Rate of decay of elephant dung in the central sector of Parc National des Virunga, Democratic Republic of Congo

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Abstract

Because of the spread of thickets and the massive regeneration of *Acacia* species that followed the drastic reduction in elephant numbers in the Lilimbi sector of Parc National des Virunga, the faecal census method is increasingly being used to determine abundance and relative densities of savannah elephant populations. A sample of 75 fresh elephant dung piles was monitored at 14-day intervals from April to July 1998 and then from January to April 1999 in the central sector of the park from the time they were fresh until they decomposed and disappeared. Decomposition of elephant droppings is principally brought about by three factors: dung beetles, termites, and mechanical disturbances such as heavy rain, fire, trampling, and foraging for insects by birds.

Additional key words: dry and wet seasons

Résumé

A cause de l'envahissement de taillis et de la régénération massive des espéces d'*Acacia* qui a suivi la réduction drastique du nombre d'éléphants dans le secteur Lulimbi, la méthode de recensement basée sur les crottes est de plus en plus utilisée afin de déterminer l'abondance ainsi que les densités relatives de population d'éléphant de savane. Un échantillonnage de 75 crottes fraiches a été suivi dans l'intervalle régulier de 14 jours jusqu'à la disparition d'avril à juillet 1998 et de janvier à avril 1999 dans le secteur centre du parc Virunga. La décomposition de crottes d'éléphant est effectuée par trois facteurs principaux, y compris les scarabées, termites et les facteurs mécaniques telles que la pluie torentielle, le piétinement, le fourrage d'insectes par les oiseaux et le feu.

Introduction

When the elephant population in Parc National des Virunga (PNVi) was cut drastically to one-sixth of its former number, *Acacia* species regenerated massively and thickets spread into neighbouring grasslands (Aveling 1990; Delvingt et al. 1990). This brushland makes it very difficult to make a direct count of the animals that are believed to be under cover at the time of a survey (Wing and Buss 1970; Jachmann and Bell 1984; Barnes et al. 1991; Dudley et al. 1992). Therefore, the faecal census method was used to determine abundance and relative densities of elephant populations in the savannah habitat of the central PNVi sector (Mubalama 2000).

Using the decay rate of dung piles to determine the density of an elephant population is a method that is little documented but one that is obviously more comprehensive for conducting a census in most of PNVi (fig. 1), which is now more than ever covered by trees and shrub savannah, changing into a woodland dominated by stands of *Acacia* spp. and *Capparis tomentosa.* Given the pronounced trend towards forest invasion of the grassland areas in recent years (Olivier 1990), we believe a comprehensive study of the rate of decay of elephant dung is needed. Our ignorance is epitomized by the lack of information available on frequency of droppings in protected areas of the Democratic Republic of Congo. To use dung density to determine elephant

