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# Nitrogen Levels in forages preferred by African elephants (*L. Africana*) in Rimoi Game Reserve and Conservation Area, Elgeyo-Marakwet County, Kenya

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**Abstract**
Evolution of herbivores is related to that of plant and animals contact. Many animals feed on various species of plants to get the required nutrients by consuming too much of any one type of defensive chemical. This study was done in 2010 in Rimoi Game Reserve and Conservation Area. The preferred plants by elephants were deduced from records of plants which showed obvious signs of recent elephant use. For each sampled tree or vegetation, areas showing signs of feeding like the leaves or bark samples were taken at browsing level for nitrogen analysis. Sampling was carried out for three hours in every two days in a week from 7.00 am. Picking was done at the onset of the planting season (start of wet season), harvesting season and dry season. Each of the collected plant was identified /tagged, tallied and air dried in the field inside a brown 'sugar paper bag' and later transported to the laboratory for analysis of nutritional content. The sampling regime was that three samples of each plant species in a season were collected and analyzed. Twenty five plants were considered for nitrogen analysis, which was composed of nineteen wild forages and six major crops raided. Eighty one samples were collected from different plant species. The Kjehldal method was used in the analysis of nitrogen. The results were analysed using analysis of variance so as to explain the relationship between preference of forage and the nitrogen levels. Results showed that, there were significant differences in the levels of nitrogen among the plant species (ANOVA, F = 23.133, df = 20, p = 0.002). There were also significant differences in the levels of nitrogen among the raided crops (ANOVA, F = 11.134, df = 5, p = 0.0325). This study showed that acacia plants had high nitrogen (N) levels than other plant species indicating that it may be the main drive in forage preference. The animals seem to use their nutritional wisdom to identify plants rich in protein.

**Keywords:** Forage, Nitrogen, Preference, Kjehldal

## 1. Introduction

The African elephant (*Loxodonta africana* Blumenbach) is the largest extant land mammal, with recorded body mass of up to 6,000 kg for males, and 2,800 kg for females. Accordingly, its dietary intake is considerable (typically 1% (dry weight) of body mass daily) and the resulting effects on vegetation can be dramatic (Baxter, 2003). The largest species among the wild animals roaming the African savannas which is the African elephant is described as an environment engineer (Asner & Levick, 2012) and the organisms have the potential to change and shape the physical structure of the landscape in which they inhabit (Wong, 2013).

There has been an emerging concern on the feeding habits among the African elephant, which include debugging and uprooting trees that has been considered to have a negative effect on other herbivores (Kohi, et al., 2011). In essence, they are considered the only animal in the African ecosystem that has the capability to modify their structure and environment (Wong, 2013). The level of impact of high elephant densities is governed by elephant feeding behavior acting in concert with other ecological and environmental factors, because elephants are mixed feeders, ingesting both grass and browse in varying proportions (Baxter, 2003). It is a native species to the African ecosystems. The poaching effects has lead to their numbers to drop and become vulnerable species (IUCN)'s Red List (Blanc, 2008).

Research findings shows elephants have positive ecosystem function (Nasseri, McBrayer, & Schulte, 2010). Elephants are located at the top of the tropic level and can modify its environment through feeding and migration (Landman, Kerley, & Schoeman, 2008). However, African elephant has the capability to modify physical structure of environment and subsequently affects the other biodiversity (Wong, 2013). The diet of elephants is composed of many plant species and plant components (Asner & Levick, 2012). Its diet is shaped mainly by their large body size and is expected to have a long gut which would translate to a long retention time. In elephants total gut length is shorter than expected and the diameter of components such as the small intestine is greater, and these together result in a reduced gut retention time (Clause *et al*., 2003).

