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RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Feed resources abundance for wild and domestic herbivores in Miombo woodlands of Western Tanzania

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Abstract

Grasses are the main feed resource for both wild and domestic grazing herbivores. Ecological processes associated with grazing have been stable for millions of years since emergence of grasses and grazers in ancient time. However, current expanding human population, escalating , degradation of natural resources, increasing socio-economic pressures and current climate changes have all increased the complexity associated with the availability of feed resources for both wild and domestic herbivores. This situation compelled initiation of the study to assess feed resources in Miombo woodlands of Western Tanzania. The study involved four districts and twenty six villages. Results indicate that livestock keepers experience feed shortage for grazing herbivores within village lands for a period of 5 to 6 months within a year. Quality of forage feed resources available in Miombo woodland for both wild and domestic herbivore vitiates with advance in dry season. Results indicate Total Digestible Nutrient (TDN) decline with advance of plants maturity from January to December. Furthermore, results indicate that nutritive value of pastures in Miombo woodlands was relatively lower during the dry season than wet season. In addition, results indicate that percentage of unavailable protein (protein bound to lignin) in pastures within Miombo woodlands was relatively lower during the dry season than wet season but the reason for this phenomenon is unknown hitherto. It has been concluded that pastures available within Miombo woodlands of Western Tanzania are relatively lower in quality during the dry season than wet season.

Keywords: domestic herbivore; feed resources; grazing, Miombo woodland; wild herbivore; Western Tanzania

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Introduction

Plants are at the base of the food chain and therefore their productivity affects herbivores which in turn support carnivores and human beings. Various environmental factors on the other hand affect availability of plants which is the main feed resources for grazing herbivores. It has been reported that ecological processes associated with grazing have probably not changed appreciably since the initial appearance of grasses and grazers in the fossil record some 45 million years ago (Stebbins, 1981). However, a rapidly expanding human population, escalating degradation of natural resources, increasing socio-economic pressures and current climate changes have all increased the complexity associated with the availability of feed resources for both wild and domestic herbivores. In addition to that, little is known about potential of feed resources that support existence of herbivores in Miombo woodlands of Western Tanzania. This poses a dilemma to wildlife managers on how to ensure sustainability of wild herbivores in this area as human encroachment, cultivation and pastoralism are taking place at an increasing rate. On top of that there is lack of adequate data to guide policy makers on requirements that should be fulfilled in order to keep domestic herbivores in villages that surround protected areas within Miombo woodlands of Western Tanzania. This situation contributes to the conflict between conservationists and pastoralists and thus

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entails the need for a study to assess the potential of feed resources to support herbivores in Miombo woodlands of Western Tanzania.

Miombo is a vernacular word that has been adopted by ecologists to describe those woodland ecosystems dominated by trees in the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (*Leguminosae*, sub-family *Caesalpinioideae*). Campbell et al. (1996) described Mombo woodlands as comprises the woodland-dominated end of the spectrum of savanna formations. The authors described further that mature, relatively undisturbed stands typically comprise a 10-20 m high, single storey, partly closed canopy of mostly pinnate-leafed trees; a discontinuous understorey of broad-leafed shrubs; and an often sparse but continuous herbaceous layer of forbs, small sedges, and caespitose, heliophytic C4 grasses which is the main feed resource for grazing herbivores. The average biomass density of indigenous large herbivores in conservation areas in which Miombo woodland is the sole or main vegetation type is estimated as 2.2 Mg DM (dry matter) km^{-2} (Bell, 1982; East, 1984). Assuming that animal densities in Miombo woodland are not artifacts of past hunting pressures or of confinement to small reserves established on marginal land (McNaughton and Georgiadis, 1986), this biomass is only about 20-30% of the biomass expected at a comparable mean annual rainfall (about 960 mm) in savanna communities underlain by volcanic rocks or sedimentary formations within rift valleys. Moreover, in contrast to the general trend for large herbivore biomass in African savannas to increase with increasing mean annual rainfall (Coe et al., 1976; Bell, 1982; East, 1984), herbivore biomass in Miombo woodland declines as mean annual precipitation (MAP) increases. Elephant (*Loxodonta africana*) and buffalo (*Syncerus caffer*) make up 75-90% of the biomass at most of these localities, although both species are more abundant in drier savannas on eutrophic soils (East, 1984). Their large body sizes allow them to utilize the abundant low quality plant matter present in Miombo woodland. In addition, elephants can reach the substantial amounts of browse that are unavailable to other species. Most of the antelope in Miombo woodland are also relatively large-bodied. Species such as sable antelope (*Hippotragus niger*) roan antelope (*H. equinus*) and Lichtenstein's hartebeest (*Alcelaphus lichtensteini*) which are characteristic of Miombo woodland and are specialist grazers that select high-protein, actively growing grass shoots from medium-height swards. To some extent, they offset periodic shortages of high-quality forage by moving seasonally between different landscape units and by selecting areas, such as those which have been recently burnt, which produce a brief but synchronous pulse of high quality food (Bell, 1982). Such responses require large foraging areas, however, which in turn mean low population densities. In contrast to grazers, specialist ungulate browsers are rare, a reflection of the shortage of browse during the latter part of the dry season, the poor nutritional quality, and general inaccessibility to the canopies of trees (Bell, 1982; East, 1984; Jachmann, 1989). Increased human activities in Miombo woodlands of Western Tanzania might have a profound effect on availability of feed resources for specialized grazers thus entails the need of evaluating quantity and quality of feed resources in this area.

