INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Feeding Habits of the Roan Antelope *Hippotragus Equinus* (Desmarest, 1804) in Gbele Resource Reserve

George Dery
Tutor, Department of Science and Mathematics
Kaleo Senior High School, Kaleo, Upper West Region, Ghana

Abstract:
Knowledge on the food habits of range animals is an essential tool for rangers and other range scientists for effective and sustainable management of rangelands and its resources. Such information provides a greater opportunity to assess the diet of animals and to evaluate any potential forage competition among herbivores. The aim of the study was therefore to use microhistology to predict the forage species consume by the roan antelope; to assess whether seasonal changes affect the diet and feeding habits of the roan antelope in the study area; and to determine the proportions of the different forage species consume by the roan antelope. The scraping method was used to study the foliar epidermal characteristics of plants. Thirty (30) faecal samples were collected along transect lines and were identified by the shape of pellets and nearby hoof prints. Microhistological faecal analysis technique was used to analyse the faecal matter. Among the plant species predicted in faecal matter, Andropogon gayanus, Hyparrhenia spp, Hyperthelia dissoluta, Gardenia spp and Afzelia africana were the most dominant forage species in the diet of the roan antelope. Browse to grass ratio was highest in the warm-dry season, low in the cool-dry season and lowest in the rainy season. There were inter-seasonal and intra-species differences ($p < 0.05$) in the consumption of plant species in all the three forage categories (grass, browse and forbs). Diet proportions of the three forages indicated that roans are mixed-feeders. On the average roans consume more grass than browse and forbs; (37% grass), (30% browse), (19% forbs) and unidentified forage (14%). The results suggested that, seasonal changes and forage type influenced the feeding habits and diet of the roan antelope.

Keywords: *Microhistology, diet, browse, forages, antelope*

1. Introduction

Gbele Resource Reserve is the northern most wildlife protected area in Ghana closest to Burkina Faso. It is situated in the upper West Region of Ghana. The reserve serves as a trans-boundary migratory route for elephants and other mammals to and from the Nazinga Game Ranch in Burkina Faso (Wildlife Division, 2009; Ghana National Parks, 2007). The reserve was gazatted purposely to conserve the large population of the majestic roan antelope in the area and the undisturbed Guinea savannah ecosystem. The roan antelope is one of Africa's most attractive antelopes that has a particularly large distribution range and occupy all savanna areas and peripheral semi-arid areas south of the Sahara(Toms and Joubert, 2005). Their optimal habitats consist of open medium to tall grasslands fringed with an ecotone of woody vegetation. These habitats are particularly well represented by shallow, grass-covered drainage systems associated with miombo woodlands. They are also partial to open savannah woodlands, the major features being medium to tall grasslands and fairly open woodland. They are mainly grazers and by preference do not feed lower than approximately 15cm from the ground (Toms and Joubert, 2005).

Despite being one of the most reproductive antelopes, it is now one of Africa's most endangered antelope species. In 1996, the roan antelope was classified as a low risk; conservation dependent species by the International Union for the Conservation of Natural Resources. However, the new IUCN (2004) red data book on mammals of Africa classified it as vulnerable. It is a specialist grazer rarely feeding on leaves, and this is one of the reasons why it is endangered in some areas. Without the protection of nature reserves and national parks they have little chance of survival (Toms and Joubert, 2005; Ignas and Norman, 1998).

Dietary information of large free-ranging herbivores has become an increasingly important tool in food resources management. Such information allows assessment of nutrition intake of animals and evaluation of potential forage competition among herbivores. The study of the food habits of herbivores is highly essential for effective and efficient range management (Holechek *et al.,* 1982; Michael *et al*., 1983).

Again, knowledge of range herbivore food habits is essential for efficient range management. This information is required for optimal forage allocation to different types of herbivores, selecting types of grazing animals that are compatible with the forage resources, selecting species for reseeding deteriorated ranges, predicting the out-come of overgrazing by different animals, identifying new

species on which to base management, and determining the suitability of domestic and wild animals for a particular range type. Presently, the knowledge of range herbivore food habits is far from complete and much more information will be needed in the future if range management effectiveness is to be improved (Holechek *et al.,* 1982).

Furthermore, food habits are useful in assessing herbivores impact on rangelands and making management decisions (Eliana and Roberto, 2002). Knowledge of food habits can be used as a management tool to assist in wildlife management, range management and rehabilitation of disturbed rangelands. The identification of plants is important in pinpointing damage to agricultural crops, forest and animal losses due to poisonous plants intake. An increasing interest in the results of diet composition is the establishment of a baseline data as preliminary information for environmental impact assessment, range improvement plans and surface reclamation. The records of foods eaten by herbivores may be used for nutritional decisions (Heady and child, 1994).

1.1. Problem Statement and Justification

In recent times the roan antelope is regarded as one of Africa's most endangered antelope species mainly due to habitat removal and poaching. In 1996, the IUCN classified the roan antelope as a low risk, conservation dependent species. However, the 2004 IUCN Red Data Book on mammals of Africa classified the animal as one of the most vulnerable antelope species due to habitat destruction resulting from environmental degradation and desertification. In 1961, the species was reintroduced into Swaziland where it became extinct due to habitat removal and poaching. Unfortunately, however, the natural causes are compounded by man–made causes which restrict the ability of wildlife to adjust. Competition with man, livestock and crops produces a fragile equilibrium which is immediately destroyed to the detriment of wildlife when the pressure of desertification increases (FAO, 1993).

Furthermore, increased desertification causes damage to animal species. Land degradation has a major impact on the environment causing biodiversity loss and loss of productive capacity. Desertification results in damage to wildlife habitat and plant species. The lack of water and food which is the result of desertification has a great impact on animals and plants in drought affected areas (Cotthem, 2008). Land degradation and desertification lead to increased predation and diseases on wildlife.

Inspite of the above challenges very little work has been done so far with regard to diet composition and feeding habits among large herbivores in Gbele resource reserve which is prone to frequent wildfires, indiscriminate harvesting of fuel wood, rapid encroachment and poaching.It is against this background that this study is been conducted to evaluate the botanical composition of the diet of the roan antelope and its feeding habits so that reserve management can strategies for optimum production and efficient utilization of forage resources in the reserve.

1.2. Research Questions

1. What do roans eat?
2. Is it possible to determine the proportions of forage species consume by the roan antelope through microhistological analysis of faecal samples?
3. Are there any seasonal changes in the feeding habits and diet of the roan antelope?

1.3. Objectives of the Study

The study has the following as its specific objectives.

1. To identify the different forage species consume by the roan antelope in Gbele resource reserve.
2. To determine the proportions of the different forage species consume by the roan antelope.
3. To assess whether any seasonal changes affect the diet and feeding habits of the roan antelope in the study area.

2. Literature Review

2.1. History and Description of Microhistology

In the last few years, information on the methodology for studying range herbivore food habits has substantially increased (Holechek *et al.*, 1982). There are a variety of analytical methods currently available to the researcher interested in herbivore diet composition. However, no single method can be considered absolutely reliable. Each of the various dietary analysis methods such as direct observation of the animal, utilization techniques, stomach content analysis, faecal analysis and fistula techniques must be considered by the researcher along with factors such as the research requirements, capabilities and budget. Many factors in data collection alone can influence the end data (Dove and Mayes, 1996).

The study of herbivore food habits using microhistological analysis of faeces was originally developed by (Baugartner and Martin, 1939) with squirrels. Since then, this method has been used by many different researchers to study the food habits of different species of herbivores including the roan antelope (Schuette *et al.,* 1998). According to Desbiez *et al.* (2009), microhistological faecal analysis means identifying plant fragments in faecal samples by comparing them to a reference collection of various plant species. Microhistological investigations from large mammals or herbivores provides the researcher with information over several periods of feeding rather than short time spans of hours or individual meals because of the time involved for residues to pass through the animal (Robbins *et al.,* 1995).Faecal materials are useful in assessing monthly, seasonal or annual diets and diets representing foods eaten on an area basis, regardless of season. Faecal analysis has been used extensively in recent years to evaluate diet botanical composition of wild herbivores. This procedure gives good precision but accuracy is a problem because of differential digestion between plant species (Holechek *et al.,* 1982).

Microhistological faecal analysis has become the most widely used method for quantifying botanical composition of masticated forage or faecal material. Recent studies have given an accurate representation of percent diet botanical composition by weight if observers use hand compounded diet to check their accuracy (Holechek*et al.,* 1982). Microhistological faecal analysis has become the most commonly used and successful method for determining micro-animal diets (Maria and Stella, 2001). Chemical and botanical analysis of faeces provides information on diet quality and composition that is not easily collected directly from grazing animals. However, faecal excreta are readily available in pastures that animals graze (Hinnant and Kothmann, 1988).

2.2. The value of Plant Epidermal Characters in Microhistology

The epidermis of grass leaves exhibits several characteristics which are useful in identifying members of the family Graminae (Dumham, 1988). Leaf epidermal characters have been used extensively in the identification of grass fragments found in faecal and stomach content of animals (Schuette *et al.,* 1998, Stewart, 1967). Epidermal micromorphology of leaves is used in emphasizing the interrelationships and segregations into major clades. Epidermal micro characters are quite important to delineate the different taxa in terms of taxonomic considerations (Raole and Desai, 2009). Indeed, foliar epidermal characters of the angiosperm depict a sufficient diversity of details due to its genetic and environmental make up. Poaceae is the widely observed family from artic to seashore and from wetlands to arid regions. Micromorphological characters are valuable for systematic studies in the family poaceae. Numerous reports on foliar anatomy are used for delimiting the different groups and specifically subfamilies or tribes in the family poaceae (Ellis, 1987). Besides the epidermal characters of leaves and stems other features; like microhairs, papillae and silica bodies have been considered of significance in segregating the taxa at various levels. Earlier, silica bodies and structure and composition have been used for the differentiation between the various grasses from the world. Leaf epidermal studies are important in segregating the different broad groups within the grasses particularly tribes and subfamilies and even up to the genera (Ellis, 1987). The techniques of plants epidermal cells analysis were used to identify the grass species in the diet of (impala) *Aepyceros melampus* (Dunham, 1988), and the roan antelope (Schuette *et al*., 1998).

