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Indigenous browse species and goats' preferences in selected districts of Gamo Gofa and Wolayta zones, Ethiopia

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Important browses in selected districts were identified using goats' preference and farmers' knowledge. A total of 296 plots (20 × 20 m area) were placed along 16 transect lines randomly laid in plane and sloppy communal grazing lands to assess frequency of occurrences and density of the browse species. A total of 48 browse species out of which 31 were recognized by farmers were observed being browsed by goats. According to the goat owners, *Balanites aegyptiaca* was the most and *Grewia bicolor* was the least preferred, while the goats' preferred *Acacia tortilis* as the most and *Flueggea virosa* as the least. In the plane area, the highest frequency of occurrence was seen for *Rhus natalensis* (62.4%) and *Acacia mellifera* (50.3%), while in the sloppy grazing area the most frequently occurring (43.9 to 54.4%) browses were *Terminalia brownii*, *Harrisonia abyssinica*, and *Grewia bicolor*. Density of *Rhus natalensis* appears to be higher both in plane (186 tree/ha) and sloppy (166 trees/ha) lands. The ranking of farmers and the goats' preference appeared closely related. Therefore, further laboratory analysis should be conducted to verify the nutritional quality of the selected browses and urgent identification and conservation of potential browse trees and shrubs should be undertaken.

Key words: Browse species, goats, grazing area, indigenous, shrubs.

INTRODUCTION

Goat farming plays a vital role in the livelihood of rural smallholders and national economy in Ethiopia. Goats are an integral part of the economic and social life of the poor smallholders in many marginal areas of the country. However, productivity of the sector is constrained by shortage of quality feeds during the dry seasons (Lorato et al., 2015; Biruh et al., 2017). The major feed sources, such as crop residues, matured and dried up natural

pastures are characterized by low nitrogen and high fiber contents (Abebe et al., 2012). Moreover, the constraints in the availability of quality grasses and other forages are often aggravated by low and unreliable rainfall situations in arid and semi-arid areas. Introduction of improved pasture and forage plants under smallholder farmer's conditions have been limited due to lack of adaptation to local environment, proper technical support and faulty

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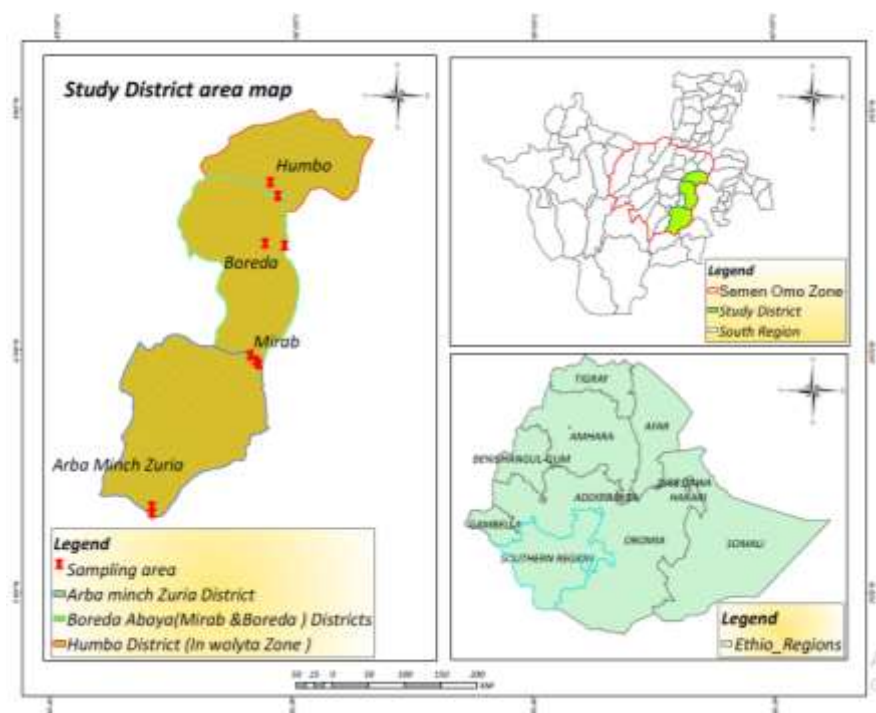


Figure 1. Map of the study area.

agronomic practices (Abebe et al., 2008). Supplementation of industrial by products such as oil seed cakes, wheat bran and molasses are inaccessible and high-priced in many developing countries like Ethiopia (Anbarasu et al., 2004).

