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Research Paper

A survey to assess the value of the legume chimero (*Bouffordia dichotoma* syn. *Desmodium dichotomum*) in mixed farming systems in North and South Wollo Zones, Amhara Region, Ethiopia

Un estudio para explorar el valor de la leguminosa nativa 'chimero' (Bouffordia dichotoma *sin.* Desmodium dichotomum) *en sistemas de producción mixta en Amhara, Etiopía*

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Abstract

This study was conducted to determine the yields and chemical composition of the legume, chimero (*Bouffordia dichotoma* syn. *Desmodium dichotomum*), at its niche in North and South Wollo Zones, Amhara Region, Ethiopia and how it is used by farmers in the region. Dry matter yields of chimero growing as spontaneous intercrop with sorghum in 3 Peasant Associations in each of the 5 sampled districts were determined as was the chemical composition of the forage, based on pooled samples. The average yield of chimero growing as a self-sown legume with sorghum was 4,400 kg DM/ha. Mean chemical composition was 15.4% ash, 22% CP, 31% NDF, 26% ADF and 5.8% ADL, while IVDMD was 61%. Mineral concentrations were: 0.6% Ca, 0.23% P, 1.5% K, 0.78% Mg, 0.01% Na, 0.27% S, 0.16% Fe, 4.4 mg/kg Cu, 45 mg/kg Mn and 12.3 mg/kg Zn. Chimero appears useful as a supplement for feeding to ruminant animals, provided no anti-nutritional factors are present. A self-sown legume that can produce at least 4 t DM/ha with 22% CP when growing with a sorghum crop seems worthy of further investigation. Further studies are needed to assess the impacts on grain and stover yields when chimero is sown with grain crops of sorghum and maize, as well as effects on soil N. The role of this legume in association with grasses warrants investigation. Multi-site evaluation of a range of ecotypes could identify more productive lines.

Keywords: Community use, dry matter yield, nutritive value, tropical legumes.

Resumen

El estudio tuvo como objetivos determinar el rendimiento de forraje y la composición química del chimero (*Bouffordia dichotoma* sin. *Desmodium dichotomum*), familia Fabaceae, en su nicho en las North y South Wollo Zones, Amhara Region, Etiopía, y conocer las formas de uso por los agricultores de la región. Se determinaron los rendimientos del chimero que crecía espontáneamente en los cultivos de sorgo de 3 asociaciones campesinas en cada uno de 5 distritos del estudio y se determinó su composición química con base en muestras agrupadas. El rendimiento promedio fue de 4,400 kg de MS/ha. La composición química promedio fue: ceniza, 15.4%; proteína cruda, 22%; fibra detergente neutro, 31%; fibra detergente ácido, 26%; y lignina detergente ácido, 5.8%. La digestibilidad in vitro de la materia seca fue de 61%. Las concentraciones minerales fueron: 0.6% Ca, 0.23% P, 1.5% K, 0.78% Mg, 0.01% Na, 0.27% S, 0.16% Fe, 4.4 mg/kg Cu, 45 mg/kg Mn y 12.3 mg/kg Zn. El forraje del chimero parece útil como suplemento para rumiantes, siempre y cuando no se presenten factores antinutricionales. Una leguminosa que ocurre en forma espontánea en un cultivo de sorgo y produce 4 t de MS/ha con un 22% de proteína cruda merece más investigación. Se necesitan estudios sobre el efecto de la leguminosa en los rendimientos de grano y biomasa de cultivos de sorgo y maíz, así como el efecto en el nitrógeno del suelo. También se requiere estudiar la factibilidad de asociaciones con gramíneas forrajeras y explorar si existe variabilidad genética en las poblaciones nativas.

Palabras clave: Leguminosas tropicales, producción de materia seca, uso comunitario, valor nutritivo.

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Introduction

Ethiopia is considered to have the largest livestock population in Africa. It is home for about 59.5 million cattle, 30.7 million sheep, 30.2 million goats, 2.16 million horses, 8.44 million donkeys, 0.41 million mules and about 1.21 million camels (CSA 2016/17).

Livestock play vital roles in generating income for farmers, creating job opportunities, ensuring food security, providing services, contributing to asset, social, cultural and environmental values and sustaining livelihoods (Metaferia et al. 2011).

