COMPARISON OF THE CONCENTRATION OF SOME MINERAL ELEMENTS IN THE NATURAL SALT-LICKS UTILIZED BY ELEPHANTS IN MT. ELGON NATIONAL PARK, KENYA

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DECLARATION AND APPROVAL

This thesis is my original work and has not been submitted in any University for a diploma or degree.

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This Master of Science Thesis has been submitted with our approval as University Supervisors.

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COPY RIGHT

DEDICATION

This thesis is dedicated to the following:

My parents Mr. &. Mrs. Sitienei, My dear husband, Yego and son Gedion.

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ABSTRACT

The study was carried out in Mt. Elgon National Park. The Elephants of Mt Elgon are known for their earth eating behaviour. Regular visits to saltlicks and caves on the mountainside have resulted in their being referred to as "Cave elephants". What is not fully understood is whether the caves visited by the elephants were as a result of intense utilization or were formed due to other geological factors and what is in them that makes the elephants go that deep. The study was designed to establish the distribution of saltlicks, determine the concentration of some mineral elements in the major saltlicks and the frequency of visits to these saltlicks. The whole park was surveyed on foot and the distribution of salt licks mapped using grid maps (Waweru, 1991). Rock soil samples were collected from the four major cave walls with signs of recent use by elephants (presence of tusk scratch marks). Rock samples were processed using Double Acid Technique (Okalebo et al., 1993). Footprints were used to study frequency of visits to the major caves.Data collected was analyzed using Statistical Package for Social Sciences (SPSS) for variance analysis. A total of seven saltlicks inside caves were identified, four of which were heavily utilized. Chemical results indicated that Potassium, sodium, phosphorus, calcium and magnesium were present in the four saltlicks. The concentration of Potassium, sodium and phosphorus was significantly higher (F37.588, 4 Df, 33.6500ppm, 30.3150ppm and 27.5500ppm) than that of calcium and magnesium (F37.588, 4 Df, 0.2230ppm, and 0.2720ppm respectively in the major caves frequented by elephants in Mt. Elgon National Park. It was also established that although the concentration of the macroelements is higher at the entrance and middle of caves, the variation in concentration with the end of the cave is not statistically significant at ($P<0.05$) thus implying a fairly uniform distribution. Analysis of the visits to the four major saltlicks studied indicated that they were only visited between the months of November and February in a year. The most frequented cave was Kitum and the least visited was Chepnyalil cave. The study showed that Elephants in Mt. Elgon National Park have salt deficiency and have resulted in venturing into caves to supplement their body element needs. The Park management can overcome this problem by having a macroelement supplement policy for the Park.

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CHAPTER ONE

INTRODUCTION

1.1.0 Background

Mt Elgon is a huge dormant volcano stride the Kenya – Uganda border. The name Elgon comes from a Maasai phrase *Ol doinyo ilgoon* meaning a mountain like "human breast". The Mt. Elgon National Park was established in 1968 mainly for conservation of wildlife and as a tourist attraction (Redmond, 1990). Other than the wildlife conservation, Mt. Elgon is known for its scenic beauty, which includes the caves. These caves, formed in the ancient volcanic age by the action of water, play a vital and unique role in the lives of the forest animals. There are many caves in Mt. Elgon National Park, and the major ones are Kitum, Makingeny, Ngwarisha and Chepnyalil. Of the four caves, the most spectacular one is Kitum, not only because of its great size, but it is also the cave most visited by the Elephants. Mt. Elgon is the habitat of the world's only known elephants which actively lick salt in underground caves (Bitok, 2002).

The National Park is known for the cave elephants and their earth eating or salt licking behaviour. The vast unique caves have been venues for traditional ceremonies and cattle saltlick areas for the local Sabaot community from as early as 1946 until 1968. Saltlicks occur as mineral outcrops in rocks. These mineral outcrops are visited by the Elephants with the purpose of eating the soil, either through biting or licking in order to supplement element requirements in their diet (Waweru, 1993).

Although Mt. Elgon is only 1^{0} North of the equator, temperatures at the summit fall below freezing point and the climate here is harsh for the animals. The elephant's diet of plants does not provide them with enough minerals, so they seek them out in the caves on the mountain (Redmond, 1990).

Lasan (1971) noted that mineral licks, like food and water, constitute one of the requirements expected in an ecological unit because vertebrates have complex nutritional requirements in the form of chemical elements. Therefore, saltlicks would supplement the minerals, which are deficient in an animal's vegetation diet (Ayeni, 1971). A major attribute to the use of mineral licks is the fact that they have high levels of sodium. Sodium is an essential element for many body functions in animals but not required by most plants. It is seen actively used by herbivores that seek other alternative sources of the mineral in what is known as a "salt drive" (Robinson and Bolen, 1984).

Bot kin *et al.*, (1973), pointed out that sodium is the sixth most abundant mineral on the earth's crust. The potential then exists in herbivores to incur sodium deficiencies in areas with low availability of sodium in the soil. Maskall (1987) attributed the geochemical studies in National Parks and Wildlife Reserves to a broad variation of trace elements available in soil. They varied from one location to the other depending on the parent rock and largely on the influence caused by soil forming processes.

Mineral deficiencies in wildlife are caused by a variety of factors that influence the movement of trace elements in soils and to the plant materials from which they are derived. Availability is influenced by the physical and chemical nature of the soil. Maskall (1991). noted that the mineral status of an animal depends on plants and more so on parts that comprise its diet, but trace elements could also be enhanced in animals diet through licking of the soil.

Mineral requirements are affected by several factors including breed, age, sex, growth rate, physiological state, level and chemical form of ingested mineral and other interaction in the diet (Pond, 1992). Leaching is the major problem in mountain areas such as in Mt. Elgon region (Redmond, 1990). This has reduced the availability of mineral capacity in plants and grasses, as most elements are lost to the soil through it. Animals are forced to look for alternative sources of mineral supplements through salt licking or "earth eating behaviour" (Redmond, 1990). While the enclosure of wildlife within small National Parks have focused attention on the capacity of soils to release adequate trace elements into the food chain, the uptake of these elements would broadly depend on the availability of the elements in the soil (McNaughton, 1988). Redmond (1990) suggests that the only method herbivores living on Mt. Elgon National Park could supplement their diet was through eating mineral rich earth or rock.

Deficiencies and imbalances of minerals are well recognized as important determinants of animal conditions such as fertility, productivity and mortality. A deficiency of any of the essential minerals results in reduced food intake (Forbes, 1995). Geochemical methods have been widely used to investigate mineral problems in crops and livestock in the United Kingdom where increasing use of intensive agricultural practices has led to pressure on the land's natural resources (Maskall, 1987). The possibility of marginal or insufficient supply of elements make the elephants in Mt. Elgon National Park to search for mineral elements inside the caves thereby risking their lives. The need for more objective research is therefore crucial in the field of natural resource management (wildlife) in order to recognize and suggest possible remedies for mineral deficiencies or imbalances in herbivorous animals.

This objective research that should be carried out by studying the mineral concentrations in soils, which include those of the natural saltlicks.

1.2.0 Study area

1.2.1 Geographical location

Mt Elgon National Park is situated on the Kenya-Ugandan border and 26Km west of Kitale Town off the Kitale – Endebes road and is about 460km from Nairobi. It covers an area of 169 square Km and lies between latitudes 1^0 00'00'' and $1^0$11'40'' North and longitude 34 ^{0} 15' 00''and 34^0 23' 14'' East. (Redmond, 1990) (Fig 1).

1.2.2 Geology, Soils, Topography and Drainage

Due to the volcanic processes, Mt. Elgon National Park soils are generally characterized by deep brown soil of volcanic origin. The nithosols are well developed and are reddish- brown to dark brown in colour. Andosols which are ashy soils with high organic matter with a mixture of black topsoils clay and loam, are also common. Nithosols are well drained but andosols have impeded drainage. Being in a mountainous region, Mt. Elgon National Parks' topography ranges from 7,200 feet to 13,835 ft above sea level, and due to the former volcanic activities and the incisive work of the radial drainage system, the slopes are very steep in some parts. Numerous springs from high points of the montane forests collect to form fast flowing streams, which feed the main rivers. Several rivers such as the Rongai, Kabeyan and Kassawai have their sources in the park (MEICDP, 1999) as shown in Fig1.

1.2.3 Climate

The climate here is characterized by marked long wet season from March to September. The wet season starts in March and ends in September with two peaks, followed by a short dry season from November to February. The annual precipitation ranges between 1,250 mm and 2,000 mm and increases with altitude (Redmond, 1990).

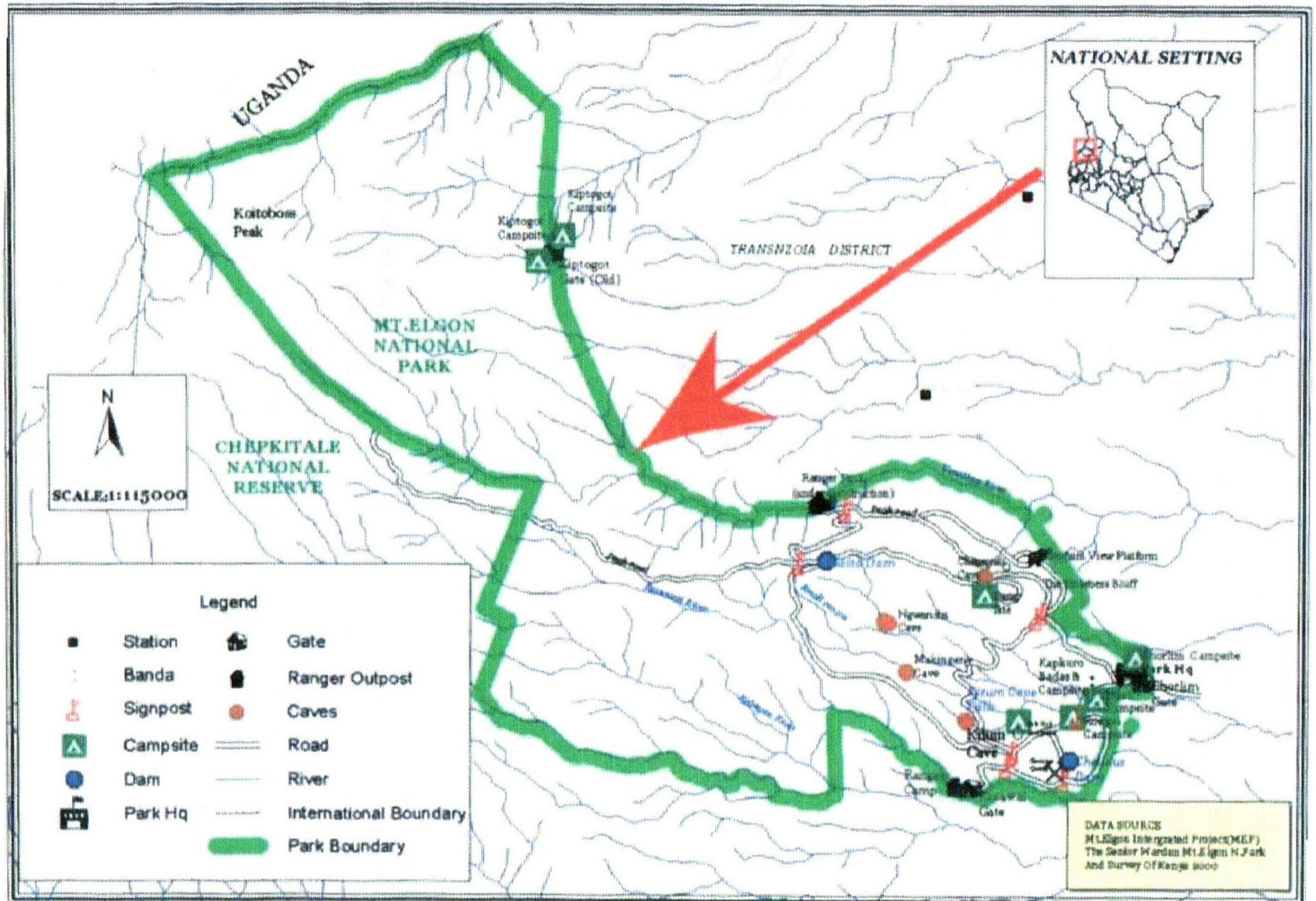

Fig. 1 STUDY AREA

Fig. 2 represents the annual monthly rainfall. The results indicate that Mt. Elgon National Park experiences two rainfall peaks, one in April and the second one in September. That is when a total of 220mm and 250mm respectively is received. Low rainfall falls between November and February.

