The relic population of forest elephants near Lake Tumba, Democratic Republic of Congo: abundance, dung lifespan, food items and movements

*Bila-Isia Inogwabini[1, 2 *], Longwango Mbende[2] and Abokome Mbenzo[2]*

[1] Durrell Institute for Conservation and Ecology

[2] World Wide Fund for Nature, DRC Programme

[*] Corresponding author: email: bi4@kent.ac.uk

Abstract

A survey of forest elephant was conducted in the southern Lake Tumba region, using both transect and forest reconnaissance methods. Three focal areas of elephants were discovered in the region stretching from Ngombe down to the region of Malebo. Due to insufficient data, only relative abundances were calculated and varied among these three different locations: 0.03 dung-piles/km (Ngombe–Lake Tumba), 0.04 dung-piles/km (Mbanzi–Malebo) and 0.33 dung-piles/km (Lukolela). Elephant trails in the Malebo–Mbanzi area were traversed 0.52 passages/day, within the range [0.50–3.0], indicating a permanent presence of elephants in the zone. Dung-piles in the dry and rainy seasons yielded an overall mean dung lifespan of μ = 109 days within the range [42–182] and seasonal mean lifespan μ = 127.6 days within [70–182] and μ = 87.33 days within [42–126] respectively. Dung-pile heights decreased following the equations y = -4.8818lnx + 16.278 and $y = 26.025e^{-0.3734+x}$ respectively. Seed counts on elephant dung-piles indicated that *Dysplasia dewevrei*, *Klainedoxa gabonensis*, *Treculia africana* and *Anonidium mannii* constituted ca 70% of seeds found in elephant dung-piles. Elephant movements were suspected by the layout of trails but their confirmation would need a more detailed study.

Key words: forest elephant, Lake Tumba, food items, elephant movements

Résumé

Une étude de l'éléphant de forêt a été menée dans la région sud du Lac Tumba, en utilisant les deux méthodes de transect et de reconnaissance de forêt. On a découvert trois domaines de concentration d'éléphants dans la région s'étendant de Ngombe vers la région de Malebo. En raison des données insuffisantes, on a calculé seulement les abondances relatives et elles variaient entre ces trois endroits différents: 0,03 tas de crottes/km (Ngombe-Lac Tumba), 0,04 tas de crottes/km (Mbanzi-Malebo) et 0,33 tas de crottes/km (Lukolela). Les pistes d'éléphants dans la zone de Malebo-Mbanzi ont été parcourues avec 0,52 passages/jour, dans l'intervalle [0,50 à 3,0], indiquant une présence permanente des éléphants dans la zone. Les tas de crottes pendant les saisons sèches et pluvieuses ont donné une durée de vie moyenne globale de crotte µ = 109 jours dans l'intervalle [42-182] et une durée de vie moyenne saisonnière µ = 127,6 jours dans l'intervalle [70-182] et µ = 87,33 jours dans l'intervalle [42 - 126] respectivement. Les hauteurs des tas de crottes ont diminué d'après les équations y =-4.8818lnx + 16.278 et $y = 26.025e^{-0.3734 + x}$ respectivement. Le nombre de graines sur les tas de crottes d'éléphants indiquaient que le *Dysplatsia dewevrei*, le *Klainodoxa gabonensis*, le *Treculia Africana* et le *Manii Annonaduim* constituaient environ 70% de celles trouvées dans les tas de crottes d'éléphants. On a eu le sentiment que la disposition des pistes correspondait aux déplacements des éléphants, mais il faudra une étude plus détaillée pour la confirmation.

