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Impact of Ethnobotanical Utilization on the Population Structure of *Androstachys Johnsonii* Prain. in the Vhembe Area of the Limpopo Province, South Africa

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Abstract

Due to high levels of impoverishment, rural communities in southern African are highly dependent on their surroundings to sustain their livelihood. However, the rampant harvesting of *Androstachys johnsonii* Prain. In Vhembe area is a cause for concern although its conservation status is of Least Concern. *Androstachys johnsonii* is a tree species used for a variety of purposes in the Vhembe Area of South Africa to maintain households. Thus in order to obtain baseline data to propose ways of preserving the species, an investigation was launched to determine the extent of usage of *A. johnsonii* at Matshena village and document its population structure via stem size classes, crown health and plant height classes. Results indicate that this tree species is being used for a variety of purposes by inhabitants, with 65% of trees surveyed showing signs of harvesting. Due to its extremely durable hardwood this species is mostly used for fencing, roofing, pillar construction, and as firewood. Additional ethnobotanical uses include fodder for goats and cattle and medicinal purposes. Of the 353 *A. johnsonii* trees measured, the majority (27%) are in the 0-10 cm stem size class, and nearly 88% are lower than 5 m in height. Trees mostly had crowns with some extent of damage, and were to a large degree multi-stemmed. From the above, it is clear that *A. johnsonii* is in dire need of formal (legislative) and traditional (tribal) protection if the population is to be managed in a sustainable manner for the preservation of future generations. It is suggested that this species be elevated in discussions with provincial environmental authorities, and community elders and chiefs be informed about the long term ecological and environmental consequences that current unsustainable harvesting practices will have on this multi-use species.

Keywords

Ethnobotanical use, Harvesting impact, Traditional protection, Environmental authorities, Multi-use species

Introduction

There is an urgent need for conservation measures and adoption of sustainable use methods throughout Africa to avoid further degradation of natural resources since such resources are important to the livelihood of poor households [1]. According to Chazdon [2], human impact in savanna environments frequently leads to vegetation changes that take place faster than natural vegetation transformations, as human-caused disturbances often occur in the form of continuous and widespread stress, e.g. frequent fires, grazing, and logging.

Stand characteristics such as tree population size and density can also be strongly modified following anthropogenic disturbances, which in turn may have important consequences for tree population sustainability [3]. Changes in tree populations are difficult to quantify directly because there are often different controls or filters on recruitment, growth, and mortality of individuals [4]. Despite these factors, there is an increasing desire to manage and monitor tree populations for the maintenance of forest ecosystem process, or to determine the long-term effects of management's activities [5]. Species and functional group size class structures can be used to assess drivers of population change in tree species [6]. In

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this regard population biology, more specifically population dynamics, attempts to explain the origin of these different kinds of structures, and understand how and why they change with time [7]. Population structure in forestry and ecological studies has been defined in terms of the size class or stem diameter distribution of individuals [8]. The population structure can be assessed by analysis of frequency distribution of stems across diameter classes [9,10]. The size class distribution data can also be used to assess the potential of the population for its sustainable use [11].

Androstachys johnsonii Prain, the Lebombo Ironwood, is a slow-growing tree species belonging to the family *Euphorbiaceae*. It is native to South Africa, Botswana, Lesotho, Namibia, Swaziland and Madagascar, where it is mostly valued for its hard wood, which is used for construction of traditional huts, and is commonly traded for use as fence poles [12]. In southern Africa with its high levels of unemployment and poor socio-economic conditions, impoverished residents are very depended on their immediate surroundings [13]. In this regard *A. johnsonii*, is viewed as a multi-use species within southern Africa, with many benefits to surrounding human communities. At the Matshena village, a typical rural village in the Vhembe district of South Africa, community members not only use this species for a variety of purposes, but also in large quantities to sustain their impoverished livelihood. This has already resulted in large areas around communities being depleted of this species. Although its conservation status is listed as Least Concern, continued over-exploitation of this species could result in its extinction in the near future. Thus in order to obtain baseline data to propose ways for preserving the species, an investigation was launched to determine the extent of usage of *A. johnsonii* at Matshena village, and document harvesting pressure on its population structure via stem size classes, crown health and plant height classes.

