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

**CLAYTON MASHAPA; PATIENCE NYABAWA; PATIENCE ZISADZA-GANDIWA; JUSTICE MUVENGWI; SHAKKIE KATIVU; EDSON GANDIWA**

1 Tropical Resource Ecology Programme, University of Zimbabwe, P.O. Box MP 167, Mt Pleasant, Harare, Zimbabwe, 2 Department of Environmental Science, Bindura University of Science Education, Private Bag 1020, Bindura, Zimbabwe, 3 Scientific Services, Gonarezhou National Park, Parks and Wildlife Management Authority, Private Bag 7003, Chiredzi, Zimbabwe, 4 Transfrontier Conservation Areas Office, Parks and Wildlife Management Authority, P.O. Box CY 140, Causeway, Harare, Zimbabwe, 5 Department of Wildlife and Safari Management, Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Zimbabwe

**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

http://dx.doi.org/10.4314/jasem.v18i1.18

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 (Tafangenyash 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°0'0" to 22°15' S and longitudes 30°15' to 32°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...
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          | Northern | Central | Southern | F$_{2,22}$ | P-value |
|-------------------|----------|---------|----------|------------|---------|
| 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.

CLAYTON MASHAPA; PATIENCE NYABAWA; PATIENCE ZISADZA-GANDIWA; JUSTICE MUVENGWI; SHAKKIE KATIVU; EDSON GANDIWA
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.

![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.](image)

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-Saharan 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.

CLAYTON MASHAPA; PATIENCE NYABAWA; PATIENCE ZISADZA-GANDIWA; JUSTICE MUVENGWI; SHAKKIE KATIVU; EDSON GANDIWA
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.

Acknowledgements: We thank the Parks and Wildlife Management Authority, Zimbabwe for supporting this study. We also thank Gonarezhou Conservation Project and the people who assisted in fieldwork, namely, Cheryl Mabika, Daphne Madhlamoto, Tendai Chinho, Chenjerai Parakasingwa, Onias Chipara and Samson Mavasa. CM is greatly indebted to Patience Mhuro-Mashapa and Savie Masenguridza-Mashapa for their support.

REFERENCES

Anderson, GD and Walker, BH (1974). Vegetation composition and elephant damage in the Sebungwe Wildlife Research Area, Rhodesia. Journal of the South African Wildlife Management Association 4(1): 1-14.

Barnes, RFW (1980). The decline of the baobab tree in Ruaha National Park, Tanzania._African Journal of Ecology 18: 243-252.

Barnes, RFW, Barnes, KL and Kapela, B (1994). Long-term impact of elephant browsing on baobab trees at Msembe, Ruaha National Park, Tanzania. African Journal of Ecology 32: 177–184.

Campbell, BM, Butler, JRA, Mapaure, I, Vermeulen, SJ and Mushove, P (1996). Elephant damage and safari hunting in _Pterocarpus angolensis_ woodland in northwestern Matabeleland, Zimbabwe. African Journal of Ecology 34: 380-388. Cumming, D

Fenton, M, Rautenbach, I, Taylor, R, Cumming, G, Cumming, M, Dunlop, J, Ford, A, Hovorka, M and Johnston, D (1997). Elephants, woodlands and biodiversity in southern Africa. South African Journal of Science 93: 231-236.

Deshmukh, IK (1984). A common relationship between precipitation and grassland peak biomass for east and southern Africa. African Journal of Ecology 22: 181-186.

Dunham, KM (2012). Trends in populations of elephant and other large herbivores in Gonarezhou national Park, Zimbabwe, as revealed by sample aerial surveys. African Journal of Ecology 50: 476-488.

Edkins, MT, Kruger, LM, Harris, K and Midgley, JJ (2007). Baobabs and elephants in Kruger National Park: nowhere to hide. African Journal of Ecology 46: 119-125.

Fornara, DA and Du Toit, JT (2008). Responses of woody saplings exposed to chronic mammalian herbivory in an African savanna. Ecoscience 15(1): 129-135.
Gandiwa, E, Chikorowondo, G, Zisadza-Gandiwa, P and Muvengwi, J (2011). Structure and composition of *Androstachys johnsonii* woodland across various strata in Gonarezhou National Park, southeast Zimbabwe. Tropical Conservation Science 4: 218-229.

