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M.Sc. Thesis

Foraging Ecology of the Giant eland (*Taurotragus derbianus derbianus*) in Senegal

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Declaration

I, Veronika Podhájecká, declare that I have elaborated my thesis independently, only with the expert guidance of my thesis supervisor Mgr. Pavla Hejcmanová, Ph.D.

I further declare that all data and information I have used are stated in the references.

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Abstract

Knowledge of foraging ecology of any animal species contributes to better understanding of its needs and enables introduction of an appropriate management measures supporting the animal's well-being. Western Giant eland (*Taurotragus derbianus derbianus*) is presently estimated to 170 individuals in the Niokolo Koba national park and has been placed on the IUCN Red List of endangered species. Thus, a conservation programme of breeding in enclosures in the Bandia and Fathala reserve has been launched in Senegal. To date, there has been very little scientific knowledge available about this antelope and no detail studies on its forage ecology have been undertaken so far. The aim of our investigation was to examine diet composition of the Giant eland through microhistological analyses of its faeces from the Niokolo Koba national park (*in-situ*) (n=30) and Bandia reserve (*ex-situ*) (n=50) in 2000-2004. In order to compare antelope's diet composition between both of the localities, effects of months during the year, age of animals and their sex, direct linear multivariate analyses in the CANOCO 4.2 package were used. 7 types of plant tissues as food items were identified, with predominant presence of leaves and wood (shoots) on the both of the localities. In spite of this, there were significant differences between localities, namely due to the high abundance of caryopsis tissue in the Bandia reserve. 6 woody plant species, *Acacia sp., Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,* and *Ziziphus mauritiana,* were identified according to tissue residuals and seeds in faeces. Diet composition significantly differed also among 3 localities within Niokolo Koba national park. In this natural habitat, the effect of the ongoing season was not proved, which could be due to low number of available samples and low frequency of faeces collection. On the other hand, the samples from the Bandia reserve were taken from concrete identified animals. The effects of season, age of the animal and weakly also the sex, were proved. The study was supported by the grant IAA 6093404.

Key words: Giant eland, *Taurotragus derbianus derbianus*, foraging ecology, microscopical analysis of faeces

Abstrakt

Znalost potravní ekologie jakéhokoli živočišného druhu přispívá k lepšímu porozumění jeho potřeb a umožňuje zavedení odpovídajících opatření směřujících k zajištění jeho blahobytu. Antilopa Derbyho (*Taurotragus derbianus derbianus*) byla zařazena na Červený seznam ohrožených druhů IUCN a její pravděpodobně poslední populace je v současné době odhadována na 170 jedinců v národním parku Niokolo Koba. Proto byl v Senegalu zahájen program záchranného oborového chovu v přírodních rezervacích Bandia a Fathala. O této antilopě je k dispozici pouze velmi málo informací a doposud nebyly provedeny žádné detailní studie zabývající se její potravní ekologií. Cílem naší práce bylo stanovit složení potravy antilopy Derbyho metodou mikroskopických analýz trusu ze vzorků pocházejících z národního parku Niokolo Koba (*in-situ*) (n=30) a rezervace Bandia (*ex-situ*) (n=50) v letech 2000-2004. K porovnání složení potravy antilop mezi oběma lokalitami, mezi různými měsíci v roce a pro závislost složení potravy na věku a pohlaví zvířat byla použita přímá lineární mnohorozměrná analýza v programu CANOCO 4.2. V potravě antilopy Derbyho bylo identifikováno 7 typů rostlinných pletiv jakožto potravních složek, z nichž převládaly na obou lokalitách listy a letorosty. I přesto byl rozdíl ve složení potravy na obou lokalitách statisticky významný, zejména přítomností obilek v potravě antilop z rezervace Bandia. Dle pletiv a semen v trusu bylo určeno 6 druhů dřevin, a sice *Acacia sp., Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,* a *Ziziphus mauritiana*. Potrava se průkazně lišila i mezi 3 lokalitami sběru trusu v národním parku Niokolo Koba. V přirozeném prostředí se neprokázal vliv postupující sezóny, což mohlo být způsobeno nízkým počtem vzorků v krátkých intervalech. V rezervaci Bandia, kde byly vzorky sbírány od konkrétních jedinců, byl prokázán vliv sezóny, věku zvířete a ve slabé závislosti i pohlaví. Studie byla podpořena grantem IAA 6093404.

Klíčová slova: antilopa Derbyho, *Taurotragus derbianus derbianus*, potravní ekologie, mikroskopická analýza trusu

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List of abbreviations

IUCN – the International Union for Conservation of Nature

ASG/IUCN – Antelope Specialist Group/ the International Union for Conservation of Nature

UNESCO - the United Nations Educational, Scientific and Cultural Organization

ECOFAC – Ecosystèmes Forestiers d'Afrique Centrale

SPEFS - the Society for the Protection of Environment and Wildlife in Senegal

NKNP – Niokolo Koba national park

ISIS - International System Species Information

Caryop - Caryopsis

UnID - unidentified

No. - Number

1. Introduction

African fauna is so rich that there are still many species left that have not been studied yet resulting in the fact there is none or just a little knowledge about them. In the case of a species that is seriously decreasing in its numbers, the lack of information is even more compelling as the understanding of the species' needs can significantly contribute to proper management decisions supporting its chances on survival and recovery from small population numbers.

Giant eland (*Taurotragus derbianus GRAY 1847*) belongs among those animal species on the Earth that have shown a continuing decline in numbers over the last decades. This decreasing trend makes the species vulnerable and threatened with a wide range of factors. Both its sub-species are on the IUCN Redlist of endangered animals. Thus, there is an urgent need to examine its overall ecology and characteristic features in as more aspects of its life cycle as possible in order to be able to provide an effective support. The knowledge gained from a continual research is the key to understanding the species'needs and thus to design the proper conservational efforts in a way that is just maximally suitable for the Giant eland's recovery.

There have been a lot of studies made for various African herbivore species dealing with the issues of forage ecology and feeding habits. The studies ranged from general ones such as comparing different strategies in herbivory by mammals (Freeland and Janzen, 1974) or comparing different models of foraging mechanisms (Belovsky, 1984; Spalinger and Hobbst, 1992; Cassini, 1994) to more detailed ones focusing on examination of concrete aspects of forage ecology of a certain species. Concretely, there was a great deal of studies undertaken in Bovidae family, where also Giant eland belongs to. Schuette *et al.* (1998) examined diets of hartebeest (*Alcelaphus buselaphus*) and roan antelope (*Hippotragus equinus*) using the long-faced hypothesis saying that skull morphology of the species dictates its capability of different grazing potential. Considering a rule the longer the face, the better capability of acquiring and masticating scarce regrowth of perennial grasses when availability of forage is lowest, it is the hartebeest that is much ahead. On the contrary, roan being not so an efficient grazer, it is forced to switch to browsing in the dry season. This is corresponding with findings of Perrin and Taolo (1999) who described by faecal analysis of plant epidermis concrete diet composition of the roan antelope after its introduction to Weenen Nature Reserve in South Africa. Feeding ecology of large (Klaus-Hügi *et al.*, 1999; Hillman and Gwynne, 1987) and small (Fritz and de Garine-Wichatitsky,

1996) social antelopes was examined as well. Hillman and Gwynne (1987) and Klaus-Hügi *et al.* (1999) studied diet composition of the Bongo antelope *(Tragelaphus eurycerus)*, although each of them used a different method. Hillman and Gwynne (1987) studied the bongo's diet through tracking and examination of rumen contents, while Klaus-Hügi *et al.* (1999) recorded food plants by browse marks along a 311-km route travelled by bongos. Despite the two different methods of the bongo's diet composition were used, the both studies ended up with the similar results showing that the species is a browser with dicotyledones from the shrub layer prevailing in its diet with main plant parts eaten being the leaves, with very little stem, fruit or seed. The bongos predominantly consume young leaves, which suggests that high protein and low fibre content influence plant choice. According to Hillman and Gwynne (1987), 116 plant species were identified as the bongo's diet. Bongo's diet in the frame of grazer-browser continuum was examined also by Cerling *et al.* (2003) through the stable isotope analysis. Results showed bongo as a browser, thus the same conclusion was made by Cerling *et al.* (2003) as by Hillman and Gwynne (1987), and Klaus-Hügi *et al.* (1999). Effects of group size on foraging choices and resource perception in impala (*Aepyceros melampus*) was studied by Fritz and de Garine-Wichatitsky (1996). The results revealed that impalas limit the intraspecific competition by controlled number of bites per single bush they feed on. Hofmann (1989) categorizes impala as a highly selective mixed-feeder, while Owen-Smith and Cooper (1987) consider it a mixed grazer-browser prefering graze. According to Sponheimer *et al.* (2003) and Cerling *et al.* (2003) impala individual specimens may vary greatly in the proportions of monocots and dicots biomass in their diets. The data for impalas gained through stable isotope analysis were the most variable ones out of the 27 southern African animal species that were analysed. Sponheimer *et al.* (2003) reports some individuals consumed 90% graze, whereas others ate up 80% browse. Sponheimer *et al.* (2003) assumes that this extreme variability probably results from sex differences and differing availabilities of monocots graze and dicots browse throughout southern Africa. Several studies also were undertaken for examination of eland (*Taurotragus oryx*) foraging ecology. The study results gained by Watson and Owen-Smith (2002) suggest that eland are able to select a diet sufficiently low in fibre content and according to these criteria they select various forage species and their parts during the season cycle. This is in perfect accordance with findings of Buys (1990) and Watson and Owen-Smith (2000) that report eland select browse of high protein forage low in fibre. Nevertheless, while some authors classify eland as a browser (Watson and Owen-Smith, 2000; Cerling *et al.*, 2003), Buys (1990) tends to claim it is an intermediate feeder as classified by Hofmann (1989). This is because of the fact that a volume of grass found in the eland's diet is greatly variable among many studies. While Watson and Owen-Smith (2000) report browse to contribute 94% to annual diet of eland with only 6% of the volume represented by grass, Buys (1990) reported grass proportions mostly varying between 20 and 45%, and some authors even state an amount of more than 50% of grass included in eland's diet (Gagnon and Chew, 2000 in Cerling *et al.*, 2003).

In the frame of studies focused on the African bovids diet, studies dealing with palatability of forage plants have been undertaken. Factors influencing the seasonal changes in palatability of woody species and the variable acceptability of the foliage to African herbivores were examined by Owen-Smith and Cooper (1987), and Watson and Owen-Smith (2002). According to Watson and Owen-Smith (2002) changes in the acceptability of unpalatable plant species over the seasonal cycle appeared to be related to the changes in proportion of young shoots of plants, as influenced by rainfall and temperature. The study animal used was eland (*Taurotragus oryx*). The plant species were typically only favoured when they offered relatively high proportion of young shoots. Nevertheless, it was total fibre being identified as the most important chemical factor influencing the acceptability to eland. Owen-Smith and Cooper (1987) examined the same issue, i.e. the palatability of woody plants to browsing ruminants and their forage selection, in free-ranging kudus (*Tragelaphus strepsiceros*), impalas (*Aepyceros melampus*), and domestic goats. The authors found out that woody species fell into two basic categories of acceptability to the animals: (1) species favoured all year-round; and (2) species generally rejected except during certain periods. Among the latter, some species were revealed to increase in acceptability during the dry season; others were favoured temporarily while new leaves predominated. Some species remained low in acceptability all year-round.

Vertical zonation of browse quality in tree canopies exposed to African browsing ungulates was examined by Woolnough and du Toit (2001). It was investigated whether the food quality of tree foliage for savanna browsers varies across their feeding height range. Leaf dry mass, total N, neutral detergent fibre and condensed tannin were measured using near-infrared spectroscopy, but here was no difference found between height levels with regard to leaf chemistry concentrations. By this, the reason why the larger herbivores use the higher zones of trees when feeding, is the larger browsers gain a bite-size advantage by browsing above the reach of the smaller species.

Despite the fact that so much effort has been invested by scientists into examination and research work of such a large number of African herbivores, and more specifically, forage ecology and diet composition of the most African bovids is already known, Giant eland has been rather omitted so far, and thus, for this species more questions remain raised than answered. According to Bro-Jorgensen (1997), the reasons for being so could be both because of antelope's suspicious nature and the fact it lives in low densities in woodland savannah with poor visibility. In the consequence, there has been very little scientific knowledge about this antelope available as there were only a few local studies carried out. The Giant eland's morphology and distribution were examined by Dorst and Dandelot (1970), and Kingdon (1982). There were no detailed studies of foraging ecology undertaken for the western sub-species of Giant eland (*Taurotragus derbianus derbianus GRAY 1847*). A team of specialists from the Czech University of Life Sciences in Prague has been participating in the Giant eland conservational efforts and basic research since 1998. In the frame of this research, 32 plant species (Annexe/Table 5) were indicated as a probable part of Giant eland diet and the traces of browsing were confirmed on 13 of them (Nežerková and Hájek, 2000). The fact that no detail study focused on the Western giant eland sub-species' foraging ecology has been done so far is why, this thesis deals with this task.

At present, the Western giant eland lives freely only in the Niokolo Koba National Park (East, 1998; Kingdon, 1997; Nežerková and Hájek, 2000), and in captivity in the Bandia reserve (Nežerková *et al.*, 2004; Antonínová *et al.*, 2004; Antonínová *et al.*, 2006) and the Fathala reserve (Antonínová *et al.*, 2006). Moreover, according to Darroze (2004) its sporadic presence was confirmed in Guinea and Mali. Niokolo Koba National Park is an *in-situ* location and the Bandia reserve represents a unique world-wide *ex-situ* breeding. The samples for the thesis were taken from these two locations.

The foraging habits of a species can be examined through various methods. The option of the proper method varies case to case and depends on a specific ecology of each particular examined species, on the purpose of the study, on the concrete conditions (terrain, season, etc.) as well as on observer's means (equipment, skills, experience, etc.). These methods can be either invasive (e.g. post-mortem examinations) or non-invasive methods (Morrison *et al.*, 1992 in Perrin and Taolo, 1999). In the case of rare or endangered animals, thus where the destruction of animals is not possible, the non-invasive methods are used (Perrin and Taolo, 1999). These can be direct or indirect ones. Direct methods are based on a direct observation of animals and their behaviour in the field (Morrison *et al.*, 1992 in Perrin and Taolo, 1999). This was however not a case of this thesis, for which all the data were gained by indirect methods because of the better suitability. Indirect methods include techniques not directly focused on the animals themselves. The data obtained by these methods arose from examination of floristic composition, browse marks on vegetation, animals' tracks and dungs (Nežerková and Hájek, 2000) and other can be gained through the microscopical analyses of faeces.

According to Cerling *et al.* (2003) most dietary estimates of African bovids are based on a combination of methods including observation of ingested plants, examination of faecal matter or stomach contents, and occasionally stable isotope analysis.

An example of an indirect method of diet examination is the 'stable isotope analysis' that was used by Cerling *et al.* (2003) and Sponheimer *et al.* (2003) for Eastern African bovids. This represents a non-invasive method based on the carbon isotopic distinction between C_3 and C_4 photosynthesis. It is based on an assumption that most dicots use the C_3 photosynthetic pathway, whereas most tropical grasses (monocots) use the C_4 photosynthetic pathway (Tieszen *et al.*, 1979 in Cerling *et al.*, 2003). The isotopic composition of animal tissues sampled, such as tooth enamel, bone collagen, hair, or faeces, records diet of animals (Cerling *et al.*, 2003; Sponheimer *et al.*, 2003). A fact that all these tissues can be analyzed for stable carbon isotops, makes it an easy and widely applicable technique (Sponheimer *et al.*, 2003). Also another fact that diets documented by this technique pertain to food ingested weeks to years before obtaining the samples, contributes to a great potential of effectivity of this method (Cerling *et al.*, 2003). Sponheimer (2003) also states that although carbon isotops cannot provide us with the rich detail often found in observational studies, they are extremely effective at quantifying relative proportions of graze and browse in an animal's diet. Based on volume of the fraction of C_4 grass in the diet, Cerling *et al.* (2003) classifies East African bovids into following categories in the context of the grazer-browser continuum: hypergrazers (>95% C_4 grass), grazers (70-95% C_4 grass), mixed feeders (>30% C_4 grass and >30% C_3 browse), browsers (70-95% C_3 browse), and hyperbrowsers or frugivores (>95% C_3 browse or fruit). Advantages of this method are that the results are readily quantifiable and the method can be used even for animals that have been dead for millions of years. On the contrary, disadvatages lie in impossibility of finer distinctions (e.g. between C_3 browsers and C_3 frugivores); only distinguish between C_3 and C_4 fractions of the diet can be made (Cerling *et al.*, 2003).

The method of microscopical analysis of faeces applied in this thesis, is also the indirect one. It is widely used in studies dealing with foraging issues and acquited well by bringing realiable results and because the great advantage of this method consists in fact that it is non-invasive one. Similarity of the results gained by the macroscopic stomach content analysis and the microscopic faecal contents analysis in ungulate diet (in *Capreolus capreolus, Cervus elaphus, Cervus nippon* and *Ovis musimon*) was examined by Homolka and Heroldová (1992) with the conclusions showing not statistically significant difference between results gained by these two methods. Perrin and Taolo (1999) used the method of faecal analysis of plant epidermis for examination of the diet of roan antelope (*Hippotragus equinus).* Also Stewart (1967) used this method for studying the food preferences of 7 species of African grazing herbivores including wildebeest (*Connochaetes taurinus*), Coke's hartebeest (*Alcelaphus buselaphus*), Grant's and Thomson's gazelles (*Gazella granti* and *G. thomsonii*), buffalo (*Syncerus caffer*), steinbuck (*Raphicerus campestris*) and common zebra (*Equus burchellii*). The long-faced hypothesis examined on diets of hartebeest (*Alcelaphus buselaphus*) and roan antelope *(Hippotragus equinus)* by Schuette *et al.* (1998) was practically verified by using microhistological analysis of faeces. Ego *et al.* (2003) studied dietary composition of wildebeest (*Connochaetes taurinus),* kongoni (*Alcelaphus buselaphus*) and cattle (*Bos indicus*) in south-central Kenya. This study managed to describe the diet composition through different seasons and also the diet preference of the three studied animal species was examined. Stewart's (1967) critical remark to the microscopical faeces analysis is that only those plant species eaten infrequently and in small quantities are missed completely in faeces. Thus, same as all scientific methods being used for forage ecology examination, neither faecal analysis method is faultless or unimpeachable but it has brought quite reliable results in many studies so far.

Findings of the thesis can be applied to further Giant eland conservational efforts and the knowledge of its forage ecology gained through this study can assure the proper ways of management and care, mainly in the captivity breeding.

2. Aim of the Thesis

Considering the overall lack of scientific knowledge about Giant eland, the purpose of my thesis was to gather existing information available at present and to bring some new findings through my own examination in order to extend the current deficient level of the knowledge about the species. Findings will be useful for future research carried out in this species which is seriously needed. This thesis will contribute to better understanding of Giant eland's ecology and to its appropriate conservation management.

The aim was to examine Giant eland's (*Taurotragus derbianus* GRAY 1847) forage ecology in general and then to assess which particular plant species or parts of plants were used as its forage (qualitative as well as quantitative assessment). The fact that two sets of data from two different localities (*ex-situ* and *in-situ*) were available for examination could bring interesting conclusions descending from the mutual comparison of these two sites. The effects of month in season as well as different age of examined animals on forage ecology were examined.

For this purpose, following 5 hypotheses were formulated:

H1: There is no effect of the site on forage composition of the Giant eland.

H2: There is no effect of the month of samples' collection on forage composition of the Giant eland in general, and within the both sites separately.

H3: There is no effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland in general and on forage composition with particularly defined various types of fruits found.

H4: There is no effect of the age of animals on forage composition of the Giant eland.

H5: There is no effect of the sex on forage composition of the Giant eland.

3. Material and methodology

3.1 Study animal

3.1.1. Giant eland (*Taurotragus derbianus)*

The Giant eland or Derby's eland (*Taurotragus derbianus* GRAY 1847), (synonym *Tragelaphus derbianus*), is the largest antelope in the world and is fast disappearing in Western Africa (Dorst and Dandelot, 1970). It belongs to family Bovidae, sub-family Bovinae, tribe Tragelaphini (Wilson ***et al.***, 2005).

The Giant eland has two sub-species with differing distribution and conservation status IUCN (1996): the Western giant eland (Figure 1), ***Taurotragus derbianus derbianus*** GRAY 1847, and the Eastern giant eland, ***Taurotragus derbianus gigas*** HEUGLIN 1863 (Wilson ***et al.***, 2005).

3.1.1.1 Morphology

It is a massive antelope with a body length of 290 cm in males, 220 cm in females and its height at the withers is between 150-176 cm in males and 150 cm in females. Male can reach weights of 450-950 kg; female 440 kg (Dorst and Dandelot, 1970). The coat is short and smooth. Its overall colour is chestnut or ruddy fawn, sometimes with a tint of a bluish grey (Bro-Jorgensen, 1997). This depends on the animal‘s age and the climatic period. It has roughly 9-14 white stripes on its flanks (Dorst and Dandelot, 1970). Bulls have a chocolate brown hair mat on the forehead. Two white cheek spots and a white stripe in front of the eye are present on each side (Bro-Jorgensen, 1997). The antelope has a black mane on its neck from which a black stripe continues along the entire length of the back (Dorst et Dandelot, 1970). From the chin to the chest there hangs an enormous black and white dewlap which is tufted at the chest level and sometimes below the jaw. White and black garters are present above the hooves and on the back of the upper forelegs (Bro-Jorgensen, 1997). Both sexes have horns. They curve in a spiral and can reach the length of up to 80-123 cm and are a greatly prized hunting trophy (Dorst and Dandelot, 1970). The ears are broad and expanded. The dark tufted bovine tail measures 55 – 79 cm (Bro-Jorgensen, 1997).

The difference between two existing Giant eland sub-species has, until now, only been determined on the basis of the morphological description (Dorst and Dandelot, 1970; Kingdon, 1982; Ruggiero, 1990). The western sub-species ***T.d. derbianus*** is characterized by smaller size, bright rufous ground colour and about 15 white stripes on its body; the eastern sub-species is larger in size, has sandy groung colour and around 12 body stripes (Bro-Jorgensen, 1997). A genetic study on the differences between sub-species is taking place at the University of Stellenbosch in the Republic of South Africa (Beck 2003, personal communication in Nežerková *et al.*, 2004).

Fig. 1 - Western giant eland (*Taurotragus derbianus derbianus*). Photo by P. Hejcmanová

3.1.1.2 Ecology and behaviour

The Giant eland is predominantly a browser (Kingdon, 1997). There are seasonal and regional variations in the food choice (Bro-Jorgensen, 1997). Browse consists of the dominant leguminous trees and some young grasses and herbs early in the wet season (Kingdon, 1997). According to Bro-Jorgensen (1997) the Giant elands are selective but flexible feeders with 65 dicotyledones recorded in their diet. By breaking or bending branches at a height of up to more than 2.5 m, Giant elands of both sexes get access to leaves at even higher levels (Bro-Jorgensen, 1997). They move long distances to drink but they can do without water for some time (Kingdon, 1997).