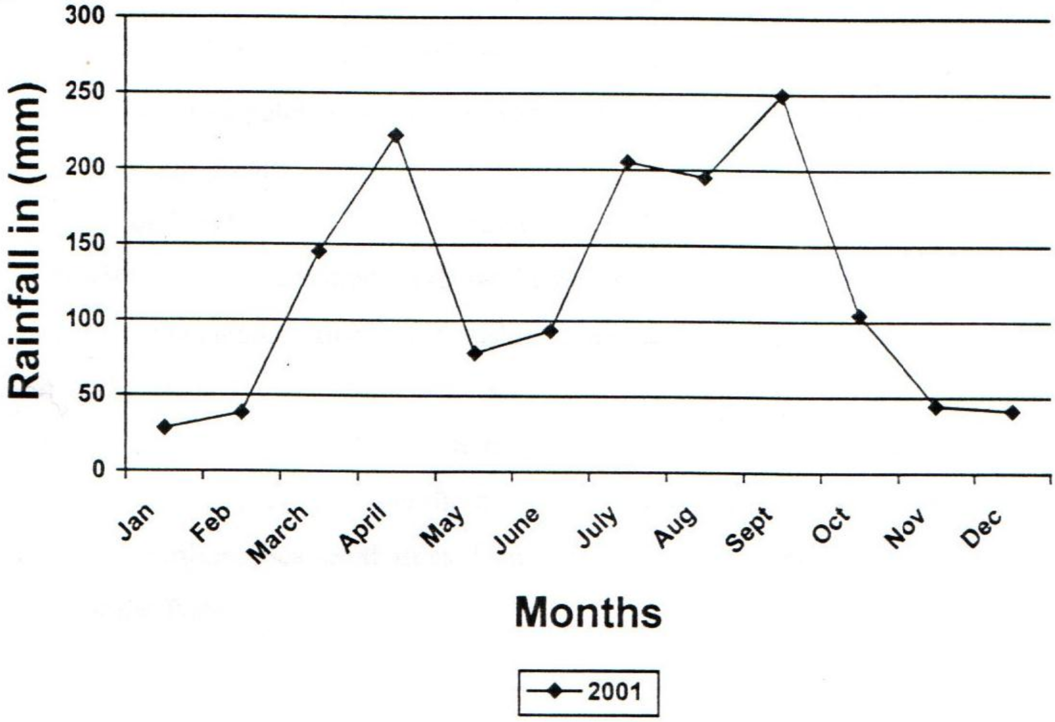

Figure 2: Annual monthly rainfall distribution in (mm)

1.2.4 Land use around the Park

The Land use around the park is characterized by mixed farming, large – scale commercial farming, forestry and some livestock farming (Bitok, 2002). The farming system is based on small units which are cultivated with hoes for subsistence, but large private farms are mechanized and are mainly cultivated for maize and coffee (Redmond, 1990). Within the park, wildlife conservation is the predominant method of land use, although subsistence honey gathering and hunting has been reported (Bitok, 2002) There is one tourist lodge, the Mt. Elgon Lodge, close to the park gate.

1.2.5 Flora

The park has a rich, not spoilt botanical diversity of tropical moist forest containing stands of the most rare and threatened species like the Podos (*Podocarpus gracillior*), Elgon Teak (*Techtona grandis)* and cedars (*Juniperus procera).* The vegetation of Mt. Elgon National Park varies from the base to the peak (Fig 3). In the highlands above 3. 100m.a s.1,the apro-alphine vegetation (*Alchemilla-Helichrysum*) with a high percentage of endemic species can be found, followed by high mountain heath (*Erica-Stoebe*) in the lower side, tussock grasslands with patches of *Helichrysum spp*, *Alchemilla* shrub and the endemic giant groundsels (*Senscio johnstonii*) near the summit. Between 1800-3000m.a.s.1 there is a vegetation belt of Montane rain forest, while between 3500-4000m.a.s.1 is the bamboo zone. From 3400-4500m.a.s.1 is the moorland and the last zone is the scattered grassland.

Bamboo, bushland, high altitude bushland, low altitude bushland, and grassland cover the north and central part of the Park. An indigenous forest covers the east, south and southeast section with small patches on the north and central parts. Moderate forest and bamboo covers the central part while the moorland covers the northwest section of the park. Scattered trees/bamboo, Scattered trees / bush and Scattered trees / grassland covers the central part of the Park.

1.2.6 Fauna

The Park has a diversity of wild game and birds. The major game includes elephants and buffaloes. The major predators are the hyena and leopards.

Below is a list of Fauna commonly found in Mt. Elgon National Park.

Common names	Scientific names
(Mammals)	
1.Elephant	*Loxodonta africana*
2.Buffalo	*Syncerus caffer*
3. Impala	*Aepyseros melampus*
4.Hyena	*Crocuta crocuta*
5. Leopard	*Panthera pardus*
6. Oribi	*Ourebi ourebi*
7. Wild boar	*Susscofa leyca.*
8. Bushbuck	*Tragelaphus scriptus*
9. Black and white Columbus	*Columbus abyssinicus*

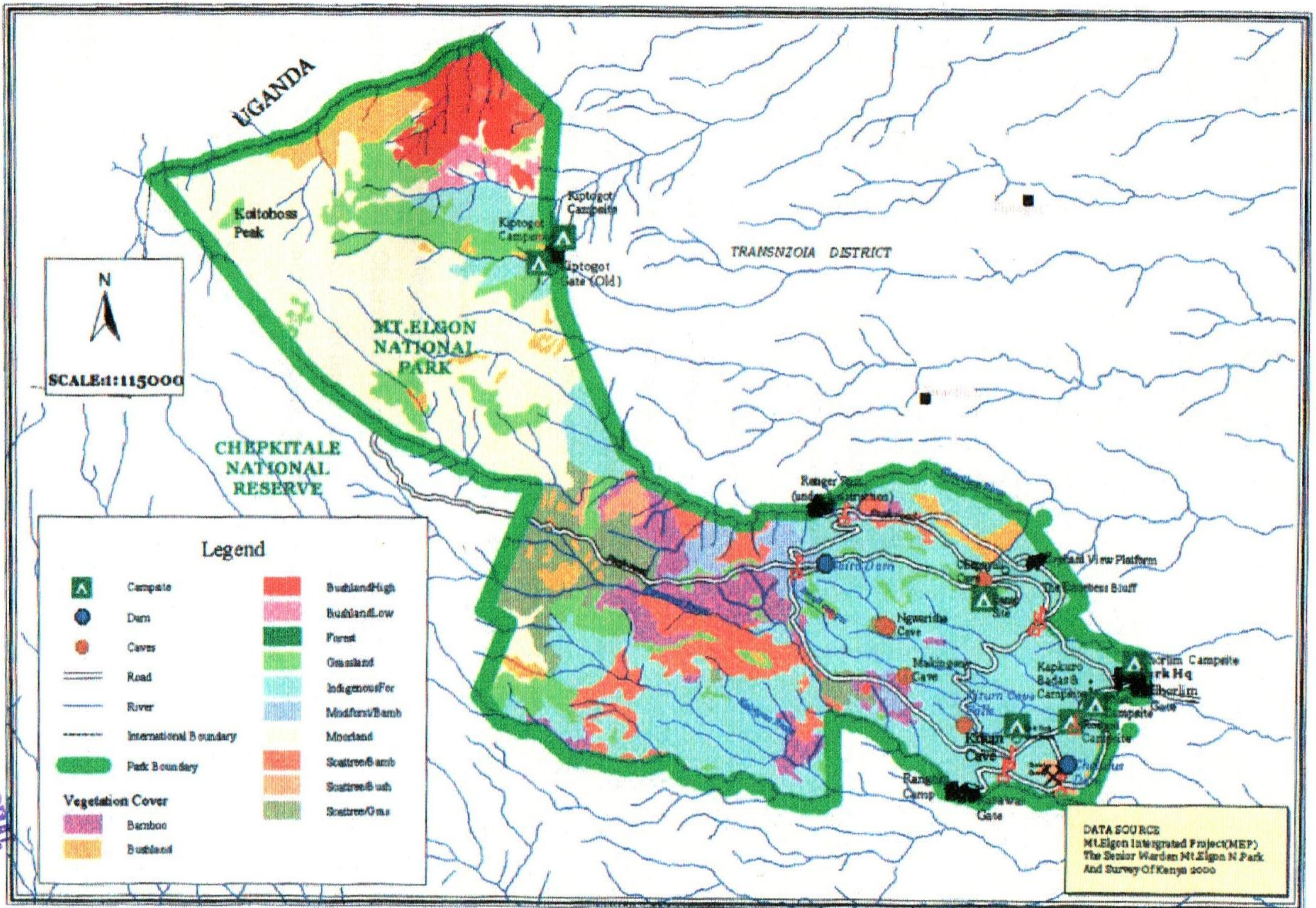

Fig. 3 **VEGETATION MAP**

Fauna (continuation)

10. Civet	*Viverra civetta*
11. Genet	*Nandinia binotata*
12. Wild boar	*Felis leyca*
13. Red headed parrots	*Agapornis pullaria*
14. Black billed turaco	***Turaco scuttii***
15. Blue monkey	*Cercopithecus mitis*
16. Bush squirrel	*Paraxerus orchraceus*
17. Golden Cat	*Felis qurata*
18. Rock Hyrax	*Heterohyrax brucei*
19. Tree Hyrax*Papio*	*Cynocephalus anubis*
20. Olive Baboon	*Papio cynocephalus*
Birds	
21. Scaly Francolin	*Francolinus squamatus*
22. Montane Francolin	*Francolinus jacksoni*
23. Great blue Turaco	*Corythaeola cristata*
24. Crowned Hornbill	*Tockus alboternatus*
25. Red headed Parrots	*Agapornis pullaria*

(Redmond, 1990).

1.3.0 Statement of the problem

For many years the elephants of Mt. Elgon National Park have been noted to engage in regular visits into caves. Observations by Redmond (1990) and park records indicate that the elephants visit the caves to lick salt (earth eating). Earth eating behaviour is common to most herbivores inhabiting mountainous areas. In the Aberdares, the road banks are heavily damaged by the elephants and sometimes blocking access (Park records). Records indicate that, due to heavy leaching of mineral elements in the soils, high altitude vegetation does not have adequate mineral nutrient needed by herbivores and as such, elephants can source it from existing rocks using their strong tusks. The case of Mt. Elgon National Park is very unique in that elephants go deep into the caves (about 300 meters) to lick salt. It has been difficult for the park management to explain why the elephants move this deep. The problem facing the management is that the chemical composition of the rocks inside the caves is not known and so is its variation from the cave entrance to the furthest point. This qualifies the need to establish the chemical composition, and variation of the cave rocks in an endevour to give an explanation for these elephant behaviour.

