Savanna elephants in montane forest: assessing the population of a landscape species in the biodiverse Udzungwa Mountains

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ABSTRACT

Savanna elephants of eastern and southern Africa have been well-studied in open habitats, while their socioecology in relatively closed habitats remains poorly understood. In Tanzania, savanna elephants make extensive use of forested habitats in at least three montane regions, including the species-rich Udzungwa Mountains where human-elephant conflict is escalating. Traditional elephant corridors between the Udzungwas and the surrounding protected areas of Selous Game Reserve and Mikumi and Ruaha National Parks are rapidly being lost to agriculture and settlements, and the perceived increase in and conflict with elephants may be an outcome of elephant population compression. The consequences for biodiverse forest habitats of confining a population of an ecosystem engineer well known for modifying its habitat, are in urgent need of investigation. We have begun the first study of this population by assessing distribution, population structure, diet and seed dispersal using counts and analysis of elephant dung along transects across the Udzungwa Mountains. Here we use all transects walked from 2007-2009 (~300 km) to show elephant distribution across 11 forest blocks, and a subset of these data (n = 689 dung piles along ~30 km of transect) from the Mwanihana forest block (where elephants are of relatively high abundance) to preliminarily assess population structure. Using dung bolus diameter to estimate elephant age and population structure is simple, low-cost and has great promise for ranger-led studies of elephants in closed forested habitats in Tanzania, and across Africa; however, this method's precision and accuracy call for further tests. Our long-term project goals include establishment of an elephant monitoring programme and HEC mitigation in this Eastern Arc forest.

Key words: **Udzungwa Mountains; savanna elephants; dung bolus diameter; corridors**

INTRODUCTION

All of Tanzania's elephants belong to the savanna elephant species *Loxodonta africana;* as in other East African countries, these animals are usually associated with arid bush, grassland with scattered trees, and deciduous miombo woodland, but they can also be found inside moist, closed-canopy forest. In Tanzania, elephants make use of forest on Kilimanjaro and Mount Meru in the north of the country, on the Mahale Mountains in the west, and on the Udzungwa and Rubeho mountains, and Mt. Malundwe in the south (Figure 1). They were also found in the forest on Mt. Rungwe within the last century (T.R.B. Davenport, pers. comm., 2009), although it is not known exactly when they were extirpated from there. Today, the only forests in the south of the country that harbour resident elephants are those in the Udzungwas. Our general aim is to improve our knowledge of savanna elephant socioecology in East African montane forests.