In an effort to alleviate the problems of quality feed supply, indigenous browse species play vital role in animal production in arid and semiarid agro ecologies (Bamikole et al., 2004; Salem et al., 2006). Because, indigenous browse species that remain green year round, provide animals with feed resource rich in protein, energy, vitamins and minerals in dry seasons, when grasses and other herbaceous plants are scarce and low in quality (Bamikole et al., 2004; Salem et al., 2006). According to Tolera and Abebe (2007) browse species have high crude protein content ranging from 10 to more than 25% which may make them to be considered as a more reliable high quality feed resource. This can help in developing sustainable feeding systems and increase livestock productivity. Therefore, indigenous browses are of great importance in dry season livestock feeding as they can provide substantial protein and energy (Abebe, 2012; Belete et al., 2012).

In this regard, the southern rift valley semi-arid areas of Gamo Gofa and Wolayta zones are among areas where rich diversity of vegetation of indigenous browse species are found widely distributed and used as feed source for animals and other purposes as well (Teshome et al., 2004; Assefa and Bork, 2014). Mixed crop livestock is the main farming practice in the area with a few agro pastoral systems (Yisehak et al., 2007). Continuous expansion of

crop land coupled with indiscriminate uses of vegetation for firewood and construction in these areas may lead to the disappearance of important indigenous browse trees and shrub species (Yisehak et al., 2007). During the time between 1985 and 2010, rapid reduction in shrub land (28.82%) and natural grass land (33.13%) and an increase in arable land (59.15%) were observed in Abaya-Chamo Basin of Gamo Gofa and Wolayta zones (Yisehak et al., 2007; Ashebir et al., 2018). Yet, there is only little information on the identification, distribution, animal preference and utilization practices of indigenous browse trees and shrub species in the entire grazing land of the basin. This suggests that there is a need for research to identify and prioritize the beneficial browse trees and shrub species in order to efficiently utilize them. Therefore, the objective of this study were to identify and assess the distribution of important indigenous browse trees and shrub species, goats' preference and utilization practice in Rift Valley area of Arba-Minch Zuria, Mirab Abaya and Boreda districts, Gamo Gofa zone and Humbo district, Wolayta zone, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was carried out in purposively selected four districts, namely, Arba-Minch, Mirab Abaya and Boreda districts in Gamo Gofa zone and Humbo district in Wolayta zone of Southern Ethiopia. The districts are located, in the Rift Valley areas around Arba-Minch and near to Soddo city, respectively (Figure 1). Arba-

Minch and Soddo cities are located at 505 and 330 km away from Addis Ababa and lies between coordinates of 5° 45' 00" N latitude and 37° 00' 00" E longitude and 6° 50' 0" North latitude and 37° 45' 51" E longitude.

The elevation of the study area at Gamo Gofa and Wolayta zones ranges from 1011 to 1660 and 1080 to 1700 m above sea level, respectively. The study districts represent mixed crop-livestock farming systems of Southern Rift Valley of Ethiopia (Tsige, 2015). They have semi-arid climatic zones in the Rift Valley area which is characterized by bimodal rainfall pattern with short rains from March to May and little rainfall between June and August followed by the peak rain falls in September to October. The mean annual rainfall in the arid and semi-arid low land areas of the study districts range between 600 and 1000 mm (Makin et al., 1975; Tsige, 2015). The mean annual minimum and maximum daily temperature in the low land area is 14.5 and 33.3°C, respectively. The summer (June - August) and winter (November - February) months are the driest months (Azeb, 2009).

The soils types include, Calcaric fluvisol associated Eutric fluvisol and Pellic vertisol, which are brownish sandy loam, loam or sandy clay loam with variable and often calcareous subsoil are the most prevalent types of soils in the study areas. The size of the land holdings varies generally from 0.50 to 6 ha. Maize, Haricot bean, potato, cotton, fruits are among major crops produced in the area. The livestock comprised mainly cattle and goats are maintained in crop livestock production system characterized by traditional extensive feeding practices, where free grazing communal rangelands are the major feed resources throughout the year (Makin et al., 1975; Tsige, 2015).

