ISSN: 2230-9926

Available online at http://www.journalijdr.com

International Journal of DEVELOPMENT RESEARCH

International Journal of Development Research
Vol. 5, Issue, 07, pp. 5002-5008, July, 2015

Full Length Research Article

GOAT FORAGING ACTIVITIES IN RANGELAND IN HIGH CATCHMENT ZONE OF MANDRARE, SOUTHERN MADAGASCAR

*[1]Randrianariveloseheno Arsène, [1]Rakotozandriny Jean de Neupomuscène and [2]Daccord Roger

[1]Department of Animal Science, Agronomical Science High School, Laboratory of Animal Nutrition, PO Box 175 Antananarivo Madagascar
[2]Swiss Federal Research Station for Animal Production and Dairy Products, Agroscope Liebefeld Posieux, CH 1725 Posieux, Switzerland

ARTICLE INFO

Article History:
Received 28th April, 2015
Received in revised form
07th May, 2015
Accepted 21st June, 2015
Published online 30th July, 2015

Key Words:
Edible, browse,
Foraging, Goat,
Madagascar.

ABSTRACT

The edible forage resources were studied with Ruminants behaviour in the High Bassin zone of Mandrare in Southern Madagascar. Analysing the floristic components and goat foraging behaviour allowed determination of nutritive value, bite rate and preference ratio in rangelands. Sampled areas were monitored to record the floristic formation within calculated parameters such as species quality index, pastoral value and preference ratio. Using six selected adult goats within mix ruminants herd (cattle, sheep and goat), foraging behaviours were analyzed by sequential recording during two periods (early dry season and later dry season). Using Principal Component Analysis, four pasturelands groups were distinguished with dominant browse species such as *Acacia farnesiana*, *Poupartia caffra*, *Kigelianthe madagascariensis* and *Rhigozum madagascariense*. Floristic composition were characterized by lower densities with 392 ± 142 plants.ha^{-1}; with higher heterogeneity (1.04 ± 0.07) and Shannon – Weaver Index (0.43 ± 0.15; $p < 0.05$). Most of 43 identified species were available to animals with a higher nutritive value. *Acacia farnesiana* rangeland was dominated by shrubs with higher nutritive value, resulting in a higher bite rate and pastoral value, and was overgrazed. The relationships between phytosociology and nutritional parameters allow for improvement of range management and native rangeland restoration with autochthonous species.

INTRODUCTION

Floristic association between herbaceous and woody strata determines the rangeland type (Letouzey in Bellefontaine *et al*., 1997). Vegetation toposequential profiles are determined by physiognomic structure and ecological conditions (Boudet *et al*., 1989). In fact, some natural formations do exist in rangeland biomes such as savannas, shrublands, steppes, velds, tundras and forestlands. Most forage resources are exploited by herbivores in extensive management systems (Gilbert *et al*., 1968; ILCA 1975). The relationships between three pastoral components such as plant, animal and environment determine two levels of production: primary (forage resource) and secondary production (animal production). Primary production is assessed from the biological structure of the vegetation. The total biomass and the forage resources are determined by canopy cover particularly for the woody plants as mentioned by Ichowicz in Bellefontaine *et al*. (1997). The total biomass production depends on environmental factors such as light intensity, soil moisture and anthropological activities such as burning regimes. The dry matter production is influenced by agroclimatic conditions, while fires decrease the forage availability (Granier *et al*., 1968). The relationship between an exploitable biomass and animal size determines the browse forage quantity. In fact, canopy structure itself limits biomass accessibility. The exploitation rate varies between animal species. Below a height of 1.2 metres, 25% of biomass is accessible to small ruminants and below a height of 2 metres, 50% of biomass is available for large stock (Daget and Djellouli, 2002). In nutritional behaviour studies, many systemic and analytic methods can be considered in the light of our knowledge of herbivores' digestive processes (Van Soest 1982). Jamenson and Hodgson (1979) found an asymptotic relationship between forage resource and intake (forage density) and a quadratic relationship between plant height and intake rate (bites). In pasturelands, the foraging

