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POACHING OF *ENCEPHALARTOS TRANSVENOSUS*, IN THE LIMPOPO PROVINCE, SOUTH AFRICA

BY

Tshianeo Mellda Ndou

Student number: 14013715

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Supervisor: Dr EM Stam

Co-supervisor: Prof MP Tshisikhawe

Declaration

I **TSHIANEO MELLDA NDOU,** hereby declare that the dissertation with the title: "Poaching of the endangered cycad species, *Encephalartos transvenosus,* in the Limpopo Province, South Africa" was submitted by me in the department of Ecology and Resource Management at the University of Venda for a Master of Environmental Sciences (MENVSC). It has not been previously submitted for a degree at this or any other university and I declare it is my own work in design and execution and that all referenced materials contained herein have been duly acknowledged.

Signature:  Date: 25/10/2021

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Abstract

Poaching is the illegal act of removing plants or hunting animal species *in situ* and *ex situ*. Poaching can lead to a population decline and in severe cases, local or global extinction. Cycad species in the Limpopo Province, South Africa, are poached for traditional medicine, ornamental and wildlife trade purposes. The study was conducted in nature reserves in the Limpopo Province which are: Mphaphuli Nature Reserve which is in the Vhembe district and is 1 300 ha in area, Modjadji Nature Reserve which is 350 ha and located in Bolobedu district north of Duiwelskloof and Lekgalameetse Nature Reserve which is situated between Tzaneen and Hoedspruit and is 18 718 ha in area. The main aim of the study was to evaluate poaching activities affecting *E. transvenosus* inside nature reserves in the Limpopo Province. The specific objectives included investigating which parts of the plants are poached, evaluating the challenges faced by nature reserves for conserving this species, and mapping the distribution of the poached cycads. For these specific objectives, field observation and open-ended questionnaire were used to collect the data. Field observations and questionnaires were conducted to investigate which part of the cycad is poached, Open-ended questions were used to evaluate the challenges that lead to poaching, and field observation was again used to map the localities of poached cycads in the reserve using a GPS. In total, 26 cycads were found to be poached from three reserves. This included eight cycad plants that were completely removed from outside Modjadji Nature Reserve, three completely removed from Lekgalameetse Nature Reserve as well as one completely removed and fourteen debarked in Mphaphuli Nature Reserve. The purported causes of the poaching were found to be unemployment, trade, inadequate reserve fencing and the demand for traditional medicine by rural local communities. It was concluded that with ongoing poaching activities in these reserves, conservation strategies need to be upgraded and their implementation intensified in order to protect *E. transevenosus* from population loss.

Key words: Nature reserves, Poaching, Extinction, Endangered, *Encephalartos transvenosus,* Cycad.

List of acronyms

GPS = Global Positioning System

QGIS = Quantum Geographic Information system

GIS = Geographic Information System

CSV = Comma delimited

IUCN = International Union for Conservation of Nature

SANBI = South African National Biodiversity Institute

SANParks = South African National Parks

CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora

NEMBA = National Environmental Management Biodiversity Act

NGOs = Non-Governmental Organizations

LEDET = Limpopo Department of Economic Development, Environment and Tourism

DEFF = Department of Environmental Affairs, Forestry and Fisheries

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

The origin of cycads dates back 280 million years. Cycads were common during the Jurassic period, when dinosaurs roamed the earth (Whitelock, 2002). The extant cycad families are Cycadaceae, Stangeriaceae and Zamiaceae and they belong to the order Cycadales (Kool *et al.,* 2012). Cycad species have leaves that resemble those of ferns and palms (Levin, 2002). They have a trunk, leaves and cones, all covered with stiff, sharp spines. Cycads are male or female in sex and when they are in a reproductive condition, they bear large cones. These species grow slowly but have a long lifespan.

South Africa has been classified as a global hotspot for cycad diversity as it has 38 cycad species (37 species of *Encephalartos* and one species of *Stangeria*). According to the IUCN (2006) red data list, of the 38 cycad species in South Africa, there are three extinct in the wild, 12 critically endangered, four endangered, nine vulnerable and seven near threatened. Ravele and Makhado (2009) noted that the populations of cycads in South Africa are declining because of poaching and illegal trade. The population of *Encephalartos transvenosus* Stapf & Burtt Davy in South Africa is declining due to poaching and illegal trade of the species (Ravele and Makhado, 2009). *Encephalartos transvenosus* falls under the family of *Zamiaceae* and it has a localized distribution in Limpopo Province, South Africa (SANBI, 2019). It is locally known as “Tshifhanga” in Tshivenda language or the “Modjadji cycad” in Balobedu.

1.2. Background of the study

Plant poaching refers to the illegal harvesting of plant species, *in situ* and *ex situ* (Brandon 2000). Poaching can lead to a population decline of cycad species. Furthermore, it leads to ecosystem disturbance. Cycad species are poached for traditional medicine, as well as ornamental and economic purpose (Mander & Le Breton, 2006). Lack of implementation of legislation leads to high numbers of cycads being poached in the Limpopo Province (Brandon, 2000). IUCN (2006) reported that due to poaching activities cycads are the most threatened group of living organisms in the world.

Of the four cycad species classified as extinct in the wild globally, three are from South Africa (SANBI, 2007). With seven of South Africa's cycad species numbering less than 100 individuals in the wild, the country is at risk of losing these species in two to 10 years if conservation measures are not intensified to reduce illegal harvesting of these cycads from the wild. Estimates suggest that given the ongoing rate of poaching and illegal trade of cycads in South Africa, 25 cycad species will become extinct in the near future (Kramer & Havens, 2009).

1.3 Problem statement

Poaching and unsustainable harvesting of *Encephalartos* species leads to a reduction in their population densities (Li & Pritchard, 2009). Challenges such as inadequate fencing, lack of sufficiently trained officials and lack of electronic equipment enhance poaching activities within the nature reserves (Kool *et al.,* 2012). Moreover, poor implementation of policies and regulations also play a role in the poaching activities inside the reserves.

Kramer and Havens (2009) asserted that poverty and unemployment play a large role in the poaching and trade of cycad species in the informal sector. With the human population on the rise and lack of access to modern medical care, rural people use traditional medicinal plants to treat sickness. Barks, leaves and roots are harvested for medicinal purpose. Extensive harvesting of the bark and roots prohibits the plant from regenerating.

Challenges such as a shortage of staff lead to high poaching activity within nature reserves. Furthermore, nature reserves in the Limpopo Province lack the equipment or systems that can aid in modern conservation strategies of cycad species. The absence of electric fences in protected areas provides access to poachers and this leads to a high number of cycads being poached due to the lack of security measures. The lack of implementation of regulations and legislation which protect cycad species also contributes to poaching activities which affect these species.

1.4 Main aim

To evaluate poaching of *Encephalartos transvenosus* within the cycad nature reserves found in the Limpopo Province.

1.4.1 Specific objectives

- To investigate which parts of *E. transvenosus* plants are being poached
- To evaluate challenges faced by the nature reserves that lead to poaching
- To map the distribution of poached *E. transvenosus* plants

1.4.2 Research questions (?)

- Which part of the *E. transvenosus* is poached the most?
- Does the challenges faced in the reserve lead to poaching?
- How does the geographic distribution of cycads influence poaching?

1.5 Justification of the study

Previous studies have focused mainly on the identification and naming of cycad species in South Africa as well as on the preservation of cycad seed (Bork, 1990). Recently, Williamson *et al.* (2016) focused on DNA barcoding cycad species to track the trade of cycads in the formal and informal sectors. Barcoding was used to identify cycad species sold in Johannesburg's Faraday traditional medicinal market in the Gauteng Province, South Africa.

The current study is unique and of great importance as it investigates poaching activity and maps the distribution of poached *E. transvenosus* inside nature reserves in the Limpopo province. Investigating the parts which are poached the most is essential because it will help identify the regeneration capacity of the cycads after poaching hence a sustainable way of harvesting the cycads can be recommended from the findings. Furthermore, it will also help in tracing the part of the cycads which are sold in the market. Evaluating the challenges faced by rangers will help in identifying areas which can be improved within the nature reserves. Mapping the distribution of poached cycads can help the rangers and LEDET official to intensify patrolling and conservation measure where poaching is occurring the most. It can be postulated that this study is important because the findings and recommendations can be used by LEDET and the nature reserve managements to improve and intensify conservation strategies in order to minimize poaching activities inside the reserves and avoid extinction risk of *E. transvenosus.*

1.6 Description of the study area

The study was conducted in nature reserves in the Limpopo Province which is characterized by beautiful contrasting landscapes which promote tourism. The province shares borders with neighboring countries Botswana, Zimbabwe and Mozambique. The study included three nature reserves that conserve and protect *E. transvenosus*, namely Mphaphuli, Modjadji and Lekgalameetse Nature Reserves (Figure 1.1).

1.6.1 Mphaphuli nature reserve

Mphaphuli Nature Reserve, in the Vhembe district, was established as an area of conservation and preservation of cycads in 1988 and is 1 300 ha in area (Ravele & Makhado, 2009). The cycad species protected in this reserve is *E. transvenosus*. The reserve is situated 35 km Northeast of Thohoyandou in the Soutspansberg mountain range at an altitude of 500 m to 1000 m above sea level. Swart *et al.* (2018) indicated that the climate in the reserve is characterized by 600 - 800 mm annual rainfall, the maximum temperature in summer is 38 °C and the minimum in winter 12 °C, while the soil pH ranges from 6.04 to 6.40.

1.6.2 Modjadji nature reserve

The Modjadji Nature Reserve was named after the successive rain making queens who have inhabited the area since the 16th century (Du Toit, 2004). Additionally, it was named in honor of Queen Modjadji. The people of the Balobedu community believe that the Queen can make it rain. The reserve is 350 ha and is found in the Bolobedu district north of Duiwelskloof (Dzerefos *et al.,* 2015). The cycad species protected in this reserve is *E. transvenosus*. The cycads found in this reserve bear fruit from December to February (summer season).

The Modjadji Nature Reserve experiences annual rainfall of 600 mm all year round and the highest rainfall occurs between November and February (Swart *et al.,* 2018). Summer temperatures are between 18°C and 31°C, while in winter they are between 8˚C and 24˚C (Dzeferos *et al.,* 2015).

1.6.3 Lekgalameetse nature reserve

Lekgalameetse Nature Reserve is an attractive mountain reserve, characterized by sparkling clear rivers, waterfalls and natural pools. It is situated between Tzaneen and Hoedspruit. It is a large 18 718 ha mountain wilderness protected area (Foord *et al.,* 2016). Due to the high availability of water there is an indigenous forest which contains a high species diversity. The cycad species which is conserved in this reserve is *E. transvenosus.*

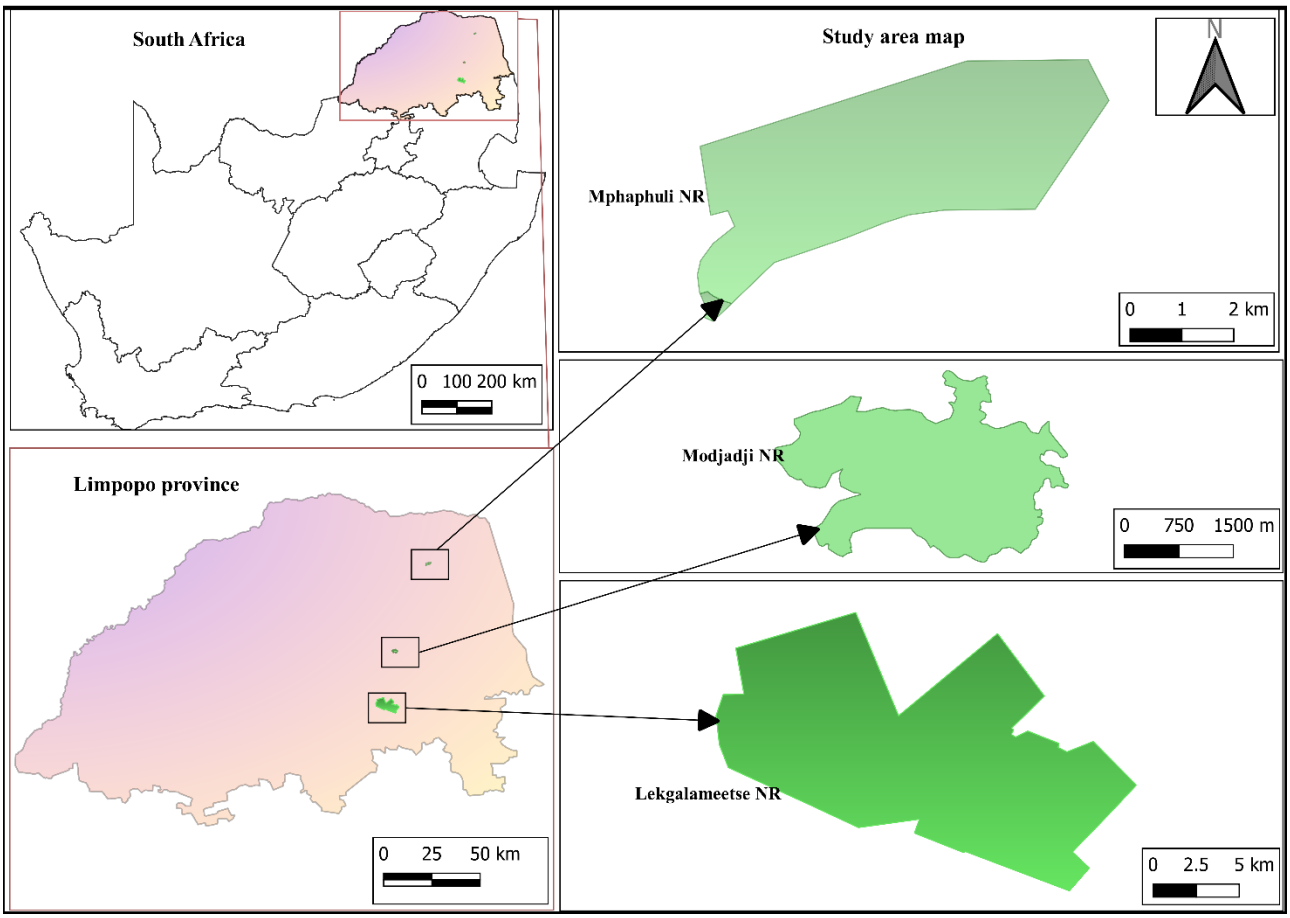

Figure 1.1: Map of cycad nature reserves in Limpopo Province

CHAPTER TWO: LITERATURE REVIEW

This chapter reviews the description of *Encephalartos transvenosus*, causes of poaching of cycad species belonging to the genus *Encephalartos,* uses of cycads, threats to cycads and the effectiveness of conservation strategies used to protect these cycads in protected areas.

