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Full Length Research Paper

Identification of potential untapped herbaceous flora in the mid rift valley of Ethiopia and their nutritive value

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This study was conducted with the objective to identify untapped herbaceous flora that were used as livestock feed and to determine their chemical composition in wet season. Twelve peasant associations (PAs) and a total of 120 households were selected for the study. Key informants were also used for vernacular name identification and utilization. Samples were also taken from their edible parts for analysis of dry matter (DM), crude protein (CP), total ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose and lignin. A total of 17 different herbs and forbs were identified which have a feed value for different livestock species. The CP values of species ranged between 10.9 to 27.86% with the highest value being recorded in *Sida ovata* Forssk. while the lowest value was recorded in *Gutenbergia rueppellii* Sch.Bip. The NDF value ranged from 26.1 to 53.16%. The highest NDF value was recorded in *G. rueppellii* Sch.Bip. and the lowest was recorded in *Achyranthus aspera* L. Generally, the differences within species and among different species in terms of chemical composition of these browses was significant. Some of them contain crude protein content of more than 190 g/kg DM, which has a capacity of supplementing poor quality roughages.

Key words: Herbs, chemical composition, nutritive value, mid rift valley.

INTRODUCTION

Ruminants form a major component of domesticated livestock in Africa, especially in the Sub-Saharan African region. Typically, ruminants in the region are mainly raised on grazing and/or browsing of on available vegetation resources. These resources are very crucial for pastoral livestock production systems as the livelihood depend on the rearing of grazing animals which are dependent on the condition and production of the vegetation (Tainton, 1999). The vegetation of the grazing lands can either be herbaceous or non-herbaceous. Herbaceous vegetation is the non-woody component of the vegetation, and it includes all graminoids and forbs (Kuchar, 1995). Accor to Holechek et al. (2005), the determination of the herbaceous composition of grazing lands is important in understanding the fodder value of individual species and their reaction with biotic and edaphic situation. The variation in herbaceous species composition will have an effect on forage yield, quality, and animal grazing behavior (Stoddart, 1975; Herlocker, 1999). This variation may be explained in terms of types of species, yield, and frequency of occurrence, density and basal cover of the herbaceous species.

Furthermore, herbaceous vegetation cover plays an important role in controlling rainfall erosion by giving a good cover and intercepting rain drops; their root system physically bind soil particles while their retardation and infiltration activity maintain soil porosity and permeability by delaying the onset of runoff (Stoddart, 1975; Herlocker, 1999). Russell (1984) gave a general description of modal plant community of the rift valley of Ethiopia. According to Russell (1984), the rift valley has

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an arid and semi-arid agro-ecology with *Acacia* bush-land to *Acacia* wood-land vegetation types which are potential to range production. But currently, the *Acacia* landscape has been changed due to the increase in human population pressure that resulted in cultivation of more crops at the expense of range vegetation. In addition to crop expansion, the existing high livestock number has aggravated the inadequacy of year round livestock feed supply. Thus, if livestock productivity has to be increased, it should consider utilization of previously untapped feed resources. An attempt to reduce or eliminate the major constraints to efficient utilization of these neglected feed resources can lead to increase in production without considerable increase in cost. Information on nutritional characterization of locally available feed resources is inadequate and where available the values are variably documented (Zinash and Seyoum, 1998).

Therefore, these feed resources have to be characterized to better understand their constraints for efficient utilization and identify relative potential of the feed as sole diet or supplement to correct specific nutrient required by animals for better performance. Thus, it is found very important to fill the information gap by documenting base line information with regard to the nutritional characterization of feeds that have local importance and that have not been characterized previously. Such information is also useful to define supplementation priories to overcome nutrient imbalances. Therefore, the objectives of this study were to identify potential herbaceous and forbs species that have importance as livestock feed in the mid rift valley of Ethiopia, and to determine their chemical composition in wet season at full maturity stage and to suggest the way forward for efficient utilization of these resources.