The reduction of the feeding range of elephants as a result of human encroachment to elephant home ranges has increased density of elephants, which effectively limit their feeding ranges and the reduction of diversity of species of vegetation and may necessitate a change in the elephant feeding behaviour (Mapaure & Mhlanga, 2000). Preferentially utilized vegetation includes those that provide shade and fruit (Duffy, van Os, van Aarde, Ellish, & Stretch, 2002). Also nutritious plants – such as calcium and nitrogen; those nutritious enough to provide energy- *Portulacaria afra*, (Boshoff, Skead, & Kerley, 2001). Forage quality and quantity are known to be important drivers of herbivore numbers and distribution (Grant, 2010). Intensity of elephant feeding behaviour and the emergent spatial patterns of change in vegetation, reflect the distribution of elephants across the heterogeneous savanna landscape (Steyn & Stalmans, 2001). Elephants are considered to be coarse feeders (Santra, Pan, Samanta, Das, & Halder, 2008; Joshi & Singh, 2008).

However, it is also widely believed that the decline in the species density in the elephant natural habitat and the preference of crops with high nutrient content both within their home range and outside may influence the feeding behaviour of elephants. Previously it has been demonstrated that elephants have preference for crops due to the species, nutritional content and other factors. Encroachment on their ranges therefore has serious implications on their survival, reproduction and management. Elephants show a preference for secondary re-growth and are strongly associated with wet habitats such as swamps, marshes and seasonally inundated forests, but can extend their feeding range to raid crops in the advent of trying to meet their nutrient requirements. The type and quality of food available determines their range of movement. For effective conservation and management of elephant populations, an understanding of their feeding behaviour is important because it is in the course of searching for food by moving between areas that they cause problems.It therefore remains unknown which critical elements or what aspects of vegetation influence the elephant's preference during foraging.

While being bulk feeders, elephants still demonstrate distinct preference or avoidance for different plant species, which in turn affects the extent and pattern of any vegetation change that may occur with elephant utilization of a habitat (Baxter, 2003). Elephant move widely to find food patches that are sufficiently rich with resources to support them, therefore the more diverse a region, the smaller the home range (Foguekem *et al*., 2011). Elephants' feeding actions is related to utilizing death of mature trees, or through other processes leading to tree mortality (Kerley, 2001; Nasseri *et al*., 2010).

Many herbivores feed on various plants to obtain a balanced nutrient uptake and to avoid toxins of defensive chemical. This involves trade-offs between foraging on many plant species to avoid toxin and specializing on one type of plant that you can (Hawethorne & Parren, 2000). The nitrogen content of a plant is only one of the many plant characteristics that are vitally important to herbivores. However, because of its central role in all metabolic processes as well as in cellular structure and genetic coding, nitrogen is a critical element in the growth of all organisms (Chen, Deng, Zhang, & Bai, 2006).

**Materials and Methods**

This study was done in Rimoi National Game Reserve and conservation area situated in Elgeyo-Marakwet County. Elgeyo-Marakwet County is one of the fourty seven (47) Counties in Kenya. The County has a total area of approximately 3,029.8 $km^2$ (Kenya National Bureau of Statistics, 2010). Rimoi Game Reserve is situated in the Kerio valley floor in the Keiyo/Baringo boundary. It is situated between longitudes $35^0$ 30' and $35^0$ 40' East and latitude $0^0$ 40'and 0°50' North. Rimoi National Game Reserve and conservation area is about 404 square kilometres (Fig.1).

The data on preferred forages by elephants were obtained by making a systematic record of the feeding behaviour. Their diet was deduced from records of plants which showed obvious signs of recent elephant use. Debarked, browsed or grazed vegetation were picked with the use of a secateur. For each sampled tree or vegetation, areas showing signs of feeding like the leaves or bark samples were taken at browsing height (1 to 1.5 m) for nitrogen analysis. The picking was done for three hours every two days a week from 7.00 am. Picking was done at the onset of the planting season (start of wet season), harvesting season and dry season. Each of the collected plant was identified, tallied and air dried in the field inside a brown 'sugar paper bag' and later transported to the laboratory for analysis of nitrogen content. The sampling regime was that three samples of each plant species in a season were collected and analyzed. The start of the planting season was in April-May, harvest season was in July-August; which also was the peak period of conflict, and start of dry season was in October-November; which showed low crop raiding. Twenty four plants were considered for nutrient analysis, which was composed of nineteen wild forages and five major crops raided in this region.