2.3. Physical Characteristics of the Roan Antelope

The roan antelope (*Hippotragus equinus)* belongs to the kingdom animalia and the order artiodactyla. The roan antelope is one of the largest antelopes in the world (Spinage, 1986). It has sloping withers accentuated by a short mane; long tufted ears and a distinctive black and white patterned face. The body colour is uniformly dark rufous to reddish fawn and females and young males being redder than adult males and resembling the female sable antelope. The horns are fairly thick and heavily ridge and curved backwards (Spinage, 1986).

According to the International Union for the Conservation of Natural Resources (IUCN, 2008), the roan antelope stands about a meter and half at the shoulder and weighs around 250kg on the average. They have a lighter underbelly, white eyebrows and cheeks and a black face, lighter in females. There is a short erect mane, a very light beard and prominent red nostrils. The horns are ridged and can reach a metre long in males, slightly shorter in females (IUCN, 2008).They arch backwards slightly. They are similar in appearance to the sable antelope and can be confused where their ranges overlap. However, sable antelope males are darker, rather than dark brown.

Theodor (1992) reported that roan antelopes are horse-sized. Horns are present in both sexes rising more or less steeply and curved backwards with the tips generally diverging and contain 20– 40 rings. Coat is short and smooth. Short stiff mane from neck to wither and in front of neck. Ears are long and narrow with tips of 3 -5cm long tufts. Crown and back of ears light brown with tail reaching heels. The upper side of the body is grey and under side grey to yellowish white. Neck mane greyish-brown with brownish-black edges (Theodor, 1992).

The name roan stresses a resemblance that is more than superficial for all the hippotragines. This species has converged most with horses and fills a similar niche (kingdon, 1997). It is possible the parallelism may be relevant to several aspects of the roans' gene biology including its distribution. Both sexes are similar but the male is more heavily built, particularly in horns, head and neck. The male has black and white facial markings which also tend to show more contrast and in this species the signalling system is almost entirely concentrated in movement of the head, ears and tail (Kingdon, 1997). The body is sand-fawn, a good camouflage to predators.

According to Richard (1992), the roan antelope is the fourth largest antelope, tall, sand-coloured with striking black and white mask and long tufted ears. The antelope has an average height of 126cm to 145cm and an average weight of 242-300kg for males and 260-280kg for females. Horns are curved backwards, massively ridged, and relatively short and ranges between 55cm-99cm (Richard, 1992). Geographically, the roan colour varies from pale grey to rufous coat with black mask and nostrils contrasting with white "eye brows", lips and jaws. Ears are coloured and tail with dark terminal tuft. Both sexes look much alike but male more robust with bigger horns, blacker mask and pendant penile sheath. New born calves are without clear markings, very similar to sable calves (Richard, 1992).

Roans are the second largest antelope species. Their pelage is greyish –brown with a hint of red. The legs are darker than the rest of the body. Young roan antelopes are much lighter and reddish-brown. The head is dark brown or black with white colour around the mouth and nose, large white patches in front of the eyes and pale patches behind them. The ears are long and narrow with dark brown hair at the tips. Roan antelope has a mane consisting of short stiff hair that is black at the tip. Horns in both sexes rise from the top of the head and sweep backwards in an even curve, ridged almost to the tips and are often described as similar scimitar-shaped. Females have two pairs of teats between their hind legs. Males are larger and built sturdier than females with longer thicker horns. The penis sheath is clearly visible. Males weigh from 260 – 300kg.Females weigh from 225 – 275kg.Males are from 150 -160cm high at the shoulder and females ranges from 140 – 160cm in the shoulder height (African Hunters Adventures, 2001 cited by Roe, 2002);

Grzimek, 1960). Roan antelope is one of the largest and most formidable African antelopes and a member of the tribe Hippotragini; the so-called horse antelope (Encyclopaedia Britannica, 2011). This is a powerfully built animal with long sturdy limbs and a thick neck that looks thicker because of upstanding mane and a beard. The head is long and narrow with a wide gape framed by long tasseled ears. Named for its colour, the roan antelope is reddish grey to reddish brown with a striking black and white facial mask. The sexes look much alike, standing 126 – 150cm high. Males are heavier and have thicker sickle-shaped horns which are 10 – 20 percent longer than those of females (Encyclopaedia Britannica, 2011). The upper body is grizzled grey to roan in colour with the legs darker. The under parts are white. On the face there is a black and white facial mask, slightly in females that consists of a white spot on either side of the eye and a white muzzle (Wilson and Reeder, 1993).

On the neck and withers is an erect dark-tipped mane, while a light "bear" is present on the throat. A long tuft of dark hair is present on the tips of the ears. The arched ridged horns are found in both sexes though slightly smaller in females (Nowak, 1991). Spinage (1986) reported that the roan antelope is one of the largest African antelopes. The roan antelope has a grey coat with black and white facial markings, very long pointed ears that are tufted at the tip and long horns that strongly curved backwards. The female is smaller to the male and has smaller and less heavily ridged horns (Parka, 1990).

2.4. Social Organization of the Roan Antelope

The roan antelope lives in smaller herds of up to 20 heads but sometimes form larger companies (Spinage, 1986). Roan antelopes commonly fight among themselves for dominance of their herd, brandishing their horns while both animals are on their knees (International Union for the Conservation of Natural Resources, IUCN, 2008).

According to Theodor (1992), the roan antelope has a home range of 50 – 100 square kilometres in size within which they wander especially in the dry season, otherwise they remain local with troops of females in ranges of 250–300 hectares, marked and defended by males. Roan antelopes are always in smaller groups of 3–15, at most 25, only near dry season in herds of up to 60 or more (Theodor, 1992). Mostly one old male keeps a strict watch on the troops with several females and young. Young males are often in separate troops for 3–4 years, having being driven away from female troops at 2½ years by older males. Roan antelopes associate with other wild beasts such as buffaloes, zebras, ostriches, but can sometimes become solitary (Theodor, 1992).

Furthermore, rival males fight on their knees with violent backwards sweeps on the horns.Female nursery groups and the bachelors establish hierarchies, probably on an age basis. Low intensify fighting is frequent among immature animals and constant skirmishing between the bachelors results in social ranking order among all the members of a group (Kingdon, 1997). Over a period of 2 to 3 months the herd bull could be ousted by a lone male that had previously moved about on the peripheries of the herd. The attachment of a herd of roan antelope to a particular locality is not reinforced by intense herding behaviour on the part of the bull. Indeed, apart from the intolerance of other males, the herd bull behaviour is not dissimilar to that of a top raking female (Kingdon, 1997). Throughout Africa, herds are commonly seen to restrict their activity to the immediate vicinity of a drinking point with sudden moves to relatively distant localities. Sometimes the moves may coincide with a change in the seasons but at times there is no obvious explanation for decamp (Kingdon, 1997). Solitary moves and bachelor groups are not frequently observed near herds. Solitary bulls can be aggressive and not only to their own species but to other species. Like most antelopes, roans thrash their corrugated horns against trees and bushes and mature male's horn the grounds as well, a practice which greatly reduces the length and blunt the tips of the older males' horns.Intraspecific conflict or contests could be severe and a patch of ground extensively ploughed up and bloody during a fight (Kingdon, 1997).

Richard (1992) reported that roans live in smaller herds and maintain a greater individual distance estimated at 7m between lying roans.A herd consists of females and young that shares a traditional and exclusive home range of 60–120 km^2.Ranges are smaller and herds tend to be larger in the dry season, but in any case herds' composition varies from day to day. Group composed largely of young animals many remain separated from hours and even days from group of adult females containing most of the mothers (Richard, 1992).Evidence of that social bond between immature classes is stronger than between mother and young. Sex and age subgroups occur whenever young of approximately the same age are present. Observation of herds in which two females were consistently nearest neighbours suggests that bonds between calves or possible mother and daughter may persist for years (Richard, 1992).Males are tolerated in the female herds until adolescence at around 2 years.Young males placate the aggression of territorial males for a time, but at age 3, they are relegated to bachelor herds where they live until maturity in their sixth year. Bachelor herds usually number under 10, rarely up to 17 head.

2.5. Ontogeny and Reproduction of the Roan Antelope

There has not been a specific breeding season for the roan antelope. Females become sexually receptive within three weeks of giving birth and are capable of reproducing every 10– 10.5 months (Walter, 1990).A pregnant female will separate from her herd prior to giving birth and remain with her new calf for about five days afterwards. After the female has re-joined the herd, the young calf remains concealed for five more weeks and subsequently join a "crèche" with other youngsters in the herd (Nowak, 1991).

Dominant males mate with females in their herd and actively defend access to those females. Males fight among themselves for positions as dominant males with a herd of females. These fights can be ferocious but rarely result in death. Males fight with their scimitar-shaped horns (African Hunting Adventures, 2001 cited by Roe, 2002).

Females go into oestrus 2 to 3 weeks after giving birth. A single calf is born after a gestation period of 260 to 281 days. Female roan antelopes become reproductively active after they reach 32 to 34 months of age (African Hunting Adventures, 2001 cited by Roe, 2002).They leave the herd for about one or two weeks before giving birth. After giving birth they return to the herd during the day and

leave the new-born in hiding for a day. They return to the calf at dusk and spend the night with it. Calves stay hidden for about four or five weeks after birth and join the herd after they are strong enough to outrun danger (Wildlife Africa, 2001 cited by Roe, 2002). Cows reach sexual maturity at the age of two years and drop their first calf at the end of their third or early in their fourth year.There is no well-defined calving season and calves may be born at any time of the year. Cows come into cycle roughly three weeks after giving birth and if they do not conceive, they again come into cycle three weeks later. The gestation period is nine months and the inter-calving period is about 320 days.This implies that cows are capable of giving birth to six calves in every five-year cycle. No other large antelope in Africa is known to have such a high reproductive rate (Toms and Joubert, 2005).

2.6. Geographical Distribution of the Roan Antelope

According to Spinage (1986), the distribution of the roan antelope encircles the Congo forest and it is one of the most common West African antelopes favouring the relatively high rainfall Sudano Guinean zone. It is also common in the woodlands south of the equator. Roan antelopes are commonly found in Africa south of the Sahara. They are geographically distributed in the Sudan roughly between 15^{o}S–15^{o}N from Gambia to West Ethiopia, South through Central and East Africa to South Mozambique, Swaziland, North Botswana, Angola and South Africa. In many regions they are extinct or threatened (Theodor, 1992).

