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Sedentarization among nomadic pastoralists of Uganda: which way to feed livestock?

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Abstract Pastoral nomadic communities of East Africa's drylands are gradually shifting towards a sedentary type of production. However, successful animal production under such settings demands for integrated on-farm management of the various animal feed resources. The objective of this study was to characterize feed resources of goats in the pastoral area of Karamoja sub-region, a dry land area in northeastern Uganda. Structured interviews were conducted involving 300 randomly selected households. Results revealed seventy plant species distributed in 31 families were fed to goats. The species were dominated by browses (trees and shrubs) 54%; herbs 21%; grasses 19%; climbers and hedges 5%. *Balanites aegyptica, Grewia similis, Acacia sieberiana, Acalypha fruticosa, Acacia albida and Cadaba farinosa* were the most frequently mentioned browse species. Farmers also use these species for other purposes notably building, human and livestock medicine, fencing, firewood and as vegetables during the dry season. Browses were available throughout the year unlike grasses and crop residues that were available seasonally. Since browses were available throughout the year in addition to being multipurpose, it is recommended that current efforts to actualize a sedentary lifestyle among Karamoja pastoralists integrate the planting and management of the most reported browse species in this study.

Keywords Goats · Feed resources · Browse · Karamoja

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Introduction

Migratory and nomadic herding of livestock have been the tradition in many African countries (Lebbie and Ramsay 1999). In the East African dry lands, which make up 70%, 50% and 40% of the land areas of Tanzania, Kenya and Uganda, respectively, communities here have for long sustained livelihoods through this practice. The farmers here keep mainly cattle, goats, sheep, camels and donkey. Goats are

particularly crucial in supporting such dry land pastoral livelihoods due to their drought-tolerant attributes and ability to thrive in low-input systems (Alexandre and Mandonnet 2005). On open rangelands, the quality and quantity of forage varies appreciably with season and climate and often leads to nutritional inadequacy for livestock (Ramirez 1999). Due to these climate-driven resource variations, pastoralists move from place to place with their animals, on mostly communally owned land, in search of water and feed for their animals. Recently however, climatic, cultural, political and demographic changes have either further reduced or fundamentally varied the total available feed resource for animals in these areas. Such changes are now compelling many pastoral communities to consider a change from nomadism to more sedentary production systems. In East Africa, there are many ongoing interventions to contribute to the realization of settled communities in the sub-region. For instance, Government of Uganda through a zonal agricultural institution is training farmers on planting and management of fodder, while the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (German Agency for International Cooperation) supports irrigated agriculture, both in Moroto and in Nakapiripirit districts (Egeru et al. 2014). Also, the "cash for work" scheme in Moroto (GIZ 2015) partly aims to achieve sustained self-reliant food-producing communities in the sub-region. This change in life style, however, is creating new challenges such as the need to deliberately and continuously manage animal feed resources on farm. Since animals have historically been continued to be integral to livelihoods in these communities, it is important that such a transition circumvents the associated animal feeding realities. Knowledge of all currently available feed resources is therefore required so that their diversity is not compromised in subsequent feeding regimes. For instance, knowledge on goat forages can be useful in choosing the most suited forage species to be managed by farmers on individual farms. It can also serve as a benchmark for future assessments on the feed variations given the ongoing land-based interventions geared toward actualizing sustained sedentary agro-pastoral system. The aim of this study was to characterize the available goat feed resources, specifically to determine the feeding systems, the goat feed resources available, challenges in feeding and copping strategies in drought period and determining the seasonal availability of these resources.