Kingdon (1997) considered that Giant eland is quite strictly confined to *Isoberlinia doca* woodland, but later studies indicate that its range includes areas of ***Terminalia-Combretum-Afzelia*** woodland where there is no *Isoberlinia*, e.g. in parts of Cameroon's North Province (Bro-Jorgensen, 1997).

Giant elands form herds up to 60 individuals (Kingdon, 1997). Whereas adult cows and juveniles generally are found in larger groups, adult bulls can also opt for solitary existence or membership of small groups (Bro-Jorgensen, 1997).

The Giant elands are highly nomadic with very large ranges and distinct seasonal movements (Kingdon, 1997).

Visual communication is quite important in this species. There is a large number of body displays and stances to express response to agression (i.e. displays of submission, appeasement, defensive threat etc.), and threat displays (glance threat, object aggression, feinted attack etc.) (Figure 2).

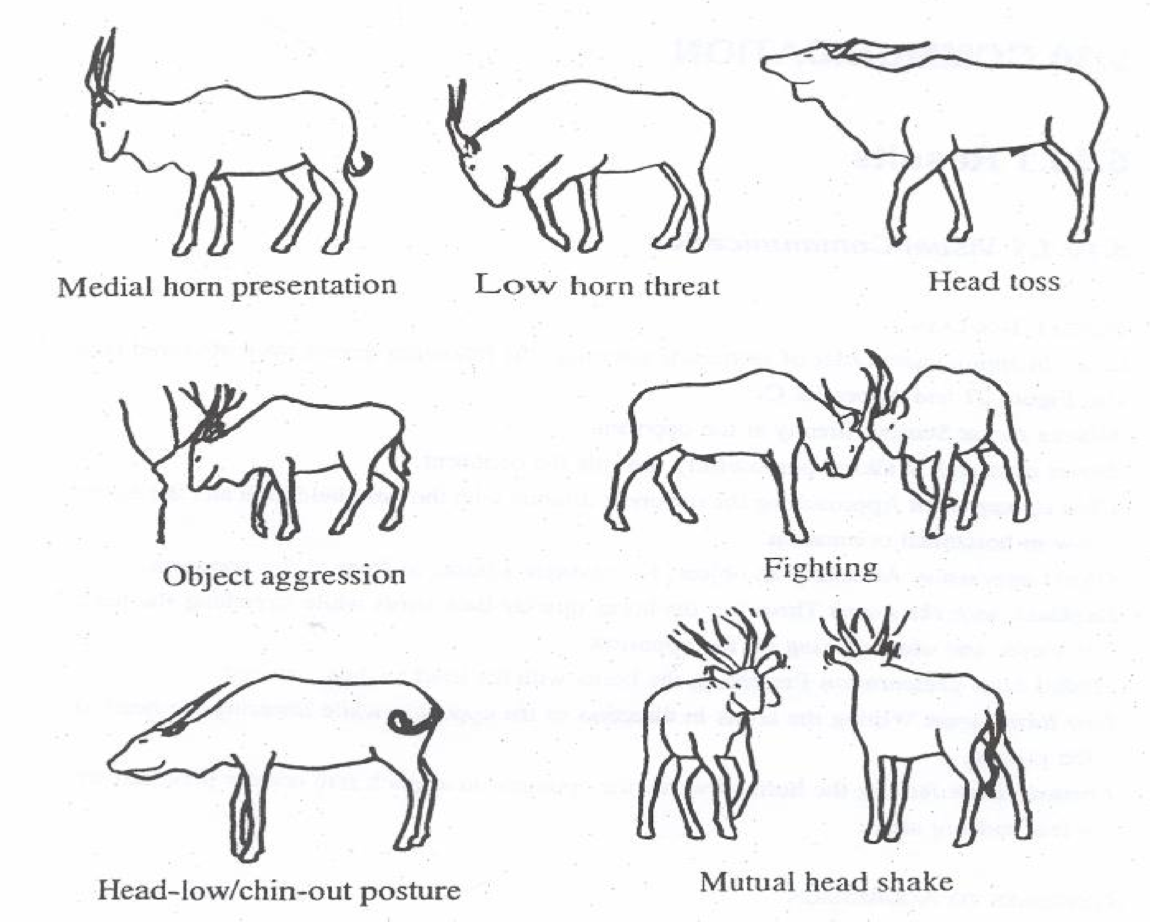

Fig. 2 - Visual displays and fighting stance (Bro-Jorgensen, 1997)

An alarm bark is emitted by both bulls and cows upon danger, the male bark being of slightly lower pitch (Bro-Jorgensen, 1997).

Giant elands of all ages are often observed rubbing their horns and forehead against trees, or , during the rains, on muddy termitaria or in muddy soil.

There are well-established dominance hierarchies in the herds. The dominance order is as follows: cows = adult bulls > juveniles >calves (Bro-Jorgensen, 1997).

Synchrony of mating is assumed (Haltenorth and Diller, 1980 in Bro-Jorgensen, 1997). In the wild, the majority of calves are born between September and November and the main rut takes place in December to February (Bro-Jorgensen, 1997). Parturition during the middle of the wet season seems adaptive, at least under natural fire regimes: at the time when nutritional and water requirements peak during late pregnancy and lactation, moist food is plentiful and the protein:fibre ratio is high (Kingdon, 1982). Furthermore, the tall grass provides cover for the young (Bro-Jorgensen, 1997). The gestation period is $8^{1/2}$ – 9 months (Haltenorth and Diller, 1980 in Bro-Jorgensen, 1997). Fertilization is assumed not to take place before 25 months of age. The youngest bull fertilizating a cow in captivity was 2 years old, however, the presence of a dominance hierarchy between bulls in the wild is likely to postpone reproduction for many years (Bro-Jorgensen, 1997).

Unlike the smaller tragelaphines who rely on remaining undetected by freezing or sneaking away from danger, the elands may face difficulty in hiding. They have the longest flight distance among the antelopes and they are reported to counter-attack their predators (Kingdon, 1982). The elands and the bongo *(Tragelaphus euryceros)* are the only tragelaphines with horned cows indicating active defence against predators. According to Bro-Jorgensen (1997), the Giant elands were found to have amazing faculties of smell, sight and hearing. Any sound detected would generally have to be confirmed by vision or smell before flight is taken but an exception is when alarm calls of other species were heard, in which case flight often is elicited without confirmation. In general, the animals in the front and rear would be most wary judging from their higher scanning rates. After a flight the juveniles and adults in the rear would be extremely cautious, often scanning in all directions for several minutes, and they would immediately resume flight at the slightest sign of danger. When regarding a suspiciously looking object, a giant eland would typically stand in alert posture and move its head abruptly from side to side or up and down, probably to observe the object from more angles (Bro-Jorgensen, 1997).

3.1.1.3. Geographical distribution and conservation status

The current distribution of the Giant eland (Figure 3) was investigated by a group of antelope specialists from ASG/IUCN who, in the framework of the project ,,Global survey and actional plans for antelopes“ in western and central Africa, carried out a detailed investigation (East, 1998).

In 1996 a team of specialists from the Institute of Tropics and Subtropics at the Czech University of Life Sciences Prague worked out a general project proposal “Antelope Preservation and On-farm Breeding for Their Economic Use in Selected West African Countries“. The project has been supported by the Czech Ministry of Foreign Affairs and FAO. Senegal has been chosen as the country of the implementation. In 1998 the first Czech – Senegalese Framework Agreement was signed and since 2000, the final form of the project, entitled “Conservation and breeding of the Giant eland (***Taurotragus derbianus derbianus)*** and other antelopes for the purpose of their economic use“, has been implemented. The project finally evolved to a much larger and more important extent and is now known as the “Conservation Programme of the Western giant eland in Senegal“. The conservation programme includes a scientific branch which considers practical measures for the species conservation such as breeding ***ex-situ***, genetic management of the bred herd, technical support of the action, etc. The Directorate of the national parks of Senegal (DNPS) is the principle acting authority in the protection effort. The Society for the Protection of Environment and Wildlife in Senegal (SPEFS) manages two wildlife reserves, Bandia and Fathala, and the first herd of Western giant eland in captivity (Nežerková ***et al.***, 2004).

Beside that, other scientific investigation was carried out through the ECOFAC project dealing with radio-telemetric monitoring of the eastern Giant eland ***(Taurotragus derbianus gigas)*** in the Central African Republic (Graziani and d’Alessio, 2004).

3.1.1.3.1 Eastern giant eland

The Eastern sub-species, *Taurotragus derbianus gigas* HEUGLIN 1863, numbers roughly 14 000 distributed over Cameroon, the Central African Republic. The population in Chad and the Democratic Republic of Congo has become extinct. This sub-species in on the Red list of endangered animals with status Lower Risk – Near Threatened (East, 1998).

Major surviving populations of the Eastern sub-species, *Taurotragus derbianus gigas,* occur in the savanna woodlands of the national parks and hunting zones of

Cameroon's North Province and northern and eastern Central African Republic (East, 1998). Ecosystems in these two countries are quite similar to the one in Senegal, though the plant dominants vary a bit.

In the Central African Republic there are the following dominant species: *Detarium macrocarpum*, *Terminalia laxiflora, Burkea africana*, *Isoberlinia doka* (Seca-Agrer, 1993 in Graziani and d'Alessio, 2004).

In the neighbour country of Cameroon the dominants are represented by *Isoberlinia doka, Terminalia laxiflora, Piliostigma thonningi, Gardenia aqualla, Maytenus senegalensis, Crossopteryx febrifuga, Combretum glutinosum, Burkea africana, Terminalia macroptera, Detarium microcarpus, Afzelia africana, Anogeissus leiocarpus, Monotes kerstingii* (East, 1998).

The eastern sub-species live both in the wild and in captivity. There are 5 individuals bred in 2 zoos in the South-African Republic and 44 individuals bred in 7 zoos in the USA (ISIS 2008).

There was an outbreak of the rinderpest epizootic in 1982-1983 causing substantial mortalities in herds as the Giant eland is highly susceptible to this disease. However, there appears to have been substantial recovery of the populations in Cameroon and Central African Republic since then. Nevertheless, further outbreaks of rinderpest spread through infected cattle are a constant threat to the Giant eland (East, 1998).

3.1.1.3.2 Western giant eland

The Western sub-species, *Taurotragus derbianus derbianus* GRAY 1847, presently estimated to 170 individuals (Renaud *et al.*, 2006). Its only sure distribution is in Senegal in Niokolo Koba national park. There were only sporadic records of these antelopes in the surrounding states of Mali and Guinea in 2003 (Darroze, 2004), in Guinea-Bissau there have not been any recent confirmed sightings at all. They have the status of Endangered (East, 1998) on the IUCN Red list of endangered species.

The natural habitat of the Western sub-species is grass savannah, shrub savannah, woody savannah, and many transitions among them located in the area of the Niokolo Koba National Park. But the most extensive vegetation formation in the Niokolo Koba is grass and woody savannah, in which high stemmed grasses predominate such as *Andropogon gayanus, Pennisetum pedicellatum, Cymbopogon giganteus, Diheteropogon amplectens, Schizachyrium sanguineum*, and others with more or less thickly growing bushes and trees such as *Bombax costatum, Burkea africana, Cochlospermum tinctorium, Cordyla pinnata, Crossopteryx febrifuga, Detarium microcarpum, Gardenia ternifolia, Lannea acida, Pterocarpus erinaceus, Sterculia setigera, Stereospermum kunthianum, Strychnos spinosa, Xerroderis stuhlmanii* and *Vitex madiensis* (Nežerková ***et al.***, 2004).

The conservation strategy of the Western giant eland includes both ***in-situ*** (Niokolo Koba National Park) and ***ex-situ*** breeding (the Bandia reserve). The Bandia reserve was established in 2000 as a fenced breeding area for protection and reproduction of the animals (Nežerková ***et al.***, 2004).

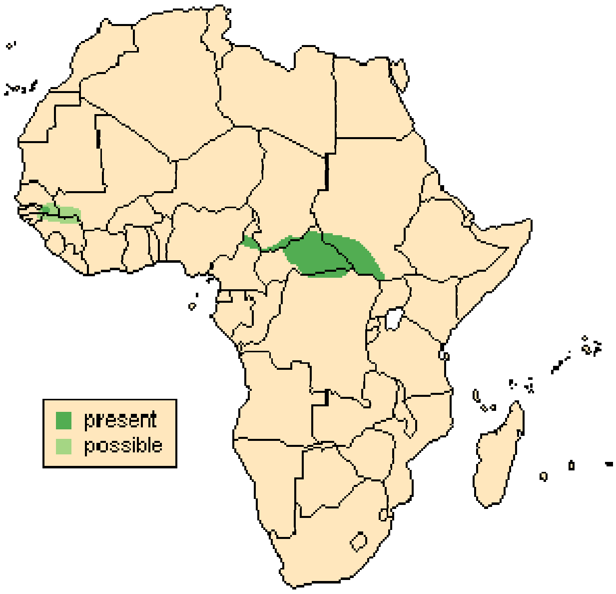

Fig. 3 – Distribution of the Giant eland ***(Taurotragus derbianus)*** (Hoffman, 2004)

3.2 Study areas

3.2.1 Niokolo Koba National Park (Senegal)

The natural habitat for the Western sub-species, ***Taurotragus derbianus derbianus,*** in Senegal is represented by the Niokolo Koba National Park (Parc National du Niokolo Koba). It is the largest and oldest national park in Senegal lying in its south-eastern part between 12°30‘- 13°20’N and 18°30‘- 13°42’W. It was established in 1954 as the last refuge for the large West African fauna in Senegal. The original area of 260 000 ha has been extended to 913 000 ha. In 1981 the Niokolo Koba National Park was proclaimed a Reserve of the Biosphere in framework of the UNESCO, "Man and Biosphere" programme and put on the World Heritage List (Anonymus, 2000). It constitutes a well preserved ecosystems of Sudanian savannah with relevant flora and fauna (Nežerková and

Hájek, 2000). Its southern border links up to the neighbouring Badiar National Park in Guinea making up Niokolo – Badiar international ecological complex and biocorridor.

There are several main types of savannah distinguished in the park: grass savannah, shrub savannah, woody savannah, and many transitions among them. If higher soil humidity, the riverine forest occures. Swamps occur as well (Madsen *et al.*, 1996 in Nežerková, 2004).

3.2.1.1 Relief

The national park‘s relief is, on the whole, flat; only in south eastern part do the foothills of the nearby Guinean Fouta Djalon mountain rise. The average height above the sea level is 100-150 m, the highest top is the table-top mountain Assirik with an elevation of 311 m.

The largest river is the Gambia, a huge flow with high steep banks overgrown with gallery forests. In the dry period the Gambia can be forded but after the first rains the river gains strength and its level can rise by up to 10 metres. Smaller, but no less significant, rivers in the park are the right hand tributaries to the Gambia Niokolo Koba and Koulountou (Nežerková *et al.*, 2004).

3.2.1.2 Soils

The basic types of soils are poorly developed tropical red soils, which in areas with increased iron content transform into a hard armour of ferrolateritic crusts, which are either entirely exposed or have a thin layer of grey silt. This armouring is called a bowal in the local language of fulbe (peulh). In the river valleys and depressions alluvial and hydromorphic soils have developed enabling dense ant thick vegetation to form.

3.2.1.3 Climate

Climatically the national park falls into the Sudanese and transitional sub-Guinean areas with rainfall being 900-1200 mm annually. There are two main seasons: the dry season lasting from November to June and the rainy season lasting from July to October. In the peak of the dry season temperatures reach 45°C (Leroux, 1983 in Nežerková *et al.*, 2004).

3.2.1.4 Vegetation

The flora of the Niokolo Koba is very rich. Of the roughly 2500 species of higher plants in Senegal NKNP has about 1500 of them (Madsen *et al.*, 1996 in Nežerková, 2004). The wealth of flora is also testified by the fact that 160 plant species managed to be determined at the first visit even though the savannah had been burnt by fire (Nežerková and Hájek, 2000). The species recorded in the park belong to 120 families, of which 4 are the most numerously represented: *Poaceae* (13.6%), *Fabaceae* (12.7%), *Cyperaceae* (7.2%) and *Rubiaceae* (5.5%). Phytogeographically NKNP can be broken up into the transitional zone of the Sudanese and Sudano-Guinean savannahs (White, 1983 in Antonínová *et al.*, 2004). The most extensive vegetation formation in the Niokolo Koba is grass and woody savannah, in which high stemmed grasses predominate such as *Andropogon gayanus, Pennisetum pedicellatum, Cymbopogon giganteus, Diheteropogon amplectens, Schizachyrium sanguineum*, and others with more or less thickly growing bushes and trees such as *Bombax costatum, Burkea africana, Cochlospermum tinctorium, Cordyla pinnata, Crossopteryx febrifuga, Detarium microcarpum, Gardenia ternifolia, Lannea acida, Pterocarpus erinaceus, Sterculia setigera, Stereospermum kunthianum, Strychnos spinosa, Xerroderis stuhlmanii, Vitex madiensis*, and interesting formations grow on the bowal – ferrolateritic crust which is almost without soil, therefore annual forbs and grasses predominantly grow here such as *Lepturella aristata, Danthoniopsis tuberculata and Lepidagathis capituliformis*. Along the rivers and temporary wadis, gallery forests form with them special microclimate, in which copious amounts of species requiring dampness and deeper soil grow. Evergreen plants and lianas such as *Saba senegalensis, Nauclea latifolia, Combretum tomentosum, Strophantus sarmentosus* can be found here. Some species grow to enormous heights of up to 30 m. Typical species are *Anogeissus leiocarpus, Ceiba pentandra, Cola cardifolia, Khaya senegalensis*, and others. The marshes in the flooded river valleys of the Gambia are only covered with a low herb and grass growth, and sporadic bushes. The reduced rainfall in recent years has led to the marshes drying up and *Mimosa pigra* bushes growing. This has become a serious problem as the marshes ensure grazing and water for the fauna, particularly in the peak of the dry period when water becomes the limiting factor in the animals‘ survival.

Apart from the seasonal rains, fire also has a significant effect on the park vegetation. The role of fire in savannah ecosystems is the subject of various and often contradicting views. Natural fires have been here since time immemorial; however their frequency of occurence was disproportionatelly lower than the frequent and uncontrolled fires. Fires are a part of the NKNP‘s management, and with good reason. Early burning after the wet season has ended, as long as the moisture remains in the soil, it is able to prevent destructive fires in the peak of the dry season when the savannah is arid. Another reason is that burning removes drying biomass thus stimulating grass growth, which is the dietary basis for the herbivores (Nežerková *et al.*, 2004).

3.2.1.5 Fauna

The NKNP represents an extensive area of preserved ecosystems in Western Africa and it is the last refuge for large animals in the area. The park is a haven for 80 species of mammals, 330 birds, 38 reptiles, 20 amphibians and 60 species of fish. The large animals from the Bovids family *(Bovidae)* that can be named are Bubale hartebeest *(Alcelaphus buselaphus major),* African buffalo *(Syncerus caffer),* Kob *(Kobus kob),* Defassa waterbuck *(Kobus ellipsiprymnus defassa),* Western giant eland *(Taurotragus derbianus derbianus)*, Roan antelope *(Hippotragus equinus)*, Bohor reedbuck *(Redunca redunca)*, Oribi *(Ourebia ourebi)*, Grimm's duiker *(Sylvicapra grimmia),* Red-flanked duiker *(Cephalophus rufilatus)*, Bushbuck *(Tragelaphus scriptus)*, from the pigs and hogs *(Suidae)*: Warthog *(Phacochoerus africanus),* Red river hog *(Potamochoerus porcus)*, and others. Apart from the ungulates we can also find other large mammals such as lion *(Panthera leo)*, leopard *(Panthera pardus)*, serval (*Felis serval*), caracal (*Felis caracal*), Striped jackal *(Canis adustus)*, African wild dog *(Lycaon pictus)*, Spotted hyena *(Crocuta crocuta),* Patas money *(Erythrocebus patas),* Vervet monkey *(Cercopithecus aethiops),* Guinean baboon *(Papio papio),* chimpanzee *(Pantroglotydes verus)*. Further there are a number of representatives from the orders *Insectivora (3), Chiroptera (15), Primates (5), Carnivora (20), Proboscidea (20), Hyracoidea (1), Tubulidentata (1), Artiodactyla (14), Rodentia* and *Lagomorpha (9)* (Anonymus, 2000).

3.2.2 The Bandia Reserve

The Bandia Reserve is situated 65 km south of Dakar, at longitude W 17°00‘ and latitude A 14°35‘. The Reserve was created on the south-western boundary of the ‘Classified Forest Bandia‘ by the Society for Protection of Environment and Wildlife in Senegal (SPEFS). The Bandia Reserve is a fenced area for the purpose of the safari-tourism and for to contribute to the protection of environment and wildlife conservation at the same time. The extent of the reserve was 460 ha at the creation in 1990, later it was extended to 650 ha and it has approximately 1500 ha at present (Antonínová *et al.*, 2006).

3.2.2.1 Relief

The reserve lies on the Rio de Oro Basin consisting of the Precambrian basement complex overlain with marine sediments and continental intercalaire of upper Eocene and Miocene Age. The relief is flat, on clay-loam saline, gravel sand and limy sand soils. The temporary water flow Somone passes through the Reserve. Three artificial watering holes were built up. The biggest one receives its water supply from the Somone River in the rainy season. In addition, a drill hole was dug in January 2000 for to assure water for animals during dry season (Antonínová *et al.*, 2004).

3.2.2.2 Climate

The Reserve receives an annual rainfall between 350 and 742,4 mm in last 10 years. Two distinguished seasons characterize the climate: dry season (from November to April) and rainy season (from July to October). The temperature differs in seasons: the average temperature in January (cold dry season) is 25°C, and then continuously increases till rainy season. Temperature reaches its maxima in August (37°C). After rains, temperature minima range between 15°C and 20°C. The average air humidity is 49.21% (minima 10-20% in April-June, maxima in August-September) (Al-Ogoumrabe, 2002 in Antonínová *et al.*, 2004).

3.2.2.3 Vegetation

The area belongs into phytochorion of the Sudanian regional centre of the endemism (White, 1983 in Antonínová *et al.*, 2004). The vegetation type of *Acacia ataxacantha-Acacia seyal* bushland is predominantly found in the study area (Lawesson, 1995). Bandia reserve and its surroundings lie in a baobab grove (Hejcmanová *et al.*, in preparation) with the dominant tree species of *Adansonia digitata, Azadirachta indica* a *Eucalyptus alba*. The shrub layer includes 5 species of *Acacia* with dominant *Acacia seyal*, furthermore *Balanites aegyptiaca, Combretum micrantum, Feretia apodantera, Grewia bicolor, Tamarindus indica* and *Ziziphus mauritiana*. The presence of *Tamarix senegalensis* indicates a salt content in soil in the bed of Somone. The herb layer is constituted by more than 50 species. The dominant species are *Achirantes aspera, Brachiaria distichophylla,* *Cassia tora, Sesbania sesban*, etc. (Al-Ogoumrabe, 2002 in Antonínová *et al.*, 2004). The vegetation within the Reserve shows different stages of succession corresponding to the time since fencing. The vegetation in area fenced at creation of the reserve in 1990 is well regenerated with dominant *Acacia seyal,* while vegetaion in area fenced 5 years later shows first stage of succession with dominant *Calotropis procera*. The vegetation outside of the Reserve is hardly damaged by overgrazing with no tree or shrub regeneration (Antonínová *et al.*, 2004).