MATERIALS AND METHODS

Study area

The study was conducted in the mid rift valley of Oromia, Ethiopia. The rift valley (includes the East Showa zone of Oromia) has a width of 40 to 60 km and is more than a 1000 km long, surrounded by highland plateaus. The altitude ranges from 500 to 2000 m above sea level (asl) and has a semi-arid climate. The area has an erratic, unreliable and low rainfall, averaging between 500 and 900 mm. The rainfall is bi-modal with the long rainy season from June to September (Abule et al., 1998). Four districts namely Fantale, Adami Tulu Jiddo Kombolcha, Arsi Negelle and Dugda Bora were selected to represent the existing farming systems. Representative peasant associations (PA's) were purposely selected in compliance with their proximity to roads and accessibility of infrastructure. Three PA's from each district (a total 12 PA's) were selected to represent the study area. Random sampling of households was employed and a total of 120 households were interviewed. Sample size determination procedure? Structured and semi-structured questionnaires were used to collect information from key informants on types of herb and forbs species available, their vernacular names, season favored, palatability, parts of plants eaten and relative attractiveness of the forage to animals or animal preferences. Group discussions were held to clarify the understanding of all issues.

Plant sampling

Herbariums of sample species were made in duplicate. One duplicate was sent to Addis Ababa University for family and scientific name identification, while the other was kept at the laboratory at the Adami Tulu Research Centre. Samples of these plant species were collected for chemical composition analysis. Sampling was undertaken at the end of the long rainy season when the herbaceous species were fully mature. During the sampling period, grasses were cut at 5 cm above the ground and leaves. The samples were kept under a shaded area until sampling for the day was completed. After this, they were sun dried until the work was completed. Finally, the dry matter (DM) of each species was determined in an oven at 65°C for 72 h. After plant sampling, the same feed types were bulked together and then thoroughly mixed and further sub-sampled. The samples were immediately weighed after sampling and put in a cloth sack and hung in the shade area until samples were transported to laboratory for drying and subsequent chemical composition analysis.

Determination of chemical composition

The oven dried samples were ground in a Willey mill to pass through 1 mm sieve for the determination of chemical composition. Feed samples were analyzed for DM and ash using the method of AOAC (2000). Nitrogen was determined using the micro-Kjeldahl method (AOAC, 2000). Crude protein (CP) was calculated as N x 6.25. The neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest et al. (1991).

Data analysis

The data were organized, summarized and analyzed using the SAS statistical package (SAS, 2001). For data involving frequencies, descriptive statistics were employed, whereas quantitative variables were analyzed using analysis of variance procedures and when the F-test showed significant differences, the Tukey test was used to separate group means (Samuels, 1987).

RESULTS AND DISCUSSION

The lists of plant herbs identified to be locally important were presented in Table 1. There are about 19 different herbaceous plant species that were identified to be important by the interviewed farmers/pastoralists in the wet season. Almost all plant species were grazed by livestock but the degree of palatability varies from season to season and species to species. According to key informants and the group discussants, during the wet season cattle select the most palatable grasses and legumes. In the dry season, however, most annual herbs are not available as animals fed on above ground cover. This is because they are below the bite of livestock or they are either in a reproductive stage as seed or dormant stage that involves any form of the vegetative

Table 1. List of herbaceous and climbing untapped plants that have importance as animal feed in the mid rift valley of Ethiopia.

Scientific name	Local name (oromiffaa)	Favored plant parts	Animal species
Galinsoga quadriradiata Ruiz & Pavon	Abbadabboo	Leaf, stem	Cattle, sheep, goats
Achyranthus aspera L.	Alaanqabeessa	Leaf	Cattle, goats
Gutenbergia rueppellii Sch. Bip	Bututtu iluu	Leaf	Cattle, sheep, goats
RHypoestes forskaolii (Vahl) R. Br.	Darguu	Leaf, stem	Cattle
Verbascum sinaiticum	Gurraa harree	Leaf	Donkey, cattle
Ocimum urticifolium Roth.	Haraamuu	Leaf	Cattle, goats
Cyathula uncinulata	Heerayyee	Leaf	Cattle, sheep, goat
Ipomoea cairica (L.) Sweet	Maraacaa	Leaf	Cattle, sheep, goats
Sida ovata Forssk.	Midhaan durbaa	All edible part	Cattle, sheep, goats
Asparagus asiaticus	Sariittii	Leaf and twigs	Goats
Clerodendrum myricoides R. Br.	Shalallee	Leaf	Cattle, sheep, goats
Lippia sp.	Sukaayii	Leaf and twigs	Sheep, goats
Jasminum floribundum Fresen.	Biluu	Leaf	Cattle, sheep, goats
Commelina benghalensis L.	Dallansiisaa	Leaf and twigs	Cattle, sheep, goats
Jasminum floribundum Fresen.	Fiittii	Leaf	Cattle, goats
Urera hypselodendron	Haliilaa	Leaf, stem	Cattle
Periploca linearifolia A. Rich.	Aanannoo	Leaf and twigs	Cattle, sheep, goats

