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Seasonal dynamic of pasture production in the Sahelian rangeland of Burkina Faso

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Abstract: Rangelands are the main feed resources for ruminants although they are being excessively exploited due to combined effects of climate changes and extensive grazing. This study was conducted in the Sahelian zone of Burkina Faso with the aim to estimate the exploitation modes of forages resources and evaluate the seasonal dynamic of herbaceous pasture production. After an identification of the pasture types and their characterisation, periodical measurements of pasture production were made from October to January. Consecutively, cattle herds, sheep and goat flocks were observed to study resources use.
The results showed five types of rangeland (plus cropped fields), which differ by the plant diversity and pasture production. The lowland rangeland has shown high potentialities, whilst low production was recorded in "tiger" bush rangeland. The herds grazing these areas were moved from the cultivated fields. The highest pasture production measured in lowland, shrubby steppe, woody steppe and tiger bush rangeland (respectively 4271 kg DM/ha, 3061 kg DM/ha, 2890 kg DM/ha and 1251 kg DM/ha) decreased quickly depending on rangeland types and the grazing pattern in the rainy season. The rate of decrease in biomass varied from 77.6% in lowland pasture in November, to 83% in woody steppes pasture in December. These results suggested adaptation strategies by herders and in animals feeding behaviour to prevent animals from starvation in dry season in the area.

Keywords: Rangelands, pasture production, herd monitoring, seasonal production.

Introduction

Rangelands are the main feed resources for ruminants in sub-Saharan Africa. In Burkina Faso, these pastures account for 85% in domestic ruminants feed, followed by crop residues (11%) (MRA, 2004). However, the rangeland productivity depends on several factors, including the effects of climate change, extensive use of rangelands with the number of livestock increasing, and expansion of cropland with the consequent reduction in pasture areas. In Burkina Faso the number of the main domestic ruminants is estimated to 8.23 million cattle, 8.003 million sheep and 11.98 million goats (DGPSE, 2010). Nearly 95% of these animals are raised in traditional transhumance and sedentary systems (MRA, 2011).

Though fodder shortage in the dry season common to all agro-ecological zones of Burkina Faso, it is more severe in the Sahelian zone. The rangelands have mainly annual plant species highly sensitive to climate variability; fodder production is generally low and highly variable from year to year. However, this is the best area of the country for livestock farming and host large herds, resulting in high stocking rates compared to the carrying capacities. Stocking rates of 198 to 259% were reported (MRA, 1999), which raises issues of balance between the needs of animals and the resources available. Pasture deficit is enhanced in the long dry season, when forage is not sufficient for livestock maintenance and production. The rangelands in Sahel consist mainly of annual herbaceous species whose development cycle and botanical composition are closely related to the spatial and temporal rainfall and their distribution (Grouzis, 1992; Hiernaux, 1996, Akpo et al, 2003). Most shrubs and trees are deciduous and palatable; their cycle is longer than grasses, have diversified components (leaves, flowers and fruits), and they are a strategical resource during the long dry season when they constitute 50 – 90% of the diet respectively for cattle and small ruminants (Cesar and Zoumana, 1998; Sanon et al, 2007a).

The studies of inter-annual vegetation dynamics have shown pasture degradation due the effect of drought and/or overgrazing (Toutain and De Wispelaère, 1977; DeWispelaère, 1990; Herrmann et al, 2005). In a recent study, Ouoba et al. (2013) showed contrasting trends in vegetation growth, depending on the year and location, related to drought situations and extreme rainfall from one year to another. However, few studies have been done on the strategic use of feed resources by livestock in this context, for their production and their survival. For sustainable development of animal production, a critical look must be put on the current status of resources and their exploitation in order to find appropriate solutions adapted to the realities of rural populations. This study aimed to estimate the dynamics of herbaceous fodder production after the end of the rainy season and appreciate the use of pasture by domestic ruminants.