1.4.0 Objectives

1.4.1 Broad objective

To establish the distribution of saltlicks in Mt. Elgon National Park, utilization by elephants, and their concentration of some mineral elements.

1.4.2 Specific objectives

1. To establish the distribution of existing saltlicks
2. To determine concentration of some mineral elements in the major caves.
3. To determine the frequency of utilization of the saltlicks by elephants.

1.5.0 Hypothesis

Saltlick utilization by elephants is dependent on the chemical composition and concentration of some mineral elements.

1.6.0 Justification

Mineral licks are important for growth and reproduction in many herbivores (Church, 1977). Lack of these elements may cause deficiency symptoms in animals' body such as loss of appetite, body weight loss and skin dullness. Elephants derive their nutritional needs through eating foliage which provide them with these elements, but when there is deficiency of such elements the elephants have adopted alternative ways of supplementing them. Mt. Elgon National Park Elephants in particular have been observed to enter caves and lick salt from the cave walls. Scientifically no studies have been conducted to establish why this behaviour. There has been concentrated number of visits by the elephants at some specific caves. The depth and cracks in the walls formed are dangerous for these animals. The research has provided baseline information on the concentration of key macroelements and its variation between caves. Finally the information can be used by the park management to develop management policies for handling the problem of macroelement deficiency in the park. The finding of the study will open up on areas for further research to understand the whole complex interactions between the elephants, other herbivores inhibiting Mt. Elgon National Park and the nutrient supply from the browse and forage. This would also enlighten the management on the levels of macroelements deficiency

CHAPTER TWO

LITERATURE REVIEW

2.1.0 Importance of mineral elements in an animal's physiology

Hirst (1975), showed that animals with uneven distribution of minerals in their diet over a given period were responding quantitatively and qualitatively to habitat factors, which relate directly or indirectly to the well being and their survival. One such factor may be minerals whose essential nature in the animal's physiology is very important. The function. requirements, deficiencies and dietary sources of the minerals discussed are described below.

2.1.1 Calcium and Phosphorous

These are major mineral constituents of the animals' bodies and are largely associated with skeleton formations. In mature animal. 99% of its calcium and 80% of its total body Phosphorous are contained in bones (Bronner, 1964). Calcium is the most abundant mineral element in the animal body. It is an important constituent of the skeleton and teeth, in which about 99 percent of the total body calcium is found. In addition, it is an essential constituent of living cells and tissue fluids (McDonal and Edwards. 1995).

Calcium is associated with blood clotting, excitability of nerves and muscles, eggshell formation and muscle contraction, whereas phosphorous is involved in animal metabolism. All animals require phosphorous, although quantitatively less of it is required more than that of calcium (Hafez and Dyer, 1969). Calcium deficiencies result in retarded growth, decreased food consumption, rickets, egg thinning and fragile bones. Phosphorous deficiencies result in loss of appetite, rickets, reduced body growth, failure to breed and weakness causes eventual death. Dissolved calcium in drinking water is an adequate source of calcium. The consumption of fungi, insects, bones and other rich calcium sources is essential for free ranging animals (Robbins, 1983). It is important to consider the calcium: Phosphorous ratio of the diet, which is generally within the range of 1:1 to 1:2 since abnormal ratio may be harmful as the deficiency of either element in the diet (McDonald and Edwards, 1995).

2.1.2 Sodium

Sodium is important in the regulation of body fluid volume, acid base balance, muscle contractions and nerve impulse transmission and is therefore necessary for growth and reproduction. Sodium requirement; for growth and reproduction of birds and mammals. range from 0.005 to 0.15 percent of the diet (Morris, 1980). Symptoms of sodium deficiency are reduced growth, softening of bones, gonadal inactivity, loss of appetite and weakness.

Excessive salt also leads to reduced intake of food. For example, addition of 30g sodium kg-1 to sodium adequate diet depressed the food intake of sheep without affecting plasma sodium concentrations (Forbes, 1995).

Animals taking foods with minimal sodium content must either conserve ingested sodium or augment sodium intake by actively consuming natural sodium supplements at the mineral licks. Potassium plays a very important part along with sodium, chloride and bicarbonate ions in the osmotic regulation of the body fluids and in the acid base balance in the animal (McDonald and Edwards, 1995).

2.1.3 Potassium

Potassium occurs primarily within the cells and functions in nerve and muscle excitability, carbohydrate metabolism and enzyme activation. The very high potassium content of growing plants and animals usually in excess of animal requirement greatly reduces the chances of potassium deficiencies occurring in free ranging or captured wildlife. Symptoms of potassium deficiencies include muscle weakness, retarded growth and tubular degeneration of the kidneys (McDonald *et al.*, 1973).

2.1.4 Magnesium

The major portion of the body magnesium, approximately 70 percent, is in the bone. It is an essential constituent of bone which is important in enzyme activation. Magnesium is abundant in both plant and animal dietary sources since it is the chelated metal in chlorophyll. The normal magnesium content of blood serum in cattle is within the range of 17 to 40 mg.

Deficiency symptoms include vaso-dilation, convulsions, reduced appetite, weight loss, defective bones and teeth, soft calcification of tissue may result in death of the organism.

2.2.0 Past records on saltlicking by elephants

All animals need salt in their diet. Animals' bodies simply cannot work without it, but too much salt can also be a problem. Animals, instinctively know how to regulate the amount of salt they eat. The salt it eats is a contribution of several macro and microelements.

The urge for salt occurs when there is a deficiency of salt in the food plant of a given region. A herd of female elephants and calves will usually stretch their trunks to search for bits of salt at a saltlick. They sometimes seek up salty dust and blow it into their mouth. An elephant family slowly file into Kitum cave to lick the salty rock, and cows keep their trunks on their calves to keep them safe in the total darkness.

In the rainforest of Africa, for example, the rain dissolves out the soluble salts from the soil. As a result, the plants that grow in these soils do not contain much salt. Any herbivore that feeds on these plants will as a result have a salt deficient diet (Redmond, 1990). When elephants are salt-hungry, they will tend to dig at any exposed soil rock with their tusks and taste it. If it turns out to be salty, they will start eating it, and the place will soon become known to the local animals as a valuable saltlick. They dig the soil or rock, then sweep up the bits with their trunks and lift these bits into their mouth. Their massive molars grind up the larger particles and the whole lot is then swallowed. An elephant may eat about 55 lbs (25kgs) of soil from an overhang cliff (Redmond, 1990).

In some places, elephant digging on cliffs has produced small caves but the roof usually collapses before the cave becomes very big. One of the places in the world where elephant salt - digging has apparently produced deep caves, is in Mount Elgon area. One such cave, known as Kitum, extends 525 ft (160m) horizontally into the mountain. It is about 13 ft (4m) high and 130 ft (40m) wide at the entrance, widening up to a width of 330 ft (100m) inside. The idea that elephants could have formed such a huge cavern seems incredible. But scientists studying the cave, and the animals that use it, think it may have been formed by elephant mining activity over many thousands of years. Each new generation of elephants has learned from its parents how to mine the salty rock deep underground. And year after year, the cave continues to grow as the elephants carry away quantities of rock in their stomachs (Redmond, 1990).

Elephant salt-digging behaviour has produced caves in some other parts of Africa and Asia; but in Kenya the best example of these large caves is on Mt. Elgon National Park in Kenya. In the dark recesses of these huge caverns, elephants feel their way to traditional mining bays deep underground. When there, they work only by touch, using their tusks as living ivory chisel to raise off lumps of Sodium-rich volcanic soil to eat it. From their earliest days, baby elephants accompany their mothers right into the caves. The cows, however, keep a careful trunk on their offspring to prevent them from wandering off and falling down a crevasse or rock face in the pitch-dark interior (Redmond, 1990).

Dudley (2002), studied elephants of Hwange National Park, Zimbabwe and observed that elephants take dirt to supplement sodium. Saltlicks were used to supplement dietary intake of sodium. Like many large herbivores, African and Asian elephants often seek out natural mineral licks in regions of soil where minerals are concentrated. Among the significant findings, female elephants consumed more mouthfuls of soil at saltlicks and spent more time feeding on soil than males. This suggested that the urge for salt was driven by nutritional requirements, which tend to be greater in females because of pregnancy and lactation (Dudley and Ricardo 2002). According to a study done on "the elemental content of animal licks" along the eastern slopes of the rocky mountains in Southern Alberta results indicated that, sheep visited mineral or saltlicks and mineral springs to ingest the earth and drink the water, or lick the rock to obtain mineral elements, presumably not in sufficient supply in their food (Cowan, 1971). Hanson (1985) noted that animals in temperate regions invariably seek out saltlicks during late spring and early summer. Further, Cowan (1971) speculated that despite the low sodium content (115 to 5500 ppm) of earth from five licks frequented by mountain goats (*Oreamnos americanus*) in the Rocky Mountain Trench in southeastern British Columbia, the licks were used to compensate for Sodium deficiency.

2.3.0 Importance of mineral elements to Animals

Research has shown that distribution and movement patterns of animals are related to concentrations of major and minor elements (McNaughton, 1988). Further, trace elements status in animals depends mostly on their diet, while the enclosure of wildlife within relatively small national parks has focused attention on the capacity of soils to release adequate trace elements into the food chain. The uptake of trace elements into plants would depend on plant species and soil properties such as soil pH, moisture content and humidity. Although majority of plants do not provide sufficient mineral elements into animal's diet, a research done on trace elements and saltlicks for horses of the Rockies indicate that salt supplementation is a vital part of any animal's nutritional element. As a matter of fact, trace elements have now been recognised universally as being essential in the horses' diet. Also, increasing evidence shows that many minerals and trace mineral elements are needed at higher levels to improve the horses' immune system so as to enable them cope with infections (Donnison, 2002).

Maskall (1991) attributed further that, the mineral deficiencies in wildlife are caused by a variety of factors, which influence the movement of the elements through the rock-soil plant-animal systems. The major sources of trace elements in soil are the plant materials from which they are derived. Element availability is influenced not only by the species and other plant characteristics, but also by the mineral status of an animal, which depends on plants, and more so on parts which comprise its diet. Trace elements can also be taken directly by animals through direct ingestion of soil (Maskall, 1991).

Leaching being the major problem in mountainous areas as in Mt. Elgon, it has reduced the availability of element capacity in plants and grasses. Therefore, most elements are lost through the leaching effect of rain on the soil. This indicates that animals would get less mineral supplement (Redmond, 1990). Many herbivores experience salt deficiency because their diet of plants does not supply them with enough minerals such as sodium and so they seek these out in any digestible form that they can find. Since elephants have been found to be mineral licking herbivores in Mt Elgon National Park (Redmond, 1990), there's need to determine the mineral composition of the natural salts available that are consumed by the wild animals, especially the herbivores.

Mineral distribution in the body is essential. All essential and non-essential mineral elements are found in body tissues and fluids of healthy animals. The levels of minerals in blood plasma often reflect the mineral status of the body. Normal and deficient blood level ranges for some essential minerals have been established and it can be used to help diagnose deficiencies. The ash content of the animal carcass is about 5.5% of carcass weight. Calcium represents about 46% and phosphorus about 29% while trace minerals constitute less than 0.3%. Mineral distribution in an animal body is uniform and the bone acts as the primary storage site, for the essential minerals. Organs such as liver, kidney and spleen also act as major storage sites, while the thyroid gland is a specific storage site for Iodine containing 70-80% of the total body mass (Church, 1977).

