
Abundance and Population Structure of Locally Useful Indigenous Woody Plants in a Sedentary Grazing System in South-Western Uganda

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ABSTRACT

This study engaged 100 pastoralists and conducted a plant inventory in 13.5 ha of grazing lands to determine the locally useful indigenous woody plant species, their abundance and population structure in a sedentary grazing system in South-western Uganda. Through descriptive and inferential statistics, 40 shrubs and 30 tree species were identified. The species were useful sources of animal medicine (85.7%), human medicine (80%), fodder and firewood (57.1%), poles (50%), timber (42.9%), shade (24.3%), food (21.3%) and raw materials for crafts (10%). *Albizia coriaria*, *Acacia hockii*, *Acacia sieberiana*, *Carissa edulis* and *Vernonia amygdalina* were the major woody plants used. For food and fodder, the woody plants were only utilized during the dry season but for other purposes, the species were resorted to any season in the year. Plant inventory recorded 39 woody plant species. *Acacia hockii* and *Rhus natalensis* existed in all the ranches and were the most abundant species (29.4% and 10.9% respectively). The average plant density was 35 trees/shrubs^{-ha}. Inverse J shape, bimodal but mostly irregular pattern were the population structure types displayed. Thus, for sustainable sedentary pastoralism in Uganda, use of indigenous woody plant species requires policy supported conservation and enrichment planting, building the capacity of pastoralists in propagation and aided natural regeneration techniques for woody plants and scientific analyses to strengthen diversified use of the major woody plant species.

Keywords: *Indigenous knowledge; regeneration; sedentary pastoralism; woody plants.*

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1. INTRODUCTION

Livestock production is among the key economically important sectors of Uganda's growing economy contributing an average of 3.9 % to the national GDP (Uganda Bureau of Statistics [1]. Within the county, livestock grazing is highly concentrated in the rangeland ecosystems, commonly referred to as the cattle corridor which covers 84,000 km² (about 35%) of Uganda's total land area [2]. For decades, due to the characteristic periodic droughts coupled with profound rainfall variability in the rangelands, the pastoralists occasionally moved their livestock in search for water and pasture [3]. In such a characteristic nomadic arrangement, woody plants served as livelihood security for the survival of people and livestock during the long dry season [4]. This equipped the pastoralists with rich knowledge on uses of indigenous woody plant species for their livelihood activities. Additionally, the seasonal migration of pastoralists ensured that sustainable utilization of indigenous woody species and ultimately conservation was achieved [5]. The time lag of no active pastoralism in a particular area promoted natural regeneration and successful recruitment of woody plants into successive growth stages.

Following a gradual increase in human population which led to land scarcity, coupled with political pressure on pastoralists to settle, sedentary pastoralism where pastoralists keep considerable herds of cattle in a defined area and on permanent basis has replaced the traditional nomadic pastoralism [6]. One group of pastoralists who used to live a nomadic life and were integrated into sedentary pastoralism are the Bahima in South-western Uganda. However, the changes in livestock grazing systems in the fragile dryland ecosystem where pastoralists operate translate into dynamics in usage of indigenous woody plant species. More so, sedentary pastoralism creates pressure on woody plants thus affecting their regeneration and recruitment potential but the magnitude is unclear necessitating detailed socio-ecological investigation.

Usually, population structure assessments which display diameter size class distributions of woody plants are used to give insights into forces a population has been exposed to in the past [7]. Woody plants can portray an Inverse J-shape pattern of population structure where there are more small woody plants than the larger ones characterized by abundant species with constant rejuvenation and recruitment. Besides, woody plants can display a bi-modal pattern of plant population structure indicative of plants which recruit seedlings in pulses such that there are discontinuities in the population structure resulting into a two layered vertical structure of a species [8]. Nonetheless, plants can display a decreasing/irregular pattern of plant population structure shaped by external disturbance in which regeneration is not keeping pace with mortality and most individuals are of the same size class or in some cases, there are no signs of seedling recruitment [9].

Thus, there is need for detailed socio-ecological studies to document the interaction between woody plants, livestock and farmers' livelihoods to develop strategies that can optimize utilization and conservation of indigenous woody plant species in a sedentary grazing system for sustainable livestock production.

1.1 Objectives

1. Assess the local uses of indigenous woody plants species by sedentary pastoralists in South- western Uganda
2. Determine the relative abundance and population structure of the woody plant species in the sedentary grazing areas in South-western Uganda

1.2 Research Questions

1. What are the local uses of indigenous woody plant species for pastoralists in a sedentary grazing system in South-western Uganda?
2. What is the level of abundance and size class distribution of indigenous woody plant species in the grazing lands in South-western Uganda?

1.3 Research Hypothesis

There is no significant difference in the abundance of indigenous woody plant species between the farms of sedentary pastoralists in South-western Uganda

2. METHODOLOGY

This study was undertaken in Kiruhura district (00° 12'S, 31° 00'E) in South-western Uganda. The methods used to collect data included survey and plant inventory assessments. Semi structured questionnaires were administered to 100 pastoralists engaged in sedentary pastoralism. The interviewed individuals were members of Ankole Ranching Scheme which was established for livestock herders in the area through Government of Uganda's strategy to promote sedentary pastoralism [10]. The scheme is occupied by 856 households in a total of 50 ranches. The sample size was determined using the formula by Yamane [11], where n = Sample size, N = total number of households for the study area, and marginal of error set at 10%. The sample size derived was 89 households.