Introduction

Between the 1970s and late 1980s, elephant poaching—supported by the ivory trade—dating back to historical times (Pekenham, 1992), increased and swept Central African forests to fuel the ivory market (Blake et al., 2007). This trade took heavy tolls on elephant populations across the species range and led to some local extinctions. In addition to poaching, habitat fragmentation led to conflict and persecution, complicating any action plan for the species conservation (Blake, 2002; Douglas-Hamilton, 1989; Douglas-Hamilton, 1988a; Douglas-Hamilton & Douglas-Hamilton, 1982). Direct consequences of the ivory trade and habitat fragmentation were felt not only in areas with herds of elephants but also and more severely in areas adjacent to and near major towns. In these areas, elephant numbers dramatically declined as poaching within the vicinity of major towns was facilitated by communication networks—principally roads—that made large markets accessible for both elephant meat and ivory. However, while poaching and local extinctions increased, the basics of the ecology of forest of elephant was not well understood; knowledge was lacking about simple yet important information for management such as abundance and distribution. Even today, elephant abundance and distribution are still either poorly or partially known within the range States (Blake & Hedges, 2004). Equally, very few concrete measures to curb declining trends in elephant populations were taken in many countries across Central Africa to the point that even now, the conservation status of forest elephants, as opposed to the situation with savannah elephants (Bossen, 1998) remains less documented and the species' taxonomic status in Africa continues to be less clarified (Vogel, 2001; Roca et al., 2001). Available knowledge is scanty and variabile in accuracy (Blake & Hedges, 2004). Historically, the Democratic Republic of Congo (DRC) counted as one stronghold of forest elephants in Central Africa (Alers et al., 1992). However, most of what is known about DRC's elephant populations is, at best, informed guesses (Alers et al., 1992). Within a few exceptional areas of the country where elephants occur in large numbers (e.g. Garamba and Salonga), the lawlessness severely affects elephants and their habitats; otherwise, little nationwide knowledge of the species exists. There is still a need to document the species distribution, its abundance and to understand its ecology in many DRC forests. This paper presents a relic population of forest elephants that resides in the region of Malebo where elephants were thought to be extinct. It focuses on elephant abundance and distribution whilst also providing findings on dung lifespan (defined as the time it takes a dung-pile to disappear) and preliminary plant species consumed by elephants in the zone.

Study site

The Malebo region (Fig. 1) is in the Lake Tumba–Lake Maindombe hinterland (Inogwabini et al., 2007a, b), straddling the provinces of Bandundu and Equateur in their administrative territories of Bolobo, Yumbi and Lukolela. This area covers ~ 40,000 km^2, of which three blocks of ~ 12,000 km^2 (representing 30%) of the total were surveyed. At its southern edge, the region is located on the Bateke Plateau and descends toward the Congo Central Basin, known as the Cuvette Centrale (Inogwabini et al., 2006). Malebo is located in an ecosystem that divides the northern swampy forests and the southern savannahs. Swampy forests, which cover most of the territory of Lukolela, are essentially composed of mixed mature forest with open understorey whose main emergent trees are *Uapaca guineensis*, *Uapaca heuloditii* and *Guibourtia demeusei* etc. (Inogwabini et al., 2006). The region is also characterized by episodes of flooding, during which water covers approximately 65% of the forest. Some portions of this region are within the newly created Tumba–Lediima Natural Reserve. In the complex of forest-savannah mosaic, forest galleries are composed of terra firma mixed mature forest, with species such as *Gilbertiodendron dewevrei* and *Entandrophragma* spp. etc. The understorey is comprised of 45–50% of the Marantaceae family and species such as *Humania liebrechtsiana* and *Megaphrynium macrostachyum*. Some of these areas were logged in the last 25–30 years to extract the wenge (*Millettia laurentii*), a high-priced black hardwood. The savannahs of the region are woody, dominated by *Hymenocardia acida* and *Annona senegalensis*. The southern limit of the study's region is about 45 km from the southern edge of the Tumba–Lediima Natural Reserve.