Study area, materials and methods

Study area

The study was conducted in Karamoja sub-region of Uganda (Fig. 1) between the months of April and December 2016. Karamoja sub-region is located between 1°4′–4.24°N and 33°50′–35°E in the north-eastern part of Uganda. It is bordered by Kenya to the northeast, east and southeast and the Republic of South Sudan to the North. The area is mostly semiarid, and it generally experiences a single wet season and a long dry season. The annual rainfall range is between 400 and 1000 mm per year, with relief-driven variations (Mubiru 2010). The total rainfall received increases across the area from east to west, allowing a graduation from pure pastoral in the east and parts of central to more agro and agro-pastoral livelihoods toward the west (Egeru et al. 2015). Basing on the fairly distinct predominant livelihoods showed by communities in the area, the region is divided into three zones: the sub-humid wet agricultural zone majorly to the west; the semiarid agro-pastoral zone mostly through the central parts; and the arid pastoral zone which dominates the eastern part. The region is currently comprised of six districts, covering an area of 27,319 km^2, which is approximately 10% of Uganda's land area. The study was carried out in the arid pastoral zone of Karamoja in the districts of Kaabong, Kotido and Moroto, respectively (Fig. 1).

Data collection and analysis

Data for this research were collected using structured questionnaires. Before the onset of the study, meetings were held with the district authorities and the extension staff. During the meetings, the objectives of the study were explained and the expected outputs discussed. We also asked for permission to access the study area, and this was granted. The leaders identified interpreters whom we worked with throughout the study period. The local leadership was asked to inform the communities about the study. A list of farmers was provided from which we randomly selected the respondents. A total of 300 respondents

