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Status of African baobab (*Adansonia digitata*) across Gonarezhou National Park, Zimbabwe

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***KEY WORDS*: Elephants, herbivory, precipitation, savanna, water sources, woodland**

ABSTRACT: An assessment was done to determine the abundance and structure of baobab (*Adansonia digitata*) across Gonarezhou National Park, Zimbabwe. Baobabs were sampled on fifteen belt transects of constant width of 300 m with fifteen baobabs in each belt transect determined the length of a particular belt transect between May and June 2012. Our results showed that there were no significant differences in basal area, height and density of baobabs across Gonarezhou. Moreover, elephant (*Loxodonta africana*) dung counts and damaged baobabs were similar across Gonarezhou. Our findings suggest a relatively similar spatial effect of elephant herbivory and other disturbance regimes on baobabs in Gonarezhou. We recommend the continuous monitoring of baobab woodland stands across Gonarezhou. © JASEM

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Although precipitation may be the primary determinant of vegetation biomass in dry savanna ecosystems (Deshmukh 1984; Prins and Loth 1988; Sankaran *et al* 2005), in Gonarezhou National Park (hereafter, Gonarezhou), disturbances, such as herbivory, mainly from African elephant (*Loxodonta africana*) herbivory on baobabs (*Adansonia digitata*), droughts, fires and human activities may also likely influence baobab woodlands (Tafangenyasha 1997; Mpofu *et al* 2012; Kupika *et al* 2014). Between the year 1980 and 2012, elephant population in Gonarezhou increased from approximately 4700 to 9125 (Dunham 2012). Taken with the results of other aerial elephant surveys conducted post 1992 drought, elephants in Gonarezhou have increased at a mean annual rate of 6% during the past sixteen years. Such a high elephant population annual rate with a population density of 2 elephants km^{-2} is a cause for concern to a park the size of Gonarezhou (Dunham 2012), especially considering the role of elephants in structuring ecosystems (Guy 1982; Cumming *et al* 1997; Midgley *et al* 2005; Guldemond and Van Aarde 2008).

In this present study, we aimed at establishing the park-wide status of baobab structure in Gonarezhou. Recent studies in Gonarezhou have not covered the entire park, with Mpofu *et al* (2012) only focusing on the southern Gonarezhou whereas Kupika *et al* (2014) focused on the northern Gonarezhou. Given the relatively high elephant density in Gonarezhou, it is thus, important to have a spatial understanding of baobab status across the entire Gonarezhou. Such knowledge is valuable for informing park management of the current status of baobab woodland and also the role of elephant herbivory.

MATERIALS AND METHODS

Gonarezhou is located in the southeast lowveld of Zimbabwe, between latitudes 21^0 00′ to 22^0 15′ S and longitudes 30^0 15′ to 32^0 30′ E and covers an area of 5,053 km^2 in extent. The park receives an annual average rainfall of about 466 mm. Gonarezhou has a relatively low relief, with the park altitude varying between 165 m above sea level to 578 m above sea level. The study area was stratified following Gandiwa *et al* (2011). Gonarezhou was divided into three strata based on natural and physical features. The Northern Gonarezhou stratum comprised of the area north of Runde River. The Central Gonarezhou stratum comprised the area south of Runde River to the railway line. The Southern Gonarezhou stratum comprised of the area south of the railway line to the Mwenezi River. All baobab woodland stands in Gonarezhou falling within the three defined

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geographic regions were selected from a vegetation map (Sherry 1977).

A standard sample belt transect width of 300 m wide was used in each geographic region, in accordance with the methods by Mapaure (2001) and Anderson and Walker (1974). The first sampled baobab in each belt transect was randomly selected according to Campbell *et al* (1996). Overall, six belt transects numbers were located in northern Gonarezhou, five in central Gonarezhou and four in southern Gonarezhou. Data were collected between May and June 2012. The following variables were measured or recorded: plant height, basal stem circumference at 1.3 m height, level of elephant damage and plant status (alive or dead). Baobab damage by elephants was assessed on a 4-point scale, from 0 = no damage, 1 = slight damage with few scars: 2 = moderate damage with numerous scars; 3 = severe damage with the tree scarred deeply and 4 = tree dead or felled (Swanepoel 1993). Moreover, elephant dung counts following Gandiwa *et al* (2011), grass height, habitat site relief elevation (using a Global Positioning System (GPS) unit) and habitat site rockiness (through visual inspection) in belt transects were recorded.

Data were first summarized by descriptive statistics for each belt transect. Baobab plant density was calculated from the formula: baobab plant density = numbers of baobab plants in a belt transect area (per km^2). Baobab variable's data were tested for normality using the Shapiro-Wilk test. Data on baobab basal area, plant density and grass height were $\log_{10}(y + 1)$ transformed, where y is the baobab variable quantity, in order to satisfy the assumptions of normality and equality of variance. One-way analysis of variance (ANOVA) with the three study geographic regions as grouping variables and measured variables as dependent variables was used to determine differences across the geographic regions. We conducted statistical tests using STATISTICA for Windows, version 6 (StatSoft 2001). Moreover, the relationship between environmental variables (habitat site relief elevation, habitat site rockiness and elephant dung density), grouping variables (geographic regions) and baobab status were analysed in CANOCO version 4.5 using Redundancy Analysis (Ter Braak & Šmilauer 2002).