Bone is formed through the deposition of calcium and phosphorus as hydroxyapatite into a protein matrix. Small amounts of other major mineral and minute amounts of some trace elements are also present in the bone. Equally important are the complex biochemical functions of the mineral elements. Minerals act in distinct ways to enable some of the body's enzyme to carry out essential reactions. Some essential minerals such as manganese, zinc and copper aid in enzyme catalysed conversions of body metabolites by attaching with the substrate being metabolized, while sodium and phosphorus, which are enzyme stabilizers act to minimize enzymatic activity by stabilizing the enzyme in its most effective conformation. The physiological and neurological functions of minerals are also essential and diverse. Muscular and neural functions require these minerals. Sodium and chloride are necessary for the regulation of osmotic pressure and pH of intestinal and systematic fluids. Copper, iron, and iodine are essential in vitamin B12, blood haemoglobin and thyroid hormone respectively (Church, 1977).

Mineral elements are absorbed from the gastro-intestinal tract by either an active or passive method. Active absorption is the pumping by the intestinal wall of minerals, from the digesta in the gastro intestinal tract into intestinal cells. Mineral elements are then absorbed in a passive manner. These include calcium, phosphorus and sodium. They will then diffuse across the intestinal walls from the digesta at a rate that is determined by the contractions of the mineral in both the digesta and the mucosal intestinal cells. Mineral elements are then absorbed primarily in the ionic form (Church, 1977). All animals are subject to mineral deficiencies. These may be caused by sub-optimal amount of a given element in the feeding; imbalance of another mineral or nutrient which decreases absorption. Any condition which increases the rate of passage of the element through the gut or body and: a metabolic antagonist which causes the animal to require a greater quantity of the element (Hafez and Dyer, 1969).

Mineral deficiency symptoms are common in most herbivores. They include reduced appetite, reduced gain or body weight loss, depraved appetite, skin, dullness, bone deformation, staggered gait and organ damage. Often, specific deficiency symptoms relate to the functions with which the mineral is associated. For example, calcium and phosphorous are necessary for bone formation and maintenance. Mineral deficiency may cause animals to look for other alternative ways of getting mineral supplements. If proper measures of supplementing mineral requirements are not achieved. Also mineral deficiencies can cause reduced growth rate (Church, 1977).

Mineral requirements are affected by several factors including breed, age, sex, growth rate, physiological state, level and chemical form of ingested minerals or interaction with other minerals in the diet (McDonald and Edwards, 1995). However, several minerals are important and therefore needed by the animals' body in order to function properly. For example, calcium and phosphorous are necessary especially for bone but also in small amounts in every cell and in substantial amounts for milk and egg production. Normal muscular activity depends on appropriate levels of calcium, potassium, sodium, and magnesium. In addition to energy and protein, all animals require minerals and vitamins in their diets most but often not all of the minerals and vitamins needed are supplied in the roughage and concentrate feeds (Theodore, 1964).

CHAPTER THREE

MATERIALS AND METHODS

3.1.0 Saltlick distribution

A reconnaissance survey was carried out to establish and map all existing natural saltlicks in Mt. Elgon National Park. With the assistance of a ranger, (who already had worked in the park long enough to know it well). the whole park was searched thoroughly on foot for existing natural saltlick and whether elephants frequented the saltlicks. Whenever a saltlick was encountered. it was described in terms of width. length and depth. Its location was also described along topographical gradient and location recorded using a field map developed for that purpose. The field map was made by plotting 2 km square grids on a 1:115,000-scale map of Mt. Elgon National Park. Each side of the 2 km square grid was subdivided into 10 equal subdivisions. Each major 2 km line was numbered using two ordinates. The subdivisions gave the third ordinate. This was done for both northings and eastings. The field map was reduced to fit an A4 size paper for ease of carrying during the fieldwork (Fig 4). The location was recorded in a field notebook, using 6 digits - the first 3 being the eastings and the last 3 the northings (Waweru, 1991). The recorded sites were plotted on a map of Mt. Elgon National Park and a distribution map produced.

3.2.0 Soil sample collection and preparation

Soil samples were collected from the four major saltlick sites identified namely Kitum, Makingeny, Ngwarisha and Chepnyalil (Fig 5). Samples were collected from sites with evidence of recent licking using a chisel and a hammer to dig the cave walls then packing each sample into a labelled paper bag ready for transport to Egerton University Soil laboratory for analysis. Inside the caves soil samples were collected from three identified points: at the entrance, middle and end. The 200m to the cave entrance was also taken, this helped in explaining the variation in saltlick concentration and composition along topographical gradient.

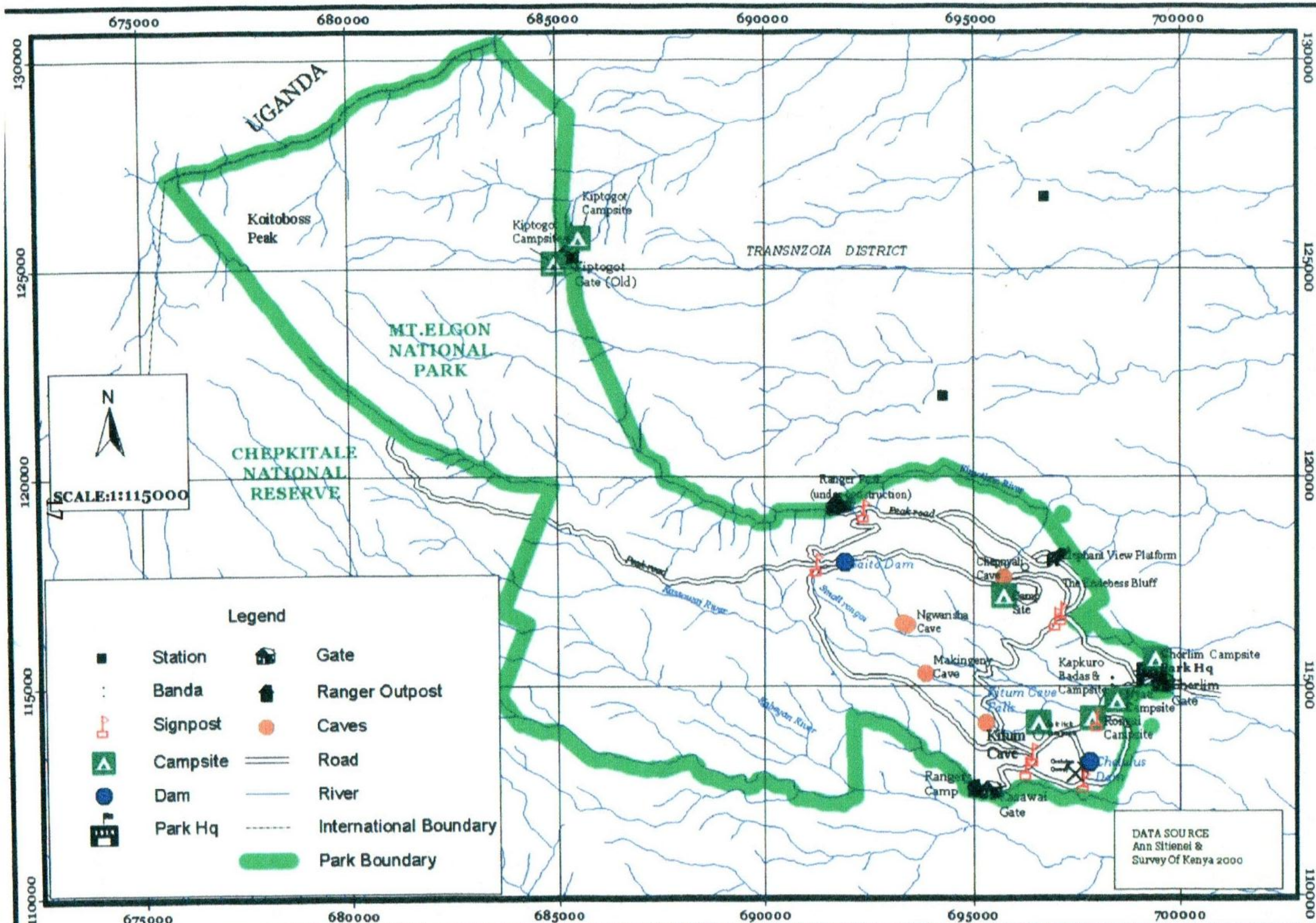

FIG. 4: GRID MAP OF MT. ELGON NATIONAL PARK

3.3.0 Saltlick utilization by elephants

The saltlick utilization pattern by elephants was assessed using indirect method. The caves were visited early in the morning and elephant footprints identified. The intensity of utilization was classified using the frequency of footprints identified that day for each cave. This was done by grouping elephant footprints into, low (1-5), medium (6-10) and high (>10). The presence of more than ten footprints indicated high frequency of visit by the elephants, while less than 1 footprint indicated low frequency as shown in 4.2 at the results section.

3.4.0 Soil Sample Preparation in the lab

To extract the cations from the soil. 5 g of air-dry rock sample (2mm) of each soil sample was weighed and placed into plastic shaking bottles and 100 ml of 1 M Ammonium acetate solution. 5 ml of each rock sample extract solution was pipetted into 50 ml volumetric flasks, 1 ml of 26.8% lanthanum chloride added and the contents diluted (ten times) to the mark with 1 M NH_4OAc extracting solution. This rock sample extract was then used for sodium, potassium, phosphorus, calcium, and magnesium determination.

3.5.0 Chemical analysis (Analytical procedure)

Laboratory analysis was done for individual identification and determination of the concentration for sodium potassium, calcium, magnesium and phosphorus. Sodium and potassium were extracted using the double acid technique and then the concentrations were determined using flame photometer (Okalebo et al; 1993).

Magnesium and calcium were determined using atomic absorption spectrophotometer (Okalebo et al; 1993), while phosphorus was extracted by the double acid technique and analyzed colorimetrically using the molybdate- vandate procedure as described by (Okalebo et al; 1993).

Determination of Calcium and Magnesium

The rock sample (from above) was diluted 10 times by pipetting 5 ml of the solution into a 50 ml volumetric flask, 1 ml of 26.8% lanthanum chloride solution added and diluted to the mark with 1 M NH_4OAc extraction solution. Standard solution of calcium were prepared by pipetting 0, 1.25, 2.5, 5, 7.5 and 10 ml of calcium standard stock solution into 500 ml volumetric flasks. To each flask, 10 ml of 26.8% lanthanum chloride solution and 100 ml of the 1 M NH_4OAc was added and made to the mark with distilled water. The sample solutions were sprayed into the atomic absorption spectrophotometer flame. The standard solutions were first measured to calibrate the instrument and to obtain the standard curve. To obtain the concentration of the element in milli-equivalents (me) per 100 g of rock sample, the graph readings were multiplied by 10 and the products divided by the equivalent weight as shown below:

$$\text{Meq Calcium/100g of rock sample} = \frac{\text{Graph reading x 10}}{20}$$

Magnesium

The rock sample extract was diluted 10 times by pipetting 3 ml of the rock sample extract solution into a 50 ml volumetric flask. 5 ml of 5000 ppm Sr as SrCl2 added and filled to the mark with the I M NH_4OAc extracting solution. Standard solutions were prepared, by pipetting 0, 2, 5, 10, 15 and 20 ml of calcium and magnesium, standard stock solution (200 ppm magnesium) into 1 litre volumetric flasks. 100 ml of 5000 ppm SrCl2 and 100 ml of 1 M NH_4OAc extracting solution was added to each flask and made to the mark with distilled water. These solutions contained 0, 0.4, 1, 2, 3 and 4 ppm calcium and magnesium respectively. The sample solutions and the standard solutions were sprayed into the flame of the atomic absorption spectrophotometer. A standard curve was obtained from the standard solution readings and the concentration of calcium and magnesium in the sample calculated in milli- equivalents (meq) per 100 g of soil by multiplying the graph reading by 10 and the product divided by its equivalent weight as follows:

$$\text{Meq Magnesium /100g rock sample} = \frac{\text{Graph reading x 10}}{12}$$

Determination of Potassium and Sodium

Potassium and sodium were determined using a flame photometer as described by Okalebo et al., 1993). The solutions were analyzed in a flame photometer. 0, 2.5, 5, 10, 15 and 20 ml of potassium and sodium standard stock solutions from the above extract were pipetted into 500 ml volumetric flasks and to each flask, 10 ml of 26.8% lanthanum chloride solution and 100 ml of the 1 M NH_4OAc extracting solution added. These standard solutions contained 0, 1.25, 2.5, 5, 7.5, and 10-ppm potassium and sodium respectively.