part. Amsalu (2000) reported that the dominant and common grass species identified in the study area varies with altitude ranges. In the mid rift valley area *Cenchrus ciliaris* was dominant in enclosures and seasonally grazed bottom land whereas *Hyparrhenia rufa* and *Hyperrhenia tuberculata* were dominant in seasonally grazed mid altitude and *Pennissetum schimperi* was dominant in top-lands (Amsalu, 2000).

The dominance of one or few species in any natural community may be related to their adaptability to the specific combination of environmental factors in a particular site (RISC, 1983). Similar to the grass species, the distribution of herbaceous flora was affected by altitude. Altitude due to its direct effect on temperature and precipitation has primary influence on vegetation of an area (Ayana, 1999; Alemayahu, 1985). Among the herbaceous species, *Ipomoea cairica (L.) Sweet, Periploca linearifolia* A. Rich., *Jasminum floribundum Fresen* and *Clerodendrum myricoides R. Br* were the most favored plant herb by cattle and sheep in the study area. Cattle grazed on the above ground part of these herbs, while they depend on the leaf of browse species. Goats mostly favor browsing on leaf of browse species, while controlled grazing is exercised when they selectively graze on some nutritious herbs.

The percentages of the respondents that indicated the utilization of different feed resources are summarized in Table 2. The most widely utilized herbs as animal feed in MRV were *Galinsoga quadriradiata Ruiz* and *Pavon* (54.2%), *J. floribundum Fresen* (63.3%), *C. myricoides R. Br.* (60.0%), *Commelina benghalensis L.* (61.7%) and *I. cairica (L.) Sweet* (76.7%). The utilization of various herbaceous flora (mainly grasses) for different livestock feed were described previously in Ethiopia (Abule, 2003; Amsalu, 2000; Beyene, 2009). According to Amsalu (2000), the proportion of highly palatable grasses was relatively low (26%) while *P. schimperi* was the most dominant grass (30%) of all herbaceous species identified in the top-land of the mid rift valley. In particular, the heavily grazed areas of the top-land were mostly invaded by densely tufted perennial *P. schimperi*, which is not often grazed by cattle.

Potential nutritive value of the herbs and forbs

The chemical composition of different herbaceous species of the study area is shown in Table 3. The CP and total ash content of *Sida ovata forssk* was significantly ($P<0.05$) higher than other herbs. The NDF content of *Lippa* spp. was significantly ($P<0.05$) higher than other herbs while *Gutenbergia rueppelii sch. Bip* had the highest ADF and cellulose content than the other species. *I. cairicial (L.) sweet* has significantly ($P<0.05$) higher lignin content than other species. The differences in nutrient content between species and within a genus could be associated with their inherent nature in terms of growth rate and stage of maturity or this could be related to morphological and anatomical differences within a genus, apart from the differences in contents of lignin and relatively indigestible cellulose and hemi-cellulose. Previous studies showed that the nutrient (protein, carbohydrates, minerals and vitamins) content and metabolisable energy (ME) density changes in relation to season (Fulkerson et al., 1998; Smith et al., 1998; Stockdale, 1999), stage of growth (Reeves et al., 1996; Mulholland et al., 1996; Nandra et al., 1998; Ayres et al., 1998; Fulkerson et al., 1999), time of day (Minson, 1990;

Table 2. Lists of feeds and percentage of respondents in the utilization of feed resources in the mid rift valley of Ethiopia.