Despite the high livestock population and favorable environmental conditions for animal production, current livestock production and productivity are far below expectations. This is associated with a number of complex and inter-related constraints such as inadequate feed and nutrition, widespread diseases, limited genetic potential of local breeds, marketing issues and inefficiency of livestock development services with respect to credit, extension, marketing and infrastructure (Negassa et al. 2011). Among these constraints, poor nutrition is a major factor limiting livestock performance (Belete et al. 2012).

While supplementing animals with concentrate feeds can increase digestibility, nutrient supply and intake (Preston and Leng 1987), concentrates are expensive and may exceed the financial limits for rural farmers. A logical alternative is to improve the nutrition of livestock by improving the quality of available feed resources like native pastures and crop residues. Another approach is to develop new forage crop varieties by selecting from within local species or through exotic introductions.

One native herbaceous legume, known locally as 'chimero' [*Bouffordia dichotoma* (Willd.) H. Ohashi & K. Ohashi] [syn. *Desmodium dichotomum* (Willd.) DC], family Fabaceae, is recognized by farmers in several districts of North and South Wollo Zones, Amhara Region, Ethiopia as a valuable livestock feed. Chimero is an herbaceous annual self-regenerating legume growing in a wild state. The stem and branches have a trailing growth habit and reach 64–90 cm in length. Leaves are trifoliolate, with the leaflets being ovate (5.8–8 cm long and 4–5 cm wide). Both the dorsal and under-sides of the leaves are hairy and green in color, while flowers are pink to violet and seeds are yellow to light brown (Figure 1). Chimero is known by other common names in the various countries where it is found, including "er qi shan ma huang" in China and "chikta", "asud" or "gander-lapto" in India. It is also found in other parts of Africa (Cameroon, Chad, Eritrea, Sudan, Uganda) and Asia (Indonesia, Myanmar).

On the basis of this scenario, the current study aimed to explore how the community uses this legume, plus identify and evaluate the chemical composition of chimero at its niche.

Figure 1. Morphology of chimero: whole plant; stem, leaves and inflorescence; and pods. (Photos: H. Abebe.)

Materials and Methods

Description of North and South Wollo Zones

South Wollo, situated approximately between 10°15'–11°30' N and 38°25'–39°30' E (Figure 2), has a total landmass of 17,067 km^2. Elevation varies from 1,000 (Chefameda) to 4,247 (Amba Ferit) masl. The annual range of temperature is 10–25 °C and drops with the increase in elevation. Frost is very common at higher elevations, specifically above 2,500 masl. Annual rainfall varies from 900 to 1,000 mm, most falling in Belg (February–May) and Meher (June–September) (Figure 3). Soil types vary with the major type in the western part of the Zone being vertisol followed by luvisol and nitosol. The southern and eastern parts of the Zone have cambisols, vertisols and dark brown silty clay soils. Water-logging occurs as a result of poor surface drainage plus shallow soil depth and soil infertility is common.

North Wollo central area is one of the 11 Zones of Amhara Regional State. It is in the northern part of the country (11°21'–12°20' N, 38°27'–39°57' E) (Figure 2) and shares a border with South Wollo Zone, South Gondar Zone, Wag Hamra Zone, Tigray Region and Afar Region. In addition to these neighboring areas, part of North Wollo's southern border is defined by the Mille River. The districts of North Wollo Zone fall under 4 livelihood zones. These are: the lowland areas, North Wollo East Plain livelihood Zone, Northeast Midland mixed cereal livelihood Zone and North Wollo Highland Belg livelihood Zone. Climatic conditions in the Zone are presented in Figure 4.