Materials and methods

Location and climate

The study was conducted in the Sahelian zone of Burkina Faso, in the village of Tongomayel, located in the province of Soum (13° 44'- 14° 50'N, 0° 32' - 2° 07'W). The area is characterized by a dry climate with low rainfall, less than 600 mm (June to September) and a long dry season of eight months from October to May (Fontes and Guinko, 1995). The dry season is characterized by the dry wind 'Harmattan', which blows from the north-east to south-west. The average monthly temperature ranges from 21 °C in January to 40 °C in April. The average rainfall for the last 10 years preceding the study, at the weather station of Djibo is 480 mm. During the study in 2003 and 2004, 391 mm and 551 mm of rainfall were recorded respectively. The vegetation is steppe type, with shrubs and trees; forest galleries are found along riversides and in some parts woody species can form more or less impenetrable bush (such as "tiger" bush). The most common tree species in the area are: *Acacia nilotica, Acacia senegal, Balanites aegyptiaca, Boscia senegalensis, Commiphora africana, Dalbergia melanoxylon, Pterocarpus lucens* and *Grewia flavescens*. The herbaceous cover is sparse and dominated by annual grasses such as *Schoenefeldia gracilis, Aristida adcensionis* and *Cenchrus biflorus* (Zoungrana, 1991).

Inventory and characterization of forage resources

Mapping

The mapping materials available consisted of aerial photographs (from 1983 at 1/50000th) and topographic map of West Africa (region of Djibo) at scale 1/200000th. The result of photo-interpretation of aerial photographs was linked to the topographic map to identify the major vegetal groups and to establish a preliminary map, i.e. a representation on paper of homogenous appearance zones, forming landscape units. The comparison of the preliminary map with the ground reality allows to make some corrections. The geographical coordinates of control points were taken using GPS, for setting in geometry the preliminary map. The information collected were scanned, giving the map of landscape units of the study site.

Field inventories

The spatial boundaries of the different landscape units (or pasture types) were used and two transects were established throughout the land in view to meet the

maximum landscape heterogeneity; three ecological stations of observation, each about 1 ha were placed per unit of landscape, giving a total of 12 stations. At each station, a description of the characteristics of the area (vegetation and environment) was made.

Points quadrat method (Daget and Poissonet, 1971) was used to analyze the herbaceous species. A total of 9 lines (20m each) were randomly placed per pasture type (3 lines of 100 sample points per inventory station); this allowed establishing the herbaceous plants list and their specific contribution.

An exhaustive inventory of woody species was done on each station and based on the following 5 classes of height: [> 1 m], [1-3 m], [3-5 m], [5-7 m] [<7m]; the list of woody species and density of woody plants per rangeland type were determined.

Evaluation of herbaceous biomass production

The maximum herbaceous biomass production was evaluated in October. In randomly selected 10 plots of 1 m² per station, herbaceous biomass were cut which is 30 m² cut per unit of pasture.

Biomass of crop residue was measured in sample square areas that were placed in the cropland of eight farmers. Three plots of 25 m^2 per crop type were set with four wooden posts in August, monitored, and then harvested in October by separating the grains from the straws or haulms. A representative sample of the residues was taken for each crop type, weighed then sun-wilted and oven dried before DM weighting.

Biomass production has been used to calculate the rangeland carrying capacity (CC) from the following formula (Boudet, 1991):

$$CC = \frac{\text{Production (Kg DM/ha) x K (\%)}}{\text{6, 25 (Kg DM / day /TLU) x period of utilization}}$$

with K (%): coefficient of utilization = 1/3 ; whilst 35% and 60% were used respectively for cereals straw and legumes haulms (Breman and De Ridder, 1991).
TLU = Tropical livestock unit, that is an animal of 250 kg;

Degree of palatability of herbaceous plants

The degree of palatability of the species was investigated using the succession theory of Dyksterhuis (1949). All species recorded in a botanical survey were classified according to their assumed reaction to grazing using the decreaser, increaser or invader groups:

- decreasers : represent plants species which tend to decrease, when the animals overgraze them as they are usually the most palatable and desirable forage species.