2.1 Inventory of Abundance and Population Structure of Indigenous Woody Plant Species

Plant inventory assessment for abundance and population structure of indigenous woody plants was undertaken in 11 ranches. Nested plots of 50 m x 50 m were established and each plot was sub-divided into smaller plots of 25 m x 25 m and 10 m x 10 m. The species, numbers and Diameter at Breast Height (DBH) of indigenous woody plants were recorded. Mature trees/shrubs (>20 cm DBH) and poles (10 cm - 19.9 cm DBH) were assessed in the entire plot of 50 m x 50 m, Saplings (5.5 cm - 9.9 cm) in a smaller plot of 25 m x 25 m while seedlings were assessed in a sub-plot of 10 m x 10 m. A total of 55 plots in 13.5 ha were covered.

The data was entered into SPSS.16.0 and Microsoft Excel computer packages for processing. Descriptive statistics were used to generate frequency tables and population structure graphs. R Software (version 1.2.5033) was used to analyze

for mean differences in the abundance of woody plant species between the ranches of pastoralists.

3. RESULTS AND DISCUSSION

3.1 Local Uses of Indigenous Woody Plant Species to Pastoralists in a Sedentary Grazing System in South-Western Uganda

The results in Table 1 revealed that 70 indigenous woody plant species were locally useful to sedentary pastoralists in the grazing areas of South-western Uganda. These comprised of 40 shrubs and 30 trees belonging to 31 plant families. Family Fabaceae had the highest number of locally useful plants (14) comprising 11 trees and 3 shrubs. The uses for the species included food, fodder, human medicine, animal medicine, firewood, poles, timber, crafts and provision of shade for sustainable ecosystem functioning of grazing lands.

The respondents' specification of 70 indigenous woody plant species used to serve different purposes affirm the importance of woody plants in the livelihoods of pastoralists. In dryland ecosystems where pastoralists operate, indigenous woody plant species are reported to play a major role in sustaining the livelihoods of pastoralists [12]. The relatively higher reported number of shrubs as opposed to trees is largely linked to the soil and climatic conditions of semi-arid South-western Uganda. Scanlan [13], reveals that the potential and amount of woody vegetation within an area are primarily determined by the soils and climate of the locality. Thus, local soil and climatic conditions could have favored more abundance of shrubs and fostered pastoralists' interface and usage.

Whereas plants of family Fabaceae have special importance for their agri-horticultural importance and multifarious uses [14], their dominance in this study could largely be attributed to the primary livelihood activity of pastoralists which is grazing. A study by Kgosikoma et al., [15], reports that most of the woody plant species considered to be suitable for browsing by pastoral farmers are leguminous species with a likelihood of high crude protein content. Such results highly explain a fact that out of the 14 plant species belonging to family Fabaceae reported in this study nine plants were utilized by pastoralists as sources of fodder.

The woody plant species reported were locally used to serve eight direct uses and one ecosystem service (Fig. 1). High utilization of the woody plant species was in the order of animal medicine (85.7%), human medicine (80%), fodder and firewood (57.1%), poles (50%), timber (42.9%), shade (24.3%), food (21.3%) and raw materials for crafts (10%). Other than food and fodder species which were resorted to in the dry season, woody plant species that served other purposes were utilized any season in the course of the year (Fig. 2).

Basing on the results, indigenous woody plants in grazing lands serve a wide range of purposes for livestock farmers. However, the pattern of utilization varies across locations as dictated by their livelihood strategies [16] For instance,

among the pastoralists of South-western Uganda, most of the woody plant species reported were utilized as medicines followed by fodder and firewood while among pastoralists in Debark district in Ethiopia, higher utilization of woody plant species was in the order of fencing posts, fuelwood and shade [17]. Thus, pastoralists possess diverse knowledge on local usage of indigenous woody plant species to meet their local needs.

The higher utilization of indigenous woody plants as sources of human and animal medicine depicts higher levels of local knowledge on use of woody plants to treat various diseases in people and animals. This could as well be explained by the long distances between grazing lands and facilities where medicine can be accessed. Usually, semi-arid areas where pastoralists operate are isolated and far from modern facilities [18]. This hinders adequate and timely access to services thus leaving pastoralists with options of optimizing locally available resources.

Following medicines, the woody plant species were essential in providing fodder and firewood resources. This emphasizes the importance of woody plant species in supplementing livestock feeds in semi-arid environments. Similarly, elsewhere, fodder trees and shrubs are increasingly recognized as an important component of animal feeding especially during the prolonged dry and crop fallow season [19], when ground herbage is scanty. As Dambe et al. [20] reports, the utilization of natural browse as quality livestock feed during the late dry season can alleviate nutritional deficiencies and maintain livestock production, particularly in arid and semi-arid environments. Such findings highly justify the absolute use of fodder trees/shrubs in the dry season by sedentary pastoralists in South-western Uganda. In the face of climate change where prolonged droughts have affected pasture growth, woody fodder plants will increasingly serve as safety nets for sustainable livestock production in the area leading to a need to promote conservation efforts for such plants.