Materials and Methods

Study areas

The study was conducted within Ugalla ecosystem dominated by Miombo woodlands that covers an area of about 30,000 square kilometers (3,000,000ha). It lies in four administrative districts of Urambo, Sikonge, Uyui in Tabora region and Mpanda in Katavi region. The area comprised with a vast of biodiversity and natural resources which have different conservation status. Ugalla Game Reserve is the core protected area within the ecosystem and covers an area of approximately 5000 square kilometers. The reserve is surrounded by several Game Controlled Areas (GCAs) and Forest Reserves most of which overlap with GCAs. Game Controlled Areas include Luganzo GCA (5,200 km^2), Ugunda GCA (3,950 km^2), Msima GCA (4,200 km^2), and Inyonga GCA (9,000 km^2). Forest reserves (FR) include; Walla River FR (1,565 km^2), Ugunda FR (1,660 km^2), Ugalla River FR (2,600 km^2), Inyonga FR (7,100 km^2), Mpanda N. E. FR (4, 500 km^2), Mpanda line FR (3, 640 km), and North Ugalla FR (1,990 km^2). Apart from game reserve, GCAs and FRs, Ugalla ecosystem also composed of two Wildlife Management Areas (WMAs) of IPOLE (2,510 km^2) and UYUMBU (838.7 km^2), they are located in the Western side of the Game Reserve. The ecosystem is surrounded by 65 villages with a population of approximately 450, 000 people, with whom expect to benefit from the services and goods in the ecosystem. Ugalla ecosystem comprise Ramsar site of Tanzania that has many important socio-economic and cultural values. Some of the most important include harvesting of wetland related products including fish, forest products, medicinal plants, honey and wildlife. Other values of importance to the local communities include flood control, water supply, and dry season grazing. Human population's subsistence economy in and around the proposed site depends largely on farming, fishing, hunting and honey gathering. Although honey gathering and fishing is not normally permitted in game reserves in Tanzania, it has been the practice to permit such activities in the game reserves in the Ramsar site as these activities predate the establishment of the reserves. Large numbers of fishing and beekeeping camps operate throughout the Ramsar site during the dry season (July to December). Permanent fishing villages are present around some of the lakes such as Lake Sagara.

Methodology

Study villages selection

Twenty six villages out of 65 villages adjacent to protected areas in Ugalla ecosystem were involved in the study where at least 6 villages were selected from each district. The villages were selected based on number of livestock keepers within the villages. The sample size was calculated according to Krejcie and Morgan (1970) as follows:

The t-value is 2 for a total number of 65 villages that surround Ugalla ecosystem with an alpha level of 0.05 and 5% acceptable margin of error. A 5 point scale based on types of livestock kept in villages (i.e., cattle, goats, sheep, chickens and pigs) and 6 standard deviations (3 to each side of the mean) was considered.

