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Phosphorous and calcium contents in forages preferred by African elephants (*Loxodonta africana*) in Rimoi game reserve and conservation Area, Kenya

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Abstract

The African elephant (*Loxodonta africana* Blumenbach) is the largest land mammal and its strategy of altering seasonally between grass and browse is related to the plants calcium (Ca) and Phosphorous (P) contents. The study was done in Rimoi Game Reserve and conservation in 2010. Forage preference was deduced from recent feeding trails of African elephants. The 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 secateurs. For each sampled tree or vegetation, areas showing signs of feeding like the leaves or bark samples were taken for nutrient analysis. Picking was done for three hours every two days a week from 7.00 am. Picking was done at the onset of the planting, harvesting and dry season. Results showed that there were significant differences in the levels of phosphorous (ANOVA; F= 112.137, df =20, P= 0.000) and Calcium (ANOVA; F= 34.553, df = 20, P = 0.000). The preferred diet of elephants showed a mean Phosphorous of 0.21± 0.03%. The study showed the elephants were under stress for both nutrients. Further investigation is required to a certain the nutrient availability in the animal alimentary canal.

Keywords: Calcium, Phosphorous, Diet, Preference

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. The diet of elephants is composed of many plant species and plant components (Nguyen & Goh, 2011) [1]. Biologically regulated whole-ecosystem stores and fluxes of nutrients, such as phosphorus, nitrogen, and carbon, are simply the sums of the stores and fluxes of the constituent organisms (Osborn, 2014) [3]. Phosphorus has more known functions than any other mineral element in the animal body. Phosphorus occurs in phosphor-proteins, nucleic acids and phospho-lipids. The element plays a vital role in energy metabolism, in the formation of sugar-phosphates and adenosine di- and triphosphates. Micro-nutrients have been found to influence food selection by herbivores. Like calcium, phosphorus is required for bone formation and a deficiency can also cause rickets or osteomalacia. Low dietary intake of phosphorus has also been associated with poor fertility, with apparent dysfunction of the ovaries causing inhibition, depression or irregularity of oestrus. Subnormal growth in young animals and low live weight gains in mature animals are characteristic symptoms of phosphorus deficiency in all species. Phosphorus plays an important role in animal reproduction and lactation (Osborn, 2014) [3].

The elephant's strategy of alternating seasonally between grass and browse is related to the plant's Calcium content. Elephant' feeding on bark is not yet fully understood. The calcium content of dicotyledonous bark is much higher (18-57mg/g) than grasses (1-5mg/g) (Whitehead, 2011) [5]. Although a diet of grasses alone could provide elephants with a sufficient intake of calcium, it is not known how much is physiologically unavailable. Supplementing the diet with bark could increase calcium intake to a safe level. Bark may serve more than one purpose in an Elephant's diet (Scholes & Walker, 2012) [4].

Relations between bark consumption and other nutrients in different studies have been inconsistent with some studies showing high debarking intensity to be positively correlated with calcium (Wittemyer, *et al*., 2012) [6]. Heterogeneity in resource quality, coupled with adaptive response in diet selection, will influence the form of nutritional gain response to deviate from that of intake response. The form of gain response depends moreover on the extent to which digestive capacity is limited (O'Conner, *et al*., 2013) [2]. Ultimately, the diet should provide all the nutrient requirements of the animal (Scholes & Walker, 2012) [4]. Nguyen & Goh (2011) [1]. have established that foods of wild elephants are lower in protein and minerals than crops, thus crop consumption could be used to supplement deficient diets. However, the authors do not indicate that this difference in quality varies with time, as crop raiding near many habitats is highly seasonal in occurrence. By sampling food items selected by crop-raiding elephants, the study by Whitehead (2011) [5]. indicated a linkage between the onset of crop raiding and the quality of grass toward the end of the wet season. Although there is consensus that nutritional deficiency may be the cause for crop raiding, some authors Whitehead (2011) [5]. suggest that the nutrients in question are mainly proteins, while others (Scholes & Walker, 2012) [4]. suggest that minerals, rather than energy and protein, may be limited in availability, leading to crop raiding.

