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Full Length Research Paper

Population biology of *Brackenridgea zanguebarica* in the presence of harvesting

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Population biology studies play a major role in understanding the ecology of our highly utilized natural resources. Intense and frequent harvesting of bark from species with a high market demand often result in ring-barking of trees. The trees subsequently die, and the species becomes rare over time. *Brackenridgea zanguebarica* Oliv. is a species in demand not only because of its medicinal value but also because it is highly regarded for its magical value. The species has a limited distribution and is found only at Thengwe in the whole of South Africa. The population structure of the species was investigated and the response of the species to harvesting pressure evaluated in order to gain an understanding of its survival strategies. In spite of the high demand for the species it seems to be surviving the harvesting pressure. *B. zanguebarica* showed a healthy population structure with lots of seedlings. The adult individuals showed a very high degree of bark regeneration as a response to bark removal from medicine men. The inverse J-shaped curve showed that the population is healthy although sharp decreases between stem diameter size classes were observed. Fewer older individuals have healthy crown covers since crown health status tends to decrease with increase in stem diameter. It is therefore important to monitor the diameter size classes that are being impacted negatively by medicinal bark harvesting for the population to remain viable at all times.

Key words: Bark harvesting, magical value, population structure, regeneration, South Africa.

INTRODUCTION

Brackenridgea zanguebarica Oliv. (Ochnaceae) has been used by the Venda people for millennia, mostly for magical purposes. Because of its magical uses the species is popularly known as the magic tree. According to Netshiungani and Van Wyk (1980), to the VhaVenda people, *B. zanguebarica* is also a plant of great medicinal importance. Some of the uses recorded in Netshiungani and van Wyk (1980), Todd et al. (2004), Tshisikhawe (2002); Van Wyk et al. (1997) are the following:

(i) to protect people against witchcraft;
(ii) protecting the whole homestead from evil people;
(iii) performing magical activities;
(iv) treatment of wounds, worms, amenorrhea, swollen ankles and aching hands; and
(vi) discouraging opponents in sporting events.

B. zanguebarica has a wide range of biological activity against eukaryotic cells, bacteria and viruses (Moller et al., 2006). The species has a restricted distribution in South Africa and has been classified as Vulnerable (VU) according to the IUCN Red List categories in South Africa (Raimondo et al., 2009). However, it occurs more wide-spread in southern Africa and its global IUCN Red List status is least concern (LC). Although plant numbers are limited in South Africa, its survival is mainly attributed to the cultural beliefs of the Vhavenda people when collecting it. Since the plant is found within the Vhatavhatsindi clan they believe for it to work as a

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medicine it has to be collected by a dedicated person from the clan. They also believe that the collector, who is not a dedicated member, can become sterile by touching the plant. Collection is also done by a naked person, which is usually during the dark to avoid being seen by passersby (Mabogo, 1990). These are some of the beliefs that are still adhered to by people from the area as well as traditional healers, and it is only the thieves and people who do not know the culture that do not honour them. Middlemen, those that collect for the traditional healers and traders, do not adhere to these cultural beliefs since for them it is about making money through collecting large amounts of medicinal material.

Because of the ever-increasing demand of this species as medicine (Botha et al., 2004; Saidi and Tshipala-Ramatshimbila, 2006; Todd et al., 2004; Tshisikhawe, 2002; Williams, 1996) it is important to assess the effect of harvesting on its population structure. Knowledge of the size-class distribution, for example, the frequency distribution of stems across diameter or circumference classes, can help in assessing the population for its sustainability. For the achievement of sustainability, resource ecology and harvesting must be approached from the perspective of plant population dynamics (Lawes et al., 2004). However, because of phenotypic plasticity care should be taken when converting size-class distributions into age-class distributions (Silvertown and Charlesworth, 2001). The aim of the study was therefore to understand the population biology of *B. zanguebarica* in the presence of harvesting in a communal area.

MATERIALS AND METHODS

Species and study region

B. zanguebarica is a deciduous shrub or small tree, which occurs in the bushveld or along the forest margins (Palgrave, 1988; Van Wyk and Van Wyk, 1997). The bark is rough or corky with a bright yellow pigment in the dead outer layers of the stems. The leaves are elliptic to obovate, glossy dark green above, paler green below, hairless, with numerous lateral and tertiary veins prominent on both sides. Margins are finely toothed with each tooth tipped by a minute gland (Van Wyk and Van Wyk, 1997). According to Netshiungani and Van Wyk (1980), these glands found along the margins of the lamina, are a characteristic that can be used to differentiate the species from other members of the Ochnaceae family.