2.1. Classification of cycads

Living cycads comprise relatively small groups of plants presently consisting of 185 species in 11 genera. New species have been discovered over the years (Bork, 1990). Cycad species are included in the phylum of the plant kingdom known as the Spermatophyta or seed plants because they produce seed and are included with other cone bearing plants in the class Gymnosperma (Mabaso *et al.,* 2018, Fig. 2.1). In the past, all living cycad species were classified in one family, the *Cycadaceae*. However, Johnson (1959) showed that three distinct groups of cycads were better delineated as separate families. In the division *Cycadophyta* there are three families, namely the *Zamiaceae*, *Cycadaceae* and *Stangeriaceae*. The *Zamiaceae* is the largest family of cycads and is divided into two subfamilies *Encephalartoideae* and *Zamioideae*. In 1753 Carolus Linnaeus described *Cycadaceae* as a family which contains a solitary genus of *Cycas* which is distributed in South-East Asia, southern China, Malaysia, Tropical Australia and different islands of the Western Pacific. The family *Stangeriaceae* contains two genera, *Stangeria* and *Bowenia* (Johnson, 1959).

The genus *Encephalartos* is the second largest genus of cycads, consisting of approximately 50 living species endemic to the African continent (Bork, 1990). The genus is classified under the kingdom Plantae, clade Tracheophytes, division Cycadophyta, class Cycadopsida, order Cycadales, family *Zamiaceae*, subfamily Encephalartoideae, tribe Encephalarteae and subtribe Encephalartinae (Bork, 1990).

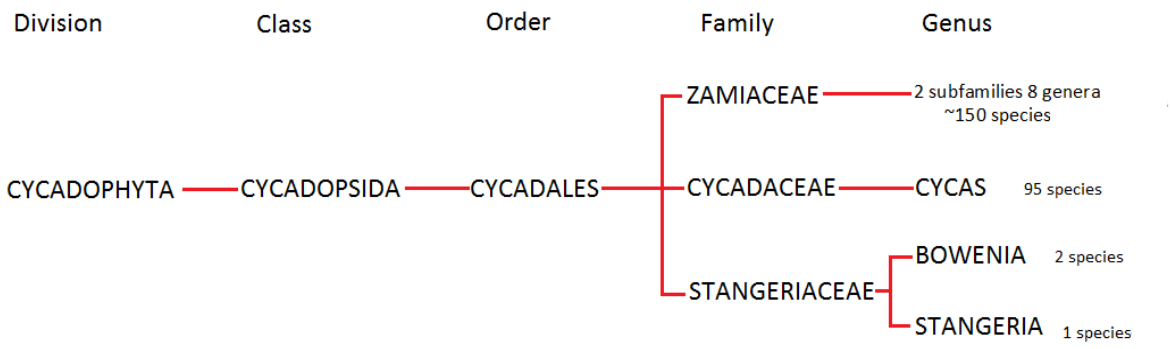

Figure 2.1: Family of cycads

2.2 Distributions of cycads

Living cycads are found in the subtropical, tropical and warm temperate regions of the northern and southern hemispheres (Pant, 1996). They occur in Australia, South America as well as Africa and are prominent in Central America and the Caribbean islands (Figure 2.2) (Hill *et al.,* 2004). The species are distributed in diverse habitats ranging from mesic to semi-arid regions. Habitat loss for cycad species is relatively faster in developing countries (Goel, 2003).

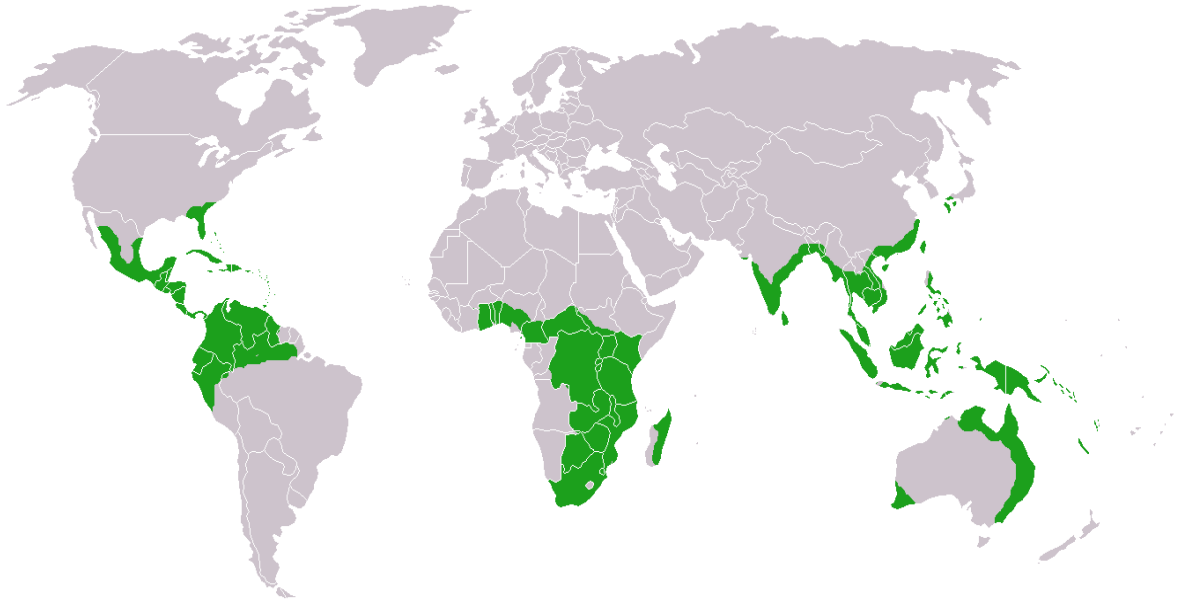

Figure 2.2: World distribution map of cycad species (Hill *et al.,*2004)

Donaldson (2003) highlighted that there are 308 species of cycads in the world and 38 are found in South Africa with 29 being endemic. Figure 2.3 shows the distribution of cycad species in South Africa. The conservation status of the cycad species in South Africa under the International Union for Conservation of Nature (IUCN) are listed as follows: 10 species are Vulnerable (VU), four species are Endangered (EN), 12 are Critically Endangered (CR), and four species are Extinct from the Wild (EW) (SANBI, 2007).

The genus *Encephalartos* is predominantly distributed in South Africa. Some *Encephalartos* species occur at high elevations with low temperatures and heavy frost (Donaldson, 1995; Goel, 2003; Whitelock, 2002). According to the SANBI (2007) red data list, all species of the genus *Encephalartos* are endangered and some are extinct in the wild. Poaching of cycad species *in situ* and *ex situ* has led to their population declines.

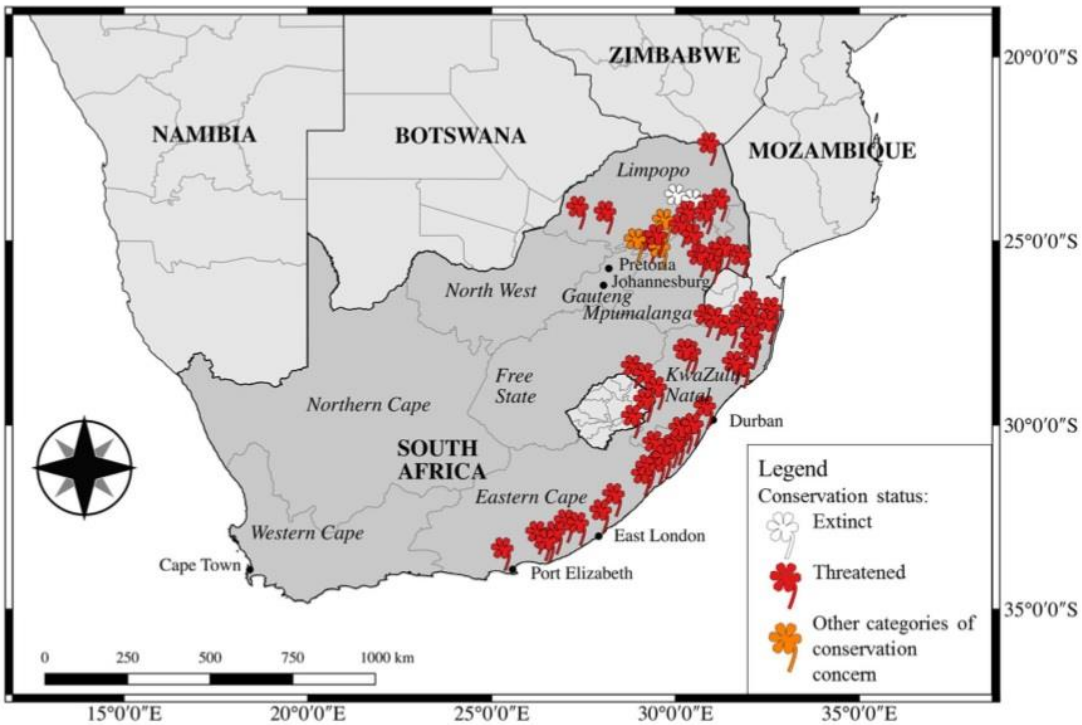

Figure 2.3: The distribution of cycads in South Africa (SANBI, 2007)

2.3 Description of the *Encephalartos transvenosus*

Encephalartos transvenosus is a tall tree that can grow over 6m in height. It is regarded as one of the tallest and one of the fastest-growing cycads in South Africa (Ravele and Makhado 2009). It grows in large colonies on the mountains in Limpopo Province in South

Africa (Ravele and Makhado 2009). The young leaves are light green and densely covered with brown hairs.

2.3.1 Leaves

The leaves of *E. transvenosus* are 1 to 3 m long and are glossy dark olive green above and matt yellowish green below with a contrasting yellow rachis (Poole, 1923). They are usually straight, but the outer leaves are often slightly recurved towards their apices (Forster & Jones, 1992). New leaves are woolly, but as the leaflets grow, some of the wool falls off.

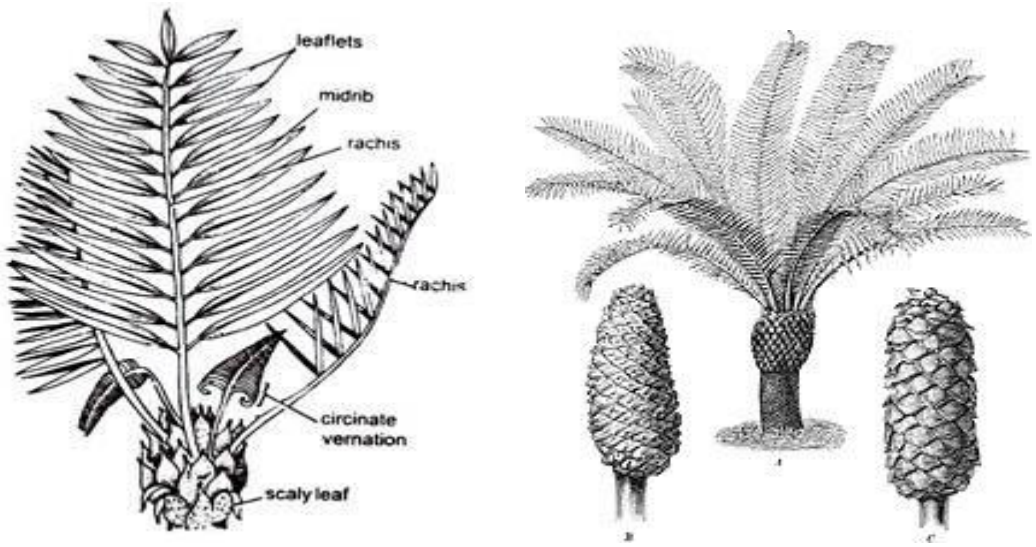

Figure 2.4: The structure of *Encephalartos* cycad (Poole, 1923)

The young leaves are light green and densely covered with brown hairs while mature leaves are numerous and form an erect to spreading crown. Pant (1996) indicated that the median leaflets are 10 to 20 cm long and 2 to 4 cm broad, usually with two to five teeth on the upper margin and one to three on the lower margin (Osborne, 1990). The leaflets reduce in size towards the base of the rachis usually ending in a series of multi-lobed prickles and one to two thorns. The thorns act as a defense mechanism from organisms that feed on cycad leaves. The petiole is 22 to 28 cm long.