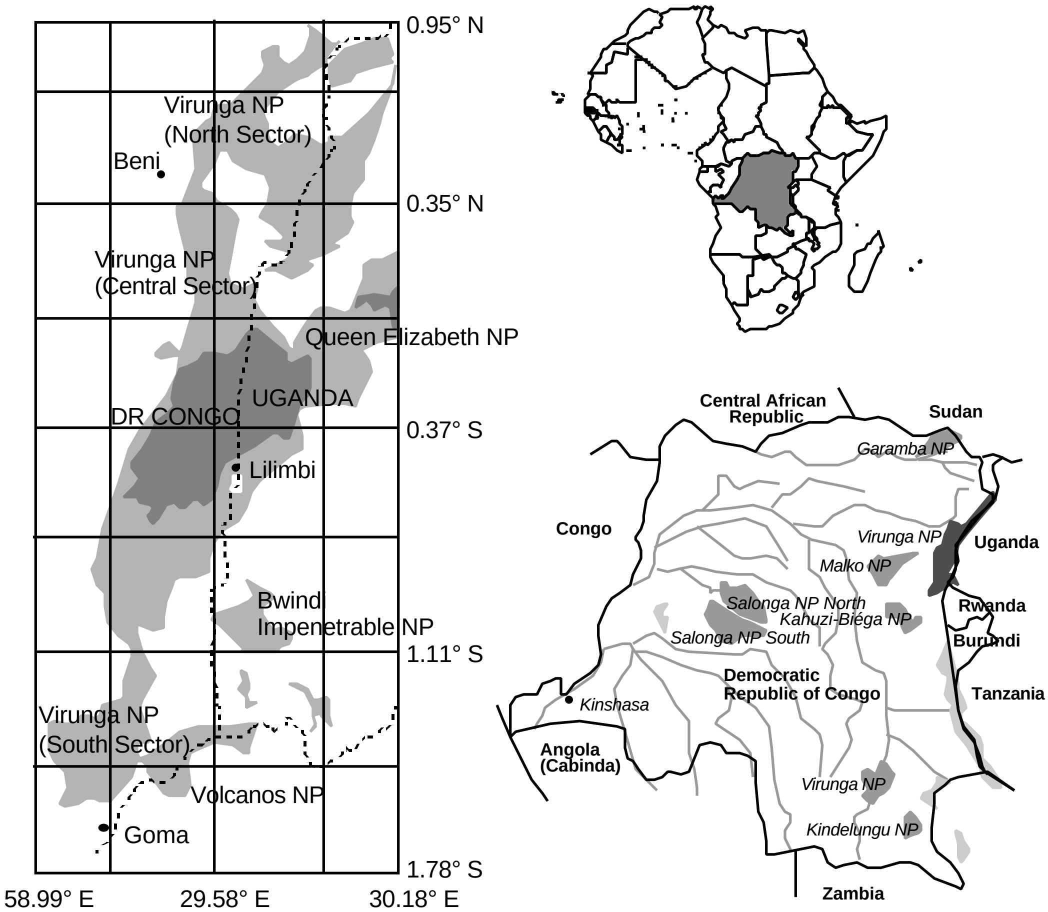

Figure 1. Location of the central sector of the Virunga National Park in DRC.

density, one must know the defecation rate and the mean dung-pile survival time or decay rate (Barnes and Jensen 1987). This often poses a major problem as there are rarely the time and enough personnel available to monitor elephant dung decay and at the same time undertake dung counts. Here we report our efforts to determine the rate of decay of elephant dung in the central sector of PNVi and the most important factors affecting dung duration.

Materials and methods

During a three-month study (April–July 1998) of the status and distribution of the African elephant (*Loxodonta africana africana*) in the central sector of PNVi (Mubalama 2000), elephant dung piles were marked and data on them collected. In a line-transect sampling cut through the area on a predetermined compass bearing, observers followed a straight line of 2.5 km and monitored dung piles. Further assessment of dung-pile decay was carried out from January to May 1999. A 100-m string, a 50-m measuring tape, a compass, numbered tags and survey forms were used (fig. 2). When a dung pile was found, the perpendicular distance from the transect line to the centre of the dung pile was measured, the position of the fresh pile of bolus or dropping was recorded, and the pile was tagged with a ribbon to facilitate locating it again. The dung pile was fortnightly revisited until it disintegrated and disappeared.

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Figure 2. Field research team assessing decay of elephant dung at Kinyonzo.

Two key factors were chosen to assess the dung decay rate: the general shape and the odour. The dung was judged for freshness as follows. If the dung was still warm, with fresh oil, very strong odour and few or no insects, it was considered to have been deposited within the previous 24 hours (0 days old). Dung with strong odour, stale oil and some insects was considered to have been deposited within the previous 24 to 48 hours (1 day old). Dung with fairly strong odour, no oil, many insects and some tiny white fungi present was considered to have been deposited within the previous 48 to 72 hours (2 days old). No dung first seen that was too old to fit into one of these three categories was monitored for decay.

Five stages of the general shape of the dung pile were considered: A – dense; B – $^1/_4$ decomposed; C – $^1/_2$ decomposed; D – $^3/_4$ decomposed; E – completely decomposed (the dung was deemed to have 'died'). This rating system follows the dung morphological categories defined by Barnes and Jensen (1987).

Odour was rated in four categories: 1 – very strong; 2 – strong; 3 – slight; 4 – none.