3.2.2.4 Giant eland and the Bandia Reserve

In 2000, the critically endangered Western giant eland (*Taurotragus derbianus derbianus*) was introduced to the Reserve for purpose to its preservation. Regarding to the fact that only the Eastern giant eland (*T.d. gigas*) is bred in world zoos till now, the breeding group in the Bandia reserve represents the breeding experience with the Western sub-species (Antonínová *et al.*, 2004).

The original breeding herd of the Giant eland (*Taurotragus derbianus derbianus*) consisted of 6 animals – one male and five females. Three females were adult and two females and the male sub-adult at the time. They were captured in the Niokolo Koba National Park in May 2000 and transported to the Bandia reserve (Antonínová *et al.*, 2004). At present, there are 2 breeding herds in the Bandia reserve. The first consists of 30 (6,15,9) and the second of 3 (1,2) animals (Antonínová 2008, personal communication).

All data for the thesis were collected in the two study areas mentioned above – the Bandia reserve and the Niokolo Koba National Park. Nevertheless, besides these areas, there are two more herds of the Western giant eland living in the Fathala reserve also located in Senegal. The both herds were transported there from the Bandia reserve; the larger herd (11 males) in March 2006 and the smaller herd of 6 (1,5) in February 2008 (Antonínová 2008, personal communication).

3.3 Data collection

3.3.1 Faeces collecting

The Giant eland's diet had to be investigated using analyses of forage rests in faeces particularly due to impossibility of direct observation of antelopes in the field. Therefore, faeces of the Giant eland were collected, namely in the Niokolo Koba national park and in the Bandia reserve. Samples were collected in various seasons in years 2000-2005 and imported continually to the Czech Republic in a form of dry pellets. There is a special enclosure built for the Giant eland in the Bandia reserve without presence of any other antelopes which made the pellet identification easier. The precise distribution of the Giant eland in its natural habitat of the Niokolo Koba national park was not known and it was not possible to localize them for sample collection. Thus, their faeces were collected by accidental findings during the investigation of the vegetation structure (Hejcmanová-Nežerková and Hejcman, 2006) or investigation of antelope abundace using method of pellet count (Homolka *et al.*, in preparation). Within the NKNP samples were collected in 3 localities: Assirik, Lengue Kontou and Mansa Fara (Annexe/Figure 33). The determination of faeces of the Giant eland in conditions of the NKNP reposed on measuring the diameter of the pellet. According to Homolka *et al.* (2008, personal communication) and according to own observation from the reference pellets from the Bandia reserve, the Giant eland as the largest antelope in the NKNP has the highest diameter, at minimum 15 mm. The samples measuring 15 mm and more in diameter were considered Giant elands' faeces. They were always dry, not really fresh, but never dating older than since last wet season. The Giant elands' faeces from the Bandia were collected always fresh, in most cases from precisely determined individual.

Samples were collected from found group of pellets by taking 5-10 representative pellets, they were dried and tagged by the date, locality, identification of antelope individual or identification number. Totally, 59 samples were acquired in the NKNP and 122 samples were collected in the Bandia reserve (Table 2, 3 /Annexe).

3.3.2 Reference catalogue

A reference catalogue, against which plant fragments found in the *faeces* could be compared, was made following the metodology used by Perin and Taolo (1999). The reference catalogue was prepared for 48 of the most common plant species (Table 4/Annexe) occuring in the examined areas, sampling leaves, branches, bark, flowers or fruits of particular plant species if available. There were also interviews made with a number of Niokolo-Koba National Park guards and guides and an empolyee of the Bandia reserve, who had a lot of knowledge about ecology and ethology of the game.

Reference slides were prepared by epidermal scrapes of all plant parts that can be potentialy consumed by the Giant eland. A piece of plant segment (e.g. a leaf) was placed on a glass slide, flooded with water and a very thin layer of it was scraped away with a scalpel. The fragments were then put in a glycerine drop onto another glass slide and covered up with a cover glass.

The sample included all the unique characteristic plant structures in order to make the identification as reliable as possible (Heroldová, 1996).

Collection of plant samples for the reference catalogue was carried out in the both study areas, i.e. in the Niokolo Koba National Park and the Bandia Reserve. In the Niokolo Koba dominant plants of different habitats were sampled. As the adults of the Giant eland browse at the height of 1,7 m and higher, vegetation showing browse marks at this height was of a special concern during the sampling as well as the plants found near the Giant elands‘ faeces. The Giant eland's potential feed plants were consulted with local rangers too. In the Bandia Reserve plant species observed directly to be browsed were sampled in preference but, in general, samples were taken from species occurring in the fenced area - both browsed and not browsed.

3.4 Microscopic analyses of faeces

The forage ecology in this thesis is examined through microscopical analyses of the Giant eland's faeces, thus using the indirect method of examination. For faecal anlyses the methodology according to Homolka and Heroldová (1992) was used. The dry pellets were left in water for cca 8 hours to get moistened sufficiently. Each pellet was then halved with a scalpel and from the inner part, material was removed with tweezers and transferred into a Petri dish. There it was diluted with water, stirred and individual particles dispersed and homogenised. The excess water with a fine sludge which contained no identifiable structures, was strained. Microscopic slide were made using an adequate part of the sample prepared and transferred onto a slide into a drop of glycerine. The individual fragments of the food remains were spread in such a way that they did not mutually overlap. The slides were examined with the microscope Nikon YS 100 at a magnification of 100x**,** and more detailed in 450x**.** Analysis consisted in identification of plant residues in all visual fields of the microscope. The food component was identified by its anatomical structure compared with standard samples from the reference collection prepared from the plants growing in the area under study. The percentage area covered by any of items was estimated. The percentage value of this area was taken as the relative volume (%v) of each food item.

Each identified part of food was classified as a food item or component (Heroldová, 1997). In order to facilitate the recognition of concrete food items and improve identification skills, some plant structures were sketched with a pencil on a piece of paper (Figures 4-11) and also photographs of the examined structures (Figures 12-20) were taken with a digital camera fixed to the microscope ocular.

3.5 Data analyses

3.5.1 Microscopical analyses

The food items were identified according to their characteristic morphological features. For better recognition ability, analysed plant structures were sketched with a pencil on the piece of paper.

1) Leaves are rather flat formations with specific features such as stomata and trichoms. Trichoms have various morphological structures that can be species specific and thus helpful in the process of identification. Similarly with the stomata, various shapes and specific pattern in their space distribution and localization on the leaf can be used as an identification tool. Dicotyledones have usually bifacial leaves (Figure 4) meaning that both sides (the upper and the lower) look like different and for the most of dicotyledones applies that there are stomata placed on the upper side only. On the contrary, in monocotyledones the both sides of the leaf (Figure 5) are the same (e.g. in presence and number of stomata) (Slavíková, 2002; Skalický and Novák, 2007).

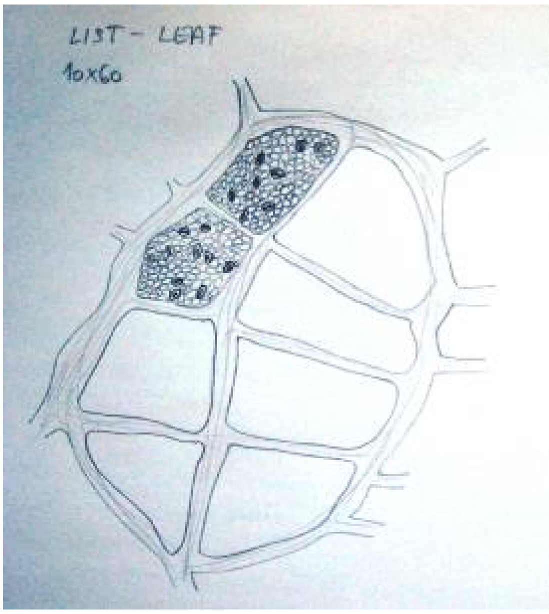

Fig. 4 - Leaf of dicotyledonous plant

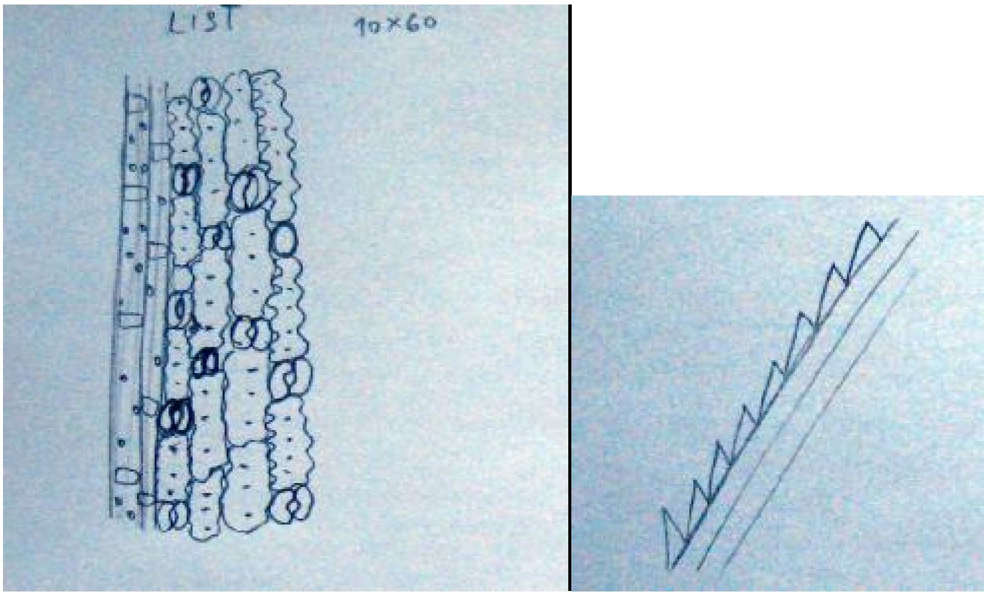

Fig. 5 – Leaf of a monocotyledonous plant – front view (left) and edge of the leaf (right) with triangle-like trichoms.

2) Woody items are found only in Dicotyledones and Gymnosperms. They can be identified according to tracheal elements (Figure 6) which fulfil conductive function in plants by transporting water and mineral nutrients from roots to upper parts of the plant body. The cells are long and thin with strongly lignified cellular walls (Skalický and Novák, 2007).

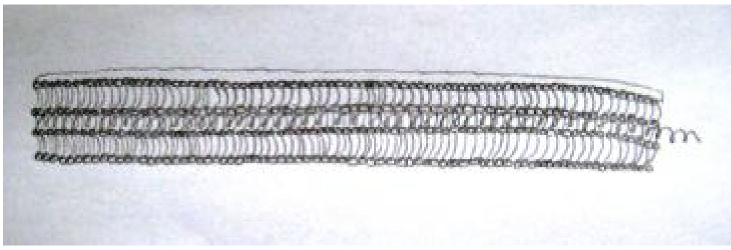

Fig. 6 – Tracheal elements of woody items.

3) Bark (Figure 7) is a secondary cover tissue represented by dead cells. It is produced by the activity of felogen, which is a secondary lateral meristem enabling secondary thickening of plant stems. It can be found in Dicotyledones and Gymnosperms, but only very rarely in Monocotyledones (tree-like species such as *Dracaena* or *Yucca*). There are special formations in the bark called lenticels which have gas-exchange function. Bark covers and strenghtens plant stem (Skalický and Dvořák, 2007).

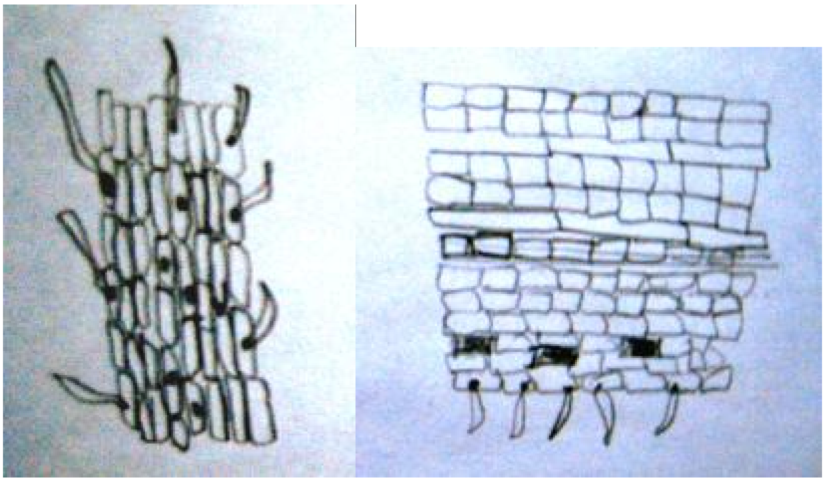

Fig. 7 – A branch covered with bark.

4) Fruit is a multicellular reproductive organ of Angiosperms. There are several types of fruits (Slavíková, 2002; Skalický and Novák, 2007). For the purpose of the thesis, only the following were concerned:

- Pod (Figure 8) is a fruit typical for *Fabaceae* and *Caesalpiniaceae* families. Pods have various colours, shapes and sizes (Slavíková, 2002; Skalický and Novák, 2007). Nevertheless, the morphological structure is very specific with layers of fibrous nets overlapping each other. Each layer is formed by the fibrous net in which the fibres are all oriented in roughly parallel lines going in the same direction, while the other layer has the same structure but the fibres are oriented in different direction, usually almost rectangular to another layer.

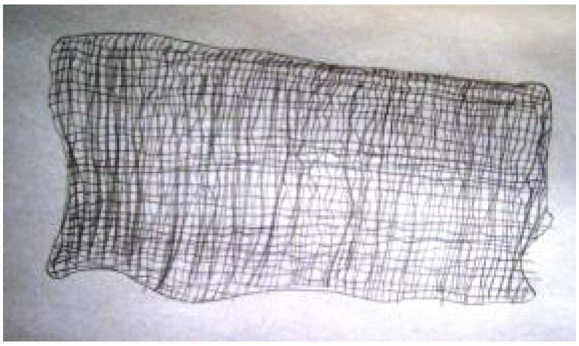

Fig. 8 – Structure of pod tissue.

- Fleshy fruit is a juicy multicellular structure. The cells are parenchymatic (Figure 9) with thin cellular walls. These cells have usually storage function storing starch grains, fats or water. This structure is variable in colour in different plant species (Skalický and Novák, 2007).

Fig. 9 – Parenchymatic thin-walled cells forming fleshy fruit structure.

- Caryopsis (Figure 10) is a specific seed-like fruit common in *Poaceae* (Slavíková, 2002). Its features are very specific. Its is usually ranging from yellow through orange to slightly brown colour and its cells are long and thin in shape, oriented in parallel lines.

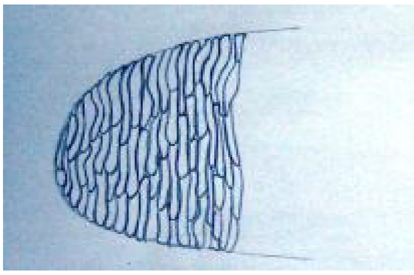

Fig. 10 – Caryopsis structure.

- Sclerenchymatic tissue (Figure 11). The cells of sclerenchym are characterized by rather short length, various shape and a very thick cellular wall. They can form continual masses, small groups or can be distributed singularly among different type of cells. This kind of tissue forms the solid plant structures with strengthening function. It can be found in fruits with hard cells such as drupe or nut (Skalický and Novák, 2007).

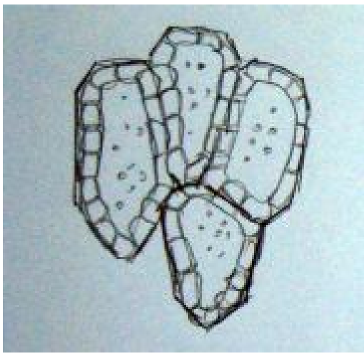

Fig. 11 – Sclerenchymatic thick-walled cells structure.

This theoretical description of plant body items structure is helpful but rather informative as there is a need to do a lot of microscopical observation of the plants gathered in the reference catalogue in order to learn all plant structures appearance properly. It takes time to learn how to identify concrete plant items. Thus, both theoretical and practical approaches are inevitable for proceeding microscopical analyses.

3.5.2 Statistical analyses

A direct linear gradient analysis was used to evaluate multivariate data, particularly a redundancy analysis (RDA) followed by the Monte Carlo permutation test with 999 permutations was carried out in the Canoco for Windows 4.0 program (ter Braak and Šmilauer, 2002). RDA is a constrained linear ordination method appropriate particularly for an evaluation of data of categorical character (sites, month of pellet collection, localities in the NKNP, sex, and age; Lepš and Šmilauer, 2003). Data evaluated by RDA were those of average contents of each item in a sample. All the results were presented in the form of an ordination diagram.

The effect of age of animal on the content of caryopsis in the Giant elands' diet in the Bandia reserve was evaluated by polynomial regression in the STATISTICA 8.0 program.

4. Results

In total there were 30 samples from the Niokolo Koba National Park (Annexe/Tables 6a, 6b) and 50 samples from the Bandia reserve (Annexe/Tables 7a, 7b, 7c, 7d) examined through the microscopical faecal analysis.

4.1 Qualitative assesment of the diet

For purpose of the microscopic faecal analyses, food items were placed into several categories. The following items were identified in the faeces: wood, leaf, caryopsis, grass, herb, bark and several types of fruit – sclerenchymatic tissue, pod, and fleshy fruit. Also the presence of trichoms (Figure 14) was recorded.

Wood (Figure 13) denotes the tissue coming from trunks, branches or ligneous petioles of trees and bushes and also lignified parts of dicotyledonous plants. As **leaf** item (Figure 12) was considered the leaf of woody plant species. Two components of leaf were discriminated: epidermis and nervature. In faecal samples from the Bandia reserve, epidermis:nervature ratio of 51,3%: 48,6% was found, while in Niokolo Koba NP this ratio was more unequal with 37,5%: 62,5%, thus favourably inclined to nervature. **Herb** is characterised as a part of a dicotyledonous plant stem. **Grass** (Figure 13) is meant as a part of leaf of monocotyledons being characterised by stomata localised in specific positions among characteristic long thin-walled cells with wavy shape placed in parallel lines. **Bark** (Figure 16) denotes a hard tissue covering the trunk or branches of woody plants (bushes and trees), usually brown in colour. It is constituted by thick-walled cells providing strength to a plant stem.

There were several types of tissues from fruits recognized: pods (Figure 17) as typical representatives of fruits of plants from *Fabaceae*, *Caesalpiniaceae* or *Mimosaceae* families; a few different types of sclerenchymatic tissues (Figure 20) – for fruits with hard cells such as *Strychnos spinosa*; then cells of a form indicating high content of pulp (Figure 18); and some particular tissue probably of some supporting function (firstly, a structure forming a top layer of some fruits called Top and secondly, a structure called Support). Even though **caryopsis** (Figure 19) constitutes botanically a type of fruit too, for purposes of the thesis this item was treated as a separate food item category being secluded from other types of fruits mentioned above. This was because of the fact that antelopes in the Bandia reserve are fed by additive feeding pellets with caryopsis as the main contain, and thus it cannot be considered as a fruit solely. As to its appearance found in faeces samples, it was a formation with characteristic long thin-walled cells placed in parallel lines. It was usually yellowish, orange or slightly brown in colour.

As it was not possible to identify all the plant material in the faeces, there was also a special category for placing the unidentified items (Un ID) to.

As to the concrete plant species representation, in 3 samples from Bandia and 1 sample from Niokolo Koba National Park, whole seeds of *Acacia sp.* were found and fragments of twigs (till 1.5 cm long). There were some samples full of sand, probably coming from salt licking. Due to particular species-specific tissue, it was possible to identify *Acacia sp., Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,* and *Ziziphus mauritiana* in the Giant eland's diet.