Richard (1992) reported that the roan antelope was formerly the widest-ranging antelope found nearly throughout the better-watered parts of northern and southern savannah, from sea level of 2400m and penetrating into adjacent arid zone, yet strictly absent from the eastern part of the southern savannah. Although now greatly reduced to both poaching and elimination of habitat, it was never an abundant species and a dominant herbivore in parts of southern range. It is a rare species in South Africa and Kenya where it is commonly found in Lambwe near Lake Victoria (Richard, 1992). Roan antelopes originally occurred over a very wide range of most wooded grasslands and they were once common all over the better watered areas of northern savannah between the tropical forest and the Sahara. In southern savannahs its distribution seems to have been patchier and has apparently been absent from large areas on the eastern side of the African continent for as long as there are records (Kingdon, 1997).

The geographical range of the roan antelope extends across broad-leaved deciduous woodlands in the northern savannah and throughout most of the southern savannah. A grazer and a browser whose preferred habitat includes lightly wooded savannah and its frequent flood plains and montane grasslands. It is mysteriously absent from Africa's eastern 'miobo' woodlands and has become scarce in its southernmost range, especially in South Africa. Formerly very common in West Africa, it has been eliminated from many areas by settlement and poaching (Encyclopaedia Britannica, 2011). Its preference for relatively open habitat along with its size and sedentary habits make this species especially vulnerable.

Kingdon (1997) reported that roans are commonly found in lightly wooded country and grasslands throughout most of central Africa. Roans have a particularly large distribution range and occupy all savannah areas and peripheral semi-arid areas south of the Sahara. They avoid forests and deserts.

2.7. Habitat Requirements of the Roan Antelope

According to the International Union for the Conservation of Natural Resources (IUCN, 2008) roan antelopes are found in woodland savannah mainly in the tropical and subtropical grasslands savannah and shrub lands biomes, which range in tree density from forest with a grassy under storey such as central Zambezian 'miombo' woodlands to grasslands dotted with few trees where they eat mid-length grass. Roan antelopes prefer open wooded land or dry bush savannahs, gallery forest, light woodland in plains and hills up to 2000m (Theodor, 1992). Nearby water is very necessary. Like the sable antelope, the roan is associated with wooded savannah which is more of a grass and tree-savannah species, tolerating taller grass and high elevations including mountain grasslands (Richard, 1992). Roans are mostly characteristics of thinly tree grasslands, park-like savannahs that are often dominated by *commiphora* or to the south by *colophospermum* (Kingdon, 1997). Roan antelopes are found in lightly wooded savannah with medium to tall grass and must have access to water (wildlife Africa, 2001 cited by Roe, 2002).

Optimal habitat consists of open medium to tall grasslands fringed with an ecotone of woody vegetation. These habitats are particularly well represented by shallow, grass – covered drainage systems associated with "miobo" woodlands and are generally referred to as "dambo". They are also partial to open savannah woodlands with the major feature being medium to tall grasslands with fairly open woodland (Toms and Joubert, 2005).

2.8. Diet Composition of the Roan Antelope

Spinage (1986) reported that the roan antelope is a grazer and a mixed feeder. The roan antelope predominantly feed on medium height fresh grass up to 90% and foliage of bushes and trees (Theodor, 1992). The roan antelope drinks daily in the morning and evening and also at mid-day in the dry season.It can go without water for three days at the outside. Like the sable antelope, the roan antelope is a selective grazer on perennial grasses that grow in leached soils of poor nutrient status which supports a low herbivore biomass, offering little nourishment in the dry season except on low ground that retains enough moisture to produce growth after the annual bushfires (Richard, 1992). The roan antelope browse to some extent up to 10 – 20% of rumen contents on forbs, leaves and pods. Like other water dependant wildlife, the roan concentrates near water points during the dry season and disperses during the rains (Richard, 1992).

According to Kingdon, (1997), roans graze on *Themeda sp, Hyparrhenia sp, panicum, paludosum Heteropogon, Digitaria horizontalis* and *Eragrostis tenella*. Medium to short term grass lengths are favoured.In addition to medium to short term grasses, they take various herbs and occasionally browse shrubs and trees, notably Grewia *barteri*, *Loncho carpus* and *Kigelia sp.* They are also fond of picking

up Acacia pods in the dry season and they have been seen feeding on mushrooms (Kingdon, 1997). In the course of daily feeding, a herd move 2–4km from water point. The amount of ground covered varies with the season, the state of the grass and with the amount of disturbances they suffer from man, predators and perhaps other ungulates near the water hole (Kingdon, 1997).An area of cushion grass many hold roans for several days. The animals often submerge their heads for as long as 48 seconds while gathering mouthful under water. They drink regularly and in great quantity, sometimes visiting water every other day during the dry season. They visit mineral licks and are said to chew at old bones.A lactating female has been noted eating soil with some avidity (Kingdon, 1997). Drying of water holes or severe scarcity of grazing occasionally brings roans together into aggregations of up to 150 individuals.The size of herd at any one time of the year might be influenced by the distribution of water and grazing and also by seasonal changes in the reproductive cycle, which might intensify male competition for females but the most commonly seen numbers are 4–18 females with young ones accompanied by a single male adult (Kingdon, 1997).

According to Schuette *et al.,*(1998) roan antelopes are grazers that prefer leaves over stems. They will browse if grazing forage is poor. The preferred feeding height is 15-150cm and green shoots are often grazed down to a height of 2cm. Roan antelopes feed grasses and other foliage in the morning and evening hours and retreat to more densely wooded areas during the middle of the day (Schutte *et.al*., 1998). Roans are grazers and by preference do not feed lower than approximately 15cm from the ground. They consequently avoid areas with high concentrations of short grazers such as impala, zebra and other wild beast (Toms and joubert, 2005). Roans are predominantly grazers, but also browse on leaves, seed pods and herbs, and they have been known to completely submerge their heads to feed on underwater plants. Where possible they drink daily or at least every other day. They chew bones to obtain minerals, particularly calcium and phosphorus.

2.9. Seasonal Changes in the Feeding Habits of the Roan Antelope

According to Schuette *et al. (*1998), diet of the roan antelope varied from one season to another. The percentage of grass in the diet of the roan antelope varied a greater extent. During the rainy season roans eats more than 95% grass. Peaks in the percentage of browse species in the diet of roans occurs at the end of the cool-dry season (October-January) and the hot- dry season (February-May). As the hot-dry season progresses, the proportion of browse in the diet of roans increases. This pre-suggested that most browse species did sprout after the wild fires in the cool-dry season. It is noticed that duringthe rainy season (June-September) the diet of roans is influenced by the abundance of different grass species. The notable decrease of browse in the diet of roans in the rainy season suggested that browse is not the preferred forage which further attested to the classification of roan as grass feeder (Spencer, 1995). In a typical hot-dry season where food presumably become less available; roans switch from being predominantly grazers (>95% grass) to mixed feeders (< 50% grass). Again, fires in November and December (cool-dry season) cause a decrease in the consumption of grass which is not entirely due to reduction in availability because grasses did regrow. The increase use of Culm materials and the decrease in leaf materials in the diet of roans usually occur in later period of the rainy season, a period where most grasses put out their reproductive shoots (Schuette *et al.,* 1998).

3. Materials and Methods

3.1. The Study Area

3.2. Location

Gbele Resource Reserve is the northern most wildlife protected area in Ghana closest to Burkina Faso. It is situated in the upper West Region of Ghana. The reserve serves as a trans-boundary migratory route for elephants and other mammals to and from the Nazinga Game Ranch in Burkina Faso (Wildlife Division, 2009; Ghana National Parks, 2007).Gbele resource reserve covers a total land area of 565 kilometers square with a perimeter of about 125km and lies partly in the Wa East, Nadowli, Sissala East and Sissala West administrative districts. The study area; the Gbele Camp is about 50km square within the 565km square of the Gbele resource reserve. It is situated between latitudes 10 degrees 22 minutes ($10^{o}22^{'}$) and 10 degrees 44 minutes ($10^{o}44^{'}$) North and longitudes 2 degrees 03 minutes ($2^{o}\ 03^{'}$) and 2 degrees 17 minutes ($2^{o}17^{'}$) West. (Wildlife Division, 2009; Ghana National Parks, 2007).

