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ASSESSMENT OF CAMEL FEED RESOURCES: WOODY SPECIES STAND STRUCTURE, SPECIES RICHNESS AND DIVERSITY IN TSABONG ECOTOURISM CAMEL PARK, SOUTH-WESTERN BOTSWANA

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ABSTRACT

Stand structure, diversity and regeneration status of woody species, were studied in Tsabong Ecotourism Camel Park (TECP), south-western Botswana. Regeneration status of the woody species, stand structure i.e., population structure, density, abundance, frequency, dominance, richness, diversity and evenness and important value index (IVI) were determined by genera and family, we used 40 quadrats of 20 m × 20 m placed systematically within TECP. There were 11 woody species in total, from 5 families and nine genera. The woody species exhibited a diversity of 2.1 and an evenness of 0.6. The average density of the woody species was 3,585 individuals ha^{-1} and varied from 768 to 19 individuals ha^{-1}. In terms of density, the five woody species with the highest density (≥ 100 individual ha^{-1}) were *Senegalia mellifera, Elephantorrhiza elephantina, Rhigozium trichtomum, Vachellia karoo and Vachellia erioloba*. Woody species occurred with frequencies ranging from 7 to 78%. The most frequently recorded woody species were *V. erioloba, S. mellifera, E. elephantina, G. flavescens and S. italica.* The dominance of woody species varied from almost 0 to 4 ha^{-1}. The dominant species included *V. erioloba, B. albitrunca* and *V. karroo*. Nine of the species exhibited dominance values of 0 or 1 $0ha^{-1}$. The ecological importance of the woody species is represented by the IVI, which ranged from 3 to 89%. The woody species with an IVI of ≥ 20%, ranked by ecological importance from highest to lowest, were *V. erioloba, S. mellifera, E. elephantina, V. karoo* and *R. trichotomum*. The population structures of only 27% of the woody species were stable, whereas most woody species (73%) showed unstable population structures, with hindered natural regeneration. Several potential research directions were presented with suggestions for the future sustainable management of TECP.

Key words: Botswana, camel feed, diversity, ecotourism, feed resources

The identification of feed resources for camel production relies on assessing the richness, diversity and regeneration status of woody plant species. Camels' diet and sustainable milk production greatly rely on the valuable contribution of woody vegetation resources.

In Botswana, camels (*Camelus dromedarius*) are kept in Tsabong, which is a semi-arid region in Kgalagadi District. They are kept in an exclosed park known as Tsabong Ecotourism Camel Park (TECP). Camels are kept in Tsabong mainly for tourism, specifically for riding purposes. Nevertheless, the camels are utilised for milk and meat production, but these products are exclusively consumed by the park employees and have not been made available for sale in the market yet.

A better equitable distribution of individuals of different woody species in the TECP is expected due to the low natural and anthropogenic disturbances since the area is fenced to exclude livestock and humans. Livestock grazing and browsing pressure affect species richness and recruitment of plant communities (Jacobs and Naiman, 2008; Levick and Rogers, 2008). Woody species are an important component of the flora of many ecosystems in Botswana, including the TECP.

Seedling densities in forest understories are dynamic and rates may vary among species and in gap and shade environments (Bazzaz, 1991). The rates also vary due to mortality, which could include abiotic stresses, such as light, drought and biotic

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factors that include herbivory/predation, diseases or competition (Janzen, 1971; Augspurger, 1984).

The major constraint that hinders the productivity of camels in Tsabong is feed shortage especially during the dry season. The study area experiences low rainfall. This results in the area having poor pasture, making it difficult to meet maintenance nutrient requirements of camels. The area is characterised by high ambient temperature and the vegetation is dominated by sparsely distributed shrubs and trees in particular *Senegalia/Vachellia* species.

The Tsabong Ecotourism Camel Park (TECP) is an exclosure that covers a 4 x 4 km fenced area where the camel herd are kept. The camels browse inside the park all year round and they do not have access to the vegetation outside the park. Moreover, the park is not divided into paddocks and no rotational grazing is practiced in the park. As a result, the park is overgrazed and heavily degraded and dominated by only few plant species such as *Senegalia/Vachellia* and *Grewia* spp. Consequently, the natural browse species found inside the park hardly meet the nutrient requirements of camels limiting their productivity. Therefore, it is important to assess the vegetation inside TECP, analyse the factors that contribute to the degradation of the area and suggest strategies that will enable regeneration of the vegetation in the park and improve the overall feed resource base of the camel park.