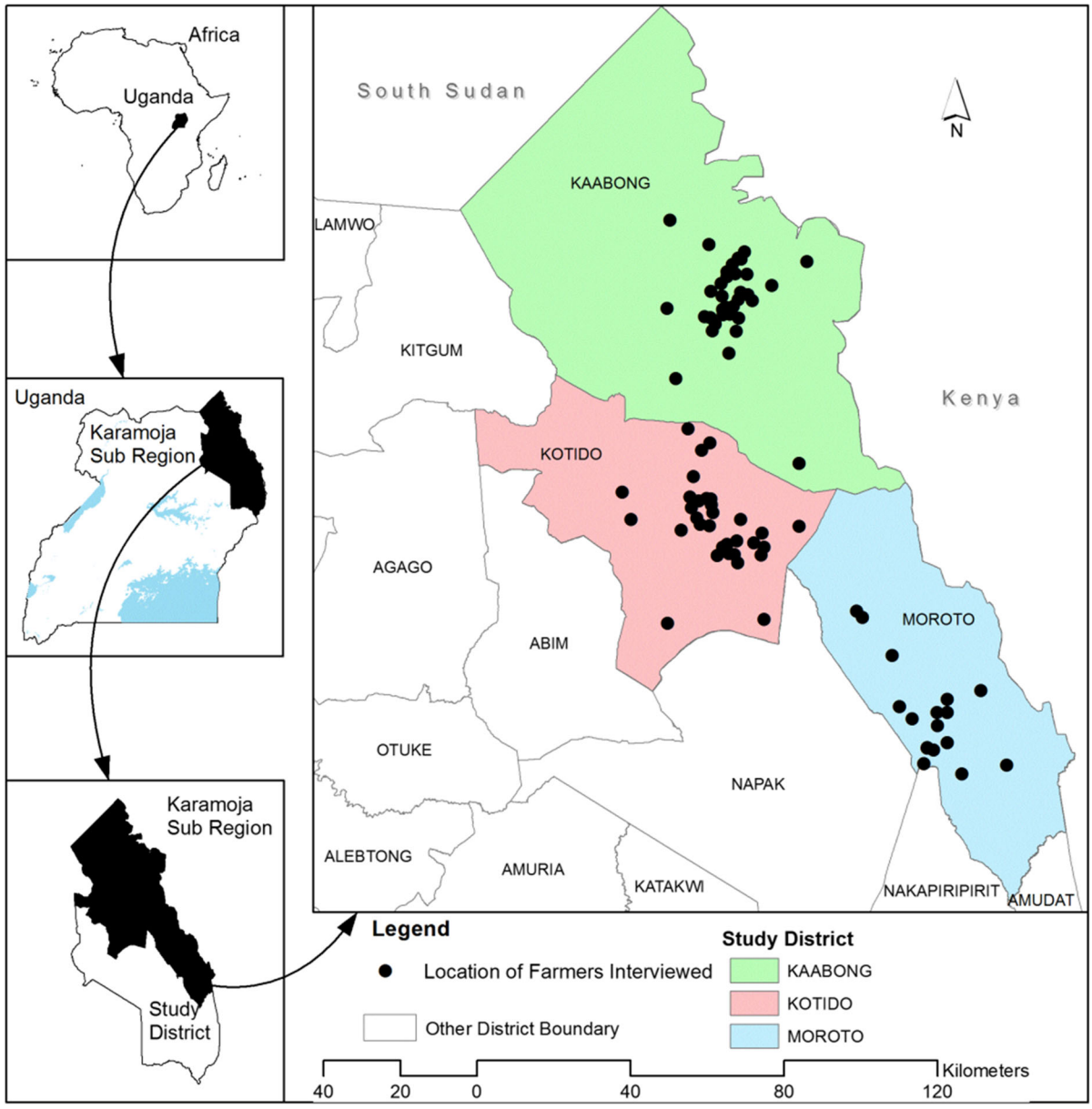

Fig. 1 Location of Karamoja sub-region, the study districts and areas where farmer interviews were carried out

were interviewed, 134, 32 and 134 respondents from the districts of Kaabong, Kotido and Moroto, respectively. Data were collected using a mixed open- and closed-ended questionnaire in face-to-face interviews. The interviews were conducted in Karimojong, the dominant local language spoken in the study area. The questionnaire covered the following broad themes: goat production systems, goat feed resources, seasonal availability of the feed and challenges faced in goat production and feeding. In the questionnaire, respondents were interviewed on the plant species and other feed resources that their goats feed on, their perceived availability across the months of the year and the main challenges faced in rearing goats. A GPS receiver was used to capture the geographical coordinates of the areas where the interviewed respondents were found. Additionally, focus group discussions were held. A total of six focus group discussions, each comprising

at least 8 individuals, were held, two in each district. In the group discussions that lasted 30 min to one hour, focus was on the major browse species that goats feed on, the time across the year when they are available, the other uses that these plants are put to and to verify information from the questionnaires. Plant voucher specimens of all species mentioned in the study were collected and taken to Makerere University Herbarium (MHU), for identification, and are deposited there. Species nomenclature follows the Flora for Tropical East Africa. Species names were checked for accuracy using the TROPICOS database (http://www.tropicos.org/). The data were analyzed using the SPSS 18.0 statistical package (2010). The analysis included descriptive statistics.

Results

Sociodemographic characteristics of goat farmers

Eighty-eight percent (88%) of the respondents encountered were male, whereas 84% had never attended any form of formal school (see Table 1). Seventy-five percent of farmers had never participated in local livestock management trainings. The majority (70%) of farmers were involved in either animal husbandry or crop farming or both. The respondents also engaged in eleven other economic activities. Twenty-seven percent of respondents practiced animal rearing as the only economic activity (Table 1). Eighty-nine percent of respondents were married. The average age of respondents was 43, with a 16–72 range.

Goat rearing practices in Karamoja

The Karamojong keep goats mainly for income (96%), meat (91%) and milk (48%). Other reasons for rearing goats in decreasing importance were cultural ceremonies (30%), provision of hides (17%) and cultural identity (6%). Free range is the most predominant production system in this region with over 90% of farmers rearing goats under this system. Each household under free range grazes all their animals (sheep, goats and cows) daily as one single herd all day. Six percent of farmers alternate between free range and tethering depending on the season and these tended to rear comparatively less goats. Only 2.3% of farmers continuously raise goats by tethering. Less than 1% of farmers interviewed practice-intensive system of production. Only 8% percent of the farmers provide housing for their goats, while 0.6% provide housing for only exotic or cross-breed goats. For farmers without housing for goats, 40% keep their goats under trees, while 60% have kraals.