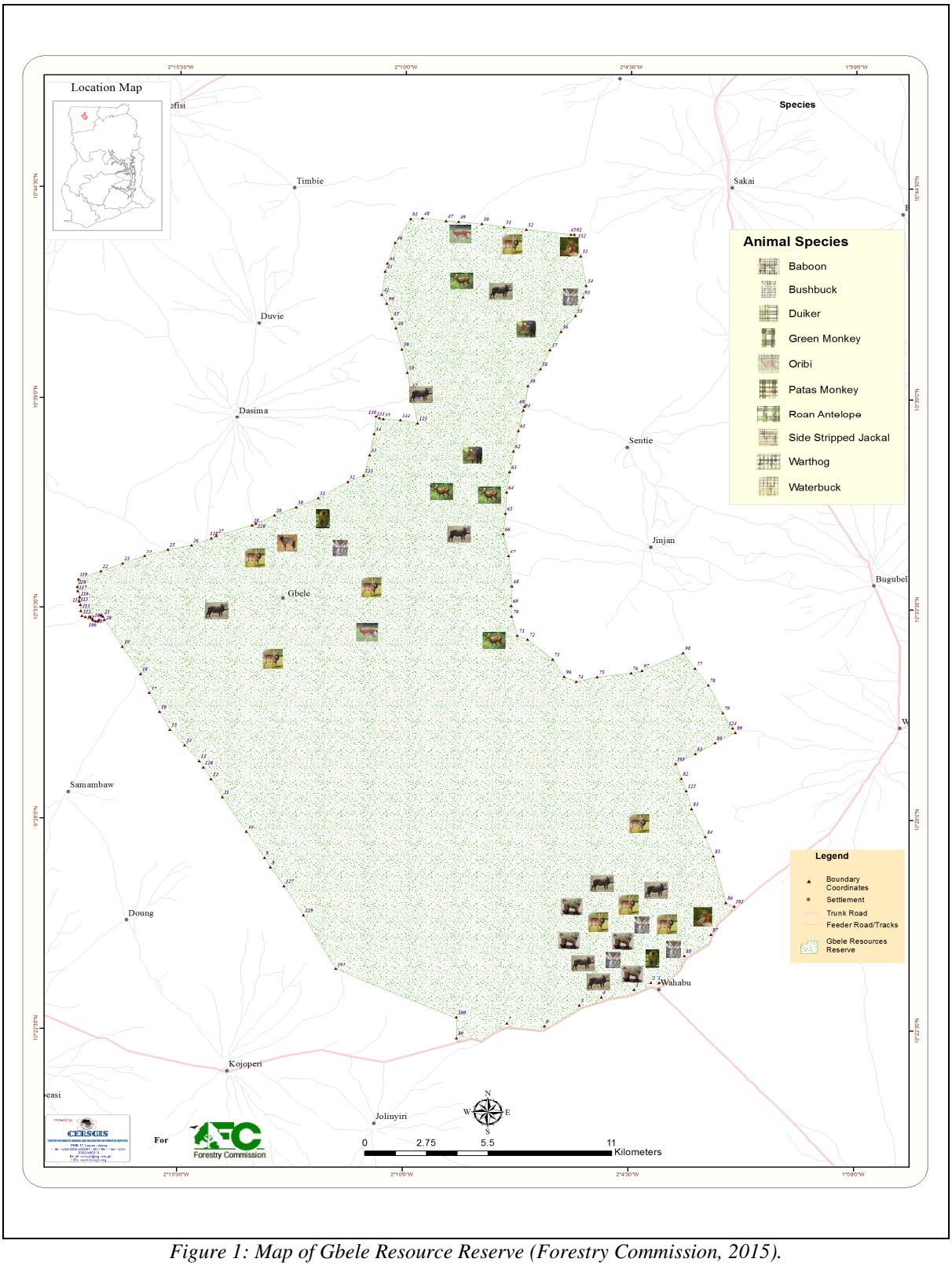

Figure 1: Map of Gbele Resource Reserve (Forestry Commission, 2015).

3.3. Topography

The topography is low lying and is between 259m to 288m above sea level. There are gentle slopes that drain the area into the Kulpawn River which flows from the west of the reserve southwards to the White Volta. The river has many tributaries that form a network of streams across the reserve. These streams often dry up in the dry season. The Kulpawn River also dries up during the dry season forming intermittent pools of water along the river. These pools serve as a major source of water in the dry season for livestock and human consumption (Wildlife Division, 2009).

3.4. Climate

There are two distinct seasons in the area. These are the rainy season which begins from May to October with peaks in August and September and the dry season which last from November to April every year. The dry season is characterized by the north- easterly cold and hammattan winds. Annual rainfall is about 1000mm. The annual temperature ranges between $21C^0$ to $32C^0$ with minimum and maximum reaching $18C^0$ in December/January and $40C^0$ in March/April (Wildlife Division, 2009, Ghana national parks, 2007).

3.5. Vegetation

The reserve is an undisturbed sample of the Guinea savannah ecosystem which stretches across the whole of West Africa. The dominant vegetation type is open savannah woodland with a grass layer that can reach up to 3 meters in height during the rainy season which is burnt off almost every year. Narrow banks of riverine forest approximately 20 meters wide grow along the Kulpawn River and its tributaries.The trees and shrubs species are fire resistant and are well-adapted to the annual bush fires in the reserve. (Wildlife Division, 2009, Ghana National Parks, 2007). There are also swamps and flood plains vegetations characterized by marshy and inundated areas. The following trees and shrubs can be found in the reserve; *Adansonia digitata, Afzelia Africana, Anogeissus leiocarpus, Parkia biglobosa, Pterocarcapus erinaceus, Vitellaria paradoxa, Daniellia oliveri*, and *Ficus spp. Khaya senegalensis* are commonly found in riverine forests. The common grass species in the reserve are; *Andropogon gayanus*, *Pennisetum polystachion*, *Eragrostis tenella* and *Hyparrhenia involucrata*.

The reserve is particularly noted for its large population of the majestic roan antelope, *Hippotragus equinus* and other ungulates such as*Loxondota Africana,Alcelaphus buselaphus*, *Syncerus caffer*,*Kobus ellipsiprymnus* and *Tragelaphus scriptus* (Wildlife Division, 2009).

4. Research Methodology

4.1. Data Collection Procedures

4.1.1. Collection of Plant Species

The Global Positioning System (GPS) was used to construct transect lines of about a 1000m across the reserve. 20 transects were systematically sampled and gridded.Four overlapping nest quadrats of 50m x 50m and 1m x 1m were laid at 200m interval along the transects to sample various browses, grasses and forbs that occur in the area (William, 2000). In each quadrat, the individual browse and grass species were recorded and identified with local names. To aid the identification of the species, field guides like; Handbook of West African Weeds (Okezie and Agyakwa, 1987), The Trees, Shrubs and Lianas of West African dry zones (Michel, 2004) were consulted. Unidentified species were preserved and sent to the University for Development Studies herbarium for identification.

4.1.2. Faecal Material Collection

Thirty (30) fresh faecal samples were collected in each of three climatic periods of four months' duration. That is rainy season (June-September), cool-dry season (October-January) and Warm-dry season (February-May), (Schuette *et al.,* 1998). Faecal materials were collected along transects by following fresh tracks of roans and recording their feeding activities. Identification of faecal pellets was made possible by the shape of the pellets and nearby hoof prints (Spinage, 1986), and also with the help of guards who have good knowledge in identifying faecal materials of the animals. Faecal materials were then air dried for 72 hours, collected and preserved until analysis. The Samples were preserved and analyzed jointly in the laboratories of the Savannah Agricultural Research Institute (SARI), Wa branch and Kaleo Senior high school Science Laboratory.

4.1.3. Determination of Leaf Epidermal Characters of Plants

Forty-eight (48) plant species made up of 12 browses, 21 grasses and 15 forbs were sampled from the area. Thirty-two (32) of them comprising 12 grasses, 10 browses and 10 forbs were used for the preparation of reference slides. Reference slides were also prepared for a few fruits and nuts that occurred in the area during the time of sampling. Mature but fresh leaves of plants were cut into smaller pieces ($1–2cm^2$). They were first boiled in water for five minutes to restore to their normal shape. The side which is not needed was damaged by scraping with a safety razor blade to facilitate the penetration of bleaching solutions in order to obtain fast removal of chlorophyll (Ogie–Odia *et al.,* 2010: Raole and Desai, 2009: Dunham, 1988: Swanepoel and De La Harpe, 1983).

The epidermal peels were then soaked in household bleach (5% sodium hypochlorite solution) for 60 till nearly colourless. The peels were washed in water, stained with 1% safranine solution for 10 minutes and cleared in 50% ethanol. Each peel was then washed in water and mounted in a drop of distilled water on a 76mmx 26 mm slide covered with a 22mmx22mm coverslip. Slides were then studied thoroughly using a Labomed CXL Digital Microscope under low and high power objective lenses of 40X and 100X magnifications as recommended by (Metcalfe, 1960). Photomicrographs of the epidermal features were taken from the slides with a Labomed Digital camera (3.0 mega pixels) fitted onto the microscope.Images and drawings from literature sources were used to aid the study of the specimens. Terminologies for the epidermal morphology such as stomata, nature of cells and cell wall structure, type of trichomes, prickle hairs, long cells, short cells and micro-hairs were that of (Ogie–Odia, *et al*., 2010);Dunham, 1988; Metcalfe, 1960).

4.1.4. Microhistological analysis of Faecal Matter

Faecal analysis was done on seasonal basis. The year was divided into three climatic periods of four months' duration. That is; rainy season (June-September), cool-dry season (October- January), and warm-dry season (February- May), (Schuette *et al.,* 1998). The outer mucoid coating of the sampled pellets was removed before analysis as it prevents epidermal fragments from separating completely (Schuette *et al.,* 1998). The remaining faecal materials were hand-ground using pestle and mortar and sieved through a 1mm sieve. About 0.5g of the remaining samples was placed in 30 ml test tubes that contained 10 ml of 10% nitric acid. The test tubes were placed in boiling water to allow the mesophyll to dissolve so that fragments can sink to the bottom. This was followed by cooling and decanting. Fragments were washed once with water and decanted before adding 5% sodium hypochlorite solution. Tubes were set aside for about 24 hours after which the bleach was decanted. Fragments were cleared in 50% ethanol for 10 minutes and stained with 1% safranine solution.

To obtain faecal plant fragments for microhistological analysis, a small quantity of each sample was then placed on a microscope slide of 76 x 26mm covered with a 22 x 22mm coverslips. Five slides were prepared from each faecal sample. A total of 30 fields per slide were examined for a total of 150 fields per faecal sample (Chetri, 2006). Slides were examined following the systematic observation process described by Spark and Malechek (1968). Observation began from the lower-left corner of each slide, moving from bottom to top, left to right in a sweeping back and forth motion using a Labomed CXL Digital Microscope under low and high power objective lens of 40X and 100X magnifications. The field-of-view was moved on each slide until fragments were identified as grass, browse, forbs, and fruits or unidentified. Forage species were identified by comparing epidermal characteristics of plant fragments in faecal samples to those of prepared reference plant material collected from the area (Metcalfe, 1960).

The examined fragments were grouped into three forage categories; which comprises of the grass and sedge families, browse species which included all woody plants, forbs which included all non-woody plants and fruits. Plants which could not be identified were grouped as unidentified grasses, unidentified browse and unidentified forbs. Fragment counts were used to quantify species composition of grasses, browse and other non-grass species in the faecal matter. Fragments were defined as possessing at least two identifying characters such as the nature of stomata, presence or absence of silica bodies, presence of papillae, nature of trichomes, nature of cells and cell wall structure, macro-hairs and micro-hairs, prickle hairs and presence of long cells and short cells (Schuette *et al.,* 1998, Dunham, 1988).

4.1.5. Experimental Designs and Treatments

The study conducted was a factorial one with the plant species; grass, browse and forbs regarded as the treatments and the seasons as the replications. The treatments were arranged in a Randomized Complete Block Design (RCBD). The three (3) different treatments; grass, browse and forbs were replicated four (4) times in each of the three (3) climatic seasons.

4.1.6. Data Analysis Procedures

Data obtained from microhistological faecal analysis was grouped according to forage category taking seasonal changes into consideration. Prior to analysis, the data was Log transformed and subsequently subjected to the analysis of variance (ANOVA) using the General Linear Model in (SAS). Fisher's least significance difference (LSD) test was used to separate means. The relative percentage frequency of species in the faecal sample was estimated using the formula; $Rf\% = \frac{n1+n2}{N} x\ 100$ Where, Rf% = Relative Percentage Frequency, n = Total number of fragments identified for a given food or forage category, N=Grand total number of fragments made in a sample. (Abbas, 1991; Chetri, 2006).