The present study focuses on the assessment and identification of Camel Feed Resources in terms of woody plant species density, richness, diversity and regeneration status in TECP. Therefore, the specific objectives of the study were to: determine woody species stand structure, density, abundance, richness, diversity, frequency, dominance and important value index and to assess the regeneration status of the woody species in TECP.

Materials and Methods

Description of Study Site

The research was conducted in Tsabong, situated in the south-western part of Botswana within the Kgalagadi South District (Fig 1). The Tsabong Ecotourism Camel Park was established in 2003 and it spans an area of 16 km^2 and at present, it accommodates around 370 camels (Seifu *et al,* 2019). There are no other herbivores within the park and the park is exclusively composed of grazing land with no additional land uses.

The Kgalagadi South District is known for its hot and dry climate, experiencing summer temperatures between 28.5 and 35°C and winter temperatures ranging as low as 1 to 12°C. Rainfall is low and inconsistent, occurring mainly during the summer months from November to March reaching an average of 146.2 mm per annum (Kgaudi *et al,* 2018) and fluctuating monthly between 0.6 and 61mm (Zweistra, 2012).

Soils in the district are mostly sandy and unproductive (Batisani, 2010), which limits arable agriculture (Seifu *et al,* 2019; Tselaesele *et al,* 2021). The area is typified by sparsely distributed vegetation mostly consisting of *Grewia, Senegalia, Vachellia* and herbaceous species (Kgaudi *et al,* 2018).

Vegetation sampling

The authors established 40 sampling plots of 20 m × 20 m (each representing 0.04 ha) that were carefully established inside TECP using the Global Positioning System (GPS). A systematic random sampling method was used while establishing the sampling plots. The first plot was laid out at the north-west corner of the exclosure. Measurements were made within the sampling plots to determine the identity of species, density, abundance, population structure, frequency, dominance, richness, diversity, evenness, importance value index and regeneration status of the wood species by genera and family. In each sampling plot, the following parameters were recorded: total number of all live individuals and diameter at breast height (DBH) per woody species with DBH > 2 cm. In the case of juveniles (seedlings and coppices < 1.5 m in height), the number of individuals of each woody species was counted and recorded. A calliper and a graduated measuring stick were used to measure the DBH and height, respectively, of the woody species.

The woody species were identified directly in the field using the available literature on the flora of Botswana and Southern Africa (Timberlake, 1980; van Wyk and van Wyk, 1997; 2007; Palgrave, 2002; Setshogo, 2002; 2005; Setshogo and Venter, 2003) and with assistance from TECP officers and local communities familiar with the flora of the area. Plant nomenclature in this article follows that of Setshogo and Venter (2003), Kyalangalilwa *et al* (2013) and Setshogo (2005).

Limitation of the study

We were unable to include a control site however, we have tried to compare our findings

with results from similar studies in analogous environments, namely Mokolodi Nature Reserve (exclosed to prevent livestock grazing, but allowing wild animals to graze), Okavango Research Institute (exclosed for more than 10 years to prevent grazing of both domestic and wild animals), Maun Educational Centre (exclosed to prevent domestic animals, but allowing grazing of wild animals), Xobe and Shorobe open/free grazing sites in Botswana and similar sites elsewhere.

Data Analyses

The woody vegetation attributes (i.e., species diversity (richness, evenness), densities (DE), frequencies (FR), dominance (DO), relative densities (RDE), relative frequencies (RFE), relative dominance (RDO) and from those values, the Importance Value Indices (IVI)) were analysed using descriptive statistics.

Species richness (S) is the total number of different woody species present in the study site and does not consider the proportion and distribution of each woody species (Teketay *et al,* 2018). Woody species richness in the TECP was evaluated using the total number of different species recorded in all the quadrats. The diversity of woody species was analysed using the Shannon Diversity Index (H′) (also referred to as the Shannon-Weiner/Weaver Diversity Index in Ecological literature) (Krebs, 1989; Magurran, 2004). The index considers the species richness and the proportion of each woody species in all the sampled quadrats (Teketay *et al,* 2018). The woody species diversity was analysed using the following formula:

$$H' - \sum_{i=1}^{S} Pi \ln Pi$$

where, H' = Shannon index, S = species richness, P_i = proportion of S made up of the i^{th} species (relative abundance).