Vegetation in the semi-arid zone of the southern Rift Valley is characterized by the presence of acacias as the dominant species of the tree and shrub layers. The most common *Acacia* species are *Acacia tortilis*, *Acacia brevispica*, *Acacia mellifera*, *Acacia nilotica*, *Acacia nubica*, *Acacia reficiens* and *Acacia seyal*. They are accompanied by many broad-leaved trees and semi-evergreen shrubs such as *Acokanthera brownii*, *Balanites aegyptium*, *Cadaba farinosa*, *Capparis tomentosa*, *Commiphora africana*, *Croton macrostachyus*, *Dichrostachys cinerea*, *Euphorbia tirucalli*, *Euphorbia candelabra*, *Harrisonia abyssinica*, *Sclerocarya birrea* and *Terminalia brownii*. The arid zone is characterized by dry thorn bush land. The common shrub species include *A. mellifera*, *Acacia etbaica*, *Acacia horrida*, *A. nilotica*, *A. tortilis*, *A. nubica*, *A. reficiens*, *Acacia senegal* and *A. seyal*. Dominant grasses include *Aristida kenyensis*, *Chloris pycnothrix*, *Hyparrhenia anthistirioides*, *Panicum atosanguineum* and *Pennisetum schimperi* in the semiarid zone (Makin et al., 1975; Teshome et al., 2004; Samson et al., 2010).

Sampling procedure and data collection

Reconnaissance field survey was conducted to have basic understanding about the study districts prior to selecting the representative study sites. Four districts were selected based on accessibility and representation of both agro-pastoral and mixed crop-livestock farming in semi-arid agro ecological zones of southern Rift Valley region of Ethiopia. Further, the livestock experts in the districts were consulted about the communal grazing and browsing sites of the selected districts. Finally, two types of grazing sites (plane and sloppy) and 3 peasant administrations (PA) in each district which have 10 households (HH) in each PAs were identified for further studies. Therefore, the study was conducted on a total of 8 grazing sites, 12 PAs and 120 goat owners who have a better knowledge of indigenous browse species from the four districts.

Altitude is the most important factor in determining plant community type (Teshome et al., 2004). Therefore, the grazing sites were classified based on the altitude representation of the semiarid agro-climatic zones as plane (1100 to 1299 m) or sloppy (1300 to

1600 m) above sea level. Two parallel transect lines of each 2.4 km long in each plane grazing lands and two parallel transect lines of each 1.6 km long in each sloppy grazing lands were randomly constructed. Within the transect lines rope quadrant of 20 × 20 m were placed at 100 m interval along each transects lines. These quadrants were used to assess the distribution of important browse tree and shrubs identified as important feed sources for goats. The measurements of boundaries of each altitude stratum were done by geographic positioning system (GPS).

Identification of browse trees and shrub species

Before starting field data collection, local development agent and goat owners who have a better experience of grazing areas and vegetation were used to select representative grazing sites in each PA to identify browse trees and shrub species that goats feed on. A flock of goats belonging to farmers was followed on communal grazing areas to identify browse species browsed by goats. Key informant farmers and development agent were used to record the local name and collect sample of each browse trees and shrubs observed being browsed by goats in the grazing lands. The observed browse trees and shrub species were recorded and sample of twigs were collected for displaying to goat owner. Specimens of each species were taken, labeled and transported to the National Herbarium of Addis Ababa University for species identification.

Goat owners' preference for indigenous brows tree and shrubs: Ten (total of 120) goat owners from each peasant administration were requested to assemble at a site to observe and rank the displayed samples of browse trees and shrubs that were being consumed by goats in the grazing sites. Their experience on the browse trees and shrubs as important feeds for goats, the parts favored by the goats, feeding practices and other uses were recorded. The equivalent species names were assigned with the help of an expert as per Kelecha (1987) and Azene (1993). Indices were calculated for ranked browse trees and shrubs which were computed by employing the principle of weighted average of (Musa et al., 2006).

Distribution of important browse trees and shrubs

The distribution of important browse trees and shrubs identified as important feed sources for goats' and utilized for other purposes were assessed. Eight parallel transect lines of 2.4 and 1.6 km long were randomly constructed in plane and sloppy grazing lands which are situated in the four districts, respectively. Rope quadrant size of (20 × 20 m) were placed at 100 m interval along each transects lines. A total of 128 sampling plots in sloppy and 168 in plane grazing sites were laid to score the frequency and density of the browse trees and shrubs. Frequency of each plant was determined by considering the number of plots in which it was recorded, as a percentage of the total plots in the respective grazing site of the four districts, while the density of the species was computed as the number of individuals of a species occupying a sampled area. The geographic location of each plot was recorded using GPS that may be used as reference points for future grazing land browse species monitoring studies. The availability of important browse trees and shrub species on the communal grazing areas were computed according to the structural parameters described by (Mueller and Ellenberg, 1974; Martin, 1995).

$$\% \text{ Frequency} = \frac{\text{Number of plots a species occur}}{\text{Total number of plots}} \times 100 \quad (1)$$

$$\text{Density of a species} = \frac{\text{The number of individuals of that species}}{\text{Sampled area}} \quad (2)$$

