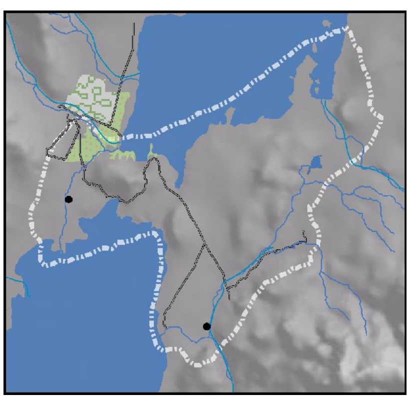


Figure 10. Distribution map of *T. dhara* in the present study area.

9. *Dendroaspis polylepsis* (Black mamba)

The distribution of this species recorded during the present study is shown in Fig. 11.

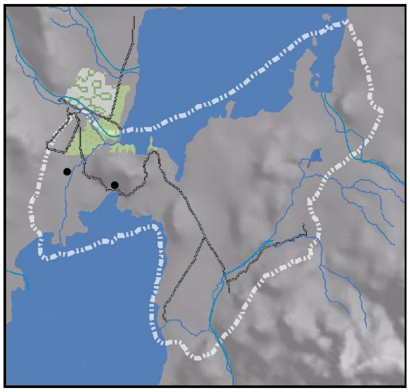


Figure 11. Distribution map of *D. polylepsis* in the present study area.

10. *Naja nigricollis* (Black-necked spitting Cobra)

This species was observed in bushland and grassland habitats of the study area.

The distribution of this species recorded during the present study is shown in Fig. 12.

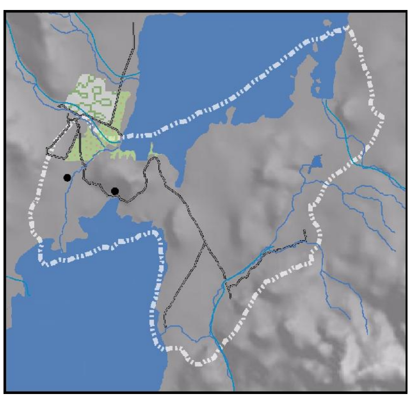


Figure 12. Distribution map of *N. nigricollis* in the present study area.

11. *Bitis arietans* (Puff adder) (Plate 7)

Local names in different Ethiopian languages- Amharic- **እፉኝት** ('*Efugnit*'); Gamo- **ሾሻ** ('*Shosha*'); Kore- **ሾሼ**('*Shoshe*'); Oromifa- **ቦፋ**('*Bofa*')

A juvenile specimen was collected from the study area from under a rock in a bushland habitat.

The distribution of this species recorded during the present study is shown in Fig. 13.

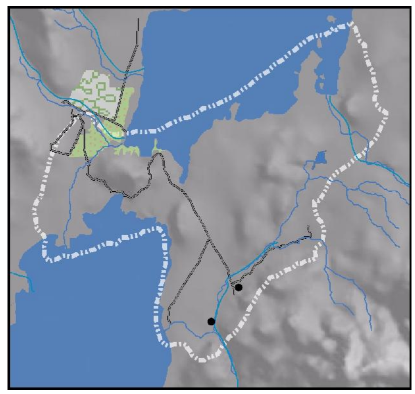


Plate 7. *Bitis arietans* (Photo by Fikirte G.S. April, 2008)

Figure 13. Distribution map of *B. arietans* in the present study area.

B. Lizards

12. *Agama agama* (Red-headed rock agama) (Plate 8 (a) and (b))

Local names in different Ethiopian languages- Amharic- ገበሎ ('*Gebelo*'); Gamo- ዘሬ('*Zere*'); Kore- **ዛርቅሌ** ('*Zarkile*'); Oromifa- ሎቱ ('*Lotu*')

The distribution of this species recorded during the present study is shown in Fig. 14.

(a) (b)

Plate 8. (a) A. *agama* female

(b) *A. agama* male (Photo by Fikirte G.S. Jan. 2008.)

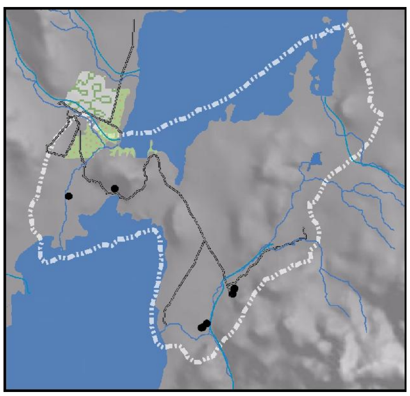


Figure 14. Distribution map of *A. agama* in the present study area

This species was usually observed in areas with rock outcrops but sometimes it was also encountered in areas with big trees. Most matured males in the study area were observed to have yellow or orange heads. It was seen in many parts of the study area. It was found widely distributed in the vicinity and around the Park area on rock outcrops, fences or other suitable places.

13. *A. doriae* (Plate 9)

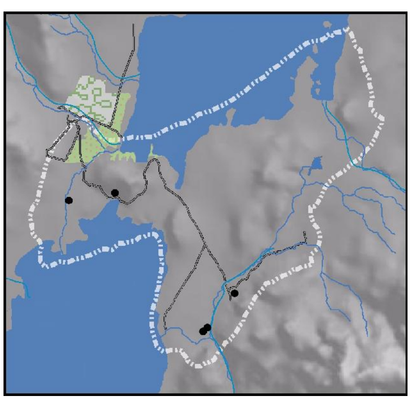
Local names in different Ethiopian languages- Amharic- ገበሎ (‘*Gebelo*’); Gamo- ዘሬ(‘*Zere*’); Kore- **ዛርቅሌ** (‘*Zarkile*’); Oromifa- ሎቱ (‘*Lotu*’)

The distribution of this species recorded during the present study is shown in Fig. 15.

(a) **(b)**

Plate 9. (a) *A. doriae* on a rock outcrop

(b) *A. doriae* crossing a road. (Photo by Fikirte G.S. March, 2008)



It was usually encountered in areas with rock outcrops. It was also encountered many times crossing roads.

Figure 15. Distribution map of *A. doriae* in the present study area

14. *Chameleo gracilis* (Slender or graceful chameleon) (Plate 10)

Local names in different Ethiopian languages- Amharic- **እስስት** ('*Esisit*'); Kore- ጎፑሬሴ ('*Gopurese*'); Oromifa- ጋረረ('*Garera*')

This species was found in places where there are trees, bushes and thickets. It was also encountered crossing roads in early mornings. The distribution of this species recorded during the present study is shown in Fig. 16.

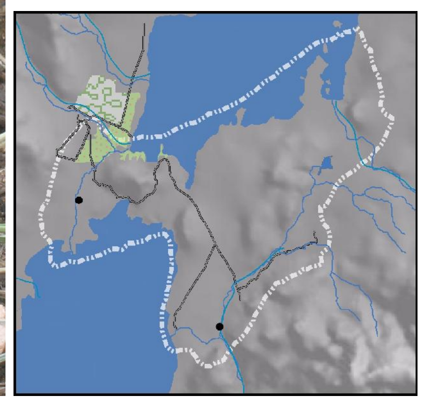


Plate 10. *Chameleo gracilis* crossing a road in the Park. (Photo by Fikirte G.S. Oct. 2007).

Figure 16. Distribution map of *C. gracilis* in the present study area

There exists a myth in the study area that this species is very poisonous and it is from this chameleon that snakes have learnt to have venom. In almost all parts of Ethiopia, a person who does not keep his word or betrays others when ever situations change is called an "*Esist*" after this reptile's , special ability to change its skin colour to escape danger.

15. *Gerrhosaurus flavigularis* (Yellow-throated plated lizard)

Local names in different Ethiopian languages- Amharic- እንሽላሊት (‘*Enishlalit*’); Gamo- ዘሬ (‘*Zere*’); Kore- ዛርቅሌ (‘*Zarkile*’); Oromifa- ሎቱ (‘*Lotu*’)

It was collected from a burrow in the ground water forest. The distribution of this species recorded during the present study is shown in Fig. 17.

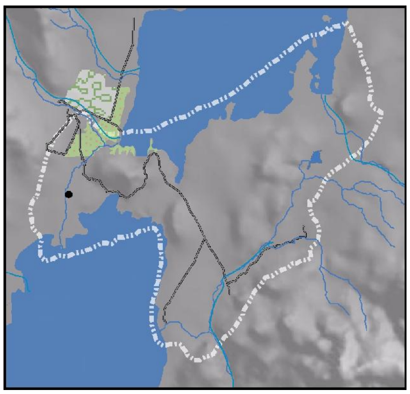
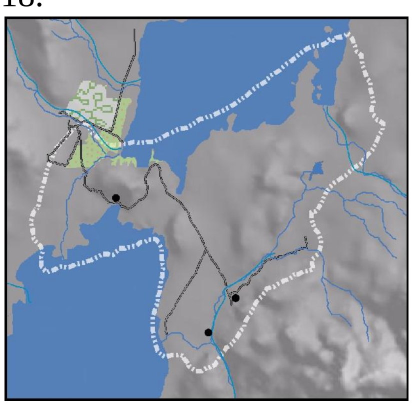


Figure 17. Distribution map of *G. flavigularis* in the present study area

16. *Hemidactylus brooki* (Brook’s Gecko)

Local names in different Ethiopian languages- Amharic- ኮርች (‘*Korch*’); Kore- ቆሪጫ (‘Koricha’); Oromifa- ቃሪጮ (‘*Karicho*’)

The distribution of this species recorded during the present study is shown in Fig. 18.