5. Results

5.1. Forage Species Identified in the Diet of the Roan Antelope

Seventeen (17) forage species made up of seven (7) grasses, six (6) browses, and four (4) forbs were identified in the faecal matter of the roan antelope through microhistogical analysis of faecal samples (Table 1). Plant species were identified based on the presence of at least two or three anatomical characteristics. Grass species were found to have possessed the following anatomical characteristics such as stomata, silica bodies, papillae, macro-hairs and micro-hairs, prickle hairs, long cells and short cells.Anticlinal cell walls of grass species varied from slightly sinuous to straight. The epidermal surfaces of all the grass species were clearly distinguished into coastal and intercoastal zones with the intercoastal zone been broader than the coastal zone. Browse species were found to have unique anatomical structures such as trichomes and regular or irregular cell shape. Numerous stomata were found on the abaxial surfaces of all browse and forbs species with few or none occurring on the adaxial epidermis. Anticlinal cell walls of browse species varied from straight to sinuous. These anatomical features were contained in the prepared reference slide.

5.2. Leaf Epidermis of some Forage Species Used to Prepare Reference Slides

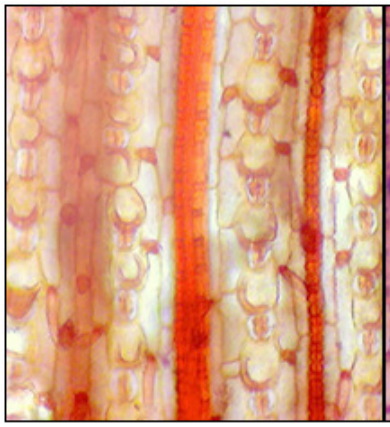

Figure 2: Hyperthelia dissoluta

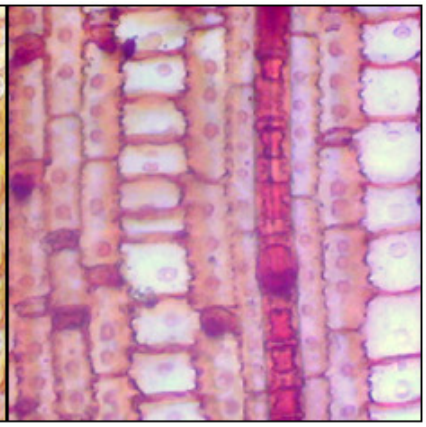

Figure 3: Andropogon gayanus

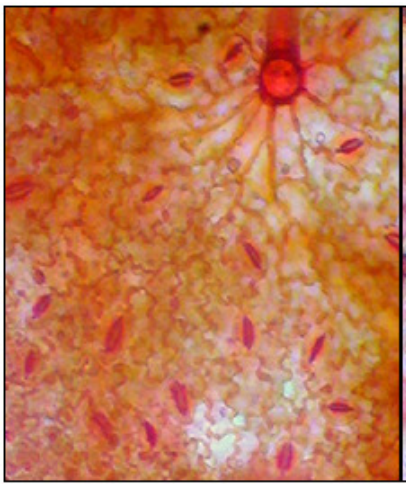

Figure 4: Anogeissus leiocarpus Image

Figure 5: Pterocarpuserinaceus

Scientific name	**Family Name**	**Common name**	**local name (Dagaare)**
Grass Species			
Andropogon gayanus	Poaceae	NorthernGamba grass	Mupilaa
Hyparrhenia spp	Poaceae	Thatching grass	Kari
Hyperthelia dissoluta	Poaceae	Yellow thatching	grassBoro
Imperata cylindrica	Poaceae	Spear grass	pulung
Pennisetum polystachion	Poaceae	Feathery grass	Sambala
Rottboellia cochinchinensis	Poaceae	Itch grass	Karinyaa
Setaria pallid-fusca	Poaceae	Cat tail grass	
Browse species:			
Acacia siebariana	Mimosaceae	Paperbark thorn	Gopelaa
Faidherbia albida	Mimosaceae	Acacia	Guoraa
Vitellaria paradoxa(fruits/nuts)	Sapotaceae	Shea nuts	Taangnaa
Afzelia africana	Caesalpiniaceae	African oak tree	Kakalaa
Gardenia Spp	Rubiaceae	Gardenia	Dazugri
Pterocarpus erinaceus	Fabaceae	African Kino	Bunegaa
Forbs:			
Desmodium. scorpiurus	Fabaceae	Beggarweed	
Evolvulus alsinoides	Convolvulaceae	Dwarfmorning glor	Zongaleri
JasminiumObtusifolium	Oleaceae	Jasmine	Wosaalong
Sesamum alatum	Pedaliaceae	Gazelle's Sesanu	Saalonpela

Table 1: List of Forage Species Identified in Faecal Matter of Roans

5.3. Utilization of Grass Forage by Roans

There was significant difference ($p < 0.05$) among the grass species consumed by the roan antelope. *Andropogon gayanus,Hyparrhenia spp*, *Hypertheliadissoluta* were the most consumed grass species. *Rottboellia cochinchinensis, Imperata cylindrica* were the least consumed grass species. *Andropogon gayanus,Hyparrhenia spp* and *Hyperthelia dissoluta* were however not significantly different $p > 0.05$) from each other. *Pennisetum polystachion, Imperata cylindrica* and *Setaria pallid-fusca* were not also significantly different ($p > 0.05$; Table 2).

Plant Species	Mean Number of Epidermal Cells
Andropogon gayanus	3.41^{a}
Hyparrhenia spp	3.30^{a}
Hyperthelia dissoluta	3.16^{ab}
Setaria pallid-fusca	2.93^{bc}
Pennisetum polystachion	2.88^{bc}
Imperata cylindrica	2.71^{cd}
Unidentified grass	2.66^{cd}
Rottboellia cochinchinensis	2.47^{d}
SEM	0.10
L SD (5%)	0.29

Table 2: Grass Forage Consumption by Roan Antelope in Gbele Resource Reserve

Means with the same superscripts (a, b, c, d) are not significantly different at $p > 0.05$.

5.4. Utilization of Browse Forageby Roans

There was significant difference $p < 0.05$ in the utilization of browse species by roans. The roan antelope exploited the following browse species in a decreasing order in terms of frequency of occurrence in the faecal matter*; Gardenia spp, Accacia siebariana, Afzelia africana* and *Pterocarpus erinaceus* (Table 3). The results showed that these species were the most consumed browse species for roans. *Gardenia spp* was significantly different $p < 0.05$ from all the other browse species. *Afzelia africana,Pterocarpus erinaceus and Faidherbia albida* were however not significantly different $p > 0.05$.

Plant Species	Mean Number of Epidermal Cells
Gardenia spp	3.21^{a}
Acacia siebariana	2.88^{ba}
Afzelia africana	2.84^{b}
Pterocarpus erinaceus	2.82^{b}
Faidherbia albida	2.68^{b}
Unidentified browse	2.62^{b}
Vitellaria paradoxa	2.21^{c}
SEM	0.12
L S D (5%)	0.36

Table 3: Browse Forage Consumption by the Roan Antelope

Means with the same superscripts (a, b c) are not significantly different at $p > 0.05$.

5.5. Utilization of Forbs Forage by the Roans

There was significant difference $p < 0.05$ among the forbs species consumed by the roan antelope. The following forbs species were exploited by the roan antelope in a decreasing order in terms of their frequency of occurrence in the faecal matter; *Desmodium scorpiurus, Jasminum obtusifolium, evolvulus alsiniodes* and *Sesanum alatum. Desmodium scorpiurus* was significantly different $p < 0.05$ from all other forbs species (Table 4). *Evolvulus alsiniodes* and *Jasminumobtusifolium* were however not significantly different at $p > 0.05$

Plant Species	Mean Number of Epidermal Cells
Desmodium scorpiurus	2.92^{a}
Evolvulus alsiniodes	2.74^{ab}
Jasminum obtusifolium	2.71^{ab}
Sesanum alatum	2.53^{b}
Unidentified forbs	2.52^{b}
SEM	0.11
L S D (5%)	0.31

Table 4: Forbs Forage Consumption by Roan Antelope in Gbele Resource Reserve

Means with the same superscripts (a, b) are not significantly different at $p > 0.05$.

5.6. Seasonal Consumption of Grass Forage

There were inter-seasonal differences ($p < 0.05$) in the consumption of grass forage by the roan antelope (Table 5). There were also intra-species differences ($p < 0.05$) in the consumption of the individual grass forage in each of the seasons (Table 5).

GRASS SPECIES	SEASONS		
	Rainy Season	Cool-dry Season	Warm-dry Season
Andropogon gayanus	3.70^{Aa}	3.38^{Ab}	$3.16^{A c}$
Hyparrhenia spp	3.52^{Ba}	3.23^{Ab}	3.15^{Ab}
Hyperthelia dissoluta	3.39^{Ba}	3.08^{BAb}	3.03^{Ab}
Setaria pallid-fusca	3.37^{Ba}	2.95^{Bb}	2.57^{Bc}
Pennisetum polystachion	3.36^{Ba}	2.83^{CBb}	2.52^{Bc}
Imperata cylindrica	3.11^{Ca}	2.77^{Cb}	2.37^{CBc}
Unidentified grass	2.85^{Da}	2.76^{Da}	2.08^{Db}
Rottboelia cochinchinensis	2.77^{Da}	2.54^{Db}	2.07^{Dc}
L S D (5%)			0.18

Table 5: Grass Forage Consumption within the Different Seasons in Gbele Reserve

Means with the same uppercase letters (A, B, CB, DC and D) in the same column are not significantly different $p > 0.05$, and means with the same lowercase letters (a, b and c) in the same row are not significantly different at $p > 0.05$.

5.7. Seasonal Consumption of Browse Forage

There were inter-seasonal differences ($p < 0.05$) in the consumption of browse species in all the three seasons. The consumption of *Gardenia spp, Pterocarpus erinaceus* and *Afzelia africana* in descending orderwas significantly different ($p < 0.05$) in all the three seasons. There were also intra-species differences ($p < 0.05$) in the utilization of browse species in each season by the roan antelope (Table 6).

