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Biomass Production and Nutritive Potential of Conserved Forages in Silvopastoral Traditional Fodder Banks (*Ngitiri*) of Meatu District of Tanzania

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ABSTRACT : Forages from grazing lands comprise conventional feed resources for ruminants in the tropical region. A study was conducted to assess fodder productivity and nutritive potential of deferred forages of six silvopastoral traditional fodder banks in central northwest Tanzania, traditionally known as *Ngitiri*. The grazing lands were dominated by low quality increaser grass species: *Eragrostis spp.*, *Aristida spp.*, *Urochloa spp., Rottboellia exaltata*, *Cenchrus spp.*, *Cynodon spp.* and *Chloris spp.,* and forbs species. The grazing lands had low vegetative basal cover that varied ($p<0.05$) from 34.7 to 75%, and low forage biomass productivity that varied ($p<0.05$) from 0.76 to 3.69 tones (t) dry matter (DM)/ha. The forages contained low crude protein (CP) that varied ($p<0.05$) from 16 to 27 g/kg DM; and had high fibre contents, which varied ($p<0.05$) from 702-725, 497-573 and 119-225 g/kg DM for neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL), respectively. The forages were poorly degraded *in sacco*, and showed low DM degradability (DMD) characteristics of 74, 473 and 576 g/kg DM for DM washing losses (a), slowly degradable feed fraction (b) and potential degradability, (a+b), respectively; and low DMD at 48 h incubation, which varied from 317-345 g/kg DM, and contained low metabolizable energy (ME), (4.2-4.36 MJ/kg DM). The herbage forages would not meet protein and energy requirements for maintenance and production, which could be reflected through low animal productivity. Further work is needed to assess animal productivity (growth, milk, draft force) from conserved forages in traditional fodder banks in the dry season. (**Key Words :** Agro-silvopastoral, Fodder Banks, Biomass, Nutritive Value, Degradability, Sukuma, Tanzania)

INTRODUCTION

Livestock production in the tropics depends entirely on rangeland forages whose quality and productivity varies tremendously, with wet or rainy season being characterized by high abundance of herbage as compared to scarce feeds during dry seasons. Rangeland quality largely dictates animal productivity response, and thus it becomes vital to match sustainable feed resources from rangelands without deterioration of the ecosystems through appropriate rangeland management schemes. In most tropical regions including Tanzania, ruminant production is most critically limited by fodder shortages in the dry season. Animal production during the dry season, for example, in semi-arid parts of north western Tanzania, is characterized by severe weight losses and sometimes mortality (Otsyina et al., 1997) due to fodder scarcity. To cope with dry season feed shortages, agropastoralists in these semi-arid areas of central and northwest Tanzania traditionally conserve forages during wet seasons as deferred feed locally known as *Ngitiri* (Brandstrom, 1985). *Ngitiri* traditional vegetation conservation system is an agro-silvopastoral technique that involves deferring crop fallow, natural woodlots and rangelands for maximum vegetation regeneration (Brandstrom, 1985). Deferred duration of woodlots, crop fallows and rangeland fallows varies from one to three years' cycle depending on both land cultivation and grazing pressures. In the Shinyanga region of Tanzania, at least 50% of crop farmers and 90% of livestock keepers conserve vegetation under a *ngitiri* conservation system (Rubanza, 1999) in their various mixed cropping systems. Vegetation conservation has been strengthened by Shinyanga region environmental and soil conservation (HASHI) and Tanzania/International Centre for Research in Agroforestry (ICRAF) afforestation programs. Products from such *in situ* conserved vegetation include sources of fodder, fuel wood, poles for construction and environmental

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recreational goals.