Evenness or equitability, a measure of similarity of the abundance of the different woody species in the study site was analysed by Shannon's Evenness or Equitability Index (E) (Krebs, 1989; Magurran, 2004). Evenness values range from 0 to 1, with 1 being complete evenness and calculated using the following formula:

$$E = H'/\ln S$$

where, E = evenness and S = species richness.

The mean density of each woody plant species (ha^{-1}) in the TECP was determined by converting the total number of individuals of each woody species recorded in all the quadrats to an equivalent number ha^{-1}.

The frequency was calculated as the proportion (%) of the number of quadrats in which each woody species was recorded from the total number of quadrats within TECP.

The dominance of the woody species, with DBH of ≥ 2 cm, was determined from the space occupied by a species, i.e. its basal area (BA). It was computed by converting the total BA of all the individuals of each woody species to equivalent BA ha^{-1} (Kent, 2012).

The Importance Value Index (IVI) indicates the relative ecological importance of woody plant species in the sampled areas (Kent, 2012). It was determined by summing up the relative values of density, frequency and dominance of each woody species. The species with the highest IVI were considered the most ecologically important in the study area (Ismael *et al,* 2017). Relative density was calculated as a percentage of the density of each species divided by the total stem number of all woody species per hectare (Teketay *et al,* 2018). Relative frequency was computed as the ratio of the frequency of the species to the sum of the frequency of all species encountered in TECP. Relative dominance was calculated as the percentage of the total basal area of a species out of the total basal areas of all species. IVI was used to compare the overall dominance and ecological significance of species.

The population structure and regeneration status of each woody species in the study area were assessed through histograms constructed by using the density of individuals of each species (Y-axis) categorised into 10 diameters classes (X-axis) (Peters, 1996), i.e.: 1 = < 2 cm; 2 = 2-5 cm; 3 = 5-10 cm; 4 = 10-15 cm; 5 = 15-20 cm; 6 = 20-25 cm; 7 = 25-30 cm; 8 = 30-35; 9 = 35-40; 10 = > 40 cm. Thereafter, based on the profile depicted in the population structures, the regeneration status of each woody species was determined (Teketay *et al,* 2018).

Results

Species Richness, Diversity and evenness

A total of 11 different woody species, representing five families and 9 genera were recorded in TECP (Table 1). Of these, one species was unidentified. The most diverse family, Fabaceae (Leguminosae), had six (about 55%) woody species. One species (roughly 9% of each) represented each of the other families (Bignoniaceae, Brassicaceae,

Tiliaceae, Thymelaeaceae, and unidentified species) (Table 1).

Vachellia, represented by three species (= 27%), was the genera with the highest richness of woody species. Each of the remaining genera (*Arthrosolen, Boscia, Elephantorrhiza, Commiphora, Grewia, Rhigozum, Senegalia, Senna* and unidentified species) was represented by a single species, accounting for 9% each. The woody species diversity (H′) and evenness (E) in the TECP were recorded as 2.1 and 0.6, respectively.

Woody Species Density, Frequency and Dominance

The total mean density of the woody species across the study area was 3,585 individuals ha^{-1} (Table 1) and ranged between 768 (*S. mellifera*) and 19 individuals ha^{-1} (*B. albitrunca*). The most densely populated woody species, in descending order, were *Senegalia mellifera, Elephantorrhiza elephantina, Rhigozium trichtomum, Vachellia karoo, Vachellia erioloba, Logolo* (unidentified) *Senna italica, Arthrosolen polycephalus and Grewia flavescens. Vachellia hebeclada and Boscia albitrunca* were the least densely populated woody species in the study area (Table 1).

The frequency of occurrence of woody species ranged from 7% to 78% (Table 1). The top 5 most frequently recorded woody species were *V. erioloba, S. mellifera, E. elephantina, G. flavescens and S. italica.* However, *A. polycephalus, R. trichotomum, Logolo, V. hebeclada and B. albitrunca* were among the less frequently recorded woody species.