RESULTS AND DISCUSSION

A total of 225 baobabs were assessed. There were no significant differences in height, plant density, basal area and elephant dung density across the Gonarezhou three geographic regions (Table 1). Overall, the total sample had 84.4% damaged baobabs and 15.6% undamaged baobabs, while 2.2% baobabs were dead (Fig. 1). Most of the baobabs were slightly damaged. Elephant impact mostly was in the form of de-barking baobab tree trunks, breaking and removing branches from their canopies and by preventing or reducing recruitment and regeneration.

Table 1: Summary of statistical analysis on baobab status across three geographic regions in Gonarezhou National Park (One-way ANOVA test)

Variable	Geographic regions			$F_{2,22}$	*P*-value
	Northern	Central	Southern		
Height (m)	13.60 ± 0.72	12.56 ± 0.58	9.84 ± 1.84	3.30	0.072
Plant density (km^{-2})	77.58 ± 10.69	52.92 ± 16.16	60.64 ± 17.23	0.86	0.447
Basal area (m^2/km^2)	165.51 ± 29.75	92.35 ± 23.37	85.54 ± 40.17	2.22	0.152
Elephant dung density (km^{-2})	210.85 ± 83.26	118.49 ± 41.28	78.79 ± 30.37	1.25	0.320

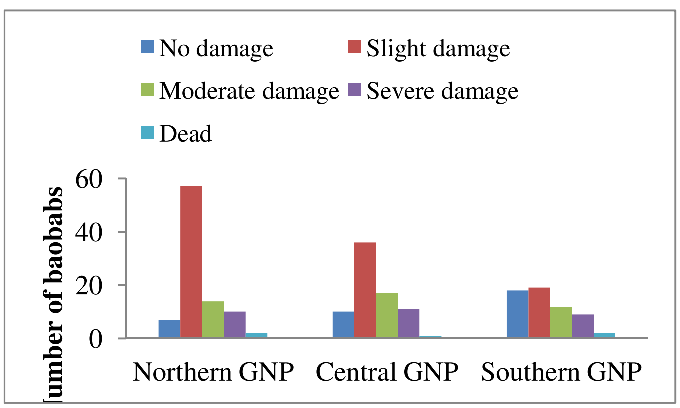

Fig 1: Elephant damage level of baobabs within Gonarezhou National Park. *Notes*: GNP represents Gonarezhou National Park.

Redundancy Analysis results of study variables showed Factor 1 accounting for 62% and Factor 2 accounting for 7% of the variance. The Northern Gonarezhou study sites had high baobab density and characterized with some high elephant damaged baobabs, whereas the Southern and Central Gonarezhou study sites had to some extent less elephant damage and also lower baobab densities. Moreover, baobabs in Central and Southern Gonarezhou were taller and had higher basal areas compared to those in northern Gonarezhou. Northern Gonarezhou transects were characterized with tall grasses compared to the Central and Southern Gonarezhou. Areas with high relief were associated with high habitat site rockiness and these two environmental variables were characterized with low elephant occupancy as depicted by a low elephant dung density. Central and Northern Gonarezhou sites were shown to be characterized by a high relief elevation with greater habitat site rockiness. Elephant dung density was negatively correlated to higher habitat relief elevation and habitat site rockiness.