***Corresponding author: [1]Randrianariveloseheno Arsène**
[1]Department of Animal Science, Agronomical Science High School, Laboratory of Animal Nutrition, PO Box 175 Antananarivo Madagascar

behaviour is determined by biomass forage resources (Meuret 1997; Delagarde *et al*., 2001) and the site environment and vegetation (Balent and Gibon, 1985, Bolibaker, 1989). In Madagascar, rangeland ecosystems represent an important vegetation type covering 34, 000, 000 hectares (70 % of Island surface). In southern zone, floristic composition is dominated by edaphic formation such as xerophyllous families such as Didieraceae and Euphorbiaceae (Cabanis *et al*., 1969) and characterized by shrubs and tree species in native rangelands (Koechlin *et al*., 1974). And livestock have an important place in agricultural activities. Especially with 90 % of national smallstock flock equivalent to nine hundred thousand (900 000) goats, small ruminants have socioeconomic and cultural value for smallholders. The relationships between plant and animal are subject to the forage resources available, both quantitative and qualitative, especially for ruminants (Toutain and Rasambainarivo, 1997). In pastoral zone, the diagnostic analysis provides a method for reseeding activity and restoring a pastoral landscape. In important pastoralism zone, to determine the impact of ruminant such as goat foraging behaviour on vegetation and managing ways is necessary to establish the sustainable use in environment function and to restore the foraging to a more productive state. The aim of this study was to describe the relationships between the vegetation of Ebelo-South Ambosary and a small group of browsing animals. This information can be helpful in determining good management practices for both the animals and the vegetation especially selecting autochthonous species for restoring native pasturelands.

MATERIALS AND METHODS

Study area

The study area is an intervention zone for an agriculture programme organized and funded by International Fund for Agriculture Development (IFAD). The region of Ebelo-South Amboasary is located at 24° 29' 0" South and 46° 2' 0" East. It covers an area of 300 km². This agro-ecological zone is suitable for pastoralism and ruminants such as cattle, sheep and goats are farmed here (PHBM, 2000). Most of topography is a located plain at a different altitude of 105 to 350 m above sea, with an area including the mountainous chain of Vohitsombe at 904 m. Included in the part of volcanic massif of the Androy, the cretaceous region contains two dominant geological types: basaltic streams and rhyolitic streams. The pedological formations are made up of four edaphic categories: complex lithosols and lower evolved soils from volcanic rocks; complex ferruginous soils; tropical ferruginous soils and low evolved soils and alluvial hydromorphic soils. The study area has a dry and subarid climate with temperatures between 15.6°C and 28.3°C and annual rainfall between 600 and 800 mm without drought (Besairie, 1972; Benzarti and Habaied, 2001; Bergaoui and Alouni, 2001).

Structural vegetation

In rangelands, some repeated and sampled surface monitoring quadrats (400 m^2) were used to determine the vegetation formation including vegetation cover, floristic density, species diversity, nutritive value and quality index of plant species (Hiernaux, 1980). Measuring the vegetation allows analyzing floristic parameters such as abundance, dominance and species probability (Burel and Baudry, 2000). The Shannon-Weaver index (H) was calculated with a combination of floristic such as Specific Contribution species i (SCi) and ecological structures as follows:

$$H = \sum_{i=1}^{n} SC_i \log SC_i$$

The maximum diversity determines the floristic richness with regard to total number of each plant species (S) and was calculated as:

$$H' = \log S$$

Animal training

In municipal zone, local smallholders with mix herds were involved selecting six adult and leader goat. The selected goats were identified by body size and colour. In rangeland, foraging behaviour was observed by sequential processes within five minutes per animal every thirty minutes. Foraging activities were described as browsing, ruminating, moving or resting (Bourbouze, 1981; Le Houérou, 1980; Meuret *et al*., 1985). During browsing activities, plant intake and bite number were recorded and analyzed in native pastureland for six successive days at two periods in two successive years during dry seasons. Observations and recording have been processed at the dominant foraging time from 08:30 to 11:00 and from 13:00 to 15:30.

Analyzing nutritional value

In monitored unit area, intake fodder species were sampled to evaluate the chemical composition which determines the forage nutritional levels, bite rate and goat foraging behaviour. During sampling, leaf and pod material weighing 1000g (fresh) from fodder plants were weighed, over dried at 60 °C for 72 hours, ground, and kept until process analysis could be done. Described by AOAC (1980), all chemical analyses were based on gravimetric methods to determine the following: dry matter by over drying at 103 ± 1°C during least 4 hours; mineral matter by incineration at 650°C during least 3 hours; total nitrogen by Kjeldhal method; Weende crude fibre content and Van Soest fractions such as Neutral Detergent Fiber by fibertec analysis and gross energy content by adiabatic calorimetry analysis with dispersed energy measurement during combustion in calorimetric bomb.