Material and Methods

Description of the study area

The Matshena study site was selected based on the availability of *Androstachys johnsonii* population and its usage by local communities. Matshena village is situated in the Mutale Local Municipality of the Vhembe District, Limpopo Province, South Africa (Figure 1). The settlement pattern is dispersed in terms of size, function, services and population. The area largely consists of communally-occupied land and includes a large number of rural settlements (estimated at 150), administered by

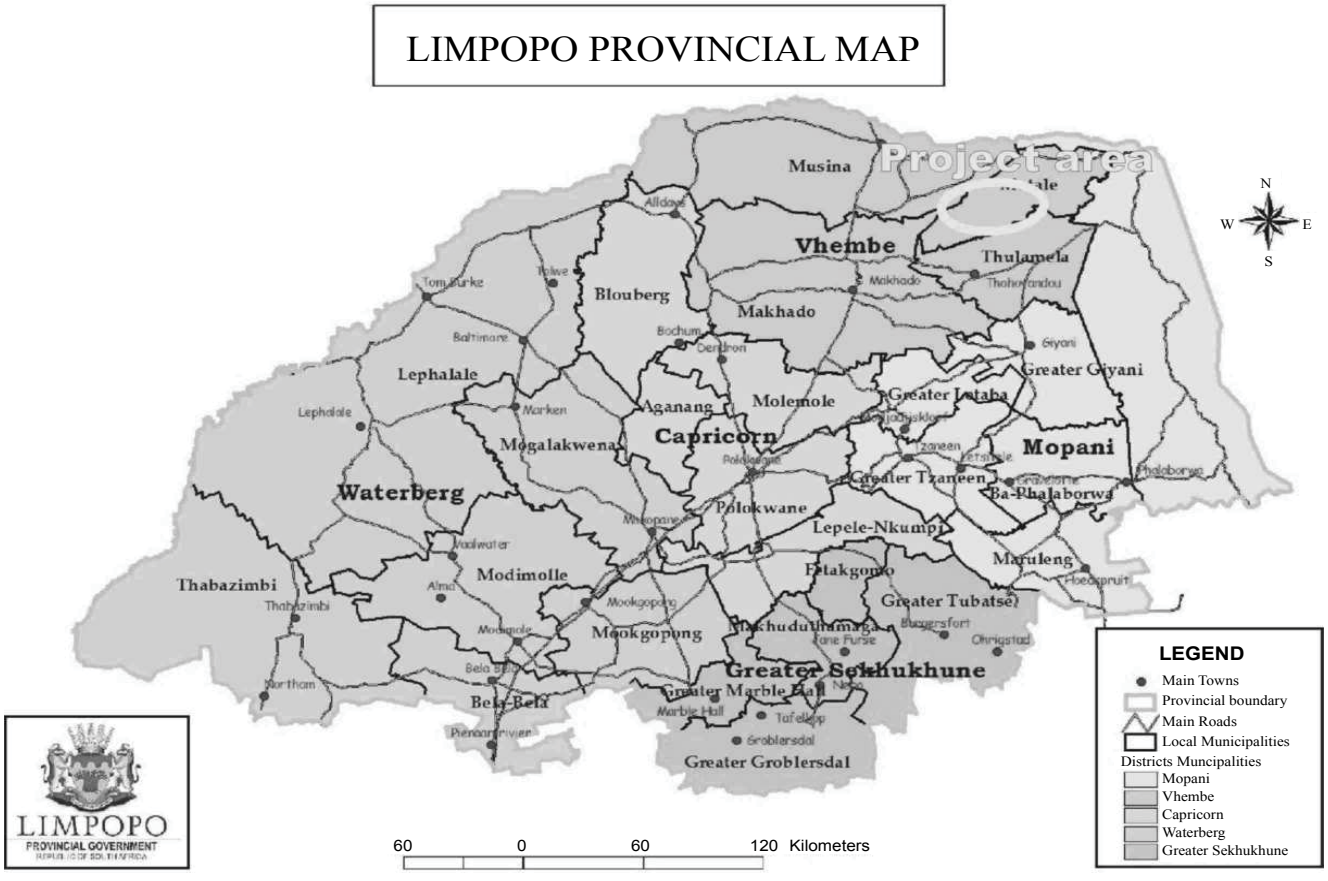

Figure 1: Mutale local municipality. Limpopo, South Africa [43].

tribal or local authorities. Economic activities are mostly commercial or subsistence farming (http://www.mutale.gov.za), with the unemployment rate standing at 48% (http://www.localgovernment.co.za/locals/view/134/Mutale-Local-Municipality # demographic). Annual summer rainfall is from 250 to over 500 mm. Temperatures vary between extremes of 1.5 and 42.5 °C, with an average of 22 °C [14].