Essentially, the equally important usage of indigenous woody plants as sources of firewood depicts the major source of domestic cooking energy to the livestock farmers. In Uganda, woody biomass is the primary source of domestic energy for households particularly in the form of firewood [21]. However, use of woody plants is the leading cause of deforestation and significant contributor to environmental degradation. With the growing need for climate change adaptation and mitigation measures, over dependence on firewood especially by pastoralists compromises the resilience strength of livestock production systems.

Worth noting, similarly to woody plant species for fodder, species that were utilised as food were resorted to in the dry season. This reveals higher significance of woody plants in providing energy resources to pastoralists during long hours of livestock grazing in the dry season in search for sufficient forage and water for the animals. These findings are in conformity with the results of Lykke et al. [4], which reveal that in the predominantly dry unpredictable conditions of semi-arid areas largely used for grazing, pastoralists have built a rich bank of local knowledge on the dynamics of different woody species and value them as food reserves that support grazing activities.

Table 1. Indigenous woody plant species used by sedentary pastoralists in South-western Uganda

Family	Species (Scientific name)	Local Name	Plant status	Responses for Uses of Species from 100 households								
				Food	Fodder	Human Medicine	Animal Medicine	Firewood	Poles	Timber	Shade	Crafts
Anacardiaceae	<i>Rhus natalensis</i> Bernh. ex Krauss	Omusheshe	Shrub	84	70	47	35	37	28	12	0	0
	<i>Rhus vulgaris</i> Meikle	Obukanza	Shrub	30	0	5	3	2	1	1	0	0
Apocynaceae	<i>Carissa edulis</i> (Forssk.) Vahl	Omuyonza	Shrub	99	28	23	13	5	0	0	0	0
	<i>Carissa macrocarpa</i> (Eckl.) A. DC.	Amatungu	Shrub	5	3	23	16	3	1	0	0	0
	<i>Thevetia peruviana</i> (Pers.) K. Schum.	Omusenene	Shrub	0	0	1	1	0	0	0	0	0
Asparagaceae	<i>Asparagus flagellaris</i> (Kunth) Baker	Akashebashebe	Shrub	0	5	13	14	2	0	0	0	0
Asteraceae	<i>Microglossa angolensis</i> Oliv. and Hiern	Kyakuyambaki	Shrub	0	2	16	12	1	0	0	0	0
	<i>Microglossa pyrifolia</i> (Lam.) Kuntze	Omuhe	Shrub	0	0	0	3	0	0	0	0	0
	<i>Pluchea ovalis</i> (Pers.) DC.	Omuneera	Shrub	0	1	3	0	0	0	0	0	0
	<i>Vernonia amygdalina</i> Delile	Omubirizi	Shrub	0	57	78	71	11	0	0	0	0
Bignoniaceae	<i>Markhamia lutea</i> (Benth.) K. Schum.	Mushambya	Tree	0	0	1	0	0	4	3	1	0
Boraginaceae	<i>Ehretia cymosa</i> Thonn.	Ekikobokobo	Tree	0	0	0	0	0	2	0	1	0
Capparaceae	<i>Capparis fascicularis</i> DC.	Kagyezanda	Shrub	0	27	0	20	0	0	0	0	0
	<i>Capparis tomentosa</i> Lam	Omukorokombi	Shrub	0	4	20	27	2	1	0	1	0
	<i>Maerua triphylla</i> A. Rich.	Omwoyante	Tree	0	64	23	24	6	2	2	0	0
	<i>Bosci coriacea</i> Pax.	Enzizi	Tree	0	0	1	0	0	0	0	0	0
Celastraceae	<i>Maytenus heterophylla</i> (Eckl. & Zeyh.) N. Robson	Kabaruka	Shrub	0	0	0	2	0	0	0	0	0
	<i>Maytenus senegalensis</i> (Lam.) Exell	Omunyabiruko	Shrub	0	11	42	42	17	15	4	0	0
Convolvulaceae	<i>Astripomoea malvaceae</i> Klotzsch.	Bingiribeta	Shrub	0	0	0	2	0	0	0	0	0
Draceanaceae	<i>Dracaena fragrans</i> (L.) Ker Gawl.	Omugorora	Shrub	0	0	1	1	0	0	0	0	0
	<i>Dracaena steudneri</i> Engl.	Ekigorogoro	Shrub	0	0	1	1	0	0	0	0	0

Research Highlights in Agricultural Sciences Vol. 3
Abundance and Population Structure of Locally Useful Indigenous Woody Plants in a Sedentary Grazing System in South-Western Uganda