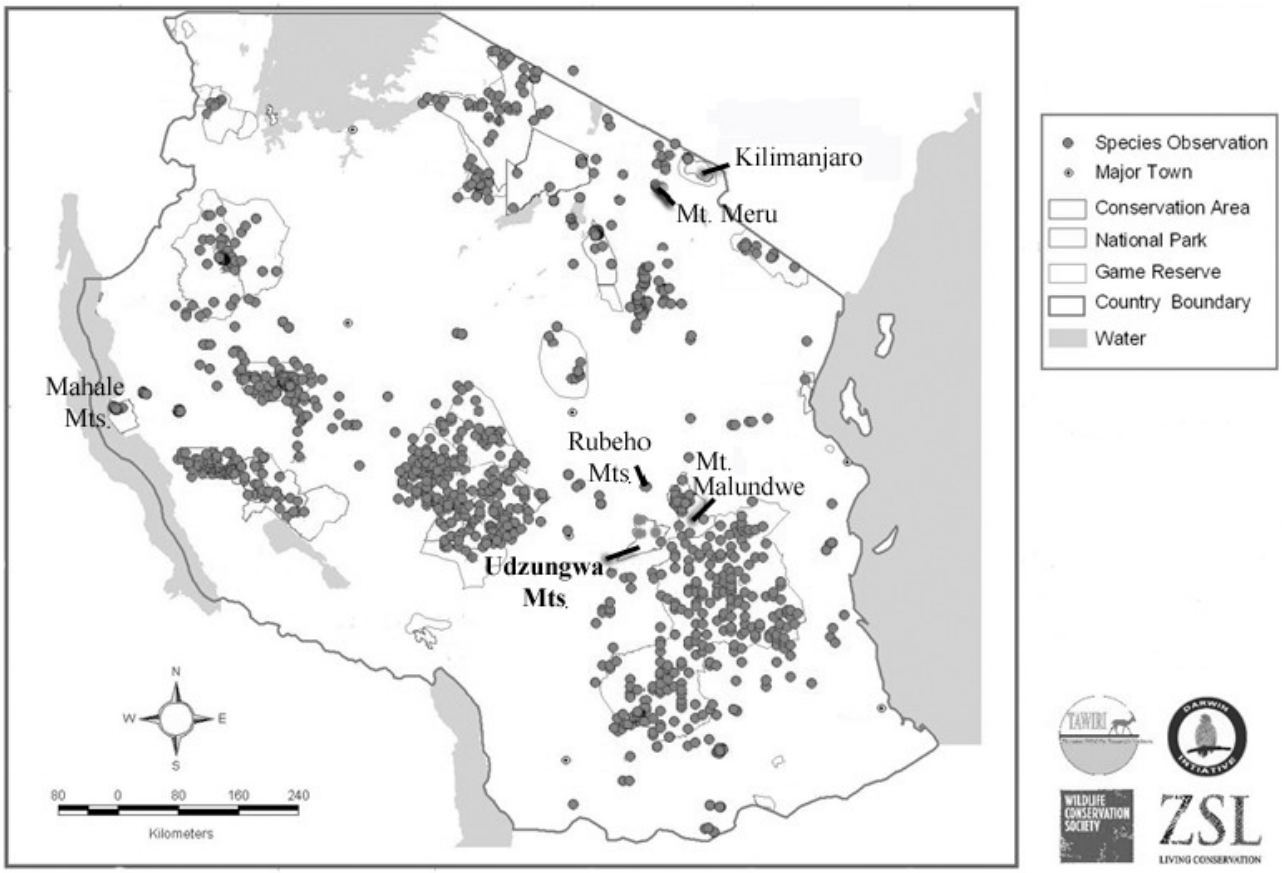

Figure 1. Sites at which savanna elephants use forest in Tanzania. Modified basemap shows distribution of elephants in Tanzania, December 2009, courtesy of the Tanzania Mammal Atlas Project (http://www.tanzaniamammals.org/content/mammals.php).

Our specific aims are to 1) assess population structure of the Udzungwa elephant population; 2) describe their ecology in the forests of Udzungwa Mountains; and 3) continue assessment of connectivity to inform corridor conservation projects in line with the ongoing country-wide corridor efforts (Jones *et al*., 2009; http://www.tzwildlifecorridors.org/) and the most recent Tanzania Wildlife Act (2009).

Our intensive investigations into elephant ecology in these mountains are at a preliminary stage, and data collection and analysis are ongoing. T. Jones has had a research presence in the Udzungwa Mountains since 2002 and therefore we have eight years of observations and opportunistic data to draw on. In this paper, we provide an overview of our current assessment of the important issues pertaining to elephants in the Udzungwa Mountains, including the status of elephant corridors, elephants' fruit consumption and dispersal of seeds, and the use of dung diameter to assess elephants' population demography. We also identify our intended areas for ongoing and future research.

STUDY SITE

The Udzungwa Mountains (7°40' S to 8°40' S and 35°10' E to 36°50' E) are a massif occupying an area of about 10,000 km^2 and representing the southernmost and largest block of the Eastern Arc Mountains (Lovett & Wasser, 1993). They also contain the largest forest blocks in the Eastern Arc, and the largest altitudinal gradient of continuous forest cover, from 300 m up to 2100 m in both the Mwanihana and Uzungwa Scarp forests.