Goats' preference test for browse trees and shrubs

The top ten browse trees and shrub species identified by the goat owners as important feeds for goat during group discussion were used for the goat preference test as methods described by Mtengeti and Mhelela (2006). Ten yearling goats were selected from Arba-Minch University goat farm. Then they were locked in a separate barn in farm of the university. Twigs with stems less or equal to 5 mm wood diameters of the ten selected browse species were collected each day early in the morning from the university vegetation park. The browse twigs were tied in a bundle of one kilogram and hung at 40 cm above the ground (to give easy access to the goats) at distance of 1.5 m apart by a twine rope to a horizontal wooden pole supported at both ends by two poles stuck in the ground. The goats were then allowed to browse twigs of the ten browse plant species for 15 min in a cafeteria fashion at 8:00 am before going to graze. The position of the twigs of each browse plant was changed every day so as to avoid positional bias. The data collection of the preference test was conducted for 7 days after three days of adaptation period. The fresh weight eaten from each browse species was obtained by subtracting the weight of the remaining twigs from 1 kg offered. Goat preference of browse species was determined from the coefficient of preference value calculated from the ratio between the intakes of each browse sample divided by the average intake of the total browse sample (Karbo et al., 1996; Bamikole et al., 2004). Browse species was considered relatively preferred if the COP value is greater than unity. The results were used to rank the various browse species by preference.

Data management and analysis

The frequency and density of the browse and shrub species in each grazing sites of the districts were similar. Thus, data of the same browse tree and shrub species in the same grazing site of the districts were then pooled together and expressed as a percentage of occurrences in all plots observed in the four districts and compared crossways the grazing sites following crosstab analysis in SPSS for windows, release 20, 2011. Differences in frequency of occurrence among percentage values were compared by Chi square test. Index method of ranking was used for ranking of goat owners browse species selection in the study districts as described by Musa et al. (2006).

$$\text{Index} = R_n \times C_1 + R_n - 1 \times C_2 + \dots + R_1 \times C_n / \sum R_n \times C_1 + R_n - 1 \times C_1 + \dots + R_1 \times C_n \quad (3)$$

where R_n = Value given for the least ranked level (if the least rank is 5th, then $R_n = 5$, $R_n - 1 = 4$, $R_1 = 1$). C_n = Counts of the least ranked level (in the example, the count of the 5th rank = C_n , and the count of the 1st rank = C_1).

RESULTS AND DISCUSSION

Identification of indigenous browse tree and shrub species as feed for goats

During field survey based on goat consumption a total of 47 indigenous browse species belonging to 47 genera and 15 families were identified in this study indicating that the area was richer in its browse plant diversity. Out of these browses 26 (55.4%) were trees while 21 (44.6%) were shrubs.

The most dominant family is Fabaceae comprising 10 (21.3%) species, followed by Capparidaceae which comprises 6 (12.8%) species. The next dominant families were Euphorbiace and Tiliaceae with 4 (8.5%) species each followed, by Anacardiace, Burseraceae, Combretaceae and Rhamnaceae with 3 (6.4%) species each and Balanitaceae and Sapindaceae with 2 (4.3%) species each. Apocynaceae, Olacaceae, Simaroubaceae, Celastraceae, Flacourtiaceae, Mimosaceae and Rubiaceae were represented by 1 (2.1%) species each, which is consistent with result of Beche et al. (2016) who reported 62 useful plants belonging to 49 genera and 31 families for Awash National Park and Belete et al. (2012) who reported 18 different browse species identified being important feed for different classes of livestock in central Rift Valley areas of Ethiopia.

Browses vary in their seasonal availability as certain browse species are deciduous while some maintain their greenness all year round. For instance in the present survey, it was noticed that *Rhus natalensis*, *B. aegyptiaca*, *A. tortilis*, *A. mellifera*, *T. brownii*, *Ziziphus mucronata* and *Tamarindus indica* were present on the grazing areas all year round. Goats frequently browsed *A. mellifera*, *A. tortilis*, *Flueggea virosa*, *R. natalensis*, *B. aegyptiaca*, and *H. abyssinica* in the grazing areas.