Demographically, at the edges of the Lake Tumba, north of the region, people are essentially agriculturalists. They are also known to practice intensive fishing during the dry seasons, which is deeply rooted in their culture. Not only is traditional

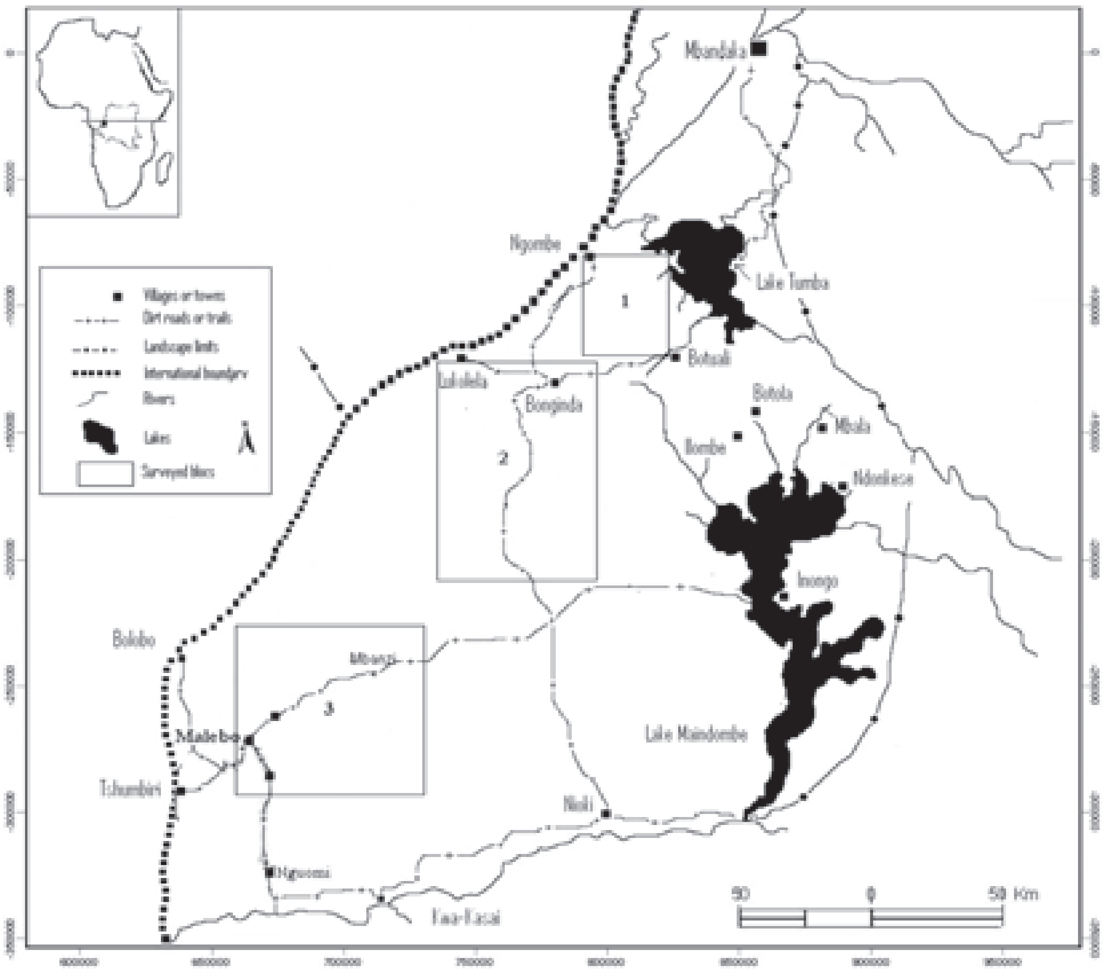

Figure 1. Elephant survey region in the southern Lake Tumba landscape, Democratic Republic of Congo.

hunting commonly practiced throughout the year, but also the intrusion of modern weapons and ammunition has become a prevalent characteristic of the entire region. In the south, traditional agriculture and pastoral activities include raising cattle, which was introduced in this region by the Belgians in the 1950s. It became the only employment possibility and has entrenched itself deeply in the local culture to the point that the practice has now dispersed across the region and symbolizes wealth. This paper provides results of the surveys that were conducted in each of the three blocks in Fig. 1, which are part of the overall ecosystem, and social and cultural scenes described above.

