CHAPTER 6

POPULATION BIOLOGY OF *BRACKENRIDGEA ZANGUEBARICA* OLIV. IN THE PRESENCE OF HARVESTING

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Abstract

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* 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, possibly because of its fine-grained nature. *Brackenridgea zanguebarica* showed a healthy population structure with lots of seedlings. The adult individuals showed a 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 diameter size classes were observed. Fewer older individuals have healthy crown covers since crown health status tends to decrease with increase in stem diameter.

Keywords: Bark harvesting, magical value, population structure, regeneration

6.1 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), Van Wyk *et al*. (1997) Tshisikhawe (2002), and Todd *et al.* (2004) 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
v. discouraging opponents in sporting events such as soccer.

Brackenridgea 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 Critically Endangered (CR) according to the IUCN Red List categories in South Africa (Raimondo *et al.* 2009). However, it occurs more widespread in southern African countries such as Zimbabwe and Zambia 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 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 illegal collectors 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 (Williams 1996, Tshisikhawe 2002, Botha 2004, Todd *et al.* 2004, Saidi and Tshipala-Rmatshimbila 2006) it is important to assess the effect of harvesting on its population structure. Knowledge of the size-class distribution, i.e. the frequency distribution of stems across diameter or circumference classes, can help in assessing the population for its sustainability (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 *Brackenridgea zanguebarica* in the presence of harvesting in a communal area.

6.2 Species and study area

Brackenridgea 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.

Brackenridgea 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 *Brackenridgea zanguebarica* was collected from the Venda region in the Thengwe study area (Figure 6.1). 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*, one of the most important and dominant species of miombo woodlands has its southernmost distribution in this vegetation unit.