B. zanguebarica is the only member of the *Brackenridgea* genus that occurs in South Africa. The Thengwe population is also the only population of *B. zanguebarica* in South Africa. The bark of *B. zanguebarica* is collected and used as medicine although its main usage is for its magical properties. This bark is collected from the stems of standing trees as well as from roots.

Data on *B. zanguebarica* was collected from the Venda region in the communal area of Thengwe study area (Figure 1). According to Acocks (1988) the vegetation type is a Sourish Mixed Bushveld. It is the veld type occupying an irregular belt between the sour types and the mixed types of the plains and valleys. Soil in this vegetation type is a sandy loam that was derived from sandstone (Cowling et al., 1997). The rainfall at Tshandama, the closest weather station to Thengwe is 688 mm (Weather Bureau, 1998).

The vegetation around the study area is classified as the VhaVenda Miombo by Mucina and Rutherford (2006). It is a unique vegetation unit and is limited to a very small area in the upper reaches of the Mbodi River Valley between Shakadza and Mafukani. *Brachystegia spiciformis* Benth., one of the most important and dominant species of miombo woodlands has its southernmost distribution in this vegetation unit.

Accessibility in the Thengwe study area is strictly controlled by the local tribal authority. The local tribal authority makes sure that the population is not exploited by collectors of medicinal materials. Collectors of medicinal material from *B. zanguebarica* are accompanied by people from the tribal offices who supervise the collection procedures. With the guidance of the local authorities, harvesters are allowed to chop down appropriate stems for collection of medicinal material.

Collection of medicinal materials from *B. zanguebarica* is done by a dedicated member of the Vhatavhatsindi clan who should be young and not yet sexually active or old enough to be no longer involved in such an activity. This is a way of ensuring that a collector who is sexually active is protected from becoming sterile based on the cultural belief system amongst the Vhatavhatsindi people. The Vhatavhatsindi people believe that the plant which is only found in their community is a gift from God and they are the sole custodian of the species. They also believe that for the medicine to be active, it should only be collected by a dedicated member from their clan.

The collection pattern is however being negatively affected by people who collect medicinal material in the absence of members of the tribal authority. These illegal collectors are people who do not observe the mythology associated with the Vhatavhatsindi clan.

Data sources

Seven 100 m × 5 m transects were constructed in order to sample the required data. The coordinates of each transect were recorded using a Geographic Positioning System. A rope was used to delineate transects. The following data were recorded on all *B. zanguebarica* individuals encountered within transects:

(i) Stem circumference (in cm) – measured with a measuring tape above the basal swelling.
(ii) Crown health – estimated using a 0 - 5 point scale with 0 indicating no crown at all and 5 an entirely healthy crown.
(iii) Bark removal area – estimated using a 0 - 5 point scale, with 0 indicating no removal and 5 indication 100% removal of bark around the stem.
(iv) Height – height of the trees was measured with a graduated height rod while for seedlings a measuring tape was used.
(v) Stem circumferences of marked individuals were sampled again after one year in order to record the growth rate.

Stem diameter measurements were classified into 6 size classes with 5 cm intervals for the purpose of the size class analysis. Natural logarithmic transformations of the density of the size classes (D) (Condit et al., 1998) of the type ln (D+1) were used to standardize the data (Lykke, 1998; Niklas et al., 2003) before calculating least square linear regressions.

The mean diameter of the population, the “centroid”, was also calculated. According to Niklas et al. (2003) a centroid skewed to the left of the midpoint of the size class distribution indicates a young and growing population, whereas one skewed to the right indicates an older, relatively undisturbed population.

The statistical significance of the differences between the slope and intercept values of the size class distribution curves were analyzed by an Analysis of covariance (Quinn and Keough, 2002) in GraphPad Prism 4.03 for windows (GraphPad software, San diego California, USA, www. Graphpad.com).