Major challenges in rearing goats in Karamoja

Apart from feed resources, diseases (63%), theft of goats (38%) and the high price of medicine for treatment of sick goats (26%) were reported as the major challenges of goat rearing in Karamoja. The most reported diseases were contagious caprine

Table 1 Social demographic characteristics of respondents interviewed in parts of pastoral Karamoja, Uganda (n = 300)

Characteristics	No. of respondents	Characteristics	No. of respondents
Sex		Main occupation	
Male	367	Crop and animal farming	210
Female	37	Animal rearing only	81
		Selling firewood	13
Marital status		Farming and mining	9
Married	268	Quarry works	8
Single	18	Retail business	2
Widowed	14	Others	10
Education			
None	252		
Primary	41		
Secondary	5		
Tertiary	2		

pleuropneumonia (CCPP), anaplasmosis, orfs, foot rot, Mange and peste des petits ruminants (PPR). In addition, 15% of farmers reported that raiding by fellow Karamojong communities or by the Turkana people of Kenya who live close to the northeastern border with the sub-region is still a major problem. Farmers (11%) reported low prices for goats, especially in the dry season, veterinary or extension workers being rare (7%) and the long distance moved to reach good market places (7%).

Goat feed resources in Karamoja

There are a variety of feeds for goats in the Karamoja sub-region (Fig. 2). Goats in Karamoja mostly feed on browses (trees and shrubs), grasses and crop residues. All respondents reported that their goats eat browse and grass, whereas 94% reported that their goats also eat crop residues.

The most eaten crop residues are sorghum stover (94%) and maize stover (61%). Twenty-five percent of respondents also reported feeding their goats on residues from a locally brewed alcoholic drink, Kwete, as supplement. From the focus group discussions, it was revealed that people eat this residue too especially during the long drought. Eleven percent of the farmers utilize a locally available salt, "engele" as mineral supplement for goats, while 14% reported intermittent use of commercial mineral supplement. The food wastes most eaten by goats are cassava (8%) and sweet potato (7%) peelings.

Seasonal variability of goat feed in pastoral Karamoja

The farmers revealed that Karamoja experiences two major annual seasons: a typical dry season running usually from October to March and a wet season from April to the end of September. Browses were able to provide feed to goats throughout the year, albeit in varying forms of forage, bark, roots or fruits. Browse foliage and twigs were the main feed derived from browse trees during the wet season, whereas bark, roots and fruits are mainly fed on by goats during the drier months. From the focus group discussions, farmers also reported that they eat fruits of plants used as browse, especially during the dry season, the time of year when they are most abundant. *Balanites aegyptica* (55%), *Accacia albida* (18%), *Grewia similis* (18%) and *Grewia mollis* (11%) were some of the browse trees whose fruits are eaten by goats. Farmers also reported drying of grass and broadleaved herbaceous plants in the form of hay or as hay. The two feed categories (grass and broadleaved herbs) were reported to be mostly abundant during the wet season. However, farmers reported that dry forage is eaten by goats too, especially during the long droughts when fresh feed reaches peak scarcity. The crop residues are a highly seasonal feed resource. According to farmers, they are abundant during the post-harvest period, which is at the end or middry season.