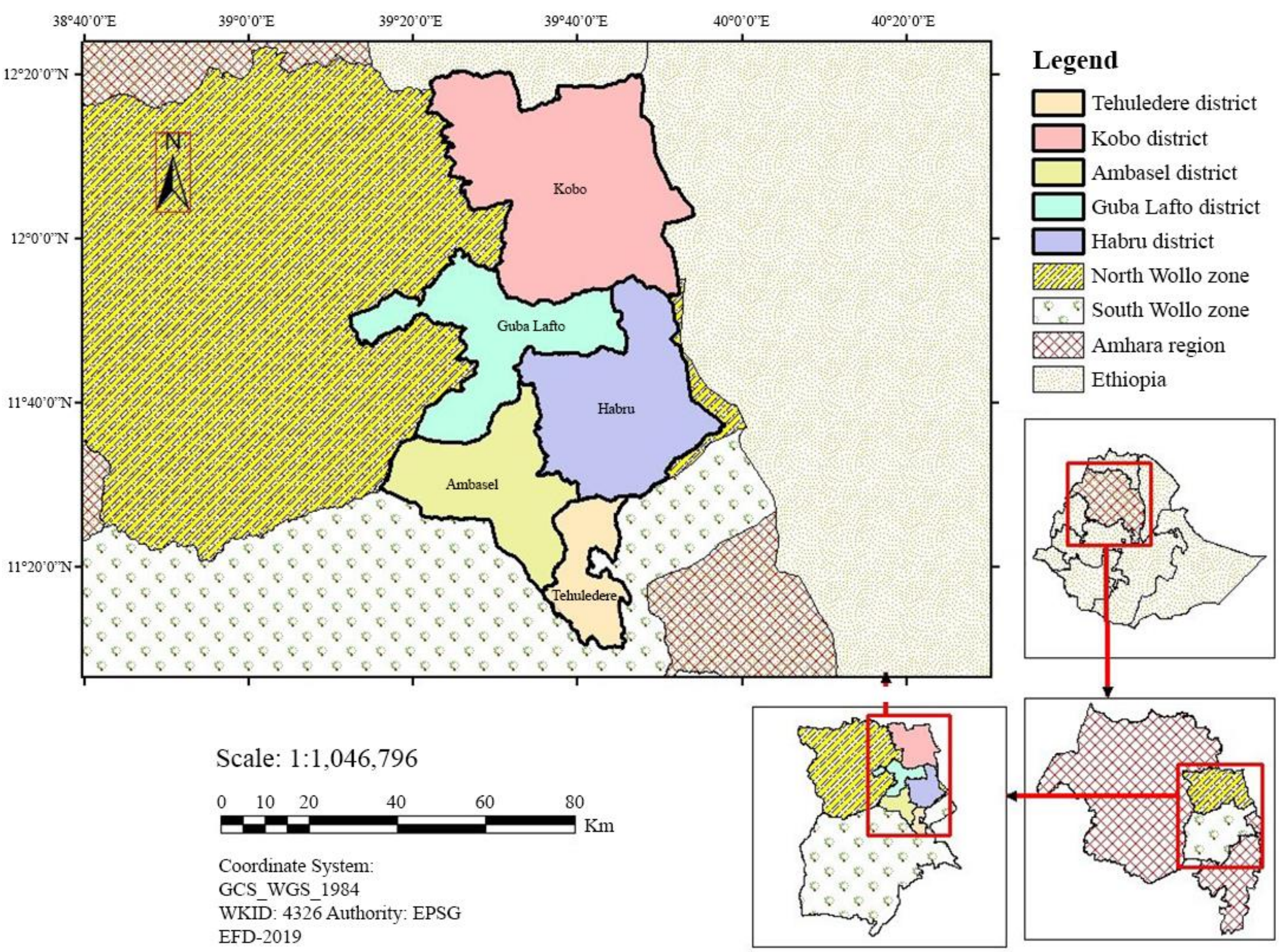

Figure 2. Map of the study area in Ethiopia.