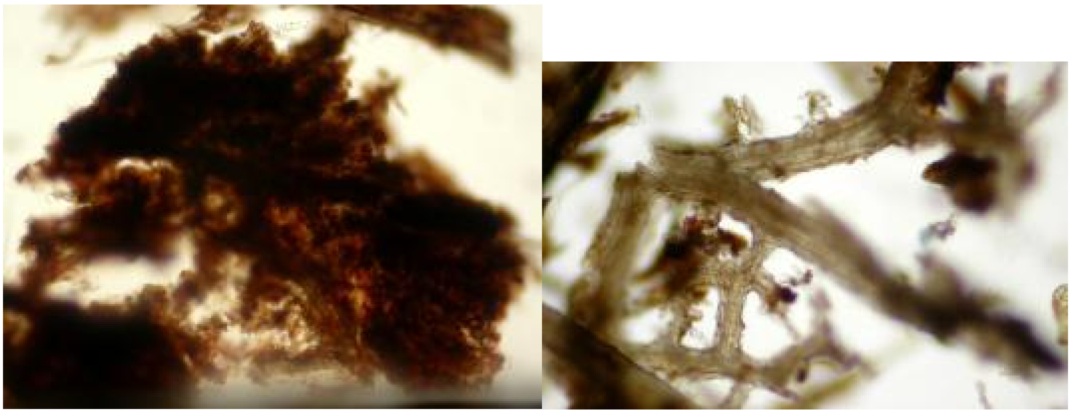

Fig. 12 - Leaf structure: epidermis (on the left) and leaf nervature (on the right) – a magnification of 100x. Photo by V. Podhájecká

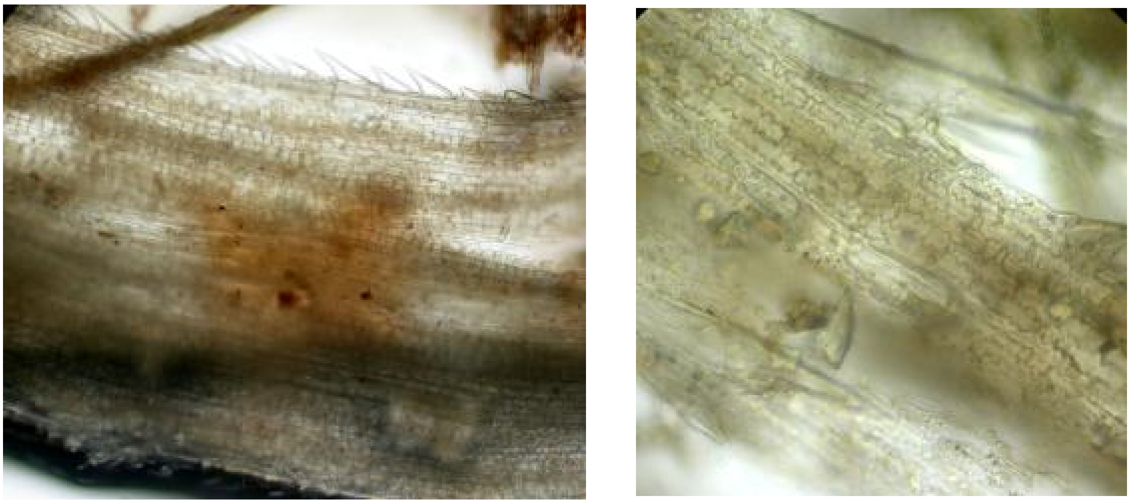

Fig. 13 - Monocotyledone plant (grass - *Poaceae*) structure at a magnification of 100x (left) and 450x (right). Photo by V. Podhájecká

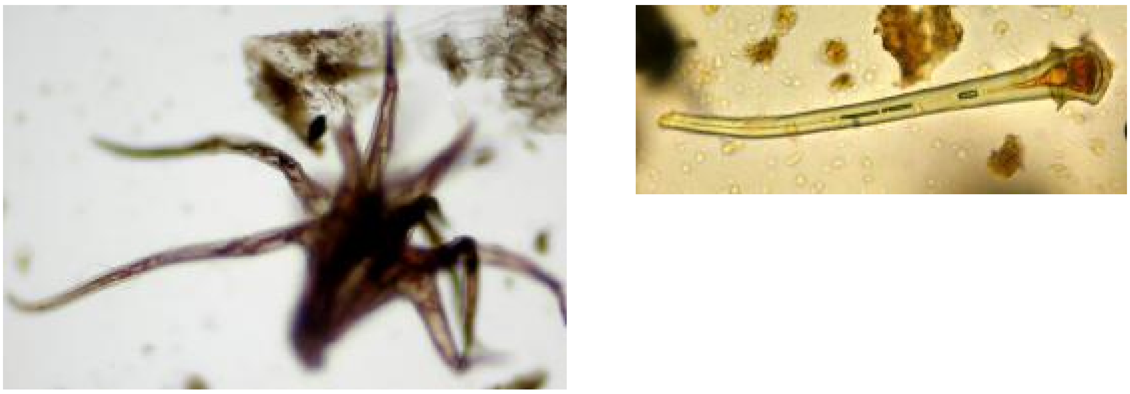

Fig. 14 - Two different trichoms - a magnification of 450x. Photo by V. Podhájecká

Fig. 15 - Woody item structure - a magnification of 100x. Photo by V. Podhájecká

Fig. 16 - Bark structure - a magnification of 450x. Photo by V. Podhájecká

Fig. 17 - Pod structure - a magnification of 100x. Photo by V. Podhájecká

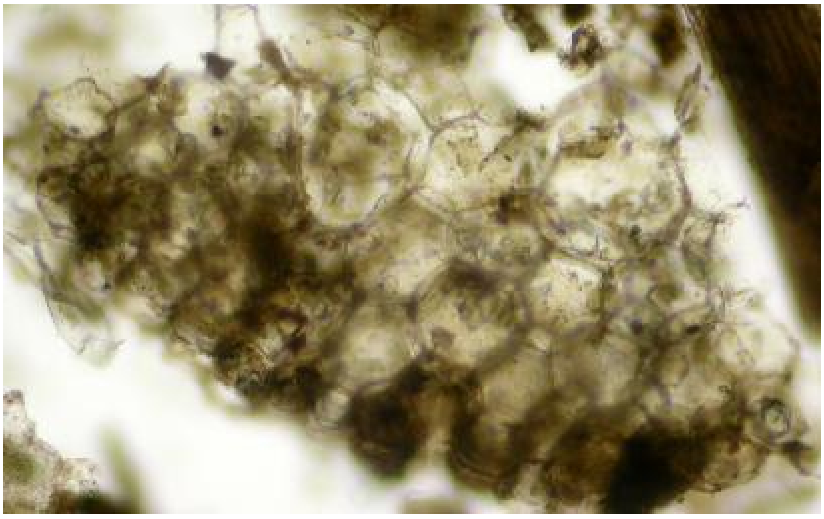

Fig. 18 - Fleshy fruit structure - a magnification of 450x. Photo by V. Podhájecká

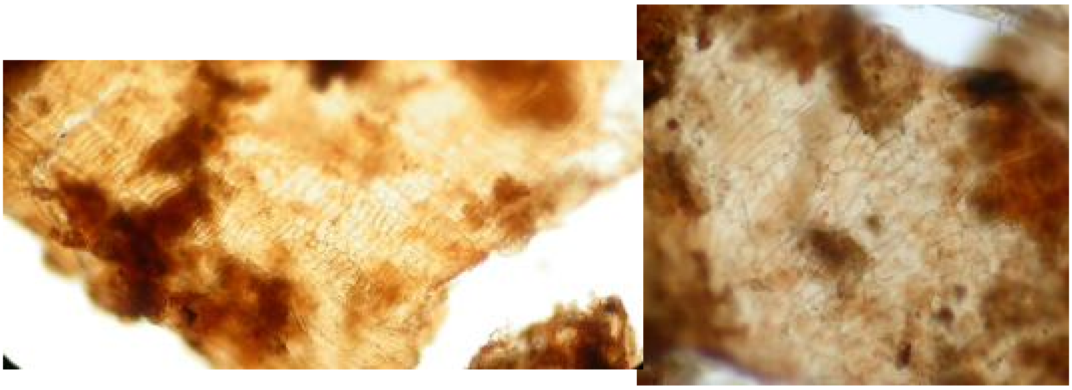

Fig. 19 - Caryopsis structure – a magnification of 100x. Photo by V. Podhájecká

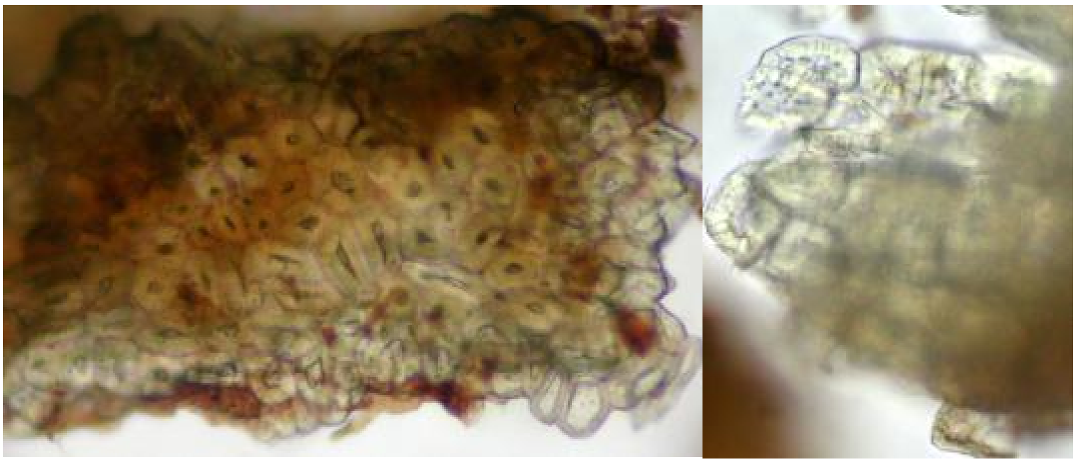

Fig. 20 - Two different types of sclerenchymatic tissue – a magnification of 450x. Photo by V. Podhájecká

4.2 Quantitative assesment of the diet

On the both examined places, the Niokolo Koba National Park and the Bandia reserve, all the food items were recorded though their quantitative representation varied and both the sites had different food items dominating (Figure 21). It is apparent that the food items represented with the highest frequency in the diet (i.e. woody items, leaf and fruit) were consumed almost equally in both locations, though with a slightly lower rate in captivity. The biggest difference in consummation rate is in the case of caryopsis food item. This one was distinctively much more eaten in the Bandia reserve. Another item that was much more represented in samples from the Bandia reserve is herb. Grass was more eaten in the Niokolo Koba National Park in contrast with bark being more consumed in the reserve. By this, the hypothesis No. 1 has been rejected – there is an effect of the site on forage composition of the Giant eland.

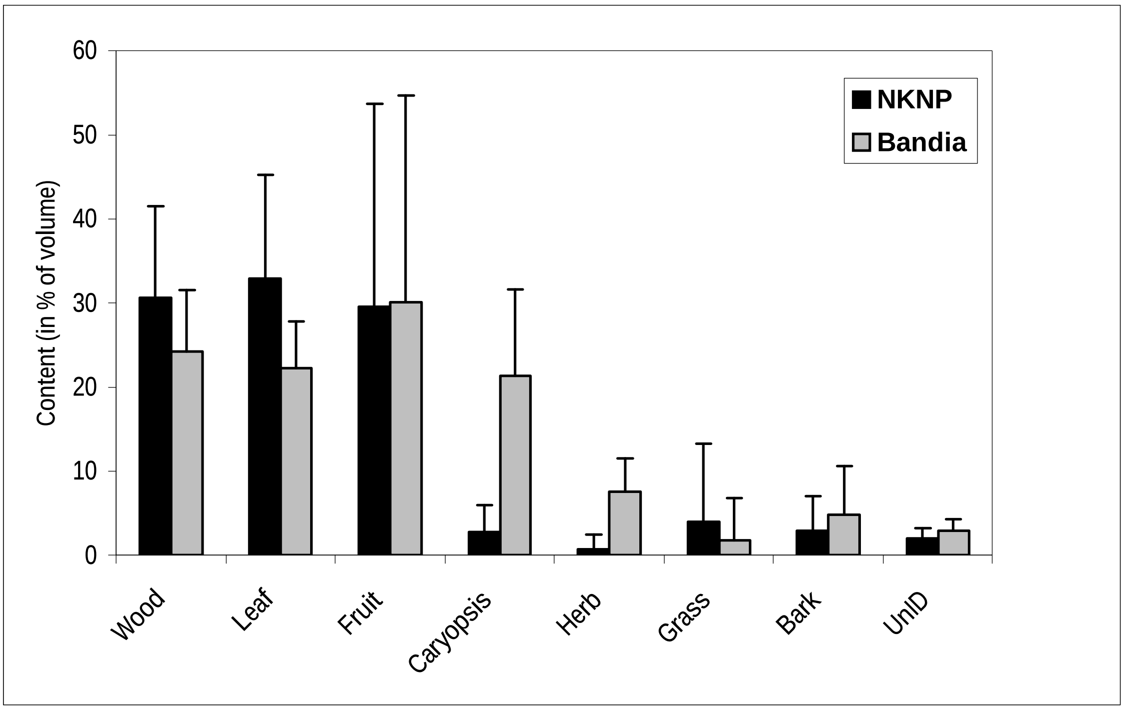

Fig. 21 – Proportional representation of food items in faeces from the Niokolo Koba National Park (NKNP) and the Bandia reserve. Note: vertical bars indicate standard deviation.

Expressed in concrete numbers, for NKNP applies that the most abundant item comprising the diet was leaf (32.5%) closely followed by wood (30.2%) and fruit (28.6%). Other items were represented at a substantially lower rate: grass (3.7%), caryopsis (2.8%), bark (2.8%), UnID (2%) and the least represented one was the herb item (0.6%).

For the Bandia reserve, the same 3 food items as in NKNP dominated in samples, although their accurate values differ a bit. The most represented items were thus the following: fruit (30%) closely followed by wood (23.1%) and leaf (21.9%). Caryopsis was recorded constituting quite a great amount of content (20.3%) in comparison to NKNP. The further decline in food items representation rate continued from herb (6.3%), bark (3.7%), UnID (2%) to the least represented item of Grass (1.5%).

Although the whole item of fruit was represented almost equally in the wild and in captivity reaching values of 28.6% and 30% respectively, the different types of fruits recognized within this item were distributed in various rates on both studied sites (Figure 22). Sclerenchym, pod and pulp cells were found in the samples in the very similar ratio, while Epidermis, Top and Support showed greater difference in representation. The dominating sub-item in the Bandia reserve was Top reaching about 17% which was distinctively contrasting with 6% found in the NKNP samples, where pod dominated.

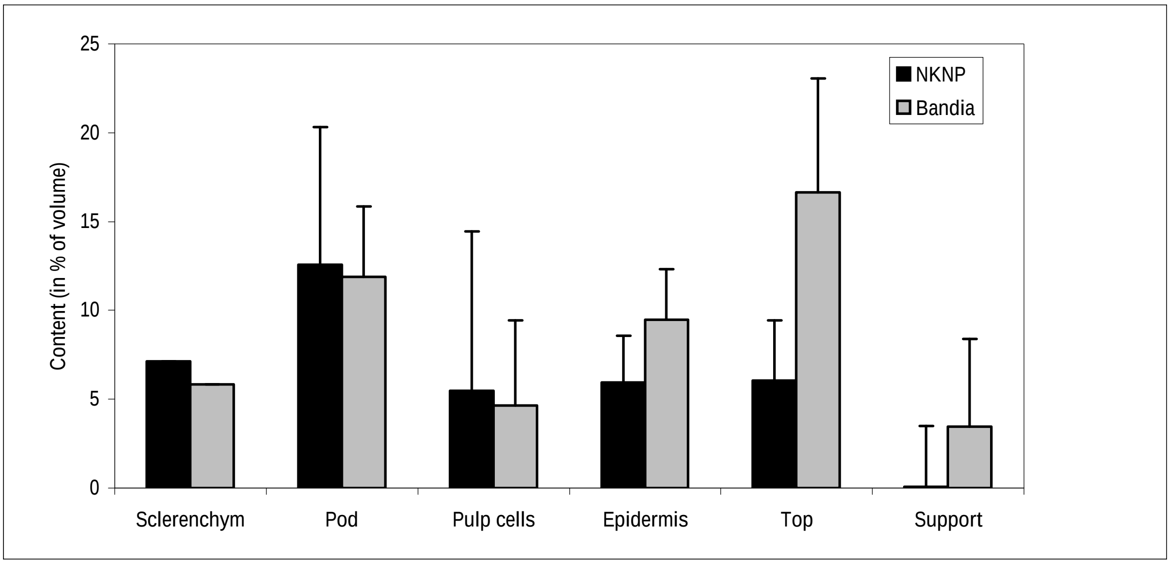

Fig. 22 – Distribution of types of fruit tissues – comparison of the both study areas.

Table 1 – Results of RDA analyses of the Giant eland's diet composition.
% explained variability – species variability explained by canonical axis 1 (all axes), F-ratio – F statistics for the test of particular analysis axis 1 (all), P-value – corresponding probability value obtained by the Monte Carlo permutation test for axis 1 (all). Abbreviations: NKNP – Niokolo Koba national park, LK – Lengue Kountou, MF – Mansa Fara.

Analysis	**Explanatory variables**	**% of explained variability (all)**	**F ratio (all)**	**P value (all)**
A1	NKNP, Bandia	20.5	20.162	**0.0010**
A2	Month	18 (16)	16.1 (6.657)	**0.0010 (0.0010)**
A3	Month	7 (49)	3.731 (2.174)	***0.0290 (0.0340)***
A4	Month	15 (64)	4.649 (3.980)	***0.0160* (0.0010)**
A5	LK, MF, Assirik	14 (54)	4.205 (2.190)	***0.0150 (0.0420*)**
A6	LK, MF, Assirik	16 (46)	5.226 (3.243)	**0.0010 (0.0010)**
A7	age	10 (31)	5.246	**0.0010**
A8	sex	10 (37)	5.073 (3.194)	**0.0010 (0.0010)**

A1: Is there any effect of the site on forage composition of the Giant eland?
A2: Is there any effect of the month of samples' collection on forage composition of the Giant eland?
A3: Is there any effect of the month of samples' collection on forage composition of the Giant eland in the Bandia reserve?
A4: Is there any effect of the month of samples' collection on forage composition of the Giant eland in the NKNP?
A5: Is there any effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland?
A6: Is there any effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland with particularly defined various found types of fruits?
A7: Is there any effect of the age of animals on forage composition of the Giant eland?
A8: Is there any effect of the sex on forage composition of the Giant eland?

The ordination diagram shows the differences of forage items for particular items (Figure 23). There was a conspicuously close relation of caryopsis, herb, and bark to the Bandia reserve. Items of leaf, wood, and grass showed the opposite, although not so closely-fitting relation to the NKNP. Fruit items constituted highly important part of the Giant elands' diet, however they did not display any particular affiliation to the site.

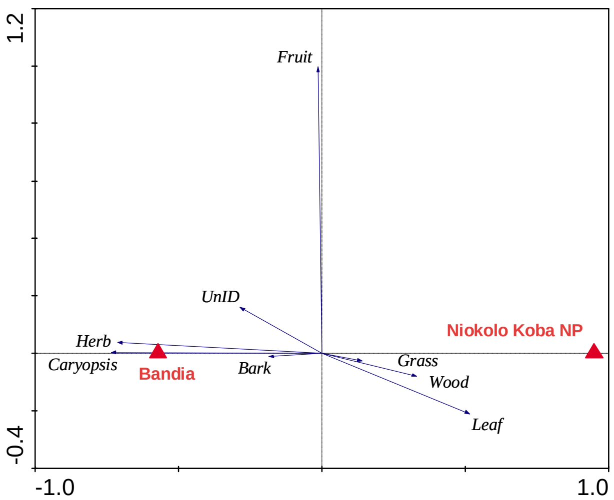

Fig. 23 - Ordination diagram showing the result of RDA analysis: effect of the site on forage composition of the Giant eland (A1 in Table 1).

Effect of month succession in the progressing dry season on the diet composition was approved (all the months mentioned – November to June - fell into dry season) in general (Figure 24), and separately in the Bandia reserve (Figure 25) and in the NKNP (Figure 26). Generally, in the beginning of the dry season (it means November in our case) the forage was influenced mainly by herbs, caryopsis, bark and unidentified items, while in April and May by grass items and fruits, and in the end of the dry season woody items and leaves were important part of the diet (Figure 24). However, if we focus on a particular site, different view of the effect of season appears. For instance, in the Bandia reserve, the effect of the season was not so strong any more (Analysis A3 in Table 1); the outcomes are clearly shifted to one investigated period (Figure 25). On the other hand, the effect of season on forage composition of the Giant eland in the wild (NKNP) was more important than in the Bandia reserve (A4 in Table 1), with highest impact of grass, caryopsis, and fruits in the antelope's diet, two latter biased to May. However, grass, as the most important effect, has a particular position because its real content in the pellets was very low (3.7% in average) and was found in 9 samples of total of 30 only. Caryopsis and fruit items occurred principally in samples collected in May. Items of leaves, woody particules, herbs, and bark had the closest affinity to pellets found in June.

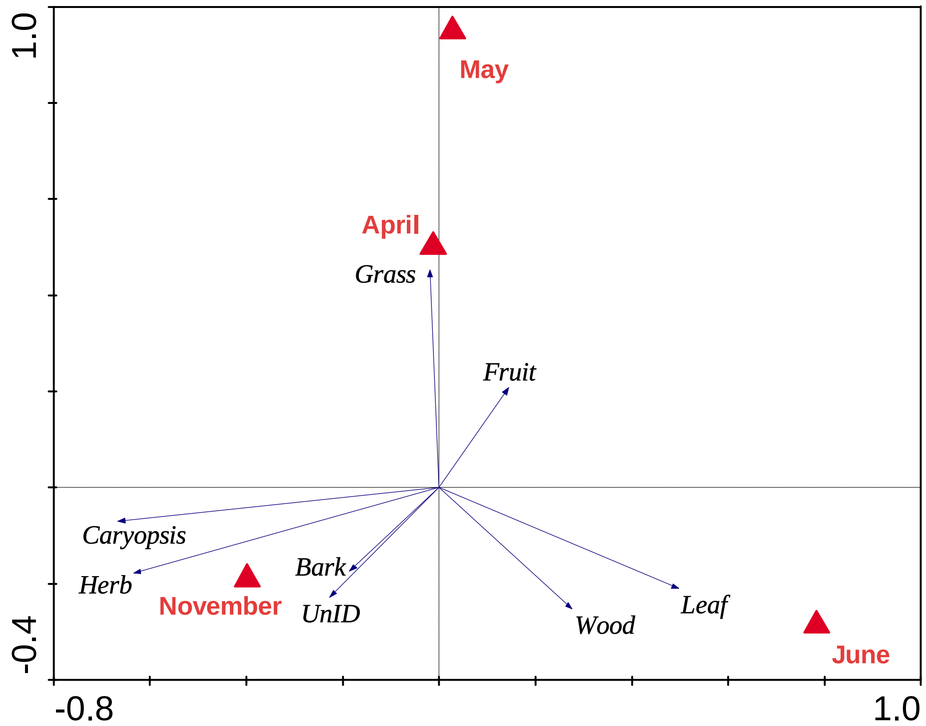

Fig. 24 - Ordination diagram showing the result of RDA analysis: effect of the month of samples' collection on forage composition of the Giant eland (A2 in Table 1).

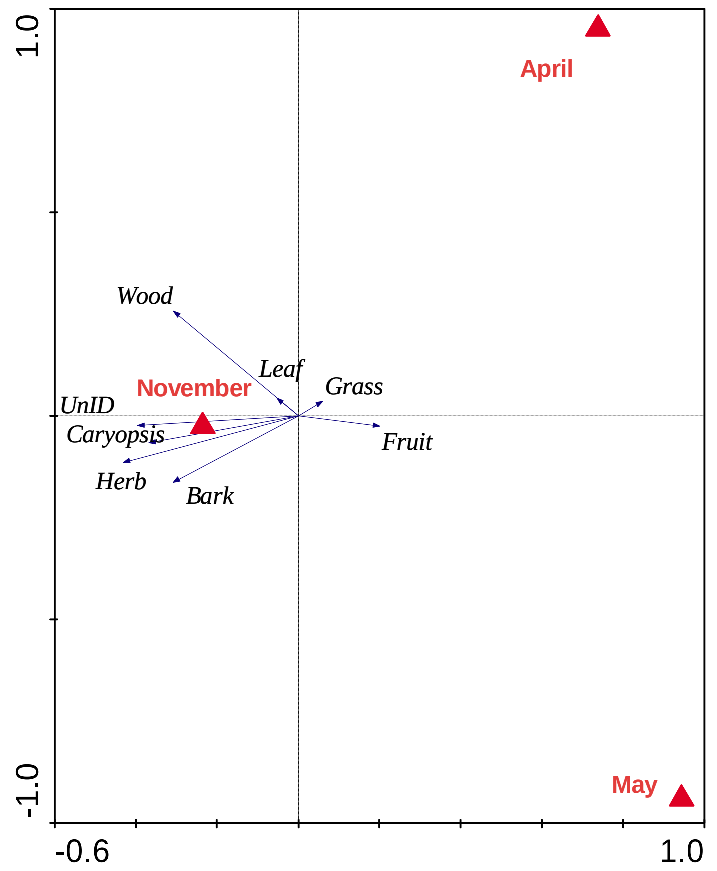

Fig. 25 - Ordination diagram showing the result of RDA analysis: effect of the month of samples' collection on forage composition of the Giant eland in the Bandia reserve (A3 in Table 1).

