Elephants as seed dispersal agents in Aberdare and Tsavo National Parks, Kenya

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Abstract

Various studies on elephants show that they perform several functions: they increase habitat mosaics in forests, diversify mammalian communities, promote biodiversity, play a vital role in maintaining links in food webs, and support many ecosystem functions and processes. This study aims to show the role of the elephant as an agent of seed dispersal. The results indicate that many plant species are dispersed by elephants and for some of these species elephants may be the obligate agents of dispersal. Removing elephants from their natural ranges or restricting their movements using electric fences may result in serious implications with far-reaching ecological impact on species diversity in the long term.

Résumé

Les différentes études réalisées sur les éléphants montrent qu'ils remplissent diverses fonctions : ils augmentent la mosaïque des habitats dans les forêts, diversifient les communautés de mammifères, accentuent la biodiversité, jouent un rôle majeur en maintenant des liens entre les réseaux alimentaires et supportent de nombreux processus et fonctions de l'écosystème. Cette étude tend à montrer quel est le rôle de l'éléphant comme agent de dispersion des semences. Les résultats montrent que de nombreuses espèces végétales sont dispersées par les éléphants ; pour certaines de ces espèces, les éléphants sont même des agents de dispersion incontournables. Le fait d'enlever les éléphants de leurs aires de répartition naturelles ou de limiter leurs déplacements par l'usage de clôtures électriques pourrait avoir de graves implications dont l'impact écologique à long terme se répercuterait sérieusement sur la biodiversité.

Introduction

Poaching of elephants in Kenya reduced the elephant population from 167,000 to about 20,000 between 1969 and 1989 (Cumming et al. 1990; KWS 1991). The onslaught resulted in numerous elephants withdrawing from many of their traditional ranges. In many districts, all elephants outside protected areas were exterminated (KWS 1991).

The absence of elephants from their natural ecosystems is likely to have far-reaching ecological consequences considering that they play a vital role in maintaining links in food webs and in supporting many ecosystem functions and processes. Various studies have shown that elephants increase habitat mosaics in forests (Kortland 1984), diversify mammalian communities (Western 1986) and promote biodiversity in general (Western 1989; Waithaka unpubl.; Mwathe 1997).

This study investigated the role of elephants in seed dispersal in the high-rainfall forests of the Aberdare Mountains and the semi-arid savanna grasslands of Tsavo National Park.

The study areas

Aberdares National Park has a population of over 4000 elephants and Tsavo has more than 8000. These parks are increasingly being isolated by the erection of electric fences and other barriers that are effectively keeping elephants away from dispersal areas where they have been the chief ecological architects.

Aberdares National Park

Aberdares National Park is located in central Kenya, between latitudes 0° 08' S and 0° 42' S and longitudes 31° 31' E and 36° 55' E. The park is mountainous, with peaks rising up to nearly 4000 m. The centre of the park consists of high-altitude moorlands with deep gorges and magnificent waterfalls. Below the moorlands lie dense bamboo and montane forests. The park constitutes more than 10% of Kenya's forests (Doute et al. 1981) and holds a unique variety of wildlife and submontane to alpine vegetation (Schmidt unpubl.).

The boundaries of the 765.7-km^2 Aberdares National Park follow approximately the 3048 m contour line. However, a fingerlike projection called the Salient (67 km^2) stretches down to 1920 m. Rainfall ranges from 1000 to 2200 mm per year, with the amount increasing with altitude.

Tsavo

The Tsavo ecosystem is located in south-eastern Kenya between 2° and 4° S and 37° 30' and 39° 30' E. It comprises approximately 40,000 km^2 of arid bushland at an altitude of 200 to 1000 m. About 21,000 km^2 of the ecosystem are contained in the Tsavo National Parks. The landscape consists of flat plains, lying on various kinds of parent rock material. The climate is typically semi-arid with average annual rainfall of 200 to 700 mm, falling in two short seasons.

The semi-arid climate is reflected in the vegetation structure, which shows an open, woody canopy with varying degrees of cover. It consists mainly of deciduous species. The ground layer is composed mainly of some short and medium-tall perennial grasses and several annual grasses and herbs (Wijngaarden 1985).