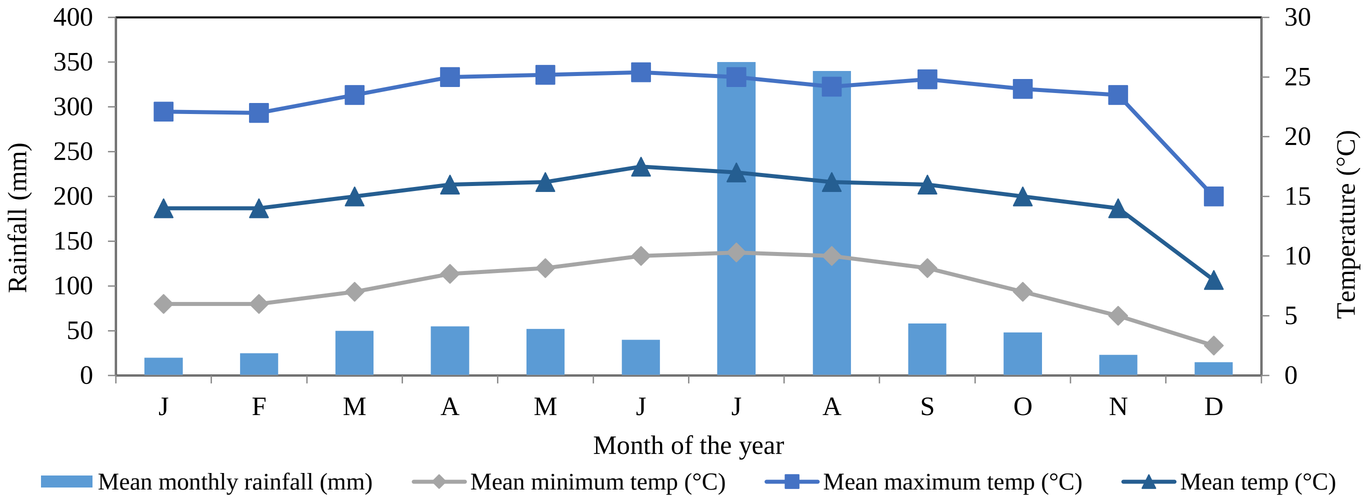

Figure 3. Rainfall distribution and temperature for South Wollo Zone [means of 16 years (2000–2015)]. Source: National Meteorological Service Agency, Kombolcha Station (NMSAKS 2019).

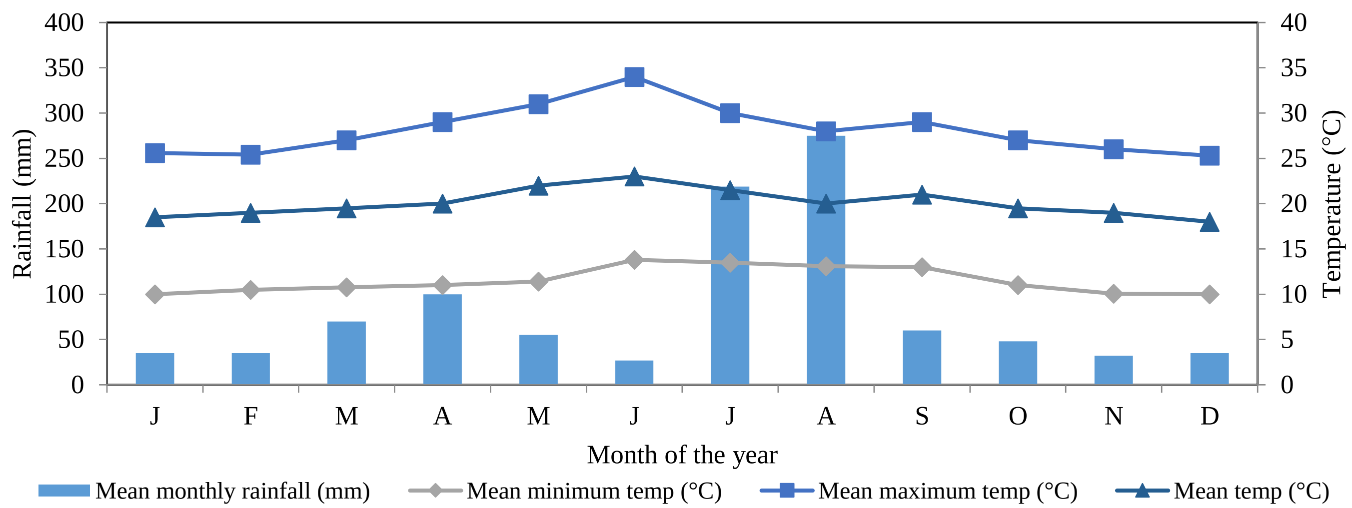

Figure 4. Rainfall distribution and temperature for North Wollo Zone [means of 16 years (2000–2015)]. Source: National Meteorological Service Agency, Kombolcha Station (NMSAKS 2019).