Vegetation use

In rangelands, forage resource availability and foraging behaviour were involved in a combined and calculated parameter within specific quality index, specific plant diversity and bite rate. This foraging ratio was corresponded to preference ratio (PR), determined to indicate the pastoral value, foraging selection. The preference ratio was calculated as follows:

$$PR = \frac{SC_{(regime)}}{SC_{(pasture)}}$$

Where

- SC_{regime} : Specific Contribution of plant species i in consumed forage;
- $SC_{pasture}$: Specific Contribution of plant species i in rangeland pasture;

Pastoral value (PV) was calculated within specific quality index and Specific Contribution of plant species i The Specific quality index is implied in specific abundance, bite rate and nutritive value. And the pastoral value was calculated as follows:

$$PV = \frac{1}{SI_{max}} \times \Sigma SC_i \times SI_i$$

With

- SI_m: maximum specific index in the permanent phytomass ;
- SI_i: specific quality index of plant i;
- SC_i : Specific Contribution of plant species i in rangeland pasture;

The specific quality index was calculated with the intake level throughout the palatability index (I_P) and the relative nutritive value of edible forage (I_e).

Statistical analysis

Two data groups were recorded such as the quantitative and the qualitative vegetation parameters in different pasturelands and goat foraging behaviour with nutritive value. Observed and calculated parameters were treated statistically using software statistical analysis (Statitcf, XLStat 6.0) which was involved in interfaces with MS Excel. The data was subjected to analysis of variance (ANOVA) tests to estimate the significant difference between variables or individual data. Principal Component Analysis (PCA) was used to establish rangeland typology within agroclimatic characteristics, botanical composition and foraging behaviour parameters. Within coefficient of determination r^2 value, linear regression allows establishing the relationships between vegetation compositions, pastoral value and foraging behaviour.

RESULTS

Floristic rangeland index

Rangeland types

The study found that rangeland areas are dominated by shrub species with 43 identified plants. 12% of species were characterized by spinescent species showing physiological and climatic adaptation. Using Principal Component Analysis (PCA) with biophysical and floristic parameters, four pasturelands groups were distinguished with regard to the dominant browse species, these being *Acacia farnesiana*, *Poupartia caffra*, *Kigelianthe madagascariensis* and *Rhigozum madagascariense*. The vegetation cover was characterized by a high variation in floristic density with 392±142 plants.ha^{-1} depending on altitude as follow as *Acacia farnesiana* in lowland; *Poupartia caffra*, *Tamarindus indica* and *Ziziphus mauritiana* in mid-altitude pastures; *Rhigozum madagascariensis* in highland pastures (Table 1). During the dry season, the rangeland cover value decreases without significant variation ($p < 0.05$). The local humidity and the accumulation of organic matter improve the available vegetation and biomass.

Shannon - Weaver Index

Following the environmental conditions, the rangeland groups were found to have a wide variation in diversity, according to the results of the Shannon – Weaver Index analysis (0.43 ± 0.15; $p < 0.05$). The relationship between altitude and floristic diversity results in high plant density and heterogeneity at lower altitudes. In lowlands, soil humidity increases the variation in the Shannon – Weaver Index as shown at period 2 (Figure 1).

Maximum diversity

In rangelands, maximal floristic diversity was varied without significant difference with 0.74 ± 0.12 ($p<0.05$). Among season variation and altitude particularly, floristic heterogeneity was higher during the wet season (first sampling period, Figure 2). During dry season, plants species availability had decreased to the extent that no significant difference was found between vegetation types ($p < 0.05$). *Acacia farnesiana* community has a higher diversity level (1.04 ± 0.07).

Table 1. Four vegetation rangeland groups in Ebelo, Mandrare high catchment zone in Southern of Madagascar

No	*Vegetation type*	*Vegetation composition*
01	*Acacia farnesiana*	*Acacia farnesiana, Adina microcephala, Ficus coccifolia, Physenia sessiflora, Antidesma madagascariensis, Mangifera indica, Secamone elliotti, Tamarindus indica, Salvadora angustifolia, Leucaena leucocephala, Mimosa delicatula, Panicum maximum, Hyparrhenia rufa., Terminalia boivini.*
02	*Poupartia caffra and Kigelianthe madagascariensis*	*Poupartia caffra, Kigelianthe madagascariensis, Ziziphus mauritiana, Secamone elliotti, Gonocrypta grevei, Albizzia boivini, Grewia lavanalensis, Grewia romboïdea, Azina tetracantha, Alluaudia procera, Didiera grandidieri, Flacourtia indica, Cedrelopsis grevei.*
03	*Poupartia caffra and Tamarindus indica*	*Poupartia caffra, Tamarindus indica, Adina microcephala, Ziziphus spina christa, Maerua nuda, Apoxylon madagascariensis, Poivrea coccinea, Tridax procumbans, Opuntia ficus indica., Albizzia polyphylla.*
04	*Rhigozum madagascariensis*	*Rhigozum madagascariensis, Ziziphus mauritiana, Kigelianthe madagascariensis, Asparagus shumanianus, Opuntia ficus indica, Mangifera indica, Grewia grevei, Acacia delicatula, Grewei romboîdae, Thilachium pouponii, Gymnosporia divaricata, Cedrelopsis grevei, Ziziphus mauritiana, Alluaudia procera, Diospyros tropophylla, Terminalia boivini.*