The standard solutions were first measured to calibrate the instrument and to obtain the standard curve. To get the concentration of the elements in milli-equivalents (Meq) per

100 g of rock sample, the graph readings were multiplied by 10 and the products divided by the equivalent weight as shown below:

$$\text{Meq Potassium (Sodium)/100g rock sample} = \frac{\text{Graph reading x 10}}{39(23)}$$

phosphorus

Where the value in parentheses is the equivalent weight of sodium soil extractable. phosphorus was determined following to the method as described by Okalebo *et al.*, (1993). The rock sample phosphorus was extracted with 0.5 M solution of sodium bicarbonate and the phosphorus content of the extract was determined colorimetrically. The suspension was filtered through Whatman No.42 filter paper to obtain a filtrate for phosphorus measurements. Phosphate standard solutions containing 0, 0.5, 1.2.5, 5, 7.5, 10 and 12.5 ppm of phosphorus were prepared. This was done by pipetting 0, 1, 2, 5, 10, 15, 20 and 25 ml of Phosphate Standard Stock Solution (250 ppm Phosphorus) into clean 500 ml volumetric flasks onto which 100 ml of the solution was added and filled to the mark with distilled water. -

10 ml of each phosphorus standard solution, 10 ml of sample filtrates and 2 reagent blanks were consequently pipetted into 500 ml volumetric flasks. 5 ml of 0.8 M boric acid were added to each flask. Beginning with the standards and the blanks, 10 ml of ascorbic acid reagent was added to each flask and made to the mark with distilled water. The contents were shaken well and the absorbance of the solutions measured at a wavelength setting of 880 nm after 1 hour. A standard phosphorus curve was obtained from the absorbance values of the Phosphorus standard solutions, which was used to estimate the concentration of phosphorus in the filtrates in ppm phosphorus. Correction for the reagent blank phosphorus concentration was made by subtracting the reagent phosphorus concentration from the sample phosphorus concentration; Hence: phosphorus in rock sample (ppm) = corrected phosphorus in solution (ppm) x 100.

3.6.0 Data analysis

Data on chemical concentration of the rock sample were analyzed using SPSS for MS WINDOWS release 6.1 (1995) for variance analyses. Data were tested for normality before parametric analyses were performed. Site variations in the concentration of sodium potassium, calcium, magnesium and phosphorus were subjected to analysis of Variance. All tests were two tailed.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1.0 Saltlick distribution

During the study, a total of seven natural saltlicks sites visited by elephants were identified as shown in the table below:

Table 1: List of Saltlicks in Mt. Elgon National Park.

No.	Name	Location
1	Kitum	Next to saltlick campsite
2	Makingenyi	On Tega road
3	Ngwarisha	Next to small Rongai river
4	Chepnyalil	Opposite Endebess bluff
5	Maji ya chumvi (campsite salt lick)	Next to Rongai campsite
6	Chelulus saltlick	Next to Chelulus dam
7	Kimothon saltlick	Next to Kimothon river

Table 1. Indicates 7 natural saltlicks studied (Fig 5). Four of the saltlicks namely Kitum, Makingenyi, Ngwarisha and Chepnyalil were in form of caves varying in depths. However Maji ya chumvi, Chelulus, and Kimothon saltlicks were ordinary saltlicks. Their distributions were geographically placed but not in defined patterns.

Among these saltlicks, include the four major caves namely Kitum, Makingenyi that were distributed on a gentle slope while Ngwarisha and Chepnyalil were distributed on a steeper slope. Others include campsite salt licks (Maji ya Chumvi), Chelulus salt lick, and Kimothon salt lick (plates 1-7) all distributed on a gentle slope. Herbivores especially elephants clearly have been observed to visit the four major caves, (salt licks) although other animals also use them. They are distributed along the path from the bottom as you ascend to the top most part of the mountain. Salt licks are located along the roadsides and at the riverbanks. The same locations were observed in the Aberdare National Park. Waweru (1993) suggests that herbivore lick or eat the soils to utilize the minerals in them as the leached minerals settle along the river and roads surfaces.

4.2.0 Description

1. *Kitum cave* is located on southern slopes of Mt. Elgon at an altitude of 2454 (Fig 5; pla1). Its height ranges between 8 and 10m, length is 160m deep and average width of 100m. It is situated 2.5 Km from the park headquarters along Tega Road. The path at the nature trail is marked according to the vegetation type, and these include:

    Rose wood (*Hagenia abysinica*) 200m;

    Elgon teak (*Olea capensis*) 300m

    East pencil cedar (*Juniperus procera*) 400m

    Its nature trail is 460m from the road. It is 20m from Rongai River that forms a waterfall on top of the cave. The cave is surrounded by a number of trees and small bushes. Among the most common trees around the cave are the cedar and podo. It is found at the bottom of the mountain.

2. *Makingenyi saltlick* (cave) is on the southeast slopes of the mountain. It is close to Kitum. It is within an altitude of 2388m (Fig 5; plate 2). Its height is 8m, length of 30m and a width of 60m. It covers a distance of 3 Km from the park headquarters and about 50m from Tega road. Small Rongai River passes over it forming a small waterfall. The vegetation cover is moist forest with a number of big and small trees containing cedar and podo. The cave is mainly known for provision of saltlicks for the cattle of the Elgon people.

3. *Ngwarisha saltlick* (cave) is on the southeast section of the mountain with an altitude of 2380m (Fig 5; plate 3). Its height ranges between 9m and 11m, length of 120m and a width of about 70m. It is 4.5 Km from the park headquarters and 430m from Tega road. A tributary of Rongai River passes 20m from it. It has a moist forest cover containing Elgon teak and bamboo vegetation. It is one of the most difficult to locate due to the extent of thorny bushes and thick bamboo cover.

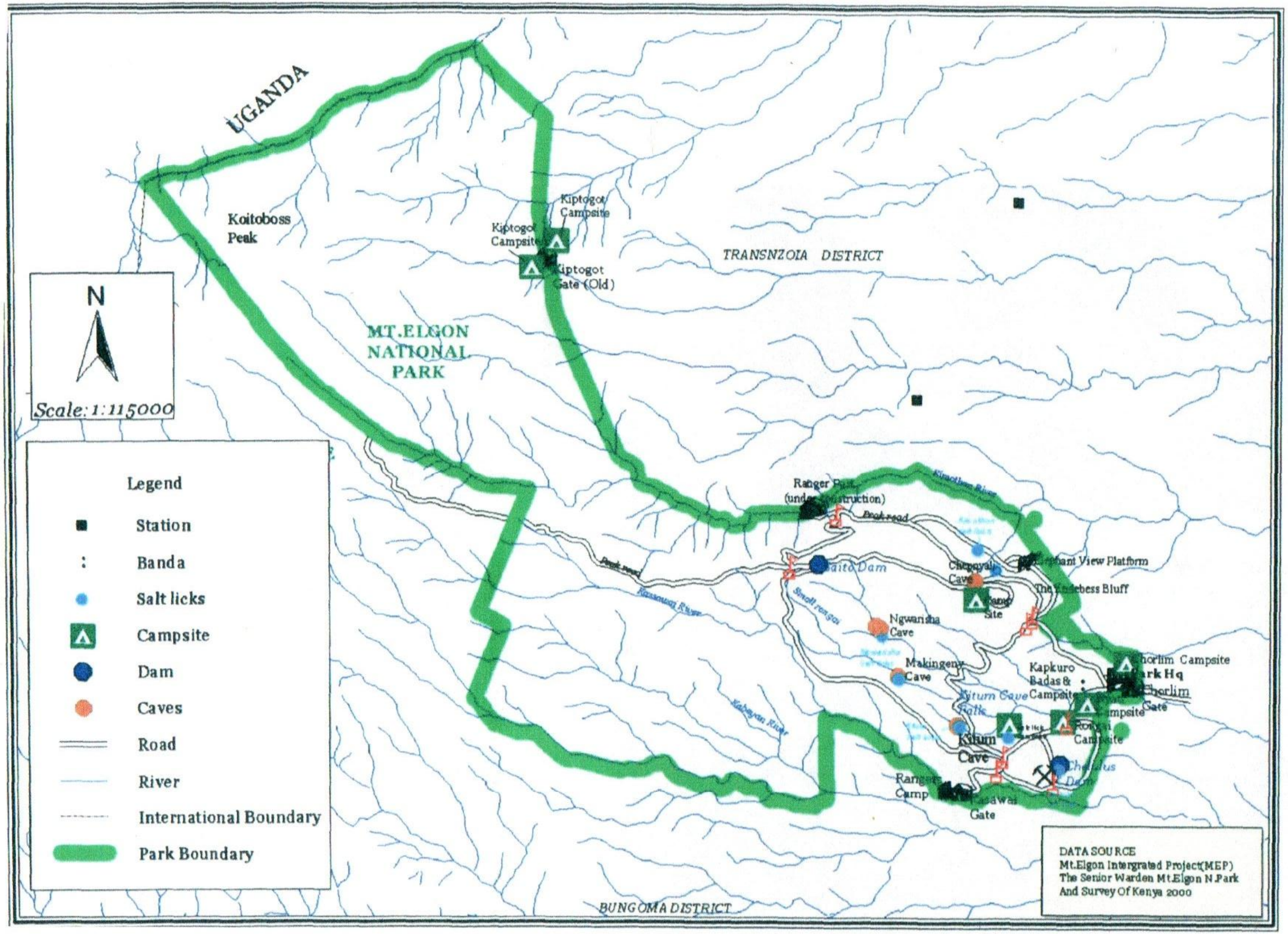

FIG. 5: DISTRIBUTION OF SALT LICKS

Plate 1: Entrance of Kitum Cave

N/B: at the bottom are grasses; in the middle are rocks that collapsed from the top section of the Cave; the middle dark region to the right is the entrance to the Cave; while the upper darker region is the path to the deep end of the Cave.

Plate [illegible]: Entrance of Makingenyi Cave

N/B: Left bottom side is vegetation; dark grey region is rock surface; the darkest region is the mouth of the Cave.

Plate 3: Entrance of Ngwarisha Cave

N/B: Left bottom corner is vegetation; middle dark area is the mouth of the cave; the upper dark grey section is the top rock surface of the cave; while tree vegetation appears on the right side of the plate.

4. *Chepnyalil salt lick* (cave) is on the southeast section of the mountain with an altitude of 2341m (Fig 5; plate 4). The height is 80m, length of 40m and a width of 50m. It is 5 Km from the park headquarters and 70m from the Peak road. Moist vegetation containing cedar and Elgon teak trees dominate the area. At the entrance are small bushes and grass vegetation.

5. *Campsite saltlick* (Maji ya Chumvi) is located along the road between Kitum cave and Rongai campsite (Fig 5; plate 5). It is 200m from the road and 2 Km from the park headquarters. One of the tributaries of small Rongai River passes through it. The vegetation around the saltlick consists of the East African aerial cedar (*Juniperus procera*), Elgon teak (*Olea capensis*) and rose wood (*Hagenia abysinica*) together with small shrubs. This is one of the most utilized saltlick by the animals in the park. The footprints around the saltlick provide evidence of frequent visitation.