Scientific name	Local name	Percentage of respondents (n)
Periploca linearifolia A. Rich.	Aanannoo	65(78)
Galinsoga quadriradiata Ruiz & Pavon	Abbadabboo	54.17(65)
Achyranthus aspera L.	Alaanqabeessa	29.17(35)
Jasminum floribundum Fresen.	Biluu	63.33(76)
Gutenbergia rueppellii Sch. Bip	Bututtu iluu	28.33(34)
Commelina benghalensis L.	Dallansiisaa	61.67(74)
Hypoestes forskaolii (Vahl) R. Br.	Darguu	29.17(35)
Jasminum floribundum Fresen.	Fiittii	63.3(76)
Verbascum sinaiticum	Gurraa harree	13.33(16)
Urera hypselodendron	Haliilaa	45.00(54)
Ocimum urticifolium Roth.	Haraamuu	28.33(34)
Cyathula uncinulata	Heerayyee	19.17(23)
Ipomoea cairica (L.) Sweet	Maraacaa	76.67(92)
Sida ovata Forssk.	Midhaan durbaa	37.5(45)
Asparagus asiaticus	Sariittii	35.83(43)
Clerodendrum myricoides R. Br.	Shalallee	60(72)
Lippia sp.	Sukaayii	37.5(45)

Table 3. Chemical composition of different herbaceous species in the mid rift valley of Ethiopia.

Scientific name	Percentage of Nutrient proportions						
	DM	Ash	CP	NDF	ADF	Lignin	Cellulose
Jasminum floribundum Fresen.	92.86^{a}	5.44^{f}	19.21^{ab}	38.07^{bcdef}	25.45^{igh}	9.09^{bcde}	15.88^{def}
Commelina benghalensis L.	88.02^{c}	11.53^{abcdef}	14.4^{b}	33.65^{abc}	18.34^{ih}	6.00^{e}	17.66^{bcdef}
Sida ovata Forssk.	90.63^{abc}	18.64^{a}	27.86^{a}	31.05^{cdef}	26.79^{cd}	8.78^{abcde}	14.76^{bcdef}
Achyranthus aspera L.	90.93^{abc}	6.32ef	14.22^{b}	26.61^{cdef}	19.23^{bcd}	7.13^{abcde}	12.18^{f}
Clerodendrum myricoides R.Br.	91.27^{abc}	10.21^{abcdef}	14.02^{b}	46.4^{ef}	37.84^{i}	11.89^{abcde}	23.84^{abc}
Ocimum urticifolium Roth	90.77^{abc}	14.4^{abcd}	16.16^{ab}	33.7^{abc}	27.39^{lgh}	9.73^{bcde}	19.11^{bcde}
Gutenbergia rueppellii Sch.Bip	90.61^{abc}	9.69^{cdef}	10.9^{b}	53.16^{abc}	46.39^{a}	14.12^{abcd}	29.98^{a}
Hypoestes forskaolii(val) R.Br.	90.33^{abc}	17.72^{ab}	22.3^{ab}	30.93^{ab}	19.35^{ih}	6.48^{e}	15.6^{def}
Asparagus asiati	94.59^{a}	9.44^{def}	17.23^{ab}	28.8	60.58^{defg}	10.34^{cde}	19.49^{abc}
Lippia sp.	89.61^{bc}	13.2^{cdef}	15.03^{ab}	46.17^{a}	43.32^{abc}	17.01^{ab}	24.35^{ab}
Apodytes dimidiate	89.45^{bc}	10.33^{abcdef}	19.82^{ab}	50.0^{ab}	33.05^{edf}	14.58^{abc}	18.05^{bcdef}
Ipomoea caircica(L.) Sweet	89.44^{bc}	11.04^{abcdef}	12.69^{b}	47.48^{bc}	43.9^{ab}	18.69^{a}	16.89^{cdef}
Galinsonga Quadriradiata	89.19^{c}	17.53^{abc}	13.79^{b}	42.65^{bc}	34.19^{de}	10.3^{abcde}	21.38^{abcd}
Cyathula uncinulata	92.53^{ab}	10.03^{cdef}	16.73^{ab}	41.91^{abc}	36.31^{eghf}	14.91^{abcde}	20.77^{ef}
Mean	90.73	11.82	16.74	39.72	33.72	11.36	19.28
SE	0.12	0.19	0.08	0.15	0.1	0.13	0.18

^{ab} Means in the same column for each parameter with different superscripts are significantly different ($p < 0.05$).