The study area falls within the Savanna Biome of South Africa [15], and constitutes the southernmost extension of the most widespread biome in Africa [16]. According to South African National Biodiversity Institution (SANBI) (2016) [17], the local municipality consists of seven vegetation types, of which the Makuleke Sandy Bushveld and Soutpansberg Mountain Bushveld are the most dominant, covering approximately 70% of the area. Just over 79% of the area is still considered natural.

Description of the species

Androstachys johnsonii is a medium-sized deciduous to semi-deciduous tree with an erect stem. Trees are commonly single-stemmed with a sparse grey green canopy. From a distance the canopy is narrow and almost pointed [18]. The species is characterised by a stem with a rough bark. The leaf blades are 3-9 × 2-7 cm and oppositely paired at right angles. They are ovate to heart-shaped with both the apex and base rounded. The upper surfaces are shiny with green to blue-green colour covered beneath the surface in dense, white, and woolly hairs [19]. It occurs in low altitude Bushveld (savanna) in pure stands on rocky hillsides and stony outcrops [20]. The wood is extremely durable and termite resistant [21]. *Androstachys johnsonii* secretes secondary compounds that suppress the establishment and growth of other species under its canopy [22].

Methodology Employed

Study population

The study was conducted between March and October 2015. To obtain permission to conduct research in the Matshena village community, the local chief was consulted to explain the aim and objectives of the research. Based on a recommendation of the local chief informants were selected. Fifty eight informants (25 men and 33 women) were selected via convenience sampling. This cohort consisted of 30% elders (65 years and older), 37% middle-aged (30-64 year olds), and 33% youth (15-29 year olds). The study population was Vhavenda people residing in the Matshena community. Two traditional health practitioners were also recruited through convenience sampling to participate in the study. Participation in the study was limited to the practitioners who resided in the Matshena community only. Consent was obtained from all participants after explanation of the study aim and objectives. Interviewees were interviewed in their Tshivenda language via a semi-structured questionnaire, which elucidated information on usage; parts used, and perceived availability. The research is aligned to the ethical guidelines of the University of Limpopo's Ethical Research Committee.

Data collection

The interviews involved face-to-face interactions between an interviewer and interviewees, to build the kind of intimacy that is common for mutual self-disclosure. The interviews were conducted in the interviewees' households. The interactions were tape-recorded for best analysis of data transcripts. These data were descriptively analysed.

The population of *A. johnsonii* was sampled using the transect method [23]. Ten transects of 100 × 5 m were laid out in the field. The following parameters were recorded from the sampled individuals: Stem circumference, plant height, and crown health assessment. Stem circumference at the base (10 cm from ground level) of the tree. This was done, due the fact that most trees were multi-stemmed. Stem data was placed into nine size classes, of 9 cm each, up to 90 cm. Plant height (only the tallest stem was measured in the case of multi-stemmed trees) was recorded with the aid of a 2 m measuring rod. The height recorded was placed into four size classes (0-5 m, 6-10 m, 11-15 m, 16-20 m). Crown health assessment was done via estimation of crown status on each individual using a sliding scale of 0 to 5 classes. The sliding scale was based on ocular observation focusing on the total health of the canopy cover. Classes of crown health were as follows: 0 = 100% crown mortality, 1 = severe crown damage, 2 = moderate crown damage, 3 = light crown damage, 4 = traces of crown damage and 5 = healthy crown. Assessing crown health is important in understanding the health status of trees since defoliation is widely used as an indicator of vitality and degree of damage in forest trees [24,25].