6. *Chelulus saltlick* is located along Chelulus quarry and Chelulus Dam along the road to Kasawai Gate (Fig 5; plate 6). It is 1.5 Km from the park Headquarters. It is within an open area surrounded by mixed vegetation containing small shrubs, grass and scattered *helichrysums spp*.

7. *Kimothon* saltlick is located next to Chepnyalil cave but along the Tega road close to Elephant platform (Fig 5; plate 7). Mixed vegetation, small trees, shrubs and grass surround it.

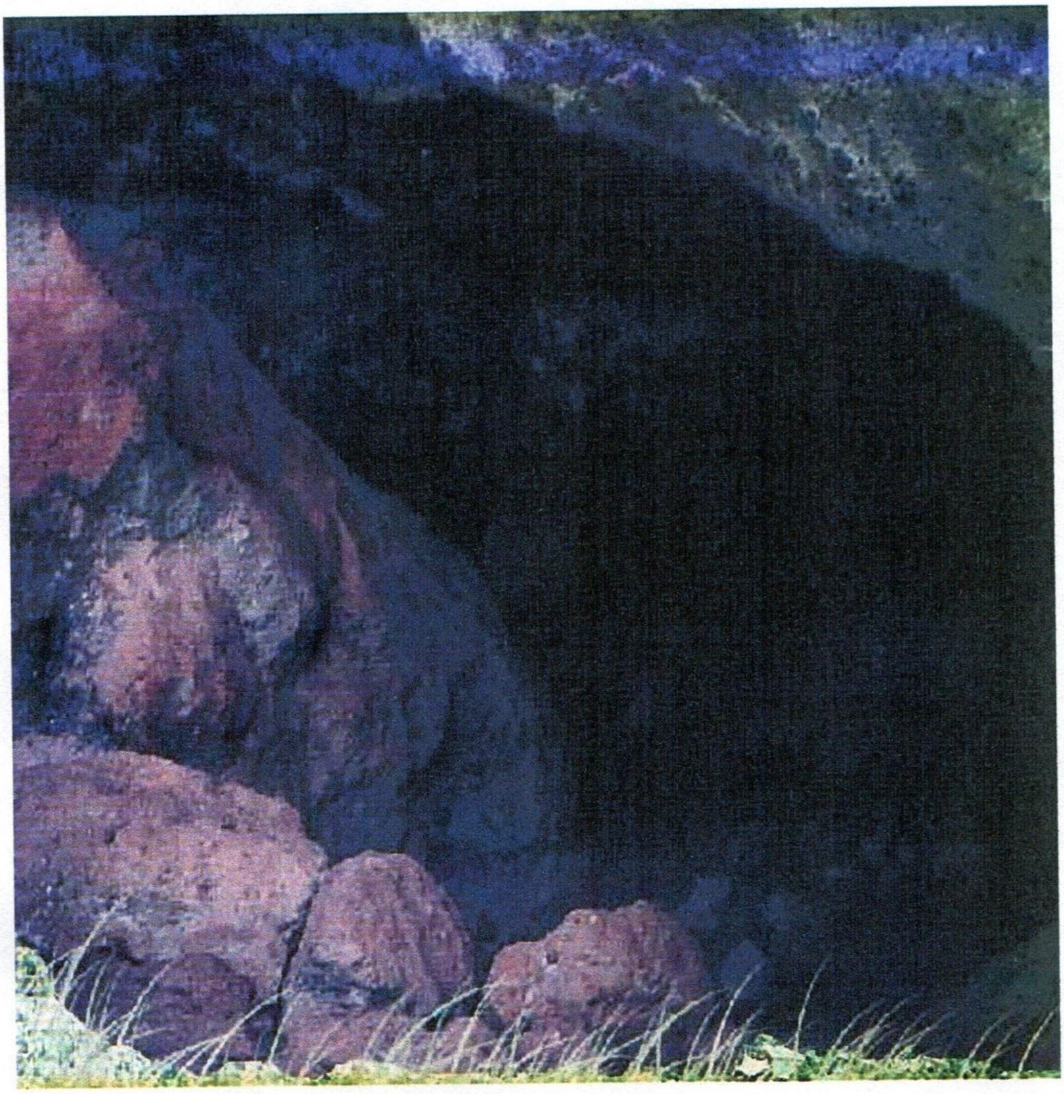

Plate 4: Entrance of Chepnyalil Cave

N/B: Bottom region is vegetation and grass cover; left are rock that fell from the cracked wall on the top surface of the cave; The darker side at the middle is the entrance to the cave; the upper right grey section is the top wall of the cave.

Plate 5: Campsite Saltlick (Maji ya Chumvi)

N/B: Bottom front region with a stream of water is the river valley rock surface; middle left and right is vegetation; middle section is the muddy saltlick with footprints of various animals; back right and left is the vegetation, road and a vehicle.

Plate 6. Chelulus salt lick

N/B: The brown section to right bottom corner is the saltlick; from the left corner to the middle and middle to the right middle is grass cover; the left top corner is the tree vegetation; looking on are the Waterbucks; at the middle top section is mixed vegetation and cloud cover on the far end; while the right top corner is the tree vegetation.

Plate 7: Kimothon salt lick

N/B: The brown patches are the saltlicks; bottom left and right to the middle is grass cover; top left and right are tree vegetation while the middle is the clear sky.

4.2.1 Discussion

All the seven saltlicks are distributed within the park. Kitum cave is located along the southern section of the park, and is on a gentle slope which makes it easily accessed by the elephants. The vegetation around Kitum cave includes the Rosewood (*Hagenia abysinica*), Elgon teak (*Olea capensis*) and East African pencil cedar (*Juniperus procera*). Makingenyi cave is located next to Kitum cave on Tega road. It is also on a gentle slope on the southern section of the park therefore making it easily accessed by the elephants. The vegetation around the park includes big and small trees containing cedar and podo trees.

Ngwarisha cave is located on the southeast section of the park is on a steeper slope compared to Kitum and Makingenyi caves. This might be probably one of the reasons why the elephants do not frequent the cave. The vegetation around this cave includes large bamboo and Elgon teak. Also there are thorny bushes which contribute to the difficulties that make the elephants not to enter the cave with ease.

Chepnyalil cave located along the southern section of the park is also on a steeper slope compared to Kitum and Makingenyi caves. This contributes to low frequency and less accessibility. The vegetation within this cave includes cedar and Elgon teak with small bushes and grass.

Campsite saltlick (Maji ya chumvi) is located along Rongai campsite. It is on a gentle slope therefore making its accessibility for the elephants easy. Being located along the road between Kitum cave and Rongai campsite, the existing human disturbances probably contribute to it being less visited. The vegetation around it contains East African cedar (*Juniperus procera*), Elgon teak (*Olea capensis*) and Rose wood (*Hagenia abysinica*) with small shrubs, which offer low element availability to meet the required mineral elements needed by elephants in their diet. As a result they are forced to search for more in the rock soils inside the caves.

Chelulus Saltlick is located between Chelulus Quarry and Chelulus dam on the southern section of the park. Its location along Chelulus quarry and Chelulus Dam creates a lot of human disturbances prompting to elephants moving away, therefore it is less visited. Though on gentle slope and therefore can easily be accessed by the elephants. The vegetation around this saltlick includes small shrubs, grass and scattered helichrysums spp.

Kimothon saltlick is located along Tega road on the southern section of the park. It is on a gently accessed slope. The vegetation around it includes small trees, shrubs and grass.

4.3.0 Saltlick utilization by elephants

4.3.1 Frequency of visits to the saltlicks.

The saltlick utilization by elephants was assessed using indirect method. The caves were visited early in the morning and elephant footprints identified. The intensity of utilization was classified using the frequency of footprints identified that day for each cave. This was done by grouping elephant footprints into, low (1-5), medium (6-10) and high (>10).

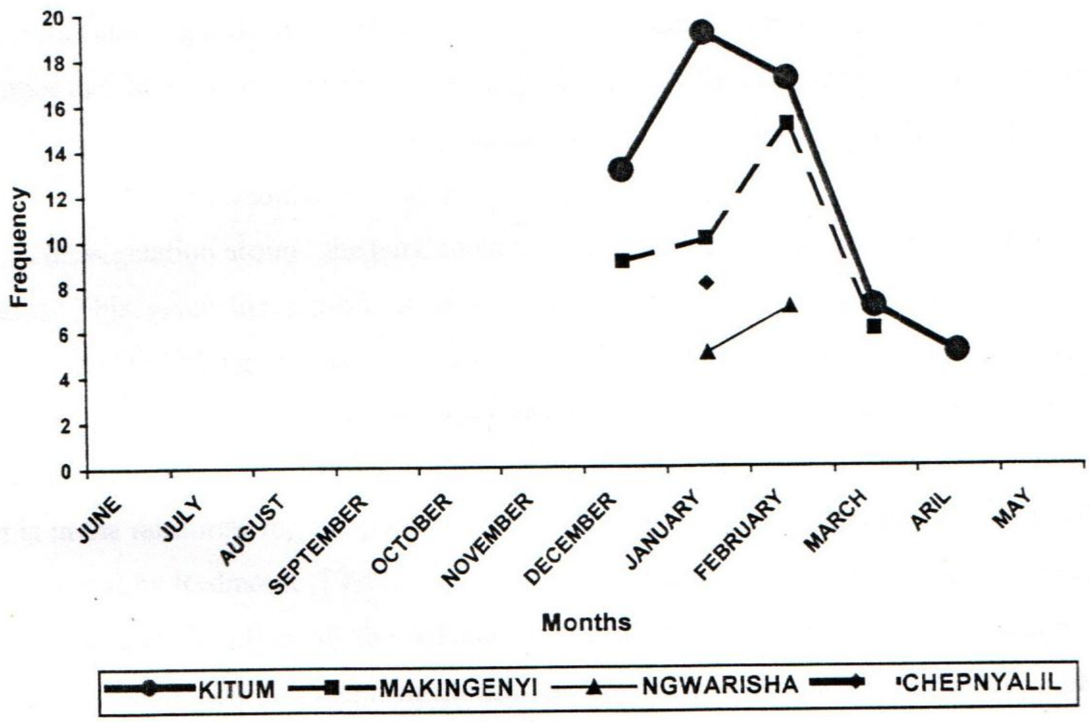

Figure 6: Frequency of Elephant visits

Figure 6 show that elephants visit and utilize Kitum frequently than the other saltlicks. There are high frequencies in Kitum than the other three saltlicks. High frequencies (>10 footprints) and low (<1footprint) were recorded between December and April. Further, the number of days recorded were high in Kitum than the other saltlicks for consecutive five month recordings. This showed that Kitum was highly frequented than the other saltlicks. Makingenyi also had high frequency between the months of December to March. While Ngwarisha and Chepnyalil received low frequencies respectively

4.3.2 Discussion

In this study, the elephant's frequency of utilization indicated that the elephants visited and utilized the minerals from the identified salt lick sites. From the frequencies at the four caves (Salt licks), it was clearly shown that the elephants had high frequencies at Kitum cave. This can be attributed to the gentleness in gradient, which made it possible for the elephants to access and utilize the minerals in the rock. Kitum was shown to have high frequency due to its high concentration of minerals especially Potassium followed by Sodium and Phosphorus useful in the formation of skeleton and regulation of body fluids necessary for growth and reproduction. High frequencies occurred during the months between November and May. It was observed that saltlicks were located along roads and river banks. These findings support Waweru (1993) study, which concluded that saltlicks are located along the roads and riverbanks.