Materials and Methods

This study was done in Rimoi Game Reserve and Conservation Area (RGRCA), situated in Elgeyo-Marakwet County in 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 (Fig.1). It covers an area of 404 square kilometres. Forage preference was deduced from recent feeding trails of the African elephant (*L. africana*). 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 secateurs. For each sampled tree or vegetation, areas showing signs of feeding like the leaves or bark samples were taken at browsing level for nutrient 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.

Fig 1: Administrative units of Keiyo District (Ministry of Finance and Planning, 2002).

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 phosphorous and calcium analysis. The sampling regime was that three samples of each plant species in a season were collected and analyzed. Twenty five plants were considered for phosphorous and calcium analysis, which was composed of nineteen wild forages and six major crops raided. The start of the planting season was in April-May, harvest season was in July-August; and start of dry season was in October-November.

Eighty one samples were collected from different plant species. The phosphorous and calcium elements were analyzed. Two bark (*A. tortilis* & *Ficus* species) samples were also analysed. The method was done according to the procedures detailed in American Public Health Association (APHA, 1998). Both analysis of variance and multiple regressions were used to obtain the relationship between preference of forage and the nutrients.

Results

The levels of phosphorus content in the wild forages are shown in Figure 2. There were significant differences in the levels of phosphorus (ANOVA, $F = 112.137$, $df = 20$, $p = 0.000$). Plants containing the high phosphorus among the plant species were: *Achyranthus aspera* (4.22 mg/Kg), *Aloe spp*. (2.92 mg/Kg), and *Sanseviera intermedia* (2.51 mg/Kg). The preferred diet of elephants in Rimoi National Game Reserve showed a mean phosphorous of 0.21±0.03%.