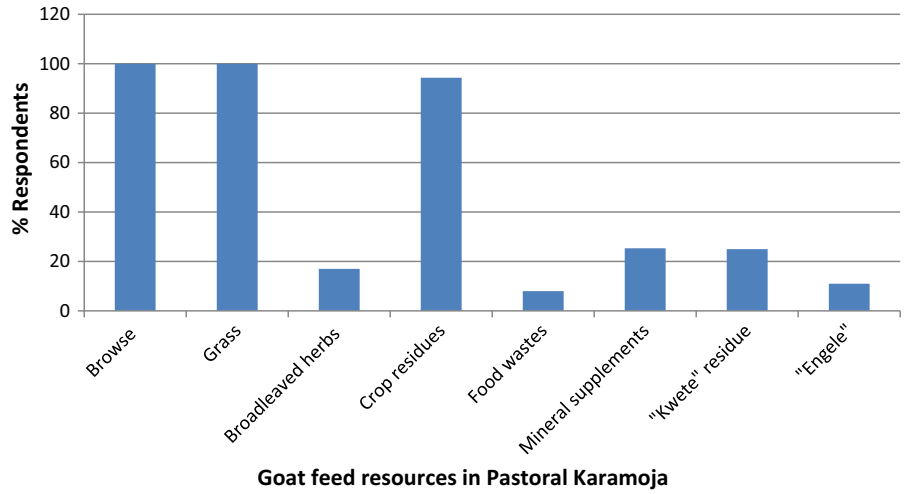

Fig. 2 The categories of feed eaten by goats in pastoral Karamoja, Uganda

Copping strategies during feed scarcity

The dry season particularly presents enormous challenge for animal production in the sub-region. However, farmers adopt several strategies to cope with the less water and fresh feed during this time. The main of them is the movement to different places with the animals daily and feeding animals on browse forage (Fig. 3).

Forage species for goats in Karamoja

The respondents mentioned several plant species that goats in Karamoja feed on. Seventy plant species, distributed in 31 families, were reported to be eaten by goats in the region (Table 3). The species were dominated by browses (trees and shrubs) 54%; herbs 21%; grasses 19%; climbers and hedges 5%. *Balanites aegyptica, Grewia similis, Acacia sieberiana Acalypha fruticosa, Acacia albida and Cadaba farinose* were the most frequently mentioned browse species. The most mentioned grass species were *Cynodon dactylon, Panicum poacoides, Setaria sphacelata, Hyparrhenia newtonii, Brachiaria fulva* and *Chrysopogon serrulatus,* whereas *Tribulus terristris*, *Ipomoea sinenensis* and *Commelina benghalensi* were the most mentioned broadleaved herbs. *Merremia pterygocaulos* and *Ipomoea pileata* were the most reported climbers. Most of the frequently mentioned goat browse species were also used for other purposes such as human food, medicinal purposes, firewood, construction materials, shade, fencing and charcoal burning. Table 2 shows the other uses other than goat feed that the community puts the goat browses species to.

Challenges in feeding goats in pastoral Karamoja

Lack of fresh forage and water for animals, especially in the dry season, are two major constraints to feeding (Fig. 4). Sixty-six percent and 41% of respondents reported facing these two challenges, respectively. Some goat feed resources ("Kwete" residues and browse fruits) are also used by humans as food, and this causes competition for the resource, especially during the dry season, with priority being given to humans.

Discussion

Feed Resources in Karamoja

Results from this study show that there is a diversity of goat feed sources in Karamoja sub-region (Fig. 2, Table 3). Having a variety of feeding options across the year is in part essential for sustenance of animal health and productivity (Andrade-Montemayor et al. 2011). Despite the diversity of goat feed resources observed in this study, most sources were highly seasonal and therefore unreliable in supplying goat feed year round without moving as is demanded by a sedentary life style. For instance, despite its abundance, grass is arguably the most seasonal of all naturally growing goat forage. The drying of grass