In rangelands, the leaves and twigs have a high nutritive value with: variable Dry Matter (DM) content 14 to 66%; variable Crude Protein between 82 and 227 g DM kg^{-1}; Crude Fibre 144 to 488 g DM kg^{-1} and gross energy between 3367 and 4998 kcal DM kg^{-1}. The sampled fodders were classified into 5 nutritional groups according to gross energy Most of shrubs species had higher energy content ($p < 0.05$; Table 3).

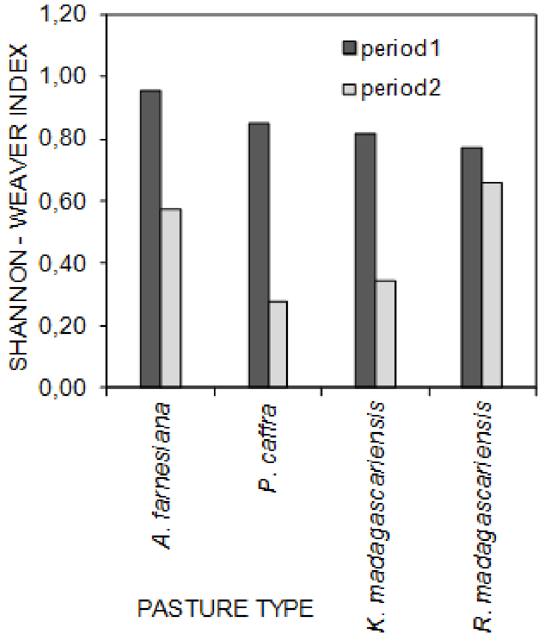

Fig. 1. Shannon - Weaver diversity index variations in four pasture types

biomass resources, the rangeland formation and the nutritive value of the forage species.

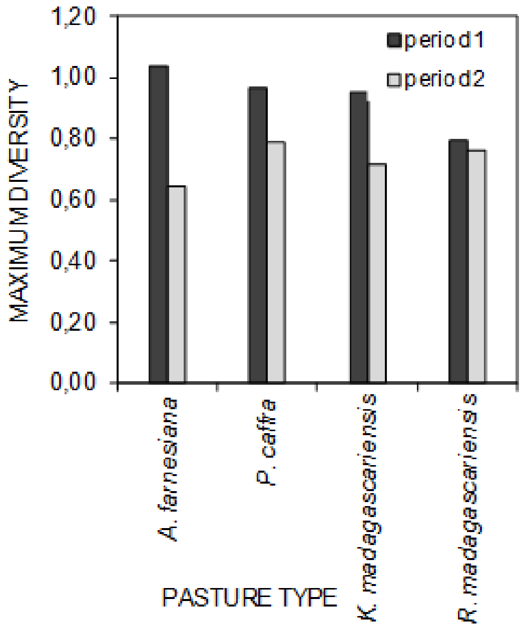

Fig. 2. Maximum diversity of pastoral area type in two periods

Table 2. Preference ratio PR in the vegetation group of fodder species

Group	PR %	*n*	CV %	Species
1	51 (43 – 57)	6	10.0	*Rhigozum madagascariensis, Opuntia ficus indica, Ziziphus mauritiana, Tamarindus indica, Acacia farnesiana, Poupartia caffra*
2	18 (15 – 22)	8	13.8	*Poivrea coccinea, Ficus coccifolia, Secamone elliotti, Apoxylon madagascariensis, Lemnitera racemosa, Azima tetracantha, Gymnosporia divariacata, Mangifera indica*
3	9 (7 – 13)	9	14.4	*Gonocrypta grevei, Kigelianthe madagascariensis, Albizia boivini, Asparagus shumanianus, Grewia lavanalensis, Psilotrichum madagascariensis, Antidesma madagascariensis, Pegoletta senegaliensis, Plectaneia elastica*
4	2 (1 – 5)	9	12.4	*Ziziphus spina christa, Rhopalocarpus madagascariensis, Maerua nuda, Tridax procambans, Boherhavia diffusa, Heteropogon contortus, Mimosa delicatula, Leucaena leucocephala, Gaertnera macrostipulata*
5	0	11	0	*Alluaudia procera, Cedrelopsis grevei, Acacia, Physenia sessiflora, Acacia angustifolia, Albizia polyphylla, Mimosa delicatula, Flacourtia indica, Didieri grandidiera, Terminalia boivini.*

(minimum – maximum); *n* number of species in the group; CV Coefficient of Variation %.