Ebeneaceae	<i>Diospyros abyssinica</i> (Hiern) F. White	Omuho	Shrub	0	0	1	1	0	0	0	0	0
	<i>Euclea latidens</i> Stapf	Omukizi	Tree	0	5	18	21	17	15	8	0	0
Euphorbeaceae	<i>Croton megalocarpus</i> Hutch.	Omutugunda	Tree	3	0	3	3	0	0	0	0	0
	<i>Erythrococca bongensis</i> Pax	Omushongashongi	Shrub	0	0	5	6	0	0	0	0	0
	<i>Euphorbia candelabrum</i> Tremaux ex Kotschy	Enkukulu	Tree	0	0	46	29	7	5	2	0	0
	<i>Euphorbia tirucalli</i> L.	Enkoni	Tree	0	0	2	4	0	0	0	0	0
	<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle	Omubwera	Shrub	0	13	34	30	10	8	3	0	0
Fabaceae	<i>Acacia abyssinica</i> Benth.	Omuniyina	Tree	0	6	7	9	16	16	12	3	0
	<i>Acacia campylacantha</i> A.Rich.	Kibeere	Tree	0	0	3	3	3	3	2	0	0
	<i>Senna didymobotrya</i> (Fresen.)H.S.Irwin & Barneby	Omugabagaba	Tree	0	0	4	4	0	0	0	0	0
	<i>Acacia gerrardii</i> Benth.	Omutongole	Tree	0	42	39	42	74	68	44	8	0
	<i>Acacia hockii</i> De Wild.	Orugando	Tree	0	73	40	46	62	37	24	0	0
	<i>Acacia persiciflora</i> Pax	Omulemampango	Tree	0	1	3	3	1	3	2	0	0
	<i>Acacia sieberiana</i> DC.	Omutyaza	Tree	0	46	40	41	77	69	55	15	0
	<i>Erythrina abyssinica</i> DC.	Ekiko	Tree	0	0	33	23	37	36	15	1	1
	<i>Erythrophleum pyrifolia</i>	Omurama	Tree	0	4	18	16	18	14	4	3	0
	<i>Indigofera emerginella</i> Steud.ex.A.Rich	Ishekazibasumba	Shrub	0	0	0	3	0	0	0	0	0
	<i>Albizia coriaria</i> Oliv.	Omusisa	Tree	0	37	59	58	73	77	79	24	0
	<i>Albizia glaberrima</i> (Schum. & Thonn.)Benth.	Omushhebaya	Tree	0	1	2	4	3	3	3	1	0
	<i>Sesbania sesban</i> (L.)Merr.	Omuniyeganyega	Shrub	0	2	5	4	3	2	0	0	0
	<i>Tamarindus indica</i> L.	Omukoge	Tree	0	0	1	0	0	0	0	0	0
Flacourtiaceae	<i>Dovyalis macrocalyx</i> (Oliv.) Warb.	Entagyegyera	Shrub	12	1	2	2	1	0	0	0	0
	<i>Macrotyloma axillare</i> (E. Mey.)	Akaenabakuru	Shrub	0	0	0	1	0	0	0	0	0
Lamiaceae	<i>Clerodendrum myricoides</i> (Hochst.)R.Br.ex Vatke	Ekisekasheke	Shrub	0	0	1	2	0	0	0	0	0
	<i>Hoslundia opposita</i> Val	Esitimwe	Shrub	3	6	31	25	0	0	0	0	0
Loganiaceae	<i>Nuxia congesta</i> R. Br.	Omumuli	Tree	0	4	3	8	10	10	8	1	1
Moraceae	<i>Ficus natalensis</i> Krauss ex Engl.	Omutooma	Tree	0	24	15	23	33	30	27	6	2

Research Highlights in Agricultural Sciences Vol. 3
*Abundance and Population Structure of Locally Useful Indigenous Woody Plants in a Sedentary Grazing
System in South-Western Uganda*

Moraceae	<i>Ficus ovata</i> Vahl	Omukunyu	Tree	0	0	3	2	4	4	4	1	0
Myricaceae	<i>Myrica kandtiana</i> Engl.	Omugyegye	Shrub	0	0	1	0	0	0	0	0	0
Nytaginaceae	<i>Boerhavia diffusa</i> L.	Obukegate	Shrub	0	1	0	0	0	0	0	0	1
Oleaceae	<i>Jasminum pauciflorum</i> Benth.	Omuremanjojo	Tree	0	0	0	1	2	3	2	0	0
Phyllanthaceae	<i>Margaritaria discoidea</i> (Baill.) G.L.Webster	Omutyibare	Tree	0	2	2	2	7	6	4	1	0
Phytolaccaceae	<i>Phytolacca dodecandra</i> L Herit	Omuhoko	Shrub	0	2	0	0	0	0	0	0	0
Rosaceae	<i>Rubus pinnatus</i> Willd.	Encerere	Shrub	22	2	3	0	1	1	0	0	0
Rubiaceae	<i>Gardenia</i> Sp	Entarama	Tree	0	1	14	19	15	17	4	1	0
	<i>Rytigynia macrura</i> Verdc.	Omurokora	Shrub	5	0	1	3	1	0	0	0	0
Rutaceae	<i>Teclea nobilis</i> Del.	Omuzo	Tree	0	4	2	4	8	7	5	1	0
	<i>Zanthoxylum chalybeum</i> Engl	Entaleyerungu	Shrub	0	0	13	9	0	0	0	0	0
Salicaceae	<i>Trimeria grandifolia</i> (Hochst.) Warb	Omwatanshare	Tree	0	0	3	1	0	0	0	0	0
Sapindaceae	<i>Allophylus africanus</i>	Omutete	Tree	24	45	46	41	45	46	21	3	1
Solanaceae	<i>Capsicum frutescens</i> L	Esheka	Shrub	54	2	15	6	3	0	0	0	0
	<i>Solanum renschii</i> Vatke	Omulyanyonyi	Shrub	0	0	5	4	0	0	0	0	0
Tiliaceae	<i>Grewia mollis</i> Juss.	Omukoma	Tree	0	60	19	25	46	44	29	3	0
	<i>Grewia kakothamnos</i> K. Schum.	Omukomakoma	Shrub	85	60	19	25	0	0	0	0	3
	<i>Triumfetta rhomboidea</i> Jacq.	Omuhingura	Shrub	0	2	22	14	0	0	1		1
Ulmaceae	<i>Scutia myrtina</i> (Burm. f.) Kurz	Omugasha	Shrub	81	15	13	9	18	1	5	0	0
Verbenaceae	<i>Duranta erecta</i> L	Omuhwahwa	Shrub	0	3	5	4	7	4	1	0	0
	<i>Lantana trifolia</i> L.	Ehuuki	Shrub	71	4	33	31	3	0	0	0	0
	<i>Verbana officinalis</i> .L	Omugoshora	Shrub	1	0	0	0	0	0	0	0	0