Materials and methods

Research methods varied according to the sub-objectives of the study. Distribution and abundance data were collected using the conventional reconnaissance and transects with variable lengths (Buckland et al., 1993; Hall et al., 1997) methods. Reconnaissance consisted of comprehensive (Walsh et al., 2001; Blake, 2002) and forest exploration (White & Edwards, 2002, Van Krunkelsven et al., 2000; Hall et al., 1997). Comprehensive reconnaissance and forest exploration differ in that comprehensive reconnaissance restricts observers to follow a compass direction with deviation $\geq 45^{o}$ from the main orientation (White & Edwards,

Table 1. Relative abundance of elephants in the southern Lake Tumba

Zone	Effort			N			τ		
Methods	1	2	3	1	2	3	1	2	3
Ngombe–Lake Tumba	46	124	-	2	5	-	0.04	0.02	-
Mbanzi-Malebo	-	148	179	-	6	96	0.04	-	0.5
Lukolela	-	107			35			0.33	

1 = Transect, effort expressed in km and τ expressed in dung-piles km^{-1}
2 = Reconnaissance, effort express in km and τ expressed in dung-piles km^{-1}
3 = Trails, effort expressed in days and τ expressed in passage day^{-1}

2000; White et al., 2001). Direct sighting and/or indirect signs of elephants were recorded. Indirect signs consisted of dung-piles, footprints, evidence of rubbings and feeding remains. Recorded information consisted of geo-referenced position of any sign of an elephant, recorded using the hand-held Garmin GPS units (Waters & Shockley, 2000). These positions were mapped *post hoc* to provide the distribution of elephants. Field survey data on elephant distribution were complemented by information gathered from local hunters hired to serve as trackers. Perpendicular distances from each dung-pile to each transect were measured with a tape measure but the sample was too small to estimate elephant density. However, the total number of dung-piles was divided by the effort measured as distance (km) to provide encounter rates τ, as it was the case of data collected from reconnaissance.

In the southern part of the study area, elephant trails were screened on a weekly basis for the dung lifespan study. Over a period of 179 days, new elephant dung-piles and/or other signs were counted and the rates/frequency of usage of permanent trails were calculated to provide an indication of the permanency of elephants in the zone. The permanency was thought to be a good surrogate for both relative abundance and reduced poaching.

Elephant trails in the Malebo region (Fig. 1) were located and used for the dung lifespan study and the identification plant species eaten by elephants in the region. Fresh dung-piles ($\pm$1 day old) on terra firma were identified and screened through their complete disappearance. At the first sighting, the heights of each dung-pile were measured using a 1 mm-error tape measure. Then the team visited the dung-piles on a weekly basis and measured subsequent heights. Apart from heights, data also included habitat types, dung exposure to the sun, and rainfall data that were collected from the field base situated approximately at a 15 km straight line distance south of the trail. The mean dung lifespan (μ) was calculated as the number of days it took all the dung samples to completely disappear. Then individual measures of dung heights were plotted and fitted to an exponential model $f(x)$, where x = a function of time. Dung heights were also plotted against the rainfall in the region in order to see whether patterns of rainfall influenced the decay rate, as suggested by Barnes et al. (1997).

Plant species that elephants consumed were identified through three methods: direct observations of feeding elephants, feeding remains and examination of dung-piles. Species that were readily identified in the field were noted while, when unsure, plant items were brought to the field base for proper identification by the field team botanists.

Results

Elephants were present in the three surveyed blocks (Fig. 1). However, relative abundance varied among the three locations (Table 1). The highest τ = 0.33 dung-piles/km was that of Lukolela (= 2 in Fig. 1). Although, the mean trail usage in the Mbanzi–Malebo (= 3 in Fig. 1) was τ = 0.52 passage/day (Table 1), there was variation among seven monitored permanent elephant trails (Fig. 2).