It was encountered in many parts of the study area and it was also observed that their numbers increased in areas where there were buildings and tents.

Figure 18. Distribution map of *H. brooki* in the present study area

17. *Hemidactylus isolepis*(Uniform-scaled Gecko) (Plate 11)

Local names in different Ethiopian languages- Amharic- **ላሽ** (‘Lash’); Kore- **ላሽ** (‘Lash’); Gamo- **ላሽ** (‘Lash’); Oromifa- **ቃሪቾ** (‘*Karicho*’)

This gecko was encountered under rocks in day time and but at nights it was also observed on and inside buildings at some height from the ground, around the springs.

The distribution of this species recorded during the present study is shown in Fig. 19.

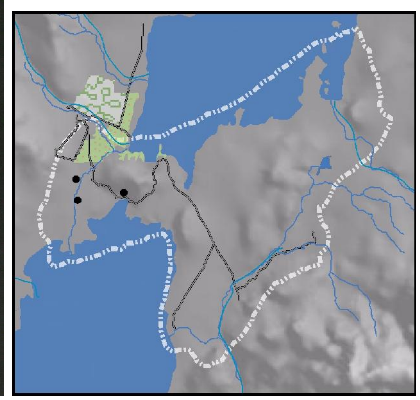


Plate 11. *H. isolepis* on a building at night. (Photo by Fikirte G.S. Jan. 2008)

Figure 19. Distribution map of *H. isolepis* in the present study area

The people around the study area believe that this species licks the hair of people during the night and makes them bald and for this reason it is named in their local language by the ‘disease’ it is thought to cause to people - ‘*lash’*.

18. *Hemidactylus ruspoli* (Prince Ruspoli’s Gecko) (Plate 12)

Local names in different Ethiopian languages- Amharic- ኮርች (‘*Korch*’); Kore- **ቆሪጫ** (‘Koricha’); Oromifa- **ቃሪቾ** (‘*Karicho*’)

It was found in bushland areas and also on buildings during the current study. The distribution of this species recorded during the present study is shown in Fig. 20.

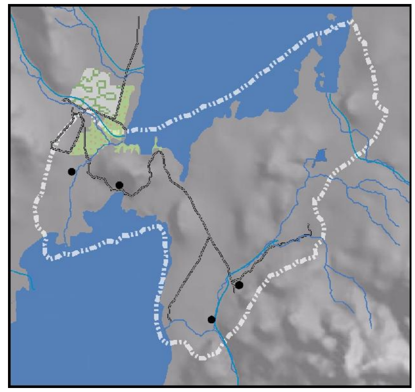


Plate 12. *H. ruspoli* on a building around the hot springs. (Photo by Fikirte G.S. Oct. 2007).

Figure 20. Distribution map of *H. ruspoli* in the present study area

19. *Hemidactylus somalicus*

Local names in different Ethiopian languages- Amharic- ኮርች ('*Korch*'); Kore- ቆሪጫ ('Koricha'); Oromifa- ቃሪጮ ('*Karicho*')

The distribution of this species recorded during the present study is shown in Fig. 21.

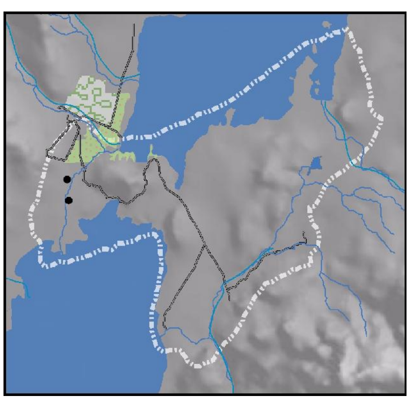


Figure 21. Distribution map of *H. somalicus* in the present study area

20. *Lygodactylus keniensis* (Kenya Dwarf Gecko) (Plate 13(a) and (b))

Local names in different Ethiopian languages- Amharic- ኮርች (‘*Korch*’); Kore- **ቆሪጫ** (‘Koricha’); Oromifa- **ቃሪጮ** (‘*Karicho*’)

This species is very common during day, but it can also be encountered during the night though with low frequency than the day. The ventral surface is yellow. The distribution of this species recorded during the present study is shown in Fig. 22.

(a)

(b)

Plate 13 (a) *L. keniensis* on a building waiting to feed upon a fly.

(b) Under side of *L. keniensis* (Photo taken by Fikirte G.S. Jan. and April 2008).

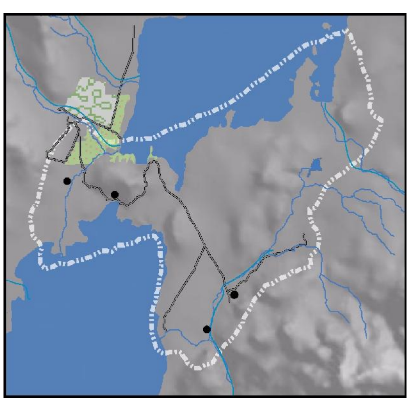


Figure 22. Distribution map of *L. keniensis* in the present study area

21. *Heliabolus spekii* (Speke's Sand Lizard) (Plate 14)

Local names in different Ethiopian languages- Amharic- **እንሽላሊት** ('*Enishlalit*'); Gamo- **ዘሬ** ('*Zere*'); Kore- **ዛርቅሌ** ('*Zarkile*'); Oromifa- ሎቱ ('*Lotu*')

The distribution of this species recorded during the present study is shown in Fig. 23.

[The local names are the same upto species no. 29]

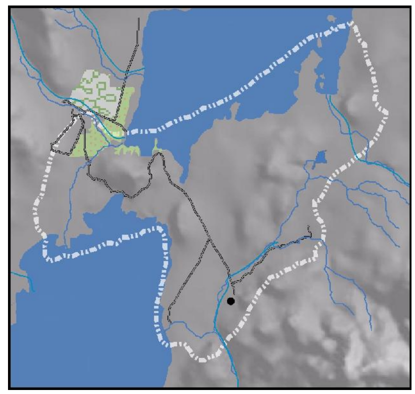


Plate 14. *H. spekii* in a sandy habitat. (Photo by Fikirte G.S. April 2008).

Figure 23. Distribution map of *H. spekii* in the present study area

22. *Latastia longicaudata* (Southern long-tailed Lizard) (Plate 15 (a) and(b))

The distribution of this species recorded during the present study is shown in Fig. 24.

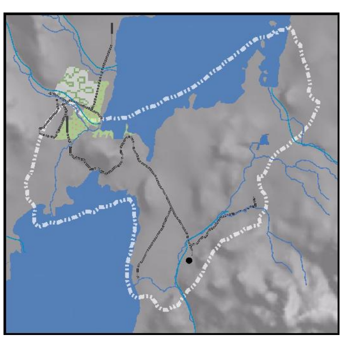


Figure 24. Distribution map of *L. longicaudata* in the present study area

(a) **(b)**

Plate 15 (a) and (b) *L. longicaudatas* found dead in the study area. (Photo by Fikirte G.S. March 2008).

23. *Lygosoma afrum* (Peter's Writhing Skink) (Plate 16)

It was collected from under rocks or cover materials in the ground water forest and in bushland habitats. The distribution of this species recorded during the present study is shown in Fig. 25.

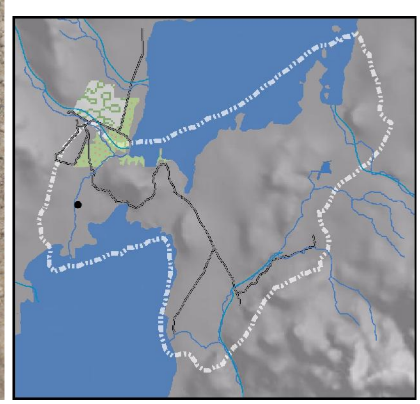


Plate 16. *Lygosoma afrum* (Photo by Fikirte G.S. Oct. 2007)

Figure 25. Distribution map of *L. afrum* in the present study area

24. *Mabuya brevicollis* (Short-necked skink) (Plate 17)

It was observed mostly in bushlands. It was also collected from inside buildings while moving under mattresses or from inside sleeping bags during the night. During the day, it was observed to hide in burrows and crevices whenever there was a slight movement. It was also observed that this species showed a relatively higher tendency to a metal sheet which was lying on the ground in early mornings than the rest of the species in the same locality.