2.3.2 Cones

Encephalartos cycads do not produce flowers, but bear reproductive structures known as cones or strobili. They are strictly unisexual, i.e., either male or female. Both sexes carry two to four cones per crown. The female cones are golden yellow and covered with fine golden hairs which disappear as the cones mature (Hill, 1992). They are oblong oval and 50 to 80 cm tall and 20 to 30 cm in diameter. The male cones are also golden yellow and are 30 to 40 cm tall and 13 to 15 cm in diameter (Sabato, 1990).

a. Female cones

The life span of a female cone is much longer than that of a male cone (Vovides, 1991). Both male and female cones have a similar period of development up until they reach pollination (Ornduff, 1990). The increase in size of the female cone and ovule is initially rapid then slows down depending on the environmental conditions (Giddy, 1990; Hill, 2004). At the mature stage the female cone begins to disintegrate from the apex downward and normally the sporophylls fall off the central axis. Each female sporophyll (megasporophyll) bears ovules near its base and these are directly attached to the stalk of the sporophyll (Caputo *et al.,* 1986).

b. Male cone

The male cone is narrower than the female cone (Jones, 1992). It also has more sporophylls and each male sporophyll (microsporophyll) produces pollen on its lower surface. These are shortly stalked at the base and arranged in groups. They produce the pollen to achieve pollination and eventually fertilization (Vovides, 1991).

2.3.3 Stem

The plant branches both from the base and along the length of the stem. Mature plants can have up to three stems of different sizes. Bamps and Lisowski (1990) showed that dormant buds on the stem may develop to form large branches if the crown or stem is damaged. The erect stem is commonly 5 to 9 m high but occasionally reaches 10 to 13 m. The stem diameter of a tall erect stem is on average between 40 and 65 cm, but in some cases can be as much as 80 to 90

cm (Raimondo, 2009). In South Africa the taller specimens of *E. transvenosus* are found in the Modjadji Nature Reserve on higher ground. The crown of the stem is covered with golden brown wool which increases in quantity when the cones or leaves emerge (Grobbelaar *et al.,* 1989).

2.4 Conservation status

Encephalartos species are poached extensively. The status of *Encephalartos* Genus is presented in (Table 2.1). In South Africa there are three cycad species extinct in the wild, 12 critically endangered, four endangered, nine vulnerable and seven near threatened (SANBI, 2007). The greatest threat facing cycads is poaching of plants from the wild to supply the domestic and international trade. *Encephalartos transvenosus* Stapf & Burtt Davy is a species endemic to Limpopo Province (Goode, 2001). It is protected under provincial and national legislation in South Africa (Limpopo Environmental Management Act (LEMA) 2004; National Environmental Management Biodiversity Act (NEMBA) Act 10 of 2004. *Encephalartos transvenosus* was listed as a rare species by Hilton-Taylor (1996). However, it is currently listed as a species of Least Concern (Donaldson, 2009). Although this species is not classified as threatened, it is experiencing population declines due to habitat destruction and poaching (Donaldson, 2009).

2.5. National and international conservation measures

2.5.1. National Environmental Management Biodiversity Act (NEMBA)

In South Africa, indigenous *Encephalartos* species are protected under provincial legislation and/or the National Environmental Management Biodiversity Act 10 of 2004. Permits issued in terms of the Threatened or Protected Species (TOPS) regulations and/or provincial legislation are needed for activities, including but not limited to having cycads in your possession, breeding cycads, moving cycads, buying or selling cycads or picking parts of a cycad.

2.5.2. Endangered Wildlife Trust (EWT)

The EWT was founded in 1973 and implements conservation research and action programs. According to Pires and Rayner (2016) the purpose of EWT is to reduce trade related threats that affect the survival of both plants and animals in the wild.

Table 2.1: Conservation status of cycads (IUCN, 2017; SANBI, 2019)

Species	Common name English (E), Afrikaans (A), Venda (V), Sotho (S), Zulu (Z), Xhosa (X)	IUCN Global	SANBI National	Location	Population trend
Encephalartos hirsutus Hurter	Venda cycad (V)	CR	CR	L	Decreasing
Encephalartos transevenosus Stapf & Burtt Davy	Tshifhanga (V)	LC	EN	L	Decreasing
Encephalartos latifrons Lehm	Albany cycad (E)	CR	CR	EC	Decreasing
Encephalartos cupidus Dyer	Bylde River cycad (E)	CR	CR	MP	Decreasing
Encephalartos eugene-maraisii Verd	Mofaka (S) / Bergpalm cyad (E)	EN	EN	M	Decreasing
Encephalartos umbeluziensis Dyer	Umbeluzi cycad (Z)	EN	CR	KZN	Decreasing
Encephalartos middelburgensis Vorster, Robbertse & van der Westh.	Middleburg cycad (E)	CR	CR	MP	Decreasing
Encephalartos laevifolius Stapf & Burtt Davy	Kaapsehoop cycad (A) / Mayiphukhu (Z)	CR	CR	MP	Decreasing
Encephalartos natalensis Dyer & Verd	Natal cycad/ Umhlungulo (Z)	NT	CR	KZN, MP, EC	Decreasing
Encephalartos senticosus Vorster	Lebombo/ Jozini cycad (Z)	VU	VU	KZN, MP	Decreasing
Encephalartos aplanatus Vorster	Umphanga wehlathi (Z)	VU	VU	EC	Decreasing
Encephalartos caffer (Thunb.) Lehm.	Umphanga wase Rhini (Z)	NT	NT	EC & KZN	Decreasing
Encephalartos arenarius Dyer	Alexandria cycad (E), Kwa Qaba cycad (X)	EN	EN	EC	Decreasing
Encephalartos lanatus Stapf & Burtt Davy	Woolly cycad (E)	NT	NT	MP	Decreasing
Encephalartos paucidentatus Stapf & Burtt Davy	Barberton cycad (E)	EN	Not listed	L, MP	Decreasing
Encephalartos longifolius (Jacq.) Lehm	Thunberg's cycad (E)	NT	Not listed	EC	Decreasing

The detection of wildlife crimes, justice for wildlife and the implementation of wildlife laws together with the Eco-use project within the EWT help in conserving the wildlife species (Swart *et al.,* 2018). Species which are a priority to EWT are cycads, Rhinos and pangolins.

2.5.3. Governmental and non-governmental organizations

a. South African National Biodiversity Institute (SANBI)

SANBI is responsible for leading, coordinating, researching, monitoring, evaluating and reporting on the state of biodiversity in South Africa (SANBI, 2007). In addition, SANBI engages in ecosystem restoration and rehabilitation, leads the human capital development strategy of the sector and manages the National Botanical and Zoological Gardens as 'windows' to South Africa's biodiversity for enjoyment and education. Examples of botanical gardens under SANBI which help in the conservation of cycad species are Kirstenbosch and Thohoyandou Botanical gardens.

b. Cycad Specialist Group (CSG)

The CSG is a component of the IUCN Species Survival Commission (IUCN/SSC) and consists of a network of cycad biologists and conservationists (Gutiérrez-Ortega *et al.,* 2018). This group has been in existence for over 30 years. The main goals of the group include coordinating extinction risk assessments for cycads, maintaining and updating consensus taxonomy for cycads and developing a network of gene banks for cycad conservation (Gutiérrez-Ortega *et al.,* 2017).

2.6. Uses of cycads

2.6.1. Medicine

Cycads have been used medicinally for the treatment of snake and insect bites as well as malignant ulcers and boils (Osborne, 1990). Additionally, a paste of *Cycas* seeds is mixed with coconut oil and used in various Asian countries for the treatment of skin complaints, wounds, ulcers and sores. Due to lack of access to modern medical facilities, people in remote rural areas use cycads to treat themselves as they cannot afford modern medicinal care or because hospitals are too far to reach in emergency situations. Hence, people use traditional ways of treating diseases because it is affordable and, in some cases, easy to access. Donaldson (2003) mentioned that the roots, leaves and bark of cycad species are used to cure stomachache, heart attack and stroke. In Sri

Lanka, *Cycas* seed flour is boiled and eaten as a remedy for bowel complaints and haemorrhoids, while in New Guinea it is used to treat wounds (Osborne, 1990).

2.6.2. Decoration and landscaping

Cycad species are popular as ornamental plants. They are used for landscape design, because of their aesthetic beauty. Cycads are often planted along the sides of entrances, such as driveways, gates and doorways (Hill, 2004). Due to the high landscaping demand, there is high rate of poaching and illegal trade in cycad species leading to a decline of populations of cycads in the wild. Hence, some species are endangered, and others have become extinct. In China, people decorate their churches with cycad fronds and in Mexico people use them to decorate during the festive season (Vovides, 1983). In rural communities of South Africa people use cycad leaves to decorate during birthday ceremonies.

2.6.3. Cycads as a food source

The earliest record of the use of cycad stems as a food source was documented by the Swedish botanist and plant collector Carl Peter Thunberg in 1775 (Bosenberg, 2006). In the Western Cape Province, South Africa, *Encephalartos* was used to make a type of bread. Furthermore, the cone of cycad species was consumed and considered a seasonal food for the local people (Giddy, 1990). Collection of cycad starch involves cutting the trunks at or near ground level and removing the outer woody material to expose the inner cylinder of fresh pith. This process is detrimental to the plant because the cycads take long to regenerate and, depending on the method of harvesting used, some of the cycads may not regenerate at all.

2.6.4. Roofing

People in rural areas used to make roofing from the leaves of cycads. Subedi (2019) noted that the leaves of some cycad species may be used as roof thatch. Before the introduction of modern housing, people would harvest the cycad leaves to make roofs for their house. Leaf harvest can lead to population decline of cycads species. A study done by Krishnamurthy *et al.* (2013) showed that a population of *Cycas circinalis* experienced reproductive decline due to leaf harvest. This can be the case for other cycads species.

2.6.5. Cycads in religion

In some countries, the leaves of cycads are used in Palm Sunday processions during celebrations of the Easter holidays (Burchmore *et al.,* 1989). In India cycads are referred to as 'church palms' because their leaves are used to decorate places of worship. In Mexico and Honduras the leaves are used for decorating altars. Bork (1990) noted that they are also used in religious ceremonies in the Philippines, New Hebrides and the Solomon Islands. In South Africa the leaves of *Encephalartos lanatus* are used for church decoration during Christmas (Bamps & Lisowski, 1990). Besides being used as decoration, cycad leaves are also used in graveyards and the whole plants may be planted in graveyards.

2.6.6. Miscellaneous uses

The wooly hairs which occur at the base of the petioles of cycads have been used for stuffing pillows and mattresses. The stem of tall *Cycas* species have been used as structural supports for dwellings. Toys and whistles are made from the dry seeds of *Dioon spinulosum* and *Cycas* species (Hill and Osborne, 2001). Fancy match boxes have been constructed from seed of the Australian cycad *Lepidozamia peroffskyana* and in India snuff boxes have been made using the seed of *Cycas circinalis (*Rayner & Pires, 2016). In Florida pipe bowls were made from the dried roots of *Zamia integrifolia* (Whitelock 2002), while in Japan cycad trunks were carved into ornamentals for export to the USA, Germany and Switzerland (Hill & Osborne, 2001).

2.7. Threats to *E. transvenosus*

2.7.1. Climate change

Climate change is a major threat to the populations of cycad species (Scott, 2008). Negron-Ortiz and Gorchov (2000) showed that the cycad populations in the Everglades National Park in Florida, USA, are declining due to prolonged wildfires caused by climate change. The study conducted by Da Silva *et al.* (2012) revealed that due to direct physiological effect *Cycas revoluta* is no longer reproducing.

2.7.2. Trade

The trade in cycads has been and is still growing exponentially. The exponential growth in commercialization of cycads will enhance their illegal harvesting, overexploitation and extinction rate in the wild. Due to economic constraints and

poverty in South Africa people are poaching and trading cycads in exchange for money to feed themselves and their families (Whitelock, 2002).