Methods

One hundred fresh dung piles from each Aberdares and Tsavo National Parks were collected in 1991 during the long rainy season (between April and July).

The samples from Aberdares were collected from the forests, glades and bushlands in the Salient while the Tsavo samples were collected from Ndara and Irima areas. The samples were transported to a greenhouse at Kenyatta University where the environmental conditions that favour seed germination were simulated. The seeds in the dung germinated and the seedlings were monitored for about 90 days. The species were identified and categorized into herbs, shrubs or trees with assistance from the University of Nairobi Herbarium. Seedlings for each species from the dung collected from Aberdares National Park were counted.

Results

Tsavo

Eighteen plant species belonging to 12 families germinated from the samples obtained from Tsavo National Park (table 1). Three species were from the family Gramineae and two each from the families Acanthaceae, Amaranthaceae, Compositae and Cucurbitaceae. Out of the 18 species, 2 were shrubs and 1 a tree; the other 15 were herbs.

Aberdares

The species that emerged from the Aberdares samples were twice as many as those found in the dung

Table 1. Species from Tsavo that germinated from seeds in elephant dung

Species name	Family	Growth form
Acanthospermum hispidum	Compositae	herb
Amaranthus graecizana	Amaranthaceae	herb
Amaranthus hibridus	Amaranthaceae	herb
Barleria sp.	Acanthaceae	herb
Bidens pilosa	Compositae	herb
Boerhavia erecta	Nyctaginaceae	herb
Chloris roxburghiana	Gramineae	herb
Commiphora schimperi	Burseraceae	tree
Cucumis aculeatus	Cucurbitaceae	herb
Cucumis sp.	Cucurbitaceae	herb
Digitaria sp.	Gramineae	herb
Eragrostis ciliata	Gramineae	herb
Euphorbia inaequilatera	Euphorbaceae	shrub
Grewia virosa	Tiliaceae	shrub
Ipomoea spaltulata	Convolvulaceae	herb
Talinum sp.	Portulacaceae	herb
Tephrosia hildebrandtii	Papilionaceae	herb
Thunbergia guarkeana	Acanthaceae	herb

samples from Tsavo. They represented 19 families: seven Gramineae species, four Compositae and three each of Acanthaceae, Solanaceae and Urticaceae. The other families each had one or two species. Out of the 36 species, 27 were herbs, 6 were trees and 3 were shrubs (table 2). A total of 422 seedlings germinated from 100 dung piles from the Aberdares, with an average of about 4 species per dung pile.

It is notable that three families, Gramineae, Compositae and Acanthaceae, contributed the greater proportion of species dispersed by elephants in both areas (58% in Tsavo and 74% in Aberdares). Graminoids of the genera *Chrolis, Digitaria* and *Eragrostis* were the only grasses found in the dung samples in Tsavo. All three were also found in the Aberdares samples.

The results show that more plant species were dispersed by elephants in the Aberdares than in Tsavo. This may be explained by the difference in the overall species diversity between the two ecologically distinct areas (Waithaka 1994). Only one tree species was identified from Tsavo samples while the Aberdares samples had six tree species. *Ficus thonningii*, for which the elephant is an obligate seed dispersal agent (Brahmachary 1995), had the highest number of tree seedlings in the Aberdares samples.

Table 2. Plant species from Aberdares that germinated from seeds in elephant dung

