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Forage biomass availability, species diversity and seasonal variation in grazing behaviour of cattle in the outskirts of Ouagadougou

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Abstract

In order to determine the exploitation of grazing areas in the outskirts of Ouagadougou by cattle herds, the grazing behaviour of cows was monitored in five villages in these during three distinct seasons, namely wet, cool dry and hot dry season. A vegetation study including a census of the woody and herbaceous stratum of grazing areas allowed for an assessment of the pasture biomass availability during the wet season. Results of the monitoring of cattle herds showed that the land type grazed by cattle in the outskirts of the city varied depending on the season. While fallows and post-harvest fields constituted the main land type grazed by cattle in the wet and cool dry season, respectively, cattle herds exploited a variety of land types in the hot dry season. Consequently, cows travelled longer distances and spent more time on walking and browsing and less time on grazing in the hot dry season than in the cool dry and wet season. The pastoral value of grazing areas during the wet season, an important indicator for the quality of the grazing areas being based on the pastoral composition and the global quality index, was estimated at 61.1 %. The biomass was mainly dominated by annual grasses and legumes. The total annual above-ground biomass produced amounted to 575 kg DM ha^{-1}, equivalent to a qualified forage production of 324 kg DM ha^{-1} and a carrying capacity of 0.084 TLU ha^{-1}. In total, over 100 different herbaceous and 48 woody species were identified, each belonging to 20 families. Despite a high diversity of woody and herbaceous species, it is recommended to reduce the grazing pressure of cattle herds in the outskirts of Ouagadougou by addressing alternative feeding strategies.

Keywords: Biomass availability, carrying capacity, cattle herds, grazing behaviour, plant species diversity

1 Introduction

The livestock production systems encountered in Burkina Faso are extensive, improved semi-intensive and intensive systems. Among the improved systems, peri-urban livestock production is developing, favoured by urbanisation and the growing demand for animal products in large cities (Roessler *et al*., 2016). This livestock system has enormous potential due to the proximity to livestock feed industries, veterinary services, livestock and fodder markets and the presence of water resources (Sanou, 2011). Nevertheless, this type of farming is still confronted with numerous constraints that limit its further development. The main constraint remains the unavailability and non-accessibility of livestock feed resources of sufficient quality and quantity throughout the year (Amole & Ayantunde, 2016). Livestock farming in the outskirts of Ouagadougou also exploits the natural fodder resources available in fallows or post-harvest fields, savannahs and shallows, which constitute natural pastures in urban and peri-urban areas, which are freely accessible for livestock herds for grazing. However, the spatiotemporal availability and productivity of these natural fodder resources are variable (Kiéma *et al*., 2014; Diawara *et al*., 2018).

Indeed, urbanisation, rapid expansion of cultivated areas, repeated droughts, soil erosion and degradation of the vegetation cover caused by humans and animals have greatly

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reduced pastoral areas and caused the degradation of natural resources (Kiéma *et al*., 2012). However, little information exists on the contribution of grazing areas to the feeding of cattle herds and on the effects of grazing on the diversity and the biomass availability on grazing areas, particularly in the outskirts of Ouagadougou. This study therefore aimed at assessing the pasture biomass availability, species diversity of woody and herbaceous plants and seasonal variation in grazing behaviour of cattle in the outskirts of Ouagadougou. This information is urgently needed to derive recommendations that will lead to reduction in the grazing pressure of cattle herds in the outskirts of large urban centres as Ouagadougou.

2 Materials and methods

2.1 Study site

The study was conducted in the outskirts of Ouagadougou, capital city of Burkina Faso, West Africa. Four villages within a radius of 12–23 km from the city centre between 1°23 and 1°37 W, and between 12°11 and 12°28 N, were selected, namely Boassa, Kamboinsé, Koubri and Ponsomtenga. Ouagadougou is located in the northern Sudanian climatic zone, which is characterised by a mono-modal rainy season and a long dry season (UN-Habitat, 2007). Climate records over the past 10 years indicate an average annual rainfall of 801 mm. Monthly rainfall in Ouagadougou in 2014 indicates that August remains the wettest month, with 223 mm of rainfall (Direction générale de la météorologie de Ouagadougou, 2014). There are two main vegetation types: A shrub savannah and a tree savannah with *Vitellaria paradoxa* C.F.Gaertn., *Lannea microcarpa* Engl. & K. Krause and *Anogeissus leiocarpus* (DC.) Guill. & Perr. as dominant species (Nikiema *et al*., 1998). All the grazing areas in the study sites were savannah, fallows or uncultivated crop fields.