Dominance of the woody species in the study area varied from 4 to nearly 0 individuals ha^{-1} (Table 1). The dominant species based on basal area were *V. erioloba, B. albitrunca and V. karroo.* Other species had minimal contributions to total basal area, each between 0.0 and 0.1 m^2/ha.

The Importance Value Index (IVI) of the woody species varied from 3% to 89% as shown in Table 1. The woody species with the highest IVI (≥ 20%) in descending order of ecological importance were *V. erioloba, S. mellifera, E. elephantina, V. karoo and R. trichotomum. On the other hand, V. hebeclada and Logolo* had IVI values below 10%. 10%.

Population structure and regeneration status of woody species

The woody species recorded in the study area were categorised into three groups based on their population structures as follows:

I. The first pattern exhibited the highest number of individuals at the lowest diameter class and progressively declining numbers with increasing diameter classes. This group of species was represented by *V. karoo, S. mellifera* and *V. erioloba* (representing 27% of the total number of species) (Fig 2).

II. The second pattern was formed by woody species which exhibited a similar diameter class distribution pattern as the first group except that individuals at the higher diameter classes are missing. This group was represented by *B. albitrunca* (Fig 2) (representing 9% of the total number of species).

III. The third pattern exhibited woody species with individuals only in the lower diameter classes (Fig 2). This pattern was represented by *V. hebeclada, E. elephantina, G. flavescens, R. trichotomum* Burch., *Logolo* (unidentified sp.) and *Arthrosolen polycephalus*.

Discussion

Forest and woodland resources in Botswana provide goods (timber, food fuelwood, medicine, etc.) and services (soil protection carbon sequestration, wildlife habit and regulation of water resources) that are important in the sustenance of livelihoods and the economy at large. Woody species are an important component of the flora of many ecosystems in Botswana, including the TECP.

Woody species richness plays a crucial role in the biodiversity of forests as resource and habitat provider for almost all other species within a forest (Malik, 2014). Species richness defines the absolute number of species present in the population of interest (Aisling *et al,* 2018). Fabaceae (Leguminosae) was the most diverse family in the present study. This agrees with work done in other parts of Botswana- (Neelo *et al,* 2013, 2015; Teketay *et al,* 2016; Teketay *et al,* 2018) and other savanna ecosystems (Atkinson- and Marin-Spiota, 2014; Muluneh *et al,* 2013).

The number of species, families and genera in this site is very low compared with values reported from other woodlands in other parts of Botswana (Teketay *et al,* 2016; Neelo *et al,* 2013, 2015) and elsewhere (Bekele and Abebe, 2016; Boz and Maryo, 2020; Dibaba *et al,* 2020; Rangkuti *et al,* 2023). The family with the highest number of species recorded was Fabaceae, with known significant roles in nitrogen fixation and enhancement of soil fertility, which are important for sustaining forage.

Although, the cause of low woody species richness was not investigated in this study, it may

be attributed to browsing and grazing pressure from camels. Browsing by camels kept in the study site could reduce species richness by direct consumption and trampling of seedlings and saplings. Sustained browsing pressure kills woody species (Levick and Roger, 2008; Staver *et al,* 2009; 2012) and prevents saplings from maturing into adults (Augustine and Decalesta, 2003; Staver *et al,* 2009). Signs of stunted growth and canopy loss were observed in the woody species, which may indicate browsing pressure exerted by camels. Furthermore, the study site is in a low rainfall area (146.2 mm per annum) (Augustine and Decalesta, 2003) and on nutrient-poor sandy soils. Therefore, the sandy soil and insufficient moisture may be affecting woody species richness. Rainfall is an important determinant describing woody vegetation communities and low rainfall limits primary productivity (Sankaran *et al,* 2005; Ward, 2005; Kraaij and Ward, 2006).