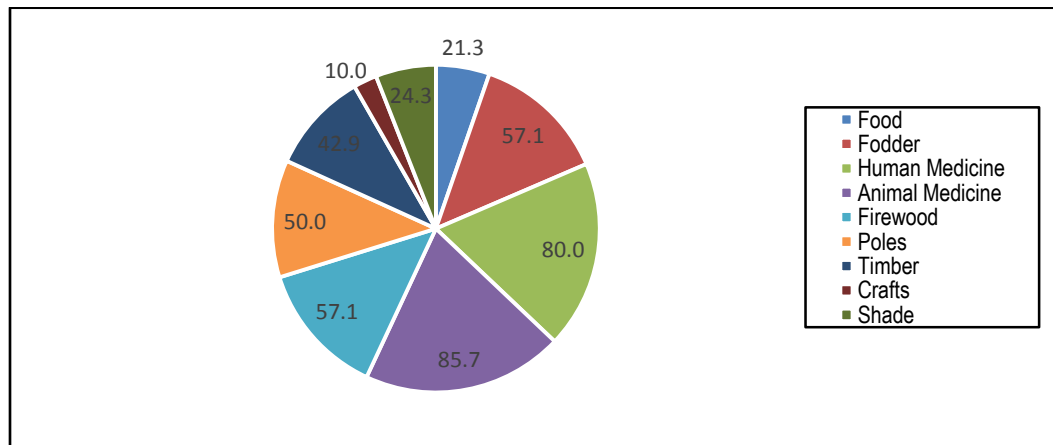


Fig. 1. Proportion of utilization of indigenous woody plant species by pastoralists

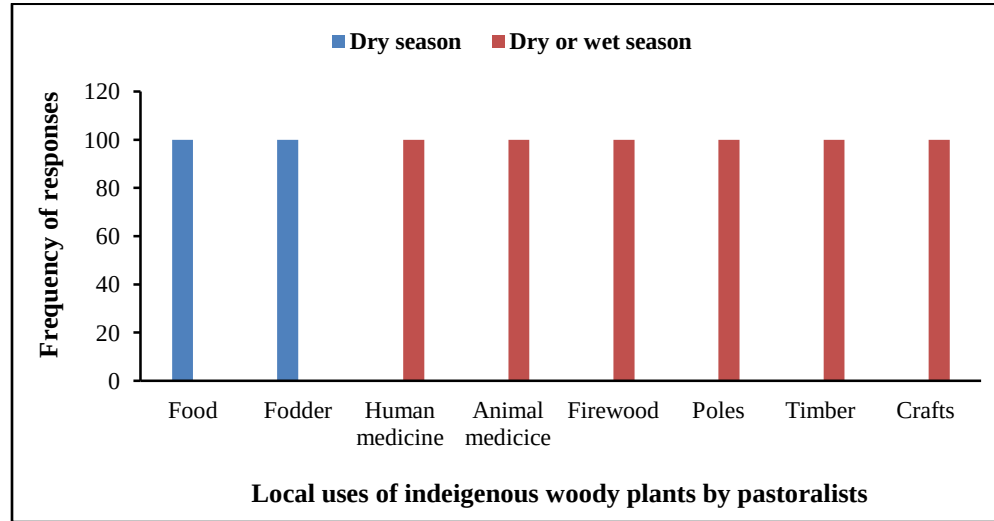


Fig. 2. Trend of utilization of indigenous woody plant species by pastoralists

For the different purposes, *Vernonia ammygdalina* was the most utilized species for animal and human medicine (n=71 and n=78 respectively), *Acacia sieberiana* for firewood and poles (n=77 and n=69 respectively), *Carissa edulis* for food (n=99), *Albizia coriaria* for timber (n=79) and shade (n=24) and *Grewia kahothis* for crafts (n=3) (Table 2). Largely, a higher proportion of male (85) and female (15) respondents utilized the woody plant species. Although majority of the respondents had no formal education, they had higher knowledge on the local uses of the indigenous woody plants than those who acquired different levels of formal education. In terms of age, respondents between 41-50 years had more knowledge on local uses of the woody plant species while those who had practiced grazing for 20-30 years had more knowledge on local utilization of the species.

The dominance of specific woody plants in local utilization by pastoralists indicates more explorative knowledge in the application of certain woody plants. This indigenous knowledge is vital in providing a starting point for scientific investigations to establish profile characteristics that could explain the higher usage of specific woody plants for different purposes. Nonetheless, as Traore et al. [22] reveals, this knowledge can be a baseline for development of products such as pharmaceuticals, industrial resources, cosmetics among other for use in modern societies and diversify income sources for pastoralists.