Table 3. Chemical composition of fodder species group

Group	n		DM	MM	CP	CF	NDF	GE
			%	g DM kg^{-1}	g DM kg^{-1}	g DM kg^{-1}	g DM kg^{-1}	Kcal.DM kg^{-1}
1	14	Average	54±10	70±16	175±40	376±72	548±95	4464±323
		CV(%)	18	22	23	19	17	7
2	7	Average	42±17	52±18	124±33	203±40	424±66	4439±259
		CV(%)	42	35	27	20	15	6
3	11	Average	49±14	85±21	171±33	289±55	471±89	4335±298
		CV(%)	28	25	20	19	19	7
4	8	Average	36±10	94±24	149±55	219±78	376±63	4102±255
		CV(%)	29	25	37	36	17	6
5	7	Average	35±15	162±46	157±45	209±47	388±79	3617±348
		CV(%)	42	29	28	23	20	10

DM Dry Matter; MM Mineral Matter; CP Crude Protein; CF Crude Fibre; NDF Neutral Detergent Fibre; GE gross Energy; sd standard deviation; CV Coefficient of Variation

Pastoral and foraging index

Preference ratio

During monitoring period, a number of plants of each species (43) were identified and involved in browsing activities rhythms (Table 2). The preference ratio is related to the

The fodder species were classified into five groups. The first group includes the most browsed forage species with the highest preference ratio of 51.0 % without significant variation. The second rangeland group containing *Azima tetracantha* and *Kigelianthe madagascariensis* is located in sandy and ferruginous soils. The fodder species are more available than forage found in lower altitude with mean preference value and mean variation of 18.0 %. In third group, the vegetation has some forage value with low accessibility with preference ratio value such as 9.4 %. The vegetation occurs in the lower altitude pastoral area and *Adina microcephala*, *Mangifera indica* and *Apoxylon madagascariense* are greatly consumed during the dry season. The fourth group was dominated by the Mesophanerophyts species and was the least browsed. Towards the end of the dry season, the plants were the least selected and the preference ratio value was lower as mentioned (2.5 %). The fifth group contained the least palatable species and were browsed the least. Some species were unpalatable or even refused plants such as Legumes and Didieraceae. In addition, the species in this group have a low availability while other plants present some difficulty in accessibility.

Pasture value

The forage biomass study indicates important plant species in different phenological stages (foliage, flowering, fruit period). Following altitude, the pastureland in low altitude present high pastoral value (24.7 %; rsd = 5.6) because the soil characteristics are marked by a humidity, an accumulation of organic matter. The pastureland of the slums have a high pastoral value (24.7 %; rsd = 5.6) which decreases in 12.6 % (rsd = 5.1) towards the end of the rainy season. During dry season, the rangeland pastoral value decreases without significant variation in $p<0.05$ Using abundance resources and biomass accessibility, the intake determination was described by relationship between bite rate and pastoral value found during the recording period in 12 rangeland types grouped into 4 vegetation types (Figure 3).

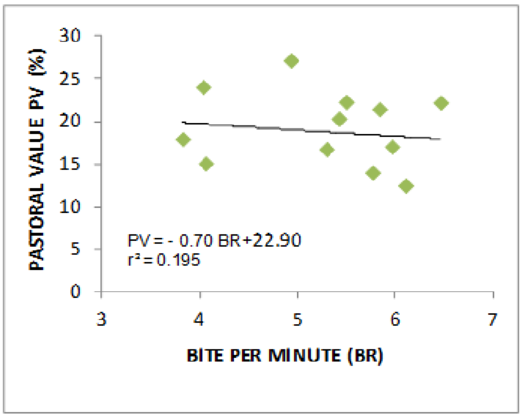

Fig. 3. Relationship between pastoral value (PV) and bite rate (BR)

All vegetation types were characterized by high species diversity. *Acacia farnesiana*- vegetation type dominated rangeland was heavily browsed with 2476 to 3292 daily bites. Intake rhythms were recorded with some variation ($p<0.05$) according to availability of vegetation and to herd management in pastoral area. Walking less significantly increases the bite rate for small ruminants ($p < 0.05$).