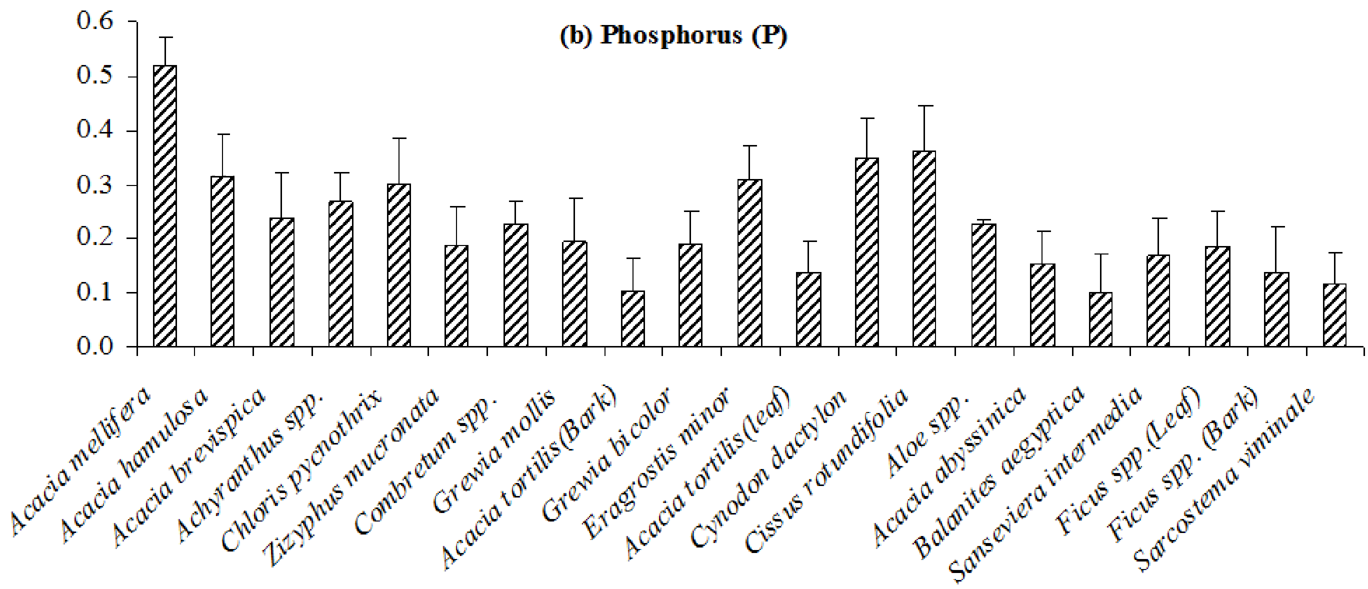

Fig 2: Concentration of phosphorus in wild forages browsed by *L. africana* in Rimoi Conservation Area

The phosphorus concentration was also determined in the raided crops (Figure 3). There were significant differences in the levels of phosphorus concentrations (ANOVA, F = 11.137, df = 5, p = 0.0052). Crop plants that contained high phosphorous level were cowpeas (0.30 mg/Kg dwt) and millet (0.35 mg/Kg dwt).

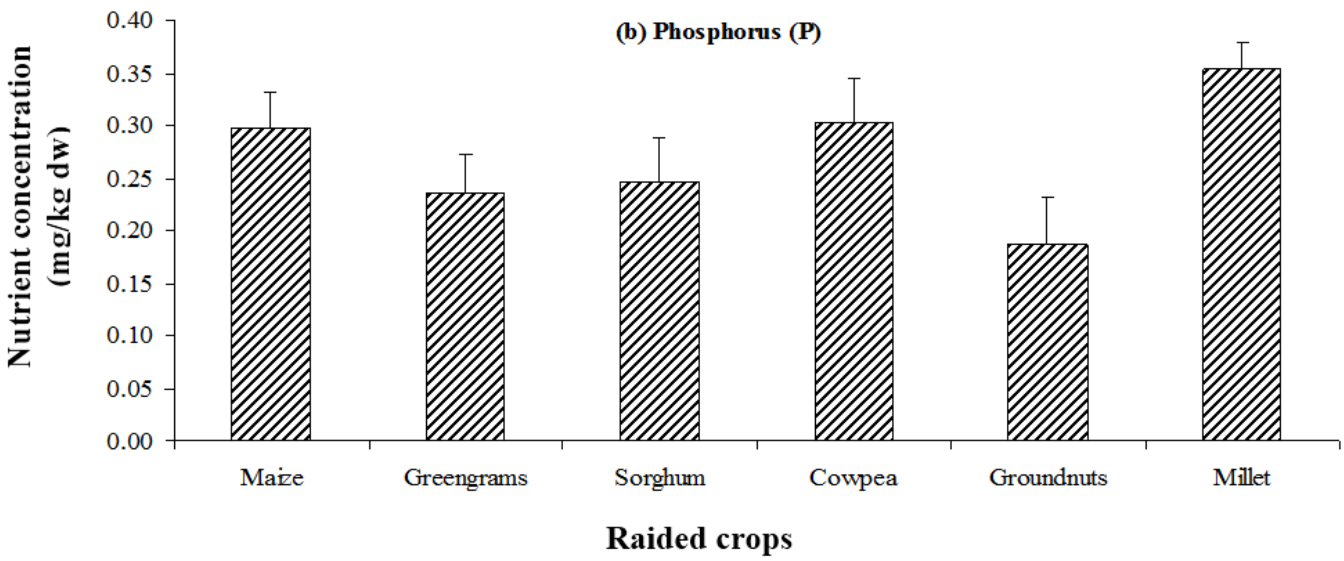

Fig 3: Concentration of phosphorus in raided crops by *L. a fricana* in Rimoi conservation area

Levels of calcium in the browsed plants are shown in Figure 4. Differences in Ca was significant among the plant species analysed (ANOVA; F = 34.553, df = 20, p = 0.0000). *A. tortilis* (Bark) (3.45 g/Kg), *Fiscus spp.* (Leaf) (3.25 g/Kg). *Ficuss spp.* (Bark) (2.82 g/Kg), *Aloe spp.* (2.53 g/Kg) and *G. Mollis* (2.36 g/Kg) had the highest concentration of Ca than other plant species.