The Shannon diversity index value recorded for this study area is like those reported for Shorobe (2.18) Island Safari Lodge (2.16) (Neelo *et al,* 2013, 2015) and inside the Okavango Research Institute compound (ORI) [(Teketay *et al,* 2018) in Botswana. In contrast, the Shannon diversity index recorded in the study site is higher than those outside the ORI compound (1.6) Mokolodi Nature Reserve (1.44) (Teketay *et al* 2016) in Botswana. These results show that woody species in the site are more diverse, though a few species were recorded. This could be attributed to the less dominance of a few species over the others, due to low habitat disturbance and environmental conditions that favour all species (Zegeye *et al,* 2006; Tadele *et al,* 2014).

The Shannon diversity index reflects the level of diversity (Susilowati *et al,* 2019) and stability (Wang *et al,* 2020) of plant communities within a site. A diversity value of 1.0 is considered very low (Zegeye *et al,* 2006).

Species evenness index (E) indicates the relative abundances of species within a community (Wilson and Witkowski, 2003; Cavalcanti and Larrazabal, 2004; Susilowati *et al,* 2019). The evenness value (0.60) recorded in this study is close to those reported inside (0.75) and outside ORI (Teketay *et al,* 2018) Xobe (0.5), Shorobe (0.6) (Neelo *et al,* 2013, 2015) in Botswana and elsewhere (Zegeye *et al,* 2011; Worku *et al,* 2012). Results suggest that there is a better equitable distribution of individuals of different woody species in the TECP. This could be attributed to the low natural and anthropogenic disturbances since the area is fenced to exclude livestock and humans. Livestock grazing and browsing pressure affect species richness and recruitment of plant communities (Jacobs and Nainan, 2008; Levick and Rogers, 2008).

The mean density of plants reported in this study (3,585 individuals ha^{-1}) is lower than that of Shorobe (Neelo *et al,* 2013), Mokolodi Nature Reserve (Teketay *et al,* 2016) and Maun Educational Centre but greater than that of Xobe (Neelo *et al,* 2013. The density of woody species in TECP ranged from 19 to 768 individuals ha^{-1}. *Senegalia mellifera, Elephantorrhiza elephantina* and *Rhigozum trichotomum* exhibited the highest mean density.

Results showed that 5 species viz *V. erioloba, S. mellifera, R. trichotomum, G. flavescens* and *S. italica* were the most frequent in this site. Which contributed over

Table 1. List of woody species recorded in Tsabong Camel Park with their families, densities (DE = individuals ha^{-1}), frequencies (FR), dominance (DO), relative densities (RDE), relative frequencies (RFE), relative dominance (RDO) and important value indices (IVI).

Species		Family	DE	FR	DO	RDE	RFR	RDO	IVI
1.	*Senegalia mellifera*	Fabaceae	768	78	0.09	21	17	14	53
2.	*Elephantorrhiza elephantina*	Fabaceae	694	65	0	19.4	15	0	34
3.	*Rhigozum trichotomum*	Bignoniaceae	676	10	0	19	2	0	21
4.	*Vachellia karroo*	Fabaceae	277	30	0.94	7.7	6.7	15	30
5.	*Vachellia erioloba*	Fabaceae	255	85	4	7	19	62	89
6.	*Logolo* (Setswana name)		243	8	0	7	2	0	8.4
7.	*Senna italica*	Fabaceae	229	55	0	6.4	12	0	19
8.	*Arthrosolen polycephalus*	Thymelaeaceae	219	38	0	6	8	0	15
9.	*Grewia flavescens*	Tiliaceae	152	65	0	4	15	0	19
10.	*Vachellia hebeclada*	Fabaceae	52	8	0	1.2	2	0	3
11.	*Boscia albitrunca*	Capparaceae	19	7	1	1	2	8	10
			3,585	447	6				300

Fig 1. Map of Africa showing the location of Botswana Source: https://maps-bostwana.com/botswana-africa-map (accessed on 281224) and study area, Tsabong village (Source: Seifu *et al,* 2019).

78% of the cumulative frequency recorded for all the species. A high frequency indicates a wider distribution of species on the site (Teketay *et al,* 2018). According to Gedefaw and Soromessa (2014), frequency provides an approximate indication of the homogeneity and heterogeneity of vegetation in a community. A high frequency indicates a wider distribution of species on the site (Teketay *et al,* 2018). A high value in higher frequency and a lower value in the lower frequency classes in a site indicate heterogeneity of vegetation (Lamprecht, 1989; Shibru and Balcha, 2004).