Forages from rangelands mostly do not meet adequate feeding and nutrition necessitating minimal exogenous protein and energy supplementation with crop residues, or browse legumes by either direct browsing in the field, or by cut and carry systems to supplement the animals in kraal (Rubanza, 1999). Multipurpose tree species (MPT) including *Leucaena spp.*, *Gliricidia spp.*, *Sesbabia spp.*, *Acacia spp.*, *Dichrostachys spp.*, have been integrated in natural woodlots, rangelands and crop fallows by HASHI/ICRAF environmental conservation and afforestation programs to cater for fodder, fuel wood, restoration of soil fertility and environmental conservation goals.

Despite its key role in crop and animal agriculture, sustainability of *ngitiri* agro-silvopastoral technology and its utilization, for example, source of fodder, could be limited by deteriorated rangelands due to over-grazing (Otsyina et al., 1997), and thus become a depleted land resource. As part of rangeland ecosystem productivity monitoring, a study was therefore conducted in Meatu district of Tanzania to assess rangeland forages' botanical species composition, fodder productivity, and forage nutritive potential in relation to livestock nutritional requirements with the main focus kept on the critical fodder scarcity in the dry season.

MATERIALS AND METHODS

Study area and climate

This study was conducted in Meatu district (3°-4° S; 34°-35° E) south of Lake Victoria in central northwest Tanzania (1,000-1,500 m above sea level) in the dry season between June and September 1997. Meatu district is located within a semi-arid zone that receives low unimodal rainfall of 600-800 mm per annum between mid-November through mid-May. Minimum and maximum temperatures vary from 18.1 to 36.5°C, respectively. Meatu district is characterized by small hills with black clay loam soils on the lower valleys, locally known as *mbuga* in *Sukuma* language or *Kisukuma*; and sandy loamy soils on the uplands, locally known as *ibushi* (Ngendello et al., 1996). Common vegetation includes scattered shrubs and trees dominated by *Acacia spp.* and *Dichrostachys spp.*, and grasses.

Selection of grazing lands and transects layout

Meatu district was selected for herbage botanical species composition and forage nutritive value study based on its high populations of cattle (308,587), sheep (79,537) and goats (154,051) and due to its characteristic dry season fodder shortages (Ngendello et al., 1996). Grazing lands that were used in this study included communal and privately owned rangelands, and one demonstration grazing land in Mwanhuzi ward, which was used as a control.

Forage sampling, botanical species identification and vegetation basal cover

This experiment was arranged in a completely randomized design (CRD) whereby forages that were used for biomass productivity and nutritive study were sampled from three-plots of 20 m×20 m in each of the six grazing lands before commencement of grazing in 1997. A total of 45 samples (15 samples per plot) were collected from each grazing land to make a grand total of 270 samples for biomass productivity and nutritive value studies. The herbages were randomly collected using a 0.25 m^2 metal quadrat thrown at random at five paces in three transects (two- diagonals and a bisector) in each of the three plots in each grazing land. Forage herbage was clipped by hand sickles to 2 cm above the ground level.

For each clipping, grass and forb species were identified into their respective botanical species composition by visual estimation before herbage was clipped using an experienced rangeland scientist. Grazing lands' vegetative basal cover (%) was estimated using a point sampling technique (Crowder and Chheda, 1982) as a proportion of the area under vegetation in each clipping. Collected forage samples were dried in a forced air oven at 60°C for 48 h to constant weight for DM determination, and bulked by plots and by grazing lands.

Grazing lands' herbage yield (tonne, t DM/ha) were estimated as described by Pieper (1978):

Forage yield (t DM/ha)

$$= \frac{(\text{Average DM yield} \times 10{,}000\ m^2)}{0.25\ m^2} \times \%\ \text{vegetative basal cover}$$

Chemical composition

Oven-dried herbage samples from the three plots in each grazing land were spread on a clean polythene sheet on a bench in the laboratory, mixed thoroughly and separately by grazing lands; then sub-divided into several quarters and re-mixed repeatedly. A total of ten representative samples from each grazing land forage were milled through a 2.5 mm sieve, bulked and sub-sampled into two-200 g representative samples and packed for chemical composition and degradability study.