Estimate standard deviation (s) = 5/6=0.83

Sample size (n) = $(t)^2(s)^2/(d)^2$

Where,

t= t-value

s = standard deviation

d=acceptable margin error Thus,

s= $(2)^2(0.83)^2/(5*0.03)^2$= 44

Since sample size (44) exceeds 5% of the total villages (65 villages), correction formula was used as follows:

n_1= n/(1+n/population) = 44/(1+44/65)= 26 villages

Sample size

Availability of pasture species in villages and protected areas was determined using quadrants as sampling frame. Sample size (number of quadrants per location) was determined based on sample size for dichotomous data procedure as follows:

n = log (1-β)/log ρ, where. n=number of quadrants per location, β=Chance of detecting weeds in quadrants, ρ=proportion of pasture species in quadrants. Basing on findings reported by Kavana et al. (2007) the proportion of weed species at low, medium and high stocking rates were 20.2, 21.4 and 26.5% that makes an average of 22.7 ≈ 23%. Thus, on average, proportion of pasture species was 77%. Sample size was then calculated at 95% chance of detecting weeds as n = log (1 – 0.95)/log 0.77

n = log 0.05/log 0.77 = 11.8 ≈12 quadrants per location. However, the number of quadrants exceeded 12 for vast grazing lands. The decision for vast grazing lands was made during sampling in the field.

Socio-economic survey

Base-line data was collected at the beginning of the study that was intended to obtain information to enable comparison of period before and after implementation of the project. Structured questionnaire was used to gather information on respondents' knowledge about importance of wildlife, their attitude towards wildlife conservation and indigenous practices that enabled co-existence of human, wildlife and livestock in the past. Respondents were given opportunity to describe trends in production of both crops and livestock and suggest possible solutions to the problems they perceive. Environmental issues were discussed so as to obtain their perception on status of natural resources such as forest and feed resources for different types of livestock kept within the villages.

Feeds resources inventories

Livestock keepers, crop farmers, extension staff, natural resource managers and researchers forums were organized in selected villages for the purpose of identifying feed resources available for ruminants. The main goal of conducting feed inventory was to match quantity of feed available and nutritional needs of livestock within villages. Herbage production curves and the nutrient available curves of feed resource were developed.

Determination of stocking rates

Samples of feeds were taken on monthly basis for laboratory analyses. Weather records particularly temperature and rainfall were also taken during the study. Samples of feedstuffs were taken to the Central Veterinary Laboratory in Dar-es-Salaam for analyses using Near Infrared equipment. Then, calculations to determine stocking rates were done based on proper use factor of 50% and Tropical Livestock Unit as 250 kg Live Weight.

Results and Discussion

Results from interview are shown in Table 1 that indicate most of livestock keepers in villages experience feed shortage for their animals for a period ranging between 5 to 6 months within a year.

Poor performance of livestock should be expected in such situation unless surplus feed available during the rainy season is well conserved and properly utilized. Through discussion, livestock keepers mentioned that unpredictable weather causes dramatic change in availability of feed resources between years. The situation of unavailability of feed resources is exacerbated by burning of pastures practiced by crop farmers during the dry season. In such situation, they are compelled to enter protected areas so as to enable survival of their animals. It will be plausible to introduce feed conservation technologies to enable livestock keepers to conserve feed resources for their herds. Feed rationing could extend period of feed availability in properly managed grazing lands. This can be practiced well in private grazing lands, however, results from Table 2 indicate that more than 50% of livestock keepers in depend on communal grazing land. This makes rather difficult to practice feed conservation strategies. Therefore promotion of private grazing land is inevitable for sustainable utilization of feed resources and avoidance of the tragedy of commons.