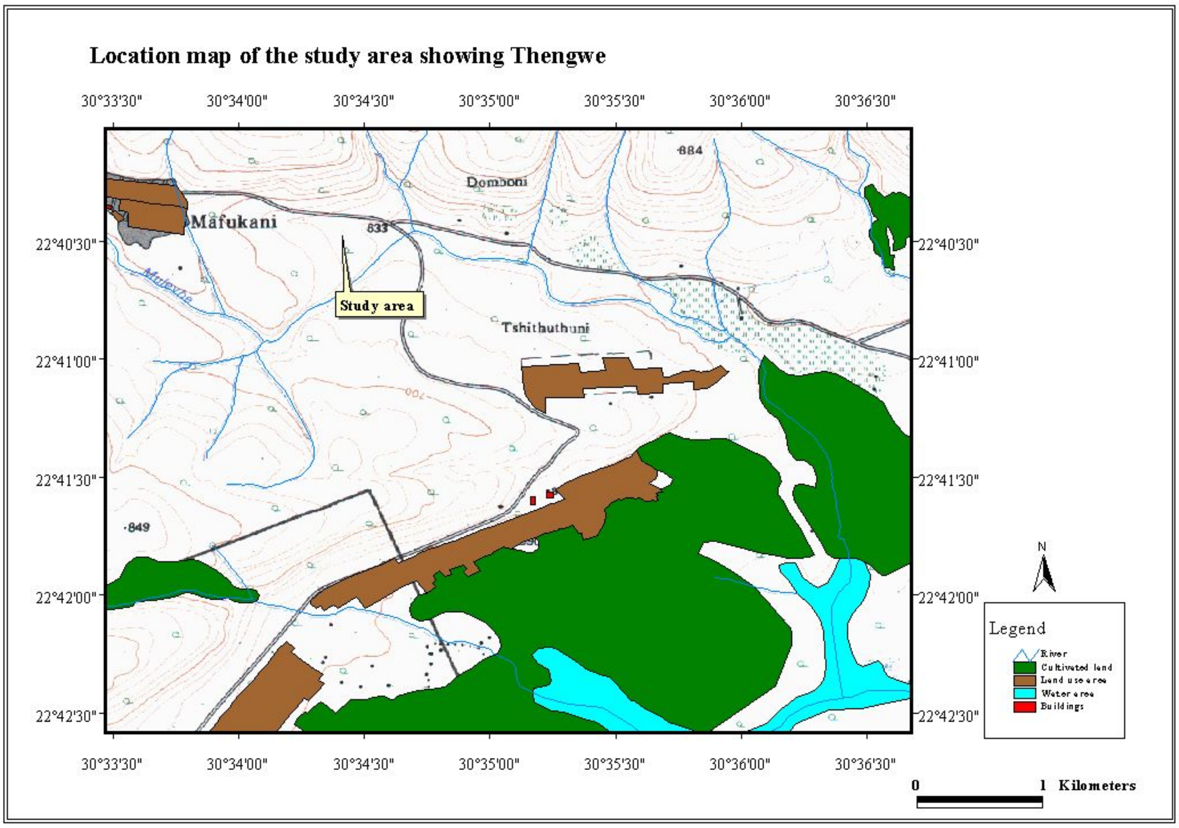

Figure 6.1: A location map showing the Thengwe study area where data on *Brackenridgea zanguebarica* was collected in 2004.

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 material. 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 material from *Brackenridgea 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 hence its common name as 'mutavhatsindi' (Ramaliba pers comm.[10]). 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 (Ramaliba pers comm[1]).

6.3 Materials and methods

Seven 100 m x 5 m transects were demarcated in order to sample the required data. The coordinates of each transect were recorded using a Global Positioning System. A rope was used to delineate transects. No control transects were demarcated due to lack of unharvested population within the same environmental gradients. The following data were recorded on all *Brackenridgea zanguebarica* individuals encountered within transects:

[10] Ramaliba, Traditional Healer, Thohoyandou, South Africa, Communication 2007

(i) Stem circumference (in cm) – measured with a measuring tape above the basal swelling. Stem circumference values were converted to diameter values for some calculations.

(ii) Crown health – estimated using a 0 – 5-point scale as follows:

0 - no crown at all,

1 – severe crown damage,

2 – moderate crown damage,

3 – light crown damage,

4 – traces of crown damage,

5 – healthy crown.

(iii) Bark removal area – estimated using a 0 - 5 point scale, with 0 indicating no removal and 5 indicating 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 transform 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 of different surveys 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).

The subcanopy and canopy densities were calculated as the sum of the number of individuals ≤30 cm circumference and larger than 30 cm circumference respectively. The use of subcanopy and canopy density, associated with frequency allows the grain of a species to be determined. The concept of species grain was developed for forests (Midgley *et al.* 1990); however, it has been successfully applied to woodlands (Gaugris *et al.* 2007, Gaugris and van Rooyen 2007) to establish which species could be harvested sustainably. The graphical model of Lawes and Obiri (2003) to determine species grain by plotting canopy density (X-axis) and subcanopy density (Y-axis) was used. The critical lower bounds for canopy and subcanopy density of 10 and 30 individuals per ha of Lawes and Obiri (2003) for forested systems were retained in this study.

6.4 Results and discussion

6.4.1 Population structure

The analysis of the population structure of *B. zanguebarica* as shown in Figure 6.2

indicates a healthy population as displayed by the inverse J-shaped curve (Peters 1996, Cunningham 2001). It is encouraging that the population has a fair amount of young individuals in the diameter class of 0–5 cm (approximately 70% of the population). However, individuals of the 0-5 cm the diameter class find it difficult to survive to the next class in large number since it shows a more than 50% reduction in the next size class of >5-10 cm diameter which constitutes approximately 23% of the population. The high mortality experienced early in the life cycle is characteristic of most long-lived species that have been studied (Silvertown and Charlesworth 2001). The more than 50% reduction is also experienced in the development of individuals from the >5-10 cm diameter class to >10-15 cm diameter class (7% of the population). The population remained at 7% in the >15-20 cm diameter class as well. 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.

