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Population dynamics of *Spirostachys africana* Sond. a species highly exploited amongst some communities of Limpopo Province, South Africa

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Abstract. *Victor PM, Tshisikhawe MP, Magwede K. 2023. Population dynamics of* Spirostachys africana *Sond. a species highly exploited amongst some communities of Limpopo Province, South Africa. Biodiversitas 24: 492-497.* Over-exploitation of important indigenous plant species impact negatively on their population structure. Unmonitored and unsustainable harvesting from plant ecosystems may inhibit plant recovery. The aim of the study was to investigate the population structure of *Spirostachys africana* in a communal area of Ha-Matsa Village in Limpopo Province, South Africa. Eleven transects of 100m x 10m were used to sample ecological parameter data from 66 plant specimens of *S. africana* species. Transects were subjectively placed within the population of *S. africana.* Data on plant height size classes and basal stem diameter size classes exhibited an almost Bell-shaped population curve. The population of *S. africana* did not have many seedlings, with the Crown health status data revealing a population with generally moderately damaged crowns (24%), while 19% of individuals had healthy crowns. The concern is the recorded 9% of dead crowns. Although the population looks great from a distance, the sampled ecological data revealed an unviable population. The *Spirostachys africana* population of Ha-Matsa Village does not have more individuals in the small size classes of both height and basal stem diameter. Conservation practice implies that if anthropogenic activities are not properly monitored, there may not be enough young individuals to support the population of *S. africana* into the future. Therefore, this study aimed to improve the assessment and the effects of harvesting on the *S. africana* species population. This study also suggests important information and guides ecologists and conservationists on sustainable harvesting practices and offtakes of *S. africana.*

Keywords: Anthropogenic, ecological, indigenous, over-exploitation, transects

INTRODUCTION

Tree species are a source of multiple benefits to the savannah, which these benefits include ecosystem maintenance by providing breeding sites for fauna and acting as a safety net against the poverty of communities, as well as delivering goods and services in the form of fuelwood, timber, and medicinal products (Madonsela et al. 2018). However, human influences on natural resources, particularly tree species, are problematic for species conservation. They mostly affect the functioning of the ecosystems and the benefits they provide (Jima and Megersa 2018) due to over-exploitation and unsustainable use of biodiversity and its components (Deepa et al. 2018). Over-exploitation, unsustainable use of natural resources, increasing agricultural expansion, fire, construction, overgrazing, and urbanization result in slow-growing trees. Such as *Spirostachys africana* on that condition leading to death and failure to recover, leading them to either rare or endangered status over time (Tshisikhawe 2012; Jima and Megersa 2018). *S. africana* is recorded as the only highly exploited member of the genus *Spirostachys* (Semenya and Maroyi 2019).

Harvesting in many other anthropogenic disturbances plays a major role in shaping the population structure of plant species (Bakali et al. 2017). The effects of harvesting usually depend on factors such as the plant part harvested, the life history of the species, the season of harvesting as well as the intensity of harvesting (Schmidt and Ticktin 2012; Soumya et al. 2019). Understanding the effects of various disturbances on plants is important in designing multiple-use management plans for semi-arid savanna systems (Van Coller et al. 2018). For example, a lack of management practices can lead to early or inappropriate harvesting of tree species. In addition, the harvesting regime (i.e., season, intensity, and interval) affects the population dynamics of species being harvested (Schmidt and Ticktin 2012). For example, early harvesting eliminates sexual reproduction ability and causes adult mortality (Uusi-Heikkilä et al. 2015). Therefore, assessing the effects of harvesting on the population of tree species is important in informing species conservation options, guiding sustainable harvesting practices and offtakes, and supporting local livelihoods (Soumya et al. 2019). According to Ticktin et al. (2018), studies considering the ecological impacts of harvesting need to take a more community or systems perspective that mirrors the multiple positive and negative links between the plant species of interest and other species and processes that may be occurring simultaneously with harvesting.

Understanding species' population dynamics (population ecology), particularly in communal areas and areas that are easily accessible to the public, is important because unsustainable harvesting of plants can drive vegetation into patchiness or narrow distribution of plant species (Botha et al. 2017). This assists in paving the way for developing sustainable harvesting strategies and conservation options for various species (Soumya et al. 2019). Population ecology studies, such as population dynamics, consider population size structure and geographical distribution of species and how and why these changes or stay constant over time (Cousins et al. 2014). These studies provide an understanding of the interactions on the impact between species and their environment (environmental conditions, resources, neighbors, and disturbance) and are important baseline information for monitoring and conserving species (Tshisikhawe et al. 2012; Cousins et al. 2014).