Guldemond, R and Van Aarde R (2008). A meta-analysis of the impact of African elephants on savanna vegetation. Journal of Wildlife Management 72: 892-899.

Guy, PR (1982). Baobabs and elephants. African Journal of Ecology 20: 215-220.

Kupika, OL, Kativu, S, Gandiwa, E and Gumbie, A (2014). Impact of African elephants on baobab (*Adansonia digitata* L.) population structure in northern Gonarezhou National Park, Zimbabwe. Tropical Ecology 55: In press.

Magadza, C, Coulson, I and Tafangenyasha, C (1993). Ecology of Gonarezhou National Park, Department of National Parks and Wildlife Management Progress report No. GNP/B3/1a/1. Harare.

Mapaure, I (2001). The influence of elephants and fire on the structure and dynamics of miombo woodland in Sengwa Wildlife Research area, Zimbabwe. Unpublished. PhD thesis, University of Zimbabwe, Harare.

Midgley, J, Balfour, D and Kerley, GI (2005). Why do elephants damage savanna trees? South African Journal of Science 101: 213-215.

Mpofu, E, Gandiwa E, Zisadza-Gandiwa, P and Zinhiva H (2012). Abundance, distribution and status of African baobab (*Adansonia digitata* L.) in dry savanna woodlands in southern Gonarezhou National Park, southeast Zimbabwe. Tropical Ecology 53: 119-124.

Owen-Smith, RN (1988). Megaherbivores: the influence of very large body size on ecology. CUP, New York.

Prins, HHT and Loth, PE (1988). Rainfall patterns as background to plant phenology in northern Tanzania. Journal of Biogeography 15: 451-463.

Sankaran, M, Hanan, NP, Scholes, RJ, Ratnam, J, Augustine, DJ, Cade, BS, Gignoux, J, Higgins, SI, Le Roux, X, Ludwig, F, Ardo, J, Banyikwa, F, Bronn, A, Bucini, G, Caylor, KK, Coughenour, MB, Diouf, A, Ekaya, W, Feral, CJ, February, EC, Forst, PGH, Hiraux, P, Hrabar, H, Metzger, KL, Prins, HHT, Ringrose, S, Sea, W, Tews, I, Worden, J and Zambatis, N (2005). Determinants of woody cover in African savannas. Nature 438:846–849.

Scholes, RJ and Walker, BH (1993). An African Savanna: synthesis of the Nylsvley study. Cambridge University Press, Cambridge.

Sherry, BY (1977). Basic Vegetation Types of the Gonarezhou National Park, Zimbabwe. Project No. GNP/3Y/2. Department National Parks and Wildlife Management, Harare.

Statsoft (2001). STATISTICA for Windows, Version 6. 2300. StatSoft, Tulsa, USA.

Swanepoel, C (1993). Baobab damage in Mana Pools National Park, Zimbabwe. African Journal of Ecology 31: 220-225.

Tafangenyasha, C (1992). Baobab damage by bush squirrel *Paraxerus cepapi* in South Eastern Zimbabwe. Unpublished. Report, GNP/B3/92. Department of National Parks and Wildlife Management, Harare.

Tafangenyasha, C (1997). Tree loss in the Gonarezhou National Park (Zimbabwe) between 1970 and 1983. Journal of Environmental Management 49: 355-366.

Ter Braak, CJF and Šmilauer, P (2002). CANOCO Reference manual and CanoDraw for Windows User’s guide: Software for Canonical Community Ordination (version 4.5), Microcomputer Power, Ithaca, New York.

Whyte, IJ (2001). Headaches and Heartaches-the elephant management dilemma. In: Schmidtz D and Willot E. (eds). Environmental Ethics: Introductory readings. Oxford University Press. pp 293-305.

Wilson, RT (1988). Vital statistics of the baobab (*Adansonia digitata*). African Journal of Ecology 26: 197-206.