- Increasers : are species which tend to increase when a range site is overgrazed. But, if the overgrazing continues for a long time, they, too, will decrease. Increasers usually are less palatable than decreasers.
- Invaders : are the least desirable plants. They tend to increase rapidly when a range site is over-grazed.

Farmers' preference of browse species

A formal survey was conducted to estimate indigenous knowledge of forage species. A sample of 70 farmers (herders, livestock owners and women) was selected randomly for the interviews. They were asked to cite the browse species they knew and which were represented in their area, as well as their importance regardless of their palatability and other utilizations. The farmers noted species important, when they are used for many purpose (animal feed and other uses such as in traditional medicinal). Species which don't have these characteristics were noted less important.

Evolution of herbaceous fodder production (pasture)

Periodical cuts of pasture biomass were done every ten days after the optimum stage of vegetation for estimating pasture growth dynamic under grazing. Measurements began ten days after the assessment of the maximum production in October 2nd (2003) and spanned to end January 2004 where residual biomass were significantly reduced. The rate of biomass decrease was evaluated as followed: (optimal biomass – actual biomass) / optimal biomass.

Herds' management

Three livestock species were considered (cattle, sheep and goats). Sedentary herd of each species was chosen for the monitoring; the cattle herd consisted of 22 heads of zebu Fulani breed; the sheep flock had 25 heads, Sahelian breed and the flock of goats, Sahel type had 34 heads. The sheep flock followed was based in the village all seasons, while cattle and goat herds were moved by the herders in the "tiger" bush during the rainy season until the end of harvest to avoid damages to crop fields.

Monitoring the use of pasture

Pasture grazing by the three groups of livestock was investigated with the herders from the start of grazing until return to the camp. During the follow-up, watering points and different pasture units visited by all the three herds were geo-referenced, by using a Magellan GPS 300 to record geographical coordinates. The monitoring

lasted from May 2003 to June 2004 and each animal species was observed for three consecutive days per month. The whole period was divided into three seasons: rainy season (June to September), post-harvest season (October-January) and dry season (February to May) to reflect the change in forage availability.

Statistical Analysis

The data of vegetation inventory and the presence of species in each rangeland type were subjected to descriptive statistics analysis. Data on density of wood plants and herbaceous biomass production were subjected to analysis of variance, according to the generalized linear model of MINITAB program (Minitab, 2002): $Yi = \mu + \alpha i + ei$, where Yi: the dependent variable, αi : the mean, ei is the effect of pasture type and ei the residual term. The treatment means which showed significant differences at the probability level of $p < 0.05$ were compared using Tukey-Kramers's pairwise comparison procedures.

Results

Map of rangeland area

The area cover a surface of 5403,6 hectares (Figure 1). Fields and fallow (36,40%) represented an important part of the landscape. Agricultural areas covered mainly the central part of the region and around the habitats. The other units according to spatial importance were shrubby steppes (41.22%), woody steppes (10, 57%), the "tiger" bush (8,40%) and lowland (3,24%) (Table 1).

Characteristics of different types of rangeland

Botanical composition

In total, seventy-two (72) species grouped in 17 families were identified. Pasture plants diversity increases from woody steppe pastures (24 sp.) to lowland pastures (49

Table 1 - Spatial importance of different rangeland types.