The observed uniform trend of higher usage of indigenous woody plant species across socio-economic factors portrays categories of concentration of knowledge on plant use among the sedentary pastoralists in South-western Uganda. Across gender categories, the relatively higher responses on utilization of the major indigenous woody plants by both men and women implies that both men and women are knowledgeable about the use of woody plants in their activities.

Worth more, the higher responses for utilization of major indigenous woody plants among individuals who had no formal education reveals accumulated experience of the pastoralists as they interacted with the woody plants in their grazing activities. Whereas the socio-cultural characteristics of pastoralists have posed numerous complexities in the access to education [23], pastoralists have had a long history of plant utilization to meet certain needs [24]. This experience enables them to have a unique understanding of the local uses of woody plant species. This justifies the observed higher usage of woody plants among respondents especially up to 50 years of age who had no formal education and information was passed on to generations justifying the dominance of knowledge among respondents who practiced grazing for 20 - 30 years.

3.2 Abundance of Locally Useful Indigenous Woody Plant Species in the Grazing Lands

In Table 3, plant inventory of indigenous woody plant species used by the pastoralists recorded 39 plants in 13.5 ha of grazing lands. These comprised 22 shrubs and 17 trees, representing 56% of the species provided by respondents through individual interviews. At farm level, *A. hockii* and *R. natalensis* were

found in all the ranches and were the most abundant species (29.4% and 10.9% respectively). Among the major woody plant species used for the different purposes, *V. ammygdalina* was not encountered in any of the sampled ranches while *A. coriaria* was recorded in 9.1% (n=5) of the ranches but with a very low abundance. Between farms, there was no significant difference in the populations of indigenous woody plant species ($p > 0.05$) and generally, local abundance of the woody plant species was low. The average density of woody species per hectare was 35 plants (Table 4).

Vegetation inventories help to confirm field occurrence of plant species at a particular point in time and may give information on local extinction of species. The pastoralists' knowledge about a greater number of woody plant species as mentioned in the interviews compared to what was recorded in the field reflects a time in the past when woody plants were more abundant and diverse as Tefera et al., [17] also reports. The results of the study depict occurrence of factors that could have led to over utilization of certain species and affected regeneration, or management activities that selectively wiped out presence of woody plant species. In the grazing areas of South-western Uganda there is increasing indiscriminate cutting of woody plants by livestock farmers with hope that more pastures will grow in the created spaces [25]. This practice largely explains the lower number of species recorded in the inventory and absence of major woody species that were mentioned to be utilized by pastoralists. The non-significant variation in abundance of woody plant species implies uniformity of grazing practices by the pastoralists. Nonetheless, the average number of 35 woody plants per hectare is regarded as a low tree density for such a production system [26]. In this era of climate change, the low tree density in the area is likely to compound livestock production challenges due to heat stress. According to de Oliveira et al. [27], during the dry season grazing lands with a higher tree density > 100 trees/ha create greater animal thermal comfort, with fewer hours of thermal stress and less radiant thermal load in the understory, thus sustaining livestock productivity.

3.3 Population Structure of Locally Useful Indigenous Woody Plant Species in the Grazing Lands

The woody plant species displayed different types of plant population structure curves. In shrubs, *R. natalensis*, *C. macrocarpa*, *S. myrtina*, *M. senegalensis*, *F. virosa* and *P. ovalis* displayed an inverse J shape type of population structure (Fig. 3A), but with a very low number of plants > 20 cm DBH. *H. opposita*, *C. edulis*, *D. erecta* and *M. heterophylla* (Fig. 3B), alongside *A. flagellaris*, *C. fascicularis*, *C. myricodes*, *R. macrura*, *S. renschii*, *E. bongesis* and *G. kakothamnus* (Fig. 3C) displayed the irregular type of population structure. For species in Graph B, some woody plants had individuals in the first (< 5 cm) and second (5.5 cm -9.9 cm) diameter classes only while species in Graph C had individuals in the lowest size class (< 5 cm) only.

Table 2. Major indigenous woody plant species used for the different purposes

Purposes	Major species	Plant	Frequency of responses by socio-economic factors														
			Total Responses	Gender			Education			Age (Years)				Years in grazing			
				M ales	Females	None	Primary	Secondary	Tertiary	20-30	31-40	41-50	51-60	<20	20-30	31-40	41-50
A.medicine	<i>V. amygdalina</i>	71	60	11	26	24	17	4	4	11	21	15	13	34	8	12	
Crafts	<i>G. kakothamnos</i>	3	1	2	3	0	0	0	0	0	3	0	0	3	0	0	
H.medicine	<i>V. amygdalina</i>	78	65	13	31	25	19	3	4	12	26	15	14	38	10	11	
Firewood	<i>A. sieberiana</i>	77	68	9	37	26	13	1	2	13	29	15	15	37	11	11	
Fodder	<i>A. hockii</i>	73	61	12	28	24	18	3	3	11	28	13	10	40	13	8	
Food	<i>C. edulis</i>	99	84	15	41	31	23	4	5	14	34	18	16	49	16	13	
Poles	<i>A. sieberiana</i>	69	61	8	29	22	17	4	2	14	27	10	12	37	9	9	
Shade	<i>A. coriaria</i>	24	20	4	20	2	1	0	2	8	12	2	6	14	2	2	
Timber	<i>A. coriaria</i>	79	69	10	31	26	19	4	4	10	30	13	11	40	14	11	