BROWSE SPECIES	SEASONS		
	Rainy Season	Cool-dry Season	Warm-dry Season
Gardenia spp	2.62^{Aa}	3.22^{Ab}	3.80^{Ac}
Pterocarpus erinaceous	2.57^{Aa}	2.87^{Bb}	3.53^{Bc}
Acacia siebariana	2.41^{BAa}	2.86^{Bc}	3.40^{Bc}
Afzelia africana	2.34^{Ba}	$2.82^{B}{}_{b}$	$3.29^{CB}{}_{c}$
Faidherbia albida	$2.32^{B}{}_{a}$	2.64^{CBb}	3.07^{CBc}
Vitellaria paradoxa	2.30^{Ba}	2.54^{Cb}	2.86^{Cc}
Unidentified browses	2.27^{Ba}	1.61^{Db}	2.46^{Da}
L S D (5%)			0.23

Table 6: Browse Forage Consumption within the Different Seasons in Gbele Resource

Means with the same uppercase letters (A, B, CB and D) in the same column are not significantly different at $p > 0.05$, and means with the same lowercase letters (a, b and c) in the same row are not significantly different at $p > 0.05$.

5.8. Seasonal Composition of Forbs Forage

There was no seasonal interaction ($p > 0.05$) in the utilization of all the forbs species identified in the diet of the roan antelope (Table 7). There were however intra-species differences ($p < 0.05$) in the consumption of the various forbs species by the roan antelope in each season.

FORBS SPECIES	**SEASONS**		
	Rainy Season	**Cool-dry season**	**Warm-dry season**
Desmodium. scorpiurus	2.86^{Aa}	3.02^{Aa}	2.89^{Aa}
Evolvulus alsinoides	2.66^{BAa}	2.87^{Aa}	2.71^{BAa}
Jasminium Obtusifolium	2.64^{BAa}	2.85^{Aa}	2.62^{Ba}
Sesamum alatum	2.58^{Ba}	2.57^{Ba}	2.61^{Ba}
Unidentified forbs	2.42^{Ba}	2.42^{Ba}	2.57^{Ba}
L S D (5%)			0.24

Table 7: Forbs Forage Consumption within the Different Seasons

Means with the same uppercase letters (A, B and BA) in the same column are not significantly different at $p > 0.05$, and means with the same lowercase letters (a) in the same row are not significantly different at $p > 0.05$.
L S D = Least Significant Difference.

5.9. Relative Proportions of the Three Forage Categories in Roan's Diet

The diet of the roan antelope consisted of a diverse species of food plants. Sixteen (16) plant species made up of seven grasses (7), five (5) browse and four (4) forbs were identified in the faecal matter of roan antelope (Table 1). The forage species estimated in the diet of the roan antelope were in the following proportions; grass (37%), browse (30%), forbs (19%) and others (14%) (Figure 6).

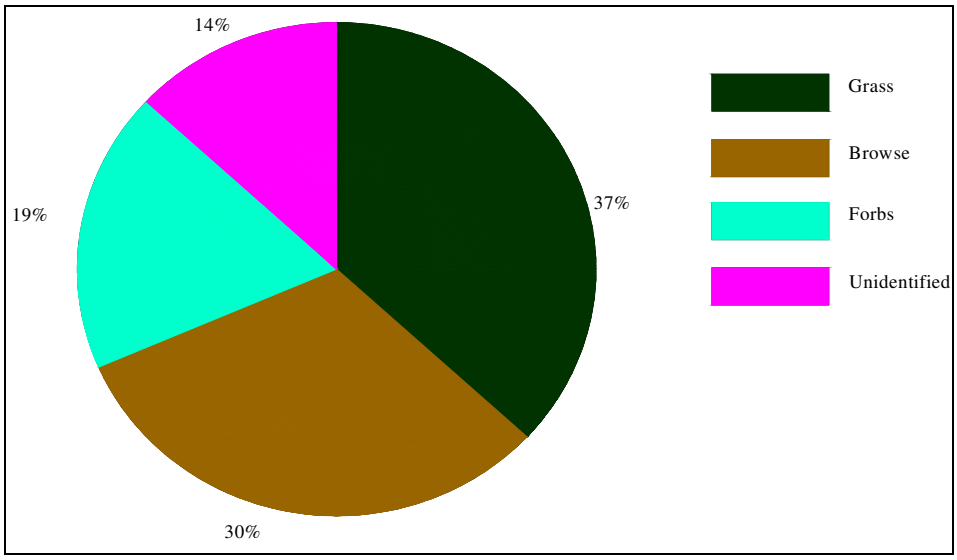

Figure 6: Diet Proportions of the Three Forage Category in the Diet of the Roan Antelope

5.9.1. Diet Proportions of the Roan antelope in the Three Seasons

In the rainy season the roan antelope's diet was estimated at 41% grass, 26% browse, 20% forbs and 13% other forage species (Figure 7). The results showed that grasses were the most consumed forage species for roans in the rainy season. Browse and forbs consumptions were low and lowest in the rainy season (Figure 7).

In the cool–dry season, there was a reduction in the consumption of grass species. Although grass consumption still remained high (37%) in this season compared to browse (29%) and forbs (20%), there was a sharp declined in grass diet compared to the rainy season. The warm-dry season witnessed a further reduction in grass consumption (33%) as compared to the previous climatic periods (41% and 37%) (Figure 7).

Browse consumption however appreciated remarkably in the warm-dry season (34%) compared to the cool-dry season (29%). Forbs consumption also witnessed a slight drop of (19%) in the warm-dry season as against (20%) in the cool-dry season. The number of other forage species however appreciated slightly (14%) in this period compared to the rainy season (13%) (Figure 7).

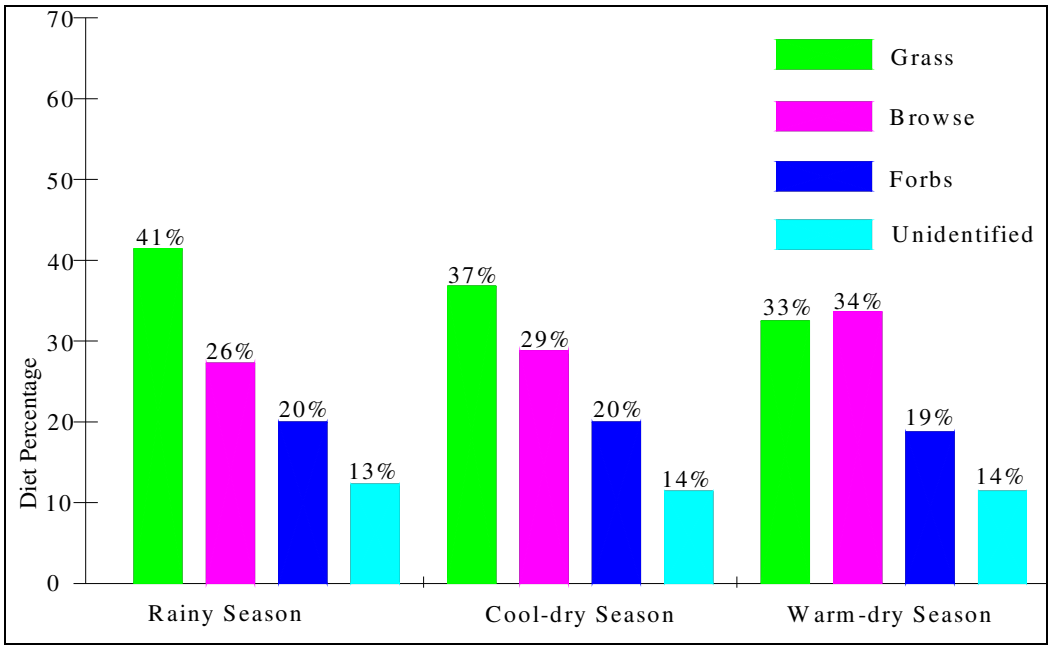

Figure 7: Percentage Compositions of Total Grass, Browse and Forbs in Three Seasons in Gbele Resource Reserve

5.9.2. Seasonal Variation of Six Most Consumed Grass and Browse Species

The consumption of individual forage species (grass, browse and forbs) varied dramatically from one season to another. Some forage species were consistently consumed by the roan antelope in all the three seasons, while others appear only in some seasons and virtually disappear during certain seasons of the year. *Andropogon gayanus, Hyparrhenia spp* and *Hyperthelia dissoluta* were the grass species consistently consumed by the roan antelope in large quantities (Figure 8). *Gardenia spp*, *Afzelia africana* and *Pterocarpus erinaceus* were also the browse species consistently consumed in large quantities. *Imperata cylindrica, Rottboelia cochinchinensis, Vitellaria paradoxa* were virtually absent in the diet of the roan antelope during the cold-dry and the warm-dry periods of the year.

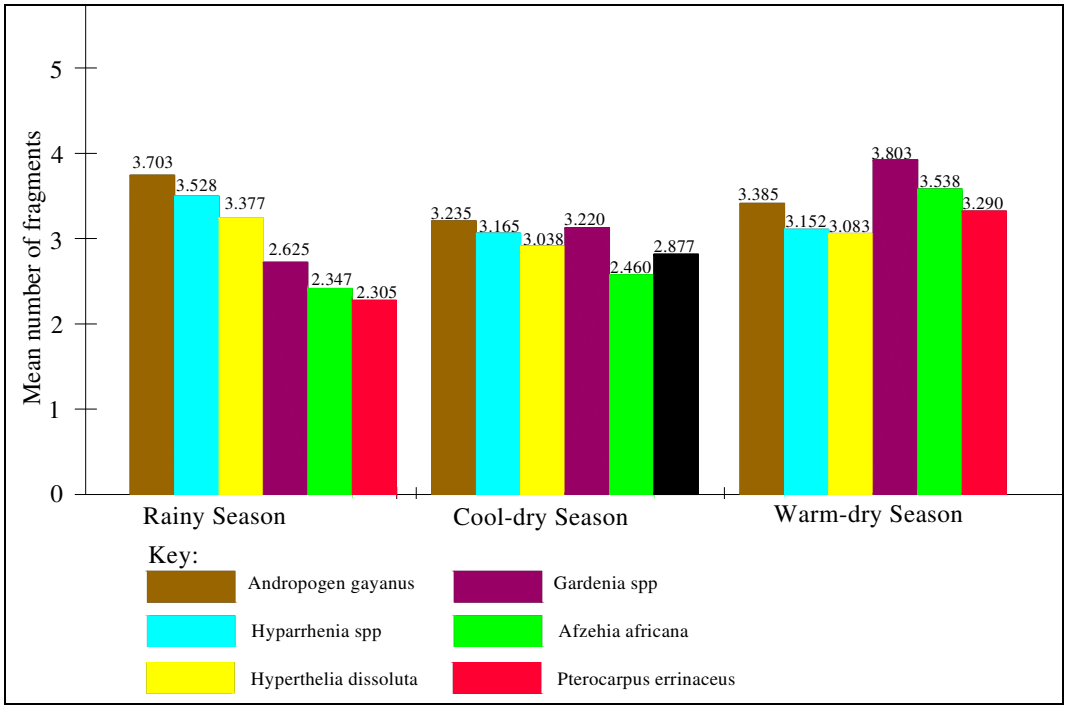

Figure 8: Seasonal Variations of Six most Consumed Grass and Browse Species

5.9.3. Browse to Grass Ratio in the Seasonal Diet of the Roan Antelope

The browse to grass ratio in the diet of the roan antelope varied from one season to another. The highest browse to grass ratio (1.04) was recorded in the warm-dry season, followed by the cool-dry season (0.77) and the lowest was recorded in the rainy season (0.62) (Figure 9).