2.7.3 Poaching in South Africa

Poaching of plants is widespread in South Africa. Cycads are a popular ornamental tree with homeowners and collectors in South Africa. Brandon (2002) highlighted that with demand outstripping legal supply, poaching and theft of cycads from protected nature reserves, public parks, landscape nurseries and private homes has become rampant. Immature cycads have been confiscated from poachers (Greg, 2004). Cycad root balls were also found in street vendor traditional markets in Durban. Bark removal is the common method of poaching *E. transvenosus* cycads. A study conducted by Bamigboye & Tshisikhawe (2020) found that bark harvesting for medicinal use is a major threat to *E. transvenosus*. Poaching has led to the loss of populations of cycads within the country and has resulted in extinction of *Encephalartos woodii* (SANBI,2007).

Figure 2.5: Bark harvesting from Mahunguwi village (Bamigboye & Tshisikhawe, 2020)

2.7.4. Cone and seed predation

In Africa, *Erethizon dorsatum* are fond of the young tissues of developing cones of various species of *Encephalartos* and will destroy accessible cones (Butt, 1991). Collins (1987) found out that Baboons destroy the immature cones by using them as playthings. He further documented that rat *Rattus fuscipes* attack the immature cones of *Macrozamia* species in Australia. This process of cone predation leads to population decline of some cycad species (Hill, 2004).

Cycad seed kernels, which contains the embryo and its food supply, together with the megagametophyte, are protected by a very hard woody coat known as the sclerotesta from being eaten by predators (Collins, 1987). However, in Australia *Rattus fuscipes,* commonly known as the brown rat, gnaws holes in one end of the sclerotesta *of Macrozamia* seeds (Butt, 1991). They consume the contents including the embryo and discard the open shell. This negatively affects reproduction and population dynamics of the cycad species. In Australia a large indigenous rodent, *Uromys caudimaculatus*, commonly known as the white-tailed rat, eat both the sarcotesta and the kernel of the seeds of *Lepidozamia hopei* (Butt, 1990). Similar seed predation also occurs in Mexico, where rodents eat the kernels of *Dioon* species (Collins, 1987).

Donaldson (1993) described that in Africa a group of weevils in the genus *Antliarhinus* have evolved a life cycle centered around the seeds of various *Encephalartos* species. The eggs of the weevils are laid in the developing ovules and the grubs feed on the kernel of the seed resulting in its destruction. Heavy infestations by the weevils result in significant seed destruction (Da Silva *et al.,* 2012). The weevil *Antliarhinus zamiae* has an elongated snout which it uses to drill through the sporophylls of *E. transvenosus* and get into an ovule from the outside of the cone and it then uses a telescopic ovipositor to deposit a batch of eggs into the ovule through the cone from the outside. The female weevil enters the cone and drills directly through the ovule before laying her eggs (Hill, 2004). The *Encephalartos* weevil *Phacecorynums funerarius* was documented by Collins (1987) as one of the species which attacks *Encephalartos* species.

2.8. Impacts of poaching

2.8.1. Impacts of poaching on targeted species

O'Grady *et al.* (2004) showed that the poaching of cycads lead to the decline in cycad population sizes and reductions in geographic range and genetic diversity, all of which contribute to an increased risk of extinction for the species concerned. When people harvest the plant illegally, they tend to remove the fully matured, largest and most reproductively valuable trees, which has disproportionately negative impacts on the regeneration capacity of the population (Sharit *et al.,* 2004).

2.9. Mitigating poaching

2.9.1. DNA barcoding

DNA barcoding can be used to investigate and prosecute wildlife crime Kool *et al.* (2012). The gene sequences can be used to identify the species in both informal and formal sectors. It is used in *Muthi* shops which trade in wildlife, and diverse plant species and endangered plants are identified using the DNA bar codes (Kool *et al.,* 2012). International Conference on the Barcode of life (CBOL, 2009) proposed the standardized use of the *rbcla* and *matk* chloroplast gene sequences as core plant DNA barcodes. In response to escalating poaching, Rayner & Pires (2016) found that South African officials are using DNA barcoding to safeguard endangered cycad species. DNA barcoding was used in the Faraday and Warwick traditional medicinal markets to identify cycad species and an estimated 50 kg of *E. transvenosus* stem was found in the Faraday market in Johannesburg and 80 kg was found at the Warwick market in Durban (Rayner & Pires, 2016).

2.9.2. Botanical gardens and seed banks

A botanical garden is dedicated to the collection, cultivation and display of a wide range of plants (Huang *et al.,* 2002). There is a wide variety of plant species grown together under common conditions, and they often contain taxonomically and ecologically diverse flora (Primack & Miller, 2009). Botanical gardens are vital in conserving medicinal plant species because they can maintain ecosystems to enhance the survival of rare and endangered plant species (Huang *et al.,* 2002). The Kirstenbosch National Botanical Garden in Cape Town, South Africa, plays a vital role in preserving cycads (Maunder *et al.,* 2001). A botanical garden can preserve species which are extinct in the wild.

Seed banks are used for storing the genetic diversity of different plants and are recommended to help preserve the biological and genetic diversity of wild plant species (Schoen & Brown, 2001). The eminent seed bank in the world is the Millennium Seed Bank Project at the Royal Botanical Gardens in the UK (Li & Pritchard, 2009). Seed banks allow relatively rapid access to plant samples for the evaluation of their properties, providing helpful information for conserving the remaining natural populations (Schoen & Brown, 2001). The aim of a seed

bank is reintroducing plant species back into the wild and actively assisting in the restoration of wild populations (Li & Pritchard, 2009).

2.9.3. Resettlement and rescue scheme

Cycad seedlings and mature plants are generally easy to transplant (Jones, 1993). Due to various reasons, for example, the need for land for farming and construction of a settlement, rescue schemes have been used in the past to rescue cycad species from areas where there is development. During “Operation Wildflower” over 6000 specimens of *Encephalartos lebombensis* were rescued from an area to be flooded upon the completion of the Jozini dam, South Africa (Whitelock, 2002). The rescued plants were not moved into the wild but were distributed to public gardens and interested cycad growers. In addition to this cycad rescue, two other rescue missions were conducted, both involving *Encephalartos* species threatened by the expansion of plantations.

2.10. Conclusion

It can be concluded that the current conservation of *E. transvenosus* is inadequate since there is high rate of population decline. Both anthropogenic activities and natural phenomena are responsible for the decline of the *E. transvenosus*. More effective conservation strategies need to be put into place to protect *E. transvenosus* from being endangered and facing extinction.

CHAPTER THREE: RESEARCH METHODS

3.1. Introduction

This chapter details the data sets used and procedures followed in the study. The methods used included investigating which parts of *E. transvenosus* were poached most, evaluating challenges faced within the nature reserves that lead to poaching and mapping the distribution of poached *E. transvenosus* in Mphaphuli, Modjadji and Lekgalameetse nature reserves.

3.2. Research design

3.2.1 Qualitative data collection

Data were collected through open ended questionnaires. Fifteen questionnaires were administered to rangers from three nature reserves: seven rangers from Mphaphuli Nature Reserve, four from Modjadji Nature Reserve and four from Lekgalameetse Nature Reserve.

3.2.2 Quantitative data collection

Data were collected through field observations. The researcher and rangers visited the sites where poaching is occurring. The map reference coordinates of poached cycads were recorded using a GPS. Poaching activities were assessed and a map of the distribution of poached cycads produced.

3.2.3 Sampling method

Purposive sampling was used in the field to select a site with a high risk of poaching and where there is more evidence of poaching activities inside and outside the nature reserves. Poaching activities were analyzed from the cycads sampled. The investigation of poached cycads was based on how many cycads were being poached and which part of the cycads were poached.

3.3 Data collection

3.3.1 Field observations

At three cycad nature reserves in the Limpopo Province (Mphaphuli, Modjadji and Lekgalameetse) field observations were used to enhance the process of understanding the spatial distribution of poached cycads. The sites where poached cycads were found were located using purposive sampling methods and the knowledge of rangers from the nature reserves. The map reference coordinates of all poached cycads were recorded using a GPS. Poaching was

categorized according to the part of the plant poached: the roots, the fruits and seeds, bark, leaves, or the whole plant.

3.3.2 Open-ended questionnaires

Open ended questionnaires were distributed to rangers who were available during the day of data collection. Questionnaires were distributed to Seven rangers in Mphaphuli Nature Reserve, four rangers in Modjadji Nature Reserve and four rangers in Lekgalameetse Nature Reserve. The main aim of the questionnaire was to determine whether the challenges that rangers face while working in the reserve impact on poaching activities occurring inside the reserve.

3.4. Data analysis

3.4.1. Descriptive data analysis

Data collected from open ended questionnaires were analyzed using descriptive analyses. Frequency and percentages were used in the analyses of the questionnaires from the rangers.

3.4.2. Inferential statistics

Correlation analysis (Pearson correlation) was used to show the relationships between hours worked, parts poached and experience of working in the reserve (years in service).

3.4.3. QGIS Map

The map reference coordinates collected using the GPS were recorded in an Excel spreadsheet and imported into QGIS software to create a distribution map of poached cycads in the reserves.

3.5 Ethical considerations

Ethical clearance was obtained from the University of Venda for the research study of reference number SES/19/GGIS/06/1220. Additionally, a permit of reference number ZA/LP/98233 was granted from the LEDET before collecting data from the nature reserves. The confidentiality of respondents was respected. Where respondents could not understand English, the questions were translated from English to Tshivenda or Sepedi.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Demographic information

4.1.1 Gender

There were no female rangers in Mphaphuli and Lekgalameetse Nature Reserve (Figure 4.1). Since Mphaphuli Nature Reserve was established in 1988 (Ravele & Makhado, 2009), it has had a high number of male rangers because most rangers were employed during the time when women were not allowed to have a profession in the 1980s. Modjadji Nature Reserve has two female rangers, with one having started working in the reserve in 2015 and the other in 2019. The two male rangers started working when the reserve was established in 1982. There is currently a gender balance in the reserve. Studies focusing on gender transformation in South Africa show that there is a slow but gradual growth of women employed in male dominated sectors (Barker, 2002). Out of fifteen rangers interviewed, (Figure 4.1), 87% (Thirteen rangers) were male and 13% (two rangers) were female.

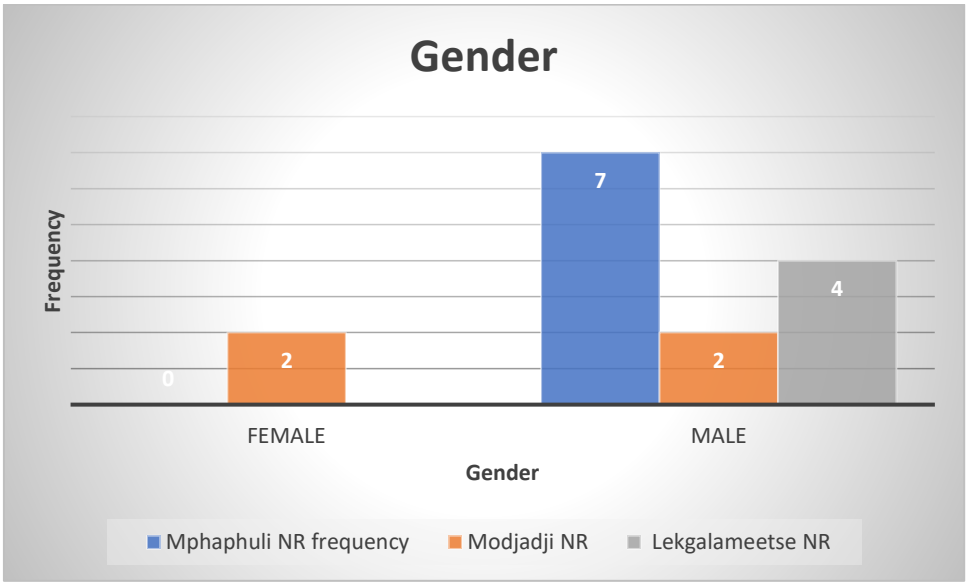

Figure 4.1: Gender of Rangers

Gender transformation and managing diversity are an organizational imperative in South Africa (Barker, 2002). It is important for companies and stakeholders to embrace the benefits of diversity and empower women (Etemesi *et al.,* 2019). Despite the fact that laws and regulations have changed and proclaimed availability of access to equal opportunities, it is evident that there are less

women who hold corporate positions in South Africa. This study found that only 13% of rangers interviewed in the nature reserves are women (Figure 4.1). According to Barker (2002) a ranger profession was originally for man who were physical fit, had the ability to run and walk long distances and the profession is still male dominated despite the laws and regulations which state that man and women are equal and should be offered equal opportunities. Despite Mphaphuli and Lekgalameetse not having female rangers (Figure 4.1), it can be alluded that women are employed as rangers in Modjadji nature reserve and this shows that the journey to gender equality of rangers is taking place.

4.1.2 Educational status

In Mphaphuli Nature Reserve 72% (five rangers) have a primary education only (Figure 4.2). However, these rangers have extensive experience in patrolling and conservation of cycads. The results from Modjadji Nature Reserve shows that 50% (two rangers) have high education levels and 25% (one ranger) has a primary education while the other one has a secondary education. The relatively high number of rangers with a higher educational level is of importance in the reserve since they are well organized and efficient in using technological equipment such as computers. The positive effect of the higher education level is also seen in data collection**.** The results from Lekgalameetse Nature Reserve mirror those of Modjadji Nature Reserve (Figure 4.2).