Fulkerson et al., 1995; Reeves et al., 1996; Lindgren and Lindberg, 1998), soil fertility or fertilizer application rate (particularly nitrogen N) (Reeves et al., 1996) and probably soil moisture status. Studies conducted with grasses such as *Brachiaria ruziziensis* and *Pennisetum purpureum,* and fodder tree species, such as *Leucaena*

leucocephala and *Calliandra calothyrsus*, showed that the overall CP concentration increased during the rainy season (Pamo et al., 2007). Seasonal differences were most evident in *Brachiaria*, where the CP level in the rainy season was three times that in the dry season (Pamo et al., 2007). Similar studies showed that on average, the leaves of the leguminous trees had 84 to 140% more CP than the grasses. The low concentration of CP in these grasses during the dry season may be responsible for poor growth, production and reproduction observed in ruminants during this season (Pamo et al., 2002; Pamo et al., 2006; Merkel et al., 1999). Cellulose and hemi-cellulose in forages represent the main sources of energy to ruminants (Merkel et al., 1999).

Overall, concentrations of NDF and ADF in grasses were much higher than in the tree leaves. Except for *Brachiaria* and *Calliandra*, there were no significant changes in NDF levels in the foliages with season, implying that the energy value of these plants does not change much with season (Pamo et al., 2007). A similar observation was reported by Garcia et al. (1996). This did not necessarily mean that the nutritive value of these forages is the same during both seasons, since the efficiency of digestibility varies with the proportions of the various cellulosic fractions (Palmer and Tatang, 1996). For instance, a high proportion of lignin reduces digestibility of cellulose (Lhoste et al., 1993; Paterson et al., 1996; Merkel et al., 1999) and the relatively high proportion of lignin and low CP proportion, in *Brachiaria* during the dry season largely explained why the productive performance of ruminants eating mainly this grass was poor during the dry season (Palmer and Tatang, 1996; Paterson et al., 1996; Merkel et al., 1999). Thus, an awareness of the factors influencing nutrient content of forage was required to allow more efficient supplementation of animals.

In the present study, *J. floribundum Fresen., S. ovata Forssk* and*, Hypoestes forskaolii* contain CP above 18%. According to ARC (1980), a minimum of 90 g CP/kg DM of the diet is necessary for adequate microbial synthesis while van Soest (1982) reported that less than 1.5% N in the feed DM (94 g Cp/kg DM) results in reduced ruminal microbial activity, which leads to a reduction in degradation of cell wall and lowered intake. Most of the Ethiopian dry forages and roughages have a CP content of less than 9%, which indicates microbial requirement can hardly be meet unless supplemented with protein rich feeds (Seyoum and Zinash, 1998). The high CP content of feeds in the class of protein supplements and herbaceous species in this study showed that there was a potential for supplementing agro-industrial by-product with locally available herbaceous species such as *J. floribundum* Fresen., *H. forskaolii* (val) and R.Br., *S. ovata Forssk* that will improve the utilization of poor quality forage. However, the supplementation of the later is impeded at present by a lack of rumen degradability and bio-availability information.

Conclusions

This study indicated that there has been a considerable reserve of plant flora that could be potentially used as livestock feed resources. *J. floribundum Fresen., S. ovata Forssk* and *H. forskaolii* contain crude protein content of more than 190 g/kg DM, which has a capacity of supplementing poor quality roughages, as this amount can be adequate to support microbial growth. These feeds, if fully exploited, could assist to increase the level of production and productivity of the huge livestock resources in the mid rift valley. However, apart from characterization in terms of chemical composition further study is needed to assess their palatability, digestibility, feed intake, animal response to the feeds and anti-nutritional factors that might be associated with these feeds in order to fully understand and enhance their utilization in the future. In addition, some of the factors that have contributed to the underutilization of locally available livestock feed resources need to be identified and researched. Livestock improvement schemes implemented in the past have not given due attention to the improvement in the management and utilization of natural flora of plants in the rift valley grasslands. Thus, there is a need to engage in indigenous forage species research in order to build a sustainable livestock production system, that embraces efficient utilization of the already adaptable multipurpose flora of plant in the mid rift valley of Ethiopia.