The vegetation around the park could not possibly supplement enough elements to the elephants. This gives the reason as to why the elephants could supplement the missing elements through licking the cave rock. Redmond (1990), noted that elephants dig the soil or rock, then sweep up the bits with their trunk and lift them into their mouth. He added that the hunger for salt occurs when there is shortage of salt in that particular region. Because Mt Elgon is in the rainforest region, plants in the region may not provide enough minerals. These was also noted by Redmond (1990), when he observed that in the rainforest of East Africa for example, the rain dissolves all the soluble salts from the soils. As a result, the plants that grow in these soils do not contain much salt and any herbivore which feeds on these plants will have a salt deficiency diet. That is why the elephants enter and lick the salts in the caves.

Makingenyi cave (salt lick), like Kitum, receives high frequency of visits because of the availability of minerals especially potassium, sodium and phosphorus, which are in high concentrations. This can be attributed to the gentleness of the slope, which makes it accessible to the elephants unlike in Ngwarisha and Chepnyalil, which had low frequencies. Makingenyi cave received high frequencies in the months between November and April, but not as high as it was in Kitum cave. Although the scattered brown patches indicate that it is utilized but the extent of utilization is low compared to those of the caves. According to the distributions it was observed that the saltlicks were distributed along roads and river banks these was observed too by Waweru,1993 in his study of elephants of Aberdare National Park Kenya were the herbivore licked and utilized the minerals in the saltlicks that were leached and settled along roads and river banks.

Comparison of frequencies of saltlicks utilization indicates that the caves had higher frequencies compared to other saltlicks despite the fact that other saltlicks indicated that they are too utilized (plates5-7) but their locations along roads contributed to human disturbances and further to low frequencies of visits.

Apart from the elephants other animals too visited and utilized the same saltlicks throughout the year. These include the bushbuck (*Tragelaphus scriptus sylvaticus*); Buffalo (*Syncerus Ceffer*); and Impala (*Acpycerros Melampus*).

High frequencies of visits were experienced during the months between November and May. These were the periods when the rainfall was less and therefore made it easy for the elephants to access the salt licks. Presence of potassium, sodium and phosphorus in high concentrations together with calcium and magnesium prompted the visits. During wet seasons, the plants could not supplement enough minerals and therefore the elephants sought for the deficient mineral in the rock soil inside the cave.

According to the annual monthly rainfall distribution, it was clearly indicated that the rainfall fell between March and October. It showed two peaks in April and September when the rainfall recorded was a total of 220mm and 250mm respectively. Low rainfall fell between November and February. That is when the elephants' visits to the caves (saltlicks) were high.

4.4.0 Mean variation in Concentration of selected Macroelements between caves

Table 2: Variation in Concentration of Sodium in ppm between caves

Cave	Mean Conc. (ppm)	Std. Deviation	F value	Significance
Makingenyi	23.0600[a]	13.4766	0.339	0.798
Ngwarisha	30.0000[a]	22.8062		
Chepnyalil	33.0000[a]	22.5610		
Kitum	35.2000[a]	20.9332		
Total	30.3150	19.2146		

Note: The means with same letter are not statistically different from each other at $P<0.05$

4.4.1 Sodium

The table above indicates that Kitum cave has the highest mean concentration of Sodium at 35.2000ppm followed by Chepnyalil at 33.000ppm. Ngwarisha at 30.000ppm, and Makingenyi at 23.0600ppm respectively. Their concentrations were not statistically different from each other at $P<0.05$.

Table 3: Variation in concentration of Magnesium between caves

Cave	Mean Conc. (ppm)	Std. Deviation	F value	Significance Level
Ngwarisha	0.1460a	0.0709	3.159	0.054
Chepnyalil	0.2840b	0.1085		
Kitum	0.2960b	0.1655		
Makingenyi	0.3620b	0.0889		
Total	0.2720	0.1322		

Note: Means with same letter are not significantly different from each other at $P<0.05$

4.4.2 Magnesium

Table 3 above shows that Makingenyi cave had the highest mean concentration of Magnesium at 0.362ppm, followed by Kitum (0.2960ppm), Chepnyalil (0.2840ppm) and Ngwarisha (0.1460ppm) caves respectively. The mean concentrations at Kitum, Chepnyalil and Ngwarisha caves were not statisticaly different from each other at $P<0.05$.

Table 4: Variation in Concentration of calcium between caves

Cave	Mean Conc. (ppm)	Std. Deviation	F value	Significance Level
Makingenyi	0.1200a	0.0543	1.473	0.260
Kitum	0.2060a	0.0904		
Chepnyalil	0.2700a	0.0652		
Ngwarisha	0.2960a	0.2609		
Total	0.2230	0.1497		

Note: Means with same letter are not significantly different at P<0.05

4.4.3 Calcium

It is indicated in table 4 that Ngwarisha cave had the highest mean concentration of calcium at 0.2960ppm followed by Chepnyalil (0.2700ppm), Kitum (0.2060ppm) and Makingenyi (0.1200ppm) respectively. These concentration was statistically significant for the different caves at P<0.05.

Table 5: Variation in Potassium concentration between caves

Cave	Mean Conc. (ppm)	Std. deviation	F value	Significance Level
Ngwarisha	19.000[a]	7.4833	2.833	0.071
Chepnyalil	32.4000[ab]	11.2161		
Makingenyi	38.2000[ab]	15.6589		
Kitum	45.0000[b]	20.8207		
Total	33.6500	16.6553		

Note: Means with same letters are not significantly different at P<0.05

4.4.4 Potassium

Results above shows that Kitum cave had the highest mean concentration of potassium at 45.00ppm, followed by Makingenyi (38.2000ppm), Chepnyalil (32.4000ppm) and Ngwarisha (19.000ppm) respectively. The concentration in Kitum cave is significantly higher than that of Ngwarisha at P<0.05 as shown in table 5.

4.4.5 Phosphorus

Table 6: Variation in Phosphorus concentration between caves

Cave	Mean Conc. (ppm)	Std. Deviation	F value	Significance Level
Kitum	19.6000[a]	7.4364	2.530	0.094
Chepnyalil	26.0000[b]	6.7823		
Ngwarisha	30.4000[b]	13.1262		
Makingenyi	34.2000[b]	6.0992		
Total	27.5500	9.8220		

Note: Means with same letters are not significantly different at $P<0.05$

Results above indicates that. Makingenyi had the highest mean concentration of phosphorus at 34.2000ppm followed Ngwarisha(30.4000ppm), Chepnyalil (26.000ppm) and Kitum (19,6000ppm) respectively. The concentration was not statistically different between Ngwarisha, Chepnyalil and Makingenyi but slightly different from that of Kitum at $P<0.05$.

4.4.6 Discussion

Mean Sodium concentration in Kitum cave was higher at 35.2000ppm followed by Chepnyalil at 33.000ppm, Ngwarisha at 30.000ppm, and Makingenyi at 23.0600ppm respectively. Statistical analysis indicates that there were no significant differences in the mean sodium concentration at $P<0.05$ as in table 2. This implies that the general distribution of Sodium is fairly uniform for the sampled caves and therefore sodium levels are similar sccross the caves. Elephants seek to supplement sodium deficiency in any of the caves since the element is necessary for growth and reproduction (Morris, 1990).

Likewise Makingenyi had the highest mean concentration of Magnesium at 0.362ppm followed by Kitum at 0.2960ppm, Chepnyalil at 0.2840ppm, and Ngwarisha at 0.1460ppm respectively. However, Makingenyi, Kitum and Chepnyalil concentrations are not significantly different from each other as shown in table 3. They slightly differ from that of Ngwarisha meaning that Magnesium levels at Ngwarisha are slightly lower.

Mean Calcium concentration at Ngwarisha was higher at 0.2960ppm followed by Chepnyalil, Kitum and Makingenyi respectively. However, the concentration was statistically significant for the different caves at $P<0.05$. This implies that Calcium has uniform distribution at the different sampled caves, implying that its level is similar across board and therefore useful in bone formation (Church, 1977)

Mean Potassium concentration was higher at 45.00ppm followed by Makingenyi (38.2000ppm), Chepnyalil (32.4000ppm) and Ngwarisha (19.000ppm) respectively. The potassium concentration in Kitum cave was significantly higher than that of Ngwarisha at $P<0.05$ as shown in table 5. Animals with potassium deficiency are more likely to visit Kitum cave than Ngwarisha. It is useful in regulation ofv body fluids (McDonald and Edwards, 1995).

Mean Phosphorus concentration was higher at 34.2000ppm followed Ngwarisha30.4000ppm), Chepnyalil (26.0000ppm) and Kitum (19.6000ppm) respectively. Makingenyi had significantly higher concentration of phosphorus than Kitum cave at $P<0.05$. This implies that animals with phosphorus deficiency are more likely to visit Makingenyi cave than Kitum therefore they need it for metabolic purposes.

4.5.0 Mean variation in concentration of selected macro elements between sampling points

Table 7: Sodium concentration across sampling points

Sampling point	Mean Conc. (ppm)	Std deviation	F value	Significance Level
200m*	10.2500[a]	3.8837	17.856	0.000
End of Cave	42.2500[b]	10.3401		
Entrance of Cave	43.7500[b]	14.7733		
Middle of Cave	46.5000[b]	7.8528		
Total	30.3150	19.2146		

Note 1: Means with similar letter are not significantly different at $P<0.05$

2: * 200 meters to the cave entrance

4.5.1 Sodium

Results above shows that the mean concentration of sodium was found highest at the middle of the cave (46.500ppm) followed by the entrance and end of the cave respectively. But their concentrations were not statistically different from each other at $P<0.05$.

Table 8: Variation in Concentration of magnesium between sampling points

Sampling point	Mean Conc. (ppm)	Std. Deviation	F value	Significance Level
200m*	0.1750[a]	0.1034	2.596	0.079
End	0.3150[a]	0.1066		
Middle	0.3425[a]	0.1330		
Entrance	0.3575[a]	0.1330		
Total	0.2720	0.1322		

Note 1: Means with same letter are not significantly different at $P<0.05$

2: * 200 meters to the cave entrance

4.5.2 Magnesium

Results above shows that the mouth of the cave had the highest mean concentration of magnesium followed by the middle and end of cave respectively. Their concentrations were not statistically different from each other at $P<0.05$.

Table 9: Concentration of Calcium across sampling points

Sampling point	Mean Conc. (ppm)	Std. Deviation	F value	Significance Level
200m*	0.1225[a]	0.1094	2.816	0.063
Entrance	0.2500[ab]	0.1061		
Middle	0.2925[ab]	0.1401		
End	0.3475[b]	0.1696		
Total	0.2230	0.1497		

Note 1: Means with same letters are not significantly different at $P<0.05$

2: * 200 meters to the cave entrance

4.5.3 Calcium

Results above shows that the end of the cave had the highest concentration of calcium followed by the middle and mouth. 200 meters to the cave entrance had the least concentration of calcium at 0.1225ppm. The concentration at end of cave, middle and mouth are statistically similar at $P<0.05$ but differed from 200m to the cave entrance.

Table10: Variation of Potassium Concentration between sampling points

Sampling point	Mean conc. (ppm)	Std. Deviation	F value	Significance Level
200 m*	22.2500[a]	5.7155	2.757	0.067
End	37.7500[ab]	17.5570		
Middle	38.5000[ab]	14.7535		
Entrance	48.7500[b]	19.5000		
Total	33.6500	16.6553		

Note 1: Means with same letters are not significantly different at P<0.05

2: * 200 meters before cave entrance

4.5.4 Potassium

Results above shows that the mouth of the cave had the highest mean concentration of potassium at 48.7500ppm followed by the middle, and end of cave. 200 meters to cave entrance had the least concentration at 21.00ppm. Mouth, Middle and end of cave had statistically similar potassium concentration at P<0.05 but differed from the 200 meters to cave entrance.