About one fifth of the Udzungwa Mountains is protected by the Udzungwa Mountains

National Park (UMNP, 1990 km^2) gazetted in 1992. An additional, similarly-sized area is protected either as Forest Reserve or Nature Reserve. The highest peak is at 2600 m a.s.l. on Mt. Luhomero in the UMNP. The Udzungwa Mountains are extremely heterogeneous and contain several different habitat types, with closed-canopy forests interspersed with areas of dry woodland and grassland. Rainfall varies from 2000–3000 mm per year on the eastern, Indian Ocean-facing, moist forest-covered slopes, to 500 mm per year in the drier 'rain-shadow' areas (UMNP unpublished data), and is concentrated in two periods: December-January and March–May.

The Udzungwas are adjacent to three protected areas: the Selous Game Reserve (SGR) and Mikumi and Ruaha National Parks. The SGR is the largest protected area on the African continent with historically one of the most important and largest elephant populations on the continent (Blanc *et al*., 2007). Two corridors link the Udzungwas with the Selous: Nyanganje and Ruipa (Jones *et al*., 2007; 2009).

METHODS

Transects

We have been surveying forest around the Udzungwas using a recce-transect method (developed by T. Jones) recording dung up to 15 m distance from the hip-chain line; in addition to dung, all elephant trails are recorded, followed to one side for approximately 25 m, and checked for dung. Dung along transects is differentiated from dung along elephant trails. The global positioning system (GPS) was used to record locations of all dung piles. Other elephant signs include tree debarking, mineral digs, clearings for root-digging, and any actual sightings of elephants or those caught on camera traps (8 forests have been camera-trap surveyed by T. Jones as part of his broader PhD study on large mammals). Here we report on elephant presence and absence in the forests surveyed, based on elephant signs. Our analysis of relative abundance will be completed for a future publication, with the eventual aim of estimating the total number of elephants in the Udzungwa forests.

Dung diameter

Because the forest habitat does not allow us to observe our study animals, we are testing the use of dung bolus size as a means to assess population structure in this forest-dwelling population (Nowak *et al*., in press). Measurements of dung diameter follow methods described in Morrison *et al.* (2005). Results for age estimation are based here on dung measured along 30 km of transects established at three survey sites in Mwanihana forest representing three habitats: montane forest, grassland, and mosaic with a dense understory (see Figure 2 for location of Mwanihana).

Dung contents

We examined dung for plant content, particularly seeds, and noted the presence of fungi to begin our investigation of the role of elephants as seed dispersers and agents of change to plant communities in these montane forests.

RESULTS

Distribution

We counted >2000 piles along >300 km of transects in 11 forest blocks in the Udzungwas. Elephants were found to be widely distributed. They use two active corridors between the Udzungwas and Selous: the Ruipa and Nyanganje corridors, with the latter representing the corridor of shortest distance between the Udzungwas and another protected area (12 km); elephants' use of the Nyanganje corridor appears to be highly seasonal (Jones *et al*., 2007; 2009).