The distribution of this species recorded during the present study is shown in Fig. 26.

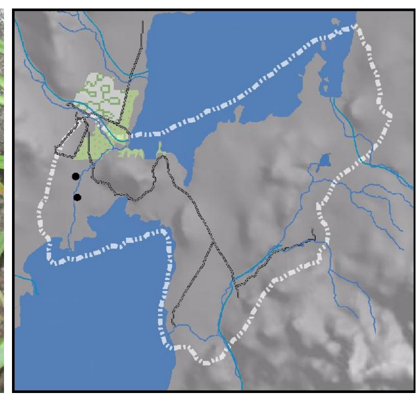


Plate 17. *M. brevicollis* male (Photo by Fikirte G.S. March, 2008)

Figure 26. Distribution map of *M. brevicollis* in the present study area

25. *Mabuya maculilabris* (Speckle-lipped skink) (Plate 18)

The distribution of this species recorded during the present study is shown in Fig. 27.

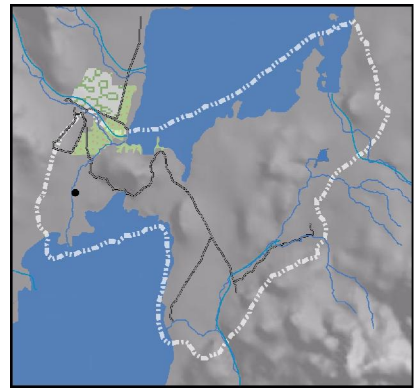


Plate 18. *M. maculilabris* in the ground water forest habitat. (Photo by Fikirte G.S. April 2008).

Figure 27. Distribution map of *M. maculilabris* in the present study area

26. *Mabuya planifrons* (Tree skink) (Plate 19)

The distribution of this species recorded during the present study is shown in Fig. 28.

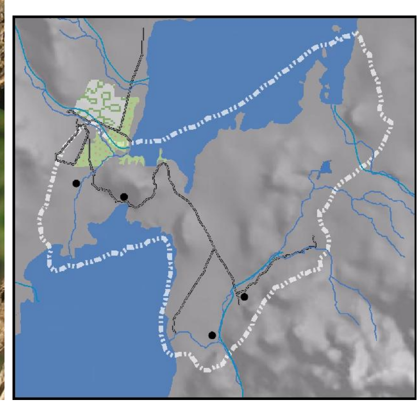


Plate 19. *M. planiforons* lying on a tree around L. Chamo (Photo by Fikirte G.S. Jan. 2008).

Figure 28. Distribution map of *M. planiforons* in the present study area.

27. *Mabuya quinquetaniata* (Five- lined skink) (Plate 20)

It was always observed on rock outcrops and it is found in many areas in the Park. It lived inside buildings, gardens and urban areas. This species prefers rocky areas or equivalent human made substitutes.

The distribution of this species recorded during the present study is shown in Fig. 29.

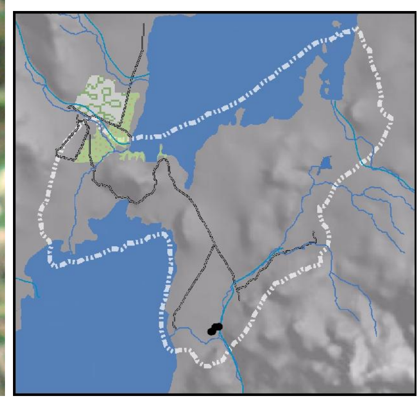


Plate 20. *M. quinquetaniata* male (Photo by Fikirte G.S. Oct. 2007).

Figure 29. Distribution map of *M. quinquetaniata* in the present study area.

28. *Mabuya striata* (Striped skink (Plate 21)

It was observed in many parts of the study area where there are rocks and was common around and inside buildings. The distribution of this species recorded during the present study is shown in Fig. 30.

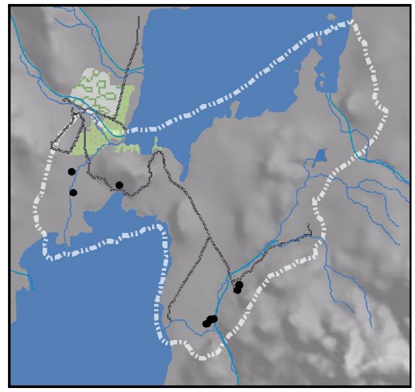


Plate 21. *M. striata* (Photo by Fikirte G.S. Oct. 2007)

Figure 30. Distribution map of *M. striata* in the present study area.

29. *Mabuya varia* (Variable skink (Plate 22)

The distribution of this species recorded during the present study is shown in Fig. 31.

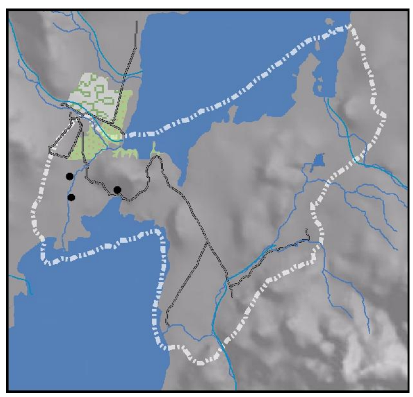


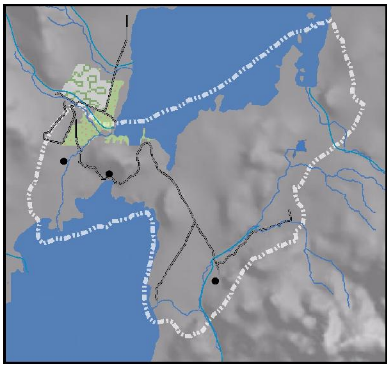
Plate 22. *M. varia* lying on a rock. (Photo by Fikirte G.S. March 2008)

Figure 31. Distribution map of *M. varia* in the present study area.

30. *Varanus niloticus* (Nile monitor)

Local names in different Ethiopian languages- Amharic- አርጃኖ ('*Arjano*'); Gamo- ጃሮ ('*Jaro*'); Kore- ጃሮ ('*Jaro*'); Oromifa- ቦፋ ('*Bofa*')

Distribution of this species recorded during the present study is shown in Fig. 32.



It is associated with rivers, lakes and similar sources of permanent water.

Figure 32. Distribution map of *V. niloticus* in the present study area.

31. *Geochelone paradalis* (Leopard tortoise (Plate 23 (a) and (b))

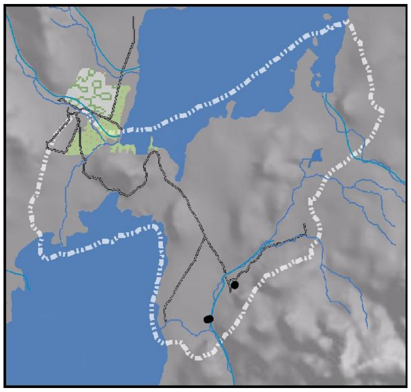
Local names in different Ethiopian languages- Amharic- ኤሊ ('*Elie*')**;** Gamo- ጌጌ ('*Gege*')**;** Kore- ጌጌ ('Gege')**;** Oromifa- ቆጫ('Kocha')

Distribution of this species recorded during the present study is shown in Fig. 33.

(a) **(b)**

Plate 23 (a). *G. paradalis* collected from a bushland

(b). The underside of *G. paradalis* (Photo by Fikirte G.S. Oct. 2007)



The people living around the study area believe that a tortoise’s urine will cause cancer due to this reason, mostly, they try to avoid contacts with a tortoise.

Figure 33. Distribution map of *G. paradalis* in the present study area.

32. *Geochelone sulcata* (African Spurred tortoise, Grooved tortoise) (Plate 24 (a) and (b))

Local names in different Ethiopian languages- Amharic- ኤሊ (‘*Elie*’)**;** Gamo- ጌጌ (‘*Gege*’)**;** Kore- ጌጌ (‘Gege’)**;** Oromifa- ቆጫ (‘Kocha’)

It was observed that both tortoise species excreted (both urine and droppings) right away when they were handled or touched by people. But *G. paradilis* species lived with humans for about 4 months does not do that anymore

The distribution of this species recorded during the present study is shown in Fig. 34.

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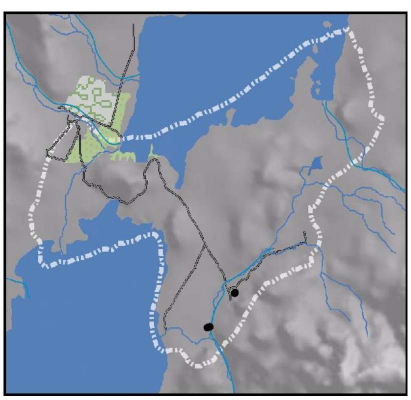


Figure 34. Distribution map of *G.sulcata* in the present study area.