Chemical composition of the grazing land forages was determined in duplicates from each of the two samples to make a total of four replicates. Ash was determined by ignition of dried samples in a muffle furnace at 550°C for 3 h (AOAC, 1990). Crude protein (CP) was determined by Kjeldahl method (AOAC, 1990). Neutral detergent fiber

Table 1. Mean herbage species composition (%) of selected grazing lands in traditional fodder banks of Meatu district

Grass species	Composition (%)
Aristida spp.	10.8
Cenchrus spp.	7.6
Chloris spp.	6.3
Corchoris spp.	0.6
Cynodon spp.	6.5
Cyperus spp.	0.6
Dactyloctenium aegyptium	4.3
Digitaria milanjiana	2.9
Eragrostis spp.	12.5
Heteropogon spp.	0.6
Panicum spp.	1.8
Rhynchelytrum spp.	1.4
Rottboellia exaltata	9.6
Setaria verticilata	1.3
Sorghum sudanese	5.4
Spermacose spp.	0.3
Total grass species	72.5
Forb species	27.5
Grand total	100.0

(NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined using methods described by Goering and Van Soest (1970), *i.e.*, without addition of sodium sulphide and α-amylase. The NDF, ADF and ADL were expressed without residual ash.

In sacco rumen degradability study

Portions (100 g) of the two-200 g sub-samples from each of the six grazing lands were further bulked into one sample, each of which was used for the degradability study. Degradability characteristics of the grazing land forage samples were determined by *in situ* incubation of an approximately 2.5 g DM forage sample in triplicates with each sample incubated in each of three fistulated Friesian× Zebu cross-bred cattle using the nylon bag (*in sacco*) technique (Ørskov et al., 1980). The animals were fed daily on *Brachiaria* hay *ad libitum* (basal diet) and 2 kg concentrates (0.25, 0.35, 0.35 and 0.05 parts maize meal, cotton seed cake, maize bran and fish-meal, respectively). The fistulated animals were supplied with minerals, and had free access to water throughout the experimental period. The DM disappearances from the rumen incubated nylon bags were determined according to Ørskov and McDonald (1979). The forages' DM degradability curves were fitted based on McDonald's (1981) mathematical model: $P = a+b\,(1-e^{-ct})$. Where P is the potential disappearance of DM at time t; a is the rapidly soluble feed fraction; b is the slowly but potentially degradable feed fraction; c is the rate of feed DM degradation; and a+b represent potential feed degradability. Degradation constants a; b and c, were computed using the NAWAY computer program (The Rowett Research Institute, Aberdeen, according to the

Table 2. Herbage vegetative basal cover and biomass productivity of selected grazing lands of Meatu district of Shinyanga region of northwest Tanzania

Grazing land	Ownership category	Basal cover (%)	Yield (t DM/ha)
1	Communal	75.0 [a]	3.69 [a]
2	Private	34.7 [b]	0.76 [b]
3	Private	44.3 [b]	1.01 [b]
4	Private	43.0 [b]	1.22 [b]
5	Communal	39.5 [b]	0.83 [b]
6	Communal	59.3 [c]	1.29 [b]
Mean		49.3	1.5
SEM		0.44	0.20
Significant effect			
Grazing land		**	**

[a, b] Means with the same super scripts along the same column are not (p>0.05) different.
** Significantly different (p<0.01).

formulae:

ME (MJ/kg DM) = 0.15 DOMD %
DOMD % = 0.98 DMD %-4.8 (MAFF, 1975).

where ME is metabolizable energy (ME); DOMD % is digestible organic matter in DM; and DMD (g/kg DM) is the 48 h DM degradability (adopted following its high correlation to *in vivo* digestibility coefficient (Chenost et al., 1970)). A coefficient of 0.15 was used to correct ME for standing hay forages.