The overall mean dung lifespan μ = 109 days, within the range of 42–182 days, with variations between dry and rainy seasons (Table 2 and Fig. 4). Over their lifespan, elephant dung-pile heights decreased following the equations $y = -4.8818 \ln x + 16.278$ and $y = 26.025e^{-0.3734x}$ for dry and rainy seasons respectively (Fig. 4).

Elephants principally consumed nine plant species (Fig. 3), with *Dysplasia dewevrei* being the most commonly counted species in dung-piles followed in decreasing order by *Klainedoxa gabonensis*, *Treculia africana and Anonidium mannii*. The four constitute ca 70% of seeds found in elephant dung-piles in the region.

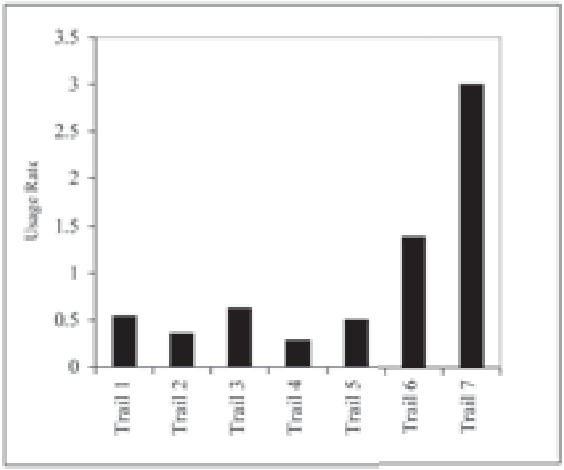

Figure 2. Elephant trail usage in the Malebo region.

Discussion

The highest relative abundance in the Lake Tumba area (τ = 0.33 dung-piles/km at Lukolela) was of comparable magnitude to the encounter of 0.39 dung-piles/km from the Salonga, several km east of the study site. However, that rate remains lower compared to other sites where elephants were surveyed in Central Africa. For example, τ = 0.33 dung-piles/km < 5.7 dung-piles/km encountered in the Nouabale-Ndoki, Republic of Congo (Blake, 2005), < 9.9 dung-piles/km in the Zanga National Park, Central African Republic and < 19.1 dung-piles/km in Minkebe, Gabon. However, lower encounter rates should be interpreted against the background of ecological parameters determining the distribution of elephants in Central Africa. Such ecological determinants include distance from major settlements and roads (Blake et al., 2008; Barnes et al., 1991). The human–route paradigm of the southern Lake Tumba region is of particular interest because all three locations (Ngombe–Lake Tumba, Lukolela and Mbanzi–Malebo) are close to the Congo River, a main route for commerce. Apart from being crossed by a major human route, Tumba is located near Kinshasa, a town of about 9,000,000 people whose pressure on natural resources is felt even at long distances far away. With these realities, it would be expected to see elephants locally extinct. The presence of elephants in this zone may only be understood by the fact that Ngombe–Lake Tumba and Lukolela are swampy zones, which may have naturally buffered intensive poaching.

The mean dung lifespan, calculated for the southern (i.e. 109 days) Lake Tumba is closer to the mean elephant dung lifespan time of 90 days used for sites across Central Africa (Blake et al., 2007) but significantly differs with 148.6 days reported from in Virunga (Inogwabini et al., 2000; Plumptre, unpublished data) and the 43.1 days calculated for the Ituri forest (Hall et al., 1996). The mean lifespan for dry season (127.6 days) was similar to 123.18 days reported from Banyang–Mbo, Cameroon (Nchanji & Plumptre, 2001). High variations observed between lifespans in rainy and dry seasons reported from this study were also similar to those recorded from the Banyang–Mbo area (Nchanji & Plumptre, 2001).
Dung lifespan is a function of multiple factors such as food content, season (rainfall), humidity, exposure to the sun and the actions of insects and other animals upon the dung-piles (Barnes et al., 2006; Nchanji & Plumptre, 2001; White, 1995; Barnes et al., 1997; Barnes & Barnes, 1992). These factors are site-specific (MIKE, 2003), although some of them might remain constant over large areas and different ecosystems within a given landscape. It was no surprise that with seasonal variation dung height decrease (Fig. 4) because this pattern is a norm in most forests in Central Africa, with data sets published from different areas such as Banyang–Mbo and Virunga having shown the same patterns. These variations, however, differ from one region to another, depending on the rainfall regime. Variations in dung lifespan time noticed in this study were closer to mountainous regions (Virunga and Banyang–Mbo). The Malebo region where this study was conducted is located at the Bateke Plateau near the great slope toward the