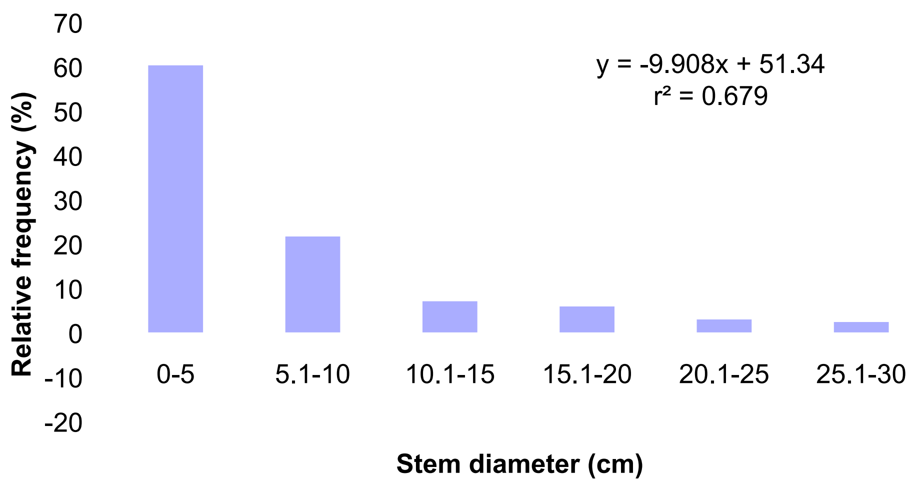

Figure 6.2: Size-class distribution of *Brackenridgea zanguebarica* from the Thengwe study area, Limpopo from data collected in 2004.

Todd *et al.* (2004) recorded 57% and 50% of individuals in the 0-5 cm which dropped in the >5–10 cm diameter class to 30% and 18% in 1990 and 1997 respectively. The population also decreased tremendously to 7% in the >15-20 cm diameter size class of 1990 while it remained at the same percentage of 18% in 1997. The *Brackenridgea zanguebarica* data of 2004 showed the presence of 3% of all individuals in the >20-25 cm diameter class as compared to 0% recorded in 1990 and 1997 data by Todd *et al.* (2004).

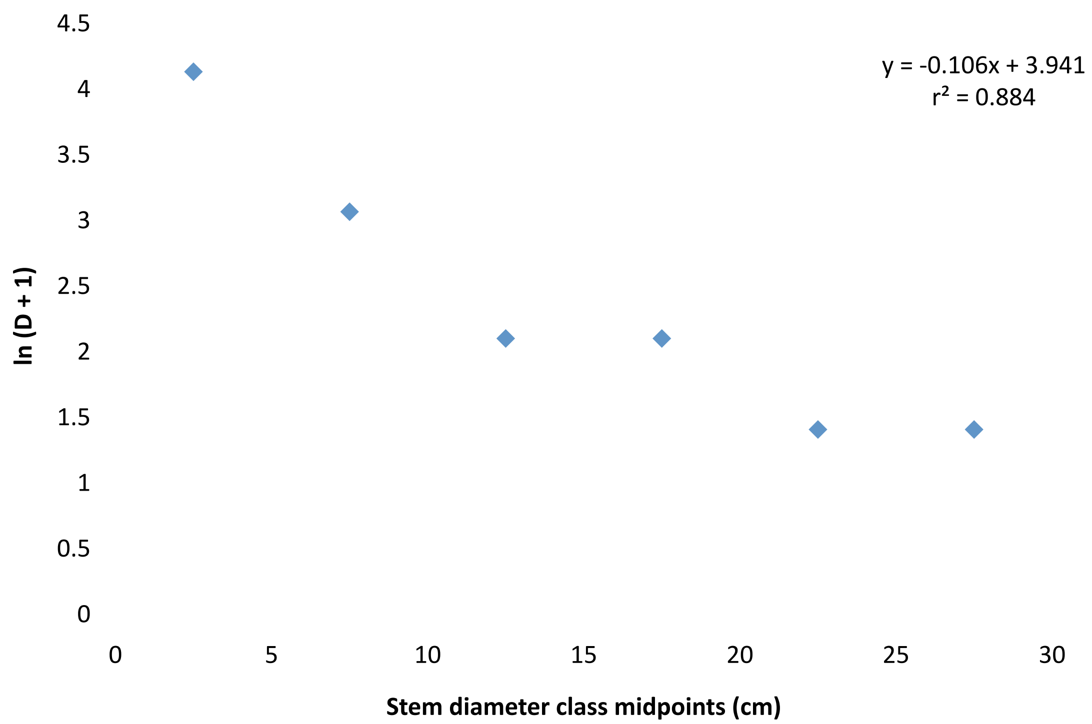

Figure 6.3: The regression of ln (D + 1) against stem diameter class midpoints for a *Brackenridgea zanguebarica* population from the Thengwe study area, Limpopo in 2004.

The position of the centroid (6.56 cm) was left-skewed in relation to the midpoint of stem diameter distributions (15.04 cm) and confirms the healthy status of the population in spite of harvesting. The linear regression on the natural logarithm of the density in the size classed against the size class midpoint (Figure 6.3) produced a significant linear regression ($r^2 = 0.8844$; $y = -0.1063x + 3.9419$; $p = 1.67 \times 10^{-3}$). 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 as has been done in Figure 6.4.