(a) **(b)**

Plate 24. (a) *Geochelone sulcata* from a bushland habitat

(b) The underside of *G. sulcata*. (Photo by Fikirte G.S. Oct. 2007)

33. *Pelomedusa subrufa* (Helmeted Turtles) (Plate 25 (a) and (b))

Local names in different Ethiopian languages- Amharic- ኤሊ (‘*Elie*’)**;** Gamo- ጌጌ (‘*Gege*’)**;** Kore- ጌጌ (‘Gege’)**;** Oromifa- ቆጫ(‘Kocha’)

The distribution of this species recorded during the present study is shown in Fig. 35.

Plate 25 (a) *P. subrufa* collected from stagnant water around Lake Chamo

(b) The underside of *P. subrufa* (Photo by Fikirte G.S. Oct. 2007)

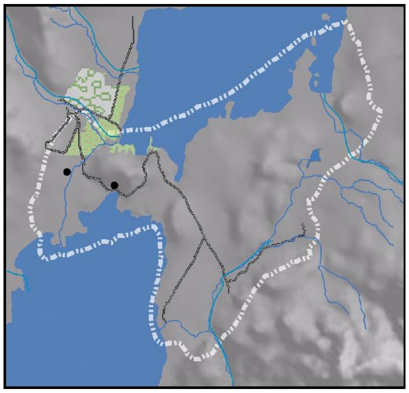


Figure 35. Distribution map of *P. subrufa* in the present study area.

34. *Crocodylus niloticus* (*Nile crocodile*) (Plate 26)

Local names in Amharic- ኣዞ ('*Azo*')

In Ethiopia it is present in protected areas in most of its distribution range in addition to Arbaminch Crocodile Ranch, which generates more money as an Ex Situ conservation measure.

Inside NNP, there is a place called '*Azo Gebeya'* (Crocodile Market) in Lake Chamo near an island called Gandjulle. As the name indicates, at this site, the crocodiles are seen lying by the shore basking and moving around always.The distribution of this species recorded during the present study is shown in Fig. 36.

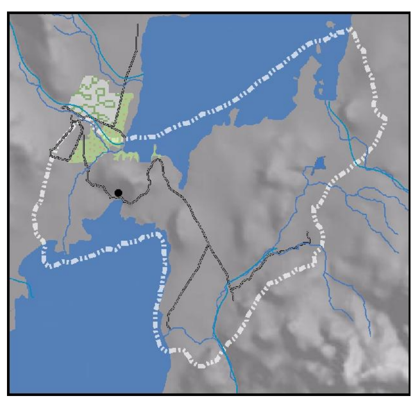


Plate 26. *C. niloticus* lying by the side of Kulfo River (Photo by Fikirte G.S. April 2008)

Figure 36. Distribution map of *C. niloticus* in the present study area.

Table 4 shows that in terms of habitat preference the bushland habitat appeared to be a choice for most of the reptiles encountered in the study period (29.69%) followed by the rocky habitat (20.31%). The ground water forest and buildings and tents were rich in lizards than any of the other reptiles. The occurrence of reptiles in and around aquatic environments and in sandy areas was low (7.81% and 3.13%, respectively). Some of the reptiles were encountered in more than one habitat type.

Table 4. The number of reptiles encountered in each habitat type.

Habitats	No. of reptile species			
	Order Squamata	Order Testudines	Order Crododylia	Total (%)
B.L	17	2	0	19 (29.69%)
GL	5	2	0	7 (10.94%)
RA	13	0	0	13 (20.31%)
A.E	3	1	1	5 (7.81%)
SA	2	0	0	2 (3.13%)
GWF	9	0	0	9 (14.06%)
B&T	9	0	0	9 (14.06%)
Total	58	5	1	64 (100%)

[BL=Bushland, GL= Grassland, RA= Rocky area, AE= Aquatic environment, SA= Sandy area, GWF= Ground water forest and BT=Buildings and tents]

The diversity of reptiles differed among the different habitat types (Table 5). This time the snakes and the lizards are dealt with separately in order to exactly know their habitat preference.

The most preferred habitats of snakes were bushland (38.1%), followed by grassland (23.8%) and the rocky area (23.8%). The chi-square test revealed that the difference among these three habitat types is not significant ($\chi^2 = 1.00$, P= 0.607). The very commonly used habitats of lizards were bushlands (24.32%), the rocky area, ground water forest and buildings and tents, each of them representing (21.62%). But the differences were not significant in all these four types of habitats ($\chi^2 = 0.91$, P=0.993).

In comparing the habitat types the most frequently used ones were the bushland (29.69%) and rocky area (20.31%), but the difference among these habitat types is not significant ($\chi^2 = 1.125$, P= 0.289).

Table 5. Diversity of each habitat type compared with the respective reptilian orders.

Parameters	Habitats						
	BL	GL	RA	AE	SA	GWF	BT
No. of species	19	7	13	5	2	9	9
D	0.81	0.59	1	0.44	1	1	1
H’	0.34	0.59	0	1.95	0	0	0
Simpson’s index	0.19	0.41	0	0.56	0	0	0
E	0.7	0.91	1	0.86	1	1	1

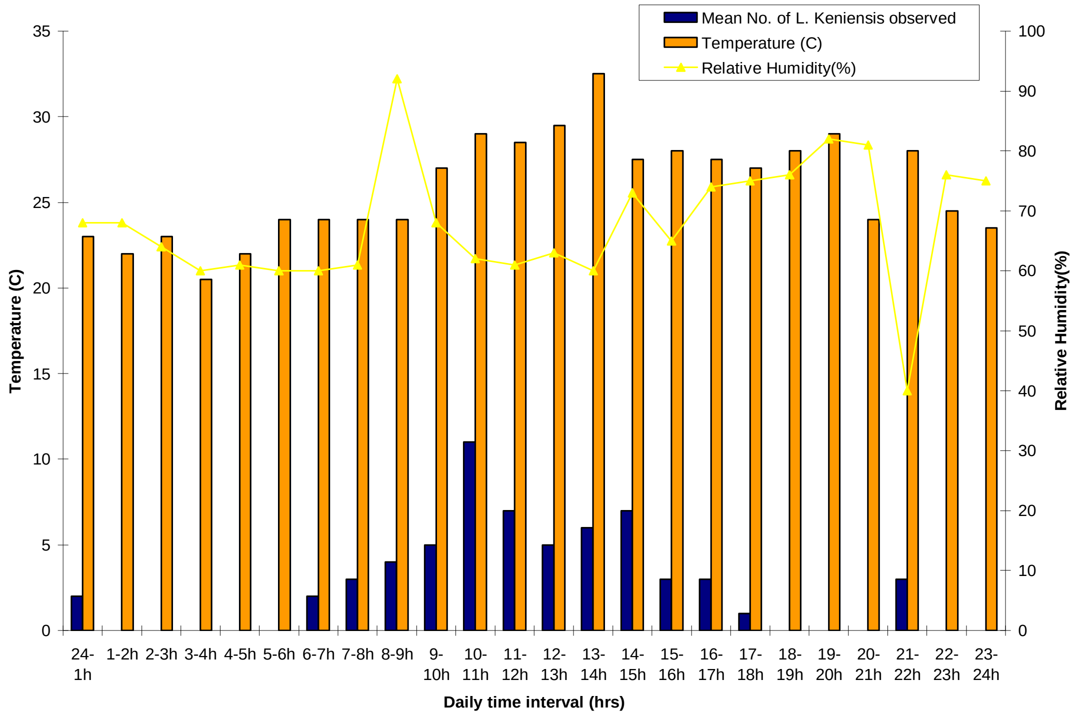
(BL=Bushland, GL= Grassland, RA= Rocky area, AE= Aquatic environment, SA= Sandy area, GWF= Ground water forest and BT=Buildings and tents)

5.2. Ecological Study

Dealing with snout-vent length and body weight the results were (mean SVL = 6.091 ± 0.629 mm; N =11) (mean SVL = 3.116± 0.107mm; N = 25) (*t* = 4.703; P<0.05) and (mean BW =10.43±3.41g; N=11) (mean BW= 1.5±0.12) (t=4.32; P<0.05), respectively for *Mabuya striata* and *Lygodactylus keniensis,* showing that *M. striata* is larger in size and weight than *L. keniensis.*