Table 1: Periods of enough feed resources

Period	Percent N=172
December to June	26.2
November to June	4.8
January to June	7.1
January to May	16.7
May to December	38.0
December to August	4.8
November to August	2.4

Table 2: Dependence of livestock keepers on grazing land

Grazing land	Percent N=172
Private	32.6
Communal	52.2
Both Private and Communal	15.2
Total	100.0

Table 3: Feed resources competition between domestic and wild herbivores

Wild animal	Frequency	Score (%)
Elephant	15	44.1
Antelope	2	5.9
Zebra	2	5.9
Buffalo	8	23.5
Wild pig	1	2.9
Hippopotamus	5	14.8
Giraffe	1	2.9
TOTAL	34	100.0

Results indicated that elephant, buffalo and hippopotamus were considered by most of the respondents as the major competitors for natural feed resources against livestock in the study areas. Low soil fertility and nutrient levels in true Miombo woodlands limit productivity and favour a low biomass density of large wild mammals that is dominated by mega-herbivores. Other scientific findings indicated that elephant (*Loxodonta africana*) and buffalo (*Syncerus caffer*) make up 75-90% of the biomass at most of the true Miombo woodlands, although both species are more abundant in drier savannas on eutrophic soils (East, 1984). Their large body sizes allow them to utilize the abundant low quality plant matter present in Miombo woodland.

Availability of forage feed resource determine the performance of herbivores in any grazing system. Availability of forage feed resources for grazing animals in ecosystem varies with season of the year. Results on abundance of feed resources in terms of dry matter are illustrated in figure 1. Availability of forage feed resources for grazing animals increases during the rainy season (January to May) then decreases during the dry season (June to December). Production of grazing animals is a dynamic process varying as a function of both plant and animal factors. Determining the proper number of animals to be placed on an area is the principal factor affecting the relative success of any grazing management strategy. This is so because number of animals affects not only individual animal performance but also production/ unit area of land.

Regardless of vegetation complex or the kind or class of animal, number of animals occupying an area over a given period of time (stocking rate) has a profound effect on herbivores production because it affects Grazing Pressure (GP) directly by virtue of its direct effect on Forage Demand (FD) and the subsequent effects of FD on forage available. Based on forage availability in this study (Fig. 1), the stocking rate has been calculated by taking into account proper use factor of forage as 50% of available dry matter. The general trend of stocking rate for livestock in grazing lands within Miombo woodlands of Western Tanzania has been deduced and illustrated in figure 2.

The relationships between stocking rate and herbivore production are extremely complex and highly variable in any herbivore production system because grazing pressure varies widely over time and space. This variation is the result primarily of variations in quantity and quality of available forage (nutrients available) over time and space as a result of both managerially uncontrollable variables, which are primarily abiotic, and controllable variables, which are primarily biotic. Major abiotic variables are climate and the inherent productivity potential of a site as defined by such factors as soil fertility, slope, and aspect (range site). Thus, quantity and quality of available forage vary seasonally, among years and range sites, and within and among geographical regions (Sims and Singh, 1978; Sala et al., 1988) regardless of the relative impact of any biotic factors. More observations are required in Miombo woodlands of Western Tanzania in order to establish the carrying capacity of grazing herbivores in Miombo woodlands under the influence of climate change.

Results from this study indicate that the quality of forage feed resources for grazing animals in Miombo woodlands of Western Tanzania vitiates with advance in dry season (i.e., from January to December). Total Digestible Nutrients (TDN) declined almost linearly from January to December as illustrated in Figure 3.

A linear regression function suggest that there is a decline of 1.4 and 0.474% for TDN and CP respectively, in natural pastures for every month starting from January towards December. Feed resources of the highest quality for grazing herbivores are found in metabolically active tissues (live leaves, stems, flowers, etc.) or storage tissue (seeds, fruits and roots). Live plant tissue is of higher quality than dead tissues. Similarly, younger live tissue by virtue of its greater metabolic activity is of higher quality than older live tissue (Huston and Pinchak, 1991). Generally, live leaf is of higher quality than live stem because of its greater photosynthetic activity. The same authors explained that nutrient quality declines as the rate of development or recruitment of new leaf tissue decreases and the rate of senescence increases. This is in