At every visit we noted the stage of dung decay. The duration of each dung pile was the number of days from date of deposition to date dung was last observed in stage D plus a random number between 0 and 14 (observation interval), following Barnes et al. (1997). The date of death of the dung pile was defined as the last day when the pile was recorded in stage E.

Surveys were restricted to one a year, owing to the expense and the limited availability of research funds. The survey form recorded the number of the fresh dung pile, its location on a map, the date of observation, and habitat (taking into account whether the soil was bare or covered). A dung pile was defined as a fresh pile of boluses produced at one time by one elephant (Barnes and Jensen 1987). As observers gained experience, whenever they saw an elephant drop dung, they noted the sex and identified individuals when possible, based on body and head size.

Test controls were performed by a team of five observers every two weeks except on three rare occasions when rains were heavy. In fact, when the rain poured after a day of test control, observers were advised to record the decay rate data again the following day to keep a close eye on the decomposition rate. During each visit notes were made for each dung pile of any animals engaged in opportunistic activities, flood and water runoff, baking of dung by the sun, and seedling and herbaceous growth on or around the dung pile that might have affected elephant dung decay (fig. 3).

Additional records made for dung piles selected for monitoring were number of boluses (noted as diarrhoea if dung was not deposited in boluses); mean diameter of the boluses; dung contents (grass fragments, leaf fragments, fruit fibre and pulp, hard seeds, wood cellulose and other fibres), and making visual estimates of the proportion. Dung piles in which any of these constituents were dominant (> 70%) were specially noted and were sorted together as a cohort for mean duration calculations.

Results and discussion

Decay rate was assessed during both the dry and the wet season. It was based on the observations of 35 and 40 cohorts of known-age dung observed during the course of the surveys. The data set collected during the study period 1998 showed the following results:

Average 54.78667 days
Variance 151.8458
Standard deviation 12.32257
Standard error 1.42288
Confidence limit 2.7888
Upper confidence limit 57.57547
Lower confidence limit 51.99787
Coefficient of variation 22.49%

These results mean that in 95% of confidence limits the values 57.57547–51.99787 bracket the true mean days.

During the dry season an elephant dung pile lasted at least 14.4 weeks before it reached stage D then E, according to both shape and odour key criteria. However, the decomposition rate speeded up during the wet

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Figure 3. Dung pile invaded by tender shoots regenerating from *Coccina grandis* and *Citrullus lanatus* seeds defecated by an elephant.

season when sometimes the sampled dung piles reached stage D and then E in less than 12.99 weeks.

The difference was significant between the dung piles of adults and yearlings in the time they took to decompose completely. Dung piles of yearlings decomposed twice as fast as those of adults. Differences were particularly marked in the rains. Grass and browsed stems seemed very fibrous and this may have contributed to yearlings avoiding them.

On account of limited time and budget, no figures for the nutrient content of either green browse (leaves and shoots) or woody browse (twigs and branches) are mentioned to explain the correlation between the variation in plant parts eaten and the elephant dung decay rate.

The data presented in this paper suggest that the decay rate of elephant dung is a complex process, which can be conditioned by seasonality with a pile of boluses lasting much longer in the dry season than in the wet. Dung piles deposited on stream banks or gulleys can be washed away by rain, but dung that remains moist, because it is in contact with marshy ground, can remain apparently fresh for longer periods. In addition, dung exposed to direct sunshine can be baked dry, hence becoming ‘fossilized’ and maintaining its form longer (White 1995).

Many animals, including insects, also depend on elephants. Elephants digest less than half of what they eat. The rest passes through them to nourish others, from micro-organisms of the soil to primates and other large mammals. Dung beetles (Scarabaeidae), termites (Termitidae) and other insects are important decomposers of dung piles. They in their turn are eaten by such birds as common ringed plover (*Charadrius hiaticula*), yellow-necked spurfowl (*Francolinus sephaena*), spur-winged lapwing (*Vanellus spinosus*), and Forbes’s plover (*Charadrius forbesi*), which are believed to feed largely on beetles and other insects, usually taken at water-edge dung piles. Although there was no strong statistical evidence to support this, observations indicated that the decomposers of dung piles acted in seasonal patterns in central PNVi, being less common in the major dry season (pers. obs.). Dung-beetle activity was confined to the wet season. This is consistent with findings by Jachmann and Bell (1984) in Kasungu National Park, Malawi.