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REFERENCES

Abule E, Gremew E, Aliye H (1998). Adami Tulu Agricultural research Center, Bulletin No.1, Oromia Agricultural Development Bureau. Fifnfine, Ethiopia.

Abule E (2003). Rangeland evaluation in relation to pastoralists' perceptions in the Middle Awash Valley of Ethiopia. A PhD thesis Presented to the University of the Free State, Bloemfontein, South Africa, p. 297.

Alemayehu M (1985). Feed resources in Ethiopia. In: Animal Feed resources for small scale livestock Producers. Proceedings of the Second PANESA Workshop, held in Nairobi,kenya11-15Nov.1985.

Amsalu S (2000). Herbaceous species composition, dry matter production, and condition of the major grazing areas in the Mid Rift Valley of Ethiopia. An MSc Thesis Presented to the School of Graduate Studies of Alemaya University, p. 95.

Agricultural Research Council (ARC)(1980). The Nutrient Requirement of Ruminants Livestock. Common wealth Agricultural Buteaux, Faraham Royal, London, UK.

AOAC (2000). Official methods of analysis (15th ed.). Association of Official Analytical Chemists, Inc., Washington D.C., USA

Ayana A (1999). Range condition and traditional grazing management in Borana. M. Sc thesis, Alemaya University of Agriculture. Alemaya, Ethiopia.

Ayres JF, Nandra KS, Turner AD (1998). The nutritive value of white clover at different stages of phenologicall maturity. Grass Forage Sci., 53: 250-259.

Fulkerson WJ, Slack K, Lowe KF (1995). Variation in the response of Lolium genotypes to defoliation, Aust. J. Agric. Res., 45: 1309-1317.

Fulkerson WJ, Slack K, Hennessy DW, Hough GM (1998). Nutrients in ryegrass (*Lolium* spp.), white clover (*Trifolium repens*) and kikuyu (*Pennisetum clandestinum*) pastures in relation to season and stage of re-growth in subtropical environment, Aust. J. Exp. Agric., 38: 227-240.

Garcia GW, Ferguson TU, Neckles FA, Archibald KAE (1996). The nutritive value and forage productivity of Leucaena leucocephala, Anim. Feed Sci. Technol., 60: 29-41.

Herlocker DJ (1999). Rangeland Ecology and Resource Development in Eastern Africa.Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Nairobi, Kenya. p. 393

Holecheck JL, Pieper RD, Herbel CH (2005). Range management: Principles and practices. 5th edn. (Pearson: New Jersey), p. 607.

Kucher P (1995). Range monitoring, evaluation and range survey methods. Southeast Range Project Technical Report. Addis Ababa, Ethiopia.

Lhoste PD, Rousseau VJ, Soltner D (1993). Manuel de zootechnie des régions chaudes. Les systèmes d'élevage. Collection précis d'élevage. Ministère de la cooperation, Paris, France, p. 288.

Lindgren E, Lindberg JE (1998). Influence of cutting time and N fertilization on the nutritive value of timothy; Crude protein content, metabolisable energy and energy value determined in-vivo versus in-vitro, Swed. J. Agric. Res., 18: 72-83.

Merkel RC, Pond KR, Burns CJ, Fisher DS (1999). Intake, digestibility and nitrogen utilization of three tropical tree legumes I. As sole feeds compared to Asystasia intrusa and Brachiaria brizantha, Anim. Feed Sci. Technol., 82: 91-106

Minson DJ (1990). Forage in Ruminant Nutrition, Academic Press, Inc., San Diego.

Mulholland JG, Nandra KS, Scott GB, Jones AW, Coombes NE (1996). Nutritive value of subterranean clover in a temperate environment. Aust. J. Exp. Agric., 36: 803-814.