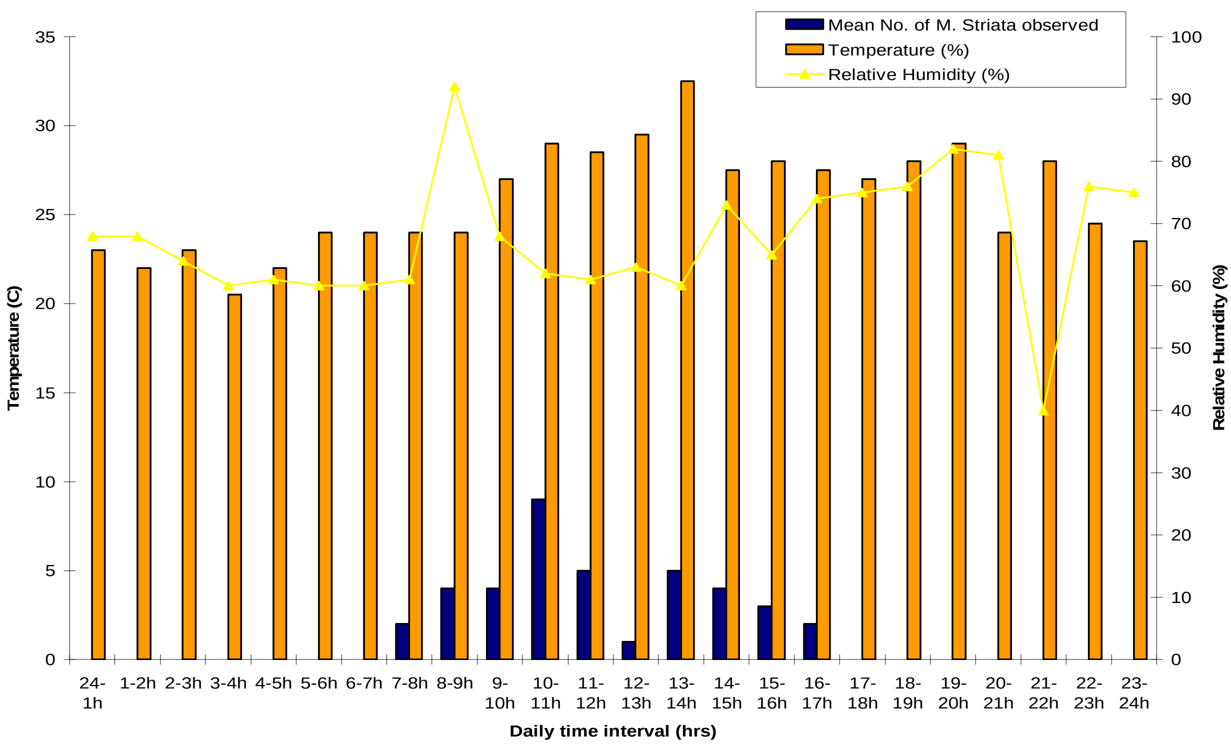
Both species were active almost the whole day, but most activity occurred during mid- morning to late afternoon. The first active *M .striata* was sighted after 8:30 a.m. The number of active lizards increased until reaching a maximum during mid day and after 3:30 p.m., the number of active *M. striata* gradually decreased, ceasing before 5:30 p.m. For *L. keniensis,* the first active individuals were recorded between 7:30 a.m. and 8:00 a.m., with a peak of activity between 10 and 11 a.m. After 5:00 p.m. individuals of *L. keniensis* were rarely observed. Even though *M. striata* is not seen during the night, *L. keniensis* was observed during the night around 10:00-11:00 p.m. and again 2:00- 3:00 a.m. Their activity patterns also differed in different seasons owing to temperature change. The number of individuals decreased during the wet season compared to the dry season as shown in Figure 3 (a), (b), (c) and (d).

(a)



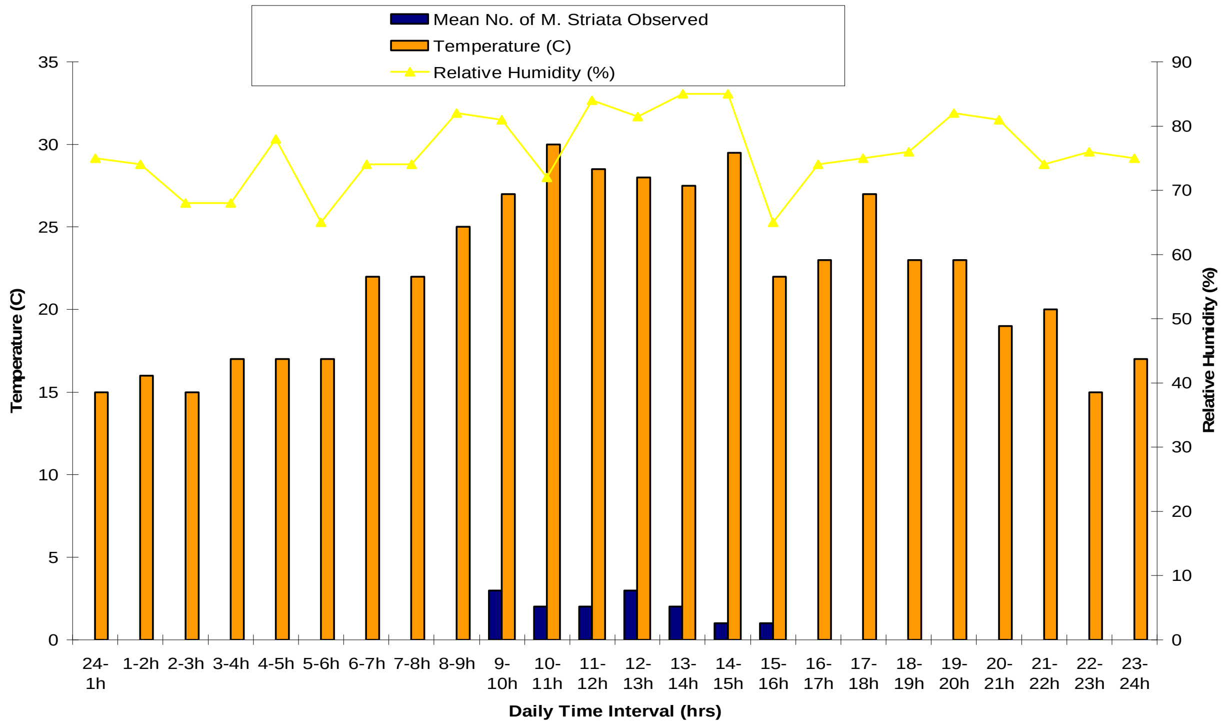
Mean No. of L. Keniensis observed
Temperature (C)
Relative Humidity(%)
Temperature (C)
Relative Humidity(%)
Daily time interval (hrs)
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
24-1h
1-2h
2-3h
3-4h
4-5h
5-6h
6-7h
7-8h
8-9h
9-10h
10-11h
11-12h
12-13h
13-14h
14-15h
15-16h
16-17h
17-18h
18-19h
19-20h
20-21h
21-22h
22-23h
23-24h

(b)



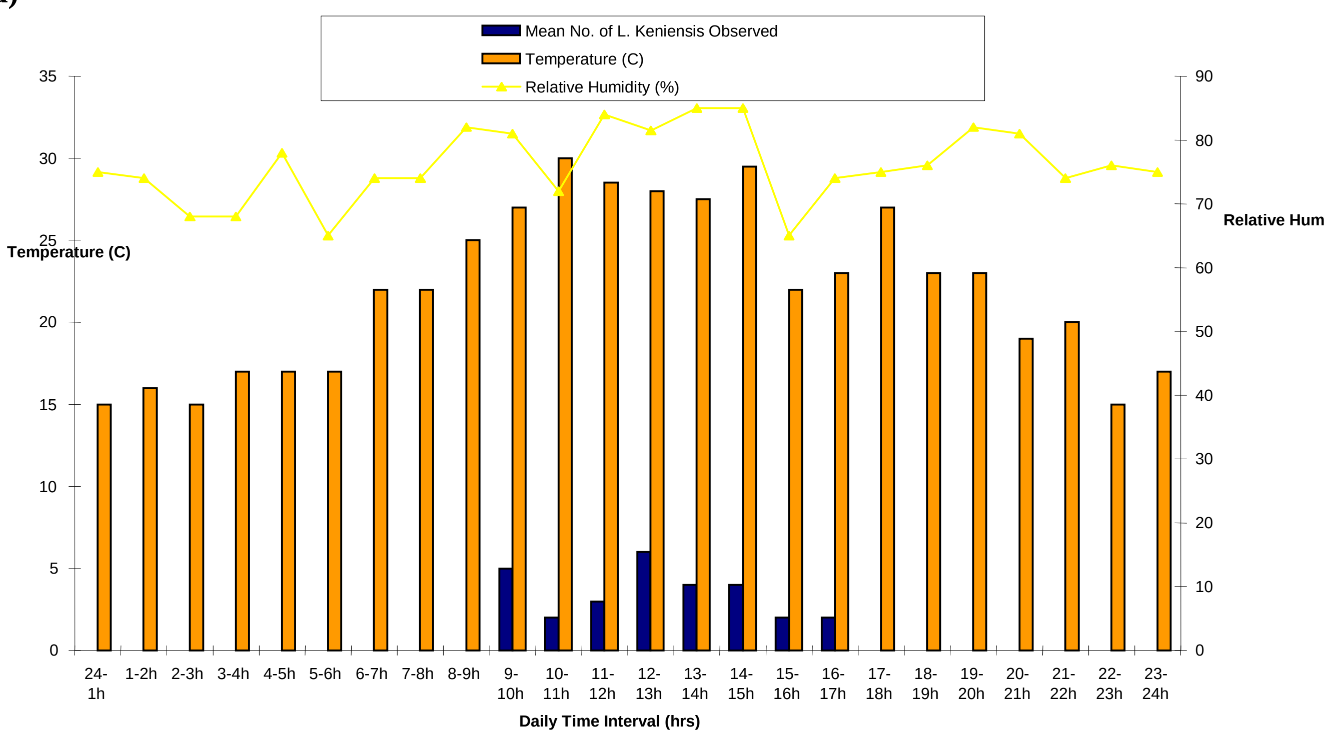
Mean No. of M. Striata observed
Temperature (%)
Relative Humidity (%)
Temperature (C)
Relative Humidity (%)
Daily time interval (hrs)
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
24-1h
1-2h
2-3h
3-4h
4-5h
5-6h
6-7h
7-8h
8-9h
9-10h
10-11h
11-12h
12-13h
13-14h
14-15h
15-16h
16-17h
17-18h
18-19h
19-20h
20-21h
21-22h
22-23h
23-24h