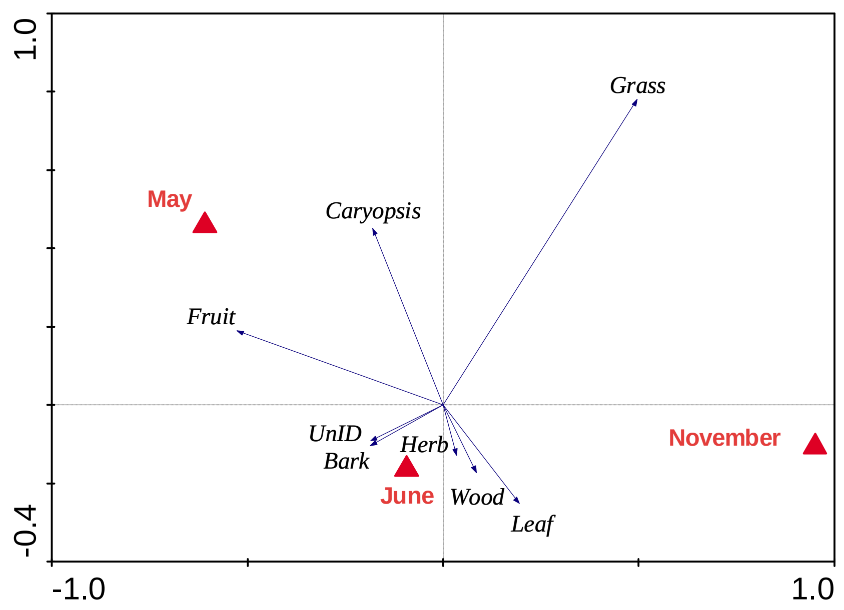

Fig. 26 - Ordination diagram showing the result of RDA analysis: effect of the month of samples' collection on forage composition of the Giant eland in the NKNP (A4 in Table 1).

Although a significant effect of particular locality of sample collection within the NKNP (Annexe/Table 33) was revealed (Table 1, Analysis A5), the ordination diagram shows that affinities of forage items to localities in the national park were generally not so strong (Figure 27). This is expressed in the graph by arrows being short and not reaching far from the axes center. On the contrary, focal points of influence of all the localities are situated far both from the axes center and places where the main food items reach.

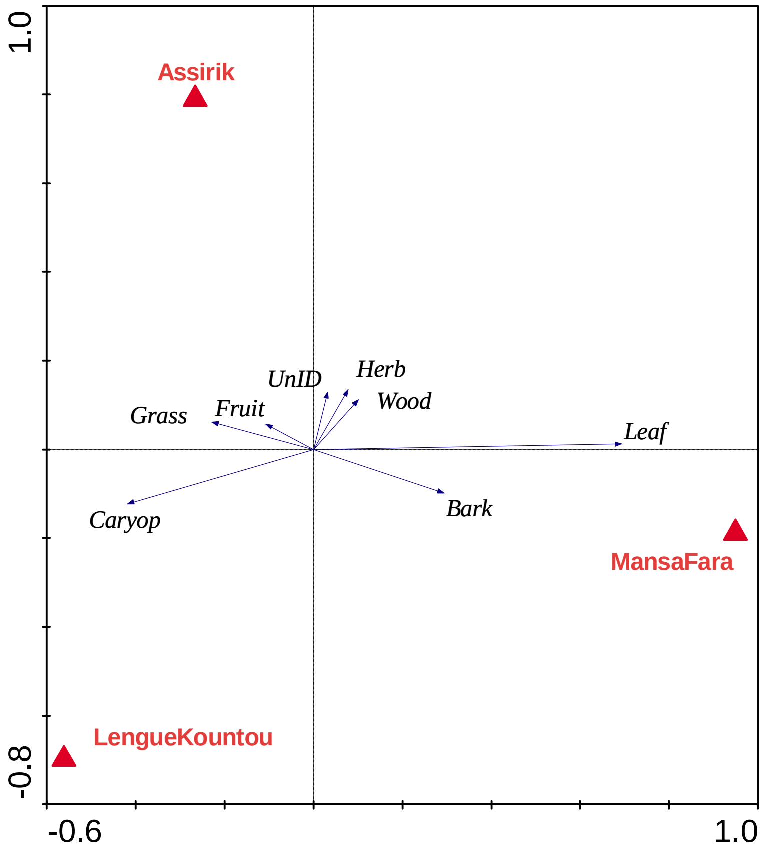

Fig. 27 - Ordination diagram showing the result of RDA analysis: effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland (A5 in Table 1).

For more profound comprehension of the effect of locality within the NKNP, a large group of fruit items were divided to more detailed parts (see Chapter 4.1.) for further analysis. In consequence, more apparent differences in diet composition among 3 examined localities were recorded (Figure 28 and 29, Table 1). While leaves of woody plants and bark were most consumed at the locality of Mansa Fara, pod constituted a substantial part of diet together at Mansa Fara and Assirik. On the contrary, at Lengue

Kountou locality sclerenchymatic tissue (probably coming from *Strychnos* or other hardfruits) predominated in samples. Caryopsis was recorded in 2 out of 3 locations only, counting 4.4% in Lengue Kountou and 2.9% in Assirik. Other items showed weak relationship to particular locality.

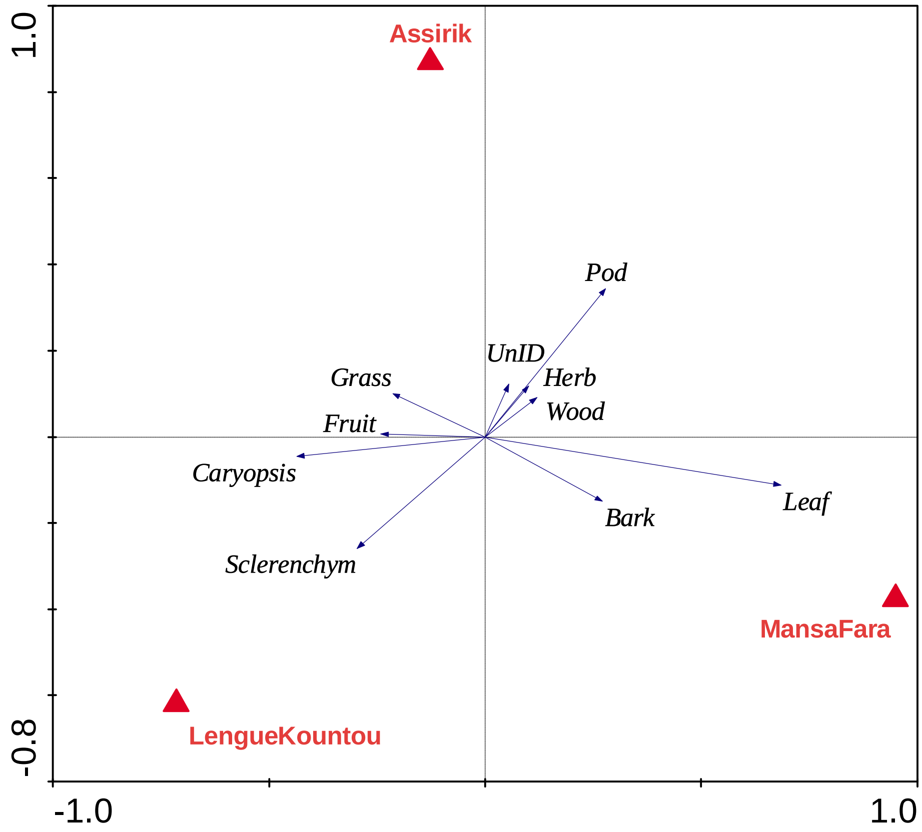

Fig. 28 - Ordination diagram showing the result of RDA analysis: effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland with particularly defined various found types of fruits (A6 in Table 1). Note: Fruit item in this case consists in other types than pod and sclerenchymatic hard items analysed separately. They include juicy or dry tender fruits.

When comparing results of RDA anlysis examining 'effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland with particularly defined various found types of fruits' (Figure 28) with simple food items representation in these three examined localities (Figure 29), interesting results emerge. For example, Figure 28 shows pod to have a very strong affiliation to Assirik and Mansa Fara, but it can be clearly seen in Figure 29 that this food item is represented as well in

Lengue Kontou locality. In similar way, leaf is rather strongly confined mainly to Mansa Fara, and a bit less to Assirik in Figure 28, but Figure 29 reveals quite high representation of this item also in Lengue Kontou region.

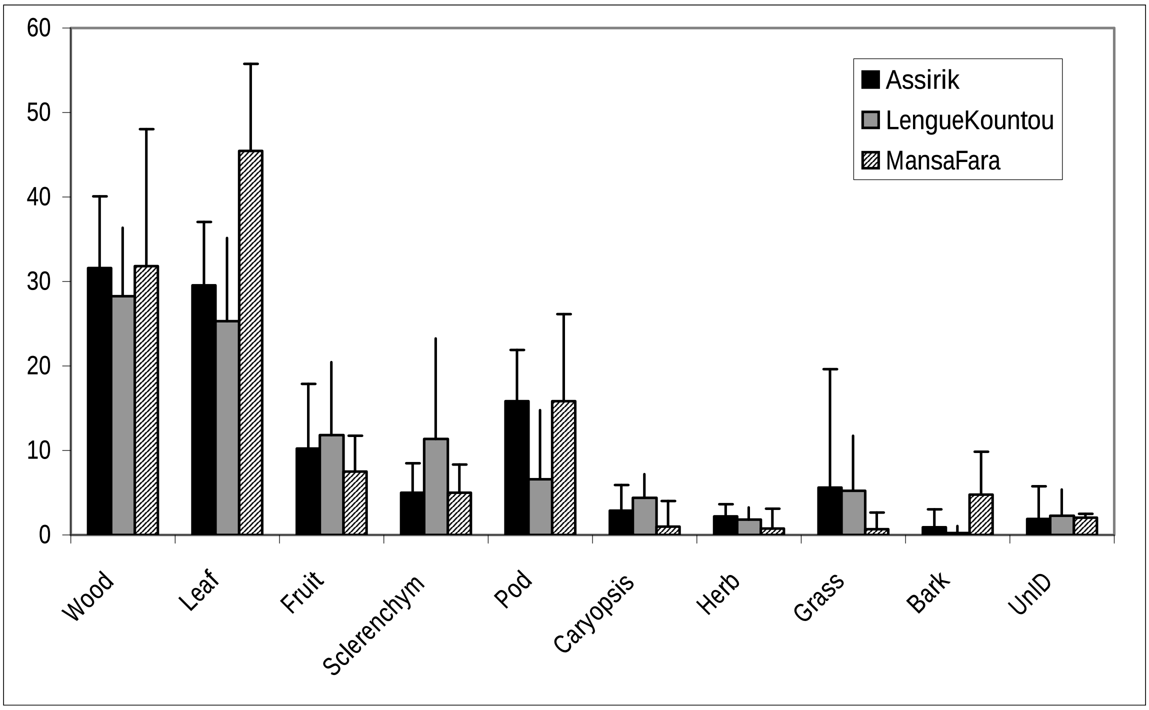

Fig. 29 – Comparison of food items representation in 3 examined localities within NKNP. Note: vertical bars indicate standard deviation.

In the Bandia reserve, the effect of age on diet composition was examined (Figure 30, Table 1). The most pronounced relationship with age of animals was approved for caryopsis item. This one was consumed in substantially higher quantities with progressing age of animals (Figure 30). Regression curve (Figure 31) testifies a possitive correlation of caryopsis consummation rate with age - higher volume contents of caryopsis were found in forage of older animals while young animals ate generally less forage containing caryopsis tissue. Other forage items do not show any particular relationship with the age of animals.

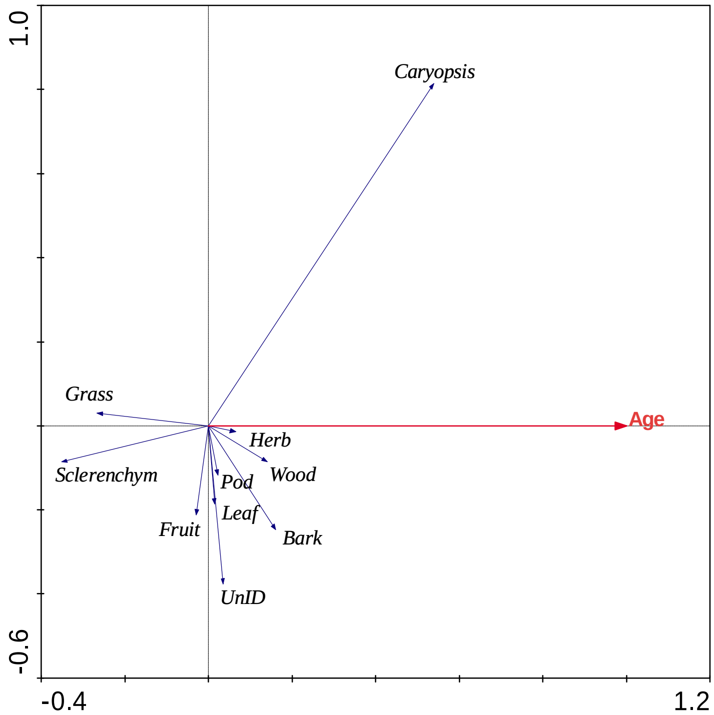

Fig. 30 - Ordination diagram showing the result of RDA analysis: effect of the age of animals on forage composition of the Giant eland (A7 in Table 1).

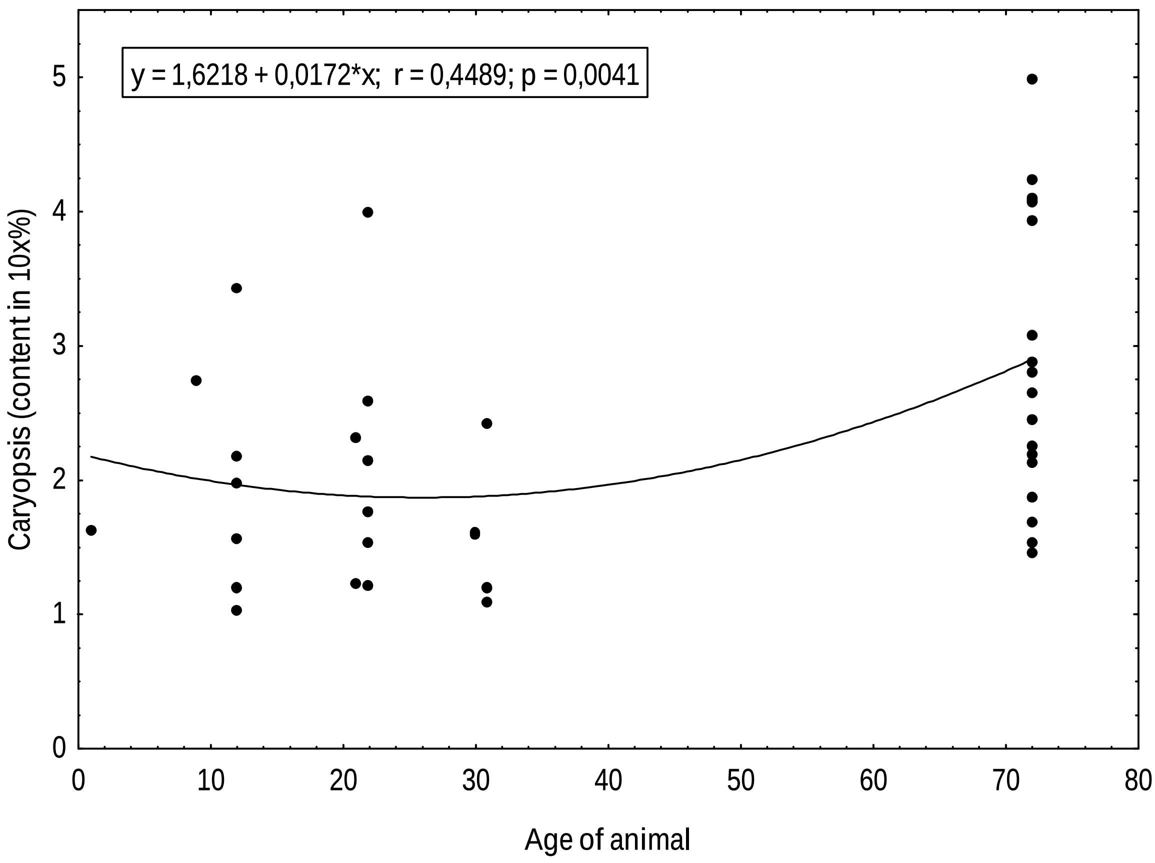

Fig. 31 - The effect of age of animal on the content of caryopsis item in the Giant elands' diet in the Bandia reserve; expressed by polynomial regression.

The results of the analysis of effect of sex on forage composition of the Giant eland showed significant differences between males and females' forage (Table 1). The ordination diagram (Figure 32) indicates that the females fed more pods and caryopsis items, whereas males ingested more leaves, fruits (except pods and sclerenchymatic fruits), and grass. The woody items, herbs, bark, and unidentified items were used by the both sexes. The sclerenchymatic fruits' items affected the most the analysis; however their content in the forage was independent of the sex of the animal.

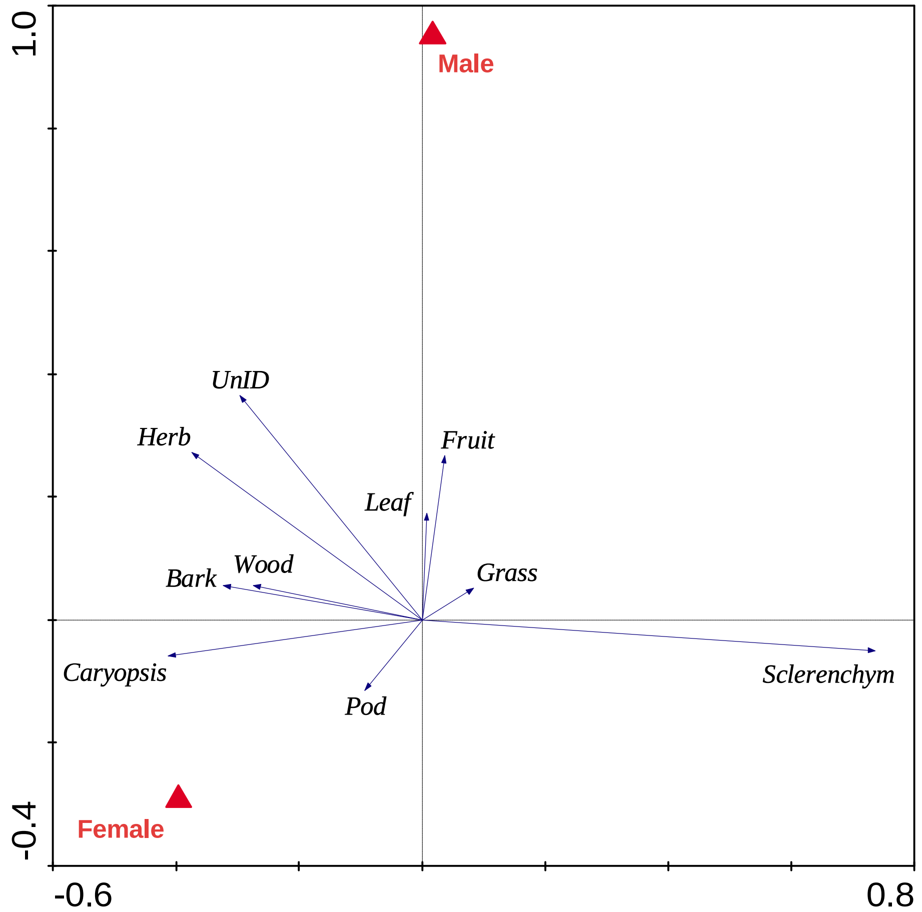

Fig. 32 - Ordination diagram showing the result of RDA analysis: effect of the sex on forage composition of the Giant eland (A8 in Table 1).

5. Discussion

5.1 Qualitative composition of the Giant eland's diet

Within the qualitative part of the microscopical faeces analysis assessment there were 7 categories of food items identified in the samples to comprise the Giant eland's diet. These were those of leaf, wood, fruit, caryopsis, herb, grass and bark. All the food items were recorded in samples from the both study areas, thus the diet was composed of the same plant tissues and structures in the wild and in captivity. Grass item, though represented in very small amount, had not been expected to constitute the Giant eland's principal diet at all. Though observations of western giant eland and its close relative eastern giant eland when foraging were rare, grass was never seen to be eaten (Bro-Jorgensen, 1997), thus considered to be excluded from the both antelope sub-species' diet.

In terms of the concrete plant species identification *Acacia sp.*, *Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,* and *Ziziphus mauritiana* were recognized in the samples to comprise the Giant eland's diet. Species identification was enabled by comparison of the sample slides with the reference catalogue slides focusing on characteristic features of species-specific tissues. Determining tissues crucial for identificaton were particularly those of fruit and leaf. Moreover, in 3 samples from Bandia and 1 sample from Niokolo Koba National Park, whole seeds of *Acacia sp.* were found and fragments of twigs (till 1.5 cm long). Identification was complicated by some of the characteristics of the tropical plants, though. In tropics, the life conditions are so harsh that plants had to evolve morphological adaptations (e.g. trichoms, thorns, pods etc.) in order to cope with the environment successfully (Valíček *et al.*, 2002). But due to the fact that these adaptations are generally the same or very similar for a lot of plant species living in the same biotope, the plant structures appearance is very similar and not species-specific. This lack of characteristic features makes the inter-specific discrimination and identification of concrete species - according to morphology only - not feasible, or very hard to do often demanding a long experience and a deep knowledge of African flora (Valíček *et al.*, 2002).

During the process of comparing the sample slides with the slides contained in the reference catalogue, there were some plant structures found in the samples that were not included in the reference catealogue, but also vice versa, i.e. the reference catalogue contained quite great numbers of plant structures pertaining to known plant species that were not identified in the faeces samples. This remark suggests the reference catalogue did not cover the whole range of antelopes' food supply in the studied areas but on the other hand, it included some plants that were not contained in the faeces. This could indicate certain antelopes' selectivity by preference of some concrete plant species while avoiding some other species by contrast. On the other hand, the reason why some plant structures found in the faeces were not covered in the reference catalogue could be the fact that not all body parts of a certain plant or not all the life cycle stages of its growth were sampled for the catalogue, thus there were some structures present then in the faecal samples that could not be found in the catalogue.

There were several types of sclerenchymatic tissue recognized, but it was not possible to assort them to concrete plant species.

There was a great amount of sand found in some samples, probably coming from salt licking.