Table 11: Variation in Concentration of Phosphorus between sampling points

Sampling point	Mean Conc. (ppm)	Std. Deviation	F value	Significance level
200m*	18.5000[a]	5.8023	4.970	0.009
End	13.7500[b]	6.3966		
Entrance	34.5000[b]	8.3467		
Middle	34.7500[b]	7.1356		
Total	27.5000	9.8220		

Note 1: Means with same letter are not significantly different at P<0.05

2: * 200 meters to the cave entrance

4.5.5 Phosphorus

Results above shows that the middle of the cave had the highest mean concentration of phosphorus at 34.7500ppm followed by the mouth and end. 200 meters to cave entrance had the least concentration at 18.5000ppm. Mouth, Middle and end of cave had statistically similar concentration of phosphorus at P<0.05 but differed from the 200 meters to cave entrance.

4.5.6 Discussion

Sodium concentration was found highest at the middle of the cave (46.500ppm) followed by the entrance and end of the cave respectively. It is therefore very likely that the middle of the cave is the favourite licking spot for animals i.e. animals start licking from inside the cave when looking for sodium as a supplement macro-element. 200m to the cave entrance had the least concentration of Sodium at 8.825ppm as shown in table 7. These findings support Dudley (2002) study, which concluded that elephants of Hwange National Park in Zimbabwe eat dirt to supplement Sodium. This view is supported even strongly in this research by the fact that Kitum cave which is the most visited cave has the highest concentration of Sodium as shown in of results.

Magnesium had the highest mean concentration at the mouth of the cave followed by the middle and end of cave respectively. 200 meters before cave entrance had the least concentration of magnesium at 0.1750ppm. Although the mouth of cave had the highest concentration, it does not significantly differ from the other sampling points. This implies that magnesium is fairly uniform in distribution within and outside the caves. This means that the elephants do not necessarily have to enter the cave to obtain the element since similar concentrations can be found outside. This implies that magnesium is not likely the mineral sought for when elephants enter a cave.

The end of the cave had the highest concentration of calcium followed by the middle and mouth. 200 meters to the cave entrance had the least concentration of calcium at 0.1225ppm. The concentration at end of cave, middle and mouth are statistically similar at $P<0.05$ but differed from 200m to the cave entrance. This generally implies that calcium is uniformly distributed within the cave but its concentration in the cave is higher than outside. Calcium had the least overall concentration compared to other minerals. This means that there are remote chances that elephants go to the caves for calcium. However the concentrations are higher, though not significant, in Ngwarisha and Chepnyalil respectively. Therefore in case of calcium supplement the elephants will visit these caves. Consequently, to get soils rich in calcium in these caves the elephants have to go deep inside the caves since the concentrations are high at the end of cave. Results of Waweru (1993) working in Aberdares National Park, indicates that calcium are probably one of the sought after minerals in the salt licks.

The mouth of the cave had the highest concentration of potassium at 48.7500ppm followed by the middle, and end of cave. 200 meters to cave entrance had the least concentration at 21.00ppm. Mouth, Middle and end of cave had similar potassium concentration at $P<0.05$ but differed from the 200 meters to cave entrance. This implies that potassium is uniformly distributed within the caves. Kitum and Makingenyi caves were the most frequented caves as shown in figure 6. Minerals tests established that the two caves have the highest overall concentration of potassium elements. This implies that the general preference of the two caves by elephants is due to the high concentration of minerals. Although other factors such as accessibility restrict elephants from visiting Ngwarisha and Chepnyalil caves, their low concentration of important macro elements does contribute to the low preference by elephants. Since the concentration declines towards the end of caves, the elephants continuously lick the rock therefore deepening the cave and with time they search for diminishing potassium minerals.

The Middle of the cave had the highest concentration of phosphorus at 34.7500ppm followed by the mouth and end of the cave. 200 meters to cave entrance had the least concentration at 18.5000ppm. Mouth, Middle and end of cave had similar concentration of phosphorus at $P<0.05$ but differed from the 200 meters to cave entrance. The implication is that phosphorus has a fairly uniform distribution within caves. Implying that, elephants could supplement the missing phosphorus at any point of the cave.

Elephants looking for phosphorus supplements are more likely to visit Makingenyi and Ngwarisha caves respectively since they have higher concentrations than other caves. Consequently in the caves they will be forced to dig the supplements at the middle of the cave.

Cowan *and Brink* (1971) suggested that it is not yet certain which mineral is the most sought at the licks, but it is clear here that the elephants seek potassium, sodium and phosphorus much more than calcium and magnesium.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1.0 Conclusion

The study confirmed that there are several natural saltlicks on the Kenyan side of Mt. Elgon National Park which are regularly visited by herbivores, among these only four saltlicks were frequently used by the elephants. These saltlicks are useful in provision of mineral elements that are necessary in an animal's diet for various body functions.

The concentration of magnesium, potassium and phosphorous varied between the caves and also within the caves indicating that the elephants can visit any cave for these mineral elements. Meanwhile the concentration of calcium and sodium showed no differences between the caves however calcium had higher concentration at the end of the caves compared to other sampling points in the caves indicating that the elephants will supplement the missing calcium by licking the soils at the end of the caves. Kitum was the most visited cave with high concentration of mineral elements especially phosphorous. This indicated that elephants frequented Kitum cave for its high concentration of elements much more than the other caves.

Results indicated that the frequencies of visits and depth of caves visited were determined by the presence of high concentration of mineral elements especially sodium and potassium in the rock soils of Mt. Elgon National Park. The elephants were observed to be visiting caves with high concentration of mineral elements than those with low concentrations to source the required mineral elements in them.

5.2.0 Recommendations

Sodium, calcium and phosphorus should be supplemented at appropriate sites where tourists can easily access the elephants. This will alleviate the problem of elephants risking their lives inside the deep caves. From the study it was observed that elephants visited the caves as far as 300 metres deep, indicating that the mineral elements are not sufficient in their diet. Therefore, they are forced to lick the salts in the caves with greater depth.

A general reconnaissance survey should be conducted in the whole park to establish the distribution of macro and microelements present in the rock soils and plants of Mt. Elgon National Park, which were not dealt with in this study. This will be important because elephants need these minerals for various biological and physiological activities. The elements which are not found in foliage will probably be in the soils thus need for more studies.

Long-term ecological monitoring programme should be established to provide information on Herbivore movement, macro and microelement deficiency in the soil and foliage. This will give a clear insight as to which elements are sought for by the elephants which contribute to their visits to the caves that are not supplemented in the foliage. Herbivore movement varies with seasons thus there is need to establish which particular season (s) elephants are present on the Kenyan side and when they are in Ugandan side and they frequency of visits to the caves.

To enhance tourism in the park, more aggressive marketing and opening of more roads to encampass all habitats would be necessary. The park management should consider diversification of tourism activities in the park. This includes rock climbing, bird watching, biking and cycling in the moorland, all these will promote tourism and increase visitor numbers hence source of foreign exchange earnings.

REFERENCES

Ayeni J. S. O. 1971. *Big game utilization of natural mineral licks in wildlife management in Savannah woodlands* (edited by Ajay S.S) Taylor and Francis Ltd. 85-95.

Bitok.A. 2002. *A Survey of Mt. Elgon Forest.* Annual report. pg 4.

Bot Kin, D.B; Jordan, P.A. and Dominick, A. S. 1973. *Sodium analysis in a northern ecosystem* National, academy of science Vol. 70 2745-2748.

Bronner, F. 1964. *Dynamics and functions of calcium in mineral metabolism* Vol. 2 part A (Edit by C. L Comar and Bronerds. F). New York Academic Press 341-444.

Church. D.C. 1977. *Livestock feeds and feeding* Oxford University Press 19-20.

Cowan,D.and Brink, R. 1971. *Assessment of the ecological importance of natural licks along the eastern slopes of the Rocky Mountains in southern Alberta.* Canada. J. Soil. Sci. 78: 202-209.

Donnison, J. 2002. *Trace elements and saltlicks for Horses.* Bridkes and bits Parksville Titheban Ltd, Canada. Pg 49.

Dudley, J. and Ricardo, M. 2002. *Geophagy in the African elephants, in relation to availability of dietary Sodium.* J. Mammology. 33: 217-218.

Forbes, J. M. 1995. *Voluntary food intake and Diet selection in farm Animals.* Anitony Rowe Ltd, UK. Pp 238-240.

Hafez, E. S. and Dyer, A. 1969. *Animal growth and nutrition.* Lea and Febiger, Philadelphia. Pg 319.

Hanson. R. 1985. *Elemental content of animal licks along the Eastern slopes of the Rocky Mountains in southern Alberta.* Canada. J. Soil. Sci. 76: 509-512.

Hirst, S. 1975. *Ungulate Habitat relationship in South Africa 55-65.*

Lasan, H. A. 1971. *Habitat management wildlife conservation with respect to fire, saltlick and water regime in wildlife management in Savannah woodlands* (Edit by Ajay, SS) Taylor and Francis Ltd. 96-105

Maskall, J. E. 1987. *The mineral status of L. Nakuru National Park, Kenya. A reconnaissance survey founded by the people's trust for endangered species.* London Pg. 16.

Maskall, J. E. 1991. *The influence of geochemistry on trace elements on soils and plants in wildlife conservation areas of Kenya.* PhD thesis, University of London. pp93-107.

McDonald, P; Edwards, R.A. and Greenhalgh J. F. G. 1973. *Animal Nutrition* 4th Ed. New York Longman Ltd. Pg 90.

McDonald, P; Edwards, R.A. and Greenhalgh J. F. G. 1973. *Animal Nutrition* 6th Ed. New York Longman Ltd. Pp 101-110.

McNaughton, S. J. 1988. *Mineral Nutrition and spatial concentrations of African Ungulates.* Nature Vol. 334:343-345.

MEICDP. 1999. Annual Report.

Morris, S. G. 1980. *Assessments of sodium requirements of grazing beef cattle.* A review, J. Anim. Sci. – Vol. 50: 145-152.

Mugo.E .N. 1999. *Review of the management of the forest resources of Mt. Elgon Ecosystem. Kenya.* Annual report, pp 16-18.

Okalebo J. R; Gathua K.W. and Woomer P.L 1993. *Analysis of Total Nitrogen and Phosphorus in plants and soils.* In: Laboratory methods of soil and plant Analysis: A working manual page 22 – 29.

Pond W.G.; Church D.C.; Pond K.R. 1992: *Basic Animal Nutrition and Feeding:* 4th Ed. John Wiley and sons, Inc. pg 303-323.

Pond W.G.; Church D.C.; Pond K.R. 1995: *Basic Animal Nutrition and Feeding:* 6th Ed. John Wiley and sons, Inc. pg 569-572.

Redmond, J. 1990. *The Cave elephant Mt Elgon national park East Africa.* Wild. J.Vol. 8: 29-37.

Redmond,J. 1990. *Animal Habitats: The Elephant in the Bush, Oxford* Scientific films. Belitha press pg 13-15.

Redmond,J. 1990. *The Elephant Book for the Ele-friends campaign,* Walker books Ltd. London. Pg 25

Robbins, T. 1983. *Wildlife feeding and Nutrition.* New York Academic press. 30-60.

Robinson, W. L. and Bolen, E.G. 1984. *Wildlife ecology and management.* Macmillan publishing Co. 130-135.

SPSS for WINDOWS release 6.1 (1995).

Theodore 1964. *Livestock and Livestock Products*. Prentice Hall, Inc. Pg 44.

Waweru, F.K. 1991. *The impacts of translocating Black Rhinoceros (Diceros bicornis) to Lake Nakuru National Park, Kenya. Ph. D. Thesis.* University of Nairobi.

Waweru, F.M.W.1993. *Mineral compositions of saltlicks in the salient of Aberdare National Park during the dry season.* A dissertation, for Bsc. Moi University Kenya.