Distribution of important indigenous browse trees and shrubs

Frequency of the most important browse species at the plane and sloppy grazing lands (Table 1). Frequency reflects the pattern of distribution and gives an approximate indication of the heterogeneity of a woody plant (Haileab et al., 2006). Based on the field investigation, out of ten indigenous browse species ranked as important feed sources of goats, only 2 (*A. mellifera* and *R. natalensis*) had frequency of occurrence greater than 48% in the plane grazing lands. Conversely, only three browse species (*R. natalensis*, *H. abyssinica* and *Grewia bicolor*) had frequency of occurrence greater than 48.4% in the sloppy grazing areas. The occurrence of *A. mellifera* in the plane grazing area was significantly higher than in the sloppy areas. *A. mellifera* had a density of 92 and 35 trees per hectare in the plane and sloppy areas, respectively. This shows how overgrazing promotes the invasive shrubs (*A. mellifera*) encroachment in the grazing lands. This idea is consistent with the finding of Skarpe (1990) who reported that overgrazing is the main cause of *A. mellifera* encroachment in an arid savanna of Botswana.

According to this author, *A. mellifera* (the shrub browse) is shallow rooted suggesting that it was favoured by an increase in water availability in the surface soil following overgrazing of the grass layer. Similarly, Svitálek (2008) and Yisehak et al. (2007) documented that *A. mellifera* is the species responsible for the ongoing bush

Table 1. Frequency (%) and distribution of the most important browse species at the plane and sloppy grazing lands.

Scientific name	Frequency of presence (%)			Density (Tree/ha)		
	Plain (1100-1299)	Sloppy (1300-1600)	P-value	Plane (1100-1299)	Sloppy (1300-1600)	P-value
<i>R. natalensis</i>	63.5	64.3	0.886	186	166	0.37
<i>A. amara</i>	38.9	28.6	0.065	120 ^a	62 ^b	0.01
<i>Z. mucronata</i>	18.6 ^a	8.0 ^b	0.009	11.4 ^a	5.2 ^b	0.03
<i>F. virosa</i>	18.6	19.0	0.916	16	15.7	0.98
<i>A. mellifera</i>	48.0 ^a	15.9 ^b	0.000	93 ^a	35 ^b	0.00
<i>T. brownii</i>	26.3	36.5	0.062	34	52	0.06
<i>A. tortilis</i>	26.9	24.6	0.651	20	13	0.18
<i>H. abyssinica</i>	25.1 ^b	53.2 ^a	0.000	28 ^b	89 ^a	0.00
<i>B. aegyptiaca</i>	33.5	41.3	0.174	30	36	0.44
<i>G. bicolor</i>	32.9 ^b	48.4 ^a	0.007	38	48	0.21

^{a,b}Row means with different superscripts differ significantly at P<0.05. ha = Hectare.

Table 2. Ranked perception of the respondents on the preferred browse parts utilized by goats.

Parts used	Farmers perception ranks				
	1 st	2 nd	3 rd	Index	Rank
Leaves	120	0	0	0.50	1
Twinges	0	7	110	0.172	3
Fruit and pods	0	113	7	0.323	2
Flowers	0	0	3	0.004	4

encroachment due to crop land expansion, overgrazing and unsustainable use for firewood collection in the Nech Sar planes and around the plane grazing areas of Southern Ethiopia. On the other hand, the occurrence of *H. abyssinica* and *G. bicolor* in the sloppy areas were significantly higher ($P < 0.05$) than those in the plane areas. In terms of tree density, there are about 52, 89 and 48 trees per hectare observed for *T. brownii*, *H. abyssinica* and *G. bicolor* in the sloppy grazing areas as compared to 34, 28 and 38 trees per hectare found in the plane areas, respectively.

This could be due to plant ecological preference (Alemu et al., 1998) and protection of vegetation clearing and crop land expansion as a part of water shade/or catchments conservation program started some ten years ago in the sloppy grazing areas that might contribute for better occurrence of these species. However, there is comparable and high frequency of occurrence was observed for *Rhus natalensis* between plane (63.5%) and sloppy (64.3%) grazing areas. This is confirmed by closely similar tree density per hectare observed for this browse in plane (186 h⁻¹) and sloppy (166 h⁻¹) grazing areas in this study. Even though the reason why *R. natalensis* is equally distributed across the different slopes of lands needs further investigation, its accessibility in both slopes of land coupled with its high preference value given by farmers, makes it important

browse plant as feed resource for goats. Abebe et al. (2010) reported that *R. natalensis* provide large proportion of forage consumed by goats and camels in the dry season in Southern Ethiopia.