Dominance was evaluated using basal area, which is an important parameter for measuring the relative importance of the woody species than simple counting of stems (Aliyi *et al,* 2015). Woody species with the largest contribution to the overall basal area in each community are considered the most important in a habitat (Bekele, 1994; Aliyi *et al,* 2015; Endris *et al,* 2017). In this study, *Vachellia erioloba* was the most dominant and important woody species (IVI = 89%, Table 1) with a basal area of 4 m^2 ha^{-1} (67%) which is about four times than that of the second most important species with a basal area of approximately 1 m^2 ha^{-1}. It is also one of the species with the highest mean densities (259 individuals ha^{-1}) in TECP (Table 1). Approximately 73% of the woody species in this site lacked trees with high DBH values and their basal area ranged between 0.0 - 0.1 m^2 ha^{-1}. This could be attributed to poor environmental conditions (moisture deficiency, poor soils and frost) and pressure from camel browsing.

Importance Value Index is an important parameter used to compare the ecological significance of species in a vegetation community (Lamprecht, 1989; Zegeye *et al,* 2006; Dirbaba *et al,* 2014; Gedefaw and Soromessa, 2014; Tilahun *et al,* 2014; Ayanaw and Dalle, 2018; Pamoengkas *et al,* 2019) and is derived from a combination of data from relative frequency, relative density and relative dominance (Kent, 2012). Woody species having the highest IVI is considered dominant in a site (Arshad *et al,* 2002; Noraimy *et al,* 2014) and more important than their counterparts with low IVI (Eyasu *et al,* 2020; Noraimy *et al,* 2014). The results revealed that *Vachellia erioloba, Senegalia mellifera, Elephantorrhiza elephantina, Vachellia karroo* and *Rhigozum trichotomum* with IVI values of more than 20 are the leading dominant and ecologically most significant woody species in TTCP. The dominant and ecologically most significant species could also be the most successful species in regeneration in the site, tolerate sandy soil, low rainfall and resist browsing by camels. Moreover, the dominant woody species belong to the Fabaceae family with some members known to have nodules formed by rhizobia, which can fix nitrogen available in the air into an organic form for their use, which helps them to grow well in the present study site characterised by sandy soils.

Tree size class distribution is an important indicator of changes in population structure and species composition of a forest ecosystem (Condit *et al,* 1998; Neelo *et al,* 2015). Population structure of woody species yields information on the history