TYPES OF PASTURE	SURFACE (HA)	PROPORTION (%)
Cropland	1967,41	36,41
Woody Steppes	571,26	10,57
Shrubby Steppes	2227,56	41,22
Lowlands	175,42	03,25
Tiger Bush	453,24	08,39
Total	5403,58	-

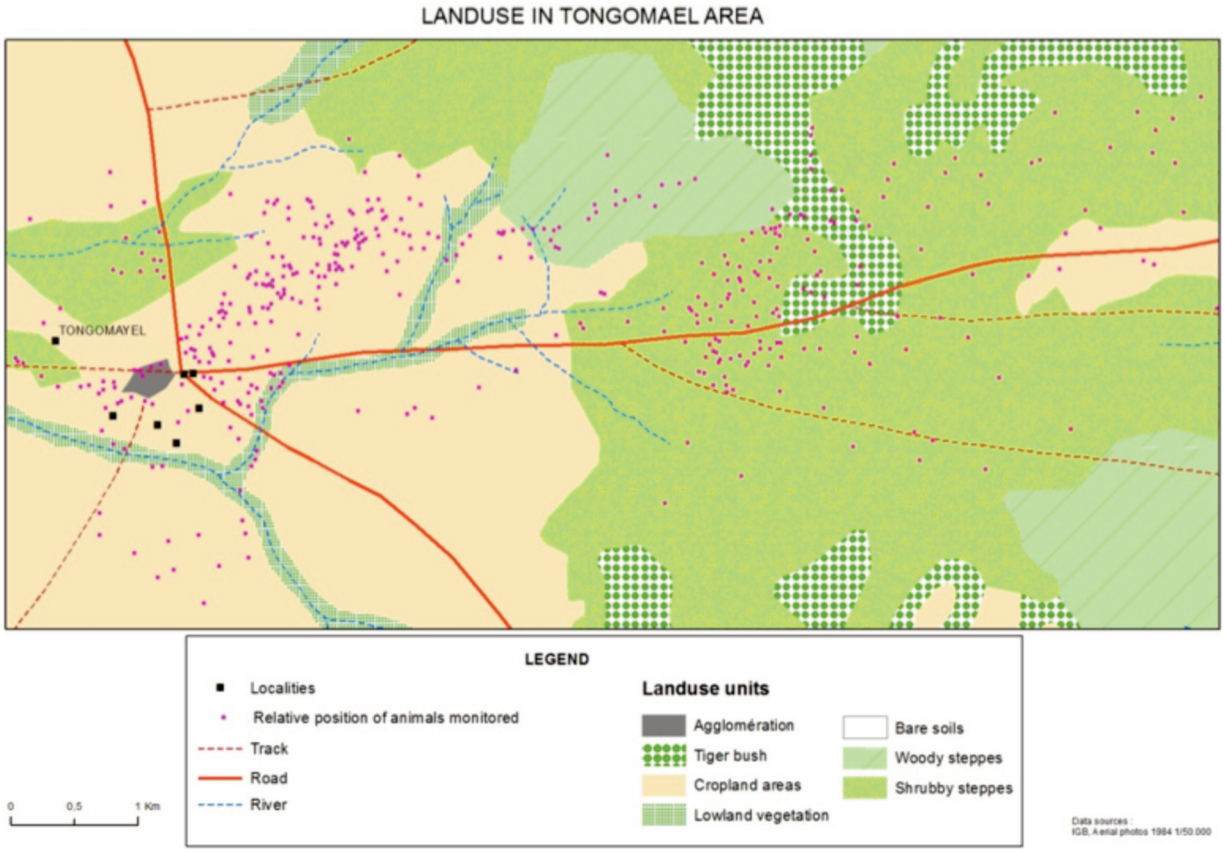

Figure 1 - Map of pasture types in Tongomayel area with the extent and limits of the different types of grazing land.

sp.). *Panicum laetum* was dominant in lowland (table 2); *Microchloa indica*, a small grass was abundant in the "tiger" bush; and in the steppes, *Zornia glochidiata* and *Brachiaria sp.* were the most common species.

The number of woody species identified was low in the shrubby-steppe rangeland (15 sp.), which also had the lowest density of trees and shrubs (222 plants / ha) (Table 3). High woody species diversity was found in lowland rangeland with 35 species. In the "tiger" bush was found the highest plant density (1590 p / ha). *Guiera senegalensis* was the dominant species in lowlands; *Pterocarpus lucens* was more present in "tiger" bush and *Acacia senegal* abundant in woody steppes.