The frequency of 8 browse species in the plain area ranges from 18.6 to 38.9% while 7 browse species in the sloppy area ranges from 8 to 41.3%. Generally, the frequency of occurrence observed for these species appears to be low. This is an indication of serious vegetation clearing due to expansion of crop land, indiscriminate use of vegetation for charcoal, fire wood and construction (poles and timber production) (Table 3). This is consistent with Fetene et al. (2016) who reported that changes in vegetation of Nech Sare National Park is attributed to degradation of existing vegetation through deforestation and replacement of existing vegetation by encroaching plants. Thus, this needs urgent identification of useful multipurpose indigenous browse trees and shrub species to conserve before they get extinct.

Utilization practices and favored parts of browse trees and shrub species

Favored parts of browse species as assessed by the farmers (Table 2). According to the key informants and conclusions derived from the group discussions, cattle

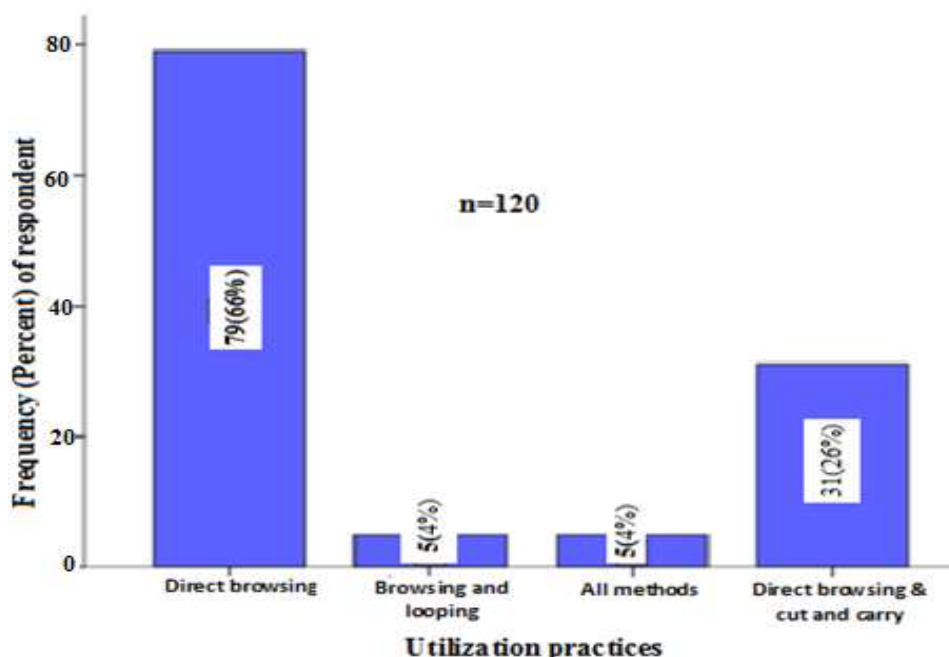


Figure 2. Browse species utilization practices.

survive on natural pastures which provide abundant grazing during rainy seasons, but quickly mature and dry up with the onset of the dry season; whereas, goats browse on trees and shrubs throughout the year. Likewise, Sanon et al. (2007) reported for the Sahelian zone of Burkina Faso that browse represented 43 to 52%, of the daily diet of grazing goats while it covers only 4 to 7% of the daily diet of grazing cattle. Similarly, Jamala et al. (2013) documented that browse can contribute as much as 30% of cattle's and 60% of goats' in Guyuk, Adamawa State (Nigeria). Utilization of browse species by livestock as a feed source has been described by Ethiopian authors as well (Takele et al., 2014; Angassa and Berhan, 2015).

Goat owners were able to identify which parts of the browse plants favored by the goats (Table 2). Accordingly, leaves, fruits and pods and twinges were the most preferred parts utilized by goats with index of 0.5, 0.32, and 0.17, respectively. For example, pods and fruits of *A. tortilis*, *A. seyal* and *B. aegyptiaca* as well as fruits and wilted fallen leaves of *A. mellifera* were mentioned as important feeds for goats during dry seasons. Herders tend to loop and cut branches from various palatable browse trees like *A. tortilis*, *B. aegyptiaca*, *T. brownii*, *Z. mucronata* and *G. bicolor* species to feed their goats during the dry season.

Browse species utilization practices as assessed by the goat owners (Figure 2). Nearly, all goats that are able to walk long distance and look healthy directly browse on the browse species in the grazing areas.

Most of the farmers (66%) in the area directly let their

goats to browse in the grazing areas while browsing and cut-carry; browsing and lopping as well as all feeding methods were practiced by 26, 4 and 4% of the farmers, respectively. Fodder feeding by cut and carry system are practiced only for young kids, sick goats, pregnant goats and castrated male kept at home for fattening. In Arbaminch area, some goat owners feed *T. brownii* leaf for fattening goats by cut and carry system. The collected browse leaves were wilted under shade before offered to the goats. The reasons why farmers wilt the leaves under shade are to prevent bloating caused by feeding fresh leaf and to increase intake of the leaves.