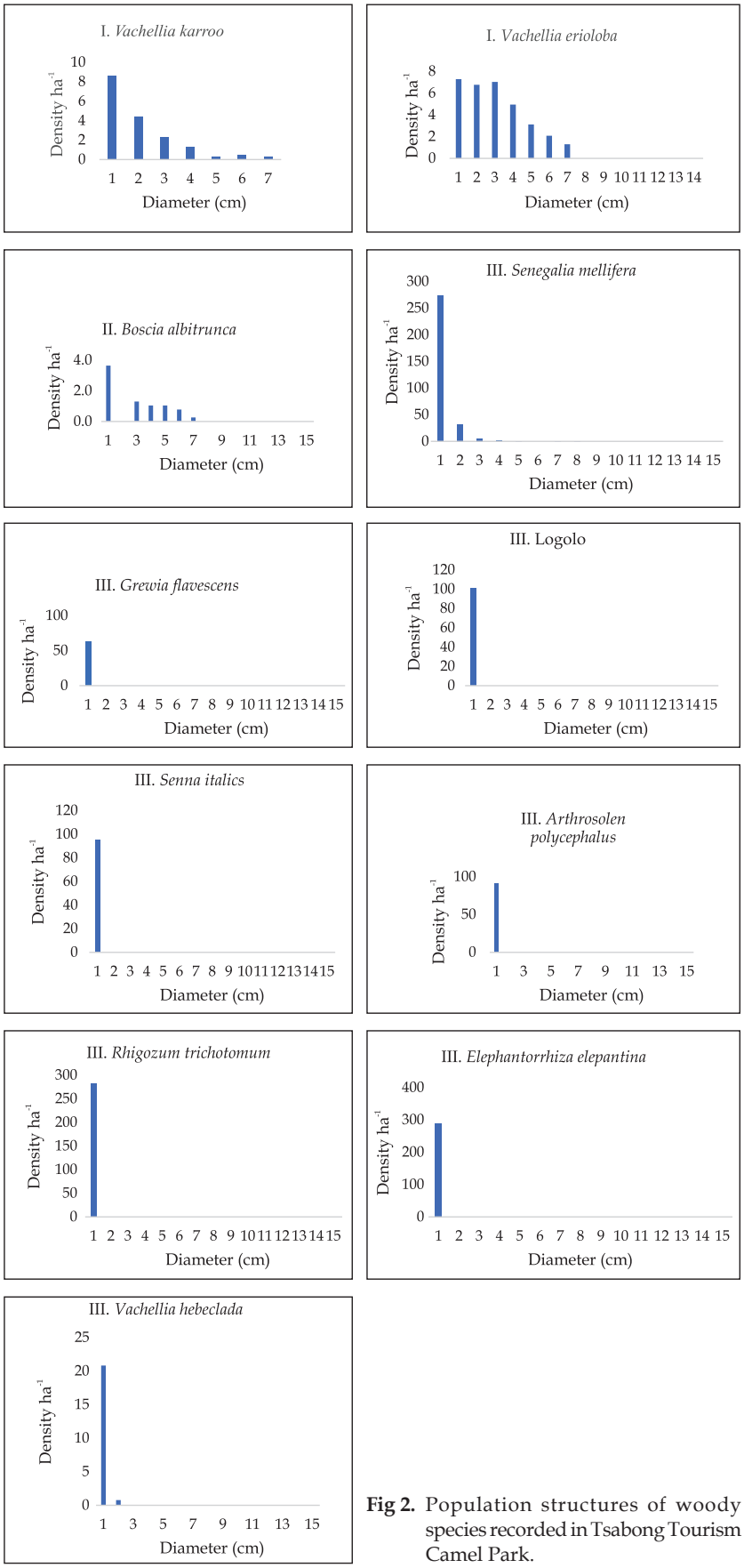

Fig 2. Population structures of woody species recorded in Tsabong Tourism Camel Park.

of past disturbance of the species and their environment (Teketay, 1997b; Wale *et al,* 2012; Neelo *et al,* 2015), which can be used to predict the future trend of the population of a particular species (Teketay, 1997a; Wilson and Witkowski, 2003; Kalema, 2010; Neelo *et al,* 2015).

The assessment of diameter class distributions of woody species in TECP resulted in the recognition of three different patterns of the population structures. In the first group, to which only about 27% of the woody species belong, the number of individuals decreased with the increasing diameter class, resulting in an inverted J-shaped population, an indication of stable population structure or healthy regeneration status (Teketay, 1997a; Alelign *et al,* 2007; Tesfaye *et al,* 2010; Zegeye *et al,* 2011; Neelo *et al,* 2015; Teketay *et al*, 2016). The woody species (about 73% of the woody species), which were categorised in the two other groups of population structure exhibited hampered regeneration, suggesting that the vegetation in TECP has been highly degraded because of a long period of open grazing/overgrazing. Human disturbance, particularly grazing, has been reported as the major reason for hampered or poor regeneration (Zegeye *et al,* 2011; Neelo *et al,* 2013, 2015). High browsing pressure can lead to the absence of seedlings or juveniles because of high seedling mortality (Trembley *et al,* 2007; Negussie *et al,* 2008; Neelo *et al,* 2013, 2015).

The population structures of woody species recorded in TECP were similar to those reported for Mokolodi Nature Reserve, which had a history of serving as a ranch and is, currently, being used as a habitat for grazing by various wild animals (Teketay *et al,* 2016).

Among the woody species that were categorised in the first

group, which exhibited healthy regeneration, are *B. albitrunca, V. erioloba, S. Mellifera and V. karoo,* which are among the relatively densest (Table 1) and preferred browse species by the camels. Despite their healthy regeneration exhibited by their population structures (Fig 2), these species lacked individuals at the bigger diameter classes, which represent the adult and reproductive individuals. On the other hand, the woody species categorised in the third group, e.g. *Grewia flavescens, R. Trichocomum, V. hebaclada, Senna italica, Arthrosolon policephalus E. elephantia* and *Logolo* (Unidentified sp.) are bound to local extermination or disappearance since they are represented by individuals only at the lowest diameter classes, i.e. juveniles (seedlings and coppices) (Fig 2). Hence, they require attention in the active management of the woodland in TECP.