Table 2 - Pasture plant diversity, specific frequency and degree of palatability in each area.

Pasture types	Number of species	Dominant species	Biological form*	Specific contribution	*Degree of palatability* **
Lowland	49	*Panicum laetum*	AG	10,19	D
		Digitaria horizontalis	AG	8,37	D
		Eragrostis aspera	AG	8,37	Ic
		Cassia mimosoides	Le	8,24	Ic
		Setaria pallide-fusca	AG	8,07	D
Tiger bush	36	*Microchloa indica*	AG	28,19	Ic
		Panicum laetum	AG	13,10	D
		Zornia glochidiata	Le	12,69	D
		Setaria pallide-fusca	AG	7,06	D
		Eragrostis tenella	AG	3,84	Ic
Croplands	35	*Eragrostis tremula*	AG	28,09	D
		Digitaria horizontalis	AG	19,10	D
		Ludwigia sp.	*OS*	5,54	Iv
		Alysicarpus ovalifolius	Le	3,29	D
		Cenchrus biflorus	AG	3,29	D
Woody steppes	33	*Zornia glochidiata*	Le	28,53	D
		Brachiaria sp.	AG	21,36	D
		Schoenefeldia gracilis	AG	8,27	Ic
		Aristida adscensionis	AG	6,84	Ic
		Dactyloctenium aegyptium	AG	5,80	D
Shrubby steppe	24	*Zornia glochidiata*	Le	26,00	D
		Brachiaria sp.	AG	16,28	D
		Panicum laetum	AG	8,54	D
		Dactyloctenium aegyptium	AG	7,96	D
		Cassia torra	Le	7,01	Iv

** AG: annual grass; Le: Legumes; OS: others species.*
*** according to the succession theory of Dyksterhuis (1949),D: decreaser; Ic: increaser; Iv: invader*

Pasture productivity

Pasture biomass in different rangeland types varied from 1251 kg / ha in "tiger" bush to 4271 kg /ha in lowland (Table 4). Shrubby and woody steppes showed intermediate productions. Considering the area of different rangeland types, the theoretical carrying capacity of the area reached 1501,4 TLU / year based on pasture production.

The highest crop residues yields were got with millet and sorghum straws, 2832 and 3424 kg DM/ ha respectively. The legume residues, usually richer in nutrients had low yields, 1163, 1127 and 535 kg DM / ha respectively for cowpea, groundnut and Bambara groundnut haulms. Taking into account the area cropped with these species, a potential production of 195,4 tons was recorded for all these residues, which could supported an animal charge of 3104 TLU/year or about 4725 TLU during the 8 months of dry season.

Table 3 - Woody species diversity and density per rangeland types.

Types of pasture	Density*	Number of species	Dominant species	Contribution (%)	Farmers' preference**
Lowland	1051 (66)[ab]	35	*Guiera senegalensis*	46,91	I
			Combretum micranthum	17,89	LI
			Balanites aegyptiaca	13,32	I
			Combretum aculeatum	9,99	LI
Tiger bush	1590 (283)[b]	25	*Pterocarpus lucens*	28,71	I
			Combretum micranthum	15,79	LI
			Boscia senegalensis	14,36	LI
			Grewia flavescens	13,36	LI
Shrubby steppe	222 (67)[a]	15	*Balanites aegyptiaca*	61,71	I
			Acacia nilotica	10.36	LI
			Guiera senegalensis	9,01	I
Woody Steppe	517(186)[a]	27	*Acacia Senegal*	21.28	I
			Boscia senegalensis	17,99	LI
			Balanites aegyptiaca	9,48	I
			Pterocarpus lucens	8,70	I

** : mean and standard deviation*
[a,b] : mean in the same column with different superscript are significantly different, p<0.05
***: I= important; LI = less important*

Rangeland utilization trend

The grazing system was regulated by herders, especially during the rainy season when the animals were under their control. The herders set temporary camps far from cropping areas in the "tiger" bush. Cattle exploited pastures of steppes, tiger bush and lowlands, walking a distance of 8-14 km per day. Goats mainly used "tiger" bush, where herders harvested leaves of fodder trees (*Pterocarpus lucens, Grewia bicolor, G. flavescens*, ...) to make them available to their animals. The flock of sheep grazed on pastures of shrubby steppe and lowlands nearby the villages in the rainy season, under the care of children. The watering of all herds took place in temporary water points traditionally dug by farmers in the area.