Statistical analysis

Data on forages' botanical species composition, vegetative basal cover, biomass productivity, chemical composition and DMD characteristics from the rumen of the three cows were subjected to the General Linear Model (GLM) procedure of SAS (1990) statistical package based on the following statistical model:

$$Y_i = \mu + R_i + e_i$$

where Y_i is the general response of a factor under investigation (species' composition, basal cover, biomass productivity and chemical composition); μ is the general mean peculiar to each observation; R is the i^{th} effect on the observed parameter due to grazing land; and e_i is the random error term.

RESULTS

Forage species composition, vegetative basal cover, and forage biomass productivity

Grazing lands were dominated by low quality and less nutritious herbage species that are commonly referred to as "increasers" (Table 1). Dominant grass species were *Eragrostis spp.*, *Aristida spp.*, *Cenchrus spp.*, *Cynodon spp.*,

Table 3. Chemical composition (g/kg DM) of conserved forages from selected grazing lands of Meatu district of Shinyanga region of northwest Tanzania

Grazing land	CP[1]	EE[2]	Ash	NDF[3]	ADF[4]	ADL[5]
1	27 [a]	10.8 [a]	95 [a]	702 [a]	497 [a]	155 [a]
2	16 [b]	7.5 [a]	104 [a]	707 [a]	573 [b]	119 [a]
3	26 [a]	4.4 [a]	65 [b]	718 [a]	561 [b]	205 [b]
4	24 [a]	10.1 [a]	67 [b]	715 [a]	530 [ab]	147 [a]
5	26 [a]	9.4 [a]	70 [b]	725 [a]	567 [b]	147 [a]
6	22 [a]	4.6 [a]	81 [b]	719 [a]	500 [a]	146 [a]
Mean	24	7.8	80	714	538	154
SEM	0.11	2.31	0.10	0.10	0.10	0.10
Significant effect						
Grazing land	*	NS	*	NS	*	*

[a, b] Means wit the same super scripts along the same column are not (p>0.05) different.
NS: Not significant (p>0.05); * Significantly different (p<0.05).
[1] CP: Crude protein; [2] EE: Ether extract; [3] NDF: Neutral detergent fiber; [4] ADF: Acid detergent fiber, [5] ADL: acid detergent lignin.

Table 4. Degradability characteristics and 48 h degradation (g/kg DM), passage rate, c (fractions/h), metabolizable energy (ME) (MJ/kg DM) of conserved forages of selected traditional fodder banks of Meatu district of northwest Tanzania

Grazing land	a	b	a+b	c	48 h	RSD	ME
1	90[a]	484[a, b]	575[a, b]	1.8[a]	345[a]	2.01[a]	4.6[a]
2	74[b]	451[a]	524[a]	1.6[a]	327[b]	1.97[a]	4.3[b]
3	78[b]	454[a]	532[a]	1.6[a]	317[b]	2.28[a]	4.2[b]
4	74[b]	453[a]	527[a]	1.9[a]	344[a]	2.22[a]	4.6[a]
5	62[b]	448[a]	511[a]	1.9[a]	326[b]	2.86[b]	4.3[b]
6	63[b]	549[b]	613[b]	1.7[a]	318[b]	2.72[b]	4.2[b]
Mean	74	473	547	1.8	329	2.34	4.4
SEM	0.2	0.3	0.2	0.01	0.2	0.004	0.03
Effect of grazing land	*	*	*	NS	*	*	*

[a, b] Means with the same super scripts along the same column are not (p>0.05) different.
NS: Not significant (p>0.05); * Significantly different (p<0.05).
a: Immediately soluble fraction; b: Slowly degradable feed fraction; a+b: Potential DM degradability.

and *Chloris spp.*, *Ipomoea spp.*, *Monechma debile*, *Indigofera spp.*, *Triumffenta spp.*, *Sida spp.* and *Erlangea spp.* were the most dominant forb species (Table 1).