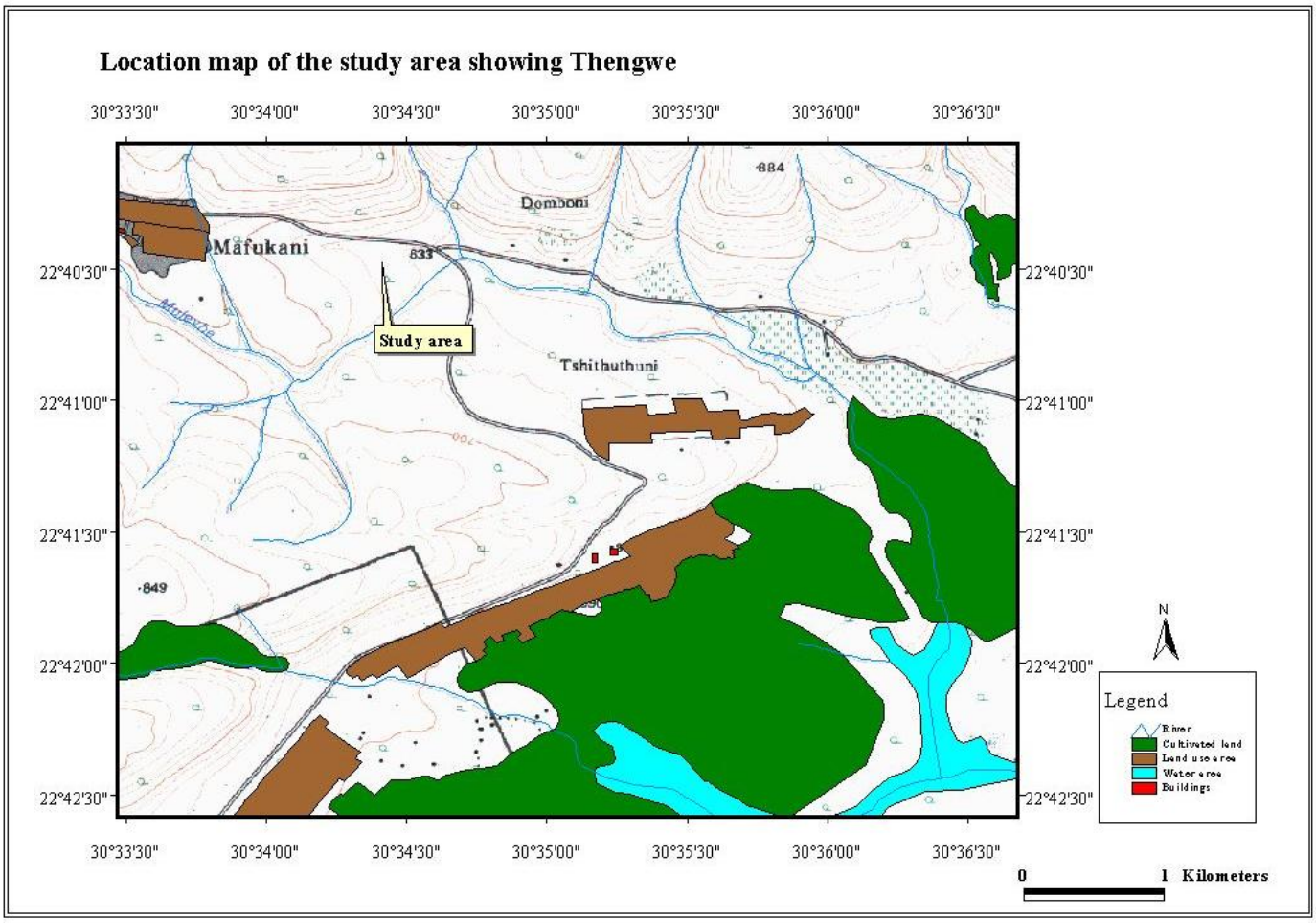

Figure 1. A location map showing the Thengwe study area where data on *Brackenridgea zanguebarica* was collected in 2004.

RESULTS

Population structure

The population sampled in the study had a fair amount of young individuals in the diameter class of 0 to 5 cm (approximately 70% of the population). However, the diameter class of 0 to 5 cm individuals found it difficult to survive to the next class in large number since it showed a more than 50% reduction in the next size class of >5 to 10 cm diameter which constituted approximately 23% of the population (Figure 2). The more than 50% reduction was also experienced in the development of individuals from the >5 to 10 cm diameter class to >10 to 15 cm diameter class (7% of the population). The population remained at 7% in the >15 to 20 cm diameter class as well.