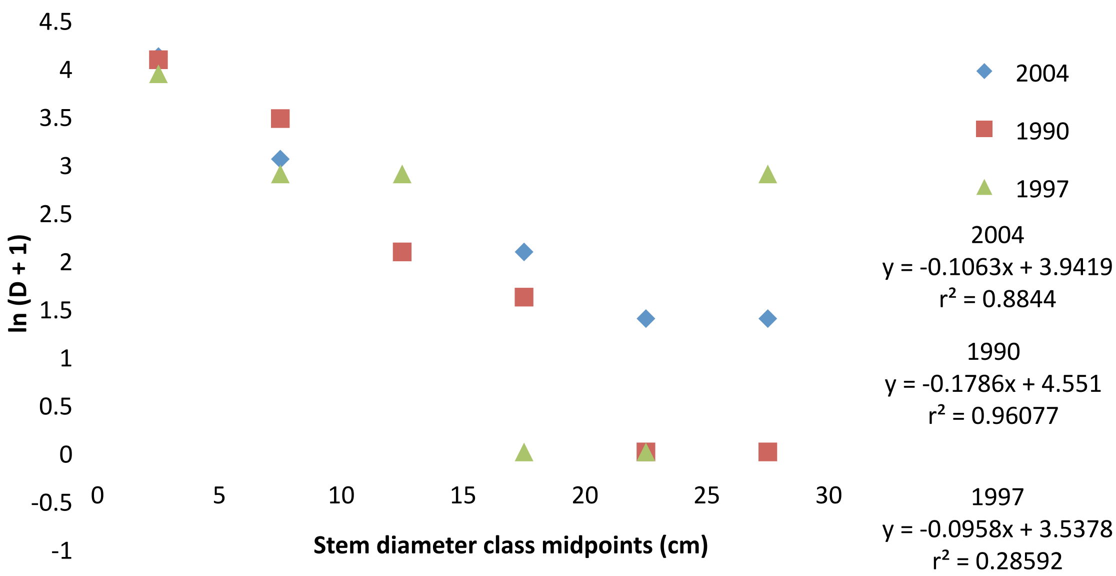

Figure 6.4: The regression of ln (D + 1) against stem diameter class midpoints for a *Brackenridgea zanguebarica* population from the Thengwe study area, Limpopo in 2004 compared to the regressions of data by Todd *et al.* (2004) in 1990 and 1997. (The 1st and 3rd points of 2004 data respectively overlapped with those of 1990 data).

The 2004 data were compared with those of Todd *et al.* (2004) in Figure 6.4. It is evident that the 1990 population regression had the steepest slope and the highest Y-intercept. 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 ($p = 0.3186$). There was also no significant difference in the slope or intercept between the 1997 and 2004 populations ($p = 0.8969$). It is therefore clear that significant changes have already occurred in the population since 1990 with the most noticeable difference being the presence of more large trees in 2004.