Knowledge of species' population size structure and information on the distributions of its abundance in time and space helps explain the relationships between the species and its environment (Cousins et al. 2014). An analysis of the frequency distribution of stems across diameter size classes can assess population size structure. Knowledge of the lifeform variables of a population can be used in a more refined analysis of its population (Tshisikhawe and Van Rooyen 2013). Moreover, a size class distribution analysis provides a practical field method for investigating population structure while illustrating the population's response to harvesting pressures (Tshisikhawe et al. 2012). Tree size-class distributions can also provide demographic information on regeneration and recovery from disturbances (Muvengwi et al. 2020). Abundant seedlings and juvenile individuals relative to adults in a population are generally interpreted as an indication of a healthy, stable, and potentially growing population. Conversely, a scarcity of seedlings and juveniles may indicate a declining population (Cousins et al. 2014). At a plant community level, species richness is considered a size-class-dependent phenomenon (Tshisikhawe 2012).

Variations in population size structure and density within a species distribution may be brought about as a result of numerous factors, such as differences in disturbance severity, habitat degradation or fragmentation, and the extent of available habitats. On the other hand, the size and density of individual populations may also vary from year to year based on spatial and temporal patterns in rainfall and disturbances (Cousins et al. 2014).

MATERIALS AND METHODS

Study area

This study was carried out at Ha-Matsa Village (GPS coordinates: 22.8715 S, 29.9657 E) located in Makhado local municipality, within the Vhembe district in the province of Limpopo, South Africa (Figure 1). The village is found within a savannah biome with predominantly a mix of Lowveld and Bushveld vegetation types. A semi-arid climatic zone represents an area with dry, cold winters and hot, wet summers and experiences periodic droughts.

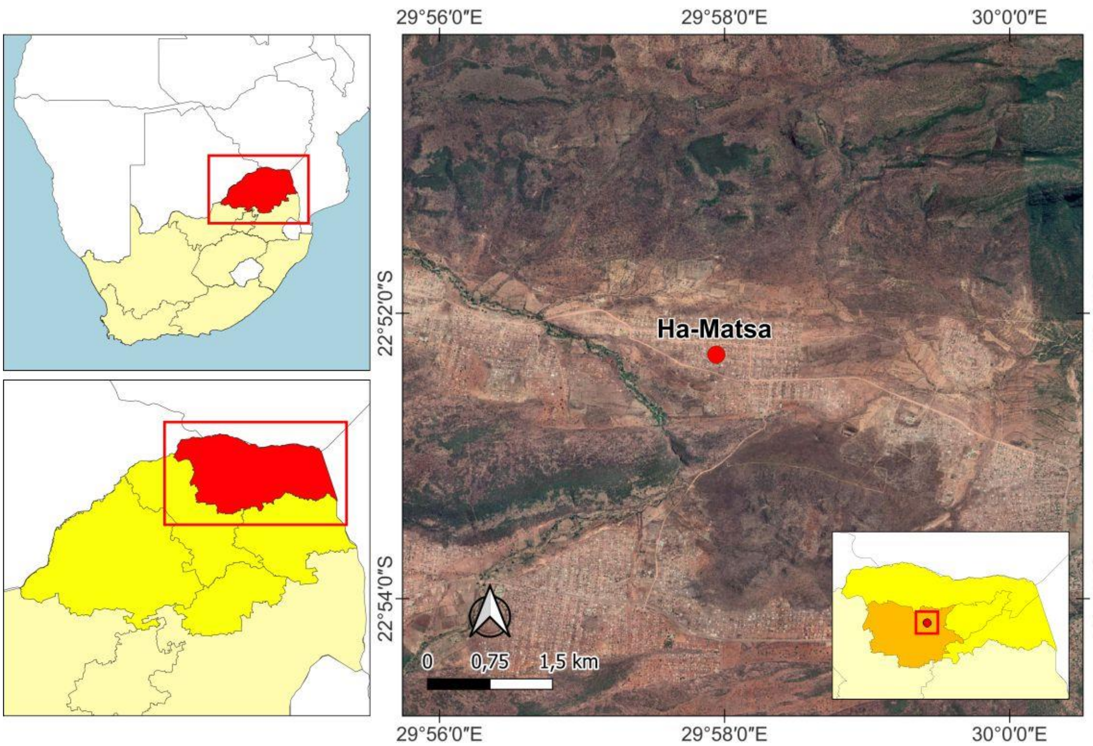

Figure 1. A map of the Ha-Matsa Village study area, Vhembe district, South Africa