Table 3. Locally useful indigenous woody plant species recorded in the grazing lands

Species	Growth form	Total number of individuals	Ranch abundance (%)	Relative abundance (%)
<i>A. hockii</i>	Tree	1528	100.0	29.4
<i>R. natalensis</i>	Shrub	566	100.0	10.9
<i>A. gerrardii</i>	Tree	435	90.9	8.4
<i>G. mollis</i>	Tree	358	81.8	6.9
<i>H. opposita</i>	Shrub	317	81.8	6.1
<i>S. myrtina</i>	Shrub	234	45.5	4.5
<i>A. flagellaris</i>	Shrub	223	90.9	4.3
<i>A. sieberiana</i>	Tree	203	63.6	3.9
<i>C. macrocarpa</i>	Shrub	202	54.5	3.9
<i>C. fascicularis</i>	Shrub	130	45.5	2.5
<i>E. candelabrum</i>	Tree	125	81.8	2.4
<i>T. nobilis</i>	Tree	109	9.1	2.1
<i>A. africanus</i>	Tree	87	54.5	1.7
<i>C. myricoides</i>	Shrub	86	45.5	1.7
<i>M. senegalensis</i>	Shrub	86	36.4	1.7
<i>D. erecta</i>	Shrub	64	9.1	1.2
<i>P. dodecandra</i>	Shrub	62	36.4	1.2
<i>P. ovalis</i>	Shrub	56	9.1	1.1
<i>F. virosa</i>	Shrub	55	27.3	1.1
<i>L. trifolia</i>	Shrub	43	45.5	0.8
<i>A. persiciflora</i>	Tree	34	18.2	0.7
<i>J. pauciflorum</i>	Tree	34	27.3	0.7
<i>R. macrura</i>	Shrub	22	27.3	0.4
<i>M. heterophylla</i>	Shrub	17	18.2	0.3
<i>N. congesta</i>	Tree	16	18.2	0.3
<i>C. edulis</i>	Shrub	13	18.2	0.3
<i>S. renschii</i>	Shrub	12	18.2	0.2
<i>E. cymosa</i>	Tree	11	9.1	0.2
<i>E. bongensis</i>	Shrub	10	9.1	0.2
<i>G. kakothamnus</i>	Shrub	10	9.1	0.2
<i>M. angolensis</i>	Shrub	10	9.1	0.2
<i>E. abyssinica</i>	Tree	9	18.2	0.2
<i>T. rhomboidea</i>	Shrub	8	18.2	0.2
<i>A. glaberrima</i>	Tree	6	18.2	0.1
<i>F. ovata</i>	Tree	5	9.1	0.1
<i>E. latidens</i>	Tree	4	9.1	0.1
<i>M. pyrifolia</i>	Shrub	4	18.2	0.1
<i>Gardenia sp</i>	Tree	3	18.2	0.1
<i>A. coriaria</i>	Tree	1	9.1	0.0

In tree species, *A. hockii*, *T. nobilis*, *A. africanus*, *A. persiciflora* and *G. mollis* displayed an inverse J shape of population structure (Fig. 4A). *A. gerrardii*, *A. sieberiana*, *E. candelabrum*, *J. pauciflorum* and *Gardenia sp* displayed a bimodal pattern (Fig. 4B) of population structure. *A. glaberrima*, *N. congesta*, *E. abyssinica*, *E. cymosa*, *F. ovata* and *E. latidens* displayed an irregular type of population structure (Fig. 4C) characterized by un uniform absence of plants in some size classes.