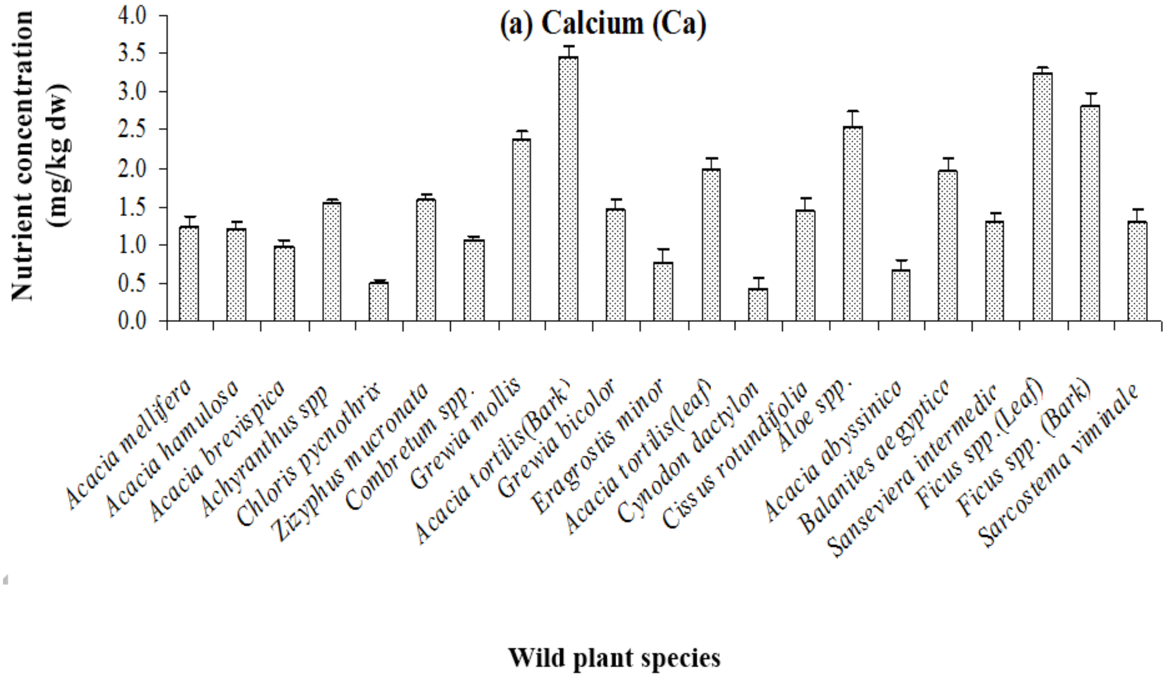

Fig 4: Calcium content in plants browsed by *L. Africana* in Rimoi Conservation Area

In the raided crops, there was significant differences in the levels of Ca among the raided crops (ANOVA; F = 11.134, df = 5, p = 0.0325). Ca was shown to be high in Cowpeas (1.95 g/Kg dw).