(C)



Mean No. of M. Striata Observed
Temperature (C)
Relative Humidity (%)
Temperature (C)
Relative Humidity (%)
Daily Time Interval (hrs)
24-1h
1-2h
2-3h
3-4h
4-5h
5-6h
6-7h
7-8h
8-9h
9-10h
10-11h
11-12h
12-13h
13-14h
14-15h
15-16h
16-17h
17-18h
18-19h
19-20h
20-21h
21-22h
22-23h
23-24h

(d)



Mean No. of L. Keniensis Observed
Temperature (C)
Relative Humidity (%)
Temperature (C)
Relative Hum
Daily Time Interval (hrs)
24-1h
1-2h
2-3h
3-4h
4-5h
5-6h
6-7h
7-8h
8-9h
9-10h
10-11h
11-12h
12-13h
13-14h
14-15h
15-16h
16-17h
17-18h
18-19h
19-20h
20-21h
21-22h
22-23h
23-24h

Figure 37 (a) and (b). Daily activity patterns (expressed as the mean number of individuals observed per day) *vs.* ambient temperature and relative humidity, of *L. keniensis* and *M. striata* during the dry season, **(c) and (d)** during the wet season.

The temporal niche breadth of M. striata (B*ij* =8.08) was less than that of L. keniensis (B*ij* =10.13) and temporal niche overlap (O*jk*) between them was 0.95 as shown in Table 6.

Table 6. Temporal, food and spatial niche breadth (Bij) and overlap (Ojk) for *M. striata* and *L. keniensis.*

	M. striata	*L. keniensis*	
Niche dimension	Bij	Bij	Ojk
Time	8.08	10.13	0.95
Space (1)	2.03	1.16	0.48
(2)	7.69	6.41	0.14
Food	6.19	2.73	0.02

[In spatial niche dimension, (1) and (2) represent micro habitat selection and height from the ground. Bij = niche breadth, Ojk= niche overlap]

The spatial niche breadths of these species were not significantly different though *M. striata* (*Bij* =2.03 and *Bij*= 7.69) has a higher niche breadth than *L. keniensis* (*Bij* =1.16 and *Bij*= 6.41) in both microhabitat selection and height from the ground. The niche overlaps, however, appear to be very and moderately low (Ojk=0.48 and Ojk=0.14) for microhabitat selection and height from the ground respectively showing that they share microhabitats than heights (Table 6).

The microhabitats used mostly by *M. striata* were rocks on the ground (56.92%) in the dry season and buildings (66.6%) during the wet season while by that of *L. keniensis* were buildings (88.12% and 70.37%) during both dry and wet seasons, respectively. Trees were the second most used microhabitats by *L. keniensis* (8.91% and 11.11% during the dry and wet seasons, respectively). The spatial niche breadth for *M. striata* (*Bij* = 2.028) was greater than that of *L. keniensis (Bij*= 1.157) and the spatial niche overlap among the two species was 0.483.

In addition to this, *M. striata* occurred in heights near the ground level while *L. keniensis* usually preferred higher heights. With regard to height selection in their microhabitats, the niche breadth of *M. striata* (*Bij* = 7.692) was greater than that of *L. keniensis* (*Bij* = 6.410) and their spatial (height) niche overlap (*Ojk*) was 0.138.

In terms of microhabitat selection, the two lizards showed a difference. *L. keniensis* preferred buildings (88.12% and 70.37%) to a higher extent followed by trees (8.91%, and 11.11%) during the dry and wet seasons, respectively. But *M. striata* preferred rocks during the dry season (56.92%) and buildings during the wet season (66.70%). In addition to this, *M. striata* was restricted to two habitat types during the wet season (buildings and rocks) unlike *L. keniensis* which occupied many habitat types except the ground during the wet season (Fig. 4).

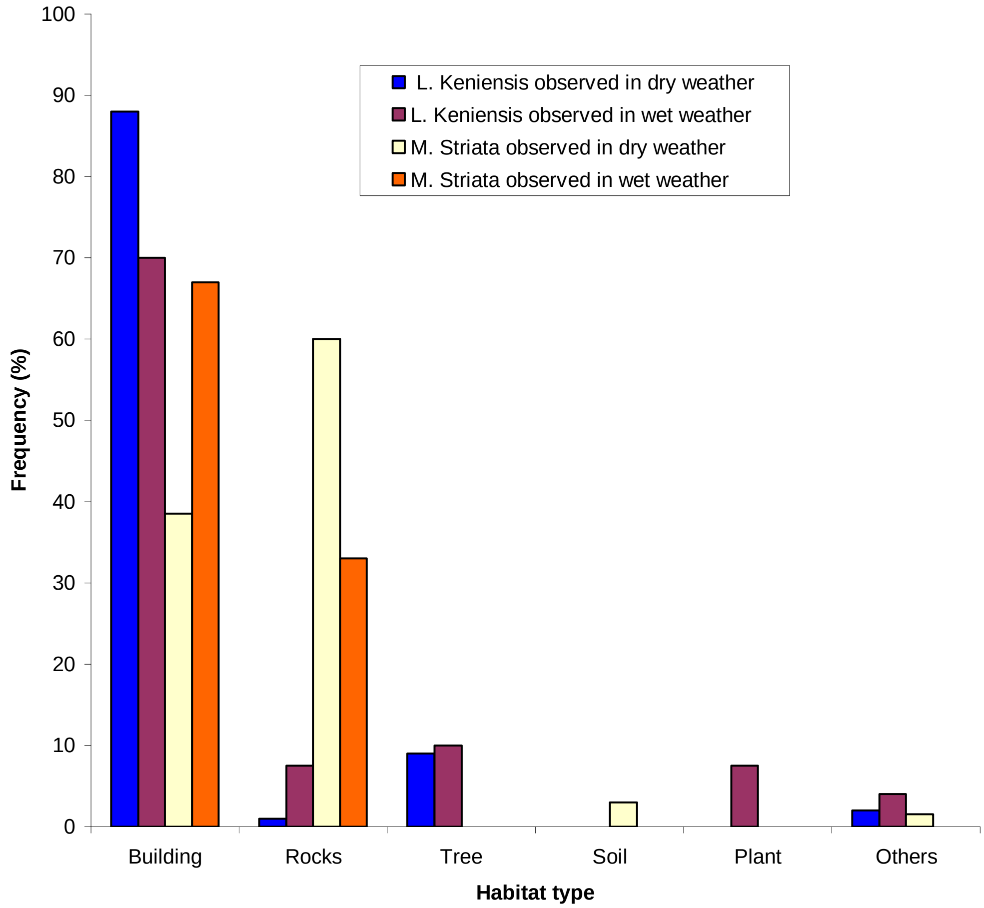


Figure 38. Frequency of the two lizard species at different microhabitats.

Preferred refugee type by the two species also differed (Table 7). *M. striata* preferred holes (43.06%) during the dry season and burrows during the wet season (61.54%), while *L. keniensis* preferred crevices during both dry and wet seasons (63.79% and 72%, respectively).

Table 7. Frequency of lizard species with their preferred refuge type during the dry and wet seasons.

Refuge type	*L. keniensis*		*M. striata*	
	Dry	Wet	Dry	Wet
Crevices	63.79%	72%	15.28%	23.08%
Holes	5.17%	0	43.06%	15.38%
Burrows	1.72%	12%	30.56%	61.54%
Vegetation	15.52%	16%	0	0
Under stone	13.79%	0	11.11%	0

Table 8 shows that the diet of both species was mainly comprised of insects. The most frequent items in the diet of *M. striata* were Orthoptera (32%) and Arachinid (12 %). The main food items of *L. keniensis* consisted of Hymnoptera (56.13%) and Coleoptera (28.13%). In addition to this, there were also pieces of stones (12 %), plant parts (8%), and *L. keniensis* (4%) that were collected from the stomachs of *M. striata* (Table 8). Nematodes were observed in 3 (27.27%) of the Mabuyas. (The food niche breadth of *M. striata* was *(Bij* = 6.19) which was greater than that of *L. keniensis* (*Bij* = 2.73) and the food niche overlap (*Ojk*) between the two species was 0.02 as shown in Table 6)

Table 8. List of the prey items, frequency (%) and volume (%) from the stomachs of the two lizard species.