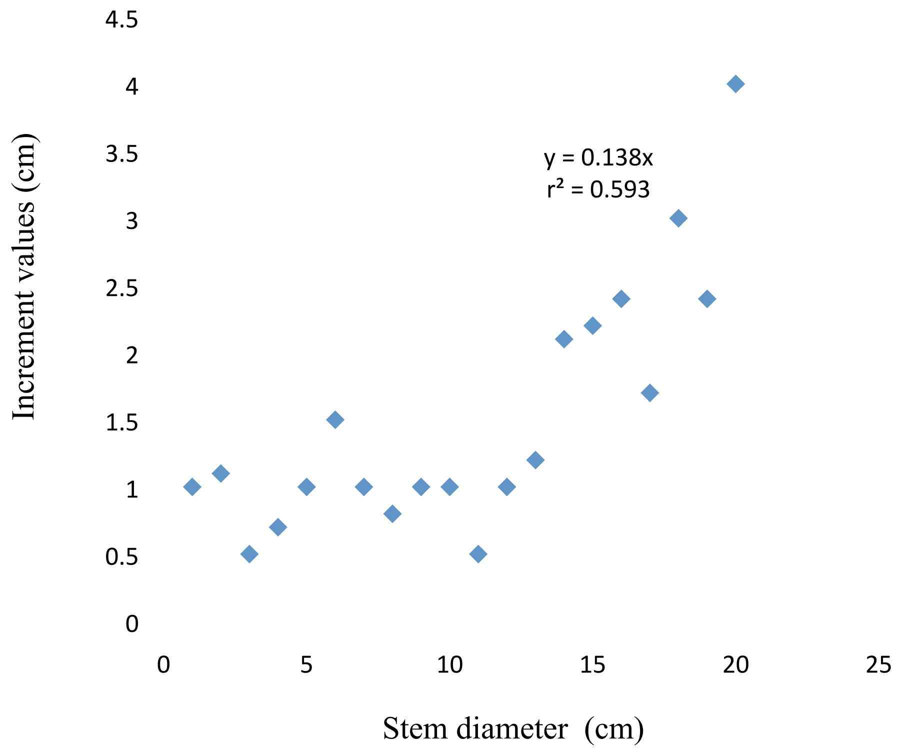

Figure 6.5: *Brackenridgea zanguebarica* annual stem circumference increment as measured at Thengwe, Venda region on data collected in 2004 and 2005.

Stem increment values of the *B. zanguebarica* population showed a linear regression as indicated in Figure 6.5 ($r^2 = 0.593$; $y = 0.138x$, linear regression forced through zero for it to be complete). The increment values were obtained from repeated sampling of stem circumference over two years. Because stem circumferences increments increase in proportion to stem size, individuals will remain longer within the smaller size classes than in larger size classes (provided that the size of all stem diameter classes is equal). For the 0 – 5 cm, >5 – 10 cm and >10 – 15 cm stem diameter classes the mean annual increase in circumference was 0.350 cm, 1.049 cm and 1.749 cm respectively. This translates into an individual remaining in the smallest size class (0 – 5 cm) for approximately 14 years, in the >5 – 10 cm size class for approximately 5 years and in the >10 – 15 cm size class for approximately 3 years.

6.4.2 Crown health

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. 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 6.6; $r^2 = 0.702$, $y = 9.782x - 9.562$; $p = 2.92 \times 10^{-2}$).

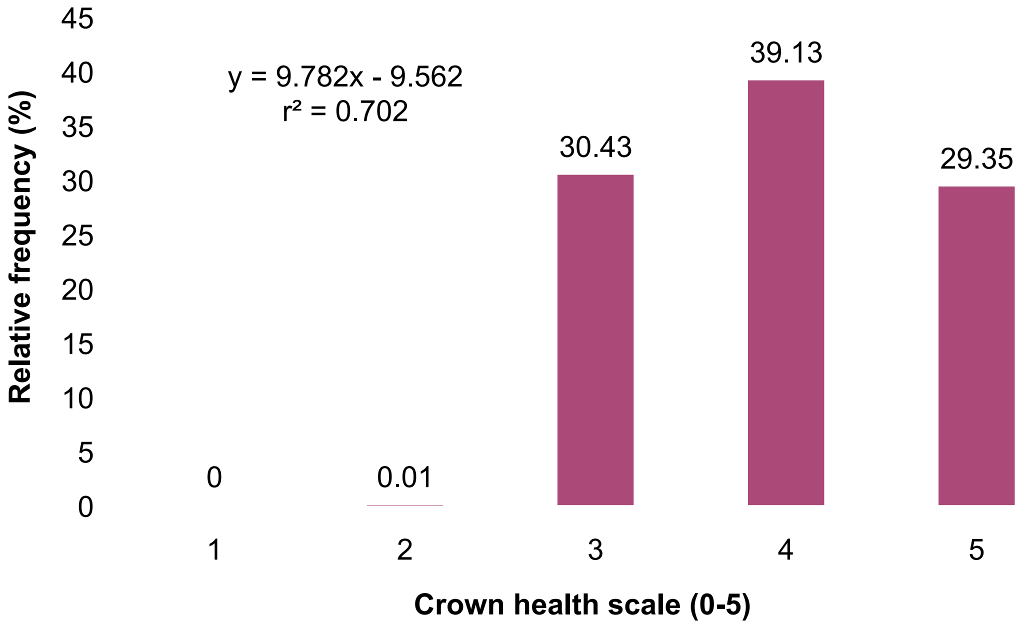

Figure 6.6: Crown health status of the *Brackenridgea zanguebarica* population in the Venda region, Limpopo, as determined by a survey in 2004. Crown health was assessed on a scale of 0-5 with 0 indicating 100% crown mortality and 5 indicating a healthy crown.