Table 2. Elephant dung lifespan in the southern Lake Tumba

Season	N	Days	μ (range) days
Dry season	31	182	127.6 (70 – 182)
Rainy season	22	175	87.33 (42 – 126)
Overall	53	357	109 (42 – 182)

flat region of the Central Congo Basin, known as the cuvette centrale. Weather patterns in this higher elevation zone are different from those of the lowland forest and are closer to those in highlands. Furthermore, the region is a forest–savannah mosaic, with most dung-piles recorded being exposed to the sun. Sun-baking has been documented to lengthen how long a dung-pile can survive in other sites, including Banyang–Mbo (Nchanji & Plumptre, 2001), Virunga (Plumptre, unpublished data) and Lopé (White, 1995). Dung height decrease equations presented for both dry and rainy seasons are similar to those published by Barnes et al. (2007) on dung decay rates. They indicate that a decrease in dung heights is related to dung decay and that rainfall, as in other areas, was among the key determinants of dung lifespan.

A comparison of food items between the Malebo region (Fig. 3) and Odzala-Kokoua (Republic of Congo), an area with an analogous environment of savannah forest mosaic suggest similar types of diet, with species such as *Anonidium mannii* and *Klainedoxa gabonensis* being also among the most consumed fruit plants (Maisels, 1996; Dowsett-Lemaire 1995a, b). *Desplasia dewevri* is a big fruit and cannot easily be swallowed by small mammals; the species may, therefore depend on elephants for its dispersal. *Anonidium mannii* has fruits preferred by many large mammals—including humans, elephants and great apes. *Anonidium mannii* has been

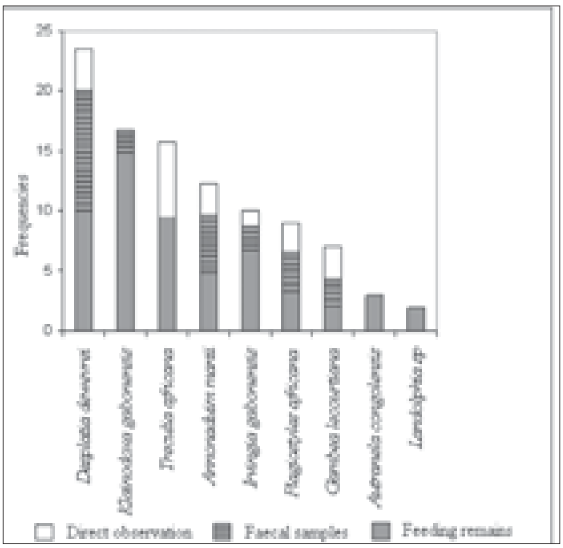

Figure 3. The most common plant species consumed by elephants as numbered from dung-piles in the Lake Tumba area of this study.