2.2 Cattle herds and seasons

Five cattle herds were selected for the present study, one each in Boassa, Koubri and Ponsomtenga, and two in Kamboinsé. The choice of herds was based on the size of the herd (≥ 10 cattle), year-round grazing of cattle and the willingness of the herd owner to participate in the study. The number of cattle per herd ranged from 13 to 70 animals (average 30 animals), with seven to 34 cows (average 16 cows) during the study period. The Sudanian Fulani/Peulh, Azawak and Gudali zebu were the dominant cattle breeds. The herds were monitored during three seasons, namely the hot dry season (March-May 2015), the rainy season (June-October 2015) and the cool dry season (November/December 2015-February 2016) in order to understand the seasonal variation in pasture biomass availability, species diversity and grazing behaviour of cattle. The herds were followed on pasture in the company of the shepherd. At the beginning of each data collection period, the grazing areas of each herd were located and geo-referenced.

2.3 Data collection

2.3.1 Vegetation study

The vegetation study included a census of the woody and herbaceous stratum of grazing areas used by the studied cattle herds during the wet season, when biomass production is at its peak (Veenendaal *et al*., 2015). We used APG III (2009) for the taxonomic reference. The census of the woody stratum was carried out by exhaustive and direct counting of the plant species present in 50×50 m plots (Botoni Liehoun *et al*., 2006). In each study site, 3-5 representative plots were randomly selected for each type of grazing land (savannah, shallow, fallow, post-harvest field) when present, totalling 92 plots. The vertical structure of the woody vegetation was assessed on the basis of the representation of species according to their height class. Two strata (A and B) were defined: Stratum A which corresponds to woody species ≤ 2 m in height and stratum B which represents those > 2 m in height (Daget & Poissonnet, 2010). The names of all woody species were recorded for stratum A and stratum B in each plot. For the census of the herbaceous stratum, we used the quadrat point method (Daget & Poissonet, 2010). For the sampling, a plot size of 10×10 m was chosen. Nine plots were sampled per study site, comprising three replicates of three levels of apparent biomass production (maximum, average and minimum). This resulted in a total of 45 sampling plots. Observations were made every 20 cm along the two diagonals of each plot, a total of 900 points in each 10×10 m plot. In each of the 45 plots, four subplots of 1 m^2 were randomly chosen for destructive vegetation sampling (Daget & Poissonnet, 2010). The total weight of the freshly harvested samples was determined immediately after harvest, followed by sorting the species by biological type (annual - Ga, and perennial grasses - Gp, annual -La, and perennial legumes - Lp, and forbs - Fb), and the fresh weight of each of the plant categories was recorded. Two samples of each plant category were taken and dried in an oven at 105 °C for 24 h to determine the dry matter content (DM).

2.3.2 Monitoring of grazing behaviour on pasture

The grazing behaviour of 15 cows (three per cattle herd) was monitored in all three seasons. The cows were selec-

ted based on their docility and a good health status. Bulls were not selected because they often leave the herd in search for mating females in other cattle herds and therefore do not represent the general movement pattern of the entire herd. Each cow was fitted with a GPS tracking collar (Holux M-241, Holux Technology Inc., Hsinchu, Taiwan; Trackstick II, Telespial Systems Inc., Burbank, USA), which recorded the grazing movements and the length of the daily grazing itineraries of the animal by logging the geographical position every 1–120 seconds over three consecutive days within each season. Additionally, the grazing behaviour of each collared cow was observed from a reasonable distance with binoculars for one of the three observation days. The observation started with the departure of the cattle herd from the homestead (usually between 8:00 and 12:00 a.m.) until their return (usually between 14:00 and 18:00 p.m.). The method is derived from that of Dicko & Sangaré (1986). It consists of observing the activities of the cow, which are grazing (consumption of grasses, dicotyledonous herbs and crop residues), browsing (consumption of fresh or dry leaves, flowers, fruits, and pods of shrubs and trees), watering, walking, social activities, and resting without or with rumination at five-minute intervals. In addition, the type of grazing land was recorded, using the following broad six categories: Savannah, shallow, fallow, post-harvest field, road, and dwelling area. Savannah is characterised as uncropped land with natural vegetation, whereas fallow represents land that was formerly planted with crops. Post-harvest fields include maize, sorghum and millet fields after harvest. Shallows are defined as flooded areas (flood plains) and dams where there is no water during the dry season, but fresh grasses for animal grazing.