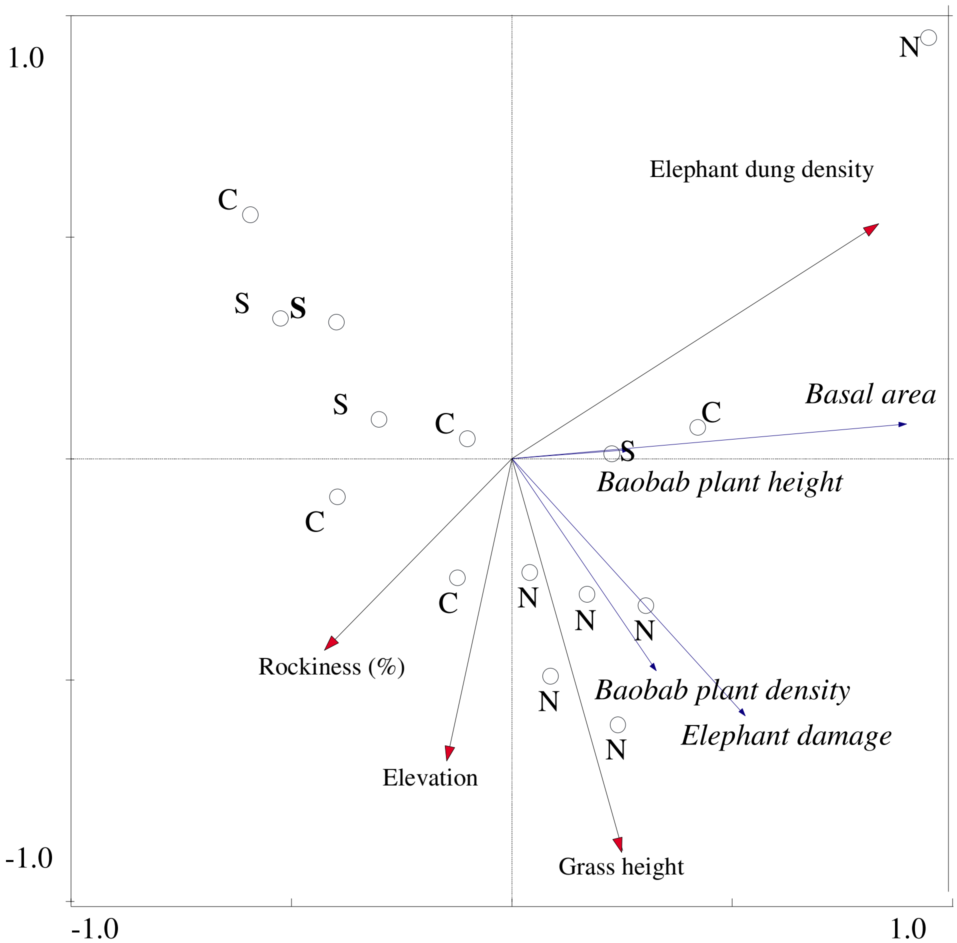

Fig 2: Ordination diagram of fifteen sample belts transect in the baobab stands, measured plant variables and environmental variables in the Gonarezhou National Park, Zimbabwe. Lettered data points denotes sample belt transect; with letter N representing belts transect in Northern Gonarezhou, C representing sample belts transect in Central Gonarezhou and S representing sample belts transect in Southern Gonarezhou.

Our study results showed no significant differences in baobab structure and abundance across Gonarezhou. This suggests that the rate of baobabs growth, recruitment and role of disturbance agents on baobabs was almost similar across the park. Furthermore, the recorded uniform pattern could also be influenced by the almost uniform climate across Gonarezhou (Magadza *et al* 1993). The recorded baobab densities in this present study appear to be within the range previously recorded in other protected areas in sub-Sahara Africa (Barnes 1980; Owen-Smith 1988). However, continued increase in elephant densities is likely going to negatively affect the baobab densities and distribution in future. For instance, it has been reported that baobab populations' declines occurred widely where elephants reached high densities that resulted in a shortage of food during the dry season (Owen-Smith 1988). Previous research has shown that in Tsavo National Park, Kenya, dense woodlands were changed into open savanna and baobabs got rare where they were once common (Whyte 2001).

Evidence of elephant damage on baobabs did not differ significantly across Gonarezhou, suggesting that baobabs were uniformly affected by elephants and also that elephants range more or less uniformly across the studied baobab stands in Gonarezhou. A high proportion of sampled baobabs (84.4%) in Gonarezhou showed evidence of elephant damage, indicating that baobabs were targeted by elephants. Pruning by elephants could strongly influence baobab sapling morphology and recruitment to adult size (Fornara and Du Toit 2008). Moreover, our results showed that approximately 2% of sampled baobabs were dead. Elsewhere, Barnes (1980) also reported that elephants killed 3% of baobab trees resulting in decline in baobab population in the Msembe area of Ruaha National Park in Tanzania.

Most of baobabs stands sampled were found in Northern Gonarezhou and baobab stands were very few in Central Gonarezhou. However, in the Southern Gonarezhou, most of the baobabs were common along Mwenezi River as also recorded by Mpofu *et al* (2012). We recorded that mountain ranges such as Chionja in Northern Gonarezhou and areas with developments and staff settlements constituted potential baobab refugia with baobabs which were slightly prone to elephant damage. Several factors including those not investigated, could explain this spatial distribution. Wilson (1988) and Barnes *et al* (1994) suggested that baobab densities are very variable across landscapes as they are affected by a number of establishment factors, such as insect outbreaks, past human activities, droughts or edaphic variables (Edkins *et al* 2007), all interacting in a complex and unpredictable ways (Scholes and Walker 1993). In Gonarezhou, Tafangenyasha (1992) suggested that herbivores (e.g., elephant and tree squirrels), drought, and increased density of associated species could bring about deaths of baobabs. Recent studies in Gonarezhou have also shown that in areas easily accessible by elephants, baobab densities are low and also baobabs are mostly damaged by elephants (Mpofu *et al* 2012; Kupika *et al* 2014). Therefore, we conclude by recommending the need for continuous baobab stands monitoring across Gonarezhou.

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