Data collection

Eleven 100 m X 10 m line transects were subjectively laid in the population of *S. africana* using aggregated measuring tapes. The transect was constructed by laying down a 100 m measuring tape in a straight line in the middle of the transect. *S. africana* individuals within five meters on either side of the 100 m measuring tape were sampled. The following ecological parameters were recorded: (i) height using a height measuring pole, (ii) basal stem diameter with a diameter tape, and (iii) crown health status using a zero to five sliding scale estimate. The sliding scale recordings were estimated concerning crown damage as follows (Tshisikhawe et al. 2012): 0: 100% mortality, 1: severe damage, 2: moderate damage, 3: light damage, 4: traces of damage, 5: healthy crown.

Each *S. africana* individual was also assessed for evidence of harvesting. In addition, the form of disturbance, either anthropogenic or natural other than harvesting, was recorded in the study site. Data were captured and analyzed for frequencies and percentages through the Microsoft Office Excel program's descriptive statistical analysis.

RESULTS AND DISCUSSION

Population structure of *Spirostachys africana*

Based on basal stem diameter (BSD), *Spirostachys africana* individuals sampled in this study were grouped into four age classes, namely, seedlings (individuals with BSD of 0.1 cm to 1cm), juveniles (individuals with BSD of 1.1 cm to 20 cm), sub-adults (individuals with BSD of 20.1 cm to 60 cm) and adults (individuals with BSD of 60.1 cm and above). Table 1 shows that ninety-six *S. africana* individuals were found in the study area, most recorded in the sub-adults (n = 60) category. Moreover, 23 young and 13 adult/mature individuals were recorded, and no seedlings were found in this study. However, two individuals resprouting from the stumps cut very close to the ground (about 10 cm) were observed and recorded under the young age class as per stem diameter.

The BSD recorded were used to determine the size-class distribution curve of the *S. africana* population. Individuals were further grouped into five categories based on their basal stem diameter. Three ideal types of size-class distribution curves can be recognized for tree populations: namely, the typical reverse J-shaped curve, the bell-shaped curve, and the straight horizontal line (Tshisikhawe and Van Rooyen 2013). Traditionally, an inverse J-shaped curve indicates healthy and stable plant populations represented by continuous recruitment of seedlings (Tshisikhawe and Van Rooyen 2013; Cousins et al. 2014). The bell-shaped curve indicates a lack of seedlings and young plants, and a high number of sub-adult individuals mostly represents it. Finally, the straight horizontal line depicts a population with a relatively low establishment of seedlings and young plants (Tshisikhawe and Van Rooyen 2013). Tshisikhawe et al. (2012) ascertained that a population that fails to recruit new seedlings has a high probability of facing local extinction. Figure 2 shows a skewed bell-shaped size-class distribution curve of the *S. africana* population at Ha-Matsa Village.

Table 1. Age class categories and frequency of recorded *Spirostachys africana* individuals

Age class	Total # of individuals
Seedlings	0
Young	23
Sub-adults	60
Adult/matured	13
Total	96

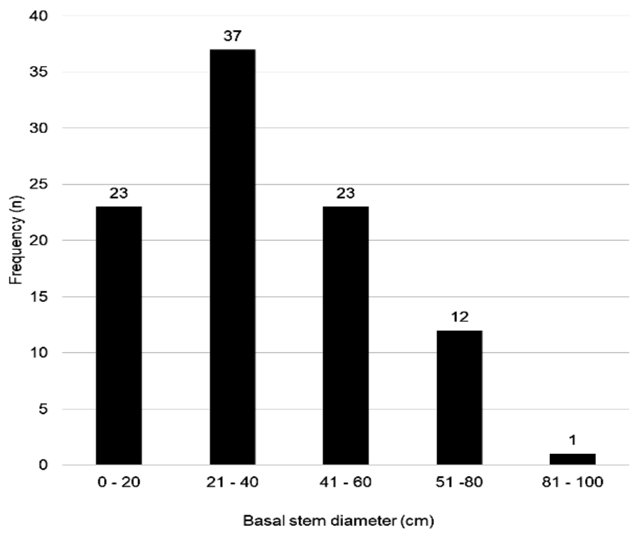

Figure 2. Basal stem diameter size-class distribution of *Spirostachys africana* population sampled at Ha-Matsa Village, Vhembe district, South Africa

The bell-shaped display curve means that the *S. africana* population at Ha-Matsa Village is failing to recruit seedlings and has a subsequent proportion of few young individuals. Cousins et al. (2014) observed a bell-shaped size-class distribution curve when they studied the population structure of *Aloe plicatilis*. They ascribed their results to low inter-annual variation in rainfall, possible theft, and herbivory of individuals in the smaller size classes that could result in episodic or no recruitment of seedlings. In the current study, the lack of recruitment of seedlings can be ascribed to the observed harvesting regimes and the fact that the study area is in an open, accessible communal land with evidence of anthropogenic activities.