The position of the centroid (6.56 cm) was left-skewed in relation to the midpoint of stem diameter distributions (15.04 cm) and confirmed the healthy status of the population. The linear regression on the natural logarithm of the density in the size classed against the size class midpoint (Figure 3) produced a significant linear regression ($r^2 = 0.934$; $y = -0.127x + 5.638$; $p = 0.0017$). The slope and Y-axis intercept of this equation can in future be used to compare other populations of *B. zanguebarica* under different harvesting regimes. It can also be used to compare the same Thengwe population over time to detect changes in population structure (Figure 4).

The 2004 data were compared with those of Todd et al. (2004). It was evident that the 1990 population regression had the steepest slope and the highest Y-intercept (Figure 4). An Analysis of Covariance indicated that the slope of the 1990 population was significantly steeper than that of the 2004 population ($p = 0.0253$), but that there was no significant difference in either slopes or intercepts between the 1990 and 1997 populations ($p = 0.3186$).

Stem increment values of the *B. zanguebarica* population showed a linear regression as indicated in Figure 5 ($r^2 = 0.765$; $y = 0.116x + 1.046$; $p = 4.47 \times 10^{-7}$).

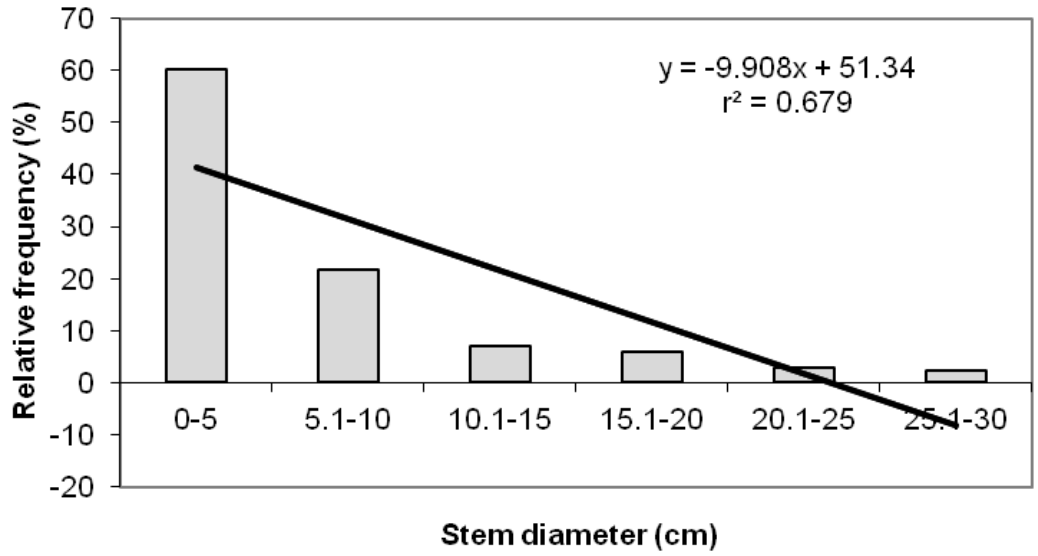

Figure 2. Size-class distribution of *Brackenridgea zanguebarica* from the Thengwe study area, Limpopo from data collected in 2004.