DISCUSSION

Floristic variation depends on altitude and favourable edaphic conditions for improved physiological adaptation according to Cabanis *et al*. (1969); Koechlin *et al*. (1974) and Le Houérou (1980). The rangeland environment has a high floristic richness and some floristic diversity. Consequently, the foraging herbivores are stimulated by quantity and quality of biomass resources. As mentioned, the browse pasture shows a lower value of heterogeneity using the Shannon – Weaver index (0.24 to 0.94) compared to the results (2.80 to 3.48) found by Rakotoarimanana (2002) in the savannah pasture zone in the South West of Madagascar, where the local conditions are more favourable (humidity and soils in particular). The pastoral areas have a lower floristic diversity (between 0.76 to 1.04 in period 1 and 0.65 to 0.72 in period 2) than diversity in Morocco by Aafi (2000; 3.46 with 17 identified species). Among other factors, the floristic diversity is influenced by the season (Wilson, 1978). The biology, structure and physiological adaptation of the plants are determined by the climatic environment (Cabanis *et al*., 1969). The climate stress determines the floristic component with a decrease in species number between *Acacia farnesiana* and *Rhigozum madagascariensis* rangeland types. With shrub forages, the herbaceous species are often not selected, resulting in the animals being in poorer condition and causing a negative impact on the woody species (Akpo, 1998).

Analysis of the chemical composition of the fodder species showed significant differences in nutritional content such as 14 – 66% Dry Matter (DM); Crude Protein: 82 – 227 g DM kg^{-1}; Crude Fibre: 144 – 488 g DM kg^{-1} and gross energy: 3367 – 4998 kcal DM kg^{-1}. According to Houérou (1980) and Graffam *et al*. (1998), dry matter content in forage tree leaves is relatively variable. The relationship between biophysical structure and nutritive value contributes to improved dry matter intake and a decreased bite rate. The browse species have a higher nutritive value than the shrub species as the results for gross energy, crude protein and crude fibre show (Table 1). According to ecological conditions and soil organic matter content, mass of dry matter content in the leaves of fodder trees was relatively variable as mentioned by Houérou 1980, Graffam *et al*. 1998 and Delagarde *et al*. (2001). In fact, photosynthesis was influenced by bio-availability of the nutritional elements for plants species. There is a relationship between leaf area, trunk cross-section and the rainfall regime especially in tropical pastureland (Fournier 1995). With vegetation type and variation in climate, the woody forages have high cell wall contents. In particular, the water limitations and ecological conditions determine the fibre content, causing accelerated lignification (Kone *et al*., 1989).

Compared to the results found by Skerman, Skerman and Cameron (1988) and Skerman (1990), the gross energy content of sampled fodder plants was higher than those of other tropical forages. The vegetation types were also characterized by forage species with variable mineral content. Pedological factors such as soil fertility are also involved in relationships with the metabolic activities of plants and soils (Le Houérou 1980). Apart from floristic succession, the fodder accessibility is determined by the vegetation structure. The results show that the bite rate value of 1 to 9 bites per minute was lower than rates found in grassland by Dicko – Touré (1980) with 57 bites per minute and by Bocquier *et al*. (1987) versus 50 to 75 bites per minute. Browsing and intake are determined by the plant height, which is different between grasses and browse species. The canopy cover and floristic density are the main influencing factors for ruminants when selecting forage species (Wilson, 1978). Foraging behaviour is affected by the floristic density and distances between shrub and browse species. Herbivores must cover greater distances to find edible biomass in woodlands where the vegetation is of a lower nutritional value. This decreases the number of bites per minute as found by Wilson and Harrington (1980) and Van Soest (1982).

As mentioned by Mkhize *et al*. 2014, phenological stage did not appear to affect the fodder intake. In interactions between rangeland type and phenology, the bite rate was higher during the period of maximum biomass resource. Daily bite rate increased during the wet season and the beginning of dry season. A decrease in the average intake speed was observed in the less accessible pastoral areas such as *Poupartia caffra* and *Kigelianthe madagascariensis* rangeland types but the ruminants increased their time spent on foraging activities. Intake rates decreased when leaf width and fibre content increase (Meuret 1997). The preference ratio decreased with increasing numbers of unpalatable species in browse plants containing substances such as alkaloids, mimosin and tannins as mentioned by Bruneton (1999). These secondary metabolites can be used to distinguish between selected and refused forage as they decrease palatability (Devaux 1973, Meuret 1997). In fact, secondary substances reduce the browse quality and are synthesised and favoured by climatic conditions such as arid and subarid environments (Wilson, 1978). The rangeland ecosystems have a higher pastoral value during the leafing stage and where there are high quality fodder species (Rippstein 1989). Rangeland pastoral value is lower than savannas formations with poor cover (Rakotoarimanana 2002).