Prey class	Prey types	*L. keniensis*		*M. striata*	
		No. (%)	vol. %	No. (%)	vol. %
Insecta	Coleoptera	22.50	11.46	6.45	1.53
	Coleoptera (larva)	5.00	2.41	0.00	0.00
	Hymenoptera	42.50	75.49	6.45	3.05
	Diptera	0.00	0.00	3.23	3.05
	Orthoptera	2.50	1.21	25.80	15.27
	Dermaptera	0.00	0.00	3.23	0.76
	Odonata	0.00	0.00	6.45	1.53
	Isoptera	2.50	1.21	0.00	0.00
	Lepidoptera	2.50	1.21	0.00	0.00
	Hemiptera	2.50	2.41	0.00	0.00
Arachnid (spiders)		0.00	0.00	9.68	6.11
Pieces of stone		0.00	0.00	12.90	3.44
Plant parts		0.00	0.00	6.45	0.76
Nematodes		0.00	0.00	9.68	3.44
L. keniensis		0.00	0.00	3.23	58.71
Digested food		20.00	4.60	6.45	2.36

The two lizards differed in the size and volume of prey items. *M. striata* consumed larger preys than *L. keniensis* (Figure 5).

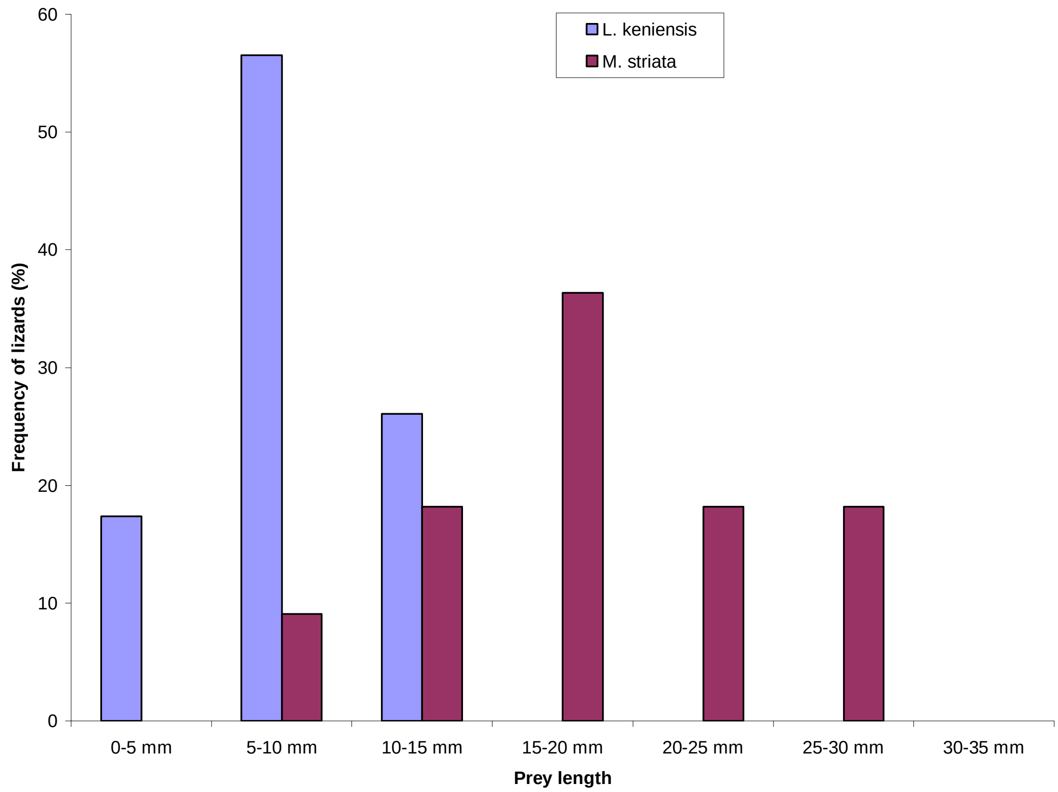


Figure 39. Frequency (%) of lengths of prey items found in the stomachs of the two lizard species.

6. DISCUSSION

6.1 Survey of Reptiles

The reptile fauna of the area is relatively rich (34 species) compared to its land area (541km^2) which equaled 0.06 species/km^2. This figure is high compared to the total herpetofauna of the country (201) with the area of 11,400,000 km^2 (0.00018 species/km^2) and in comparison with other African countries like Egypt which has 106 reptile species in 1,019,600 km^2 (0.0001 species/km^2). The differences in relative species richness can be attributed largely to habitat diversity and productivity. Out of the 38 reptiles (12 snakes, 22 lizards, 1 crocodile, 2 tortoises and 1 terrapin) that were encountered in the present study, all snakes and lizards also occurred in different regions of Ethiopia as indicated in Largen and Rasmussen (1993) and Largen and Spawls (2006).

Duckworth *et al.*, (1990) reported that Morris (1967) recorded 18-19 amphibian and reptilian species in NNP and near Arbaminch. Six of these were encountered in the present study and two of them are also recorded from the Addis Ababa University Zoological Natural History Museum. The Addis Ababa University Zoological Natural History Museum has also eight reptile specimens from NNP and Arbaminch (*M. brevicollis, Mochlus sundevalli, C. resinus, B. arietans, D. polylepsis, P. sibilans, D. scabra* and *T. dahara*) of which, six were encountered during the study period.

A survey carried out in NNP by Duckworth *et al.*, (1990) has revealed 17 species of reptiles Out of these, 11 species were recorded in the present study area two were recorded from the Addis Ababa University Zoological Museum. In addition to these specimens, Kirubel Tesfaye (1985) recorded *Naja nigricollis* (Black-necked spitting cobra) from the Park.

Largen and Rasmussen (1993) recorded seventeen species of snakes from NNP. Seven species from this list were not encountered during the present study. Four species were added from the present study to the ophidian fauna of the area. Largen and Spawls (2006) recorded seventeen saurian species from the area out of which only two species were not recorded during the present study, while the present study added five species of lizards as new records to the fauna of the area. In addition to these records, two species from Testudines was recorded for the first time. The sum of the new records from the present study was eleven species (29% of the total recorded species).

One species (*Geochelone sulcata*) is listed by IUCN as vulnerable. With this perspective, a *Local Red List* category according to "*Lake Tana-Associated Wetlands Red List Categories 2006*" one species "The python" has been assigned into the category of *Critically Endangered* because population of the species has been declining due to habitat fragmentation and loss, this python is critically threatened partly due to habitat loss and persecution by humans, blamed for killing of domestic animals, especially shoats (goats and sheep) and partly due to resentment from cultural taboos. Two species "The Nile crocodile and Nile Monitor" are assigned into the category of vulnerable. Among the species recorded 9 species are listed in appendix II of CITES.

Diversity of the reptiles belonging to the order Squamata appeared to be higher than that of orders Crocodylia and Testudines. This finding complies with the findings of the Duckworth *et al.,* (1990), which recorded fourteen species from the Order Squamata, one from Order Crocodylia and two from Order Testudines. The bushland and grassland habitats harboured most of the reptiles but according to Duckworth *et al.,* (1990), the areas that supported most of their reptile records were Kulfo Riverine Forest, followed by the bushlands. They did not record reptiles from grasslands. This might be due to their attention in recording other species and they only recorded reptiles on opportunistic basis. Had they searched under logs and rocks, the result might have been different.

There was an overlap in the distribution of many of the reptiles in different habitats suggesting that those might be the regions that have favourable environmental conditions. To understand factors that affect the distribution of these reptiles, it is necessary to examine the case of each species in detail to get more information on their preference of different environmental factors as recommended by Costa *et al*. (2008).

Snakes**,** venomous or non- venomous types, were being killed inside the Park for no apparent reasons. There are some Amharic proverbs that fuel this hostile feeling against snakes, for instance "*Ebab yelibun ayto egir nessaw*", which can be translated as 'God denied the snake from possessing legs knowing what it has in its mind'. This is usually used with a connotation that a snake is a symbol for evil spirit. This negative cultural belief is a very good example of the outlook on snakes in the Ethiopian society. On the other hand, the people residing around the study area may be in danger of snake bites. The researcher has witnessed two fatal snake bites within a month; one was a 9 year old boy and the other was an old man of around 65-70 years of age.

6.2 Ecological Study

Differences among sympatric lizard species usually result from differences in the use of three resources: space, time and food or some combination of these three. However, differences in resource utilization among sympatric species may simply reflect their specific ecological needs rather than competitive pressures (EJR and Rocha, 2004). If these two lizard species are really competing for limited resources in their surrounding, they are expected to partition at least one niche resource to allow coexistence (Rouag, 1999 as cited in Rouag *et al.,* 2007).