2.4 Processing of data and statistical analyses

2.4.1 Pasture biomass availability and species diversity

The species richness and density were determined for the census of woody plants. Species richness is defined as the total number of species encountered at a site, while the density is the number of individuals of a species per unit area (individuals/ha). For the herbaceous stratum, the frequency (FS_i) and specific contribution (CS_i) of each species were calculated. CS_i was used to calculate the pastoral value of the herbaceous layer which determines the quality of the pasture. The following equation was used (Akpo & Grouzis, 2000):

$$VP(\%) = \frac{1}{3} \sum (CS_i \times IS) \quad (1)$$

where VP (%): Pastoral value in percent, $\frac{1}{3}$: Coefficient for the biomass that is potentially consumable over the year, CS_i: Specific contribution of species i, and IS: Species quality index. IS ranges between 0 and 3, with species not contributing to the pastoral value having an IS equal to 0, and those contributing to a low, medium and high pastoral value having an IS value equal to 1, 2, and 3. The total amount of herbaceous biomass and the total amount of qualified forage biomass (both in kg dry matter per hectare, $DM\,ha^{-1}$) were estimated. The latter was obtained by multiplying the total amount of herbaceous biomass by the overall pastoral value of the herbaceous layer. The amount of qualified forage biomass was then used to determine the carrying capacity (CC) of the pasture. We used the general procedure that consists of multiplying the total amount of qualified forage biomass by a correction factor k_i and then dividing by the average yearly feed requirements of a livestock unit. Following Tiendrébeogo & Sorg (1997), we used a correction factor of $\frac{1}{3}$ and a daily feed intake of $6.25\,kg\,DM\,TLU^{-1}$. It is commonly assumed that a tropical livestock unit (TLU) is an animal of 250 kg live weight.

Finally, species diversity was calculated for both woody and herbaceous plants, using various diversity indices, including the Shannon index which combines the species richness and abundance, Pielou's eveness which compares the relation of abundance among species, and the Simpson index which expresses the probability that two individuals randomly selected from all individuals in a recording do not belong to the same species.

2.4.2 Grazing behaviour and GPS tracks

GPS recordings of individual daily tracks were transferred to a computer using the HOLUX ezTour and Trackstick Manager software. Incomplete or inconsistent records were removed from the database, resulting in a set of 92 GPS track records for statistical analysis. The daily distance covered during grazing by each cow was directly obtained from the GPS device. It was noted by the observer once the GPS had been removed from the animal upon return to the farm. The total daily time spent on pasture is the time interval between the departure from the farm and return of the cattle herd from pasture. The percentage of time spent on each activity on pasture was calculated in relation to the total time spent outside the farm.

Microsoft excel was used to enter and process the quantitative data. XLStat software version 2015 was used for the statistical analyses. Analysis of variance (ANOVA) was used to test the possible effects of the season on time spent on activities during grazing, average grazing time, average distance walked for grazing and the type of grazing areas used by the studied cattle herds. The Newman-Keuls posthoc test was used for pairwise comparisons of means. Data normal-

Table 1: *Seasonal preferences of the land type grazed by cattle herds in the outskirts of Ouagadougou.*

	Itineraries	*Shallow*	*Post-harvest field*	*Fallow*	*Savannah*	*Settlement*	*Road*
Season	*N*	*Share (% of time)*					
Wet	15	1.1^a	0.0^a	73.7^b	8.7^a	16.1	0.4
Cool dry	15	12.4^a	68.7^b	10.4^a	8.6^a	0.0	0.0
Hot dry	15	41.8^b	0.0^a	21.2^a	32.4^b	4.5	0.1
SEM		27.1	38.0	35.1	22.4	23.4	1.0
P-value		< 0.001	< 0.001	< 0.001	< 0.01	0.15	0.48

SEM: Standard error of the mean. Means in the same column with different superscript letters significantly differ at $p < 0.05$.

ity was checked in XLSTAT using Shapiro-Wilk test while variance homogeneity was checked using Levene's test as required for performing ANOVA. A general threshold value of $p < 0.05$ was used to assess statistically significant differences.

3 Results

3.1 Land types grazed by cattle herds

The land type used by cattle herds for grazing varied between seasons ($p < 0.05$) (Table 1). During the hot dry season, cattle grazed mainly in the shallows and savannahs. In the wet season, particularly fallow land was exploited to meet the feed requirements of cattle herds. Finally, during the cool dry season, cattle grazed the post-harvest fields with millet, sorghum and maize stover, as well as legumes such as cowpeas and groundnuts haulms (Table 1).

3.2 Floristic composition and species diversity of grazing areas used by cattle herds

In total, 48 woody species belonging to 20 families were documented for the land grazed by cattle herds in the outskirts of Ouagadougou. The most represented families were Fabaceae (25.0 %), Combretaceae (16.7 %) and Anacardiaceae (14.6 %; Supplementary Table 1). The average density of woody plants in the outskirts of Ouagadougou amounted to 665 trees ha^{-1}, of which 493 trees ha^{-1} for stratum A and 172 trees ha^{-1} for stratum B. High densities were observed for the species *Eucalyptus camaldulensis* Dehnh. and *Guiera senegalensis* J.F. Gmel. (187 individuals ha^{-1} and 93 individuals ha^{-1}, respectively), belonging to the families Myrtaceae and Combretaceae. The different diversity indices calculated for the 48 woody plant species were 4.2 (Shannon index), 0.7 (Pielou's eveness) and 0.1 (Simpson index), respectively.