This result agrees with the report of Gaiballa and Lee (2012) and Getachew et al. (2017) who reported that leaves of browse trees were fed to livestock by cut and carry system. Similarly, Hassen et al. (2010) also documented that leaves, pods, twigs and flowers were parts of the browse species mostly utilized by livestock. Furthermore, Teferi (2006) has concluded that goats are better than cattle by feeding directly on foliage of browse species.

Goat owners' ranking of browse trees and shrub species

Indigenous browse tree and shrubs species identified and ranked by goat owners as important feed for goats (Table 3). From the initial list of 48 browse species identified, the first top ten ranked by the goat owners were taken as important feed for goats. The most important browse

Table 3. Indigenous browse species, their use and ranking by goat owners as important feed for goats.

Scientific name	Index	Rank	Other uses
<i>B. aegyptiaca</i>	0.113	1	1, 3, 7, 9,10
<i>R. natalensis</i>	0.108	2	1,2, 5,10
<i>A. amara</i>	0.097	3	1,6,7, 9
<i>H. abyssinica</i>	0.083	4	1, 6
<i>T. brownii</i>	0.067	5	1, 2, 3, 4
<i>A. mellifera</i>	0.060	6	1, 5, 8
<i>F. virosa</i>	0.059	7	1, 2
<i>A. tortilis</i>	0.059	8	1,3,5,7, 8, 9
<i>Z. mucronata</i>	0.054	9	1,2, 6,7, 9
<i>G. bicolor</i>	0.047	10	1, 2, 5,10

1= Firewood, 2 = fruit for human consumption, 3 = charcoal, 4 = farm tool handler, 5 = fencing, 6 = life fence, 7 = home construction (Timber and poles), 8 = bees forage, 9 = shade, 10 = medicine.

species mentioned as feed for goats in ranking order was *B. aegyptiaca* while the least was *G. bicolor*. Among the ten species, *R. natalensis*, *Albizia amara*, *H. abyssinica* and *Flueggea virosa* were shrub, while *B. aegyptiaca*, *A. tortilis*, *Z. mucronata*, *G. bicolor*, and *T. brownii* were trees.

The goat owners mentioned that browse species which stayed green throughout the year are much more useful than those species shedding their leaves during the dry season. For example, *B. aegyptiaca* and *R. natalensis* were the most preferred species reported in terms of providing green forage in the dry seasons. Some of the fodder species favored by goats are similar to those described by many authors in Ethiopia (Teferi, 2006; Dargo and Hailu, 2019; Belete et al., 2012). Belete et al. (2012) identified *A. tortilis*, *B. aegyptiaca*, *G. bicolor* and *D. cinerea* are the most widely utilized browse species in the mid Rift Valley areas. Dargo and Hailu (2019) documented *G. bicolor*, *T. brownii* and *Ziziphus spina-christi* in Babile district. Teferi (2006) documented the wide distribution of *B. aegyptiaca* and *T. brownii* in Northern Ethiopia.

On the other hand, many of these browse species had several other uses. All browse species were used for firewood, 5 for construction (Timber and poles), 5 for shade, 5 for human edible fruit, 3 for making charcoal, 3 for making live fence, 3 for fence, 2 for making tool handles and 2 for bees forage. This is consistent with 54 multipurpose plants reported by Beche et al. (2016) for Awash National Park that includes 35 medicinal species, 22 wild edible species, 39 forage species and 45 species used for construction, fuel and firewood. This indicates that the multiple uses of browse trees and shrubs coupled with expansion of crop land in the area may lead to disappearance of some important browse species. Most of the goat owners were able to identify and name the different indigenous browses, those with beneficial

browse value and other uses. However, all of them neither knew how to manage indigenous browses nor conserve to improved and for sustainable use in feeding their animals.

Goats' preference for browse trees and shrub species

Ranks of indigenous browse trees and shrubs species preferred by goats (Table 4). The rank order of preference (highest to least) for goats during 7 days of feeding was *A. tortilis*, *B. aegyptiaca*, *H. abyssinica*, *A. mellifera*, *A. amara*, *T. brownii*, *Z. mucronata*, *R. natalensis*, *G. bicolor* and *F. virosa*. Coefficient of preferences (COP) showed that only six of them have their COP be up to unity while the rest plants were below unity.