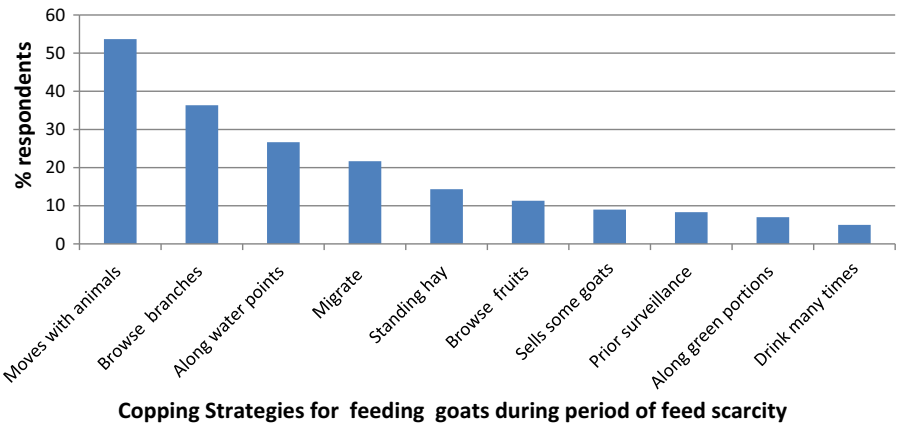

Fig. 3 Strategies used by the Karimajong to ensure adequate feed for goats during periods of feed scarcity

Table 2 Browses species used for other purposes other than goat feed

	Other uses other than goat feed that common browse species are put to							
Browse species	1	2	3	4	5	6	7	8
Balanites aegyptica	*		*					*
Acacia albida	*		*			*	*	
Growea mollis	*		*				*	
Acacia nilotica	*	*	*	*				
Dichrostachys cinerea			*	*			*	
Ormocapum trichocapum				*				
Acalypha fruticosa					*			*
Grewia similis	*			*	*		*	
Acacia sieberiana		*		*				
Acacia senegal		*		*				

Other uses of browse species: 1 food/vegetable, 2 medicinal use, 3 firewood, 4 construction, 5 fencing, 6 home shade, 7 eaten by cows, 8 charcoal making

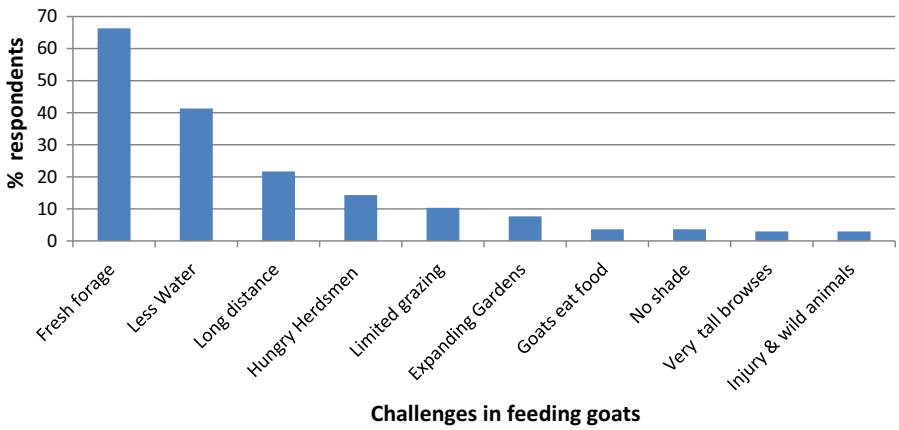

Fig. 4 Challenges faced by the Karimajong farmers in feeding goats

during the dry season as revealed by farmers renders this feed type less dependable. The effect of the dry season conditions coupled with the low-input nature of production system observed in Karamoja inevitably leaves farmers perpetually prone to negative effects on animal productivity. Crop residues were the third most reported feed for goats in this study. Despite this, crop residues are dispersed, seasonal, relatively small in quantity and given the large herds that most pastoralists keep, it is a less dependable source of feed. Additionally, it requires more organized and extensive crop production systems to regularly produce them in reasonable amounts and preferably processes into silage or hay. This calls for more investment, yet according to Tabuti and Lye (2009), this sub-region is one of the most poor and marginalized communities in Uganda. However, if the recent expansion of crop lands is upscaled and food security programs like the government's "food for work" made more individualized and more extensive, the potential of crop residues as feed for goats can be better harnessed. Indeed, results from this study provide evidence that crop residues could play an important role as goat feed since majority of pastoralists encountered in this study practice crop agriculture in addition to animal rearing.