The grazing lands had low mean vegetative basal cover of 49.3%; which varied (p<0.05) from 34.7 to 75.0% in grazing land 2 and 1, respectively, (Table 2). Forage biomass productivity varied (p<0.05) among grazing lands from 0.83 (grazing land site 5) to 3.69 t DM/ha in grazing land site 1, which had (p<0.05) highest forage biomass productivity.

Chemical composition

The herbage forages harvested from the grazing lands had poor nutritive potential reflected by low CP that ranged from 16 (grazing land 2) to 27 g/kg DM (grazing land 1), (Table 3). There was no (p>0.05) difference in CP content between the grazing land forages, except for grazing lands 1 and 2 which had (p<0.05) the highest and lowest CP, respectively. There was no (p>0.05) difference in NDF between the grazing land forages. The NDF ranged from 702 to 725 g/kg DM in grazing lands 1 and 5, respectively. Acid detergent fiber (ADF) varied (p<0.05) from 497 g/kg DM) (grazing land 1) to 573 g/kg DM (grazing land 2). There was no (p>0.05) difference in ADL between grazing land forages except forages harvested from grazing land 3, which contained (p<0.05) higher ADL than the rest of the rangeland forages.

Forage degradability

Conserved forages in *ngitiri* traditional fodder banks were characterized by (p<0.05) low *in sacco* DM degradability characteristics (Table 4). The forages had (p<0.05) low DM washing losses (a)**,** which varied (p<0.05) from 62 to 90 g/kg DM in grazing lands 5 and 1, respectively. There was no (p>0.05) difference in the (a) value between the grazing land forages except for forages harvested from grazing land 1, which showed (p<0.05) higher DM washing losses than the rest of grazing lands' forages. The slowly degradable feed fraction (b)**,** varied (p<0.05) from 448 g/DM (grazing land 5) to 549 g/DM (grazing land 6). The grazing land forages showed low potential degradability (a+b) that varied (p<0.05) from 511 g/kg DM (grazing land 5) to 613 g/DM (grazing land 6), which was not (p>0.05) different from the rest of grazing land forages (Table 4). There was no (p>0.05) difference in the DM degradation rate constant between grazing land forages (1.6-1.9% DM fractions/h). The 48 h DMD varied (p<0.05) from 317 to 345 g/kg DM in grazing lands 3 and 1, respectively. Forage harvested from the different grazing lands had low energy potential with mean ME of 4.36 MJ/kg DM. The forages' ME varied from 4.2 MJ/kg DM (grazing lands 3 and 6) to 4.6 MJ/kg DM (grazing land 6).

DISCUSSION

Vegetative basal cover, forage species composition, and forage biomass productivity

Both low biomass yield and predominance of "increaser" grass species in most rangelands largely indicate over utilization of the rangelands' ecosystem. The observed herbage species in the study area reflect typical East African semi-arid herbage forage species (Pratt and Gwyne, 1977), indicating poor and disturbed soils in these semi-arid areas of north-western Tanzania. *Aristida spp.*, *Cenchrus spp.*, *Dicanthium annulatum, Heteropogon contortus, Sorghum sudanese,* or *Thermeda triandra* represent grass species that grow under low to medium rain-fed areas (Göhl, 1981). This semi-arid zone in central and north-western Tanzania is characterized by marginal soils (light, sandy, disturbed soils) (Pratt and Gwyne, 1977), which in conjunction with weather and climatic factor interactions, especially low rainfall, affect adversely persistence of grass and vegetative species, and thus their forage quality and yield.