Nitrogen was analyzed using Kjehldal methods. All the methods were done according to the procedures detailed in American Public Health Association (APHA, 1998). All the data were analyzed by descriptive statistical analysis. Analysis of variance and regression was used to obtain the relationship between preference of forage and the nitrogen content. The nutrients were subjected to ANOVA to examine the extent of variation within the season so as to make a decision on their influence on foraging preference.

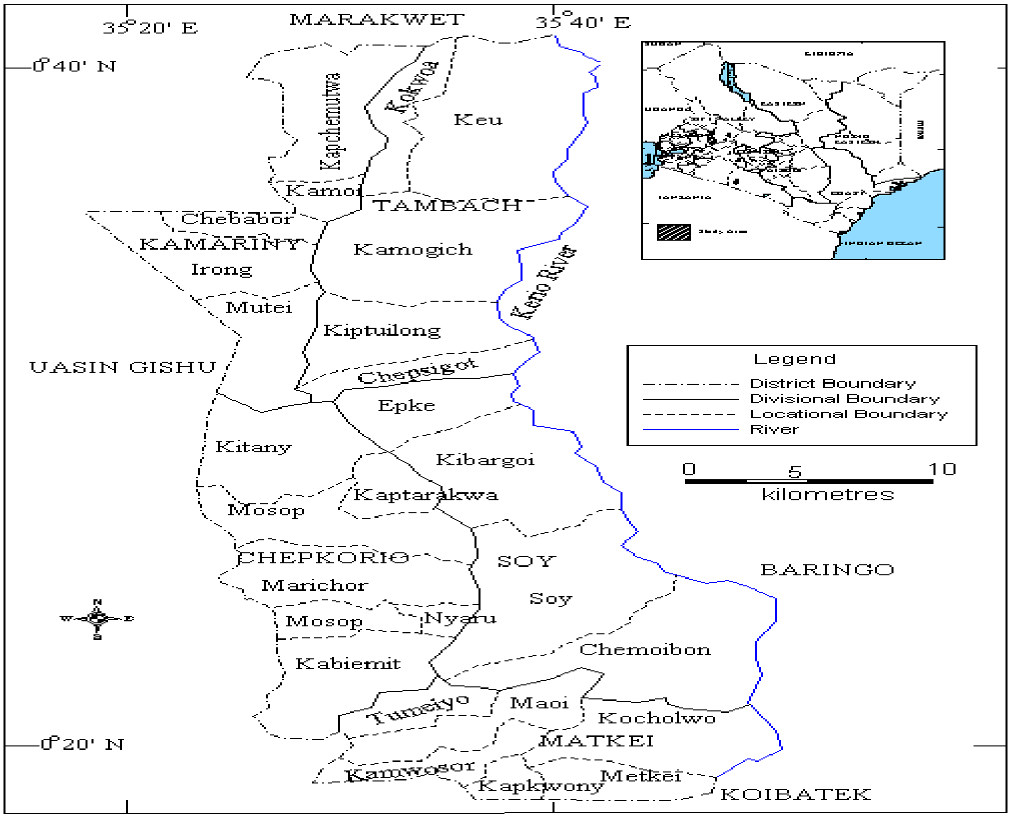


**Fig.1:** Administrative units of Keiyo District

**Results and Discussions**

The Nitrogen level was determined in the wild forages and raided crops by *L. africana africana*. The levels of nitrogen content in the wild forages are shown in Figure 1.1. There were significant differences in the levels of nitrogen among the plant species (ANOVA, F = 23.133, df = 20, p = 0.002). Plants that contained high nitrogen contents were: *Acacia mellifera* (2.77%), *Acacia hamulosa* (2.75%), *Achyranthus* a*spera* (2.65%) and *Chloris pycnothrix* (2.51%).