Unlike grasses and crop residues that were found to be seasonal, browses (trees and shrubs) provided feed to goats across the year. Browses tend to persist even

Table 3 Plant species mentioned as feed for goats by respondents in Kaabong, Kotido and Moroto Districts of Uganda

	Local name	Family name	Growth form	No. of respondents
Species (*voucher no.*)				
(a) Woody species				
Balanites aegyptica L. DEL (NSU 31)	Ekorete	Balanitaceae	Tree	203
Grewia similis K. Schum. (NSU 01)	Ngomo	Tiliaceae	Shrub	145
Acacia sieberiana DC. (NSU 55)	Etirir	Mimosaceae	Tree	144
Acalypha fruticosa Forssk. var. fruticosa (NSU 05)	Eteteleit	Euphorbiaceae	Shrub	135
Acacia albida L.DEL (NSU 26)	Egirigirio	Mimosaceae	Tree	133
Cadaba Farinosa Forssk. (NSU 44)	Ering	Capparaceae	Tree	123
Dichrostachys cinerea L. Wright and Arn. (NSU 02)	Etirai	Mimosaceae	Tree	120
Grewia Mollis Hochst. (NSU 27)	Ekaale	Tiliaceae	Tree	112
Ormocarpum trichocarpum Taub.Engl. (NSU 4)	Etheperai	Papilionaceae	Shrub	106
Acacia senegal Del. (NSU 48)	Ekodokodoi	Mimosaceae	Tree	96
Acacia nilotica Del. (NSU 43)	Ekapelimen	Leguminosae	Tree	89
Capparis Tormentosa Lam.(NSU 76)	Erogorote	Capparaceae	Tree	78
Acacia abyssinica Hochst. (NSU 45)	Ekoromoi	Mimosaceae	Tree	67
Euphorbia turicalli L. (NSU 25)	Eligoi	Euphorbiaceae	Tree	58
Acacia abyssinica Hochst. (NSU 06)	Eminit	Mimosaceae	Tree	49
Commiphora africana A. Rich. Engl. (NSU 30)	Ekadeli	Burseraceae	Shrub	47
Azadirachta indica A. Juss. (NSU 20)	Elira	Meliaceae	Tree	44
Harrisonia abbisinica Oliv.	Ekere	Simaroubacea	Tree	44
Ziziphus abyssinica A. Rich. (NSU 07)	Ethelang	Rhamnaceae	Shrub	38
Capparis fascicularis DC. var. elaeaguoides Gilg. De Wolf (NSU 47)	Ekadwelia	Capparaceae	Shrub	37
Grewia villosa Willd. (NSU 70)	Epongai	Tiliaceae	Shrub	27
Dalbergia malanoxylum Guill. & Perr. (NSU 64)	Eregai	Papilionaceae	Shrub	26
Acacia mearnsii De Wild. (NSU 21)	Ekwakwa	Mimosaceae	Tree	25
Combretum collinum Fresen. (NSU 18)	Epie	Combretaceae	Tree	20
Combretum molle G. Don (NSU 22)	Ekuyon	Combretaceae	Tree	19
Tamarindus indica L. (NSU 54)	Eperu	Caesalpinaceae	Tree	14
Boscia salicifolia Oliv. (NSU 14)	Edwel	Capparaceae	Shrub	14
Haplocoelum foliolosum Hiern Bullock (NSU 65)	Ekapangiten	Sapindaceae	Shrub	13
Species name				
(b) Herbaceous species				
Cynodon dactylon L. Pers. (NSU 12)	Emuria	Poaceae	Grass	165
Panicum poacoides Stapf (NSU 60)	Elet	Poaceae	Grass	156
Setaria sphacelata Schumach. Moss (NSU 60)	Esiloit	Poaceae	Grass	111
Hyparrhenia newtonii (Hack) Stapf (NSU 77)	Emma	Poaceae	Grass	105
Brachiaria fulva Stapf (NSU 73)	Elapanat	Poaceae	Grass	77
Chrysopogon serrulatus Trin. (NSU 75)	Etuko	Poaceae	Grass	56
Tribulus terristris L. (NSU 11)	Esuguru	Zygophyllaceae	Herb	51
Hyparrhenia cymbaria (L.) Stapf. (NSU 74)	Nyekou	Poaceae	Grass	40
Cyperus maculatus Boeck. (NSU 17)	Echogoromoit	Cyperaceae	Sedge	37
Pennisetum mildbreadii Mez (NSU 10)	Emokorat	Poaceae	Grass	23
Ipomoea sinenensis Desr. Choisy (NSU 35)	Eliaro	Convolvulaceae	Herb	18