Nine browse species consumed by camels were identified in the park of which *Boscia albitrunca* is the browse species most preferred by the camels (Kgaudi *et al,* 2018). The result may explain the relatively low mean density (19 individuals ha^{-1}) of the species in TECP (Table 1).

In a study undertaken to determine the major browse species consumed by dromedary camels in Tshabong (Kgaudi *et al,* 2018), 9 species of plants were reported by respondents as being the major sources of feed in TECP. The nine species belonged to 7 families and 7 genera of flowering plants. Fabaceae and *Vachellia* exhibited the highest proportion 33.3 and 22.2%, respectively of the 9 browse species. This is also consistent with results from the present study in which Fabaceae (55%) and *Vachellia* (27%) showed the highest number of species. Of these, four of the woody species, namely *B.albitrunca, R. trichotomum, S. mellifera* and *V. erioloba,* have been recorded in the current study. Three of these species, namely *B. albitrunca, S. mellifera* and *V. erioloba* have been reported to have good forage value (Hendzel, 1981; Kgaudi *et al,* 2018). In addition, *S. mellifera* and *V. erioloba* exhibited relatively high mean densities (768 and 255 individuals ha^{-1}, relatively) in TECP (Table 1).

The forage values of the nine plant species were categorised as poor (22%), intermediate (22%) and good (56%) (Hendzel, 1981; Kgaudi *et al,* 2018). As just indicated above, the camels prefer the *B. albitrunca* tree whose foliage is evergreen, although some leaves are shed around flowering time. The mature leaves and twigs of *B. albitrunca* have a crude protein content of 9.04% (Aganga and Adolga-Bessa, 1999; Alias and Milton, 2003; Kgaudi *et al,* 2018) and are rich in vitamin A (Palgrave, 2000; Kgaudi *et al,* 2018). The leaves also contain high quantities of calcium, phosphorus, potassium and sodium, like other browse species, such as *G. flava* and *Senegalia mellifera* (Alias and Milton, 2003; Kgaudi *et al,* 2018). The roots provide a valuable food source for both animals and humans (Palgrave, 2000) although, the leaves and twigs are the preferred source of forage for livestock (Alias and Milton, 2003).

Nine browse species consumed by camels were identified in the park of which *Boscia albitrunca* is the browse species most preferred by the camels. However, the nutritive value of the major browse species consumed by the camels should be analysed and documented.

The results revealed that TECP contains a relatively low species, genera and family richness as well as diversity and evenness values of woody species. The density of woody species is relatively high, though dominated by individuals of a few species, notably *V. erioloba, S. mellifera, E. elephantia, R. trichotomum* and *V. karoo*. None of the species was recorded in all the quadrats. The basal areas (dominance) of almost all of the woody species were negligible, which indicates the absence or inadequate number of big-sized trees, which, in turn, suggests that TECP is still in the building or recovery phase after its exposure to heavy grazing and browsing impacts, especially because of over-stocking of camels with its associated over-grazing.

The woody species with the highest IVI values in TECP, which are indicative of high ecological importance, include, in descending order of ecological importance, were *V. erioloba, S. mellifera, E. elephantina, V. karoo* and *R. trichotomum*. On the other hand, *V. hebeclada*, exhibited the lowest IVI value.

Out of the 11 woody species, only 3 (about 27%) exhibited stable population structures, which is also indicative of good regeneration status while the rest (8 woody species = about 72%) showed unstable population structures, which could be attributed to their hampered regeneration. Therefore, there is a need to investigate the factors responsible for the unstable population structures and hampered regeneration of these woody species.

The woody vegetation of TECP should be managed and regulated properly by giving due attention to the enhancement of regeneration of the woody species with the hampered regeneration, especially those that are frequently visited and browsed by camels. It is recommended to introduce interventions, such as resting periods, rotational grazing or exclusion zones to allow species to mature.

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