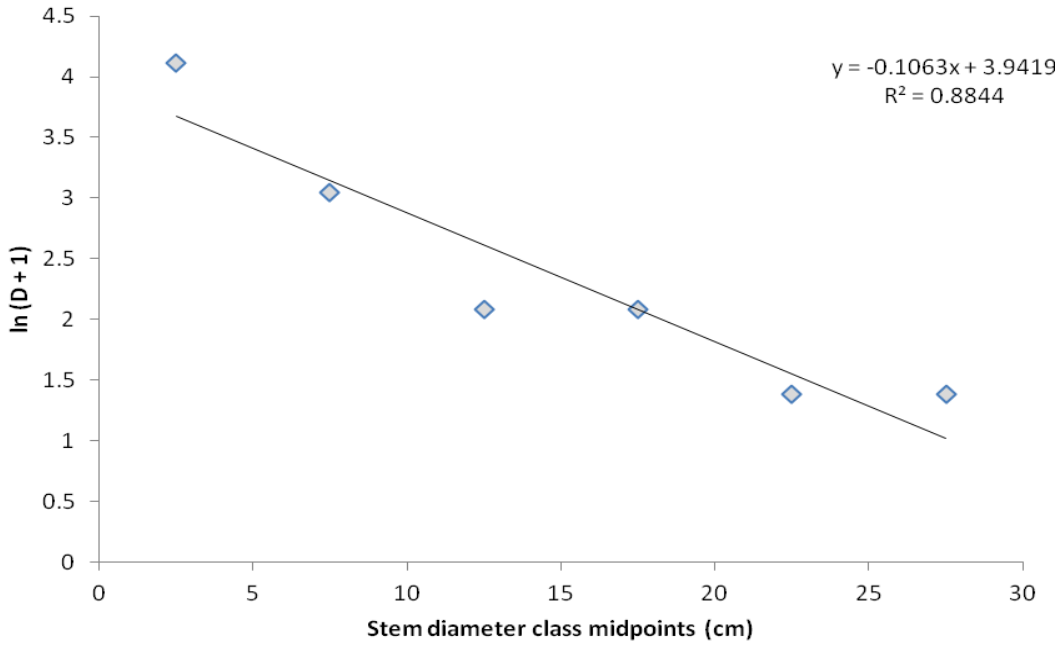

Figure 3. The regression of ln(D + 1) against stem diameter class midpoints for a *Brackenridgea zanguebarica* population from the Thengwe study area, Limpopo in 2004.

The increment values were obtained from repeated sampling of stem circumference over two years.

Crown health

The crown health status of *B. zanguebarica* population was found to be good since all the individuals showed a generally good health with the scale ranging from 3 to 5 (Figure 6; $r^2 = 0.702$, $y = 9.782x - 9.562$; $p = 2.92 \times 10^{-2}$). In spite of the intense harvesting pressure on the population crown health status of *B. zanguebarica* population was impressive considering the fact that none of the trees showed crown status in the 0 category of the sliding scale.

In general, crown health status deteriorated with an increase in size of the stem circumference. Fewer older individuals had healthy crown cover as shown in Figure 7 in 2004.

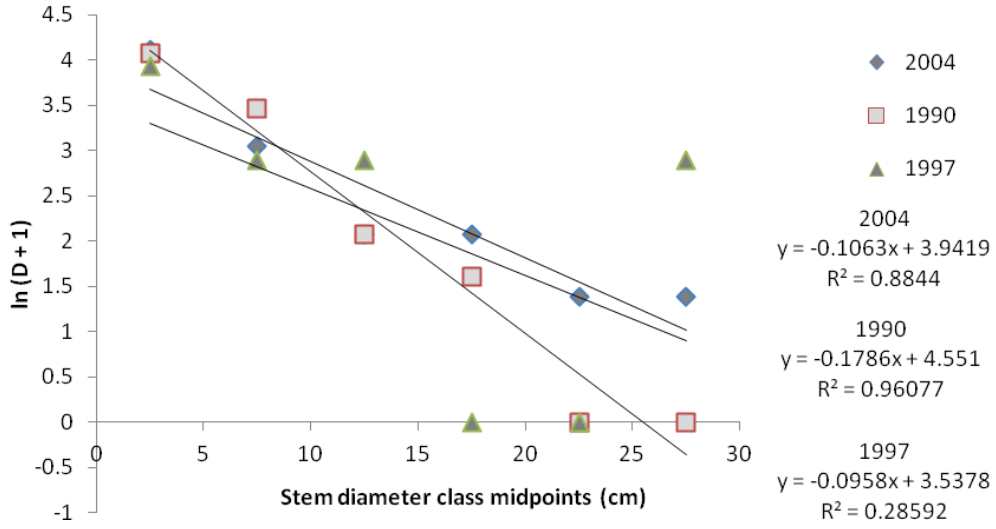

Figure 4. The regression of ln (D + 1) against stem diameter class midpoints for a *Brackenridgea zanguebarica* population from the Thengwe study area, Limpopo in 2004 compared to the regressions of data by Todd et al. (2004) in 1990 and 1997.