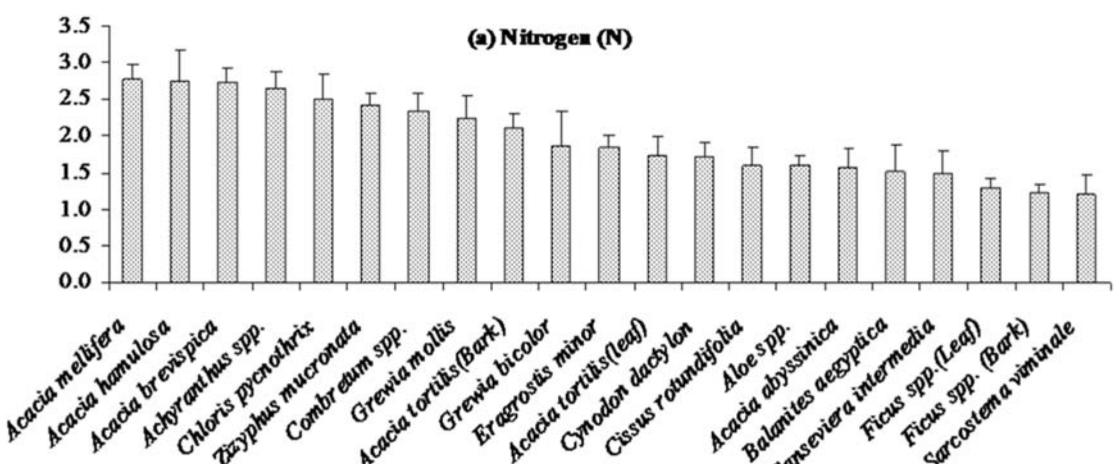


Figure 1.1: Concentration of nitrogen in wild forage browsed by *L. Africana* a*fricana* in Rimoi Game Reserve and Conservation Area

The nitrogen concentration was also determined in the raided crops (Figure 1.2). There were significant differences in the levels of nitrogen among the plant species (ANOVA, F = 11.134, df = 4, p = 0.0325). Crop plants that contained high nitrogen level were green grams (2.12%) and groundnuts (1.44%).

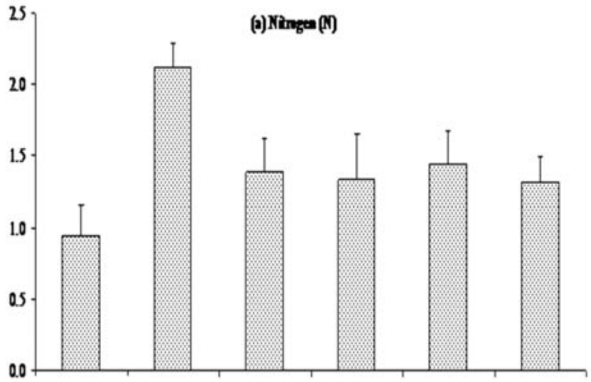


**Fig. 1.2:** Concentration of nitrogen in raided crops by *L. africana africana* in Rimoi Game Reserve and conservation area

When logistic regression was performed to determine the relative contribution of the nitrogen to the model of the feeding preference of *L. a. africana* on the wild forages, results showed that, nitrogen was a determinant in the feeding preference (Figure 1.3). Regression plots showing the relationships between the food preference and levels of nutrient elements in forages preferred by *L. africana africana* in Rimoi Conservation Area. The regression fit using linear regression and the regression coefficients are also indicated in the figures.