During the post-rainy season, after the crop harvest and collection of all legume residues and some residues of millet and sorghum by farmers for conservation, herders of cattle and goats move in the fields. All the animals grazed these crop residues and weeds, then gradually as the availability decreased, the livestock was moved to other areas. Goats quickly moved to "tiger" bush rangelands where browse species began to lose their leaves and fruits / pods. The temporary water points not yet dried and small wells dug were used by farmers for watering.

During the dry season, there was a considerable reduction in herbaceous forage availability as well as browse fodders. The herders of cattle while targeting areas where

Table 4 - Currying capacity and theoretical animal stocks per rangeland types.

	PRODUCTION (KG MS/HA)	CC (TLU/HA/YEAR	SUPERFICIES (HA)	THEORETICAL ANIMAL STOCK (UBT)
PASTURE TYPES				
Lowlands	4271[a]	0,66	175,42	114,950
Shrubby Steppe	3061[b]	0,47	2227,56	1046,134
Woody Steppe	2890[b]	0,44	571,26	253,296
Tiger Bush	1251[c]	0,19	453,24	86,993
CROP RESIDUES				
Millet	2832	0,43	4542	10465,44
Sorghum	3425	0,52	1520	2895,24
Cowpea	1163	0,31	769	2513,07
Groundnut	1128	0,30	230	774,41
Bambara groundnut	535	0,14	206	1460,99

[a,b,c]: means in the same column with different superscript are significantly different, p<0.05

there was still some fodder available, avoided the animals to walk long distances as they were very weak at that time. The cattle herd received in the morning cereal straws before going to pastures. The herders of goat and sheep shook trees especially of the genus Acacia (*senegal*, *seyal*) shedding pods for their animals. "Tiger" bush and lowland rangelands had some residual grasses, leaves, litter and pods still available and were grazed further. At this time *Guiera senegalensis* was much sought because of the leaves and dry fruits as well as the regrowth of green leaves after the stems have been cut by herders. The animals were watered from wells dug-out or boreholes in the village.

Dynamics of pasture production in different rangelands

The seasonal dynamics of herbaceous biomass resulted in a continual decline in biomass after the period of maximum production, more stress in some pasture types than the others (Figure 2). Yet in late November residual plant biomass in "tiger" bush pastures was significantly reduced, resulting in premature stopping of the measurements. In the lowlands, herbaceous production recorded was significantly lower in November than that of October, which was also lower than in January. The same trend was observed in shrubby steppes pastures. In woody steppe the decrease was much more pronounced in January.

A biomass decrease rate of 76% was recorded in the lowland (table 5) between October and January indicating a speed of 22.1 kg DM / ha / day. Residual biomass