Questionnaire-based survey on community use of chimero

A survey was conducted from 10 October 2018 to 20 November 2018 in North and South Wollo Zones. From North Wollo Zone, Habru, Gubalafito and Kobo districts and from South Wollo Zone, Ambasel and Tehuledere districts were assessed. Three PAs (Peasant Associations) from each district were selected as representative of the study area. Random sampling of households within these PAs was employed. The sample size was determined by using the formula given by Yamane (1967):

$$n = \frac{N}{1 + N * (e)^2}$$

where: n is sample size, N is number of households and e is the desired level of precision (0.05).

A total of 387 households were interviewed from 12,262 households in the population representing the selected PAs. Structured and semi-structured questionnaires were used to collect information on: the season in which chimero is harvested and consumed by livestock; which parts of chimero are preferred and by which animal species; abundance; harvesting and conservation methods; ease of browsing; and additional uses. The questionnaires were pretested prior to commencing the survey to ensure respondents understood all questions clearly.

Sample collection, dry matter yield, chemical composition and in vitro dry matter digestibility of chimero

Samples of chimero were collected from sorghum-growing farmers from each PA, pressed, labeled, dried and transported to the National Herbarium of Addis Ababa University for identification, based on the Flora of Ethiopia (Hedberg 1996). Three samples of vegetative parts of chimero were collected from each Kebele (the lowest administrative unit of a certain area or PA) at random and pooled for chemical composition and in vitro dry matter digestibility (IVDMD) determination.

At the 50% flowering stage chimero was harvested from each PA using 1 × 1 m quadrats (9 quadrats per PA) for dry matter (DM) yield determination. Plants were harvested at ground level and fresh biomass weighed immediately. A subsample of 15–20% of the total weight was taken, weighed and placed in a paper bag for DM determination. The samples were oven-dried at 105 °C for 24 h.

Nutritive value analysis. The oven-dried samples were ground in a Wiley mill to pass through a 1 mm sieve for the determination of chemical composition. To determine ash concentration, samples were ignited in a muffle furnace at 550 °C (AOAC International). Crude protein (CP) concentration was determined using the Kjeldahl method (AOAC International), while neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) concentrations were determined according to Van Soest et al. (1991). In vitro dry matter digestibility (IVDMD) was determined according to the 2-stage method outlined by Tilley and Terry (1963). All chemical composition and IVDMD analyses were carried out at the Nutrition Laboratory, Holeta Agricultural Research Center.

Mineral composition analysis. Three samples of chimero were collected from each PA (total of 45 samples) and delivered to the JIJE analytical testing service laboratory, Addis Ababa for the analysis of macro-minerals: calcium (Ca), phosphorus (P), potassium (K), sodium (Na), magnesium (Mg) and sulfur (S); and micro-minerals: cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), selenium (Se) and zinc (Zn). Na and K were determined by flame spectrophotometry (AOAC International, Official method 966.16); Ca and Mg by EDTA titration (AOAC International, Official method 962.01); P by spectrophotometry (AOAC International, Official method 965.17); S by magnesium nitrate ashing – turbidimetry; Co, Cu, Fe, Mn and Zn by flame AAS (AOAC International, Official method 985.35); and Se by Graphite Furnace AAS (AOAC International, Official method 985.35).

Statistical analysis

The primary data collected for this survey were analyzed using descriptive statistics such as means, frequency distributions, percentages and standard deviations using SPSS (2007).

Results

Household characteristics

The household characteristics of the respondents are presented in Table 1. Overall, in the present study 84.2% of the respondents were male- and 15.5% female-headed households. The overall average age of the respondents in the study districts was 46.8 years.

Landholding and land use pattern of the households

In the study districts, the average total crop land and private natural grazing land owned by the households was 2.76 ha (range 2.49–3.56 ha) and 0.62 ha (range 0.54–0.8 ha), respectively (Figure 5). No respondents had fallow land or improved pasture land. The average landholding of the respondents in the study was greater than the average national landholding size (0.96 ha/household) (CSA 2011).

The samples of chimero from each Woreda (third-level administrative divisions of Ethiopia) were sent to the National Herbarium of Addis Ababa University for identification and confirmed as being *Desmodium dichotomum* (Willd.) DC. This plant was initially named *Hedysarum dichotomum* by Willdenow in 1802 and

Table 1. Household characteristics of the respondents in the study districts in North and South Wollo Zones, Ethiopia.