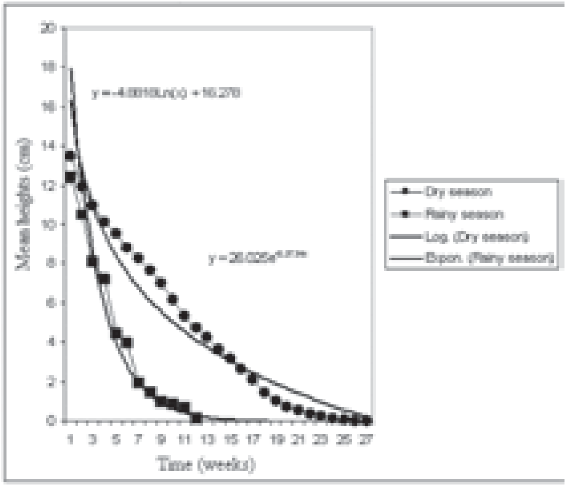

Figure 4. Dung lifespan and dung height decrease equations (rainy and dry seasons), Malebo region.

suggested to be a key fruit species because it has been documented to occur more frequently in elephant dung in previous studies (Blake, 2002). However, the tree of the *Annodium manii* is always left standing near fields when people clear forests for agriculture because humans also prefer the species' fruits. These two facts may lead to exacerbated human–elephant conflict. Several incidents of elephants crop-raiding in fields near villages have occurred over the last few years. Among these incidents, about 50% (n=21) were near Mbanzi (Fig. 1, Inogwabini & Mbende, in prep.) a village where *Anonidium mannii* trees are conspicuously left near fields and human houses. The presence of the *Anonidium mannii* may explain these incidents, although a more systematic and thorough study is needed to draw sound inferences. Human-elephant conflict has been explained as fighting over resources, including fruits, in several other areas across the species range (Hoare, 2000, 1999; Lahm, 1996; Kangwana, 1995)

The systematic monitoring of elephant trails has provided indications of the presence of elephants and a mean for a simplified monitoring tool. Over time, we have been counting the accumulated presence and absence of dung-piles on various trails in order to monitor the elephant's relative abundance in the region. Trail frequentation as a monitoring scheme has been used in the Nouabale–Ndoki area (Blake, pers. comm.), with relatively viable results. It is suggested here that relative permanent frequentation of trails by elephants may provide a sensible and inexpensive method for the monitoring of the elephant populations.

Furthermore, all trails in the Mbanzi–Malebo area (Fig. 1) lead to the north. We hypothesize that that direction may indicate a long ranging movement among the three blocks (Fig. 1) though this would require a firm confirmation from proper studies supported by such techniques as GPS Telemetry.

Acknowledgements

This work has been partially funded by USAID's programme, The Central Africa Regional Program for the Environment. However views expressed by the authors do not reflect those of USAID. We are most thankful to WWF US for permission to use the data, and WWF DRC for helping with the necessary official documents to carry out field research in Lake Tumba landscape.

References

Alers, M.P., Blom, A., Sikubwabo, K.C., Masunda, T. and Barnes, R.F.W. (1992). 'Preliminary assessment of the status of the forest elephants in Zaire'. *African Journal of Ecology* 30:279–291.

Barnes, R.F.W., Majam, J.N., Asamoah-Boatang, B. and Agyei-Ohemeng, J. (2006). 'The survival of elephant dung piles in relation to forest canopy and slope in southern Ghana'. *Pachyderm* 41:37–43.

Barnes, R.F.W., Asamoah-Boateng, B., Naada-Majam, J. and Agyeio-Hemng, J. (1997). 'Rainfall and population dynamics of elephant dung-piles in the forests of southern Ghana'. *African Journal of Ecology* 35:39–52.

Barnes, R.F.W. and Barnes, K.L. (1992). 'Estimating decay rates of elephant dung-piles in forest'. *African Journal of Ecology* 30:316–321.

Barnes, R.F.W., Barnes K.L., Alers M.P.T. and Blom, A. (1991). 'Man determines the distribution of elephants in the rain forests of northern Gabon'. *African Journal of Ecology* 29:54–63.

Blake, S. (2002). 'The Ecology of Forest Elephant Distribution and its Implications for Conservation'. Ph.D. Thesis. Edinburgh: University of Edinburgh.