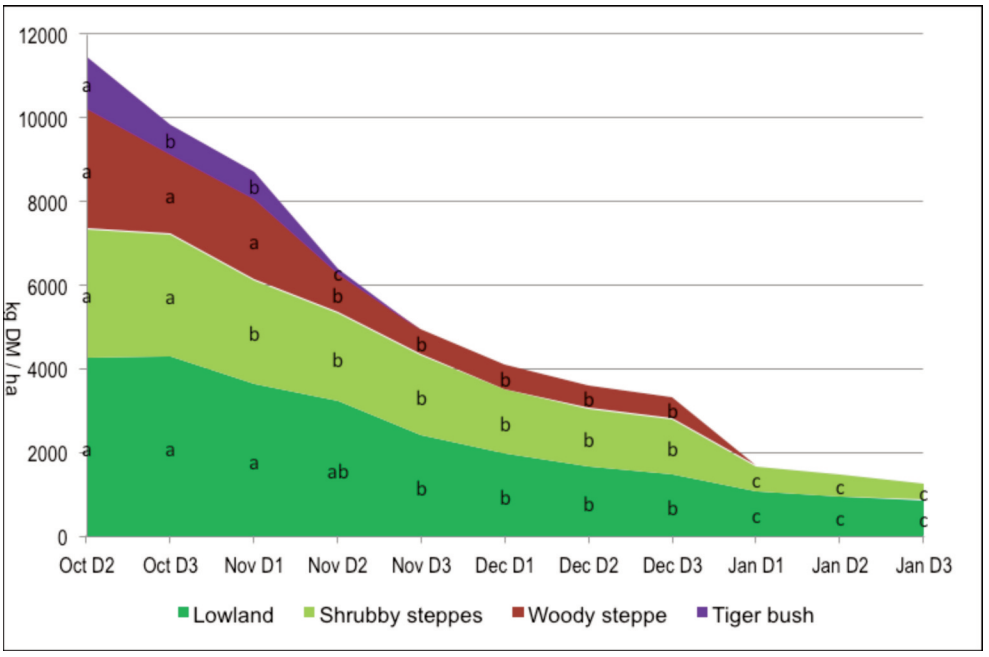

Figure 2 - Evolution of herbaceous pasture biomass in different rangeland types (D=decade) (a,b,c: Means of biomass in same rangeland unit with different letters are significantly different, p<0,05).

recorded in late January in shrubby steppe corresponded to a decrease rate of 83% compared to the optimal production, with a speed of 13.6 kg DM / ha / day. In December, more than 80% of the biomass was finished in the woody steppes, with a speed of 11.7 kg DM / ha / day. "Tiger" bush pastures with lower production and exploited intensely during the rainy season, known high speed of biomass decline in November, 13.04 kg DM / ha / day, corresponding to a decrease rate of about 88%.

To sum up, residual herbaceous biomass in late January was only about 1/5th of the maximum production. Hence there is a need to make rescue to other resources or techniques to improve forage production for maintaining livestock during the dry season.

Discussion and conclusions

General characteristics of the rangelands

The studied rangelands are part of the types described by Zoungrana (1991) and Sanon et al. (1995). Shrub-steppes and woody steppes types are similar to pastures of sandy soils and silt sandy soils respectively. The difference in herbaceous and woody

Table 5 - Decreasing rate of pasture biomass (%) in comparison to the maximum biomass.

Types of pastures	November	December	January
Lowlands	39,13	59,49	76,07
Shrubby Steppe	22,98	38,30	83,15
Woody Steppe	70,98	82,66	-
Tiger Bush	87,85	-	-

plant diversity according to rangeland types may be due to the varied environmental conditions such as soil factors, level of humidity and soil depth. The heterogeneity of the Sahelian environment, which results in plant diversity and different pasture productivity, in addition to the inter-annual variability of rainfall, is stressed by several authors (Grouzis, 1988; Penning and De Vrie Djiteye, 1991; Zoungrana, 1991). Beside, human activities could also have an influence; and physiognomy of shrub-steppe could be the result of shifting cultivation and selective cutting of trees; hence the specific poverty of woody flora and the low density of plants.