5.2 Quantitative composition of the Giant eland's diet

Quantitative assessment revealed the fact that although the accurate numeric values of concrete food items consummation rate were different for the Bandia reserve and the NKNP, the proportional ratio of food items remained approximately maintained. In the both studied areas, three food items represented with the highest abundance in samples were identical. Both the areas were dominated by wood, leaf and fruit items. In the NKNP, wood and leaf items comprising the diet in 30.2% and 32.5% respectively, outreached the values recorded in the Bandia reserve, i.e. those of 23.1% and 21.9%, respectively. This corresponds with the previously examined floristic composition of the site indicating woody plants as the dominating type of vegetation in the NKNP. Another food item found in a large volume in the samples was caryopsis in the Bandia reserve. In this location caryopsis constituted 20.3% compared to 2.8% found in the NKNP. This great difference in caryopsis representation between samples originating from the two sites can be explained by providing feeding pellets to animals living in captivity. During the microscopical examination of the feeding pellets, caryopsis structure was clearly recognized as the main compound constituting the feeding pellets volume. By this it is assumed that the item of caryopsis found in the Bandia reserve samples came mostly or exclusively from this source. On the other hand, in the NKNP where there was only natural forage supply for antelopes with no additional food supplements, the item was found in only a small volume in the faeces. Items of herb, grass and bark were consumed only in small quantities on the both sites. Nevertheless, herb was more frequently consumed in the

Bandia reserve which is concordant with a forage supply of the reserve where herbs dominate underbrush, while in the NKNP it is grass that is dominating.

With an average amount of 2.6% of grass in the diet, Giant eland can be classified as a super-browser according to the categorization criteria established by Cerling *et al.* (2003). The super-browser category was defined for the diet comprised by more than 95% of browse which fits perfectly to this thesis results.

Fruit posing one of the three main forage composition contains reached 28.6% in the NKNP and 30% in the Bandia reserve that is very similar values. In order to obtain more detailed picture of the item representation in samples, this one was sub-divided into several types according to specific structure and tissues. These types showed various distribution throughout the both study areas. The biggest difference in items representation was recorded in cases of Top and Support which were found in the Bandia reserve at a rate much higher than in the NKNP. This can probably be explained by the diverse food supply available on the sites with some special type of hard fruits prevailing in the Bandia reserve.

As showed in Figure 23, there was a conspicuously close relation of caryopsis, herb, and bark to the Bandia reserve. Items of leaf, wood, and grass showed the opposite, although not so closely-fitting relation to the NKNP. Fruit items constituted highly important part of the Giant elands' diet however they did not display any particular affiliation to the site. Reasons for being so remain unclear, though. More faecal samples are needed to analyse and more overall studies dealing with Giant eland's forage behaviour must be undertaken in order to understand linkage in relationships between plants consumed and sites, where they grow.

By all above, hypothesis No.1 saying 'There is no effect of the site on forage composition of the Giant eland' was rejected. The localities diverge in type of savannah consequently related to various vegetation composition (Nežerková *et al.*, 2004; Al-Ogoumrabe, 2002 in Antonínová *et al.*, 2004), hence differing forage supply with corresponding representation of woody plants, herbs, grasses, etc. unique to each of the two examined areas. Last but not least, the factor of different area size affects Giant eland's feeding habits and forage preference.

The effect of the month of samples collection on the diet composition in general (Figure 24), and separately in the Bandia reserve (Figure 25) and in the NKNP (Figure 26) was positively approved, and thus Hypothesis No. 2 was rejected. Affiliation of food items to certain months was detected. Nevertheless, too few samples were analysed and they were generally collected in a narrow timespan to be able to make valid statements about the relationships involved in the process. For instance, a lot of samples from the Bandia reserve were collected in November 2004 (as clearly displayed on scatterplot of Figure 25), thus results may reflect the effect of availability of data from that period and not the selectivity of animals in selected month in relation to other periods.

Although a significant effect of particular locality of sample collection within the NKNP was recorded (Table 1, Analysis A5), affinities of forage items to localities in the national park were generally not so strong (Figure 27). Nevertheless, apparent differences in diet composition among the three examined localities were recorded (Figure 27 and 28, Table 1). While leaves of woody plants and bark were most consumed at the locality of Mansa Fara, pod constituted a substantial part of diet together at Mansa Fara and Assirik. On the contrary, at Lengue Kountou locality sclerenchymatic tissue (probably coming from *Strychnos* or other hard fruits) predominated in samples. The great difference in pod and sclerenchymatic tissue item contents could be in accordance with the food supply of the localities (representation of these species in vegetation), and thus their utilization by Giant eland. Caryopsis was recorded in small quantities in Lengue Kountou and Assirik only. Other items showed weak relationship to particular locality. Hypothesis No. 3 saying ‘There is no effect of the locality of samples’ collection in the NKNP on forage composition of the Giant eland in general and on forage composition with particularly defined various types of fruits found’ was rejected.

In the Bandia reserve, direct observation of animals and collection of fresh pellet samples from identified animals enabled to analyse the effects of characteristics related to individuals. Influence of age and sex on diet composition was examined. In the reserve, the possitive correlation of caryopsis consummation rate with age of animals was detected (Figure 30 and 31). Higher volume contents of caryopsis were found in forage of older animals while young animals fed generally less forage containing this tissue. Considering the fact caryopsis item was included in the feeding pellets that were provided to animals into a cratch in captivity, this representation of caryopsis is in accordance with field observation of animals’ behaviour by the cratch. Younger animals had not an exclusive access to the feeding pellets as they were expelled by older bigger more dominant animals. By this, the limited access of young animals meant a smaller chance to feed and thus the amount of caryopsis consumed was smaller. By this, the hypothesis No. 4 saying ‘There is no effect of the age of animals on forage composition of the Giant eland’ was rejected.

Significant differences between males and females' forage (Table 1) were found out through analysis of effect of sex on forage composition. As indicated in the diagram of Figure 32, females fed more pods and caryopsis items, whereas males ingested more leaves, fruits (except pods and sclerenchymatic fruits), and grass. The woody items, herbs, bark, and unidentified items were eaten by the both sexes. The sclerenchymatic fruits' items affected the analysis the most; however their content in the forage was independent of the sex of the animal. Hypothesis No. 5 saying 'There is no effect of the sex on forage composition of the Giant eland' was rejected.

With respect to the rate of food items representation with wood, leaf and fruit items constituting the bulk of the diet, through the classification of African ruminants according to Hofmann (1989), Giant eland would be placed in 'concentrate selectors' category. According to browser-grazer continuum classification, Giant eland can be considered a browser.

5.3 Comparison of the both Giant eland sub-species' diet composition

The only data concerning Giant eland's diet available in literature mention just browsing young leaves and buds (Kingdon, 1982), leguminous trees, some young grasses and herbs early in the wet season (Kingdon, 1997) and the only plant species described is *Isoberlinia doca* (Kingdon, 1982; Estes, 1992) and *Julbernardia* (Kingdon, 1997) as the dominant species of the Giant eland's natural habitat. The results of the thesis extend this listing with fruits, herbs and in a limited extent also grasses. The concrete plant species identified in the faeces samples were ***Acacia sp.***, ***Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,*** and ***Ziziphus mauritiana.*** In the frame of its research, a team of specialists from the Czech University of Life Sciences in Prague who has been participating in the Giant eland conservational efforts since 1998, indicated 32 plant species (Annexe/Table 3) as a probable part of Giant eland's diet and the traces of browsing were confirmed on 13 of them (Nežerková and Hájek, 2000). All the species identified by faecal analysis in this thesis are included on the list of those 13 species observed to be browsed in the field.

Impossibility of comparing the thesis results with some previously found out data related the foraging ecology of the western sub-species of Giant eland leads to comparison with results of the study examining this issue in the eastern sub-species (***Taurotragus derbianus gigas*** HEUGLIN 1863). The studies were undertaken by Bro-Jorgensen (1997) who studied food choice and selectivity in different seasons in the North Province of Cameroon, and Graziani and d'Alessio (2004) who did primarily radio telemetric monitoring of the eastern sub-species, but also examined its diet composition. In the frame of the Bro-Jorgensen's study (1997), changes in the plant species abundance and antelopes' preferences were recorded with the progressing dry season, at the time of transition to the early rainy season and during its flow. However in the case of the western giant eland examination, all year round foraging ecology pattern could not be assesssed due to the absence of samples from the rainy season. In the frame of Bro-Jorgensen's study (1997) very useful findings came also from the percentage quantification of main plant species represented in the eastern giant eland sub-species' diet. The results of the study revealed the following findings: averaged over the study period, the most abundant green-leaved dicotyledones were in order *Terminalia laxiflora*, *Maytenus senegalensis*, *Combretum glutinosum*, *Butyrospermum parkii*, *Afzelia africana*, *Annona senegalensis*, *Gardenia aqualla*, and *Terminalia macroptera* altogether accounting for 69% of the vegetation composition. Nevertheless, Bro-Jorgensen (1997) reported seasonal variation in the dominating species abundance. In the early dry season, *Maytenus senegalensis*, *Combretum glutinosum*, and *Butyrospermum parkii* were very abundant accounting for 68.7%. In the late dry season, *Terminalia laxiflora*, *Terminalia macroptera*, *Piliostigma thonningii*, *Annona senegalensis*, and *Combretum glutinosum* comprised 55.1%. In the early rainy season, *Afzelia africana*, *Terminalia laxiflora*, and *Annona senegalensis* accounted for 46.2%. For the purpose of this thesis focused on the western sub-species, no such quantification of vegetation cover providing food choice for the antelopes was done. As to the most important plant species represented in the eastern sub-species' diet, Bro-Jorgensen (1997) reports *Terminalia laxiflora*, *Afzelia africana,* and *Annona senegalensis* accounting of 45.2% of plants eaten. In another study area, *Isoberlinia doca* (not present in the previous area) and *Combretum glutinosum* were the most eaten plant species. Similarly, in the frame of Graziani and d'Alessio's study (2004) carried out in Central African Republic, quantification of the main plant species constituting eastern sub-species' diet was examined. An amount of 53.4% of the annual diet was comprised of *Hymenocardia sp.*, *Adenolichos paniculatus, Bridelia ferruginea, Landolphia owariensis, Grewia mollis, Cissus caesia*. Out of the plant species mentioned above to comprise main part of the eastern giant eland's diet, none of those reported by Bro-Jorgensen (1997), and only one of the species reported by Graziani and d'Alessio (2004), *Hymenocardia sp.*, was identified in the samples to comprise the western giant eland'diet in this thesis. Though, out of the plant species reported by both Bro-Jorgensen (1997), and Graziani and d'Alessio (2004) as those represented in eastern sub-species' diet in a smaller amount, *Acacia sp.* and *Strychnos spinosa* were also identified in the western sub-species' diet. Thus, conformity in concrete plant species consummation in eastern and western giant eland' diet was found out for *Hymenocardia sp.*, *Acacia sp.*, and *Strychnos spinosa.* The overall difference in the plant species representation between the eastern and western giant eland's diet could be explained both by different plant species composition in vegetation cover of Cameroon, Central African Republic and Senegal, and by different method used for the research of the antelope's diet.

Bro-Jorgensen (1997) indicated 65 dicotyledones, and Graziani and d'Alessio (2004) 65 plant species (not more closely specified whether dicotyledones entirely) in the eastern sub-species' diet. The list of concrete species differs a bit due to different locations where the both studies were carried out. Nevertheless, they both identified the same amount of 65 plant species in the eastern species' diet, while there were only 32 plant species indicated by Nežerková and Hájek (2000) as a probable part of western sub-species' diet. With more studies undertaken focusing on western giant eland's foraging ecology, this list of 32 species will probably be further extended.

As to the sand found in the faeces of the western giant eland, this probably originates in salt licking, which is performed by antelopes in order to gain some minerals by ingesting the soil (Bro-Jorgensen, 1997). The sand was recorded in the samples coming from the NKNP and they were collected in November, i.e. in the dry season. On the contrary, Bro-Jorgensen (1997) only observed salt licking after the first rains in April in the Northern Cameroon when rains turned hard soil into edible mud.

Bro-Jorgensen's (1997) results indicate leaves as by far the most frequently eaten plant parts in the eastern giant eland's diet. With respect to the very close relationship of the two antelope sub-species and similar general living conditions, it is not surprising that leaves also constituted the most frequently consumed plant parts in the western giant eland's diet, in latter case accompanied by wood and fruit food items. On the contrary, no grass was recorded by Bro-Jorgensen (1997) in the eastern giant eland's diet as opposed to the average proportion of 2.6% found in the faeces samples of the western giant eland. Although, Bro-Jorgensen (1997) mentions findings of Hillman and Fryxell (1988) who reported small amounts of freshly sprouting grass early in the wet season appearing in the diet of the eastern sub-species.

Bro-Jorgensen (1997) characterizes eastern sub-species as selective but flexible feeders which can be applied in the same way to western giant eland' foraging behaviour as well.

According to Nežerková and Hájek (2000) outside the natural milieu which western giant eland is attached to, the animal is compelled to accept local nutritional offer. When comparing its diet composition between the NKNP (i.e. the natural habitat) and the Bandia reserve (*ex-situ* breeding), the difference is apparent. Though, in the Bandia reserve the antelopes are provided with the feeding supplements, they still retain a high rate of the natural forage in their diet. This fact leads to claim they showed high adaptability to new environmnent and accepted local nutritional offer successively in accordance with Nežerková and Hájek's statement.

5.4 Comparison of the elands' (*Taurotragus sp.*) diet composition

When comparing western giant eland (*Taurotragus derbianus derbianus*) to another related species, eland (*Taurotragus oryx* PALLAS), both similarities and disimilarities appear in the matter of forage ecology. Eland is characterized as highly selective mixed feeder (Estes, 1992; Watson, Owen-Smith, 2000) or intermediate feeder (Hofmann, 1989), while Giant eland would be placed into category of concentrate selector respecting the Hofmann's criteria. According to Estes (1992) eland has extremely varied diet consisting primarily of browse, but also including fruits, pods, seeds, herbs, tubers, and grasses when green and tender. Based on the faecal analysis results of this thesis, the same applies for Giant eland‘s diet composition, except for tubers. Browse of elands is formed by foliage and herbs according to Kingdon (1997), and similarly according to Watson et Owen-Smith (2000) of succulent, forb and woody species. According to Kingdon (1997) elands can tolerate tougher and more aromatic foods than other Tragelaphines. Through studies of eland's forage ecology, some concrete plant species were identified in the diet. For comparison with the plant species found in the Giant eland's faeces in the dry season, these of myrrh (*Commiphora*) and bush willows (*Combretum*) were indicated as the major foods of eland. Moreover, *Acacia* seeds and reed syringa (*Burkea*) were other favoured dry-season foods sometimes browsed in poor-quality scrub by elands. *Acacia* seeds were also found in the Giant eland's faeces originating from the both study areas of the Bandia reserve and the NKNP. Early flushes of grass and herbs were reported to attract elands, notably females more than males which contrasts with the findings of this thesis applying for Giant eland. In the Bandia reserve, females fed more pods and caryopsis items, whereas males ingested more leaves, fruits (except pods and sclerenchymatic fruits), and grass. The woody items, herbs, bark were used by the both sexes. In accordance with Kingdon (1997) stating elands ate *Acacia* pods in quantities during dry season, the same phenomenon was revealed in Giant eland's forage ecology in the frame of the thesis results.

Buys (1990) reports large amounts of dicotyledones included in the eland's faeces during the winter. On the other hand, he reports the proportion of browse in the samples to decline sharply during the rainy season and, at the same time, according to Watson et Owen-Smith (2000), most grass was eaten by eland in the early wet season when grass offered young green foliage. Unfortunately, there are no data mapping feeding behaviour of Giant eland in rainy season for any comparison. Watson and Owen-Smith (2000) report the annual proportion of grass in eland diet quite low (about 6%) in contradiction to Buys (1990), whose results report that grasses never formed less than one third of the fragments identified in the faeces examined in his study. Based on results of this thesis applying to Giant eland, and according to Watson and Owen-Smith (2000) regarding eland, woody species comprising dwarf shrubs and shrubs made up the bulk of the food eaten by the both antelope species.

According to Buys (1990), and Watson and Owen-Smith (2000) eland are browsers selecting browse of high protein forage low in fibre. There were no analyses made for nutritional assessment of the Giant eland's forage in the frame of this thesis, thus it is hard to pass judgment on this statement in relation to Giant eland's foraging habits. But in general, grass content which is rich in fibre especially with the progressive dry season, constituted only very small part of the diet which could indicate Giant eland's selectiveness against the fibre forage. Instead, antelope's focus is rather aimed at more nutritionally rich leaves, fruits and herbs.

According to Hillman (1979 in Buys, 1990) eland are essentially browsers which have adapted to living in a grazing environment.

5.5 Limits of used methodology

Speaking in general usually no faultless methodology exists, it can be rather said that every methodology has its strengths and weaknesses. The methodology used in this thesis poses no exception.

Collection of samples was carried out in the dry season only. In the Bandia reserve this was done during the period of November – May, in the Niokolo Koba National Park during November – June. The samples were collected randomly, incontinually and it was not always possible to identify for how long they were already lying on the ground. These facts limit the capability of forming a general picture of the Giant eland's forage ecology. Certainly, the examination of antelopes' forage behaviour in the rainy season would bring to light many interesting facts making the whole research more complex as well as the comparison of the feeding habits in dry and rainy season would definitely provide very interesting and valuable informations. On the other hand in the given amount of time that was available for elaboration of this thesis, it was maybe a wiser decision to analyse 80 samples mapping the dry season than to analyse smaller amount divided between the dry and rainy season. In that latter case, there could be a comparison between the seasons made, but the data sets for statistic analyses would be comprised of substantially lesser amount of indications making the results less realiable and more burdened with a statistical discrepancy. So, there was a choice to make and the idea of more accurate analyse of samples from one season only (dry season) was preferred in the end.

Neither vegetation coverage or plant species representation were quantified within the two study areas. By this, relation of antelopes‘ forage selectivity and its availability could not be assessed nor antelopes‘ preference for some rare or abundant plant species could be evaluated.

As to the microscopical faeces analysis method itself, there are apparently some limitations to it (Stewart, 1967; Homolka and Heroldová, 1992; Heroldová, 1996). Although the basic principle lies in a premise that plant tissues are not fully damaged during digestion in the gastro-intestinal tract and their residues can be then put through a botanical identification using a microscope, in fact it is not always true (Stewart, 1967). Namely, there is a different digestibility of various plant tissues varying greatly according to the tissue structure, age and composition. Often young soft plant tissues or blossoms are totally digested and no rests remaining detectable in the faeces. By this, there can certainly be some plant items consumed by antelopes, but these cannot be found in the faeces. Also, as mentioned already earlier in this discussion chapter, tropical plants have evolved morphological adaptations on climatic conditions that make them similar in appearance, thus it is harder to identify plant species, because of lack of species-specific features. According to Stewart (1967) microscopical faeces analysis method can be used in cases where the numbers of animal and plant species are fewer and the data obtained are usually qualitative only.

Capability of correct plant species discrimination and identification is to some extend dependent on each person’s skills and experience (Homolka and Heroldová, 1992). In fact, some plant species can be present in the samples, but insufficient knowledge and lack of long-term experience with botanical identification of plant rest can make these left overlooked or non-recognized. Thus, consultation with a person skilled in botany field is necessary.

On the contrary reliability of the method was confirmed by the fact that food items known for being constituting dietary supplements were recognized in the faeces. In the Bandia reserve, antelopes' diet is supplemented during dry season with feeding pellets comprised mainly of caryopsis, which was identified in the faeces samples.

By critical assessment of a methodology or a method used, the weaknesses can be recognized and avoided in the future. The methodology or the method can be further developed and innovated resulting in their more effective utilization and benefit. Each step of the research process is a valuable experience. Even when a trial proves to be an error in the end, the experience can serve as a clue for the next time. By this, wrong trials are eliminated with time progression and successful trial results are gathered together heading to the final solution.

6. Conclusions

There were 7 categories of food items identified in the samples to comprise the Giant eland's diet. These were those of leaf, wood, fruit, caryopsis, herb, grass and bark. All the food items were recorded in samples from the both study areas, thus the diet was composed of the same plant tissues and structures in the wild and in captivity. Even the proportional ratio of food items representation within the both study areas was maintained almost the same. Leaf, wood and fruit comprised the bulk of the diet. Food items of herb, caryopsis, and bark were recorded in the faeces samples at lower rate of representation and against all expectations, a small amount of grass was found in the faeces to constitute the diet, too. The concrete percentage food items representation between the two sites differed, though. For NKNP the most abundant item comprising the diet was leaf (32.5%) closely followed by wood (30.2%) and fruit (28.6%). Other items were represented at a substantially lower rate: grass (3.7%), caryopsis (2.8%), bark (2.8%), unidentified items (2%) and the least represented one was the herb item (0.6%). For the Bandia reserve, the same 3 food items as in NKNP dominated in samples, although their accurate values differ a bit. The most represented items were thus the following: fruit (30%) closely followed by wood (23.1%) and leaf (21.9%). Caryopsis was recorded constituting quite a great amount of content (20.3%) in comparison to NKNP, due to its content in supplementary feeding pellets. The further decline in food items representation rate continued from herb (6.3%), bark (3.7%), unidentified items (2%) to the least represented item of Grass (1.5%). The different rate of concrete food items representation is probably determined by differing vegetation structure and thus diverse food supply of the both locations.

According to the results above western giant eland can be classified as a browser.

Concrete plant species identified in the diet were *Acacia sp.*, *Boscia angustifolia, Grewia bicolor, Hymenocardia acida, Strychnos spinosa,* and *Ziziphus mauritiana*. Identification was done based on characteristic plant tissues by comparison to reference catalogue slides.

All the five hypotheses formulated at the beginning of the research were rejected. Just to remind, these were framed as follows: H1: There is no effect of the site on forage composition of the Giant eland; H2: There is no effect of the month of samples' collection on forage composition of the Giant eland in general, and within the both sites separately; H3: There is no effect of the locality of samples' collection in the NKNP on forage composition of the Giant eland in general and on forage composition with particularly defined various types of fruits found; H4: There is no effect of the age of animals on forage composition of the Giant eland; and H5: There is no effect of the sex on forage composition of the Giant eland. All the examined factors, i.e. those of site, month of sample collection, locality within the NKNP, sex and age of animals were proved to affect diet composition. Though, too little samples were analyzed to be able to make these relations clear.

It is important to bear in mind that a small number of samples analyzed and the fact they all were collected in dry season only, makes it impossible to extrapolate these findings to general level of the Giant eland's foraging behaviour. This is one of the very first steps in the giant eland's foraging ecology research, though, and further studies are needed to verify, compare and extend these conclusions. For more complex examination mapping the foraging ecology all year-round, further research is necessary. When more of these studies are done one day, the whole conception of the Giant elands' forage ecology will be clearer and better understood. There is an urgent need to fully comprehend the Giant eland's feeding demands and to assure appropriate management.

7. References

AL-OGOUMRABE, N. 2002. Les aires protégées au Sénégal: étude du cas de la Réserve de faune de Bandia: adaptation des animaux sauvages introduits et aspect socio-économique. Thèse UCAD EISMV Dakar, N°7, pp. 193. In ANTONÍNOVÁ, M.; NEŽERKOVÁ, P.; VINCKE, X.; AL-OGOUMRABE, N. 2004. *Herd structure of the Giant eland (Taurotragus derbianus derbianus) in the Bandia Reserve, Senegal. Agricultura Tropica et Subtropica*, Universitas Agriculturae Praga, Vol. 37:1 – 4.