Species name	Family	Growth form	Seedlings (no.)
Achyranthes aspera	Amaranthaceae	herb	11
Allophylus abyssinicus	Sapindaceae	tree	1
Barleria ventricosa	Acanthaceae	herb	7
Bidens pilosa	Compositae	herb	2
Cassipourea malosana	Rhizophoraceae	tree	1
Cerastium afromontanum	Caryophyllanceae	herb	6
Chloris virgata	Gramineae	herb	3
Convolvulus kilimandschari	Convolvulaceae	herb	3
Cynodon dactylon	Gramineae	herb	12
Cyperus rigidifolius	Gramineae	herb	4
Cyperus sp.	Cyperaceae	herb	1
Digitaria velutina	Gramineae	herb	9
Diospyros abyssinica	Ebenaceae	tree	2
Dovyalis abyssinica	Flacourtaceae	tree	1
Droguetia debilis	Urticaceae	herb	4
Eleusine jaegeri	Gramineae	herb	12
Eragrostis tenuifolia	Gramineae	herb	8
Ficus thonningii	Moraceae	tree	15
Galium spurium	Rubiaceae	herb	1
Hibiscus vitifolius	Malvaceae	shrub	1
Hypoestes verticillaris	Acanthaceae	herb	12
Justicia striata	Acanthaceae	herb	10
Lagunaria cylindrica	Cucurbitaceae	herb	8
Laportea alatipes	Urticaceae	herb	3
Microglossa pyrifolia	Compositae	herb	6
Oxalis corniculata	Oxilidaceae	herb	24
Pennisetum clandestenum	Gramineae	herb	4
Schefflera sp.	Araliaceae	tree	4
Senecio hadiensis	Compositae	herb	1
Sida cuneifolia	Malvaceae	herb	1
Solanum aceleastrum	Solanaceae	shrub	21
Solanum nigrum	Solanaceae	herb	5
Solanum schumannianum	Solanaceae	shrub	14
Stipa dregeana	Gramineae	herb	3
Tagetes minuta	Compositae	herb	2
Urtica massaica	Urticaceae	herb	200

Discussion

Although we attempted to collect samples from the existing habitats, the location of dung piles was unlikely to bias the results because elephants are known to forage widely within the study areas. Furthermore, considering that food in elephant gut is retained for an average of 33 hours (Spinage 1994), the habitat from which the dung was collected was not necessarily the source of the foliage.

This study shows that elephants are important agents of seed dispersal for many plant species. Although the study did not go into experimental detail to show whether elephants are obligate dispersal agents for particular species, the results highlight the importance of elephants in seed dispersal, in both high- and low-rainfall areas.

The potential for the elephants to disperse seeds in the Aberdares is high. A hundred dung piles produced 422 seedlings, an indication that the number of seeds dispersed in this manner was quite large, considering that there are over 4000 elephants in the area (MGM Environmental Solutions 1999) and each defecates roughly 17 times a day (Barnes and Jenzen 1987). By extrapolation, elephants in the Aberdares have the potential of 'planting' 272,000 viable seeds daily in the park. Such dispersal at a much lower scale is true for Tsavo and may be the case for other intermediate rainfall areas.

Judging from this study, the loss of elephants in many parts of Kenya (KWS 1991) can be expected to have far-reaching consequences. The results indicate that many plant species that are dispersed by elephants—and for some of these species elephants may be the obligate agents of dispersal—are likely to be affected if elephants are exterminated or excluded from their habitats. This implies that, among other factors, the absence of elephants may create a species-poor community, negatively affecting species associations and other ecological processes.

The role of the elephant as an agent of seed dispersal has been discussed by a few authors. Alexandre (1978) found 21 out of 71 species he sampled in Tai Forest, Ivory Coast, were adapted to dispersal by elephants. Elephants have also been identified as important dispersal agents of *Balanites wilsoniana*. When they are absent, fruits that are generally toxic to other animal species rot and fail to germinate (Waring and Schlesinger (1985). Similarly, Jansen (1979) observed that *Simaba cedron* trees growing in tropical forests of Central America share fruit characteristics with *Balanites* and concluded that the present restricted distribution of *Simaba* was related to the extinction of the mastodons in the last 10,000 years.

Jansen and Martin (1982) suggested that megafaunal extinction in the Pleistocene resulted in loss of dispersal agents for a number of tree species in the central African dry forests, resulting in habitat impoverishment. Jansen (1981) made a similar case for the drier rangelands of Central America, where plants resilient to browsing by smaller ungulates have proliferated since the extinction of the megafauna. Owen-Smith (1987) advanced a key hypothesis to account for the cascade of extinctions among the smaller mammals during the Pleistocene, which saw the disappearance of 50% of the mammalian species. He suggested that the extermination of the megamammals had a domino effect as the vegetation closed up and eliminated the habitat for small mammals. He cited Hluhluwe Game Reserve in South Africa as a modern analogue where, since the elimination of the elephants a century ago, the local extinction of three grazers and a sharp reduction of several others to vulnerable levels coincided with the invasion of woody vegetation.