Rangers did not choose their profession based on their educational status or background. Moreto *et al.* (2017) reported that some rangers chose the profession because of their passion for nature and the outdoors, while others chose the profession because they had no other job options. Indigenous knowledge and passion has been proven to be helpful in conserving different plants and animals (Palmer & Bryant, 1985).

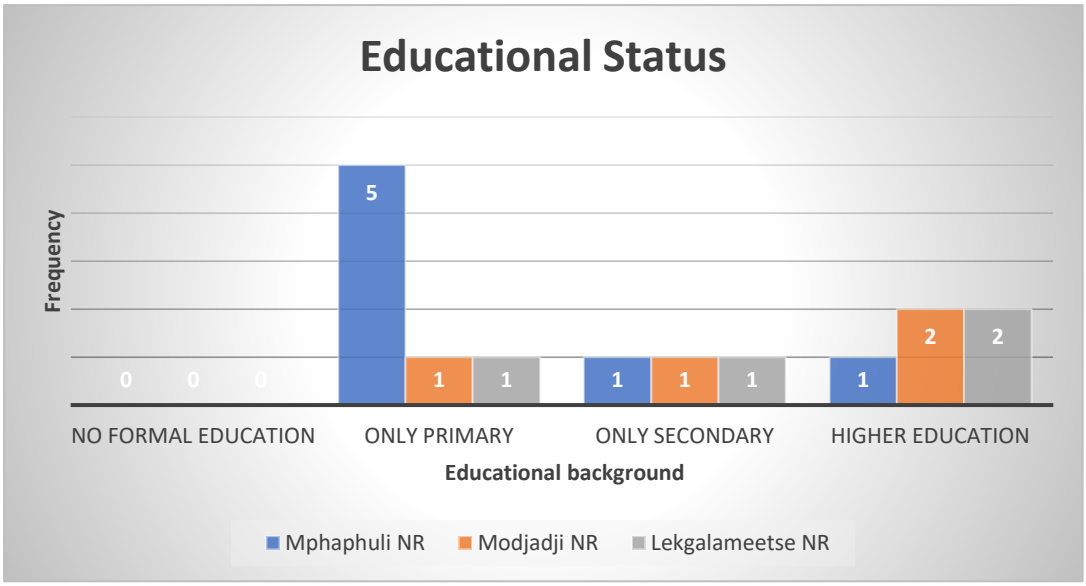

Figure 4.2: Educational status of rangers in all reserves

4.1.3 Age distribution

The results from the questionnaires show that most of the rangers that work inside the reserve are above the age of 53 (Figure 4.3). In addition, the rangers who have been found to be above the age of 53 in Mphaphuli Nature Reserve started working when the reserve was established in 1988 (Ravele & Makhado, 2009). The benefits of having field rangers who have been working in a reserve for a long time is that they are experienced. This is beneficial when patrolling the reserve because they are familiar with the formal and informal activities that occur within the reserve. It is noteworthy that these rangers are also exposed to Government training. These factors play a large role in conservation because the rangers have more experience and training according to the years they have been working in the reserve. However, Henson *et al*. (2016) indicated that rangers who have worked in a nature reserve for a long time may lose interest and be unmotivated if the expectation of protecting species is not fulfilled. This has been found to have a negative effect on conservation, because the rangers lose the motivation to perform daily duties such as patrolling (Moreto *et al.,* 2016). It was therefore suggested that hiring young people may have a positive conservation impact because they may be more motivated (Henson *et al.,* 2016; Miller *et al.,* 2009).

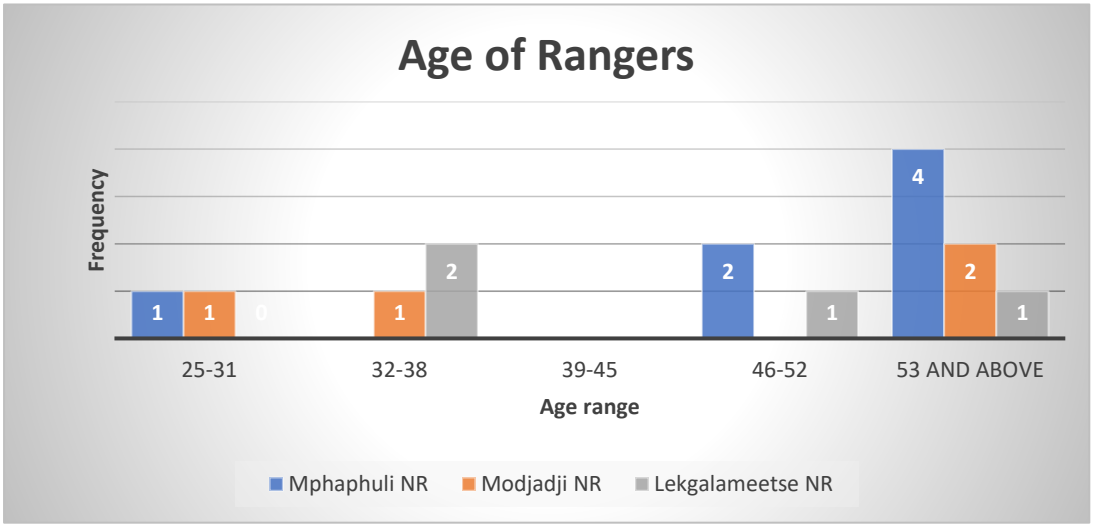

Figure 4.3: Age distribution of the rangers in all three reserves

4.2. Alleged causes of poaching

4.2.1 Alleged causes of Poaching in Mphaphuli Nature Reserve

- Drug Manufacturing

It was not known by the rangers which type of drug is manufactured from *E. transvenosus.* However, 9% of the rangers indicated that drug manufacturing is one of the causes that is leading to poaching in Mphaphuli Nature reserve (Figure 4.4). Bamigboye *et al.* (2017) stated that *E. transvenosus* is harvested and sold as a drug. Rangers emphasized that with the increasing demand for drug manufacturing, more conservation efforts must be put in place to reduce the poaching and trade of *E. transvenosus.*

- Traditional Medicine

According to 9% of the rangers, *E. transvenosus* is poached for medicinal purposes. Most people in rural areas depend on traditional medicine for healing and curing of diseases. It is estimated that 60% of South Africans consult traditional healers for medicinal care (Van Wyk, 2011) and these healers use medicinal plants to treat the diseases of their clients. This puts a strain on natural resources and enhances the illegal harvest of medicinal plants which can lead to local or global extinction (Wiliams *et al.,* 2013). Tadmor *et al.* (2002) highlighted that inappropriate methods of collection, processing and storage contribute to a negative impact on populations of African medicinal plants. Poachers harvest cycads and sell them to traditional healers who then make traditional medicine of it. Bamigboye *et al.* (2018) highlighted that 68% of South

African cycads have been harvested for medicinal purposes. Their study further indicated that *Encephalartos woodii* is extinct due to illegal harvesting for traditional medicine.

- Inadequate Fencing

A fence plays a major role in the conservation and preservation of the species protected in a nature reserve. Eighteen percent of the rangers indicated that inadequate fencing contributes to poaching in the reserves. The maintenance of fences in provincial owned reserves has been found to be below standard, which makes it easier for poachers to gain access (Camm *et al.,* 2015). In Mphaphuli Nature Reserve the fence is broken and poachers enter with ease. The broken fence was found to be in the Northern part of the reserve which shares borders with Mahunguwi village. Hayward and Kerley (2009) stated that the erection and maintenance of fence is expensive. They further noted that in South Africa there are high levels of poaching inside protected areas due to the lack of maintenance of existing fences and the erection of low-quality fences. Due to the state of the fence in Mphaphuli Nature Reserve cycads were poached inside the reserve.

- Pedestrian route inside the reserve

Although accessing a Nature Reserve without authorisation is regarded as trespassing, in Mphaphuli Nature Reserve the villagers walk through the reserve to surrounding villages (Tshifudi, Tshidzini and Mahunguwi) which the reserve shares borders with. Due to this, rangers from Mphaphuli Nature Reserve found it difficult to distinguish between poachers and people using the pedestrian route through the reserve. This study found that cycads which grew along the route used by pedestrians were poached the most. Thus, the route inside the reserve was found to be one of the main causes of poaching inside the reserve.

- Unemployment

Most young people from the surrounding villages are unemployed and may be stealing the cycads to sell them to formal and informal traders (Skwono *et al.,* 2019). Hence 46% of the rangers mentioned unemployment as one of the major causes of poaching. Poachers are often from local communities next to the

reserves (Milliken *et al.,* 2012). Poachers can be classified into three categories: subsistence, commercial and syndicated poachers (Wildlife Campus, 2016). Subsistence poachers are poachers who illegally harvest or hunt to provide for themselves and their families. This type of poaching has been shown to be enhanced by high unemployment rates in communities near nature reserves (Wildlife Campus, 2016).

- Trade / selling

Encephalartos species form part of an extensive trade in indigenous plants for traditional medicine in South Africa which in 2007 was valued USD 412 million per year (Moeng & Potgieter, 2011).

The bulk of medicinal plant trade takes place in informal street markets and involves the sale of unprocessed or semi-processed products (Mander & Le Breton, 2006). Cycad species are poached and then sold to shops and street vendors (SANBI, 2019). Thirty-five percent (35%) of rangers indicated trade as one of the causes of poaching of cycads (Figure 4.4).

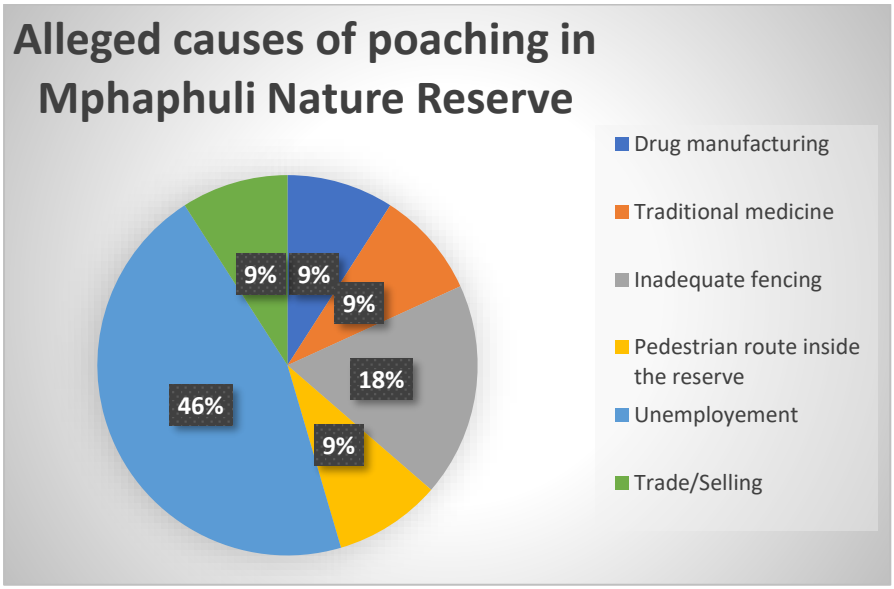

Figure 4.4: Alleged causes of poaching in Mphaphuli Nature Reserve

Although the results recorded in this study do not highlight the ornamental use of cycads, *E. transvenosus* has been cited in literature to be sold as ornamental at a price range from R6000 to R7000 (Skwono *et al.,* 2019).

4.2.2. Alleged causes of poaching in Modjadji Nature Reserve

- Traditional medicine

Similar to the alleged causes of poaching mentioned by the rangers from Mphaphuli Nature Reserve, twenty five percent (25%) of the rangers from Modjadji Nature Reserve highlighted traditional medicine as one the causes of poaching of *E. transvenosus (Figure 4.5)*. With Modjadji Nature Reserve being located in remote rural areas, it can be argued that rural people use traditional medicine to treat their sickness more than they use modern medicine. The traditional medicine made from cycads is used by traditional healers to treat wounds, stomach aches, strokes, heart attacks (Ravele & Makhado, 2009) and wounds (Ndawonde *et al.,* 2007). The parts of the cycads used in the treatment of these diseases are mainly the roots, leaves and bark.

- Trade/ selling

Trade was highlighted as one of the causes of poaching. People are selling plants including *E. transvenosus* to sustain their lives. With lack of regulations of harvesting and selling *E. transvenosus*, people harvest and poach the cycads in an unsustainable manner which could lead to extinction of the species. Tshisikhawe (2002) found that the bark of *E. transvenosus* was traded at traditional medicinal shops and street vendors in different districts in the Limpopo Province and across South Africa. Mander and Le Breton (2006) stated that there is an exponential growth in the trade of cycads in the markets.