Characteristic		District											
		Habru (n=85)		Gubalafito (n=73)		Kobo (n=70)		Ambasel (n=80)		Tehuledere (n=79)		Overall (n=387)	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Gender	Male	73	18.9	62	16.0	58	15.0	68	17.6	65	16.8	326	84.2
	Female	12	3.1	11	2.9	12	3.1	12	3.1	14	3.6	61	16.5
Age (Mean ±SD)		46.9±7.28		46.5±7.46		47.2±7.33		47.0±7.36		46.3±7.33		46.8±7.32	

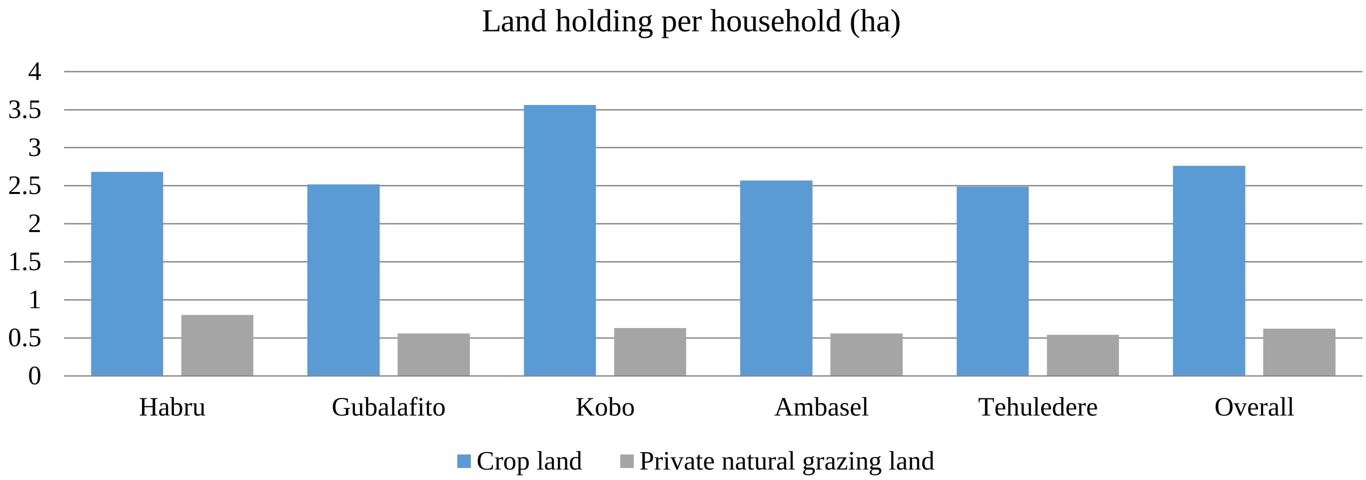

Figure 5. Landholding patterns of the surveyed households in 5 districts of North and South Wollo Zones, Ethiopia.

changed to *Desmodium dichotomum* by de Candolle in 1825. Following recent studies by Ohashi et al. (2018), the new scientific name *Bouffordia dichotoma* (Willd.) H. Ohashi & K. Ohashi has now been accepted as appropriate for this species.

During the wet season, most respondents (80.4%) indicated that their first choice for forage was weeds and green crop chop, with crop residue and natural pasture being the main second choices (40.8 and 39%, respectively) and natural pasture (40.1%) and crop residue (39.5%) the main third choices (Table 2). Green crop chop is defined as a harvested forage crop without allowing it to dry in the field. In the overall ranking, weeds and green crop chop were the most important, crop residues the second most important and natural pasture the third choice.

During the dry season, 100% of respondents used crop residues as the primary feed resource, while crop aftermath was second choice (80.4%) and hay (60.2%) the third choice. Stover was the first choice of fodder in the dry season since it includes crop residue. Crop residues are defined as material left after the crop has been harvested, e.g. teff straw, barley straw, wheat straw, chick pea hulls, sorghum and maize stover, while crop aftermath is a second-growth crop.