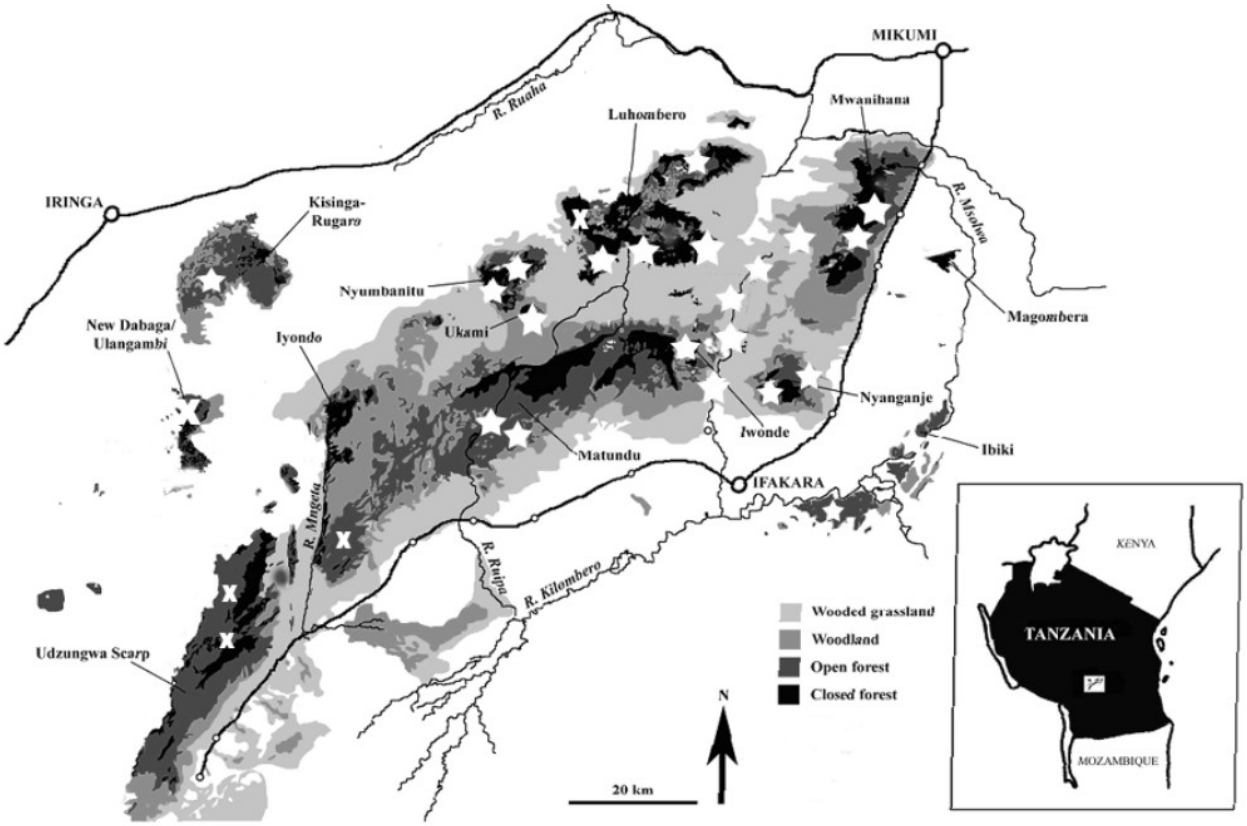

Figure 2. Preliminary distribution map of elephants in the Udzungwa Mountains, showing presence (stars) and absence (crosses) based on elephant sign in the areas surveyed from 2007-2009. Modified from basemap produced by A.R. Marshall.

Dung diameter

We counted 689 dung piles along 30 km of transects in Mwanihana of which 137 had intact boli (20%). Intact boli were 2-6 months old with a mean age of 3.3 months ± 1.6 SD. The mean number of boli in a pile was 5.4 ± 2.2 SD. A second intact bolus was measured in 15 of 137 piles with no significant difference between diameter of boli from the same pile, indicating that within defecation variance was not a significant source of error in our analysis. We were unable to look at within-individual defecation variance as we were unable to assign individual IDs to boli. Our three survey sites in Mwanihana were geographically close together (~6 km apart), as was sampling in time and we therefore had a high probability of detecting different individuals with our dung diameter measurements (see Nowak *et al.*, in press). The mean dung diameter was 11.0 cm ± 2.1 SD and the mean age predicted from dung diameter was 16 years ± 5.6 SD (Figure 3a-b).