In spite of the intense harvesting pressure on the population, crown health status of the *B. zanguebarica* population was impressive considering the fact that none of the trees showed a crown status in the 0 category of the sliding scale. It shows that most of the individuals sampled have healthy canopies, which is a good sign of a well-managed population. As long as the stem is not ringbarked the species has the ability to regrow its bark and continue to have a healthy crown status.

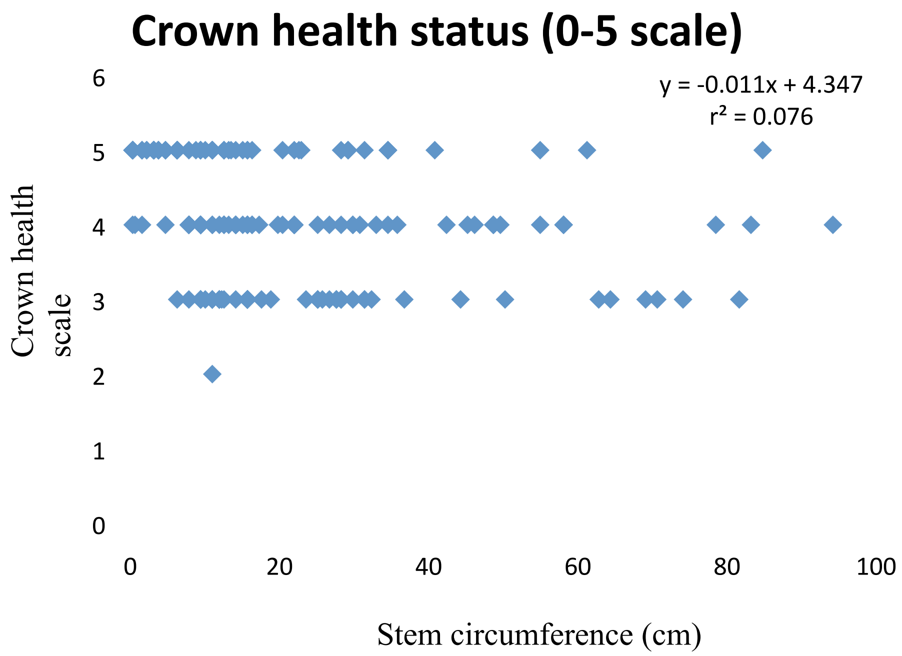

Figure 6.7: Correlation of crown health status and stem circumference of all individuals of *Brackenridgea zanguebarica* sampled in the Venda region, Limpopo, as determined by a survey in 2004.

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). In general, crown health status deteriorated slightly with an increase in the stem circumference. Therefore, fewer older individuals have health crown covers as shown in Figure 6.7 ($r^2 = 0.076$, $y = -0.011x + 4.347$, $p = 2.4 \times 10^{-4}$).

6.4.3 Bark removal areas

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

Only 13% of the sample collected in 2004 as shown in Figure 6.8 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 harvesting practice is attributed to the close monitoring of medicinal material collection enforced by the local tribal authority. However, it should be noted that harvesters prefer collecting medicinal material through the removal of entire stems from *Brackenridgea zanguebarica* individuals and therefore the stems remaining on the plants do not show signs of bark removal. Investigating entire stem removal could not be done since it could have involved disturbing plants that could not be allowed.