Plant heights assessments

The plant heights were categorized into five class sizes, and percentage representation for each category was also calculated (Figure 3). According to Lennox (2019), an adult/mature *S. africana* can grow to 10-18 m tall. Fifty percent of individuals recorded in the current study were found to occur in the middle height category (4.1-6 m), followed by 33% of individuals between 6.1m and 8m tall. A low number of small tree heights between 0 and 4 m (13%) and trees taller than 8 m (9%) was recorded. Only 3% of *S. africana* trees (n = 3) recorded in this study were found to have reached about 9.5m tall, which means that only 3% of the surveyed population managed to reach their maximum height and most likely maturity stage.

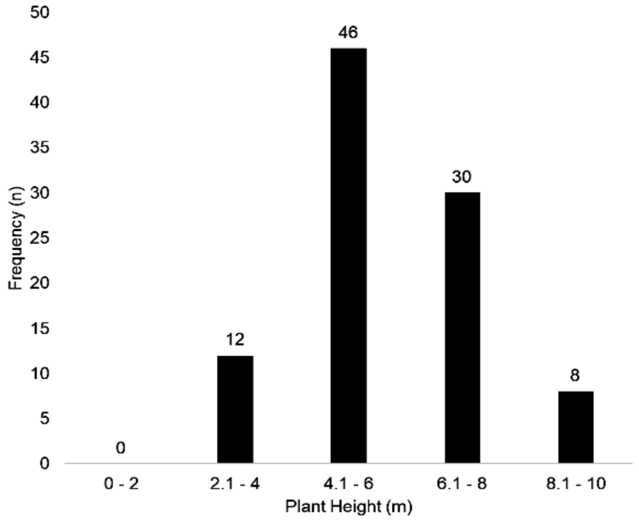

Figure 3. Height class distribution of *Spirostachys africana* population sampled at Ha-Matsa Village, Vhembe district, South Africa

Observations in the current study clearly indicate that harvesting regimes have impacted the height of *S. africana* species. The impact of branch harvesting possibly explains the lack of seedlings in the study area. Bakali et al. (2017) studied the population structure of *Androstachys johnsonii* and recorded a low percentage of individuals that reached their maximum growth height, similar to the current study. They associated repeated harvesting of *A. johnsonii* as a reason for most individuals not reaching maximum height. The plant height measurement data further confirms that the *S. africana* population of *Ha-Matsa* is not recruiting new seedlings that will mature into seed-producing adults, resulting in an unstable population.

Harvesting impact on *Spirostachys africana*

The most direct impact that harvesting has is on the harvested individual's survival, growth, and reproduction (Ticktin and Shackleton 2011). Sixty percent (n = 58) of *S. africana* plants surveyed were found to have evidence of harvesting. No evidence of harvesting was found in the remaining 40% (n = 38) sampled *S. africana* trees. Harvesting of *S. africana* in this study varied from harvesting bark and branches/canopy section to a complete chopping down of a whole tree. Cutting by panga, axe, and/or saw was observed and found to be the most preferred method to harvest required tree parts. The results further show that a large number of adult/matured (i.e., individuals with a basal stem diameter of greater than 20 cm) *S. africana* individuals (n = 53) have been harvested. Evidence of harvesting multiple parts of *S. africana* in the adult/matured age class was also observed in twenty-three individuals. That excludes three trees that were completely cut down with only stumps left.

Stem harvesting

The current study found evidence of stem harvesting on 11% of *S. africana* trees surveyed. Interestingly, harvesting of stems was predominately found on *S. africana* trees with multiple stems. Apart from the three adult/matured trees that were completely chopped down with only a stump left, only a single stem from those trees with more than one stem was cut. That could suggest that individuals harvesting *S. africana* stems have some level of understanding of the need to harvest the species sustainably. In addition, evidence of resprouting was observed at the base of all *S. africana* stumps that were assessed. Bakali et al. (2017) also found a similar form of resprouting of *A. johnsonii* at the base of stumps after harvesting. This pattern of resprouting was associated with the height at which the tree was cut and is understood to have an impact on sources of buds for resprouting.