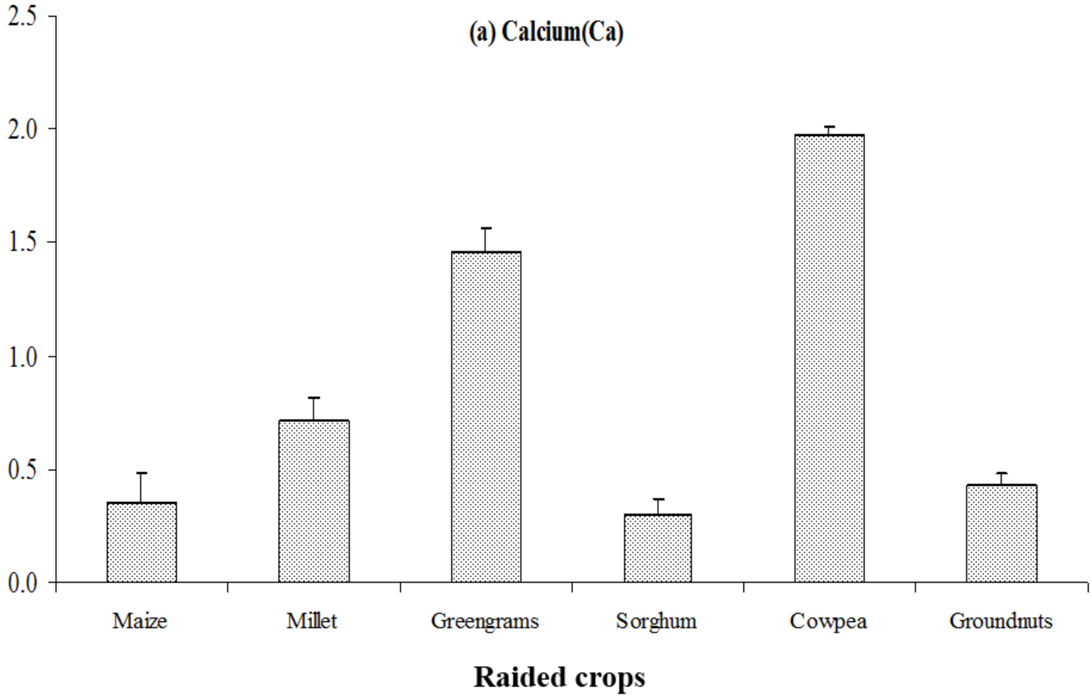

Fig 5: Calcium content in crops raided by *L. africana* in Rimoi Conservation Area

Discussion

Phosphorous (P) is considered as one of the most limiting nutrients in elephant food within the tropical environments. The study showed that there were significant differences in P concentration among the preferred plant species. The preferred diet of elephants in Rimoi National Game Reserve showed a mean that was consistent with Wanderi's (2007) detailed study of Kenyan elephant forage items showing P to be between 0.5% and 0.25%, though it deviated from that of Omondi (2010) [13]. in other tropical environments where by forages exhibit low concentrations. The deviations could have been contributed by variations on the soil types as a result of location.

Calcium (Ca) drive has properties common to other appetitive drives and most likely has an effect on the animal's behavior. Debarking of trees shows that the animals may have been under stress for this particular element, especially in situations where the herd is composed of animals with high demand for Ca, for example lactating or in calf elephants. The utilization of the bark (*A. tortilis* and *Ficuss* species) may be as a result of probably low presence of alkaloids in the plants or fixation of the element could be low. The study also showed elephants in this region preferred acacia plants which formed the bulk of their diet and this deviated from the findings of Clauss, *et al*., (2010), where he found out that the diet was dominated by grass. Variation too could be because this region is dominated by Acacia plants when compared with the grasses. The Acacia plants probably were browsed more because they remained leafy and offered forage during dry season because of their ability to conserve water and hence nutrients required by the elephants. *Ficus* species and *A. tortilis* bark were shown to be consumed frequently by *L. africana* because this part of the plant showed little fluctuation of nutrients unlike other parts, which do agree with the findings of Kozaki (2012) [9] where they found that Acacia topped the list of preferred species that are debarked. The bark consumed by elephants contained high levels of Ca, which is similar to other studies conducted by Krishnamani, *et al*., (2010) [10]. And Robins (2013) [14].

The study showed also that, it is most likely that Ca influenced the behaviour of elephants towards crop raiding. Ca drive has properties common to other appetitive drives and could have an effect on the animal's behaviour. Though geophagy has been associated with acquisition of minerals (Bazely, 2012; Mcdowell, 2012) [8, 12], there was no evidence that elephants in this region consume soils.

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