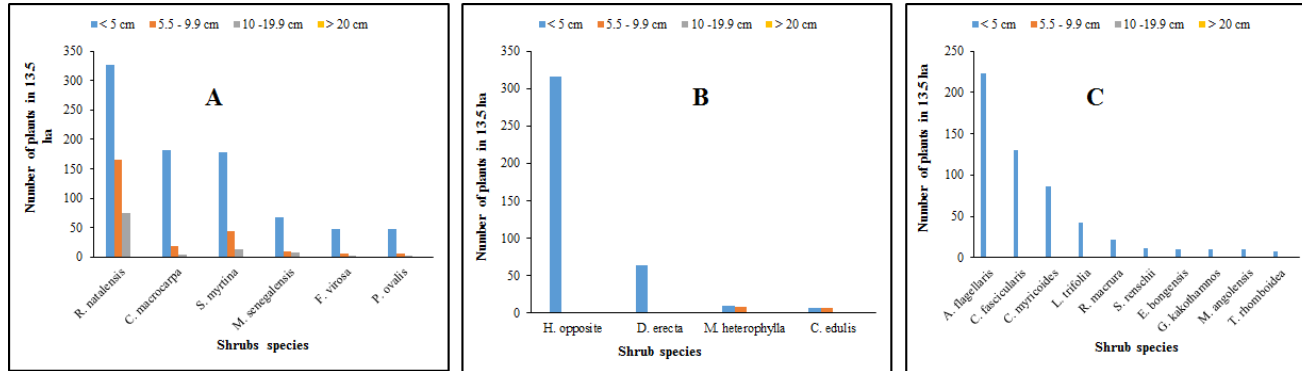


Fig. 3. Population structure types of shrubs in the grazing lands

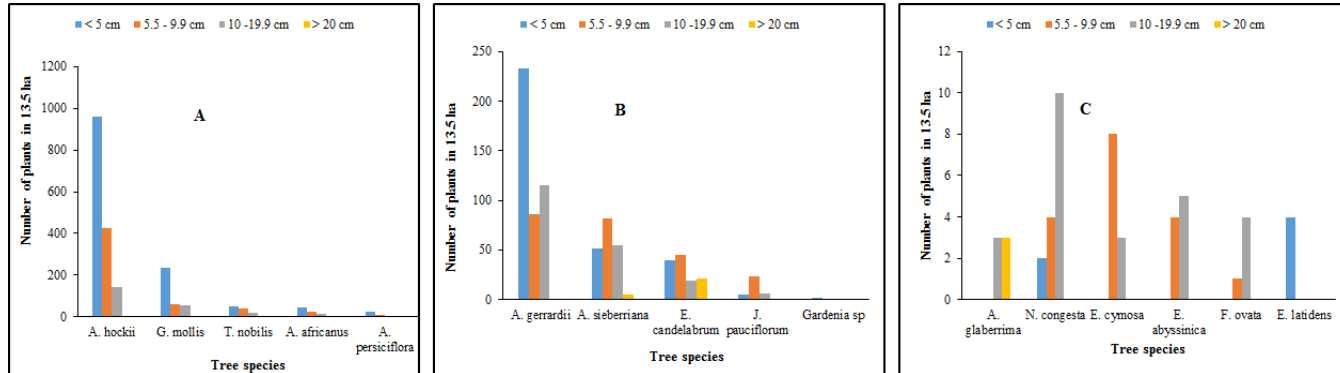


Fig. 4. Population structure types of trees in the grazing lands

Table 4. Abundance of locally useful indigenous woody plants at farm level in grazing lands

Ranch number	Number of species in a ranch	Total number of woody plants	Number of woody plants/ha
1	14	542	40
5	7	285	21
6	10	171	13
7	10	180	13
12	13	441	33
16	11	330	24
20	15	405	30
28	19	507	38
40	42	435	32
44	20	505	37
48	26	1398	104
Mean	17	473	35

The population structure patterns of woody plant species provide an important indicator of their conservation status. The inverse J shape pattern of population structure displayed by the certain trees and shrubs is typical of a self-sustaining population where seedlings are recruited continuously into bigger size classes [8]. In a sedentary grazing system in South-western Uganda, this could be attributed to improvement in land tenure which increased control of use of woody plant species. Previously most of the grazing lands in Uganda were considered to be common property for all pastoralists and no one was held responsible for over exploitation of the plants [28]. Security of land tenure which enhances ownership of woody species by individuals provides an important platform for ensuring sustainable conservation of species by pastoralists.

Besides inverse J shape, the bi-modal and irregular patterns of plant population structures displayed by most of the species recorded is largely attributed to exploitation of specific size classes such as poles thus hindering recruitment into bigger diameter classes. Harvesting of mature classes of woody plants usually removes species which could provide seeds for the next generation [29]. Such results call for intervention actions to check the population gap if regeneration of woody plants species in pastoral lands is to be sustained.

Worth more, the high density of seedlings for irregular patterns reveals existence of mature woody plants in the past which shed seed prior to harvesting. Upon favorable conditions, the seedlings sprouted to higher densities. This confirms the results of Nabasumba et al. [11] where in the sedentary grazing areas of South-western Uganda, there is increasing indiscriminate cutting of woody plants by livestock farmers. This action threatens existence of woody plant species outside protected areas and risks sustainable livestock production activities in the fragile dryland ecosystem thus calling for appropriate interventions.

4. CONCLUSION

This study established that 70 indigenous woody plant species were locally useful to the sedentary pastoralists of South-western Uganda. The species served eight direct purposes and one ecosystem service where most species were used as sources of human and animal medicine, but also to a greater extent as sources of fodder and firewood. These findings confirmed that indigenous woody plant species still play a vital role in sustaining the livelihoods of sedentary pastoralists and their grazing activities. Thus, efforts that promote wise use of these resources are needed. The low field occurrence of woody plant species reflected in the gap between what was recorded through individual interviews and inventory assessment, coupled with low levels of species abundance and dominance of irregular pattern of population structure confirmed utilization pressure. More so, inventory results of this study reflected absence of deliberate efforts to conserve woody plant species in grazing lands for sustainable pastoralism production.

5. RECOMMENDATION

To improve and promote sustainable livestock production in the sedentary grazing system in Uganda, this study recommends policy supported conservation and enrichment planting alongside building capacity of pastoralists in propagation and aided natural regeneration techniques for woody plants. More so, this study recommends provision of alternative sources of domestic cooking energy to curb over harvesting of woody plants and bio-chemical scientific analyses to profile and characterize the dominant woody species utilized for different purposes to strengthen the diversified use of the major woody plant species.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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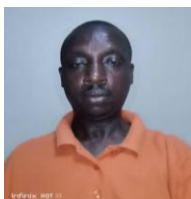
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