Some of the browses species favored by goats in this study are consistent with *A. mellifera*, *B. aegyptiaca* and *A. tortilis* reported by Emiru et al. (2014) in Aba'ala district of Afar region and *A. mellifera* and *Z. mucronata* reported by Skarpe et al. (2007) in a semi-arid savanna of Botswana. This study revealed that, *A. tortilis* was the first favored browse consumed by goats followed, by *B. aegyptiaca*, while *B. aegyptiaca* was the first and *A. tortilis* was the 8th choice of the farmers.

The differences between the farmers choice and goat preference could be attributed to the physical structure such as the shape and size of thorns, and low leaf yield of *A. tortilis* might have biased the farmer to choose *A. tortilis* leaf at 8th ranking position. Moreover, according to the conclusion derived from the group discussion, prior experience of feeding goats on *A. tortilis* pods during dry seasons appears to be another reason that contributes for its leaf being the 8th choice of the farmers. This is confirmed by Devendra (1989) that observed herdsmen

Table 4. Mean intake and coefficient of preference of selected indigenous trees and shrubs fed to Woyto Guji goats.

Scientific name	Mean $\pm$ SD g/head/15 min	COP	Rank
<i>G. bicolor</i>	449.3 $\pm$ 12.5	0.957	10
<i>A. amara</i>	500.0 $\pm$ 217.9	1.065	5
<i>B. aegyptiaca</i>	564.3 $\pm$ 134.5	1.202	2
<i>H. abyssinica</i>	548.6 $\pm$ 86.8	1.169	3
<i>Z. mucronata</i>	478.6 $\pm$ 111.3	1.019	7
<i>F. virosa</i>	450.0 $\pm$ 170.4	0.959	9
<i>R. natalensis</i>	477.2 $\pm$ 56.8	1.016	8
<i>A. tortilis</i>	665.7 $\pm$ 54.5	1.418	1
<i>A. mellifera</i>	521.4 $\pm$ 132.9	1.111	4
<i>T. brownii</i>	488.5 $\pm$ 150.3	1.041	6

SD= Standard deviation, COP = coefficient of variation.

in semi-arid Kenya taking their flocks to *A. tortilis* land during dry seasons to feed on ripe pods shaken from the trees. According to this author, the pods make up about 50% of total daily intake during this period and potentially invaluable protein concentrate for small ruminants.

Based on rank order, *R. natalensis* was the 7th favored browse of the goats, but it was the 2nd choice of the farmers. The reason why the goat owner ranked second could be due to its readily available, remain green throughout the year and easy accessibility for browsing might bias the farmers as if it is more preferred by the goats. Moreover, the focus group discussion revealed that relative abundance, palatability and accessibility necessarily determine the selection of browse species by the farmers. On the other hand, the lower preference of the goats to the browse could be attributed to the high condensed tannin contents of the browse, which might reduce its palatability as compared to those favored browses. This is evidenced by its high condensed tannins content (224.5 g/kg DM) reported by Abebe et al. (2012). Similarly, in support of the present study Nampanzira et al. (2016) reported that *R. natalensis* leaf were inferior in rumen degradability compared to *H. abyssinica* which may best explain the observed low coefficient of preference of the *R. natalensis*. On the contrary, Mengistu et al. (2016) reported that despite high tannin levels, *R. natalensis* was the most preferred species by goats. According to this author, the condensed tannin levels at the observed DMI of the browse species did not determine preference of the goats, instead it appeared to be based on hemicelluloses level. The other 6 indigenous browse tree and shrub species choice of the farmers was closely similar with the preference of the goats.

CONCLUSIONS AND RECOMMENDATIONS

Most of the farmers were browsing their goats freely in the communal grazing areas. Some important browses

trees and shrub species identified as important feed sources of goats and have other uses; frequency of occurrence in the communal grazing areas were low. These species includes *B. aegyptiaca*, *A. tortilis*, *Z. mucronata* and *F. virosa*. Whereas, few species such as *A. mellifera* which is favored by goats, but considered as invasive shrubs of the grazing areas and *R. natalensis* occurrence along both plane and sloppy areas were relatively high due to their drought and browsing tolerance. As perceived by the goat owners, other uses of *A. mellifera* and *R. natalensis* were low compared to others. Identifying important multipurpose indigenous browse trees and shrub species is essential to exploit them efficiently for sustainable livestock production. It is therefore, important to identify and conserve such vital plant resources before it gets extinct. Nutritional quality of important indigenous browse trees and shrub species identified based on goat preference and farmers' needs to be verified by conducting laboratory chemical analysis.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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