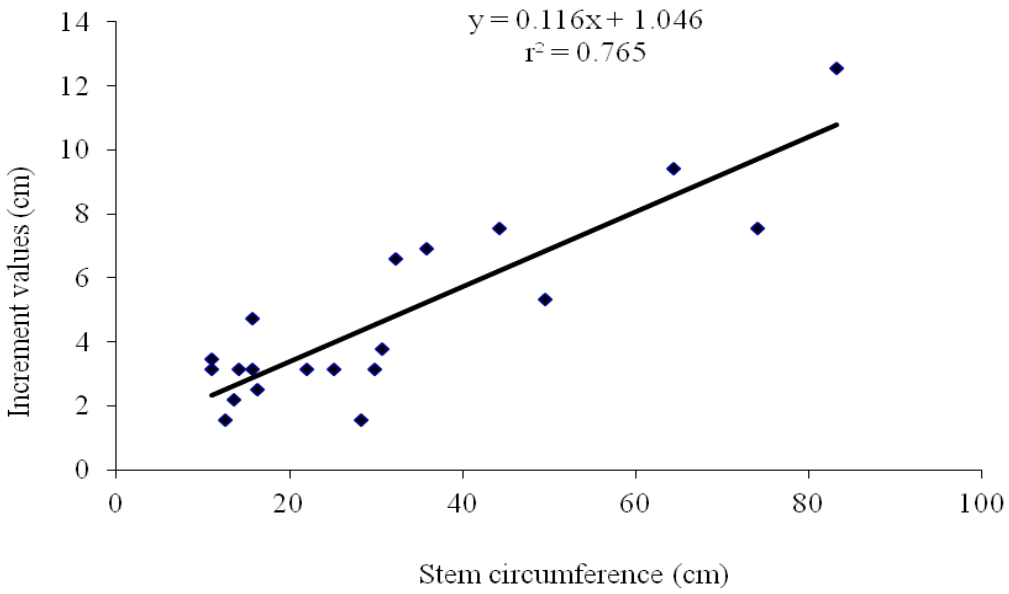

Figure 5. *Brackenridgea zanguebarica* annual stem circumference increment as measured at Thengwe, Venda region on data collected in 2004 and 2005.

Bark removal areas

Only 13% of the sample collected in 2004 as shown in Figure 8 showed some signs of bark removal with 1% of it showing 100% bark removal around the stem. Eighty-seven percent of the sample showed no signs of bark removal at all. This good state of affairs is attributed to the vigilant approach towards medicinal material collection enforced by the local tribal authority. However, it should be noted that harvesters preferred collecting medicinal material through stem removal from *B. zanguebarica* individuals and therefore the stems remaining on the plants do not show signs of bark removal.

It is important to note the size classes of stems that are mainly harvested in *B. zanguebarica* species. Harvesters preferred *B. zanguebarica* individuals with stem circumference of >20 to 30 cm size classes as shown in Table 1. However, the number of individuals harvested in the >20 to 30 stem circumference class represented only

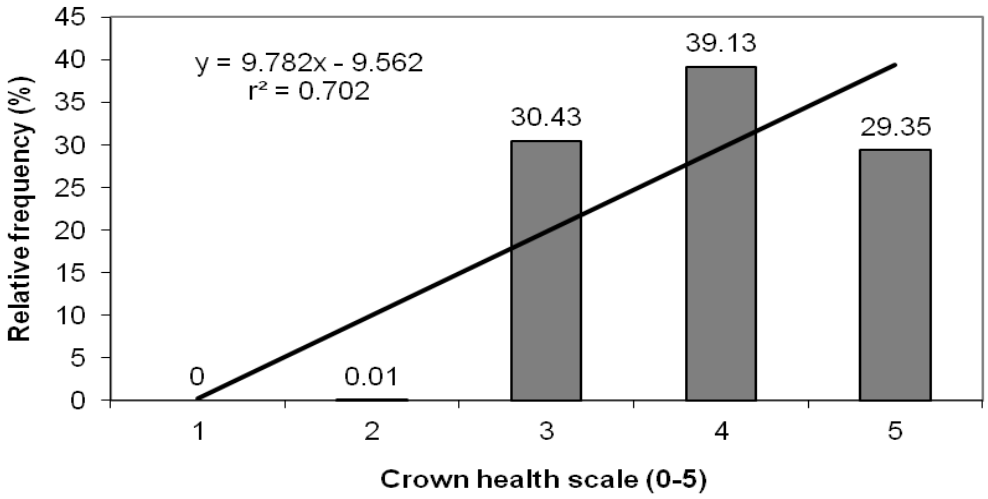

Figure 6. Crown health status of *Brackenridgea zanguebarica* populations in the Venda region, Limpopo, as determined by a survey in 2004. Crown health was assessed on a scale of 0-5 with 0 indicating 100% crown mortality and 5 indicating a healthy crown.