Results and Discussion

Ethnobotanical survey

Use categories: Results indicate that 65% of surveyed trees showed signs of harvesting. This is not surprising seeing that trees are being used for a variety of purposes by inhabitants. Due to its extremely hardwood this species is mostly used for fencing (mentioned by 59% of respondents), roofing (14% indicated this use), housing wall pillars (8% of responses), and as firewood (30% of responses). A validation assessment by the principal researcher confirmed that most fences were made of *Androstachys johnsonii.* Additional ethnobotanical uses include using it as fodder for goats and cattle (49% of responses), and medicinal purposes (4% of responses).

Fencing using *A. johnsonii* boles was not only done around homesteads, but also involved demarcating kraals (domesticated animal enclosures) and gardens. Villagers noted that the preference of this species stems from the fact that *A. johnsonii* boles are strong and not easily destroyed by termites. Villagers also indicated that fences made from this species can last for close to 10 years.

For construction, *A. johnsonii* stems are used to make roofing for huts and thatched buildings. Most pit toilets in Matshena village were divided using the stems of this species. Some community members indicated that residents used the stems to create the outer wall of houses before plastering it with mud. This finding is similar to that found by Murungweni, et al. [26] for Gonarezhou National Park in the southeast low veld of Zimbabwe. The preference for this species as construction material comes as no surprise as Airy Shaw [27] noted that the wood is heavy, with a density of 810-960 kg/m^3 at 12% moisture content. The Janka side hardness is 11 270-12 580 N and Janka end hardness is 18 230 N. The wood is fairly easy to saw and work in spite of its hardness, and holds nails and screws well. It is very durable. In South Africa, poles used for huts showed no sign of deterioration after 40 years. The wood is resistant to fungal, termite, *Lyctus* and marine borer attacks.

Feeding was catalogued as the second most used category of *A. johnsonii*. Cattle and goats are fed either fresh or dry leaves; albeit only during periods of drought and famine. Seeing that most savanna trees in southern Africa are deciduous and lose their leaves during the long winter period (May to September), it is not surprising that subsistence farmers resort to a deciduous to semi-deciduous species such as *A. johnsonii.*

It was surprising that only 30% of respondents noted the use of *A. johnsonii* as a source of firewood, seeing that this area has high levels of unemployment, which make inhabitants significantly more dependent on their surroundings, especially for fuel. However, interviewees indicated that its use as a fuelwood does not necessarily relate to its heating properties for cooking and bathing using normal pots, but brewing home-made traditional beer in drums. Because the drums are tall it is difficult for smoke to find its way into the beer. This is due to the fact that *A. johnsonii* produces a thick black smoke with an unpleasant smell when burned, which is said to spoil the taste of food.

Only 4% of community members (these were traditional healers) indicated using this species in traditional medicine. These healers indicated that they use the bark along with the roots to make a decoction for treating sexual problems (unspecified). However, Maroyi [28] indicated that roots of this species are used to treat infertility in women in Zimbabwe. Possibly the same use may be apparent in Matshena community. Traditional treatment, by traditional healers, of infertility and sexual problems in women, commonly focuses on fungal infections. In this regard the antifungal properties of *A. johnsonii* were validated by Molotja, et al. [29], who found that decoctions taken from bark inhibited *Fusarium solani*, *Aspergillus flavus*, while *Aspergillus niger* was killed by root extracts. These fungi are however generally associated with plants and not humans, therefore further studies should confirm the possible antifungal properties related to vaginal fungal infections.

Utilized parts: As indicated above in the use categories, different parts of *A. johnsonii* such as stem, leaves, roots and bark are used for various purposes by villagers of Matshena village. Stems are the most used part, eliciting 60% of responses, followed by leaves (33%), roots (4%) and bark (2%). The low response for leaves, roots, and bark is understandable, since leaves are only used as a fodder during times of drought and famine, so it would be low in the minds of respondents. Furthermore the low frequency of mention of roots and bark come from the few (n = 2) traditional healers interviewed.

Perceived availability status: Eighty one percent of respondents reported that *A. johnsonii* species is still highly available on mountainous areas adjacent to the village, while 15% indicated that the species is still moderately available around Matshena village, with only 4% indicating that it is becoming scarce around the village. However, the perception that trees are still highly abundant is false. As indicated in the introduction, *A. johnsonii* is nearly extinct from the flat lying areas around Matshena village, with trees still only abundant in highly inaccessible areas such as mountainous slopes. Schmidt, et al. [30] indicated that *A. johnsonii* is found to be dominant in poorly drained soil and rocky outcrops; areas typical of the high-lying ridges of the mountains where this species is now found around Matshena village. Respondents indicated that the distance needed to travel for harvesting this species is excessive (not specified), and in most cases not worth it. To some extent these factors play major roles in limiting overharvesting of this species. Increased distance and time for fuel wood harvesting is being reported [31-33] much more regularly for most parts of southern Africa.