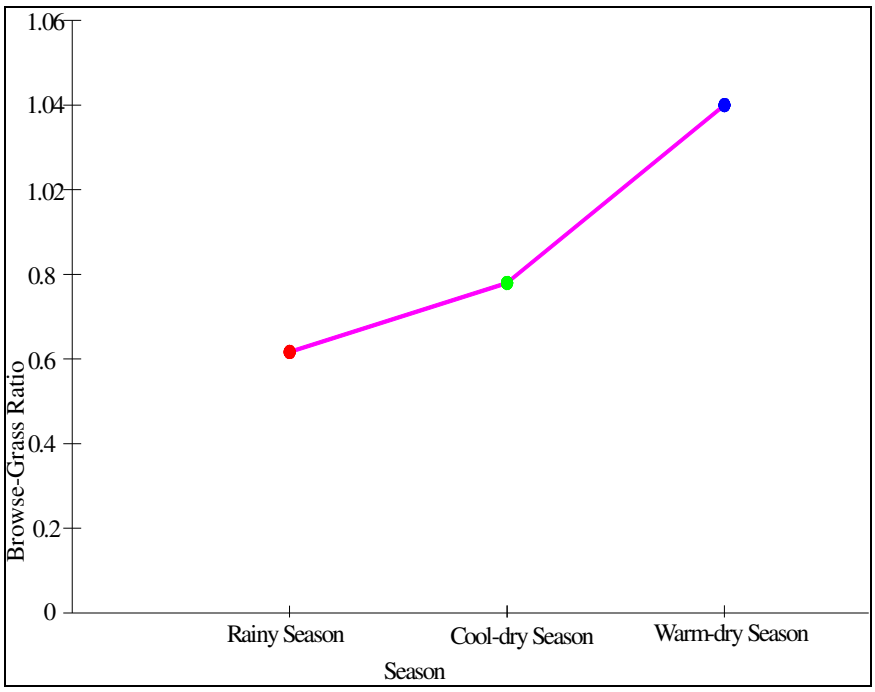

Figure 9: Browse to Grass Ratio in the Seasonal Diet of the Roan Antelope in Gbele Resource Reserve

6. Discussion

6.1. Diet Composition of the Roan Antelope

The diet of the roan antelope consisted of a diverse species of food plants (Chetri, 2006; Schuette *et al.,* 1998). The mixed proportions of forage in the diet of the roan antelope in this study are in close agreement with the findings of (Schuette *et al.,* 1998; Spinage, 1986) who reported that the roan antelope is a grazer and a mixed feeder. Kingdon, (1997) reported that the roan antelope grazes on medium to short term grass lengths and browses various shrubs and trees. In this study, the average grass consumption was (37%), browse (30%), Forbs (19%) and other unidentified (14%).

In the warm-dry season, fruits of *Acacia siebariana* and *Faidherbia albida* were also recorded. The figures recorded for these fruits were however very minimal in the cool-dry season and the rainy season mainly due to the absence of these fruits during this period of the year. Also, fruits of *vitellaria paradoxa* were recorded in the rainy season and the hot-dry season respectively. The presence of these fruits in the diet was probably due to their availability in both seasons as compared to *Acacia Siebariana* and *Faidherbia albida* whose fruits were available only in the warm-dry season.

Kingdon, (1997) also reported that, roans are fond of picking up acacia pods in the dry season, visiting mineral licks and chewing at old bones and soil. The proportion of unidentified forage species (14%) confirms that roans consume a wide variety of food species that could not easily be identified from a microscope slide. Generally, the consumption of forage species varied dramatically from one season to another mainly due to vegetation changes which resulted from changes in climatic conditions.

6.2. Seasonal Changes in the Diet of the Roan Antelope

In the typical rainy season (June-September) the diet of the roan antelope was dominated by grass forage. Schuette *et al.,* (1998) reported that, roans consumed more than (95%) grass in the rainy season compared to other periods of the year. The results of this study further confirmed earlier reports presented by Spinage (1986) that the roan antelope predominantly feeds on medium height fresh grass up to (90%) in the rainy season. The higher preference for grass diet in the rainy season could be attributed to the abundant growth of new succulent grasses stimulated by the onset of the rains.The proportion of grass in the diet of the roan antelope was higher than all other forages. These findings confirmed earlier submissions made by Schuette *et al.* (1998) and Spinage (1986) that roans are predominantly grazers. Browse consumption in the rainy season was on a relatively low side compared to the hot-dry season. This outcome is in close agreement with the findings of (Richard, 1992) that the roan antelope browses to some extent up to (10–20%) rumen content of forbs, leaves and pods during certain periods of the year.

In the cool-dry season (October–January), the proportion of grass forage in the diet of the roan antelope declined to (37%). This reduction could be attributed to the relatively low supply of high quality grass. Chetri (2006) reported that most grasses senesce during this period of the year and grasses that had matured fully are avoided by animals. The proportion of grass diet was lowest in the warm-dry season (33%). The warm-dry season was the one in which the consumption of grass forage had drastically declined. This outcome is in close agreement with earlier reports made by Schuette *et al.,* (1998) that roans usually switched from being predominantly grazers (>95% grass) in the rainy season to mixed feeders (<50% grass) in the hottest period of the dry season (February–May).
Again, the rainy season witnessed the least consumption of forbs and browse species. This could be due to the availability of high quality grass forage which attracted roans more than browse and forbs during this period of the year. The proportion of other unidentified forage species was high in the warm-dry season than in other seasons. These results are in consonance with early works done by (Kingdon, 1997) that roans consumed pods of various kinds, mushrooms, bones and soil during the dry period of the year. Also, during this time the animals were probably feeding on new shoots which have higher digestibility than mature plants or they might have eaten other forage species which were not covered in slide preparation.Holechek *et al.* (1982) also pointed out that fragments of forage species may differ between species during digestion, therefore the relative proportions of species appear different.

6.3. Forage Selectivity by the Roan Antelope

Among the six most important forage species, *Andropogon gayanus* was the most consumed species. These species dominated all other species in the rainy and cool-dry seasons except the warm-dry season. Its average proportions were highest (3.70 and 3.23) among all other species during the rainy season and the cool-dry season. These findings are in close relationship with earlier reports by Schuette *et al.* (1998) that roans continue to use *Andropogon* species throughout the year mainly due to its low ratio of reproductive or vegetative shoots to physically inhibit roan's use of their leaves than in the case of other grass species.
Among the browse species, *Gardenia spp* was most consumed as it dominated all other browse species in the diet of the roan antelope throughout the three climatic periods. Its proportion was highest in the hot-dry season (3.80) and lowest in the rainy season (2.62). This is in close agreement with that of Richard (1992) that roans browse to some extent (10%–20%) of rumen contents. Its continuous dominance among the browse species indicated that it was the most preferred browse species for roans.

6.4. Browse to Grass Ratio in the Diet of the Roan Antelope

The browse to grass ratio varied from one season to another. The highest browse to grass ratio (1.04) was recorded in the hot-dry season. The ratio however declined slowly and reached the lowest (0.62) in the rainy season. The main reason that could have accounted for the high browse to grass ratio in the hot-dry season is the low moisture content in the soil during this period which retards the growth of nutritious grass species until the returns of the rains in June. The lowest browse to grass ratio recorded in the rainy season could also be attributed to the availability of fresh and nutritious grass species which made roans to switch from high browse diet in the warm-dry season to a grass diet in the rainy season. These results are in closed consonance with earlier reports made by Schuette *et al.,* (1998) that roans usually switched from being predominantly grazers (>95% grass) to mixed feeders (<50% grass) in the Warm-dry season when grasses presumably become less available. In this study, although the number of fragments of food plants recorded was quite high, leaves of delicate and succulent forage species could not appear on slide and therefore could not be identified, perhaps due to complete digestion.
Holechek *et al,* (1982) also pointed out that microhistological faecal analysis gives good precision but accuracy is a problem because of differential and incomplete digestion between plant species.In the study, only a smaller proportion (14%) was recorded as other unidentified forage in the three climatic periods of rainy season, cool-dry season and warm-dry season. Vavra and Holechek (1980) also reported that faecal analysis does not incorporate all species in an herbivore's diet because of the destruction of some plant species that may occur during slide preparation.

7. Conclusion and Recommendation

7.1. Conclusion

The results of the study suggested that diet of the roan antelope is composed of a variety of forage species which are consumed in different proportions in relation to different seasons of the year. Seasonal comparison of roan's diet indicated that its feeding habits varied from one season to another. These variations were influenced by the prevailing climatic and environmental conditions. In the rainy season where roans are faced with greater plant availability, they presented a more selective behaviour by consuming grasses than any other forage species. This behaviour was probably influenced by such factors as availability and palatability of fresh grasses. In the dry season however, where food presumably became less available due to poor forage supply coupled with reduced forage quality, the number of ingested plant species consumed by roans rose from being predominantly grasses to browse, forbs and others.

7.2. Recommendations

Based on the research findings, the following recommendations are made:
1. Further studies should be conducted in the area over an extended period of four years to determine whether the feeding habit of the roan antelope is consistent or otherwise.
2. Further research on the epidermal characteristics of plant species should be extended to cover other camps of the reserve in order to obtain a comprehensive and detail database of epidermal features of forage species in the entire reserve for reference purposes.