- Drugs manufacturing

As in Mphaphuli, drug manufacturing was highlighted to be one of the causes of poaching in Modjadji Nature Reserve. Twenty five percent (25%) of the rangers indicated that drug manufacturing is a leading cause of poaching. Drug manufacturing remains one of the pressing alleged causes of poaching that needs to be investigated so that it can be known which drug is manufactured from *E. transvenosus.*

- Unemployment

As a way of making a living unemployed people are poaching the cycads to sell so that they can sustain their lives. The rangers highlighted that unemployed people are the ones who mostly engage in poaching activities. Although not stated how much, The World Wildlife Fund (2012) highlighted that the payment given to recruited unemployed young people from local communities drives them to engage in poaching activities. The results on the alleged causes of poaching are indicated in figure 4.5.

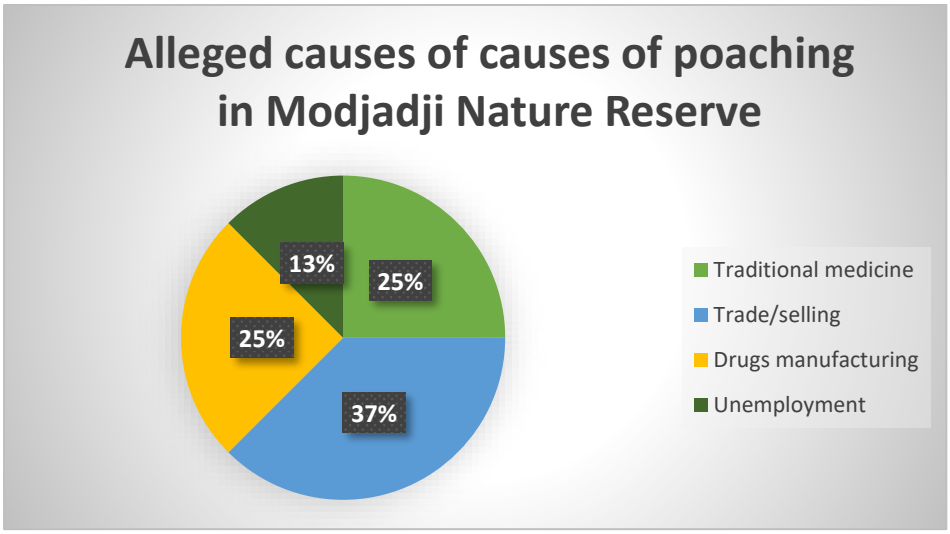

Figure 4.5: Alleged causes of poaching in Modjadji Nature Reserve

4.2.3. Alleged causes of poaching in Lekgalameetse Nature Reserve

- Traditional Medicine

Traditional medicinal use is also a reason for poaching in the Lekgalameetse Nature Reserve. Twenty five percent (25%) of the rangers highlighted traditional medicine as one of the causes of poaching of *E. transvenosus* (Figure 4.6).

- Trade/Selling

Trade of *E. transvenosus* remained the highlighted cause of poaching in all nature reserves. This further proves that the laws implemented to restrict people from trading and harvesting the cycads need to be implemented in order to protect the cycads. A sustainable way of harvesting the cycads needs to be provided so that people do not overexploit the cycads.

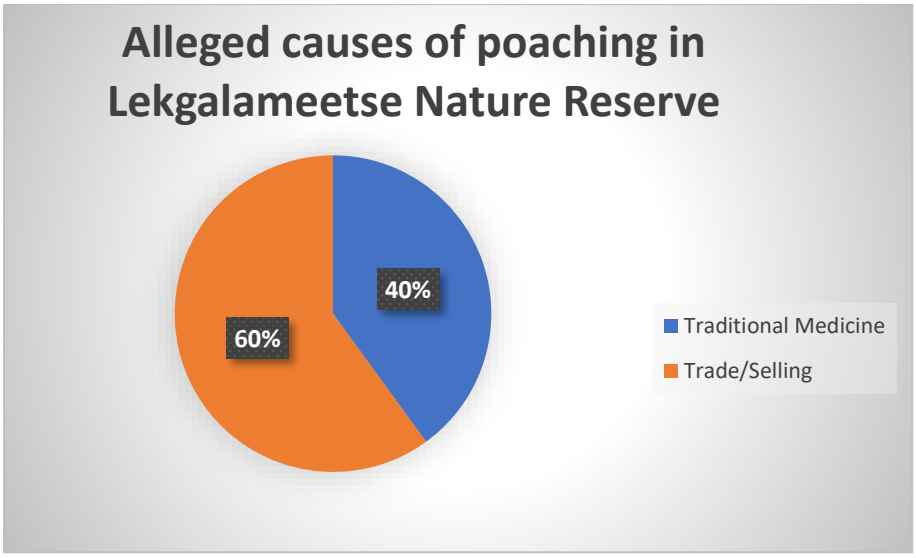

Figure 4.6: Alleged causes of poaching in Lekgalameetse Nature Reserve

4.3 Experience of workers and hours worked in the reserve

In reference to Appendix 1 question number 4 and 5, correlation analysis was used to find out the significance of hours worked, experience working in the reserves and poachers arrested (figure 4.7). It was revealed the relationship between number of poachers arrested and experience of rangers is significant and positive ($\alpha = 0.797^{**}$; $p < 0.01$). In other words, as the number of years or experience working in the reserve increases, the chances of catching poachers also increase. Thus, a ranger with more work experience is more likely to catch poachers than a new entrant. The results might suggest that experienced rangers might be more familiar with the poachers' behaviour patterns, poaching hotpots and have developed skills in patrolling. There were no other significant relationships observed. For instance, there was no significant relationship between number of hours worked and number of poachers arrested ($\alpha = -0.198$; $p > 0.01$). In other words, the numbers of poachers arrested in each reserve does not depend on the numbers of hours worked by the rangers.

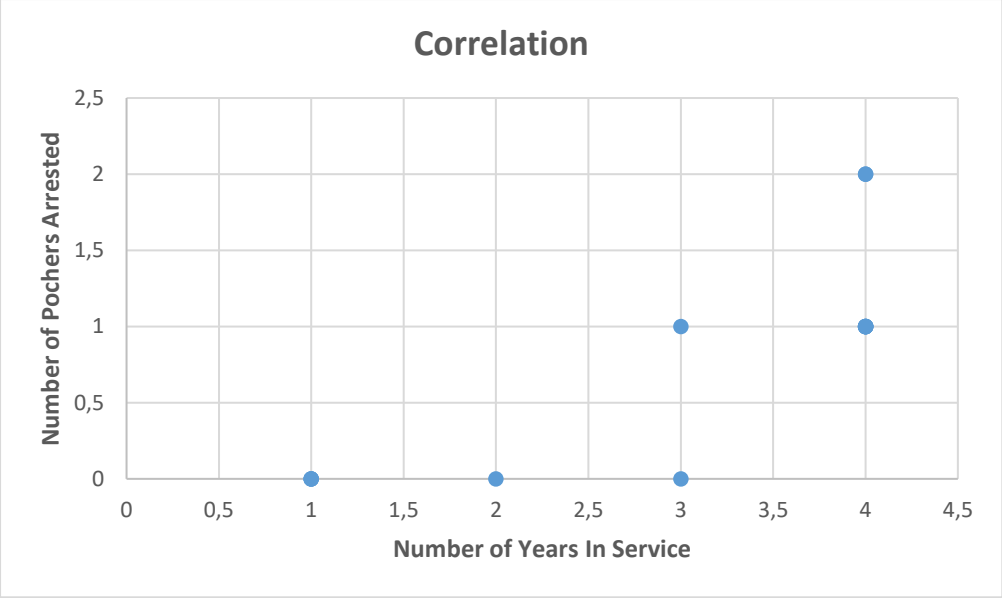

Figure 4.7: Correlation between hours worked, experience working in the reserve and poachers arrested

4.4. Characteristics of poaching

Characteristics of poached cycads inside and outside the reserve is represented in Table 4.1. The geolocations of poached cycads are represented in codes A1 to C3. It was found that cycads which are completely poached were in lower terrain or gentle slope and outside the fence while cycads which are debarked were found high on steep hills. The characteristics found in this study correlates to the descriptive characteristics of *E. transvenosus* described by Skwono *et al.* (2019) when highlighting the conditions that cycads species grow in.

Table 4.1: Poaching characteristics with respect to geolocations and terrains

Nature Reserves	Geolocation Codes	Poaching type	Terrain	Accessibility
Mphaphuli	A1	Completely removed	Gentle slope	Easy
	A2	Debarked	Hill	Minor difficulties
	A3	Debarked	Hill	Minor difficulties
	A4	Debarked	Hill	Minor difficulties
	A5	Debarked	Hill	Minor difficulties
	A6	Debarked	Hill	Minor difficulties
	A7	Debarked	Hill	More difficult
	A8	Debarked	Hill	More difficult
	A9	Debarked	Hill	More difficult
	A10	Debarked	Hill	More difficult
	A11	Debarked	Hill	More difficult

	A12	Debarked	Hill	More difficult
	A13	Debarked	Hill	More difficult
	A14	Debarked	Hill	More difficult
	A15	Debarked	Steep slope	More difficult
Modjadji (poached outside the reserve)	B1	Completely removed	Hill	Next to the road. With easy accessibility
	B2	Completely removed	Hill	Easy
	B3	Completely removed	Hill	Easy
	B4	Completely removed	Hill	Easy
	B5	Completely removed	Hill	Easy
	B6	Completely removed	Hill	Easy
	B7	Completely removed	Hill	Easy
	B8	Completely removed	Hill	Minor difficulties
Lekglameetse	C1	Completely removed	Gentle slope	Easy
	C2	Completely removed	Hill	Minor difficulties
	C3	Completely removed	Hill	Minor difficulties

4.5. Parts of the cycad plant poached

In Mphaphuli Nature Reserve rangers highlighted that the poachers poach the bark. Of 15 cycads poached, 14 were debarked and one was completely removed. In Modjadji Nature Reserve all eight cycads poached had been completely removed. The rangers indicated that these poaching incidents happened outside the reserve, because cycads are easily accessible on the outside and, as there is a road, it is easy for poachers to transport the cycads. In Lekgalameetse Nature Reserve the three poached cycads were completely removed.

4.6. Method of poaching

- Bark Removal

From the field observations and questionnaires conducted with the field rangers it appears that the poaching method is dependent on the size of the cycad, the elevation where it occurs and its accessibility. In Mphaphuli Nature Reserve the method of poaching used the most is debarking (Figure 4.8). This may be because the cycads in Mphaphuli Nature Reserve are large and heavy and occur at high elevations. As they are difficult to transport, the poachers remove their bark instead. In Mphaphuli Nature Reserve the one cycad which was completely removed, was located at a lower elevation than the 14 cycads which were debarked. Okubamichae *et al.* (2016) discovered, using repeated photographs, that cycads in the Limpopo Province were declining more than in

other provinces in South Africa. They also indicated that the population is unsustainable due to bark harvesting for trade and medicinal purposes. Raimondo *et al.* (2002) showed that bark harvesting of the stem caused a population decline of *E. transvenosus.*). Additionally, Bark removal provides an entry point for stem borers and disease organism such as fungi which destroys the plant (Bamigboye & Tshisikhawe, 2020).

- Removing the whole plant.

Removing the whole plant was common in Modjadji and Lekgalameetse Nature Reserve. This method of poaching causes ecosystem destruction. In Modjadji and Lekgalameetse Nature Reserves cycads were completely removed from their natural habitat. Removing the whole plant has a negative impact on the population of cycads while removing the bark disrupt the energy flow of the plant and as a result the plant suffers from lack of food supply to the roots (Bamigboye & Tshisikhawe, 2020). Adeeyo *et al.* (2020) reported that the harvest and use of whole plants threatens the population of the plant and it is not sustainable, especially when harvesting occurs at a high rate and high quantity.

