## FIELD NOTES

# Decay rate of elephant dung in Conkouati-Douli National Park, Republic of Congo

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## Introduction

Dung surveys are commonly used to monitor elephant (*Loxodonta africana cyclotis*, Blumenbach, 1797) populations in forest environments. To estimate elephant density from dung density two parameters are required: 1) the dung deposition rate, and 2) the rate of dung decay (Barnes and Jensen 1987; Barnes 1996; Theuerkauf and Gula 2010; Vanleeuwe 2010). The rate at which elephant dung decays is non-linear and is affected by numerous variables including environmental factors such as rainfall, exposure to sunlight, and temperature, and biological factors such as elephant diet and the action of decomposers, particularly fungi and insects but also small mammals foraging for seeds. These complex interactions result in seasonal, inter-site and intra-site variation in decay rates (White 1995; Barnes 1996; Barnes et al. 1997; Breuer and Hockemba 2007; Theuerkauf et al. 2009). For this reason it is recommended that researchers conduct their own studies of dung decay rates to ensure accurate population estimates (Hedges and Lawson 2006).

## Study site

Conkouati-Douli National Park is located on the southern coast of the Republic of Congo, along the border with Gabon. The park covers an area of 5,050 $km^2$; approximately 76% (3,850 $km^2$) of it is terrestrial and the remaining 24% (1,200 $km^2$) forms the Republic of Congo's only marine protected area. Conkouati-Douli is the most biodiverse protected area in Congo, encompassing a wide variety of habitats and species. The park is classified as a RAMSAR site for its important wetlands birdlife; it is a listed candidate to become a UNESCO World Heritage Site and is a high priority site for great apes in the IUCN Great Ape Conservation Action Plan due to its large number of Central African chimpanzees (Vanleeuwe and Morgan 2012).

## Methods

Seasonal movement patterns result in a large variation in elephant numbers. To control for this variation, dung counts are ideally conducted at the end of a season, ensuring that dung piles recorded during the count were deposited in the elapsed season. Dung decay studies are therefore best conducted during the same season that dung counts are conducted. In Conkouati-Douli, onset of the rains renders the terrain difficult to access and dung counts are therefore conducted at the end of the dry season, before onset of the rains.

The elephant dung decay study therefore took place during the dry season to make the results pertinent for elephant monitoring in Conkouati-Douli. A large herd of elephants was spotted around the park headquarters at the onset of the dry season, allowing us to tag 57 dung piles that were all less than 24 hours old at the start of the study.

Dung piles were marked and the habitat, canopy cover and slope were recorded for each pile. Canopy cover was classified into four categories as 0) no

Table 1. Stages of decay as per Barnes and Jensen, 1987

| Stage | Condition of dung pile |
|---|---|
| A | pile intact, very fresh, moist, with odour |
| B | pile intact, fresh but dry, no odour |
| C1 | more than 50% of the pile is distinguishable, some has disintegrated |
| C2 | less than 50% of the pile is distinguishable, the rest has disintegrated |
| D | pile completely disintegrated, forms a flat mass |
| E | decayed to the stage where it would be impossible to detect at 2-m range in the undergrowth, and it would not be seen unless directly underfoot |

canopy, 1) 0–25% cover, 2) 25–50% cover, and 3) 50%+ cover. Slope was classified as: 0) no slope, 1) 0–25% incline, 2) 25–50% incline, and 3) 50%+ incline.

Dung piles were monitored weekly and their stages of decay classified according to Barnes and Jensen (1987). Dung piles were considered fully decayed when they reached stage E (Table 1).

As the exact number of days between the final observation of dung as stage D and its transition to stage E was unknown, a random number between one and seven was added to calculate survival time and decay rate (Barnes et al. 1997; Breuer and Hockemba 2007).