Table 3 continued

	Local name	Family name	Growth form	No. of respondents
Blepharis madaspatensis L. Polhill (NSU 71)	Ekaala	Acanthaceae	Herb	14
Commelina benghalensis L. (NSU 13)	Ebutachwei	Commelinaceae	Herb	23
Digitaria abyssinica A. Rich. Stapf (NSU 16)	Ekodopei	Poaceae	Grass	20
Phyllanthus nummulariifolius Poir. (NSU 03)	Ewokoet	Euphorbiaceae	Herb	10
Solanum incanum L. (NSU 15)	Etulero/Ekabulokong	Solanaceae	Herb	21

a woody species and b herbaceous species (species mentioned by less than 10 respondents are excluded from this list)

during the dry season (Hungwe et al. 2013). Browses can provide tender shoots which contain higher crude protein concentration, less fiber and therefore more nutritive (Evitayani et al. 2004), even during the dry season. This is in contrast to the lignocellulosic cereal straw (Al-Masri and Zakawi 1994) and the mostly fibrous and seasonally fluctuating grass. Given that there are ongoing interventions to promote a settled life style among pastoral communities in Uganda, it is imperative that planting and management of browse on individual farms is encouraged in such a way that the trees do not negatively affect crop production during the cropping season. This will strongly support goat feeding under sedentarized systems given the year-long ability of browses to provide feed for goats. Since browses are the major feed to goats during the dry season (Nampanzira et al. 2015), this practice can also contribute to lessening the dry season goat feeding challenges reported by farmers. Naturally growing browses can also be selectively managed concurrently within the expanding crop lands. Successful management of such forage can eventually drive the motivation to deliberately plant and manage them on more farms run under sedentarized systems. Additional benefits of deliberately increasing browse species are that they serve multiple benefits (Table 2) in addition to being goat feed. They can also contribute in mitigating climate change, having the ability to sequester atmospheric carbon dioxide (Dhillon and Van Rees 2017; De Stefano and Jacobson 2018; Shrestha et al. 2018; Fornara et al. 2018) and improving crop yields, especially in semiarid areas (Fahmi et al. 2018) such as Karamoja. Several factors may be influencing choice of browse species as shown by farmers' responses such as perceived nutritional benefits or sheer vigor that allows for quick regeneration after repeated browsing. Therefore, given the large number of browse species reported (Table 3), the performance of the most reported browses needs to be investigated for parameters including biomass production and nutritive value. Additionally, their ability to be artificially propagated should be investigated. Such knowledge can be invaluable when selecting a combination of species to popularize in settled agrosystems.

Conclusion

Browses, grass and crop residues dominate the feeding resources for goats in Karamoja. But the marked seasonality of grass and crop residues creates recurring animal nutritional deficits across the sub-region. Browses are multipurpose, tend to provide different forms of animal and human feed across the year and therefore have the potential to offset the dry season feed deficit in the sub-region.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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