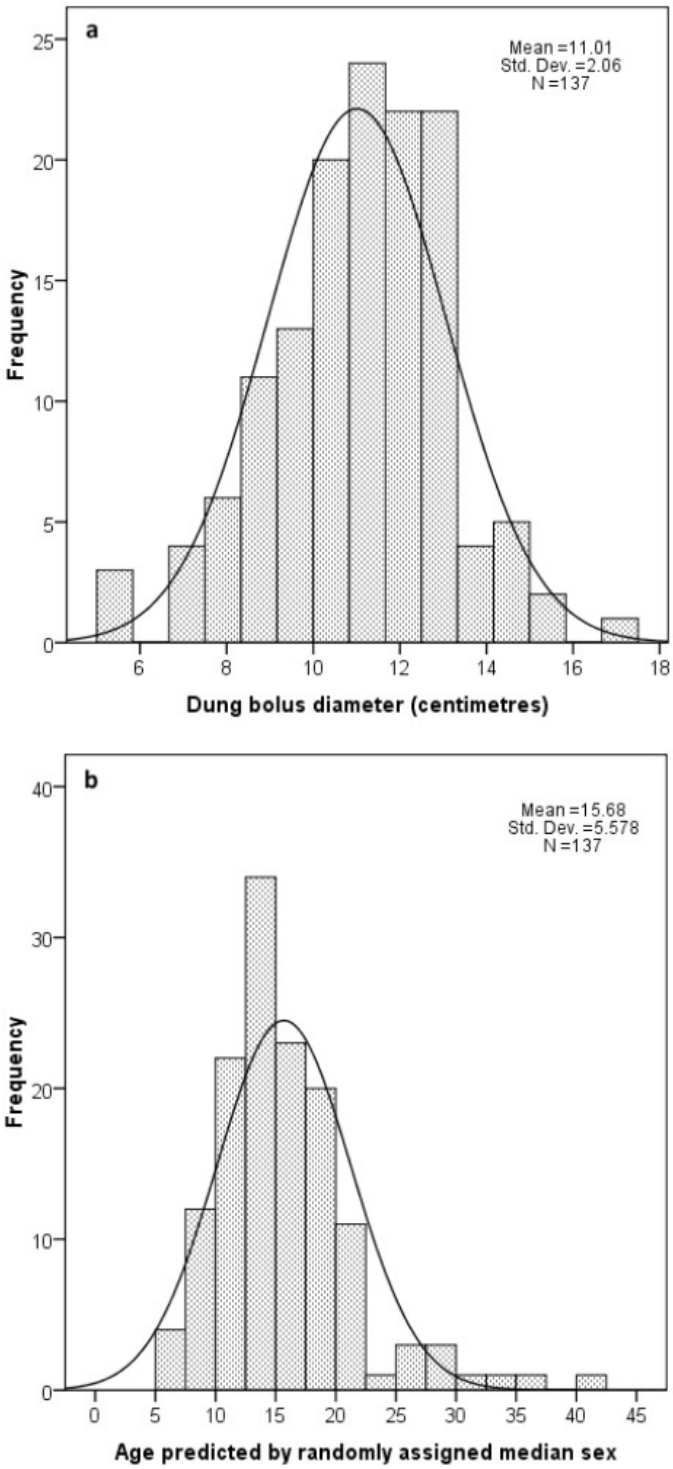

Figure 3a-b. Frequency and range of (a) dung bolus diameter and (b) age, as predicted from dung bolus diameter.

Dung contents

Most dung contained bark, roots, twigs and leaves, fungi, *Aframomum sp.* (wild African ginger), seeds including *Treculia* which typifies closed-canopy riverine forest, seeds of climbers particularly *Coccinia sp.* (Table 1), and even the spiny parts of the climber *Smilax sp*. *Coccinia sp.* was often seen germinating in dung. Over 50% of dung piles had >1 conspicuous fungi. Nearly 50% of boli contained seeds with 27 seeds being the maximum number found in one bolus and seeds of up to three species found in a single bolus. Termites, ants and larvae were found to inhabit many dung piles.

Table 1. Preliminary list of identified seeds found in elephant dung across several survey sites.