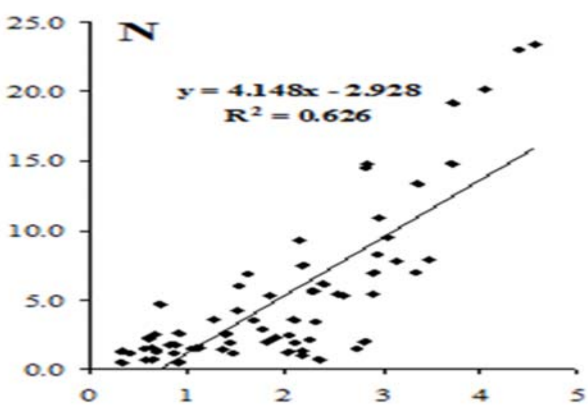


**Figure 1.3:** Nitrogen content in the wild forages

Results showed tharelationships between the feeding preference and element concentrations in the food crops were influenced by nitrogen (12.8 %, p = 0.0000) (Table 1.0).

Table 1.0: Relative contribution of nitrogen to the regression model of the feeding preference by *L. africana africana* on the wild forages in Rimoi Conservation Area.

| | Coefficients | Contribution to the model | Standard Error | P-value |
|---|---|---|---|---|
| Intercept | -7.5354 | - | 1.3487 | 0.0000 |
| N | 1.4692 | 12.7977 | 0.3229 | 0.0000 |

Acacia plants had high nitrogen levels than other plant species indicating that it may be the main drive in forage preference. These results concur with findings of Foguekem, Tchamba, Gonwouo, Ngassam and Loomis (2011) which indicated that protein concentration influence animals to select food of desired nutritive value. The animals probably use their nutritional wisdom to identify plants rich in protein. This may be the reasons why results show elephants to utilize more of the Acacia plants in this region than any other plant species. Observation made in this study shows that elephants may change vegetation composition due to this influences, which agrees with the findings of O'Connor, Goodman and Clegg (2007) which showed that elephants were responsible for the decline in Acacia plants.

Furthermore, Gandiwa, Magwati, Zisadza and Chinuwo (2011) reported that plants damaged by elephants increased with increasing elephant utilization. The study findings suggest that *A. tortilis* woodland is gradually being transformed into open woodland (Wahbi, Kaouther, Lamia, Mohsen, & Larbi, 2013). Hean and Ward (2012) showed that Acacia seedlings are tolerant to interference events such as herbivory (Wahbi *et al*., 2013).

Nitrogen (N) had the strongest positive correlation with elephants debarking behavior. Bark of *Acacia tortilis* and *Ficus species* offers a diet that is less variable in quality as the results of this study showed, which do agree with studies made by Wanderi (2007), where he found that crude protein in the bark did not vary significantly over the seasons. Results too indicated that shrubs contain high N than the grasses which may be influencing the elephant forage preference. The nutritional value of grass declines steadily as leaves age over the growing season (Georgiadis & McNaughton, 1990). In this region, grass was limited because of the climate which was mainly dry and the observed large livestock population numbers which graze on them. The mean Crude protein (CP) of elephant diet in this region was comparable with the findings of Dierenfeld (1994), which range from 10-12 % based on captive elephants. Crops in this region showed a low level of N than the browse plants. Results showed that there were significant differences in nutrient levels among the crop plant species raided, with green grams showing high nitrogen content in its tissues followed by Cow peas and Maize. This result indicates that elephants probably selected nutritious food, as opposed to selecting the most available. Crops maintain their nutrient quality after they mature, which probably may explain why results show peak period of crop raiding appearing during crop harvests, which also is the late wet season. This preposition may help in predicting the crop raiding period and thus take measures to prevent crop damage.

**Conclusions**

In conclusion, the results were analysed using analysis of variance so as to explain the relationship between preference of forage and the nitrogen levels. The findings revealed that there were significant differences in the levels of nitrogen among the plant species. The study showed that variation in forage preference was explained by the nitrogen concentration, indicating that it influences the foraging behaviour of elephants on whether to select a plant or not. On the other hand, acacia plants had high nitrogen (N) levels than other plant species indicating that it may be the main drive in forage preference from the study results. The animals seem to utilize their nutritional intelligence to identify plants that were rich in protein.

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