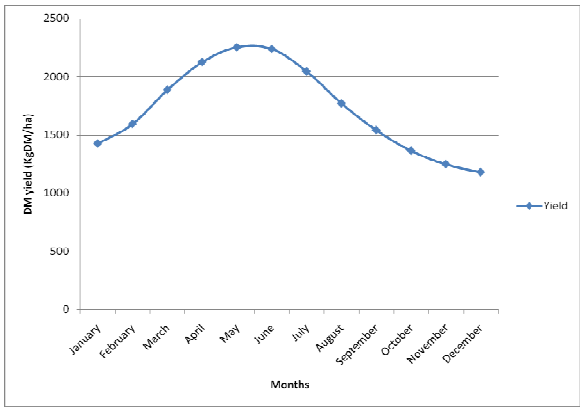

Fig. 1: Natural pasture availability in Miombo woodlands of Western Tanzania

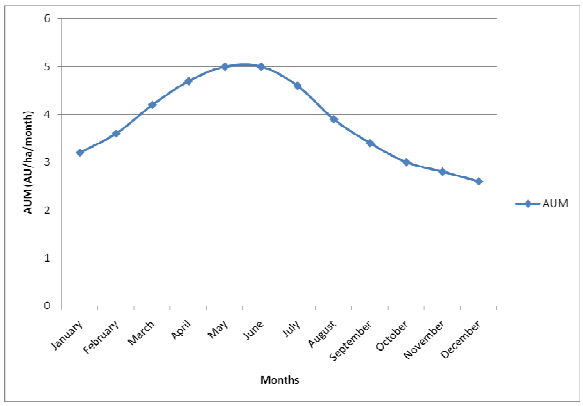

Fig. 2: Stocking rate in village grazing lands in Miombo woodlands of Western Tanzania

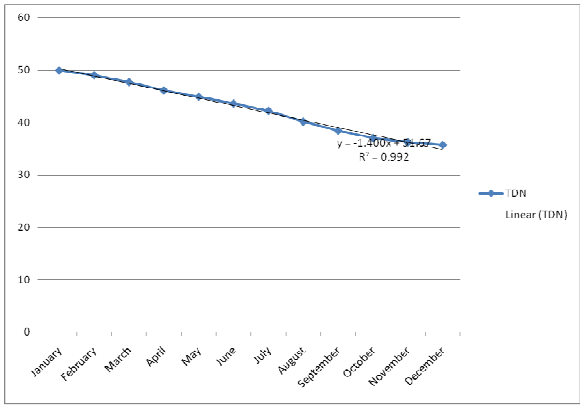

Fig. 3: Trend of Total Digestible Nutrients in Miombo woodlands of Western Tanzania

agreement with observations made in this study where total digestible nutrient and crude protein content declined as the pastures matured and finally dried from January to December (Fig. 3 and 4). This could be explained as the increasing amounts of senescent material that dilute nutrient density (Greene et al., 1987). Concurrent changes in the leaf to stem ratio also occur as a plant matures. In terms of the energy flow and standing crop (g/m^2), available gross energy ($Kcal/m^2$), usually peaks when stems have elongated in mid-anthesis (Huston and Pinchak, 1991). However, the same authors reported that maximum available net energy (NE $Kcal/m^2$) occurs earlier in the late vegetative and early anthesis stages before significant reproductive culm elongation occurs.

The abiotic factors which affect forage quality the most important are air temperature and soil moisture. These environmental conditions modify the rates at which live material is accumulated and senescence occurs (Huston and Pinchak, 1991). Average temperatures and rainfall of the study areas are shown in figures 5 and 6.

Huston and Pinchak (1991) generalized that the leaf and stem tissue of grasses grown at high temperatures is lower in both digestibility and crude protein content. The same authors explained that lignifications and the formation of structural carbohydrates (NDF) occur rapidly at elevated temperatures causing a concomitant reduction in the cell soluble fraction. However, results from this study indicated higher crude protein content in pastures of Sikonge district (Fig. 7) and higher NDF content in pastures of Urambo district (Fig. 8). This could be attributed to differences in soil nutrients and characteristics among the districts.

Herbivores require protein in the diet to supply nitrogen (ammonia) and amino acids for intra-ruminal microbial activity and amino acids for cellular-level tissue metabolism. Suboptimal protein supply to the microbial population in the rumen results in a lowered fermentation rate, decreased digestibility of food consumed and decreased voluntary intake (Kempton and Leng, 1979). This implies that protein is an important nutrient for the proper utilization of herbivores feed resources in Miombo woodlands of Western Tanzania. Protein requirements in ruminants include protein and/or nitrogen requirements of the ruminal microbial population. Generally, microbial requirements are met at 6-8% crude protein in the diet and the animal requirements range from 7-20% in the diet depending upon species, sex and physiologic state (Huston and Pinchak, 1991). Normally, animal protein requirements are satisfied by a combination of microbial and dietary escape protein. Therefore, partitioning of crude protein available in feed resources indicated that available crude protein during the wet season is higher than the dry season. This entails the need for supplementation of ruminants animals for better performance during the dry season.