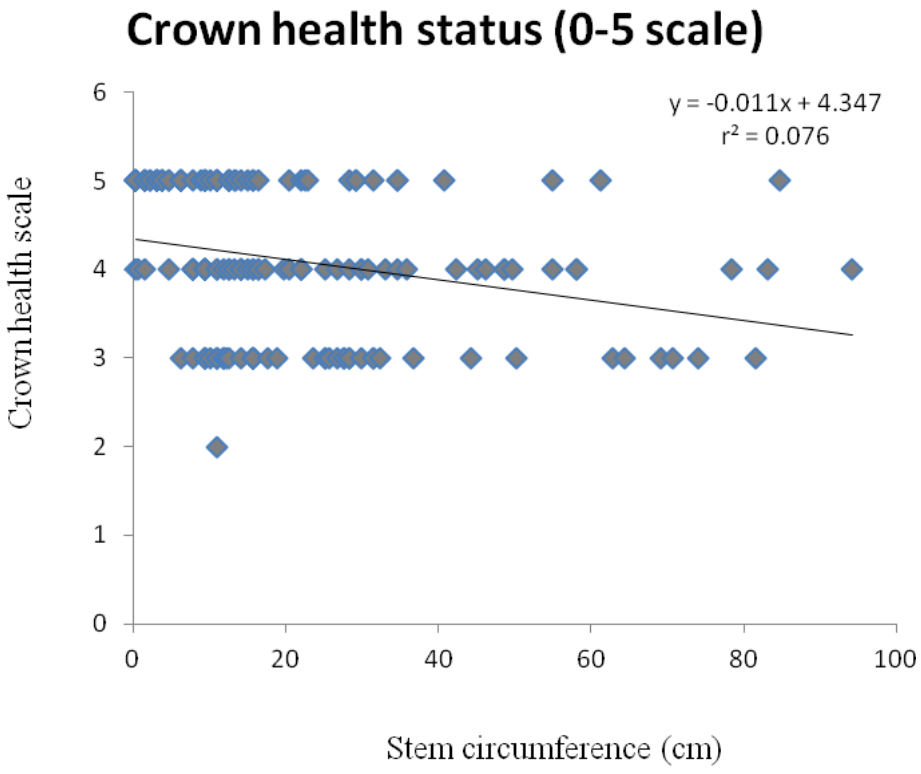

Figure 7. Correlation of crown health status and stem circumference of all individuals of *Brackenridgea zanguebarica* sampled in the Venda region, Limpopo, as determined by a survey in 2004.

34.61% of the entire size class. The >60 to 70 cm and >70 to 10 cm stem circumference size classes showed the largest proportion of harvested individuals, that is 100% and 67% respectively (Table 1).