Slight variations in both vegetative species composition and dry season forage yield production among grazing lands could partly be explained by variability in soil type and fertility. For example, *Cynodon spp.*, *Urochloa spp.*, *S. sudanese* and *Digitaria spp.* were dominant in grazing lands with black clay soils ("*mbuga*"). In contrast, *Aristida spp.*, *Cenchrus spp.*, *Chloris spp.*, *Eragrostis spp.* and *Rhynchelytrum spp.* were dominant on sandy loam soils or "*ibushi*". Relatively higher herbage biomass production in rangeland site 1, which was under joint management between HASHI/ICRAF and Mwanhuzi village government, than other grazing lands, suggests optimal utilization of the sward. Length deferred, grazing duration and grazing pressure influence persistence of grass species and enhance vegetative regeneration that has been associated with improved nutrient flow in rangeland ecosystems (Pratt and Gwyne, 1977). Predominance of undesirable grass and forb species in most grazing lands due to loss of biodiversity of desirable nutritious forage species, referred to as "decreasers", could be associated with high grazing pressures due to high stocking rates in Meatu district and the entire Shinyanga region (Ngendello et al., 1996).

Chemical composition

Observed low mean CP of forages in *ngitiri* traditional fodder bank was on the lower side of CP values of most tropical grasses (20-70 g/kg DM) in the dry season (Göhl, 1981; Skerman and Riveros, 1990). The forages' mean CP content was also lower than those reported by Otysina et al. (1997) from the same study area (30-40 g/kg DM) in the dry season, and even lower than forages harvested in the northern highlands of Tanzania (Shem et al., 1995). Low CP values of these conserved forages could mainly be explained by advanced forage maturity. For example, Minson (1990) noted a drop in CP to less than 50 g/kg DM in tropical grass forages after full bloom stage. Differences in CP content between this study and literature values could be explained by forages' genotype, stage of growth, soil types and climatic factors such as temperature and precipitation (Crowder and Chheda, 1982; Mero, 1997) due to their influence on nutrient accumulation in plants. Low CP content of grazing lands' forages in the dry season was far below the minimum CP requirement of 80 g/kg DM for optimal ruminal microbial activity (Annison and Bryden, 1998).

High cell wall contents (CWC), namely, NDF, ADF and ADL, were mainly due to high lignification following advanced forage maturity (Minson, 1990; Van Soest, 1994). Skerman and Riveros (1990) had similarly reported high NDF, ADF and ADL values in tropical forages at advanced forage maturity. High NDF, ADF and ADL values reflect high extent of cell wall lignification (Van Soest, 1994) that could be associated with decreased cell contents (CP, sugars, vitamins, minerals) and forage digestibility.

Forage degradability

Low *in sacco* DMD characteristics reported in the current findings could mostly be explained by high CWC compared to low cell contents (CC) due to advanced forage maturity and maximum fibre lignification. The forages' fibre component limits ruminal microbial degradation (Van Soest, 1994) and both rate and extent of fibre digestibility (Fonseca et al., 1998). The a degradability constant represents an immediately soluble feed fraction. The b fraction determines the minimal proportion that persists as an indigestible residue, which occupies space in the rumen (Ørskov and Ryle, 1990). The grazing land forages contained low a, high b, and low potential degradability (a+b) feed fractions that suggest low feed digestibility potential, low intake and evacuation rates. Slight variations in DM degradability characteristics between grazing land forages' could be explained by differences in rate, extent and potential degradability that exist within both temperate and tropical grass species (Minson, 1990; Mero, 1997). The grazing lands' forages had lower ME values than those reported by Shem et al. (1995) for cultivated, local grasses and crop residues from the highland areas of Tanzania, suggesting a need for protein and energy supplementation for optimal animal performance by grazing cattle.

CONCLUSION

Traditional fodder banks in Meatu district rangelands were dominated by undesirable, less nutritious and unpalatable grass species that indicate over-utilization of the rangeland ecosystem. The noted low mean forage biomass productivity of 1.5 t DM/ha, and low mean CP content of 24 g/kg DM in the dry season would not sustain livestock production unless corrected with protein and energy sources. The forages were characterized by low degradability and ME potential due to high fibre lignification that could be associated with poor nutrient supply to the animal. Therefore, for improved animal productivity in the dry season in Meatu district, there is a need for protein and energy supplementation of ruminant livestock fed on deferred feed in *ngitiri* traditional fodder banks.

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