8. Acknowledgements

I am most grateful to all those whose ideas and information I have borrowed towards the production of this work. I am highly indebted to my supervisor, Professor, S.K. Oppong, who sacrificed his precious time and energy to diligently supervise me to come out with fruitful results. My profound gratitude goes to the management and staff of Gbele Resource Reserve for granting me permission to carry out this study in the reserve. Special mention is made of the assistant park manager, Mr. Polycarp and Mr. Richard and Mr. Baka for their invaluable support during my work at Gbele. My sincere thanks also go to all friends who in diverse ways have contributed immensely to the preparation of this work.

9. References

i. Abbas,A. (1991). Feeding strategy of Coypu (Myocastor coypus) in Central Western France. Journal of Zoology. 224: 385-401. http://dx.doi.org/10.111/j.1469. Accessed June 3, 2013.
ii. Baugartner, L.L and Martin A.C(1939). Plant histology as an aid in squirrel's food- habit studies. Journal of wildlife Management. 3 (3): 266-268.Availlable online at https://www.sciencebase.gov/catalog/item. Accessed June 20, 2012.
iii. Chetri, M. (2006). Diet Analysis of Gaur, Bos gaurus gaurus (Smith, 1827) by Microhistological Analysis of Faecal Samples in Parsa Wildlife Reserve, Nepal. Our Nature. 4:20-28. Available online at www.lib.icinod.org/record/12231/files Accessed September 24, 2013.
iv. Cotthem, W.V. (2008). Drought Effects on the Environment and some Solutions. Available online at www.greenpacks.org.Accessed February 5, 2011.
v. Desbiez, A. L. J., Rocha, F. L. and keuroghlian, A. (2010). Interspecific association between anungulate and a carnivore or a primate. Acta Ethological press. Available online at www.beheco.oxfordjournals.org/content. Accessed March 3, 2012.
vi. Dove, H. and Mayes, R.W. (1996). Plant wax components; a new approach to estimating intake diet composition in herbivores. Journal of Nutrition. 126 (1): 13-26. Available online at www.ncbi.nlm.nih.gov/pubmed/8558293. Accessed November 15, 2013.
vii. Dunham, K.M. (1998). The Epidermal characters of some Grasses from North–West Zimbabwe. Kirkia. 13(1):153-195. Available onine at www.africabib.org. Accessed February 12, 2012.
viii. Eliana, E. B. and Roberto, M. B. (2002). Sample Numbers for Microhistological Estimation of Vizcacha Diets. Journal of Range Management. 55 (5): 498-501. Available online at https://journals.uair.arizona.edu. Accessed September 6, 2012.
ix. Ellis, R. P. (1987). A procedure for standardizing comparative leaf anatomy in the poaceae; the past twenty five years. Proceedings of the International Symposium on Grass Systematics and Evolution. Washington D. July, 1986. 31Pp.
x. Encyclopaedia Britannica, (2011). "Roan antelope", Encyclopaedia Britannica.Online at http:// www.britannica.com/EBchecked/topic/505211/roanantelopes. Accessed May 20, 2012
xi. Dove, H. and Mayes, R.W. (1996). Plant wax components; a new approach to estimating intake diet composition in herbivores. Journal of Nutrition. 126 (1): 13-26. Available at www.ncbi.nlm.nih.gov/pubmed/8558293. Accessed June 20, 2014.
xii. FAO, (1993). Impact of desertification on wildlife. Forest Resources Division, Forestry Department. United Nations, Viadelle Terme diCaracalla, 00100 Rome Italy. Available at ftf://ftf.fao.org/docrep/fao/008/j6854el. Accessed June 15, 2014.
xiii. Ghana National Parks, (2007). Ghana Tourism Home Page. www.ghanatourism.info. AccessedMay 10, 2012
xiv. Grzimek, M. and Grzimek,B. (1960). Census of plains animals in Serengeti National Park, Tanganyika. Journal of Wildlife Management.24 (1): 27–37. Available online at http://www.jstor.org/stable/3797353. Accessed July 12, 2014.
xv. Heady, H. F. and Child, R.D. (1994). Rangeland Ecology and management. Westview Press Inc. Oxford, London. Pp 387.
xvi. Hinnant, R.T. and Kottmann, M.M. (1988). Collecting, Drying and Preserving Faeces for chemical and Microhistological Analysis. Journal of Range management. 41(2): 168-171. Available online at http://digitalcommons.library.arizona.edu/objectviewer. Accessed May 8, 2013.
xvii. Holechek, J. L., Vavra, M. and Piepe, R. D. (1982). Botanical composition determination of range herbivores diets. A review.Journal of Range Management. 35 (3): 309-315. Available online at www.https://journals.uair.arizona.edu. Accessed May 25, 2013.
xviii. Ignas, H. and Norman, S.(1998). Seasonal Selection of soil types and grass Swords by roan antelope in South African savanna.African Journal of Ecology. 36 (1): 57-70.
xix. International Union for the Conservation of Natural Resources (2009). Red List.www.iucnredlist.org. Accessed June 24,2012.
xx. Kingdon, J. (1997). The kingdon Field Guide to African Mammals. Academic press, London and New York: Natural World.
xxi. Maria, A. D. and Stella, M. G. (2001). Technical Note: A simple method for preparing referenceslides of seed. Journal of Range Management.54 (2): 191–193. Available online at https://journals.uair.arizona.edu. Accessed June 12, 2012.
xxii. Metcalfe, C.R. (1960). Anatomy of the monocolydons. Gramineae. Oxford University. Clarendon Press, London.
xxiii. Michael, L. M., Martin, V. and William, C.K. (1983). A comparison of Four Methods used to determine the Diets of Large Herbivores. Journal of Range Management.36 (3): 302-306. Available online at www.oregonstate.edu. Accessed May 12, 2013.
xxiv. Michel, A. (2004). Trees, Shrubs and Lianas of West African dry zones. 2nd edition Margraf Publishers GMBH, MNHN, Wageningen. The Netherlands. 578Pp.

xxv. Nowak, R. M. (1991). Walker's Mammals of the World, Fifth Ed. Vol. II, MD: Johns Hopkins University press, Baltimore.

xxvi. Ogie–odia, E.A., Eseigbe. D., Llechie M.N., Erhabor, J. and Ogbebor, E. (2010). Foliar epidermal and phytochemical studies of grass Cymbopogon citratus (STAPF), Axonopus compressus (P. BEAUV) and Eragrotis tremula (S.W.BEAUV) in Ekpoma, Edo state, Nigeria. Science World Journal. 5 (1): 20-25.Available online at www.scienceworldjournal.org Aceessed May 20, 12.

xxvii. Okezie, I. A. and Agyakwa, C. W. (1987). A Handbook of West African Weeds. International Institute of Tropical Agriculture, Ibadan, Nigeria. 528 Pp.

xxviii. Parker, S.p. (1990). Grzimer's Encyclopaedia of mammals' vol. 5, McGraw-Hill publishing Company, New York.

xxix. Raole V.M. and Desai,R. J. (2009). Epidermal Studies in some Members of Andropogoneae.

xxx. (Poaceae). Not. Bot. Hort. Agrobot. Cluj. 37 (1) 59-64. Available online athttp://not-bot-horti-agrobo.blogspot.com/ Accessed November 4, 2012.

xxxi. Richard, D.E. (1992). The Behaviour Guide to African Mammals. The University of California press Ltd, Berkeley and Los-Angeles, California. 512Pp.

xxxii. Robbins, C.T., Spalinger, D.E. and Wouter,V. H.(1995). Adaptation of ruminants to browse andgrass diets. Are anatomical–based browsers–grazer interpretations valid? Oecologia. 103 (2): 208–213. Available online at www.springer.com. Accessed May 20, 2013.

xxxiii. Roe, B. (2002). "Hippotragus equines" Animal Diversity Web. Available online at http://animaldiversity.ummz.umich.edu/site/accounts/information/Hippotragus equinus.html. AccessedJune 12, 2012.

xxxiv. Schuette,J.R., David. M., Robert. L. L. and Jonathan, A. J. (1998). Diet of hartebeest and roan antelope in Burkina-Faso, support of the long-faced hypothesis. Journal of Mammalogy. 79 (2): 426-436. Available online at http://ww.jstor.org/action

xxxv. Sparks, D.R. and Malechek, J.C. (1968). Estimating percentage dry weight in diets using a microscopic technique. Journal of Range management. 21: 264-265.

xxxvi. Spencer, L.M. (1995). Morphological correlations on dietary resource partitioning in African Bovids. Journal of Mammalogy. 76: 448-471.

xxxvii. Spinage, C.A. (1986). The Natural History of Antelope. Facts on file publications, New York. 518 Pp.

xxxviii. Stewart, D.R.M. (1967). Analysis of plant epidermis in faeces; a technique for studying the food preferences of grazing herbivores. Journal of Applied Ecology. 4: 83-111

xxxix. Swanepoel, J.J. and De La Harpe, A.C. (1983). Preparation of epidermal tissues for light microscope studies of Vitis-leaves. Journal of Ecology. 4 (1): 19-53.

xl. Theodor, H. (1992).A Field Guide to Mammals of Africa including Madagascar. William and sons co. Ltd, South China, Hong Kong.

xli. Toms, R. and Joubert, S. (2005). Roans 200 years later. Africa's First on-line Science Magazine. Available online at http://www.scienceinafrica.com/biotechnolo. Accessed August 12, 2014.

xlii. Vavra, M. and Holechek, J. L.(1980). Factors influencing Microhistological Analysis of Herbivores Diets. Journal of Range Management. 33(5): 371-374. Available at www. oregonstate.edu. Accessed August 20, 2013.

xliii. Walter, F.R.(1990). Roan and Sable antelopes. In Grzimek's Encyclopaedia of Mammals. Edited by S.P. Parker. New York: McGraw-Hill. Volume 5. 437- 447Pp

xliv. Wildlife Division, (2009). Wildlife and Nature Reserves in Ghana. Available online at www.wildlifeghana.com//gbele.html. Accessed June 4, 2012.

xlv. William, J.S (2000). Editor; Ecological Census Techniques, a Handbook. Cambridge University press, UK. Pp 115-117.

xlvi. Wilson, D.E. and Reeder, M. D. (1993). Mammal Species of the World (2nd Edition). Smithsonian, Institution press, Washington. Available at http://nmnhwww.si.edu/msw/ Accessed October 6, 2012.