The predominance of annual grasses in all pasture types is characteristic of Sahelian pastures as highlighted by Grouzis (1992). The high plant diversity and production in lowland pasture could be explained by the favorable soil conditions in this environment. Indeed, these lowlands would benefit from water and organic matter runoff from slopes; and Breman and de Ridder (1991) estimates that the amount of water seeped into this unit is 25% greater than the rainfall. The low biomass production observed in the "tiger" bush can be explained in part by the structure of this vegetation type, which has a specific characteristic marked by the dominance of woody plants and a pattern of alternating bare soil strips, acting as impluvium (collection basin of rainwater and runoff) with linear and dense thickets following the contours, and perpendicular to the direction of the gentle slope (Hiernaux & Gerard, 1999). The floristic composition dominated by *Microchloa indica*, an annual grass of low productivity and compactness soil influence also the production. In addition, this unit is used extensively in rainy season as it is animals' sanctuary during this time. The pastoral interest of this unit relies on the browse woody species (1590 plants/ha). Likewise, Hiernaux and Gerard (1999) report high productivity of "tiger" bush in terms of browse production with 689-2094 kg DM/ha depending on the sites. Similarly, Sanon *et al.* (2007b) studying the production of browses accessible to animals of three species representing 29% of woody plants population in this rangeland, found 972 kg DM/ha.

Rangeland utilization trend

The modes of pasture grazing by different herds point two key strategies: the removal of animals from cultivated areas to avoid crop damage, and the use of feed resources available in time and space. During the post-rainy season, livestock return in cropped areas is fundamental because the fields benefit from dung left by animals as organic fertilizer. Hence crop-livestock integration is well practiced in the area and could contribute to the intensification of the agro-pastoral productions (personal communication).

Dynamics of pasture production in different rangelands

In general, most of the works on vegetation dynamic deal with interannual variations in production or botanical composition (Cissé, 1986; Herrmann et al, 2005). The biomass curves shows biomass decreasing faster as the annual production of the unit is low ("tiger" bush and woody steppe), but also in relation with the intensity of exploitation during the rainy season. Of course during rainy season the most frequented grazed pastures are "tiger" bush and woody steppe only. During this season, as it is animal's sanctuary around these units, the intensity of grazing increase and aggravated depletion of forages. It is also found in lowland some sites where the grasses are mown for hay making, or *Andropogon gayanus* is cut to get straw (straw mat). These practices could be compromising for vegetation of heavy utilized areas, leading to degradation over the long period. These findings are comparable to those reported by George (1998) in arid savanna in Kenya, where utilization rates (comparable to loss of biomass in pastures) of 53.5 to 85.3% were found on sites grazed excessively.

However, some authors endorsed that the biomass production in pastures dominated by annual species decreases rapidly after the end of the growing season, due to the dispersion of seeds that may constitute up 25% of the plant biomass at maturity (Cissé, 1986; Grouzis, 1988; Fournier, 1991). A part from animals foraging, there is senescence (biological ageing) of herbaceous plants that are mostly annuals and the losses caused by the wind, the primary consumption of termites or other insects and livestock trampling.

Generally, the high rate of biomass decrease indicates that extensive grazing exerts considerable pressure on herbaceous biomass in this ecosystem. Indeed, large herds went to transhumance to the wetter areas, while the herds of small size (less than 30 cattle) remain in the area year round. The rapid pasture biomass decrease confirms that grazer animals will more suffer fodder deficit compared to browsers in the dry season. As consequences, ruminants (cattle, sheep and goats) obligated to change in diet by consuming more browses during this season (Sanon et al. 2007a). In

accordance with, Schlecht *et al.* (1999) reported that the feed consumption of cattle grazing Sahelian pastures is primarily limited by the availability of forages.

In conclusion, this study highlighted the heterogeneity of Sahelian pastures revealed by varied production and botanical composition. The use of different types of rangeland relies not only on fodder availability but also on strategies to avoid crops destruction by the animals. These strategies show the complementary of both crop and livestock activities that are well integrated in the study area. The herbaceous biomass dynamic indicate a quick decrease after the rainy season essentially due to the exploitation by animals. Therefore, herbivores exert considerable pressure over the herbaceous layer in this area and this exacerbates degradation in heavily exploited areas. There is a critical period in the animals foraging, starting from February when animals are more and more under famine compromising their survival in late dry season. The use of complementary feeds resources and intervention to improve sustainably forage productivity are essential for rescue sedentary livestock.

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