Moreover, field teams noted on three occasions that elephant dung was scattered by baboon (*Papio cynocephalus doguera*), red river hog (*Potamochoerus porcus*) and African civet (*Viverra civetta*), who broke and dispersed the boluses as they foraged in elephant dung piles for seeds and insects (pers obs.).

Several contributing factors may have played a key role in prolonging the duration of elephant dung piles, including sun baking and the roots of fast-growing seedlings holding boluses intact.

The droppings of elephants provided an exceptionally good source for identifying food materials use, since the bolus contains a relatively large percentage of undigested material (Benedict 1936). Freshly browsed food plants with tracks and droppings nearby were used occasionally as indicators of foods eaten. The inflorescences of certain grasses were selected during the rains and their bases in the dry season (Field 1971). Browse leaves have little silica but are rich in other minerals, and this may have contributed to their greater palatability. Elephants preferred grasses in the wet season, as observed from their defecation. They turn to browse only in the dry season when the grasses have withered (Buss 1961; Bax and Sheldrick 1963; Hanks 1969; Field 1971; Wyatt and Eltringham 1974; Laws et al. 1975; Williamson 1975; Guy 1976; Olivier 1978).

In addition, the anatomy of the elephant digestive system makes the elephant more sensitive than the ruminant to toxic plant secondary compounds. This would then force elephants to diversify their supplementary foods. Thus in the wet season the bulk of the elephants’ diet would be provided by grasses, containing low concentrations of toxins, and would be supplemented by small amounts from a range of other species (Olivier 1978).

Elephants were sometimes very selective, preferring to feed on thatching grass (fig. 4) more frequently and in larger quantities than any other grass, including rush grass (*Sporobolus consimilis*), speargrass (*Heteropogon contortus*) and palisade grass (*Bracharia brizantha*). In woodlands near grasslands, they also ate *Acacia sieberiana*, *Aeschynomene elaphroxylon*, *Azima tetracantha*, *Capparis tomentosa*, *Carissa edulis*, *Citrullus lanatus*, *Coccinia grandis*, *Cyperus articulatus*, *Maerua mildbraedii*. *Panicum maximum* and *Securinega virosa*. For lack of time, we did not perform a more robust sampling on grazing and browsing patterns during the course of the survey. Thus there is a critical need to undertake such a study in the near future, to understand any relationship in the savannah elephant population between food preference and duration of their dung.


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Figure 4. An adult elephant feeding on succulent and nutritious *Cynodon dactylon* grasses fringing the marsh near Lulimbi headquarters.

Obtaining the precise age of elephant dung by its decay rate can be difficult. The difficulty of doing so, however, is not sufficient reason to abandon logic in analysing the data. In the past 10 years, many publications have dealt with age-estimation techniques. However, many of these papers are of questionable value for future workers, not because of the techniques themselves, but because authors did not provide useful estimates of the accuracy of their techniques. The problem of the present paper is that it omits statistical treatment, thus hindering efforts to evaluate age-estimation accuracy and limiting its worth in analysing collected data.

Further study on dung decay and environmental variables should investigate this to see whether a generally applicable relationship can be found to relate weather, food availability and elephant dung decay rate. This would enable researchers undertaking similar surveys to apply decay rates and factors affecting the duration of elephant dung piles in either rain forest or savannah from other sites with more confidence.

Conclusion and recommendations

Nearly all papers on this subject of decay rate refer to the technical difficulty of estimating the decay rate of elephant dung. They especially refer to the inadequacy of the statistical treatment used to assess the accuracy and confidence limits of the techniques and to do regression analysis. Recently several papers have called attention to inaccuracies in the procedures. To improve the quality of the age-estimation literature, future reports dealing with elephant dung decay rate should include estimates of accuracy, mean duration (days), rainfall (mm), mean humidity (%) and regression of mean square-root transformed duration of elephant dung piles and environmental variables.