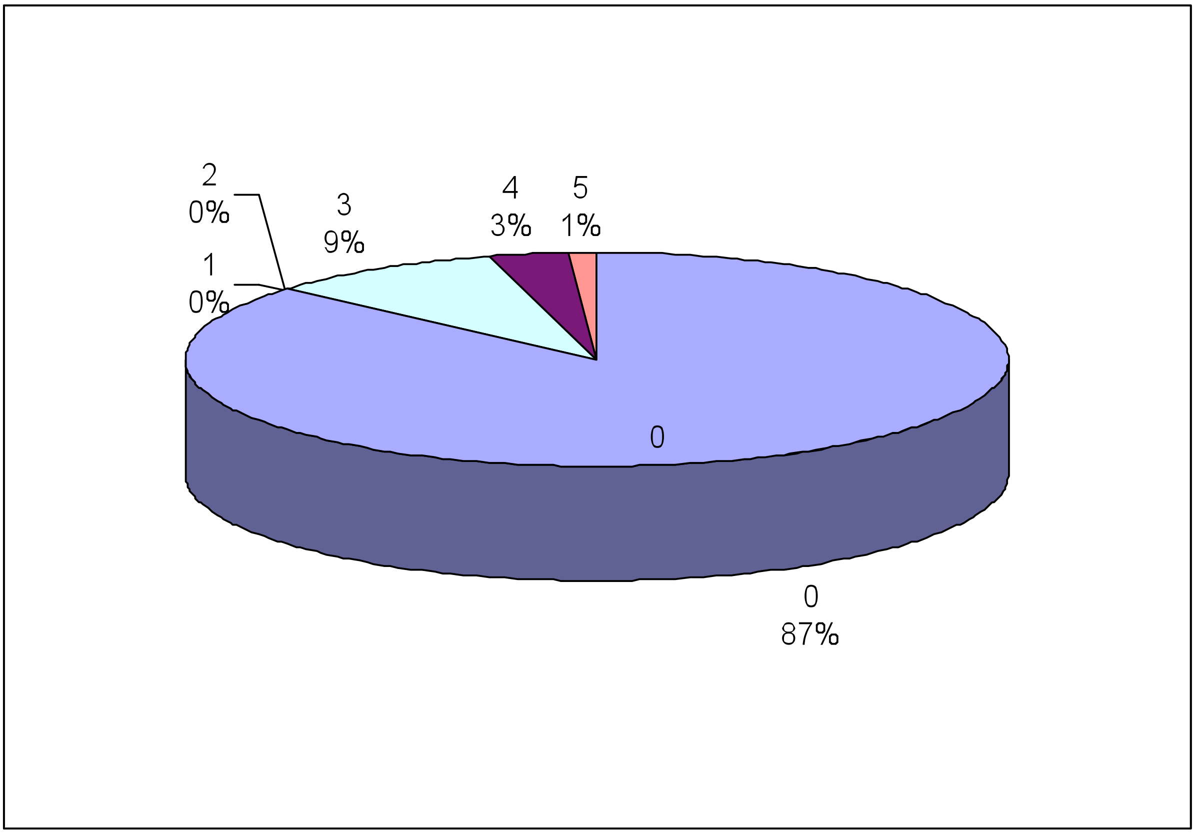

Figure 6.8: Bark removal estimates percentages on *B. zanguebarica* individuals from data collected in 2004 on a sliding scale of 0-5 with 0 indicating no removal and 5 indicating 100% removal of bark around the stem.

It is important to note the size classes of stems from which barks are mainly harvested. Harvesters prefer *Brackenridgea zanguebarica* individuals with stem circumference of >20 to 30 cm size classes as shown in Table 6.1. However, the number of individuals harvested in the >20-30 stem circumference class represented only 34.61% of the entire size class. The >60-70 cm and >70-10 cm stem circumference size classes showed the largest proportion of harvested individuals, i.e. 100% and 67% respectively (Table 6.1).

Table 6.1: 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

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.

6.4.4 Regeneration

Tree species respond differently to bark harvesting in terms of coppice regrowth (Geldenhuys 2004). The *Brackenridgea zanguebarica* population at Thengwe has stumps of trees that have been chopped to ground level. Although the species has the potential to resprout through coppicing it is recommended not to cut the tree to ground level since it will always take a long time to regenerate to maturity. The cutting of stems for medicinal purposes should where possible be limited to individuals with multi-stems. Removing stems from multi-stemmed individuals helps in maintaining the population since the remaining stems will still produce seeds while the removed stem is regenerating.

Obiri *et al.* (2002) concede that management systems that marginally alter the resource availability and whose off-take patterns do not exceed resource regeneration should be encouraged. An optimal harvesting system should take into consideration the availability of harvestable materials, rate of use as well as their potential to regenerate and maintain the sustainability of the population.

Figure 6.9: Stem of *Brackenridgea zanguebarica* showing bark regeneration on a harvesting scar caused by illegal harvesters as pointed out by the researcher in the Brackenridgea Nature Reserve, Thengwe. (Photo: K Magwede, Samsung Digimax 130).

Brackenridgea zanguebarica shows the ability to regrow its bark after being harvested (Figure 6.9). According to Todd *et al.* (2004) the bark appears to grow back relatively quickly after being harvested by producing a surface callus from the wound callus. Bark recovery, leading to persistence of individuals and populations, is a species-dependent trait (Delvaux *et al.* 2009, 2010). This bark regeneration ability in *Brackenridgea zanguebarica* is very important for the survival of mature individuals within the population. Furthermore, it is important for a population to recover from the loss of exploited individuals through demographic processes that allows continuous recruitment and establishment of new seedlings (Guedje *et al.* 2007).