Conclusions

Goat foraging behaviour processes were considered as referential activities for Ruminants in pasturelands. Abiotic and biotic investigations can be used in the study of the forage resource factors. Diachronic method was involved in analytical and systematic approaches to clarify the relationships between animals and plants in pastoral areas. Goat foraging was characterized by shrubs species in pastureland different types. Agroclimatics and pedological factors have influenced the rangeland used by ruminants such as goat behaviour. Foraging satisfaction implied goat production to use higher nutritive species. With high pastoral value, goats tend to decrease the intake rate and the activities rhythms in pasturelands. In lower altitude areas, high forage availability corresponds to a high bite rate and to decrease total foraging duration. Consequently, resources forages have influenced ruminants foraging behaviour which were characterized by lower kinetics intake rate with lower floristic availability. And, specific availability have implied in foraging satisfaction and rangelands use. In fact, vegetation resource, pedoclimatic function and ruminant flock moving have determinate the relationships between animal and plant in forage system for sustainable development. Ensuring the resource stability and adaptation of climate changes, abundant autochthonous species are involved to improve rangeland conditions, to restore natural pastureland and to manage the forage resources.

Acknowledgements

Authors greatly acknowledge International Fund for Agriculture Development (IFAD) Programme in Madagascar and farmers and smallholders for assisting and monitoring plant species.

REFERENCES

Aafi, A. 2000. Floristic diversity in Pinus ecosystem (*Abies marocana* TRAB.) (Takassentane National Park). *Wildlife and Nature. FAO / UNEP - Int Rev. Nature case in Africa. 16*(1): 15–19.

Akpo, L. E. 1998. Tree effects on herbaceous vegetation in some phytocenoses in Senegal. Climatic variation according to climatic gradient. *Dissertation Thesis for third cycle - Faculty of Sciences and Technics – University of Cheink Diop Dakar*. 133 p.

AOAC 1980. Methods of analysis of the Association of Official Analytical Chemists. *Thirteenth edition - AOAC* - pp. 125 - 142.

Balent, G. and Gibon, A. 1985. Goat and livestock intake measurement in grassland outside experimental site in Pyrenees Centre. *Research Paper - CIRAD - DSA*. pp 312–319.

Bellefontaine, R., Gaston, A. and Petrucci, Y. 1997. Planning of natural forests in dry tropical zones. *FAO – Conservation paper 32.* www. fao . org / doc rep.

Benzarti, Z., and Habaied, H. 2001. Survey of drought persistence in Tunisia by using of Chestnut Chains. (1909–1996). *Sécheresse. 12*(4): 215–220.

Bergaoui, M., and Alouni A. 2001. Characterization of meteorological and hydrological drought. *Sécheresse. 12*(4): 206–213.

Besairie, H. 1972. Geology of Madagascar. I- Sedimentary lands. *ORSTOM-XXXV*. 463 p.

Bocquier, F., Theriez, M., and Brelurut, A. 1987. Food recommendations for sheep in lactation. *Bull. Tech. INRA - CRZV Theix, 70*, pp 199–211.

Bolibaker, B. A. 1989. Sheep foraging behaviour in *Acacia cyanophylla* system. *Proceeding of the XVth International Grassland Congress, INRA*, pp 1563–1564.

Boudet, G., Gaston, A. and Mekigout, P. and Roy, F. 1989. Sampling vegetation by aligned point-centred quadrants and multivariable analysis for pasture value assessment in native sahelian grasslands. *Proceeding of the XVIth International Grassland Congress – INRA,* pp 1431–1432.

Bourbouze, A.1981. Native grasslands using in different production system. *Symposium International, ITOVIC – INRA,* pp 429–457.

Bruneton, J. 1999. Toxic plants. Dangerous plants species for man and animal. *Tec. and Doc*, *3rd.,* 529 p.

Burel, F. and Baudry, J. 2000. Landscape study: concepts, methods and practices. *Tec. and Doc 2nd ed.,* 359 pp.

Cabanis ,Y., Cabanis, L. and Charbouls, F. 1969. Vegetation and vegetation groups of Madagascar and Mascareignes. *Tome I.* 389 p.

Daget, P. and Djellouli, Y. 2002. Ecoclimatic approach for pastoral potentiality in Sahelian Region. *Sécheresse, 3*(2) : 73–79.

Delagarde, R., Prache S., D'hour P. and Petit, M. 2001. Fodder intake for Ruminants in grasslands. *Fourrages, 166*, pp 189–212.

Devaux, C. 1973. Toxic plants or famous toxic for livestock in Western Africa. *Livestock and Veterinary Medecine Review in Tropical Country –IEMVT, Agrostology Service.* 148 p.