Chimero emerges spontaneously under sorghum crops (Figure 6). It is categorized as green chop for immediate feeding to livestock since the farmers have no experience in preserving forage, e.g. in the form of hay, as a feed resource for the dry season. Most farmers do not sow any forage for livestock feeding and prefer to use naturally occurring grass, grass hay, crop residues, green chop,

Table 2. Types of feed resources used in the wet and dry seasons in 5 districts of North and South Wollo Zones, Ethiopia.

Feed resource	Priority level (%)					Overall Ranking
	1st	2nd	3rd	4th	5th	
Wet season						
Natural pasture	-	39	40.1	20.7	-	3
Hay	-	0.4	33.9	65.7	-	4
Crop residues	19.6	40.8	39.5	-	-	2
Agro-industrial by-products	-	-	-	19.6	60.2	5
Green chop, weeds	80.4	19.6	-	-	-	1
Dry season						
Natural pasture	-	19.6	39.4	40.6	-	4
Fodder trees	-	-	-	20.4	-	
Hay	-	-	60.2	19.6	20.2	3
Crop residues	100	-	-	-	-	1
Crop aftermath	-	80.4	-	19.6	-	2
Agro-industrial by-products	-	-	-	-	20.8	5

fodder trees and crop aftermath and do not keep records of how much was sown and produced. It is normally harvested when the sorghum is heading and not progressively throughout the growing season of the crop. The amount of ground covered by the plants at harvesting differed from farm to farm and even within the same farm because farmers broadcast sorghum seed at sowing so there was little consistency. To determine DM yield of chimero in our study, we sampled the legume from within the sorghum crop when chimero was displaying 50% flowering (at approximately 3 months after emergence).

Figure 6. Chimero growing spontaneously under sorghum. (Photo: H. Abebe.)

All categories of animals were fed chimero including oxen, sheep and goats for growth and fattening, cows for higher milk production and mules, horses and camels for energy. While all farmers did not have all classes of animal at the time of the survey, they indicated that at some time they had owned all types and fed them chimero. Farmers rated the animal preference through long periods of observation and experience and considered chimero was most preferred by cattle (273 from 387 respondents) (Table 3). According to the information gained during survey work, there was limited indication that different animal species had a special preference for different parts of chimero, although some farmers said equines preferred to eat stem and small ruminants preferred to eat pods. All respondents (100%) preferred chimero as a feed source over other locally available herbaceous legume feed resources, e.g. *Neonotonia wightii*. No respondent conserved/stored chimero, treated it in any way, sold it or used it for any purpose other than feeding his/her livestock. No farmers have received formal training on how to conserve and preserve important indigenous forage legumes for feeding later.

Table 3. Frequency of feeding chimero, class of animals fed and plant parts preferred in 5 districts of North and South Wollo Zones, Ethiopia (total respondents: 387).

Variable	Frequency	Percentage
Categories of animals fed chimero		
Large ruminants	387	100
Small ruminants	387	100
Equines	387	100
Camels	387	100
By which animal more preferred?		
Large ruminants	273	70.5
Small ruminants	65	16.8
Equines	6	1.6
Camels	43	11.1
Parts of chimero preferred		
Stem	86	22.2
Leaf	258	66.7
Seed pod	43	11.1

All respondents used the self-regenerating chimero with sown crops (78.8% with sorghum and 21.2% with maize) and indicated that it was abundant for harvesting in the months September–November. All farmers used a cut-and-carry system for utilizing the chimero.

The average yield of 3–4-months-old chimero as assessed under the grain crops was 4,400 kg DM/ha with a range of 4,100–4,800 kg DM/ha between districts. Possible factors contributing to variation across districts might be variation in rainfall, soil characteristics and competition from the grain crops.

Chemical analyses revealed that mean concentrations of various components in chimero were: 22% CP (DM basis), 31% NDF, 26% ADF and 5.8% ADL, while IVDMD was 61%. Mineral concentrations were: 0.6% Ca, 0.23% P, 1.47% K, 0.78% Mg, 0.01% Na, 0.27% S, 0.16% Fe, 4.4 mg/kg Cu, 44.9 mg/kg Mn and 12.3 mg/kg Zn. There was no variation between sites in chemical composition.