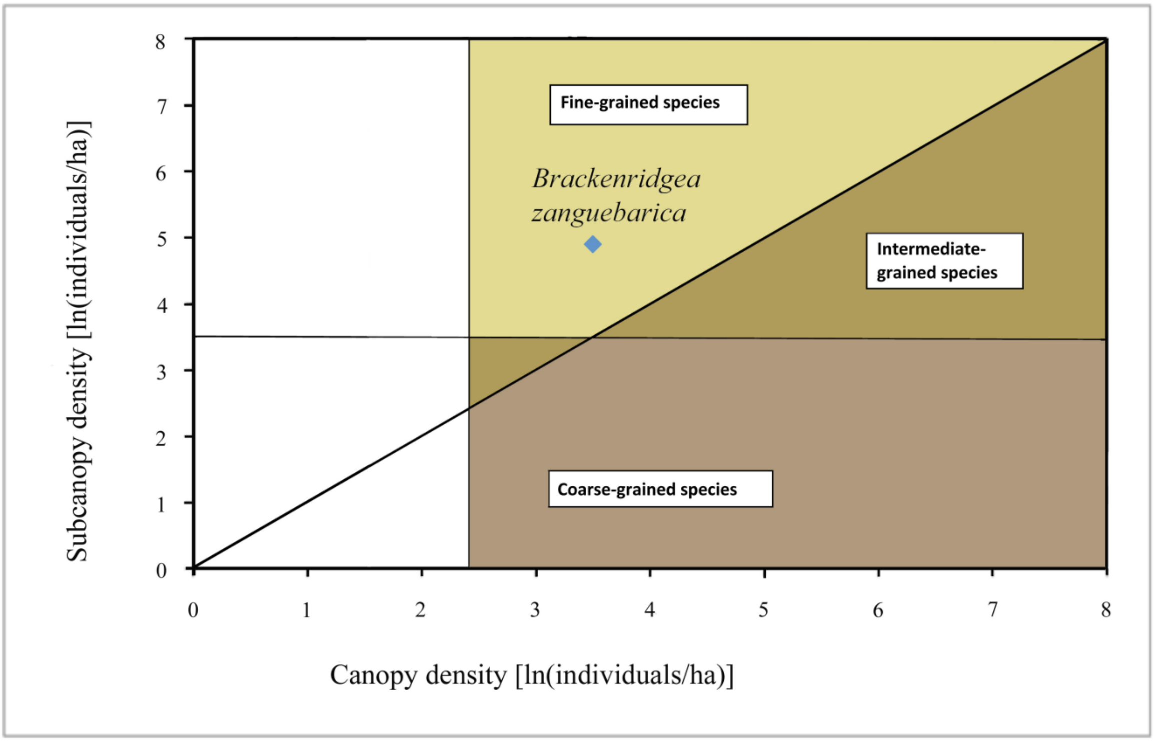

Figure 6.10: Species grain of the *Brackenridgea zanguebarica* population of Thengwe from data collected in 2004.

The *Brackenridgea zanguebarica* population from Thengwe study area could be classified as a fine-grained species (Figure 6.10). It would therefore appear possible to harvest this species sustainably provided more than 10 reproducing individuals are maintained in a hectare and 30 subcanopy individuals per hectare, since a ln value of above 2.3 on canopy density and 3.4 on subcanopy density indicate 10 and 30 individuals and above respectively in a hectare. *Brackenridgea zanguebarica* individuals are not used for construction or other purposes and bark-harvesting for medicinal purposes represents the only form of harvest. According to Obiri *et al.* (2002) the species grain theory suggests that fine-grained species should be able to withstand moderate levels of use, because these species show continuous recruitment of young individuals. Therefore with the proper harvesting techniques and close monitoring, *B. zanguebarica* may survive moderate harvesting levels.

6.5 Conclusions

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 *Brackenridgea 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 more large individuals. The species is able to regenerate from bark removal although it is important to analyze its response from repeated harvesting.

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 material do not follow the collection procedures recommended 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 *Brackenridgea zanguebarica*.

6.6 Acknowledgements

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