ANONYMUS. 2000. Plan de gestion du parc et de sa péripherie. Ministère de l'Environnement, Direction des Parcs Nationaux, Dakar, 219 pp. (Unpublished).

ANTONÍNOVÁ, M.; HEJCMANOVÁ, P.; VÁHALA, J.; MOJŽÍŠOVÁ, L.; AKAKPO, J.A.B.; VERNER, P.H. 2006. Immobilization and transport of Western giant eland (*Taurotragus derbianus derbianus*) from the Bandia reserve to the Fathala reserve in Senegal. *Gazella*, Vol. 33: 75-98.

ANTONÍNOVÁ, M.; NEŽERKOVÁ, P.; VINCKE, X.; AL-OGOUMRABE, N. 2004. Herd structure of the Giant eland (*Taurotragus derbianus derbianus*) in the Bandia Reserve, Senegal. *Agricultura Tropica et Subtropica*, Universitas Agriculturae Praga, Vol. 37:1 – 4.

BECK, personal communication. In NEŽERKOVÁ, P.; VERNER, P.H.; ANTONÍNOVÁ, M. *The conservation programme of the Western giant eland* (*Taurotragus derbianus derbianus*) *in Senegal* – Czech Aid Development Project. 2004. *Gazella* Vol. 31: 87 – 182.

BELOVSKY, G.E. 1984. Herbivore optimal foraging: a comparative test of three models, *American Naturalist,* Vol. 124: 97-115.

BRO-JORGENSEN, J. 1997. The ecology and Behaviour of the Giant Eland (*Tragelaphus derbianus,* Gray 1847) in the Wild and Why Do Antelopes Form Groups?. Zoological Society of San Diego. Master's thesis, University of Copenhagen.129 pp.

BUYS, O. 1990. Food selection by eland in the western Transvaal. Mammal Research Institute – University of Pretoria, Pretoria. S. – *Afr.Tydskr. Naturnaav.,* Vol. 20(1): 16-20.

CASSINI, M.H. 1994. Behavioral mechanisms of selection of diet components and their ecological implications in herbivorous mammals, *Journal of Mammalogy,* Vol. 75, No. 3: 733-740.

CERLING, E.; HARRIS, J.M.; PASSEY B.H. 2003. Diets of East African Bovidae Based on Stable Isotope Analysis. *Journal of Mammalogy*, Vol. 84(2): 456-470.

DARROZE, S. 2004. Western Giant Eland (*Taurotragus derbianus derbianus*) presence confirmed in Mali and Guinea. In *Antelope Survey Update*, Number 9: November 2004, IUCN/SSC Antelope Specialist Group Report (eds. Chardonnet, B. & Chardonnet, Ph.), pp. 64-65. Fondation Internationale pour la Sauvegarde de la Faune, Paris, France, pp : 21-23.

DORST, J.; DANDELOT, P. *Guides des Grands Mammiféres D'Afrique*. Delachaux et Niestlé Éditeurs. Paris. France. 1970. 286 pp. ISBN 2-603-00095-0.

EAST, R. *African Antelope Database 1998.* IUCN/SSC Antelope Specialist Group Report. IUCN Publications Service Unit. Cambridge. United Kingdom. 1998. 434 pp.

EGO, W.K.; MBUVI, D.M.; KIBET, P.F.K. 2003. Dietary composition of wildebeest (*Connochaetes taurinus*), kongoni (*Alcephalus buselaphus*) and cattle (*Bos indicus*), grazing on a common ranch in South-Central Kenya. *African Journal of Ecology*, Vol. 41: 83 – 92.

ESTES, R.D. *The behavior guide to African mammals: including hoofed mammals, carnivores, primates.* University of California Press, Ltd. London. England. 1992. ISBN 0-520-08085-8.

FREELAND, W.J.; JANZEN, D.H. 1974. Strategies in herbivory by mammals: the role of plant secondary compounds, *American Naturalist*, Vol. 108, No. 961: 269-289.

FRITZ, H.; DE GARINE-WICHATITSKY, M. 1996. Foraging in a social antelope: effects of group size on foraging choices and resource perception in impala, *Journal of Animal Ecology*, Vol. 65: 736-742.

GAGNON, M.; CHEW, A.E. 2000. Dietary preferences in extant African Bovidae. *Journal of Mammalogy* 81: 490–511. In CERLING E., HARRIS J.M., PASSEY B.H. 2003: Diets of East African Bovidae Based on Stable Isotope Analysis. *Journal of Mammalogy*, Vol. 84(2): 456-470.

GRAZIANI, P.; D'ALESSIO, S.G. 2004. Monitorage radiotélémetrique de l'Eland de Derby (*Tragelaphus derbyanus gigas*) dans le Nord de la République Centrafricaine. Programme regional ECOFAC composante zones cynegetiques villageoises (R.C.A.). Instituto di Ecologia Applicata (I.E.A.). Rome. 77 pp.

HEJCMANOVÁ, P.; HEJCMAN, M.; AZIZ, C.A.; ANTONÍNOVÁ, M.; PAVLŮ, V. Restoration of dryland savannah after exclusion of livestock grazing and wood collection in Senegal (*in preparation*)

HEJCMANOVÁ-NEŽERKOVÁ, P.; HEJCMAN, M. 2006. A canonical correspondence analysis (CCA) of the vegetation–environment relationships in Sudanese savannah, Senegal. *South African Journal of Botany*, Vol. 72: 256 – 262.

HEROLDOVÁ, M. 1996. Metody studia potravy kopytníků. Akademie věd České republiky, Ústav ekologie krajiny, Brno. Příloha kandidátské dizertační práce.

HEROLDOVÁ, M. *Trophic niches of three ungulate species in the Pálava biosphere reserve.* Institute of Landscape Ecology, Academy of Sciences of the Czech Republic, Brno, 1997, 52 pp.

HILLMAN, J.C. 1979. The biology of the eland (*Taurotragus oryx* Pallas) in the wild. Ph.D. thesis, University of Nairobi. In BUYS O., 1990: Food selection by eland in the western Transvaal, Mammal Research Institute – University of Pretoria, Pretoria. S. – *Afr.Tydskr. Naturnaav.,* Vol. 20(1): 16-20.

HILLMAN, J.C.; FRYXELL J.M. 1988. Sudan. In BRO-JORGENSEN, J. 1997. *The ecology and Behaviour of the Giant Eland (Tragelaphus derbianus, Gray 1847) in the Wild and Why Do Antelopes Form Groups?.* Zoological Society of San Diego. Master's thesis, University of Copenhagen.129 pp.

HILLMAN, J.C.; GWYNNE, M.D. 1987. Feeding of the Bongo antelope, *Tragelaphus eurycerus* (Ogilby, 1837), in south west Sudan. *Mammalia,* Vol. 51, No.1: 53-63.

HOFMANN, R.R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 78: 443-457.

HOMOLKA, M.; HEROLDOVÁ M. 1992. Similarity of the results of stomach and faecal contents analyses in studies of the ungulate diet. *Folia Zoologica*, Vol. 41 (3): 193-208.

HOMOLKA, M.; HEJCMANOVÁ, P.; ANTONÍNOVÁ, M.; HEROLDOVÁ, M.; KAMER, J. Estimating antelope relative abundance by pellet counts in the West African savanna *(in preparation*)

HUFFMAN, B. 2004. *Your guide to the world's Hoofed Mammals* [online]. Last revision 2004/03/22. [cit. 2008-04-22]. Available from <http://www.ultimateungulate.com/Artiodactyla/Taurotragus_derbianus.html>

International System Species Information (ISIS) – Species Holdings [online]. c2008, last revision 2008/01/11.[cit. 2008-01-13]. Available from <http://app.isis.org/abstracts/Abs78955.asp>

KINGDON J. *East African mammals Vol. III. Part C: Bovids*. Academic Press Inc. London Ltd. 1982. ISBN 0-12-408344-7.

KINGDON J. *The Kingdon Field guide to African Mammals*. A&C Black Publishers Ltd. London. 1997. 476 pp. ISBN 0-7136-6513-0.

KLAUS-HÜGI, C.; KLAUS, G.; SCHMID, B.; KÖNIG B. 1999. Feeding ecology of a large social antelope in the rainforest., *Oecologia* Vol. 119: 81-90.

LAWESSON, J.E. *Opera Botanica – Studies of woody flora and vegetation in Senegal*. AKA- PRINT A/S. Copenhagen. Denmark. 1995. ISBN 87-88702-87-1.

LEPŠ, J.; ŠMILAUER, P., 2003. Multivariate analysis of ecological data using CANOCO. Cambridge University Press, Cambridge.

LEROUX, M. 1983. Le climat de l'Afrique Tropicale. The climat of Tropical Africa.- Editions Champion, Paris. In NEŽERKOVÁ, P.; VERNER, P.H.; ANTONÍNOVÁ, M. *The conservation programme of the Western giant eland (Taurotragus derbianus*

derbianus) in Senegal – Czech Aid Development Project. 2004. *Gazella,* Vol. 31: 87 – 182.

MADSEN, J.; DIONE, D.; TRAORÉ, S.A.; SAMBOU, B. 1996. Flora and vegetation of Niokolo Koba National Park, Senegal. In: NEŽERKOVÁ, P.; VERNER, P.H.; ANTONÍNOVÁ, M. *The conservation programme of the Western giant eland (Taurotragus derbianus derbianus) in Senegal* – Czech Aid Development Project. 2004. *Gazella*. Vol. 31: 87 – 182.

MORRISON, M.L.; MARCOT, B.G.; MANNAN, W.R. 1992. Wildlife habitat relationships – concepts and applications. In PERRIN, M.R.; TAOLO, C.L. *Diet of introduced roan antelope at Weenen nature Reserve, South Africa*. *S. Afr. J. Wildl. Res.* 1999. Vol. 29(2): 43-51.

NEŽERKOVÁ, P.; HÁJEK, I. 2000. Wildlife in national park of Niokolo Koba (Senegal) and its ecological background, with special regard to diet of Giant Eland. Universitas Agriculturae Praga, *Agricultura Tropica et Subtropica*, Vol. 33: 44 – 51.

NEŽERKOVÁ, P.; VERNER, P.H.; ANTONÍNOVÁ, M. 2004. The conservation programme of the Western giant eland (*Taurotragus derbianus derbianus*) in Senegal – Czech Aid Development Project. *Gazella,* Vol. 31: 87 – 182.

OWEN-SMITH, N.; COOPER, S.M. 1987. Palatability of woody plants to browsing ruminants in a South African savanna. *Ecology,* Vol. 68(2): 319-331.

PERRIN, M.R.; TAOLO, C.L. 1999. Diet of introduced roan antelope at Weenen nature Reserve, South Africa, *S.Afr.J.Wildl.Res.,* Vol. 29(2): 43-51.

RENAUD, P.C.; GUEYE, M.B.; HEJCMANOVÁ, P.; ANTONÍNOVÁ, M.; SAMB, M. 2006. Inventaire aérien et terrestre de la faune et relevé des pressions au Parc National du Niokolo Koba. Plan d'Urgence, Rapport Annexe A, Aout 2006, 74pp.

RUGGIERO, R. 1990. Lord Derby's Eland. East African Wildlife Soc., *Swara,* Vol. 13, No. 6: 10-13.

SCHUETTE, J.R.; LESLIE, D.M.; LOCHMILLER, R.L.; JENKS, J.A. 1998. Diets of hartbeest and roan antelope in Burkina Faso: Support of the long-faced hypothesis, *Journal of Mammalogy,* Vol. 79(2): 426-436.

SECA-AGRER, S.A.1993. Cartographie de la végétation de la Zone Pilote de Sangba. 25 pp. In GRAZIANI, P.; D'ALESSIO, S.G. *Monitorage radiotélémetrique de l'Eland de Derby (Tragelaphus derbyanus gigas) dans le Nord de la République Centrafricaine*. Programme regional ECOFAC composante zones cynegetiques villageoises (R.C.A.). Instituto di Ecologia Applicata (I.E.A.). Rome. 2004. 77 pp.

SKALICKÝ, M.; NOVÁK, J. *Botanika I.: Anatomie a morfologie rostlin*. Česká zemědělská univerzita v Praze. Praha. 2007. 146 pp. ISBN 978-80-213-1724-6.

SLAVÍKOVÁ, Z. *Morfologie rostlin*. Univerzita Karlova v Praze. Nakladatelství Karolinum. Praha. 2002. 218 pp. ISBN 80-246-0327-6.

SPALINGER, D.E.; HOBBS, N.T. 1992. Mechanisms of foraging in mammalian herbivores: new models of functional response, *American Naturalist,* Vol. 140: 325-348.
SPONHEIMER, M.; LEE-THORP, J.A.; DERUITER, D.J.; SMITH, J.M.; VAN DER MERWE, N.J.; REED, K.; GRANT, C.C.; AYLIFFE, L.K.; ROBINSON, T.F.; HEIDELBERGER, C.; MARCUS W. 2003. Diets of Southern African Bovidae: Stable Isotope Evidence. *Journal of Mammalogy,* Vol. 84(2): 471-179.

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,* Vol. 4: 83-111.

TER BRAAK, C.J.F.; ŠMILAUER, P. 2002. CANOCO Reference manual and CanoDraw for Windows user's guide: Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, New York.

TIESZEN, L.L.; SENYIMBA, M.M.; IMBAMBA, S.K.; TROUGHTON, J.H. 1979. The distribution of C3 and C4 grasses and carbon isotope discrimination along an altitudinal and moisture gradient in Kenya. *Oecologia* 37:337–350. In CERLING, E.; HARRIS, J.M.; PASSEY, B.H. *Diets of East African Bovidae Based on Stable Isotope Analysis.* 2003. *Journal of Mammalogy,* Vol. 84(2): 456-470.

VALÍČEK, P.; HLAVA, B.; HOLUBOVÁ, K; HUŠÁK, S.; KOKOŠKA, L.; MATĚJKA, V.; MICHL, J.; PAVEL, L.; POLESNÝ, Z.; WRÓBLEWSKÁ, E.; ZELENÝ, V. *Užitkové rostliny tropů a subtropů.* 2. vydání, Academia, nakladatelství Akademie věd České republiky, Praha, 2002. 486 pp. ISBN 80-200-0939-6.

WATSON, L.H.; OWEN-SMITH, N. 2000. Diet composition and habitat selection of eland in semi-arid shrubland, East African Wildlife Society, *African Journal of Ecology,* Vol. 38: 130-137.

WATSON, L.H.; OWEN-SMITH, N. 2002. Phenological influences on the utilization of woody plants by eland in semi-arid shrubland. East african Wild Life Society, *African Journal of Ecology*, Vol. 40: 65-75.

WHITE, F. 1983. The vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map. Natural Resources research 20. UNESCO, Paris. In ANTONÍNOVÁ, M.; NEŽERKOVÁ, P.; VINCKE, X.; AL-OGOUMRABE, N. 2004. *Herd structure of the Giant eland (Taurotragus derbianus derbianus) in the Bandia Reserve, Senegal*. *Agricultura Tropica et Subtropica*, Universitas Agriculturae Praga, Vol. 37:1 – 4.

Mammal Species of the World [online]. WILSON, D.E.; REEDER D.M. (editors), John Hopkins University Press, 2, 142 pp. 2005. [cit. 2008-01-08]. Available from <http://www.press.jhu.edu>

WOOLNOUGH, A.P.; DU TOIT, J.T. 2001. Vertical zonation of browse quality in tree canopies exposed to size-structured guild of African browsing ungulates. *Oecologia,* Vol. 129: 585-590.

Annexe

Fig. 33 – Niokolo Koba National Park: localities of faeces samples collection (Assirik, Lengue Kontou and Mansa Fara).

Note: the localities are marked with yellow elipse.

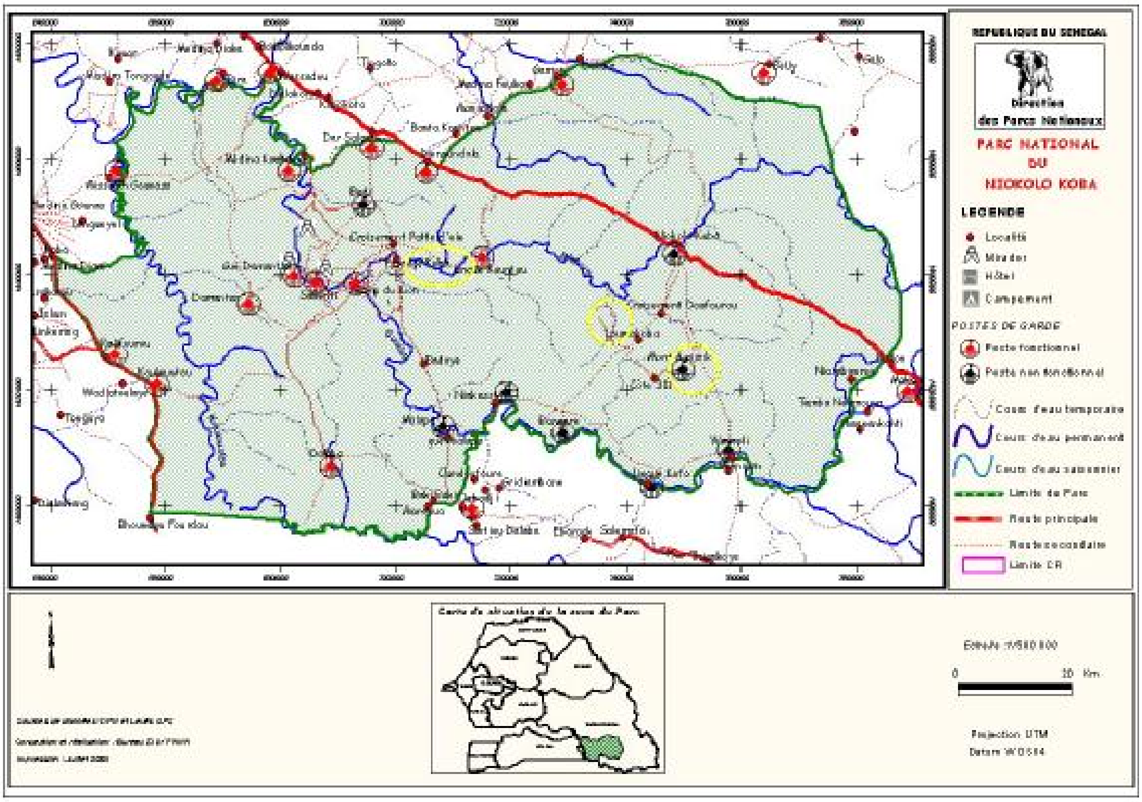

Table 2 – The list of faeces samples. The Bandia reserve.

Sample No.	Date	Antelope	Sex	Age (month)
1	11/2004	Malapa ?	f	adult
2	11/2004	Dayane ?	f	12
3	11/2004	Sokone	m	12
4	11/2004	Křivorohá	f	22
5	11/2004	Thelma	f	31
6	11/2004	Křivý Roh	m	21
7	11/2004	???	m	12
8	11/2004	Niokolo	m	adult
9	11/2004	Bembou	f	adult
10	11/2004		f	22
11	11/2004	Thelma	f	31
12	11/2004	Tatřetí	f	22
13	11/2004	Dagana	f	30
14	11/2004	Dalaba ?	f	adult
15	11/2004	Tatřetí	f	22
16	11/2004	Dagana	f	30
17	11/2004	Sokone	m	12
18	11/2004	Tamba	f	adult
19	11/2004	Niokolo	m	adult
20	11/2004	Matam	m	12
21	11/2004	Tatřetí	f	22
22	11/2004	Dalaba	f	adult
23	11/2004	Malapa	f	adult
24	11/2004	Dalaba	f	adult
25	11/2004	Salémata	f	adult
26	11/2004	Malapa	f	adult
27	11/2004	Pravobočka	f	21
28	11/2004	???	m	1
29	11/2004	Bembou	f	adult
30	11/2004	Ušák	m	22
31	11/2004	Tamba	f	adult
32	11/2004	???	m	12
33	11/2004	Dayane	f	12
34	11/2004	Thelma	f	31
35	11/2004	Dalaba	f	adult
36	11/2004	Toubab	m	9
37	11/2004	Malapa	f	adult
38	11/2004	???	f	adult
39	11/2004	Niokolo	m	adult
40	16/5/2004	Niokolo	m	adult
41	10/4/2004	?		
42	10/4/2004	?		
43	10/4/2004	?		
44	10/4/2004	?		

45	10/4/2004	?		
46	10/4/2004	?		
47	16/5/2004	?		
48	16/5/2004	?		
49	16/5/2004	?		
50	16/5/2004	?		
51	16/5/2004	?		
52	16/5/2004	?		
53	16/5/2004	Dalaba	f	adult
54	16/5/2004	Křivorohá	f	
55	16/5/2004	Malapa	f	adult
56	16/5/2004	prcek		
57	16/5/2004	Salémata	f	adult
58	16/5/2004	?		adult
59	16/5/2004	?		
60	16/5/2004	?		adult
61	16/5/2004	?		
62	25/1/2003	?		
63	9/12/2000	?		
64	22/1/2002	?		
65	16/12/2002	?		
66	25/1/2003	?		
67	25/1/2003	?		
68	25/1/2003	?		
69	4/3/2003	?		
70	4/3/2003	?		
71	11/12/2003	?		
72	11/12/2003	Niokolo	m	adult
73	11/12/2003	?		
74	12/12/2003	Salémata	f	adult
75	12/12/2003	?		
76	12/12/2003	?		
77	12/12/2003	?		
78	12/12/2003	?		
79	13/12/2003	Dalaba	f	adult
80	13/12/2003	Dagana	f	
81	14/12/2003	Pravobočka	f	
82	14/12/2003	Tamba	f	adult
83	14/12/2003	Thelma	f	
84	14/2/2005	Niokolo	m	adult
85	14/2/2005	Dalaba	f	adult
86	14/2/2005	Thelma	f	
87	14/2/2005	Dagana	f	
88	14/2/2005	Dagana	f	
89	14/2/2005	?		
90	14/2/2005	Malapa	f	adult
91	14/2/2005	?		

92	14/2/2005	?		
93	14/2/2005	?		
94	14/2/2005	?		
95	14/2/2005	?		
96	14/2/2005	?		
97	14/2/2005	?		
98	14/2/2005	?		
99	14/2/2005	?		
100	26/5/2005	?		
101	26/5/2005	?		
102	26/5/2005	?		
103	26/5/2005	?		
104	26/5/2005	?		
105	26/5/2005	?		adult
106	26/5/2005	?		
107	26/5/2005	?		
108	26/5/2005	?		
109	26/5/2005	?		adult
110	26/5/2005	?		adult
111	26/5/2005	?		
112	26/5/2005	?		adult
113	26/5/2005	?		
114	26/5/2005	?		
115	26/5/2005	?		
116	26/5/2005	?		adult
117	26/5/2005	?		
118	26/5/2005	?		
119	26/5/2005	?		
120	26/5/2005	?		
121	26/5/2005	?		
122	26/5/2005	?		