Dicko – Touré, M. S. 1980. Measuring the secondary of pasture and applied example in the study of an extensive production system in Mali. *Proceeding of the International Symposium on the Browse in Africa,* pp 247–253.

Fournier, C. 1995. Hydric fonction of six co-existent browses species in Sahelian savannas (Ferlo Region Northern Senegal). *Mission and Document. ORSTOM*, *132,* 165

Gilbert, J., Capitaine, P. and Serres, H. 1968. Blow pigs experience in grasslands. *Livestock and Veterinary Medecine Review in Tropical Country -IEMVT,* 21(2): 219–225.

Graffam, W., Dierenfeld , E. S., Pattilo G., and Bass, L. 1998. Evaluation of eight species of native Texas browses as suitable forage substitutes of Black Rhinoceros (*Diceros bicornis*). *Nutrition Department - Wildlife Conservation Society. Bronx, NY.* 8 p.

Granier, P., Lahore, J. and Dubois, P. 1968. Native grasslands in Madagascar: productivity, real practices. *Livestock and Veterinary Medecine Review in Tropical Country –IEMVT, 21*(2): 203-217.

Hiernaux, P. 1980. Inventory of the browse potential of bushes trees and shrubs in an Area of the Sahel in Mali: method and initial results. *Proceeding of the International Symposium on the browse in Africa, ILCA*, 197-203.

ILCA 1975. Monitoring and cartography of African tropical grasslands. *Acts of seminar – Bamako / Mali –* 399 p.

Jamenson, W. S., and Hodgson, J. 1979. The effects of daily herbage allowance and sward characteristics upon the ingestive behaviour and herbage of calves under strip grazing management. *Grass and Forage Science, 34*, 261–271.

Koechlin, J., Guillaumes, J. L. and Morat, P. 1974. Flora and Vegetation of Madagascar. *ORSTOM, CRAMER.* 645 p.

Kone, A. R., Richard, D. and Guérin, H. 1989. Cell wall content and crude protein of browses species in Central Africa. *Proceeding of the XVIth International Grassland Congress / INRA*. 947–948.

Le Houérou, H.N. 1980. Browse in Africa. The current state of knowledge. *Proceedings of the International Symposium on the Browse in Africa –ILCA,* 491 p.

Meuret, M. 1997. Foraging intake of Small stocks in rangelands and under woods grasslands. *Anim. Prod., 10,* pp 391–401.

Meuret, M., Bartiaux, N. and Bourbouze, A. 1985. Foraging assessment of herd dairy goats in forest pasturelands. Direct recording methods of bite rate - Scorer oxidize chromium methods. *Ann. Zoot., 32*(2): 159–180.

Mkhize, N. R.., Scogings, P. F., Nsahlai, I. V. and Dziba, L. E. 2014. Diet selection of goats depends on season: roles of plant physical and chemical traits. *African Journal of Range and Forage Science*, 31 (3): 209 – 214.

PHBM, 2000. Assessment report of High Catchment Mandrare Policy. *International Fund for Agriculture Development, Division of Africa II, Department of Management Program*. 185 p.

Rakotoarimanana, V. 2002. Fire, grasslands and *Heteropogon contortus* (L.) P. Beau en Roen Le Shult savannas dynamics in Southern of Madagascar (Sakaraha Region). Thesis Dissertation of *Doctorat. EES Sciences, Biology and Ecology of Vegetation, Option: Ecology of Vegetation.* 171 p

Rippstein, G. 1989. Harvesting, conservation et use of fodder in inter tropical regions. *IEMVT – Synthesis 9,* 166 p.

Skerman, P. J., Skerman, R. F., and Cameron, D.G. 1988. Tropical forage legumes. *Plant production and protection. FAO,* 2, 692.

Skerman, R.F. 1990. Tropical grasses. *Plants production and protection. FAO, 23*, 852.

Toutain, B. and Rasambainarivo, J. 1997. Agropastoralism mission and fodder production in South Western of Madagascar. *CIRAD, EMVT - DELSO.* 113 p.

Van Soest, P.J. 1982. Nutritional ecology of the ruminant: ruminant metabolism, nutritional strategies, cellulolytic fermentation and the chemistry of forage and plants fibers. *O & B. Books Cornell University.*373 p.

Wilson, A. D, and Harrington, G. N. 1980. Nutritive value of Australian browse plants. *Proceeding of the International Symposium on the Browse in Africa*. *ILCA* 291–297.

Wilson, C. 1978. Plant realtions and pastures. *Commonwealth Agricultural Bureaux.* UK. 428 p.

****