Results shown in figure 10 indicate that the percentage of digestible crude protein during the wet season is higher than the dry season. This implies that herbivores in Miombo woodlands of Western Tanzania tend to perform better during the rainy season than dry season due to better supply of nutrients from pastures during the wet season.

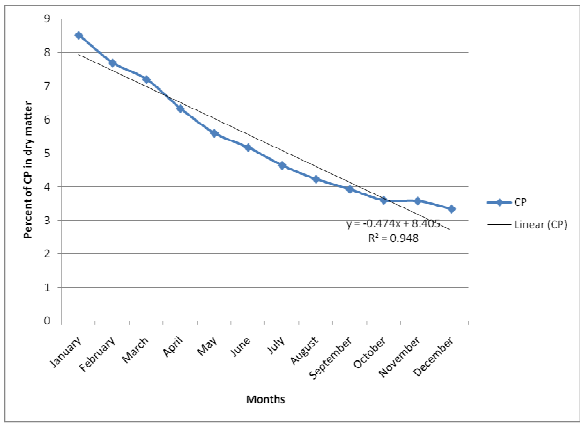

Fig. 4: Crude protein in pastures in Miombo woodlands of Western Tanzania

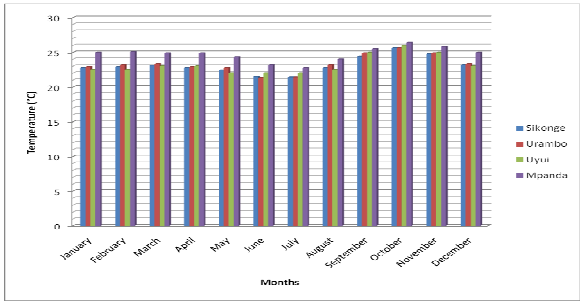

Fig. 5: Average temperatures in Miombo woodlands of Western Tanzania

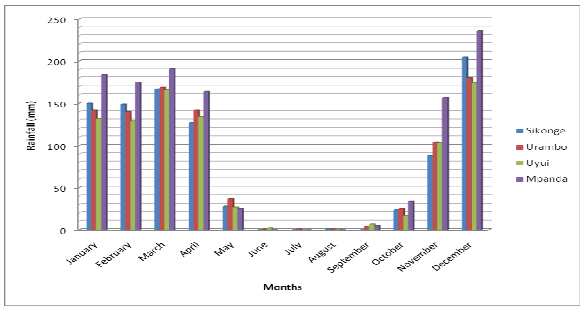

Fig. 6: Average rainfall in Miombo woodlands of Western Tanzania

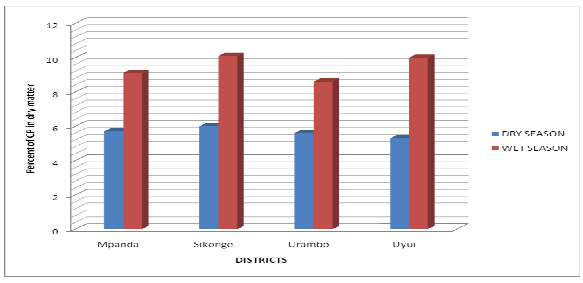

Fig. 7: Crude protein content of pastures in different locations

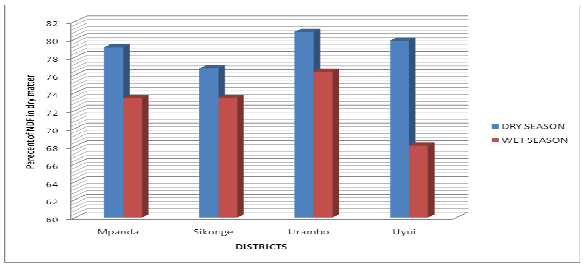

Fig. 8: Neutral Detergent Fibre of pastures in different locations

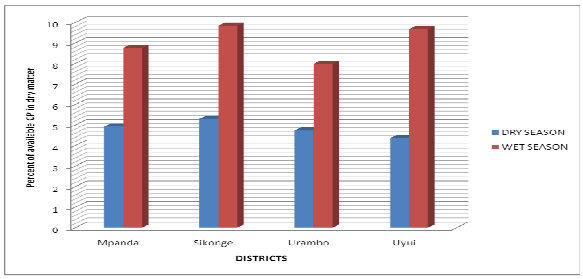

Fig. 9: Available crude protein of pastures in different locations

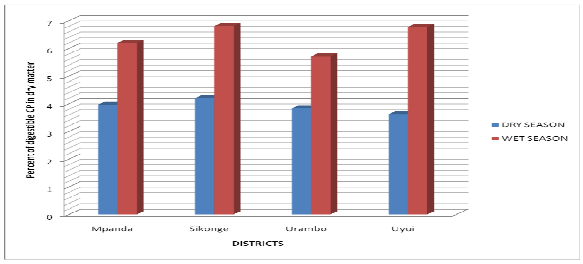

Fig. 10: Digestible crude protein of pastures in different locations

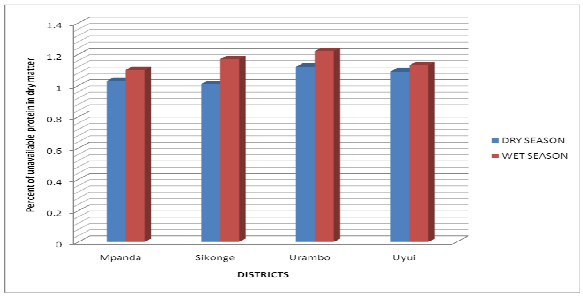

Fig. 11: Unavailable crude protein of pastures in different locations

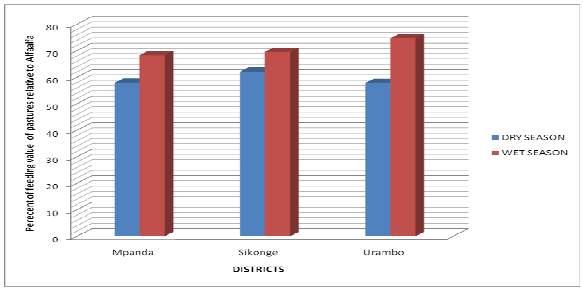

Fig. 12: Relative forage values of pastures in different locations

Results shown in figure 11 indicate that despite of relatively higher availability and digestibility of crude protein during the wet season, the crude protein which is tenaceously bound to the lignin (unavailable protein) is relatively higher during the wet season than dry season. These results were in considerable agreement with those of Yayota et al (2008) though their observations were based on dwarf bamboo with three seasons (winter, autum and summer) while this study conducted in Tropical conditions that considered rangeland pastures with only two season (dry and wet seasons) The reason for this phenomenon is still not well documented.

Generally, the pastures of Western Tanzania Miombo woodlands are relatively high in quality during early vegetative growth (wet season) but quickly declines in quality as the forage accumulates and matures (during dry season). The feeding value of pastures observed in this study is relatively lower than the feeding value of Alfalfa (*Medicago sativa*) as shown in figure 12.

Conclusion

- Pastures available within Miombo woodlands of Western Tanzania are relatively higher in quality during early vegetative growth (wet season) but quickly declines in quality as the forage accumulates and matures (during dry season).
- The feeding value of Miombo woodlands' pastures is relatively lower than the feeding value of Alfalfa which implies that keeping of high producing livestock in Miombo woodlands of Western Tanzania requires supplementary feeding throughout the year.

Recommendations for further studies

- Find out the reasons for relatively higher percentage of unavailable protein in pastures of Miombo woodlands during the wet season than in dry season
- Assess the feeding value of fodder trees available in Miombo woodlands and delineate how they can complement poor quality of pastures during the dry season or during extended droughts that result from effects of climate change (i.e., identify tree species valuable for mitigation of climate change in terms of feed resources for both wildlife and livestock in Miombo woodlands of Western Tanzania).

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