Blake. S. and Hedges, S. (2004). Sinking flagships: the case of forest elephants in Asia and Africa. *Conservation Biology* (18)5:1191–1202.

Blake, S., Strindberg, S., Boudjan, P., Makombo, C., Inogwabini, B.I., Omari, I., Grossmann, F., Bene-Bene, L., de Semboli, B., Mbenzo, V., S'hwa, D., Bayogo, R., Williamson, E.A., Fay, M. and Maisels, F. (2007). 'Forest elephant crisis in the Congo Basin'. *PloS Biology* 5(4):1–9.

Bossen, B. (1998). 'Research on African elephant (*Loxodonta Africana*) (Blumenbach 1797): a biography'. *African Journal of Ecology* 36:371–376.

Douglas-Hamilton, I., Karesh, W.B. and Kock, M.D. (2008). *Roadless Wilderness Area Determines Forest Elephant Movements in the Congo Basin*. PLoS ONE.

Douglas-Hamilton, I. (1989). 'Overview of status and trends of the African elephant'. In: S. Cobb (ed.) *The Ivory Trade and the Future of the African Elephant*. Oxford: Ivory Trade Review Group.

Douglas-Hamilton, I. (1988a). 'The greateast African elephant disaster'. *Swara* 11:8–11.

Douglas-Hamilton, I. (1998b). 'Tracking African elephants with a Global Positioning System GPS) Radio Collar'. *Pachyderm* 25:81–92.

Douglas-Hamilton, I. & Douglas-Hamilton. O. 1982. *Battle for the Elephants*. New York, USA: Viking.

Dowsett-Lemaire, F. (1995a). *Contribution à l'étude de la végétation forestière du Parc National d'Odzala (Congo)*. Groupement AGRECO-CTFT. Unpublished Report.

Dowsett-Lemaire, F. (1995b). *Etude de la végétation des mosaïques foret-savane au Parc National d'Odzala (Congo) et essai de cartographie*. Groupement AGRECO-CTFT.

Hall, J.S., Inogwabini, B.I., Williamson, E.A., Omari, I., Sikubwabo, C. and White, L.J.T. (1997). 'A survey of Elephants (*Loxodonta africana*) in the Kahuzi-Biega National Park lowland sector and adjacent forest in eastern Zaire'. *African Journal of Ecology* 35:213–223.

Hoare, R.E. (1999). 'Determinants of human–elephant conflict in a land use mosaic'. *Journal of Applied Ecology* 36:689–700.

Hoare, R.E. (2000). 'Project of the Human–Elephant Conflict Task Force (HETF): results and recommendations'. *Pachyderm* 28:73–77.

Inogwabini, B.I., Hall, J.S., Vedder, A., Curran, B., Yamagiwa, J. and Basabose, K. (2000). 'Conservation Status of large mammals in the mountain sector of Kahuzi-Biega National Park, Democratic Republic of Congo in 1996'. *African Journal of Ecology* 38:269–276.

Kangwana, K.F. (1995). 'Human–elephant conflict: the challenge ahead'. *Pachyderm* 19:11–14.

Lahm, S.A. (1996). 'A nationwide survey of crop raiding by elephants and other species in Gabon'. *Pachyderm* 21:69–77.

Maisels, F.G. (1996). 'Synthesis of information concerning the Parc National d'Odzala, Republic of Congo'. Groupement AGRECO-CTFT. Unpublished report.

Nchanji, A.C. and Plumptre, A.J. (2001). 'Seasonality in elephant dung decay and implications for censusing and population monitoring in south-western Cameroon'. *African Journal of Ecology 391:24.*

Pakenham, A. (1992). *Scramble for Africa – White man's conquest of Dark Continent from 1876 to 1912*. Perennial/Time Warner Books.

White, L.J.T. (1995). 'Factors affecting the duration of elephant dung piles in rain forest in the Lope Reserve, Gabon'. *African Journal of Ecology* 33:142–150.