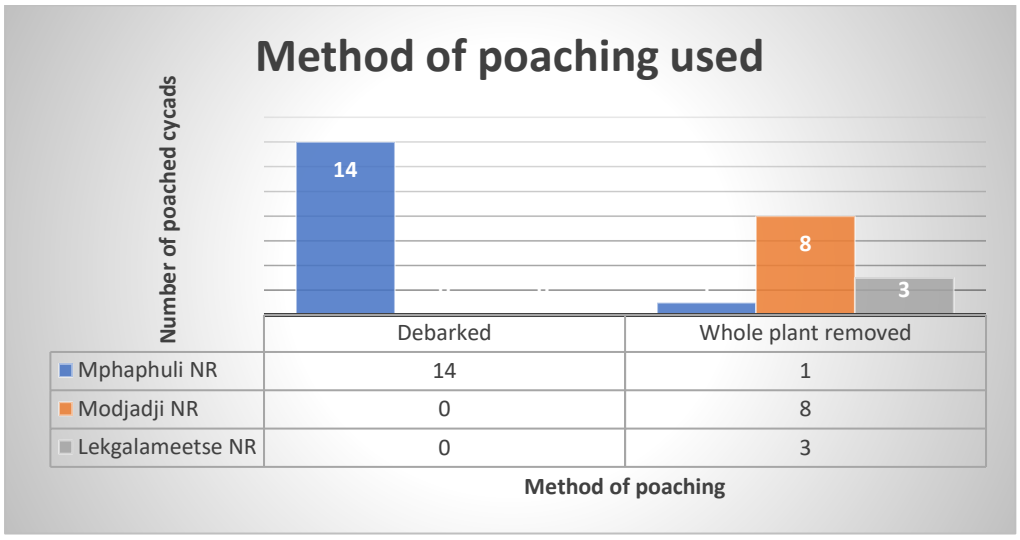

Figure 4.8: Method of poaching used

4.8 Mitigating poaching

a. Botanical gardens

As a way of minimizing the poaching activities within the nature reserves in Limpopo province, Scientific and modern techniques can be used to protect the cycads from poaching activities and extinction risk. As highlighted from literature

review of this study, Botanical gardens can be used to protect endangered plant species. In South Africa, The Kirstenbosch National Botanical Garden in Cape Town, South Africa, plays a vital role in preserving cycads (Maunder *et al.,* 2001). Additionally, in Limpopo province in the Vhembe district, The Thohoyandou Botanical Garden which is under SANBI is also playing a major in planting and protecting *E. transvenosus* species.

b. Seed banks

Seeds of the endangered plant species can be stored and preserved as a way of protecting the species from facing extinction. Seed banks allow relatively rapid access to plant samples for the evaluation of their properties, providing helpful information for conserving the remaining natural populations (Schoen & Brown, 2001).

c. DNA Barcoding

DNA barcoding can be used to trace poached *E. transvenosus* that is being sold in market. DNA barcoding was used in the Faraday and Warwick traditional medicinal markets to identify cycad species and an estimated 50 kg of *E. transvenosus* stem was found in the Faraday market in Johannesburg and 80 kg was found at the Warwick market in Durban (Rayner & Pires, 2016).

4.9. Measures taken to protect cycads

4.9.1 Measures taken in Mphaphuli Nature Reserve

- Patrolling

The results from the questionnaires with the rangers from Mphaphuli Nature Reserve show that all seven rangers patrol the reserve as a way of protecting the cycads. They indicated that since the reserve is big, they mostly patrol the area where cycads are found as this makes it easier for them to monitor the cycads. They also monitor poaching activity in the reserves through patrolling. Furthermore, it is through patrolling that the rangers record data of cycads together with incidents of poaching that might have occurred. It is through patrolling that the rangers arrest poachers who are caught poaching the cycads.

The questionnaires carried out with the rangers revealed that they patrol the reserve each time they come to work. However, they cannot patrol the whole

reserve because some cycads are located in areas which are hard to reach. With no patrolling vehicle it is hard for rangers to cover a large area because they only walk when patrolling. According to Hilborn *et al.* (2006) patrolling is one of the effective methods in conservation which reduces poaching in protected areas. However, Young *et al.* (2011) who assessed the spatial patterns of poaching in the US found that without conservation equipment such as proper fencing, cameras and helicopters it is impossible to predict poaching hot spots in the reserve.

- Visiting households with cycad species

As part of a public awareness programme, the DEFF and LEDET through Mphaphuli Nature Reserve host tribal meetings with the Chief and community members whereby the people having *E. transvenosus* at their homestead are encouraged to report the cycad and are issued with a permit for it. When given the permit the owner of the house is responsible for protecting this cycad. This strategy is essential in protecting the cycads outside the reserve.

- Planting seedlings

As a way of protecting the *E. transvenosus* species from extinction risk, rangers are planting seedlings in order to keep the population of cycads alive. These seedlings are planted in the lowveld of the Nature Reserve and some are planted next to the gate of the reserve to symbolize the core species that is being protected in the reserve.

4.9.2 Measures taken in Modjadji Nature Reserve

- Patrolling

The rangers in Modjadji Nature Reserve patrol the reserve both inside and outside (Figure 4.9). They also patrol the households which have cycads. They patrol both on foot and when using a car.

- Visiting households with cycads species

With Some of the population *of E. transvenosus* also found outside the Modjadji Nature Reserve, the rangers patrol outside and visit the households which have

cycads species. It is the responsibility of the owner of the household to keep the cycads in their home safe.

- Law enforcement

Law enforcement entails arresting people who are caught stealing cycads and prosecuting them. With the arrests that have been made in this reserve there is still poaching activities that are occurring. A prison sentence of up to 10 years or a R10 million fine can be given to poachers in possession of a whole cycad or illegally trading in cycads or cycad parts (Cousins & Witkowski, 2017). The rangers indicated that there is lack of implementation of these laws and regulations and that is contributing to increasing poaching activities. Although some poachers are arrested, sometimes they are given a lighter sentence and in situations like those, they come back and commit the same crime again.

4.9.3 Measures taken in Lekgalameetse Nature Reserve

- Patrolling

In Lekgalameetse Nature Reserve Rangers indicated that the areas which are hard to access are monitored by a helicopter from time to time. Although the helicopter does not patrol and monitor reserve all the time, it can be highlighted that having a helicopter in protected areas is very essential because it is able to monitor cycads which are in inaccessible areas impossible for humans to patrolling. Aerial photographs can also be taken using a helicopter and that can help in viewing and monitoring the population of *E. transvenosus.*

- *Planting seedlings*

The rangers in Lekgalameetse also plant *E. transvenosus* seedlings as a way of reviving the population. These seedlings are now planted along the walking routes in the reserve that are closer to offices and renting houses. This is done because poachers cannot poach in these areas since they are always occupied. These cycads now serve as decorations and are of aesthetic value to the people who visit Lekgalameetse Nature.

- Law enforcement

Law enforcement is also used as a way of minimizing poaching activities and protecting the cycads.

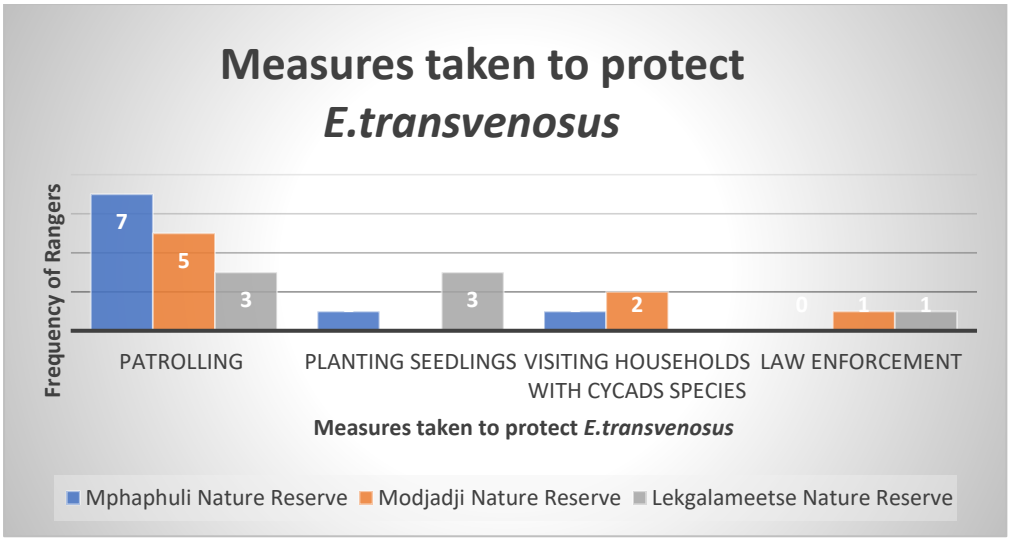

Figure 4.9: Measures taken to protect the cycads in all reserves

4.10. Challenges faced in nature reserves

Challenges faced by rangers inside the reserve are shown in Figure 4.9 and results are discussed below.

4.10.1 Challenges faced in Mphaphuli Nature Reserve

- Safety

The poachers are armed with axes, sharp panga blades or knives when poaching in the reserve and the rangers indicated that it is not safe for them to chase poachers as they may get killed. Questionnaires conducted with rangers from Mphaphuli Nature Reserve further highlighted that they do not have guns to protect themselves and the two-way radios that they have work in a limited range. This is a high risk to them when they are patrolling or monitoring the area in the mountain. The rangers indicated that since the reserve is in a bushy mountainous area it is not safe for them. They further highlighted that they could be attacked by wild animals.

- Few Rangers

There are not enough rangers and this results in poaching activities occurring in the reserve, because there are few rangers in the nature reserves. The advantage of having more rangers in the reserve is that when patrolling they can cover a wide area in the reserve. Since two of the nature reserves studied are large, it is essential to have rangers to monitor poaching activities and capture data of poaching incidents. Furthermore, the movement of rangers in the reserve can intimidate poachers which can limit the number of poaching

activities in the reserve. Most of the nature reserves are big and remote therefore more rangers are needed to patrol the area. The rangers further indicated that they do not patrol during the night.

- Electronic Equipment

Electronic equipment is important in conservation. Equipment such as computers, radio phones, GPS, cameras, drones and Anti-Poaching Systems (APS) are efficient in recording and monitoring poaching activity in protected areas. Mphaphuli Nature Reserve does not have computers to record data and this was observed during data collection as some of the data were not captured by the rangers from this reserve. Anti-poaching systems such as the Perimeter Intruder Detection System (PIDS) can be used in protected areas and can help in detecting poachers entering reserves (Jones *et al.,* 2011). Cambron *et al.* (2015) proposed fencing with motion sensors and laser curtains to detect poachers crossing a fence in a nature reserve. Furthermore, Mulero *et al.* (2014) suggested that drones equipped with heat sensors and camera devices be introduced in reserves to locate poachers. Although these electronic devices are useful in conservation and preventing poaching activities in nature reserves, they are expensive and require high maintenance which is difficult to accomplish in nature reserves found in local communities of developing countries.

- Patrol vehicle

Out of all three reserve studied, Mphaphuli Nature reserve was the only one without a patrolling vehicle (Figure 4.10). As the reserve is large, a patrolling vehicle is very essential as it can help the rangers cover more area over a short period of time when patrolling and it is easy to move from point A to point B using a vehicle. With the availability of patrolling vehicles, it was highlighted by the rangers from Modjadji and Lekgalameetse that it is easy to patrol the reserve inside and also outside because it is easy for them to move around the area.

4.10.2 Challenges faced in Modjadji Nature Reserve

- Safety

Modjadji Nature Reserve is prone to wildfires and it was indicated that it becomes unsafe during this season, because fire fighters take long to come and extinguish or control the fire. Hence this put the lives of rangers in danger as they cannot protect

themselves against fire outbreaks. It is therefore harder to patrol during the dry season.

4.10.3 Challenges faced in Lekgalameetse Nature Reserve

- Few rangers

Shortage of rangers was also indicated to be a challenge in Lekgalameetse. the reserve is 1333 ha in area and needs more rangers to patrol during the day and night to prevent poachers from poaching both plant and animal species protected in the reserve.

- Safety

The rangers from Lekgalameetse indicated that they do not feel safe when working in the reserve. They fear being attacked by wild animals and armed poachers.

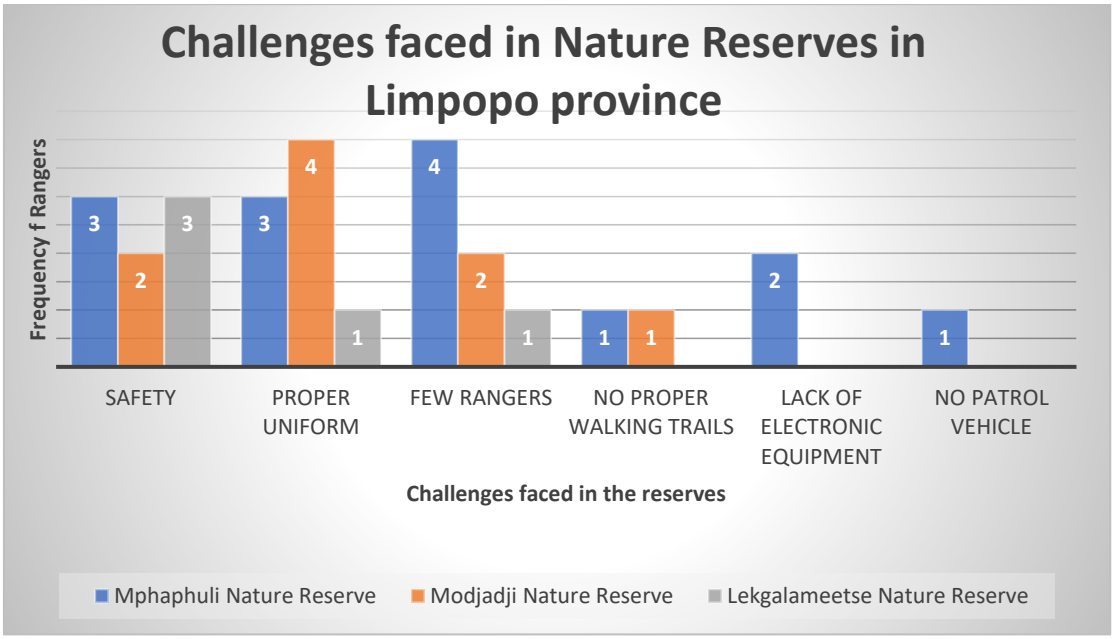

Figure 4.10: Challenges faced in nature reserve

4.11. Poachers arrested

Two poachers were arrested in Mphaphuli, four in Modjadji Nature Reserve and two from Lekgalameetse Nature Reserve. The rangers highlighted that the poachers who get arrested and granted bail, come back and commit the same crime repeatedly. Forsyth (2008) in his study of “The game of wardens and poachers” found that there are poachers who poach alone, poachers who are very experienced at poaching, poachers who never talk about their poaching

experience and poachers who are familiar with the geographic location where poaching is occurring. His findings shows that to arrest all these kinds of poachers, the use of informants is very important and always leads to the arrests of poachers.