Population Structure

Harvesting impact

This study found that 65% of the plants showed signs of harvesting. Harvesting of *A. johnsonii* trees ranged from collecting pieces of roots and bark for medicinal purposes (minor damage) to removing branches, using pangas (bush knife), and boles via saws (major dam-

age). *Androstachys johnsonii* trees showed evidence of resprouting from the base after being harvested. Rathogwa, et al. [34] noted that if old *A. johnsonii* trees were cut close to the ground, it is possible that no bud clusters are left and hence there were no more sources of buds. It is possible that these clusters are not only sources of buds but also storage structures. The fact that harvesting resulted in survival (via resprouting) may indicate that the contribution of current photosynthesis to survival of *A. johnsonii* is large [35]. Furthermore, the location of buds in *A. johnsonii* as clusters above the stem base seems to be causing difficulties as to which individual bud must develop independently of the cluster.

In Matshena village repeated harvesting has led to a lowering of the tree strata. The impact of repeated harvesting on trees can be detrimental. Gandiwa, et al. [36] further noted that it is likely to modify and influence state-and-transition dynamics in *A. johnsonii* woodland, thus affecting the resultant population structure. Emmanuel, et al. [37] noted that disturbances such as harvesting of trees by humans for fuel and building materials is also likely to result in increased mortality, due to a decline in fitness, and resistance to environmental factors such as droughts.

Stem circumference

The majority (36%) of the 353 stem circumferences measured fell within the 0-10 cm size class. As the size classes increased in thickness the numbers of plants in that class fell markedly, with the least number (n = 1) of individuals in the 81-90 cm stem size class. However, it must be noted that the 0-10 cm size class included seedlings, juveniles, and harvested adults. Disturbances such as harvesting of trees by humans for fuel and building materials is likely to greatly change the size class distribution of harvested species and also result in increased mortality [38]. Furthermore the removal of medium-sized stems and that of large reproductive trees may lead to a lack of sub-adults in the larger stem diameter classes [39] thereby reducing seed availability leading to a decrease in tree regeneration that may result in a substantial decline in population numbers [40]. This in all likelihood is what is happening with *A. johnsonii* around Matshena village. From a conservation and sustainability point of view this is worrisome.

Crown health status

The population of *A. johnsonii* is dominated (42%) by trees that had just light crown damage (class 3), followed by trees (22%) with moderate damage (class 2), 14% of trees had just traces of damage (class 4), while 13% had 100% damage (class 1), and 9% had healthy crown (class 5). Thus very few trees (9% only) displayed healthy crowns, with 91% showing some degree of damage. The high proportion of damaged crown is reason for concern, because according to Stravinskiene, et al. [41] the morphological parameters of trees are the diagnostic features for assessment of health in trees. The negative response of trees through defoliated crowns is an indication of unfavourable conditions for their growth and development.

Tree height

Of the 353 sampled trees, only 1 was found to have reached its maximum height of 16-20 m. Eighty eight percent of individuals were found to occur in the lowest height class (0-5 m), with 7% falling within the 6-10 m height class, and 1% in the 11-15 m height class. It must be noted that plants occurring in the 0-5 m class include seedlings, juveniles, and adults that have been harvested for construction purposes. The lowering of the *A. johnsonii* tree strata via repeated harvesting could in the long term have dire negative consequences. These include limiting factors like shading, temperature, and water availability. In addition, Molotja and Ligavha-Mbelengwa [42] found that converting *A. johnsonii* woodlands to shrub lands chokes its understory plants and such plants might eventually die out.

Conclusion

It is clear from the study that the community of Matshena village have preferences when harvesting *A. johnsonii* wood resources. It is recommended that when they harvest such species they should exclude a certain site for a specified period so as to give the plants chance to recover and resprout again. This will help in the conservation and management of *A. johnsonii* s.

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