Seen in a larger context, the implication of losing elephants from their natural ranges may have far-reaching ecological impact in the long term. Removing elephants from areas where their interactions with ecosystem components have evolved over thousands of years may be extremely catastrophic. To avoid such eventualities, elephants should be recognized as a biological species that plays a key role in ecosystem functions, and every effort should be made to allow them to move freely. In many parts of Kenya where their survival is threatened by incompatible land-use practices, possibilities of initiating conservation programmes that promote coexistence between people and elephants should be explored. This would be more appropriate than the current widespread effort to restrict elephant movements using electric fences.

This paper does not explore several issues. For example, the rate of seed germination between field and experimental conditions could be different. Probably some of the seeds that germinated under experimental conditions would not have done so in the wild. Similarly, it would have been interesting to compare germination rates between the seeds of the same species that had gone through the digestive system with those that had not. However, plans are under way to undertake these studies.

References

Alexandre, D.Y. (1978) Le rôle disseminateur des éléphants en forêt de Tai, Cote d'Ivoire. *La Terre et la vie* 32, 47-72.

Barnes, R.F.W., and Jenzen, K.L. (1987) How to count elephants in forest. *AERSG Technical Bulletin* 1, 1–5.

Brahmachary, R.L. (1995) Seed dispersal through the elephant. In: Daniel, J.C., and Datye, H., eds., *A week with elephants: proceedings of the International Seminar on Asian Elephants.* Bombay Natural History Society, Bombay. p. 389–393.

Cumming, D.H.M, Du Toit, R.F., and Stuart, S.N. (1990) *African elephant and rhinos: status survey and action plan.* IUCN/SSC AE&RSG, Gland, Switzerland.

Doute, R., Ochanda, N., and Epp, H. (1981) Forest cover mapping in Kenya using remote sensing techniques. Kenya Rangeland Ecological Monitoring Unit, Nairobi.

Jansen, H.D. (1979) New horizons in the biology of plant defences. In: Rosenthal, G.A., and Jansen H.D., eds., *Herbivores: their interaction with secondary plant me-*

tabolite. Academic Press, New York. p. 331–348.

Jansen, H.D. (1981) Patterns of herbivores in a tropical deciduous forest. *Biotropical* 13, 271–282.

Jansen, H.D., and Martin, P.S. (1982) Neotropical anachronisms: the fruits the Gomphotheres ate. *Science* 215,19–27.

[KWS] Kenya Wildlife Service (1991) *Elephant conservation plan, 1991*. KWS, Nairobi.

Kortland, A. (1984) Vegetation research and the 'bulldozer' herbivores of tropical Africa. In: Chadwick, A.C., and Sutton, C.L., eds., *Tropical rainforest.* Special Publication of the Leeds Philosophical and Literary Society, Leeds, England. p. 205–226.

MGM Environmental Solutions Consultants (1999). Evaluation of the Elephant Conservation and Community Wildlife Programme. Final report.

Mwathe, K. (1997). Elephant-habitat studies in Shimba Hills National Reserve. KWS-WWF Report.

Owen-Smith, N. (1987) Pleistocene extinctions: the pivotal role of herbivores. *Paleobiology* 13, 351.

Schmidt, K. (unpubl.) The vegetation of Aberdares National Park, Kenya. Ph.D. thesis, 199, Universitstsverlag, Innsbruck.

Spinage, C. (1994) *Elephants.* T. and A.D. Poyser Natural History, London.

Waithaka, John (unpubl.) The ecological role of elephants in restructuring wildlife habitats and their impact on land use patterns. Ph.D. thesis, 1994, Kenyatta University, Nairobi.

Waring, R., and Schlesinger, W.H. (1985). *Forest ecosystems: concepts and management.* Academic Press, New York.

Western, D. (1986) An African odyssey to save the elephant. *Discover,* October, 56–70.

Western, D. (1989) The ecological role of elephants in Africa. *Pachyderm* 12, 42–45.

Winjgaarden, Willen van (1985) *Elephants–trees–grass–grazers*. ITC Publication, No. 4. International Institute for Aerospace Survey and Earth Sciences, Wageningen, Netherlands.