Table 3 – The list of faeces samples: Niokolo Koba National Park.

Sample No.	Date	Locality
1	2000	NKNP
2	24/5/2001	LK- enclosure
3	24/5/2001	LK- enclosure
4	5/6/2001	LK– 300 m od vel. hráze
5	9/6/2001	LK- bank of Niokolo river
6	20/6/2001	LK - enclosure - Z od I4
7	2002	Secteur Soumaniko
8	2002	Aerodrome Niokolo
9	2002	Secteur Mt. Assirik
10	12/5/2002	Piste Bassari – Badi x Patte d'Oie
11	14/11/2002	LK– 170 m SE from salt marsh
12	14/11/2002	LK– 170 m SE from salt marsh
13	14/11/2002	LK– 170 m SE from salt marsh
14	14/11/2002	LK– 170 m SE from salt marsh
15	14/6/2003	Mare Tourmadala
16	14/6/2003	Mare Tourmadala
17	14/6/2003	Crossroads Assirik x Wouroli
18	14/6/2003	Crossroads Assirik x Wouroli
19	14/6/2003	Crossroads Assirik x Wouroli
20	14/6/2003	Crossroads Assirik x Wouroli
21	14/6/2003	Crossroads Assirik x Wouroli
22	14/6/2003	Crossroads Assirik x Wouroli
23	14/6/2003	Crossroads Assirik x Wouroli
24	14/6/2003	Crossroads Assirik x Wouroli
25	15/6/2003	Mare Mansafara
26	15/6/2003	Mare Mansafara
27	15/6/2003	Mare Mansafara
28	15/6/2003	Mare Mansafara
29	15/6/2003	Mare Mansafara
30	15/6/2003	Mare Mansafara
31	15/6/2003	Mare Mansafara

32	15/6/2003	Mare Mansafara
33	15/6/2003	Mare Mansafara
34	15/6/2003	Mare Mansafara
35	15/6/2003	Mare Mansafara
36	15/6/2003	Mare Mansafara
37	15/6/2003	Mare Mansafara
38	15/6/2003	Mare Mansafara
39	15/6/2003	Mare Mansafara
40	15/6/2003	Mare Mansafara
41	20/6/2003	Mare Simenti
42	22/6/2003	LK– poste
43	22/6/2003	LK– poste
44	22/6/2003	LK– dikes
45	22/6/2003	LK– dikes
46	24/6/2003	Piste Bassari – Badi x PO
47	24/6/2003	Piste Bassari – Badi x PO
48	24/6/2003	Piste Bassari – Badi x PO
49	24/6/2003	Piste Bassari – Badi x PO
50	24/6/2003	Piste Bassari – Badi x PO
51	24/6/2003	Piste Bassari – Badi x PO
52	9/1/2004	Niokolo_riviere
53	25/4/2004	LK
54	4/04	LK
55	4/04	LK
56	4/04	LK
57	5/04	LK
58	6/5/2004	LK
59	31/1/2005	LK - LK2 (S od T08)

Note: LK = Lengue Kontou

Table 4 – Reference catalogue – list of plants

No.	Plant name
1.	*Acacia albida*
2.	*Acacia nilotica*
3.	*Acacia seyal*
4.	*Acacia sieberiana*
5.	*Annona senegalensis*
6.	*Anogeissus leiocarpus*
7.	*Borassus flabellifer*
8.	*Boscia angustifolia*
9.	*Burkea africana*
10.	*Capparis sp.*
11.	*Carex sp.*
12.	*Cassia torra*
13.	*Cochlospermum tinctorium*
14.	*Combretum glutinosum*
15.	*Combretum nigricans*
16.	*Crossopteryx febrifuga*
17.	*Detarium microcarpum*
18.	*Detarium senegalense*
19.	*Entada africana*
20.	*Feretia apodanthera*
21.	*Gardenia ternifolia*
22.	*Grewia bicolor*
23.	*Grewia flavescens*
24.	*Guiera senegalensis*
25.	*Hexalobus monopetalus*
26.	*Hibiscus asper*
27.	*Hymenocardia acida*
28.	*Hyptis suaveolens*
29.	*Icacina senegalensis*

30.	*Juncus sp.*
31.	*Lannea acida*
32.	*Lannea velutina*
33.	*Leptadenie nastada*
34.	*Merremia aegyptiaca*
35.	*Mitragyna inermis*
36.	*Nauclea latifolia*
37.	*Oxytenanthera abyssinica*
38	*Penisetum sp.*
39.	*Piliostigma thonningii*
40.	*Pterocarpus erinaceus*
41.	*Pterocarpus lucens*
42.	*Strychnos spinosa*
43.	*Tamarindus indica*
44.	*Terminalia avicenoides*
45.	*Vitex madiense*
46.	*Xeroderris stuhlmanii*
47.	*Ximenia americana*
48.	*Ziziphus mauritiana*

Table 5 - Browse marks recorded in the Niokolo Koba National Park and the Bandia reserve according to Nežerková and Hájek (2000)

Species	Guards of NP Niokolo Koba	Own field observation	Employee of R. Bandia
Acacia nilotica	+		+
Acacia seyal	+		+
Anogeissus leiocarpus	+		
Aphania senegalensis			+
Balanites aegyptiaca			+
Boscia angustifolia		+	
Boscia senegalensis			+
Cassia torra			+
Cochlospermum tinctorium	+		
Combretum aculeatum			+
Combretum glutinosum		+	
Combretum sp.	+	+	
Crossopteryx sp.			
Detarium microcarpum	+		
Feretia apodanthera	+	+	+
Gardenia sp.	+	+	
Grewia bicolor	+	+	+
Grewia flavescens	+	+	
Hexalobus monopetalus	+	+	
Hymenocardia acida	+	+	
Ipomoea muricata			+
Isoberlinia doka	+		
Lannea acida	+		
Lannea velutina	+		
Mitragyna inermis	+	+	
Pseudocedrela sp.	+		
Pterocarpus erinaceus	+	+	
Spondias mombin	+		
Stereospermum kunthianum	+		
Strychnos innocua	+		
Strychnos spinosa	+	+	
Ziziphus mauritiana	+	+	+

Table 6a – NKNP: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)
(Table 6a continues on the next page as Table 6b displaying more food items)

Sample No.	Date of collection	Month of collection	Site	PNNK locality	Wood	Leaf epidermis	Leaf nervature	Leaf total	Sclerenchym	Pod	Fleshy fruit	Fruit Top	Fruit Support	Fruit total
1	2000	?	NKNP	?	2,72	0,45	1,28	1,73	0,35	1,57	0,50	0,50		2,93
2	24/5/2001	May	NKNP	LK	2,79	0,49	0,85	1,34	2,92	0,90	0,65	0,32	0,45	5,24
3	24/5/2001	May	NKNP	LK	1,12	2,12	1,27	3,39	0,20	0,58	0,27		0,30	1,35
4	5/6/2001	June	NKNP	LK	2,62	1,21	1,04	2,25	1,06	1,25	0,65		0,56	3,51
5	9/6/2001	June	NKNP	LK	2,35	0,65	1,35	2,00	1,85	1,79	1,29	0,70	0,27	5,90
6	20/6/2001	June	NKNP	LK	4,34	0,59	0,78	1,37	0,88	2,10	0,62		0,53	4,14
7	2002	?	NKNP	SS	2,74	1,08	1,92	3,00	1,22	0,62	0,68	0,52	0,63	3,67
10	12/5/2002	May	NKNP	PB-BxPO	2,83	0,44	0,85	1,29	3,33		1,47	0,51	0,83	6,15
11	14/11/2002	November	NKNP	LK	3,06	1,85	1,75	3,60	0,23		0,42			0,65
12	14/11/2002	November	NKNP	LK	2,90	1,64	2,06	3,70	0,16		0,36			0,52
13	14/11/2002	November	NKNP	LK	2,86	1,45	1,50	2,94	0,73		0,56			1,29
14	14/11/2002	November	NKNP	LK	3,39	1,36	2,02	3,38			0,47	0,35		0,82
15	14/6/2003	July	NKNP	Mare T	3,61	1,66	2,23	3,89	0,93	1,54	0,80	1,46	0,70	5,43
17	14/6/2003	July	NKNP	KA x W	4,42	2,50	1,29	3,79	0,48	1,72	0,22	0,70		3,12
18	14/6/2003	July	NKNP	KA x W	3,91	1,62	1,12	2,74	0,19	2,54	0,38			3,11
19	14/6/2003	July	NKNP	KA x W	2,45	1,02	2,03	3,05		0,85	0,39		0,80	2,04
20	14/6/2003	July	NKNP	KA x W	2,00	0,97	2,88	3,84	0,45	1,39	0,45	0,30		2,59
21	14/6/2003	July	NKNP	KA x W	2,52	1,84	1,32	3,16	0,74	2,32	0,50			3,56
22	14/6/2003	July	NKNP	KA x W	2,80	1,56	1,17	2,73	0,49	1,93	0,50			2,91
23	14/6/2003	July	NKNP	KA x W	3,01	1,19	1,71	2,90	0,30	0,93	0,51		0,30	2,04
24	14/6/2003	July	NKNP	KA x W	4,58	0,96	0,69	1,66	0,34	1,99	0,43			2,76
25	15/6/2003	July	NKNP	Mare M	1,95	3,86	0,89	4,74	0,72	1,00	0,38		0,67	2,77
26	15/6/2003	July	NKNP	Mare M	1,62	3,10	2,51	5,61	0,40	2,10	0,44			2,94
27	15/6/2003	July	NKNP	Mare M	2,16	2,45	2,89	5,34	0,52		0,41			0,93
28	15/6/2003	July	NKNP	Mare M	2,90	2,55	2,59	5,14		3,95	0,65			4,60
29	15/6/2003	July	NKNP	Mare M	1,92	3,08	2,36	5,44	0,97	1,20	0,63			2,79
30	15/6/2003	July	NKNP	Mare M	3,26	2,37	2,27	4,64	0,64	0,97	0,42		1,20	3,22
31	15/6/2003	July	NKNP	Mare M	3,34	2,03	1,66	3,68	0,50	1,14	0,46			2,10
32	15/6/2003	July	NKNP	Mare M	6,51	1,23	1,27	2,49		0,50	0,36			0,86
33	15/6/2003	July	NKNP	Mare M	4,98	3,22	0,60	3,83	0,77	1,80	0,52	0,60		3,69

Table 6b - NKNP: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)

Sample No.	Date of collection	Month of collection	Site	PNNK locality	Grass	UnID	Herb	Bark	Caryopsis
1	2000	?	NKNP	?		0,17		0,32	0,47
2	24/5/2001	May	NKNP	LK		0,14		0,70	0,95
3	24/5/2001	May	NKNP	LK		0,12		0,33	0,58
4	5/6/2001	June	NKNP	LK		0,55		0,73	0,54
5	9/6/2001	June	NKNP	LK		0,13			0,34
6	20/6/2001	June	NKNP	LK		0,13			0,75
7	2002	?	NKNP	SS	4,70	0,18			0,74
10	12/5/2002	May	NKNP	PB-BxPO	1,05	0,26			0,44
11	14/11/2002	November	NKNP	LK	0,64	0,17			0,23
12	14/11/2002	November	NKNP	LK	0,42	0,18	0,25		
13	14/11/2002	November	NKNP	LK	1,65	0,14		0,50	0,33
14	14/11/2002	November	NKNP	LK	1,47				0,23
15	14/6/2003	July	NKNP	Mare T		0,16	0,67	0,50	0,30
17	14/6/2003	July	NKNP	KA x W		0,13			0,49
18	14/6/2003	July	NKNP	KA x W		0,11	0,30		0,53
19	14/6/2003	July	NKNP	KA x W		0,14			
20	14/6/2003	July	NKNP	KA x W		0,15			0,66
21	14/6/2003	July	NKNP	KA x W	0,70	0,58			
22	14/6/2003	July	NKNP	KA x W	0,73	0,41			
23	14/6/2003	July	NKNP	KA x W		0,15		1,25	
24	14/6/2003	July	NKNP	KA x W		0,24			
25	15/6/2003	July	NKNP	Mare M		0,15			
26	15/6/2003	July	NKNP	Mare M		0,14			
27	15/6/2003	July	NKNP	Mare M		0,17		1,40	
28	15/6/2003	July	NKNP	Mare M		0,20			
29	15/6/2003	July	NKNP	Mare M		0,20	0,70	0,90	0,90
30	15/6/2003	July	NKNP	Mare M		0,30		0,70	
31	15/6/2003	July	NKNP	Mare M		0,20			
32	15/6/2003	July	NKNP	Mare M	0,60	0,25		0,70	
33	15/6/2003	July	NKNP	Mare M		0,22		0,60	

KA x W = Assirik x Wouroli crossroads, LK = Lengue Kontou, Mare M = Mare Mansafara, Mare T = Mare Tourmadala, PB-BxPO = Piste Bassari – Badi x Patte d'Oie, SS = Secteur Soumaniko

Table 7a - Bandia: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)

(Table 7a continues on the next page as Table 7b displaying more food items in Samples No. 1-34, and Tables 7c a 7d for Samples No. 35-51)

Sample No.	Date of collection	Month of collection	Site	Wood	Leaf epidermis	Leaf nervature	Leaf total	Sclerenchym	Pod	Fleshy fruit	Fruit Top	Fruit Support	Fruit total
1	11/2004	November	Bandia	2,50	0,98	1,01	1,99	0,40	0,90	1,87			
2	11/2004	November	Bandia	3,15	0,92	0,80	1,72		1,50	1,19			
3	11/2004	November	Bandia	2,58	1,16	0,96	2,11	0,60	2,47	1,56		0,85	0,90
4	11/2004	November	Bandia	3,21	1,46	1,38	2,84	0,55	1,32	1,54	1,00	2,00	
5	11/2004	November	Bandia	2,91	0,84	1,01	1,86	0,23	1,01	1,20			
6	11/2004	November	Bandia	2,13	1,45	0,96	2,41	0,40	1,38	2,31	0,90		2,75
7	11/2004	November	Bandia	1,78	2,24	0,92	3,16	0,52		1,68	0,40		
10	11/2004	November	Bandia	2,31	1,45	1,74	3,19	0,30	2,40	1,45			1,50
11	11/2004	November	Bandia	2,59	0,61	0,58	1,18	1,03	0,91	1,02			
12	11/2004	November	Bandia	2,42	1,42	0,98	2,40		1,79	1,76			1,50
13	11/2004	November	Bandia	1,69	1,28	0,75	2,03	0,20	0,90	1,08	0,40	0,20	
14	11/2004	November	Bandia	1,80	1,37	0,67	2,04	0,42	1,18	1,21		1,00	
15	11/2004	November	Bandia	5,07	0,82	0,86	1,68	0,18	0,35	1,61			
17	11/2004	November	Bandia	2,94	0,76	0,90	1,66	0,30	0,52	1,53			
18	11/2004	November	Bandia	1,80	0,77	0,90	1,67	0,73	1,29	2,58	0,70		
19	11/2004	November	Bandia	2,58	0,53	0,88	1,41	0,25	2,25	1,58	0,35		
20	11/2004	November	Bandia	2,27	0,77	1,30	2,07	0,22	0,92	1,97	0,70	1,32	
21	11/2004	November	Bandia	2,35	0,58	1,04	1,62	0,51	1,26	4,24	0,73	0,90	
22	11/2004	November	Bandia	3,05	0,58	1,44	2,02	0,46	1,39	2,12		3,00	
23	11/2004	November	Bandia	2,48	0,73	1,03	1,76	0,49	1,08	2,16			
24	11/2004	November	Bandia	2,54	0,58	0,93	1,51	0,41	0,87	3,99	0,30	1,50	
25	11/2004	November	Bandia	2,85	0,65	1,48	2,13	0,53	1,11	2,18	0,40	0,70	
26	11/2004	November	Bandia	3,04	0,61	1,36	1,96	0,32	1,05	4,08			
27	11/2004	November	Bandia	2,15	0,81	1,59	2,40	0,33	1,04	2,87	0,25		
28	11/2004	November	Bandia	1,93	0,83	1,62	2,45	0,43	1,39	3,06			
29	11/2004	November	Bandia	2,34	0,60	1,28	1,88	0,20		4,07	0,80		
30	11/2004	November	Bandia	2,03	1,22	2,39	3,62	0,28	1,04	1,23	0,47		
31	11/2004	November	Bandia	2,86	0,95	2,73	3,68	0,48	0,85	1,61	0,26		
33	11/2004	November	Bandia	1,74	0,98	1,45	2,42	0,57	1,09	3,93	0,48		
34	11/2004	November	Bandia	3,35	0,96	1,44	2,40	0,37	0,80	2,14	0,72	0,80	

Table 7b - Bandia: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)

Sample No.	Date of collection	Month of collection	Site	Grass	UnID	Herb	Bark	Caryopsis
1	11/2004	November	Bandia		0,42			1,87
2	11/2004	November	Bandia		0,39	1,50	1,55	1,19
3	11/2004	November	Bandia		0,64	1,26	1,13	1,56
4	11/2004	November	Bandia		0,62	1,25	0,40	1,54
5	11/2004	November	Bandia		0,26	0,81		1,20
6	11/2004	November	Bandia		0,73	1,12	1,15	2,31
7	11/2004	November	Bandia		0,62	1,07	1,31	1,68
10	11/2004	November	Bandia		0,51	0,93	1,51	1,45
11	11/2004	November	Bandia	2,50	0,31	0,94	0,75	1,02
12	11/2004	November	Bandia		0,33		1,80	1,76
13	11/2004	November	Bandia		0,36	1,44	0,94	1,08
14	11/2004	November	Bandia	1,87	0,27	0,99	0,53	1,21
15	11/2004	November	Bandia		0,20	0,95	0,89	1,61
17	11/2004	November	Bandia		0,22	0,69	0,90	1,53
18	11/2004	November	Bandia		0,22	0,78	0,60	2,58
19	11/2004	November	Bandia	1,00	0,64	1,30	0,94	1,58
20	11/2004	November	Bandia		0,33	0,80	0,50	1,97
21	11/2004	November	Bandia		0,29	0,62	0,99	4,24
22	11/2004	November	Bandia		0,22	0,75	0,66	2,12
23	11/2004	November	Bandia		0,33	0,67	0,38	2,16
24	11/2004	November	Bandia	1,10	0,25	1,24	0,70	3,99
25	11/2004	November	Bandia		0,22	1,24	0,72	2,18
26	11/2004	November	Bandia		0,22	0,93	0,63	4,08
27	11/2004	November	Bandia		0,21	0,68	0,40	2,87
28	11/2004	November	Bandia		0,20	0,90		3,06
29	11/2004	November	Bandia		0,19	0,88	0,50	4,07
30	11/2004	November	Bandia		0,34	0,40		1,23
31	11/2004	November	Bandia	0,40	0,26	1,09	0,55	1,61
33	11/2004	November	Bandia		0,25	0,45		3,93
34	11/2004	November	Bandia		0,33	1,91		2,14

Table 7c - Bandia: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)
(this table is continuation of Tables 7a and 7b, but displaying results for Samples No. 35-51; the same applies to Table 7d)

Sample No.	Date of collection	Month of collection	Site	Wood	Leaf epidermis	Leaf nervature	Leaf total	Sclerenchym	Pod	Fleshy fruit	Fruit Top	Fruit Support	Fruit total
Sample No.	Date of collection	Month of collection	Bandia	4,35	0,91	1,20	2,11	0,68	2,67	0,67			4,01
35	11/2004	November	Bandia	2,15	1,13	1,88	3,01	0,38	0,72	0,88			1,98
36	11/2004	November	Bandia	2,03	0,51	1,81	2,32	0,44	2,11	0,25			2,80
37	11/2004	November	Bandia	2,03	0,72	1,79	2,51	0,84	0,80	0,56	1,75		3,95
38	11/2004	November	Bandia	2,10	0,79	1,83	2,62	0,86	1,05	0,52			2,43
39	11/2004	November	Bandia	2,55	0,72	1,46	2,19	0,83	0,86	0,20	1,40		3,29
40	11/2004	November	Bandia	2,50	0,67	1,51	2,18	0,30	1,14	0,43			1,87
41	16/5/2004	May	Bandia	2,19	0,58	1,82	2,39	1,05	1,13	0,50	0,48		3,16
42	10/4/2004	April	Bandia	3,57	0,68	1,60	2,28	0,71	1,07	0,36	0,66		2,80
43	10/4/2004	April	Bandia	2,78	0,40	1,74	2,13	0,86	1,08	0,32	0,82		3,08
44	10/4/2004	April	Bandia	2,70	0,43	1,63	2,06	1,03	1,13	0,24	0,47		2,88
45	10/4/2004	April	Bandia	1,88	0,35	2,78	3,13	1,28	1,33	0,36	0,60		3,57
46	10/4/2004	April	Bandia	1,60	0,37	0,95	1,31	1,19	1,07	0,28	0,54		3,08
47	10/4/2004	April	Bandia	1,06	0,45	1,98	2,44	1,16	1,43	0,20	0,47		3,25
48	16/5/2004	May	Bandia	1,45	0,49	2,31	2,80	1,04	0,85	0,51	0,50		2,91
49	16/5/2004	May	Bandia	1,56	0,31	1,45	1,76	1,59	0,91	0,20	0,58		3,28
50	16/5/2004	May	Bandia	1,28	0,32	1,00	1,32	1,92	0,88	0,20	0,39		3,38
51	16/5/2004	May	Bandia	4,35	0,91	1,20	2,11	0,68	2,67	0,67			4,01

Table 7d - Bandia: Representation of food items in the western Giant eland's diet - mean values for each sample expressed in % of volume (100% = 10)

Sample No.	Date of collection	Month of collection	Site	Grass	UnID	Herb	Bark	Caryopsis
35	11/2004	November	Bandia		0,19	0,36		2,64
36	11/2004	November	Bandia		0,23	0,43		2,73
37	11/2004	November	Bandia		0,20	0,73		4,99
38	11/2004	November	Bandia		0,16	0,47		2,24
39	11/2004	November	Bandia		0,27	0,55		2,45
40	11/2004	November	Bandia		0,24	0,81		2,80
41	16/5/2004	May	Bandia	1,10	0,19	0,97		3,24
42	10/4/2004	April	Bandia	1,20	0,18	0,30		1,09
43	10/4/2004	April	Bandia	0,50	0,19	0,40		1,19
44	10/4/2004	April	Bandia		0,19	0,30		1,84
45	10/4/2004	April	Bandia		0,22	0,30		1,73
46	10/4/2004	April	Bandia		0,17	0,65		1,14
47	10/4/2004	April	Bandia		0,15	0,33		1,33
48	16/5/2004	May	Bandia		0,18		1,15	0,52
49	16/5/2004	May	Bandia		0,18	0,80		0,99
50	16/5/2004	May	Bandia		0,16	0,30	0,40	1,64
51	16/5/2004	May	Bandia		0,15	0,40		1,12