DISCUSSION

Population structure

The results of the population structure (Figure 2) of *B.*

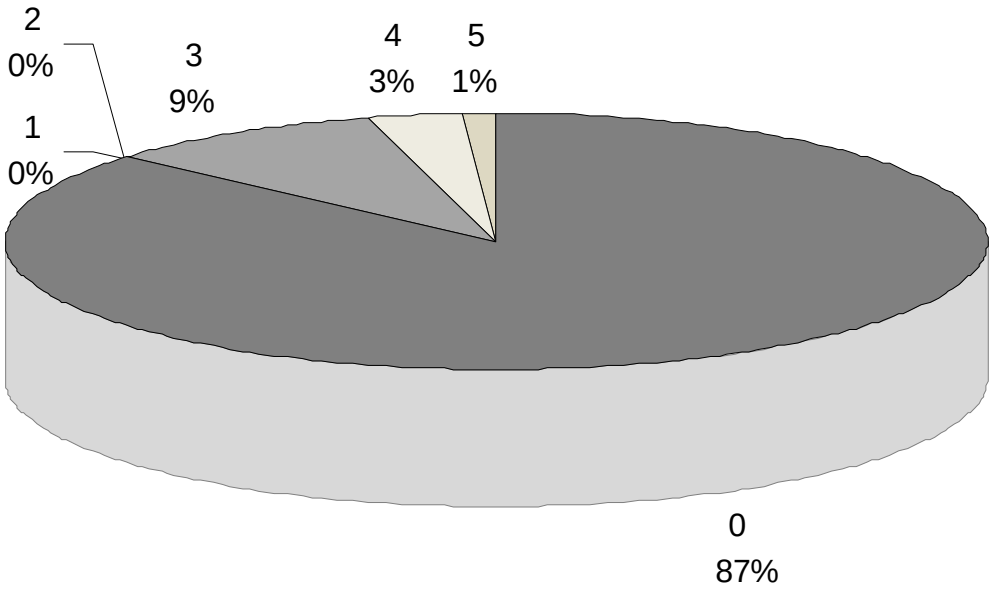

Figure 8. Bark removal estimates percentages on *B. zanguebarica* individuals from data collected in 2004 on a sliding scale of 0 to 5 with 0 indicating no removal and 5 indicating 100% removal of bark around the stem.

Table 1. Extent of harvesting on *Brackenridgea zanguebarica* individual trees through stem removal in data collected in 2004 at Thengwe study area.

Stem circumference size class (cm)	No. of harvested individuals	No. of unharvested individuals	Total number of individuals	Percentage of size class harvested
0-10	1	58	59	1.69
>10-20	1	50	51	2.00
>20-30	9	17	26	34.61
>30-40	1	10	11	9.09
>40-50	2	6	8	25.00
>50-60	2	3	5	40.00
>60-70	4	0	4	100
>70-80	2	1	3	66.67
>80-90	1	2	3	33.33
>90-100	0	1	1	0

zanguebarica indicated a healthy population as displayed by the inverse J-shaped curve (Cunningham, 2001; Peters, 1996).

The relative frequency reduction trend in the different size classes concurred with that recorded by Todd et al. (2004) from data collected in 1990 and 1997. Todd et al. (2004) recorded 57 and 50% of individuals in the 0 to 5 cm which dropped in the >5 to 10 cm diameter class to 30 and 18% in 1990 and 1997 respectively. The population also decreased tremendously to 7% in the >15 to 20 cm diameter size class of 1990 while it remained at the same percentage of 18% in 1997. The *B. zanguebarica* data of 2004 showed the presence of 3% of all individuals in the >20 to 25 cm diameter class as compared to 0% recorded in 1990 and 1997 data by Todd et al. (2004). There was also no significant difference in the slope or intercept between the 1997 and 2004 populations ($p = 0.8969$). It was therefore clear that significant changes have already occurred in the population since 1990.

According to Niklas et al. (2003), the ability of the population to fill space as gauged by stem size frequency distributions appears equally well achieved either by many small or a few large individuals.

Crown health

A large number of individuals with stem circumferences

of less than 40 cm showed healthy crowns (values 3, 4 and 5 on the sliding scale indicating only traces of crown damage or light crown damage). This assessment was a good sign of a well-managed population. Crown health is regarded as a good indication of overall tree health (Sunderland and Tako, 1999). Zierl (2004) has indicated that defoliation is widely used as an indicator for the vitality of forest trees and the degree of damage.

Bark removal areas

To avoid ring-barking of trees the traditional authority accompanied medicinal material collectors to the field. However, ring-barking of trees still occurred due to the high level of illegal harvesting. The bark theft on *B. zanguebarica* had also extended into the Brackenridgea Nature Reserve despite the presence of conservation officials during the day.

Although bark removal may contribute to the loss of crown health of forest species, it is important to devote more efforts to the identification of other possible stress factors that may cause forest decline. According to Zierl (2004), in some cases the decline may be due to natural processes that involve environmental stresses such as water availability or exceptionally high or low temperatures.

In conclusion the use of size-class distributions is regarded as a practical field method for assessing harvesting impacts and for illustrating the response of plant populations to harvesting pressure. Overall, the *B. zanguebarica* population has been found to be healthy as shown in the distribution curve. However, a comparison with size class distribution curves from 14 years previously, showed that significant changes had occurred in the size class distribution of the species and there were currently fewer small individuals.

In the *B. zanguebarica* population the supervised removal of medicinal material through stem cutting does not seem to have a negative effect on the crowns of the remaining stems. Such kind of practice should be encouraged amongst the tribal authority since it helps in maintaining the physiognomic structure of the vegetation. However, it is becoming evident that illegal collectors of medicinal materials do not follow the collection procedures supported by the tribal authority. Although the species has the ability to regrow its bark after bark harvesting, this does not mean that bark can be indiscriminately harvested. It is therefore important to determine the harvesting limit of *B. zanguebarica*.

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