Discussion

This survey has shown the important role that chimero plays as a self-sown legume with grain crops in this part of Ethiopia, especially for use as a source of feed during the wet season. Not surprisingly, the forage was fed using a cut-and-carry system as it would not be appropriate to allow livestock access to the plants while growing with the sorghum or maize crops. Further studies would seem to be warranted to determine the impacts of growing the legume with the grain crops on grain and stover yields of the crops as well as on soil improvement. Another aspect would be the possible contribution it could make to the diets of livestock during other times of year, especially if sown into native pastures.

The finding from this study that crop residues from sorghum and maize stover plus teff straw were the most important feed sources during the dry season agrees with the report of Abate et al. (2010) that straw from maize, sorghum and teff was used mainly during the dry season in southeastern parts of the country. Contrary to the current study, Desalw (2008) reported that the major dry season feed resources for cattle were natural pasture (55.7%), crop residues (20.7%), stubble (14.3%) and hay (9.3%). Most farmers fed chimero to large ruminant animals and assumed that it would fatten animals rapidly, especially oxen. In this study it has not been possible to locate any data on how well animals perform when fed this legume and how it might compare with other legumes grown under these conditions.

It was of considerable interest that all respondents preferred chimero over other locally available herbaceous legume feed resources, such as *Neonotonia wightii*. In the preference table (Table 3) the percentages of respondents listed indicated that particular animal categories had highest preference for chimero. For example, 6 (1.6%) farmers indicated that equines had the greatest preference and 43 (11.1%) farmers indicated that camels had the greatest preference. Similarly, 86 (22.2%) farmers stated that animals preferred to eat stem over leaf and pods, 258 (66.7%) indicated that animals preferred to eat leaf over stems and pods, while 43 (11.1%) indicated that animals preferred pods over leaf and stems. A preference for stem over leaf and pods is surprising but according to farmers' explanations during survey work, most indicated that equines preferred to eat stem and small ruminants preferred to eat pods. Despite there being surplus production of chimero in September–November, the crop growing season when good rainfall was received and other non-crop residue feed resources should have been most readily available, no respondents conserved and stored chimero as either hay or silage for use during periods of feed scarcity. However, data suggest that considerable amounts of other hays were fed in both wet and dry seasons, more so in the dry season, the major types being sorghum and maize stover, teff residue and natural grasses. The opportunity obviously exists to conserve this relatively high protein source for feeding during the winter-spring period when both quantity and quality of available feed, especially native pastures, stovers etc., are low. There are numerous references in the literature that a supplement of high protein forage increases intake of low quality roughage and improves animal performance (Adu et al. 1990; Melese et al. 2014). However, as no farmers have received formal training on how to conserve and preserve important indigenous forage legumes for feeding later, a technology transfer program would need to be mounted to achieve this end.

Conclusions

This study has shown that many farmers in the study area grow grain crops and chimero is self-sown in these crops from residual seed (soil seed bank). Farmers feed it using a cut-and-carry system to all classes of livestock. Mean yields obtained of 4.4 t DM/ha were quite significant and would provide a valuable source of forage for stock. As mean CP concentration of the forage was 22%, this forage could be used as either a supplement to other feeds or as a complete feed. However, the presence of anti-nutritive factors in the forage should be investigated. As little research has been conducted on this very promising species, much more effort should be devoted to determining if more productive ecotypes are available and how yields of the forage can be maximized. The impacts of sowing this species with grain crops on grain and stover yields of the crops should be examined as well as its role if sown into native pastures. Conservation for feeding at times of low feed quality and availability seems a logical method to utilize the forage and this process should be investigated as well as mounting a technology transfer program to promote conservation.

Post script

Since completing this survey the author has collected seed from 26 populations of *Bouffordia dichotoma* from a number of districts in the South Wollo, North Wollo and Oromia Zones of Ethiopia (10–12º N, 39–40º E; 1,470–1,890 masl) following the Ethiopian biodiversity institute collection format for forage genetic resources conservation.

Mean annual rainfall at collection sites varies from 500 to 1,557 mm. The seeds are currently stored at Wollo University and the author will undertake preliminary evaluations of these populations as part of his Ph.D. studies to assess what degree of variation exists in the natural populations in the region.

Acknowledgments

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(Note of the editors: All hyperlinks were verified 17 December 2019.)

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