Nandra KS, Mullholand JG, Jones AW, Scott GB, Coombes NE (1998). Lamb production and feed intake in relation to degradability characteristics and metabolisable protein content of dried subterranean clovers. Anim. Feed Sci. Technol., 70: 281-293.

Reeves M, Fulkerson WJ, Kellaway RC (1996). Forage quality of kikuyu (*Pennisetum clandestinum*): The effect of time of defoliation and nitrogen fertilizer application and in comparison with perennial ryegrass (*Lolium perenne*). Aust. J. Agric. Res., 47: 1349–1359.

Pamo TE, Tendonkeng F, Kadjio JTT, Kwami HN, Taboum RK, Kana JR, Tegodjeu A (2002). Evaluation of the comparative growth and reproductive performance of West African Dwarf Goat in the Western Highland of Cameroon., Development and Field Evaluation of Animal Feed Supplementation Packages. Proceeding of the Final Review Meeting of an IAEA Technical Co-operation Regional AFRA Project Organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and held in Cairo Egypt, 25–29 November 2000, pp. 87-96.

Pamo TE, Fonteh FA, Tendonkeng F, Kana JR, Boukila B, Djaga PJ, Fomewang G (2006). Influence of supplementary feeding with multipurpose leguminous tree leaves on kid growth and milk production in the West African Dwarf goat. Small Rum. Res., 63: 142-149.

Pamo TE, Boukila B, Fonteh FA, Tendonkeng F, Kana JR, Nanda AS (2007). Nutritive value of some grasses and leguminous tree leaves of the Central region of Africa. Anim. Feed Sci. Technol., 135: 3-4.

Paterson RT, Roothaert RL, Nyata OZ, Akyeampong E, Hove L (1996). Experience with *Calliandra calothyrsus* as a feed for liverstock in Africa. In: D.O. Evans, Editor, Proceeding International workshop on the genus calliandra Winrock Internal, Bogor, Indonesia, pp. 195-209.

Palmer B, Tatang MI (1996). Calliandra calothyrsus forage for the tropics—A current assessment. In: D.O. Evans, Editor, Proceeding Inter. Workshop on the Genus Calliandra Winrock Int. Bogor, Indonesia, pp. 183-194.

SAS (2001). Institute Inc./STAT User's Guide Version 8.2, Statistical Analysis Systems Institute Inc., Cary, NC, USA.

Samuels ML (1987). Statistics for Life Sciences. Collier Macmillan Publishers, London, UK Seyoum Bediye and Zinash Sileshi, 1989. The Composition of Ethiopian Feed stuffs, Research Report no. 6. Institute of Agric. Res. Addis Ababa, Ethiopia, 33pp.

Smith KF, Simpson RJ, Oram RN, Lowe KF, Kelly KB, Evans PM, Humphreys MO (1998). Seasonal variation in herbage yield and nutritive value of perennial ryegrass (*Lolium perenne* L.) cultivars with high or normal herbage water-soluble carbohydrate concentrations grown in three contrasting Australian dairy environments. Aust. J. Exp. Agric., 38: 821-830.

Stoddart LA, Smith AD, Box TW (1975). Range management. Third edition. McGraw-Hill, New York, p. 532.

Stockdale CR (1999). Effect of season and the time since defoliation on the nutritive characteristics of three irrigated perennial pasture species in northern Victoria; Energy, protein and fibre. Aust. J. Exp. Agric., 39: 555-565.

Seyoum B, Zinash S (1989). The Composition of Ethiopian Feed stuffs, Research Report no. 6. Institute of Agricultural Research; Addis Ababa, Ethiopia, p. 33.

Russel SA (1984).The environment of Ethiopian Rift valley compared to other Areas of Africa, In: Richards stewart, (ed). ILCA Bulletin.No, 17. ILCA. Addis Ababa, Ethiopia.

Tainton NM (1999). Veld management in South Africa. In: N. M. Tainton (eds). University of Natal Press, Pietermarizburg South Africa, p. 532.

Van Soest PJ, Robertson JB, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Dairy Sci., 74: 3587-3597.

Van Soest PJ (1982). Nutritional ecology of ruminants. O and B books. Inc. Oregon, USA.