It may be a useful method for comparing the use of different areas within one major vegetation type or for comparing the use of the same vegetation type between years as long as the dropping counts are done at the same time each year.

From that prospect, elephant feeding behaviour in PNVi should be a worthy study in the near future, to elucidate fully the savannah elephant defecation rate per day as a key step towards obtaining elephant population estimates. This study blazes a trail for future research on elephant dung piles, food preference and dung duration, and more so because these savannah elephants seem to show seasonal variation in defecation rate. Estimating the rate of dung decay remains a time-consuming process. But it can be used in regular monitoring of a cohort to keep information up to date and to identify in environmental correlates any differences observed between different surveys that may get under way in the future.

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References

Aveling, C. 1990. Comptage aérien total des buffles et éléphants au Parc National des Virunga. Programme Kivu; Sous-programme Virunga.

Barnes, R.F.W., Asamoah-Boateng, B., Naada Majam, J., and Agyei-ohemeng, 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., Barnes, K.L., Alers, M.P.T., and Blom, A. 1991. Man determines the distribution of elephants in the rain forests of northeastern Gabon. *African Journal of Ecology* 29:54–63.

Barnes, R.F.W., and Jensen, K.L. 1987. How to count elephants in forests. *African Elephant and Rhino Specialist Group Technical Bulletin* 1:1–6.

Bax, N.P., and Sheldrick, D.L.W. 1963. Some preliminary observations on the food of elephants in Tsavo Royal National Park (East) of Kenya. *East African Wildlife Journal* 1:35–40.

Benedict, F.G. 1936. *The physiology of the elephant*. Carnegie Institution, Washington. 302 p.

Buss, I.O. 1961. Some observations on food habits and behaviour of the African elephant. *Journal of Wildlife Management* 10:131–148.

Delvingt, W., Mankoto ma Mbaelele and Lejoly, J. 1990. *Guide du Parc National des Virunga.* Commission des Communautés Européennes, Bruxelles. 191 p.

Dudley, J.P., Mensah-Ntiamoah, A.Y., and Kpelle, D.G. 1992. Forest elephants in a rainforest fragment: preliminary findings from a wildlife conservation project in southern Ghana. *African Journal of Ecology* 30:116–126.

Field, C.R. 1971. Elephant ecology in the Queen Elisabeth National Park, Uganda. *East African Wildlife Journal* 9:99–123.

Guy, P.R. 1976. The feeding behaviour of elephant (*Loxodonta africana*) in the Sengwa Area, Rhodesia. *South African Journal of Wildlife Research* 6:55–63.

Hanks, J. 1969. Seasonal breeding of the African elephant in Zambia. *East African Wildlife Journal* 7:167–174.

Jachmann, H., and Bell, R.H.V. 1984. The use of elephant droppings in accessing numbers, occupance and age structure: a refinement of the method. *African Journal of Ecology* 22: 127–141.

Laws, R.M., Parker, I.S.C., and Johnstone, R.C.B. 1975. *Elephants and their habitats.* Clarendon Press, Oxford.

Mubalama, L. 2000. Population and distribution of elephants (*Loxodonta africana africana*) in the central sector of the Virunga National Park, eastern DRC. *Pachyderm* 28:44–55.

Olivier, R.C.D. 1978. On the ecology of the Asian elephant, *Elephas maximus* Linn., with special reference to Malaysia and Sri Lanka. PhD thesis, Cambridge University. 454 p.

Olivier, R. 1990. The Queen Elisabeth National Park Management Plan 1990–1995. Uganda Institute of Ecology and Agriconsulting SpA, Kampala.

White, L.J.T. 1995. Factors affecting the duration of elephant dung piles in rain forest in the Lopé Reserve, Gabon. *African Journal of Ecology* 33:142–150.

Williamson, B.R. 1975. The condition and nutrition of elephant in Wankie National Park. *Arnoldia* 7:1–20.

Wing, L.D., and Buss, I.O. 1970. Elephants and forests. *Wildlife Monographs* 19:1–92.

Wyatt, J.R., and Eltringham, S.K. 1974. The daily activity of the elephant in the Rwenzori National Park. Uganda. *East African Wildlife Journal* 12:273–289.