Plant type	Family	Genus species
Trees	Anacardiaceae	*Sorindeia madagascariensis*
	Annonaceae	*Lettowianthus stellatus*
	Cecropiaceae	*Myrianthus holstii*
	Chrysobalanaceae	*Parinari excelsa*
	Moraceae	*Treculia africana*
		Antiaris toxicaria
	Olacaceae	*Ximenia americana*
	Rubiaceae	*Vangueria infausta*
Shrubs	Clusiaceae	*Harungana madagascariensis*
Climbers	Apocynaceae	*Saba comorensis*
	Connaraceae	*Agelaea pentagyna*
	Cucurbitaceae	*Coccinia sp.*
	Rubiaceae	*Keetia sp.*
	Rutaceae	*Toddalia asiatica*
Grasses/herbs/sedges	Cyperaceae	*Carex sp.*
	Piperaceae	*Piper capensis*
	Poaceae	*Olyra latifolia*
Human food crops	Anacardiaceae	*Mangifera indica*
	Poaceae	*Zea sp.*
	Rutaceae	*Citrus sp.*

DISCUSSION/CONCLUSIONS

Distribution

The Udzungwa Mountains have a mosaic of habitats and many very steep slopes, yet sign of elephants was found on top of all major peaks in the Udzungwas, including the highest of these (Luhombero) at 2600 m. Elephants used a range of forest types, from areas with little to no understory to areas with a dense understory and a high abundance of lianas/climbers. The Udzungwas are likely a forest refuge in the network of protected areas in south-central Tanzania where water and food are abundant on a year-round basis and where illegal poaching is under tight control.

Dung diameter

The frequency distribution of dung diameter in the Udzungwas was comparable to Petit Loango, Gabon where a similar sample size was used (Morgan & Lee, 2003). A greater than 17 cm bolus suggested the presence of at least one prime-old male. Our minimum dung diameter (5.5 cm) was between that found in Amboseli (Morrison *et al*., 2005) and Kasungu (Jachmann & Bell, 1984) and as expected larger than that found for small-bodied forest elephants in Petit Loango (Morgan & Lee, 2003) (Table 2).

Table 2. Comparison of maximum and minimum elephant dung diameter in the Udzungwa Mountains with that in Amboseli National Park (Kenya), Kasungu National Park (Malawi) and Petit Loango (Gabon).

Bolus diameter	**Site**			
	Udzungwa Mts., Tanzania	**Amboseli, Kenya**	**Kasungu, Malawi**	**Petit Loango, Gabon**
Maximum	17.2 cm	18.0 cm	18.5 cm	16.0 cm
Minimum	5.5 cm	4.8 cm	6 .0 cm	4.0 cm
Reference	This study; Nowak *et al*., in press	Morrison *et al.*, 2005	Jachmann & Bell, 1984	Morgan & Lee, 2003

The Udzungwa population appeared to be young relative to that in Amboseli but does contain adults of reproductive age (>10 yrs old). Some possible sources of error are described in detail in Nowak *et al*. (in press), but overall, the use of dung bolus diameter appears to be a promising method for estimating elephant age in this closed, forested site.

Summary of research priorities

Our future research will include age estimation based on a bigger sample size from more sites; estimating density with *Distance* after incorporating data on dung decay; mapping elephant distribution; establishing a seed bank for comparative seed dispersal study; and incorporating elephant monitoring into the park's long-term management plan. We also plan to model the effects of the elephant population on forest structure and forest-dependent plant and animal species, if corridors are cut off. Ultimately, crop-raiding patterns and an assessment of effectiveness of local human-elephant conflict mitigation measures need to be assessed to accomplish enlightened land use planning.

Threats/conservation issues

The main threats to elephant populations in the Udzungwas are the loss of corridors from clearance for sugar cultivation, cattle grazing, burning and commercial logging (Jones *et al*., 2007), and from the ensuing perception that human-elephant conflict is increasing. We are hopeful that with the protection of wildlife corridors, dispersal areas, buffer zones and migratory routes now written into the new Wildlife Act (2009; p. 25), the Udzungwa-Ruaha-Mikumi-Selous network will remain a functioning and thriving ecosystem.

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