## Results

A total of 57 dung piles were monitored from March to September 2005. The majority (75.4%, $n$ = 43) were found in forest habitat with 12% ($n$ = 7) in scrub, 10% ($n$ = 6) in savanna grasslands and 1.8% ($n$ = 1) in farmland. Mean survival time of dung piles was 158.3 days (SD ± 12.6, 95% CI 1551–61); the mean rate of decay was 0.00637 per day (SD ± 0.0007, 95% CI 0.0618–0.0656). Dung survival ranged from 89 days to 174 days; however, all but one of the dung piles survived for a minimum of 147 days. There was no significant difference in the survival time of dung piles by habitat type (Kruskal-Wallis, $X^2$ = 1.616, df = 3, $p$ = 0.656), canopy cover (Kruskal-Wallis, $X^2$ = 5.839, df = 2, $p$ = 0.054) or slope (Kruskal-Wallis, $X^2$ = 2.212, df = 2, $p$ = 0.331).

## Conclusions

Investigating dung decay rates across a large landscape can be a laborious undertaking involving significant commitment to time and resources (Kuehl et al. 2007). By opportunistically targeting a large herd near the research station, we ensured that all dung was less than 24 hours old at the start of the study, which minimized the effort needed to monitor the dung piles. The study was carried out entirely during the dry season to ensure dung decay rates were relevant to elephant monitoring in Conkouati-Douli, which takes place at the end of the dry season.

The survival time of dung piles in Conkouati-Douli is one of the longest reported in the literature. Variation in survival time was also low relative to similar studies. These differences may be partly due to many studies reporting combined figures for wet and dry seasons (e.g. Breuer and Hockemba 2007; Olivier et al. 2009). While we did not detect any effect of habitat type, canopy cover or slope on dung pile survival time it is likely that this was due to the small sample size and low variability in survival time.

Further study is needed to fully understand the factors affecting the decay rate of elephant dung piles in Conkouati-Douli. Nevertheless, this study provides a site-specific decay rate for Conkouati-Douli, which has been used to calculate the elephant population in 2005, 2008, 2010 and 2013.

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## References

Barnes RFW. 1996. Estimating forest elephant abundance by dung counts. In: Kangwana K, ed., *Studying* *elephants*. AWF Technical Handbook no. 7. African Wildlife Foundation, Nairobi. p. 33–48.

Barnes RFW, Asamoah-Boateng B, Naada Majam J, Agyei-Ohemeng J. 1997. Rainfall and the population dynamics of elephant dung piles in the forests of southern Ghana. *African Journal of Ecology* 35:39–52.

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

Breuer T, Hockemba MN. 2007. Forest elephant dung decay in Ndoki Forest, northern Congo. *Pachyderm* 43:43–51.

Hedges S, Lawson D. 2006. *Dung survey standards for the MIKE Programme*. CITES MIKE Programme, Nairobi.

Kuehl HS, Todd L, Boesch C, Walsh PD. 2007. Manipulating decay time for efficient large mammal density estimation: gorillas and dung height. *Ecological Applications* 17(8):2403–2414.

Olivier PI, Ferreira SM, van Aarde RJ. 2009. Dung survey bias and elephant population estimates in southern Mozambique. *African Journal of Ecology* 47:202–2013.

Theuerkauf J, Gula R. 2010. Towards standardisation of population estimates: defecation rates of elephants should be assessed using a rainfall model. *Annales Zoologici Fennici* 47:398–402.

Theuerkauf J, Rouys S, van Berge Henegouwen AL, Krell, FT, Mazur S, Muhlenberg M. 2009. Colonization of forest elephant dung by invertebrates in the Bossematie Forest Reserve, Ivory Coast. *Zoological Studies* 48(3):343–350.

Vanleeuwe H. 2010. Predictive mapping of season distributions of large mammals using GPS: an application to elephant on Mount Kenya. *Methods in Ecology and Evolution* 1(2):212–220.

Vanleeuwe H, Morgan D. 2012. Great ape research for better protection in Conkouati-Douli National Park. US Fish and Wildlife Service Final Report GA 96200-0-G071, Washington.

White LJT. 1995. Factors affecting the duration of elephant dung piles in rain forest in the Lope Reserve, Gabon. *African Journal of Ecology* 33:142–15.