The time niche breadth of *L. keniensis* was wider than that of *M. striata*, which is most probably because of their differences in the extent of activity period. *L. keniensis* was active for about 2 hours, when *M. striata* was not active. *L. keniensis* is described as usually active in the morning and late afternoon (Spawls *et al.*, 2002), which is not the same as what was observed in the present study. The number of *L. keniensis* observed reached its peak during mid-day and also early in the afternoon. In addition to this, *L. keniensis* was completely diurnal as stated by Spawls *et al.,* (2002), but in the current study, it was also observed during nights (around 4:00-7:00 p.m.) on buildings. These differences in activity period might be related to the differences in the microhabitats used (Grover, 1996). *M. striata* was usually seen at heights near the ground level while *L. keniensis* was mostly found on buildings and trees.

The two species of lizards overlapped almost completely in temporal niche resulting in high overlap of these species to partition the other niche dimensions (spatial and/ or food niches). According to Schoener (1974), high overlaps along one dimension of the niche may be compensated by low overlaps along another. In line with this, the high temporal overlap was compensated by low spatial and food overlaps in the present study. It has also been observed that sympatric lizards in Kalahari Desert and dry areas of North America may shift their temporal niches to allow ecological coexistence in an efficient and successful way (Huey and Pianka 1977; Huey *et al.,* 1974). However, the sympatrical lizard species *Psammodromus algirus* and *Acanthodactylus erythrurus* (Lacertidae), from the Parc National d'El Kala, north-eastern Algeria, overlapped greatly in their spatial and food niches, but they differed greatly in their temporal niche overlap and activity pattern, which let them to co-exist (Rouag, *et al.*,2007).

As explained by Carothers and Jaksic (1984), time, in particular, is very unlikely to constitute an independent niche dimension for lizards. Lizards can change their selections of microhabitat use and food choice when there are scarce food resources to decrease interspecific competition. This shows microhabitat and food are dependent niche dimensions (Dunham, 1983). Therefore, the partitioning of the two niche dimensions might depend on their temporal niche overlap. As discussed by Toft (1985), time (be it durinal or seasonal) is partitioned only as a secondary way of partitioning the other two resources.

As suggested by Rouag *et al.,* (2007), temporal niche partitioning might be a general rule for lizards that occur in sympatry. Since the co-existence of these two species is most likely to be affected by temporal niche partitioning can be seen as the most important niche dimension in determining their co-existence (Wahungu *et al*., 2004).

The high overlap in temporal niche is compensated by the low overlap values of spatial and food niche dimensions. Although *M. striata* had higher spatial niche breadths, both species are recorded to have a lower microhabitat niche breadth values. This shows a high specialization in microhabitat and substrate selection (Wahungu *et al*., 2004).

The two lizards have a moderate overlap (0.48) when dealing with microhabitat selection. They also showed a very low overlap (0.14) of heights from the ground. This could be explained as a result of avoiding competition for resources (Wahungu *et al*., 2004), protection mechanism against predators (Bauwens *et al*. 1999) and reflecting their different morphological adaptation (Losos *et al*., 1993; Melville and Swain, 2000; Melville and Schulte, 2001). Furthermore, it is a known fact that in lizards, as in all reptiles, temperature difference among different habitats is a manipulative factor affecting their survival, which leads to conclude that they take into account this issue while selecting their place. So preferring different substrate temperatures might also be another case leading to a difference in their microhabitat choices as stated for *Sceloporus* lizards by Adolph (1990).

In terms of height from the ground, *M. striata* appeared to have a wider niche breadth than *L. keniensis.* But, *L. keniensis* frequently used heights that are well above from the ground on buildings and trees. *M. striata* on the other hand, was almost never observed on trees but inside buildings, when it was seen above some heights. There is also a difference in their activity pattern, which might have resulted due to the differences in vegetation coverage in the microhabitats used (Grover, 1996). *L. keniensis* used microhabitats with a greater vegetation height above the ground, which had more shades than the ground or rocks on which *M. striata* inhabited. This preference of heights is also explained similarly by Spawls *et al.*, (2002). Such differences reflected dissimilarity in exposure to sunlight (especially in the hottest hours of the day), facilitating reduced activity periods of the species on higher heights (EJR and Rocha, 2004). This difference in microhabitats may have resulted in the difference in their food niche. These lizards had a low overlap value in their food niche partitioning. However, both species are mainly insectivorous (Simbotwe and Garber, 1979). The majority of preys in *M. striata* included Orthopteras and Arachinids, which did not match exactly with the findings of Simbotwe and Garber (1979), who stated that Isoptera and Coleoptera are the main prey items followed by Orthopteras and Arachinids. In this specific case, *M. striata* might have left feeding up on Coleopteras as a mechanism of reducing competition with *L. keniensis.* The main prey items of *L. keniensis* from the present study area are Hymnopteras and Coleopteras and the findings of Simbotwe and Garber (1979) for *L. capensis*, which is in the same genus with *L. keniensis,* show that Hymnoptera and Orthoptera are their main food items in Zambia. It was also shown that there were pieces of stones and plant parts in the stomachs of *M. striata* but not in *L. keniensis.* This could be attributed to the fact that *M. striata* is mostly found on heights that are close to the ground, which might be a mechanism of avoiding a competition for food among the two sympatric lizards as discussed by Simbotwe and Garber (1979).

According to Simbotwe and Garber (1979), there exists no relationship between the size of lizards (snout-vent length) and the size of prey items they utilized. But Schoener (1968); Lister (1976), Simon (1976) as cited in Simbotwe and Garber (1979) have stated that the mouth gape is important in lizards because they swallow their prey whole. Moreover, Vitt and Zani (1998) have found out that the lizards they studied differed in prey size and much of this variation appeared to be the result of body size difference. According to Vitt and Zani (1998), though larger sized lizards tend to eat larger sized preys, it does not necessarily mean that larger lizard species eat more than the smaller ones.

A combination of differences in microhabitat selection, prey types and prey sizes contributes to niche segregation in the studied sympatric lizards occurring near the Forty Springs in NNP. These lizards were able to co-exist by partitioning the spatial and food niche in their surrounding which might have decreased their competition for the same resource.

7. CONCLUSION AND RECOMMENDATIONS

The current study provides an initial survey of NNP reptiles, their distribution and also identifies areas with high potential for future reptile biodiversity inventorying. As the study time was very short, it might not reveal all the reptiles that inhabit the Park area.

The Park is found to have a rich herpetofauna, especially that of lizards, compared to its size and the most preferred habitats were bushlands and rockyareas.

The sympatrical lizards *Lygodactylus keniensis* and *Mabuya striata* were able to coexist by partitioning their spatial and food niches while overlapping widely in their temporal niche.

The following recommendations are suggested for: -

- Future plans of the Park should seek to expand detailed surveys with respect to both taxonomic and geographic coverage of reptiles; similar to large mammals and birds.
- Environmental clubs in schools should work upon creating awareness that not all snakes are venomous. They should teach children to see them as they are not unique, but animals.
- Universities, different NGOs and National Parks should encourage researchers to fill the gap in herpetology in Ethiopia.
- Local people around the Park should be given some tips on how to minimize the risk of snake bites.

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Appendix

Appendix I. Herpetological field data sheet

Sheet No.: Date:

Investigator: Locality: Humidity =

Time = Temp. =

NO	SP	SX	AG	AT	ST	RH	WC	HT	VC	H	DV	DR	RT	AS	FS	REMARKS

No. Record number SP: Species (M, L) SX: Sex (Male “M” or Female “F”) AG (Juvenile “J”, Adult “A”) AT: Ambient temperature ST: Substrate temperature RH: Relative humidity, WC: weather condition (Sunny “S” cloudy “C”, Rainy “R”, Windy “W”) HT: Habitat type (Soil “S”, Plant “P”, Tree “T”, Building “B”, Others “O”), VC: Vegetation community, H: Height above the ground, DV: Distance from the first vegetation, DR: Distance run to the refuge site RT: Refuge type (Crevice “C”, Hole “H”, Burrow “B”, Vegetation “V”, Under stone “US”, Tree bark “Tb”), AS: Activity status (Foraging “F” , Basking “B”, Hiding “H”, Mating “M”, Fighting “Ft”), FS: Feeding strategy (Active search “AS”, Sit and weight “ST”, Visual scanning “VS”)

Declaration

I, the undersigned, declare that this is my original work. It has never been submitted in any institution and that all sources of materials used for the thesis have been duly acknowledged.

Name: Fikirte Gebre Senbet

Place: Addis Ababa University

Signature …………………….

Date ………………………….

This thesis has been submitted for examination with our approval as

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Date …………………………

Co-advisor: Afework Bekele, Professor

Signature ………………………

Date …………………………