Bark harvesting

According to Delvaux et al. (2009), harvesting bark or roots can be more damaging to tree survival. However, their study found that tree response to bark harvesting regimes is species-specific. Tshisikhawe et al. (2012) found that *S. africana* bark is harvested for medicinal purposes. In the current study, evidence of bark harvesting was observed on 39% (n = 27) of the trees surveyed. Seventy percent of trees with evidence of bark harvesting were sub-adults, followed by adults/matured with 22% and only 8% of adults/matured trees. Most trees were lightly damaged, with only one individual showing evidence of bark stripping (Figure 4). Therefore, bark harvesting in the current study did not significantly impact the health and survival of the *S. africana* trees surveyed.

An old scar from bark harvesting was also observed on the exposed root of one of the *S. africana* individuals. Interestingly, the same root with a bark harvesting scar was found to be recovering and had evidence of root suckering. It is important to note that none of the literature reviewed had indicated that *S. africana* can grow through root suckering, making this study the first to establish root suckering in this species.

Crown health

Changes in canopy density influence light regime and other microclimatic changes, such as air and soil temperature or humidity (Wagner et al. 2011), and may influence species diversity and abundance. Therefore, the condition of tree crowns is an important indicator of tree health (Morin et al. 2015). The crown health data showed that the *S. africana* population of *Ha-Matsa* is dominated by trees with some level of crown damage (Figure 5). Twenty-four percent of the trees were found to have a moderately damaged crown, followed by 20% of trees with a severely damaged crown, 15% with a lightly damaged crown, 14% with traces of crown damage, and 9% of trees that had complete mortality of crown, or the crown was completely removed. Nineteen percent of the trees displayed healthy crowns; however, some of these trees with the healthy crown had other parts harvested, particularly the bark. Thus, a high number of *S. africana* found in this study had evidence of crown harvesting or disturbance.

Figure 4. An individual with severe bark harvesting as observed at Ha-Matsa Village, Vhembe district, South Africa

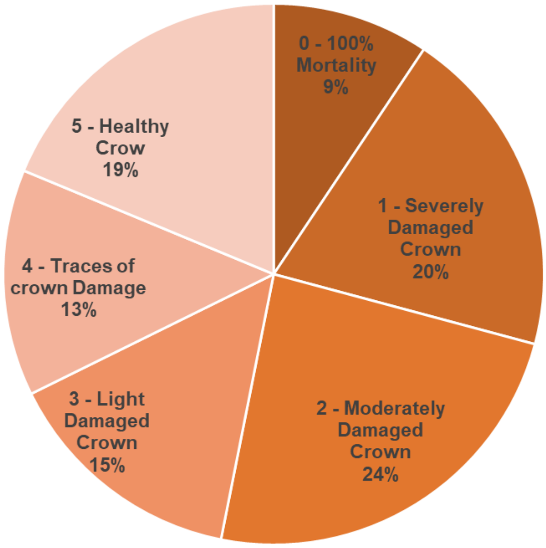

Figure 5. Crown health status of *Spirostachys africana*

Anthropogenic activities such as fires observed in this study and severe weather conditions could be driving plants in this area into distress. Morin et al. (2015) ascertained that crown dieback is the most important crown condition variable for predicting tree species' survival. The impact of crown harvesting observed in the current study suggests that most *S. africana* trees at Ha-Matsa Village are unhealthy. That can also be associated with the decrease in growth and seed production rate, potentially explaining why no seedlings were observed in this study.

In conclusion, Severe harvesting, particularly wood harvesting, lowers woody species' structural variables, i.e., height, stem basal area, and canopy cover (Muvengwi et al. 2020), resulting in a greater probability of reducing seed availability as a result leading to a decreased or no regeneration of a population. Stressed plants tend to reduce their growth rate and seed production subsequently. This study's data clearly indicates that *S. africana* is harvested for different uses and that multiple parts/organs of these trees are utilized, with the canopy or crown of this species being severely impacted. The BSD data and tree height data indicate the *S. africana* population of Ha-Matsa Village is predominately represented by sub-adults and fewer adult/matured trees, as well as a few young trees. Most trees surveyed were found to have unhealthy crowns due to the harvesting severity, particularly in the crown and stem sections. Anthropogenic activities observed in the study area and extreme weather conditions negatively impacted seedlings' establishment.

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