4.12. Distribution map of poached *E. transvenosus*

In Modjadji Nature Reserve there were no incidents of poaching inside the reserve, however, poached cycads were found outside the reserve. There were cycads which could not be recorded because they were located in places which were hard to reach. Bamigboye and Tshisikhawe (2020) highlighted that as some cycads are hard to reach, it is the reason why they are still surviving because poachers cannot get to them. Figure 4.8 shows a map of Mphaphuli Nature Reserve with the distribution of poached cycads. The debarked cycads were large and found at high elevations, far from any road, making removal of the complete plants unfeasible.

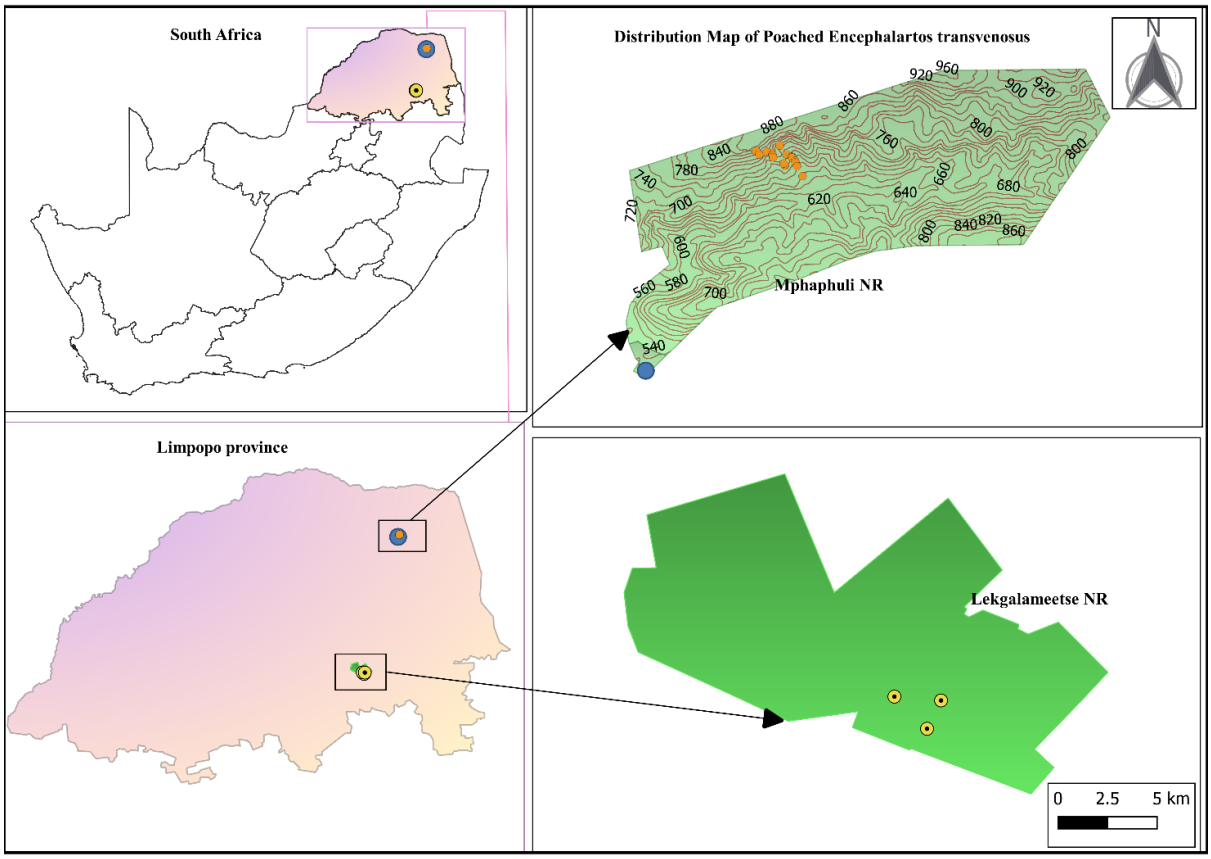

Figure 4.10: Distribution of poached cycads in Mphaphuli and Lekgalameetse Nature Reserves were blue symbol represents cycads which were completely

removed and Orange symbols represents cycads which were debarked from Mphaphuli Nature Reserve and Yellow symbols representing cycads which were completely removed from Lekgalameetse Nature Reserve.

CONCLUSION AND RECOMMENDATIONS

Conclusions

This research study aimed at evaluating poaching activities within the cycad nature reserves in Limpopo Province.

In reference to objective one of this study it can be concluded that there are two common ways of poaching and thus include bark harvesting and removing the whole plant. The method of poaching defers according to reserves, size and location of the cycads. Debarking method was the common means of poaching in Mphaphuli Nature Reserve whereas at Modjadji and Lekgalameetse Nature Reserve the common method of poaching was removing the whole plant.

In reference to objective two and three, the findings from the study revealed that the challenges faced in reserves do lead to poaching of cycads. Poaching activity in Modjadji Nature Reserve was recorded outside the reserve as it becomes easy for poachers to access the cycads. Thus, cycads in high elevations were not poached and are protected against anthropogenic activities. From the findings, it can be concluded that a proper fence limits the access of poachers to the reserve**.**

Based on the results it can be concluded that poaching is a major problem in the studied nature reserves. Such poaching activities can be prevented by installing proper fencing, hiring more rangers, and providing a patrolling vehicle.

Research questions answered

- **Which part of the *E. transvenosus* is poached the most?**

Poaching was different in the reserves studied. In Mphaphuli Nature Reserve the bark was poached the most, while in the other two reserves removing the whole plant was common.

- **Does the challenges faced in the reserve lead to poaching?**

From the findings of this study, it can be concluded that challenges faced in natures do lead to poaching. In Mphaphuli there is no proper fence to prevent poachers from entering the reserve. In Modjadji there is a strong wired fence and poaching activities was only recorded outside the reserve.

- **How does the geographic distribution of cycads influence poaching?**

Poached cycads were found in lower elevations and in areas easy to access (see figure). Cycads in higher elevations could not be recorded because they are located in mountainous areas which are hard to access. It was found that in Lekgalameetse Nature Reserve cycads in higher elevations are censused using a helicopter.

Recommendations for Mphaphuli Nature Reserve

Based on the observations from Mphaphuli Nature Reserve the following recommendations were made:

- More rangers should be employed to patrol during the night
- Erecting of electric fences to prevent poachers' access to the reserve
- Planting of *E. transvenosus* cycads in higher elevations to increase the population of cycads that are naturally persevered within the nature reserve
- Provision of patrolling vehicles to increase the coverage of patrolled areas in the protection of cycads
- Provision of updated electronic equipment (Computer, GPS, Walkie Talkie phones etc.) to help the rangers in capturing the data of cycads
- Provide the rangers with proper protective uniforms and guns to protect themselves when patrolling

Recommendations for Modjadji Nature Reserve

- Since more cycads were poached outside the reserve, Compensation of people who stay closer to the nature reserve and have *Encephalartos* species should be implemented as a strategy to protect the cycads
- Create a task team to deal with wildfires that are destroying cycads.
- More rangers should be employed to patrol during the night

Recommendations for Lekgalameetse Nature Reserve

- Have more rangers to patrol during the night
- Plant *E. transvenosus* cycad seedlings

Areas for future research

- Further research to be conducted on the use of *E. transvenosus* cycads in drugs manufacturing.
- Research on weevils that pose a threat to *E. transvenosus* cycads
- Regenerating capacity of *E. transvenosus* cycads after poaching
- The effects of climate change on *E. transvenosus* cycads

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7. APPENDICES

Appendix 1: Questionnaires (?)

Participants: Rangers from Mphaphuli, Modjadji and Lekgalameetse nature reserve

1. Gender (?)

Female	
Male	

2. Educational status (?)

No formal education	
Only primary education	
Only secondary education	
Higher education (Tertiary)	

3. What age do you fall under?

18 – 24	
25- 31	
32 -38	
39-45	
46-52	
53 and above	

4. How long have you been working in the reserve?

……..

5. What are your working hours?

……

6. What are the causes of poaching in the nature reserve?

- ……
- ……

7. Which part of the Cycad species is being poached the most?

……

8. What is the method of poaching that poachers mostly use?

Harvesting Method	Mark **(X/✔)**
Stripping	
Debarking	
Root harvesting	
Others (please specify)	

9. What is the number of poachers you have arrested?

……

10. What tools are mostly used by the poachers?

……

11. What is the government doing to reduce poaching of cycads species?

……

……

12. What are the conservation policies inside the reserve?

……

……

13. What are the measures that are taken to protect the cycads?

……

……

14. What are the challenges you face in the Nature Reserve when conserving the cycads?

……

……

15. What can you recommend to the following?

(a) The government

……

……

(b) The community

……

……

(c) Researchers

……

……

Appendix 2: Ethical Clearance

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Ms TM Ndou

STUDENT NO:
14013715

PROJECT TITLE: Poaching of endangered *Encephalartos Cycad* species in Limpopo Province.

PROJECT NO: SES/19/GGIS/06/1202

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr EM Stam	University of Venda	Supervisor
Prof MP Tshisikhawe	University of Venda	Co - Supervisor
Ms TM Ndou	University of Venda	Investigator – Student

Type: Masters Research
Risk Level: Straightforward research without ethical problems
Approval Period: February 2020 – February 2022

The Animal, Environment and Biosafety Research Ethics Committee (AEBREC) hereby approves your project as indicated above.

General Conditions
While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following.

- The project leader (principle investigator) must report in the prescribed format to the REC:
  - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project
  - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
  - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project. The project leader must apply for approval of these changes at the REC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date; a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the RECs retains the right to:
  - Request access to any information or data at any time during the course or after completion of the project,
  - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
  - withdraw or postpone approval if:
  - Any unethical principles or practices of the project are revealed or suspected.
  - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
  - The required annual report and reporting of adverse events was not done timely and accurately,
  - New institutional rules, national legislation or international conventions deem it necessary

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: February 2020

Name of the AEBREC Chairperson of the Committee: PROF IEJ BARNHOORN

Signature: .....

Date: 13/02/2020

Director Research and Innovation

Signature: .....

Date: 14/02/2020

UNIVERSITY OF VENDA
DIRECTOR
RESEARCH AND INNOVATION
2020 -02- 14
Private Bag X5050
Thohoyandou 0950

University of Venda
PRIVATE BAG X5050, THOHOYANDOU, 0950, LIMPOPO PROVINCE, SOUTH AFRICA
TELEPHONE (015) 962 8504/8313 FAX (015) 962 9050
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Appendix 3: LEDET Permit

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
ECONOMIC DEVELOPMENT, ENVIRONMENT & TOURISM

DO SCIENTIFIC RESEARCH ON PLANTS

(Issued in terms of the provisions of the Limpopo Environmental Management Act 2003, Act no.7 of 2003).
In terms of and subject to the provisions of the abovementioned legislation and the regulation framed thereunder, the holder of this permit is hereby authorized to catch and/or collect the species and number of plants specified on the table below for scientific purpose in the property mentioned on this permit.

Permit Holder

Name	NDOU TSHANEO MELIDA	
Trade Name	N/A	
ID/Passport Number	9507090687082	
Address [Physical / Postal]	SHAKADAZA VILLAGE STAND NUMBER 30002	P.O BOX 1729 SHAKADZA 0958

Permit Details

Permit No :	ZA/LP/98233		CITES PERMIT MANAGEMENT ENVIRONMENTAL AFFAIRS LIMPOPO PROVINCE
Reference No :	CPM/26373/2019		
Date Issued :	2019-07-22	Stamp:	
Valid until :	2020-07-22		
Paid (ZAR):	R 55.00		
Receipt No :	1124137		

Farm Name / Organization	District	Province	Country
	N/A	Limpopo	South Africa

See Special Condition

Species Name	Scientific Name	Quantity	Note

Printed by: Seakamela TK

2019-07-22 — Printed Date:

2019-07-22 — Effective Date:

Signature of Permit Holder

I acknowledge, accept and understand fully the permit conditions as described.

WILDLIFE TRADE & REGULATION

20 Hans Van Rensburg Street, Polokwane, 0700, Private Bag X 9484, Polokwane, 0700
(Switchboard) Tel: +2715 293 8300 Fax: +27 15 293 5018 Email: permits@ledet.gov.za Website: www.ledet.gov.za
LimpopoLEDET www.Facebook.com/pages/LEDET @LimpopoLEDET

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