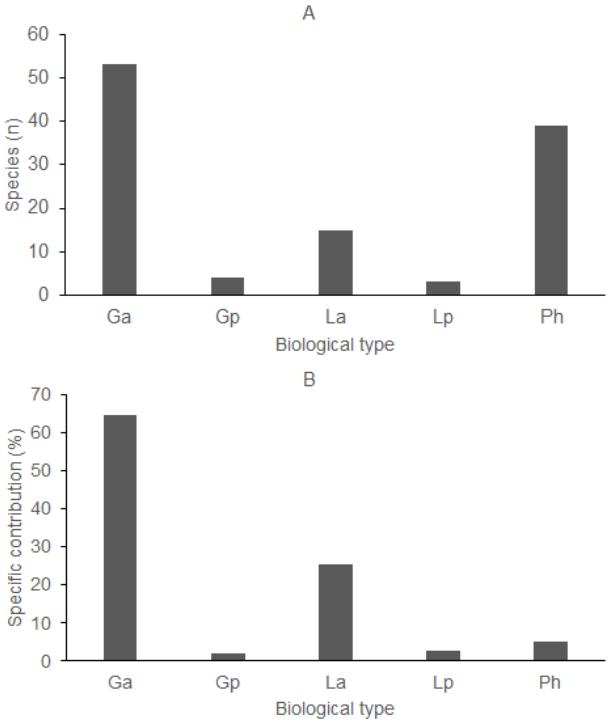

Fig. 1: *Frequency (A) and specific contribution (B) of biological types of herbaceous plants.*
Ga: Annual grasses, Gp: Perennial grasses, La: Annual legumes, Lp: Perennial legumes, Fb: Forbs.

For the herbaceous stratum, a total of 114 different species from 20 different families were identified. The most represented families were Poaceae (48.7 %) and Fabaceae (15.7 %) (Supplementary Table 2). Fifty-three (53) species out of the total of 114 species were Ga. Fb was numerically the second biological type with 39 species, followed by La (15 species), Gp and Lp with 4 and 3 species, respectively. In terms of specific contribution of each biological type, Ga (64.7 %) still came first, followed by La (25.5 %), Fb (5.0 %), Lp (2.8 %) and Gp (2.0 %) (Fig. 1).

The diversity indices attested a high diversity of the herbaceous flora and good distribution of individuals among the recorded species (Shannon index: 4.7, Pielou's eveness: 0.69 and Simpson index: 0.07). In spite of this, only five species (or 4.3 %) had a $CS_i \geq 5$ %. These were *Zornia glochidiata* DC. (14.3 %), *Microchloa indica* (L.f.) P.Beauv. (11.8 %), *Loudetia togoensis* (Pilg.) C.E.Hubb. (10.2 %), *Elionurus elegans* Kunth (8.6 %) and *Brachiaria xantholeuca* (Schinz) Stapf (7.0 %). They were mainly represented by Ga of the family Poaceae, except *Zornia glochidiata* which is an La.

3.3 *Biomass production and pastoral value of the herbaceous vegetation*

The herbaceous and qualified forage biomass production of the land grazed by cattle in the outskirts of Ouagadougou was dominated by Ga (59.0 %) and La (24.0 %). Accordingly, the total amount of herbaceous biomass and the total amount of qualified forage biomass was calculated at 575 ± 453.4 kg DM ha^{-1} and 324 ± 255.6 kg DM ha^{-1}, respectively. The resulting CC was 0.05 ± 0.037 TLU ha^{-1} per year. The herbaceous species' distribution in the different classes of specific pastoral quality was as follows: Species with no pastoral value (IS = 0) 10, species with low pastoral value (IS = 1) 50, species with medium pastoral value (IS = 2) 28, and species with good pastoral value (IS = 3) 26. Thus, the pastoral value of the herbaceous layer was estimated at 61.1 %.

3.4 *Grazing itineraries and grazing behaviour of cattle*

The longest daily distances travelled by cattle herds in the outskirts of Ouagadougou were recorded in the hot dry season with an average of 11.4 km compared to 8.9 km and 8.3 km respectively in the wet and cool dry seasons ($p < 0.05$). On the other hand, there was no difference between the distances travelled during the wet and cool dry seasons ($p \geq 0.05$) (Table 2). On the contrary, the daily grazing time was relatively constant throughout all seasons, ranging from 7.1 h in the wet to 7.3 h in the cool dry season. The results did not reveal any significant difference in the duration of grazing outside the farm. As a consequence, the highest travel speed of cattle herds was calculated for the hot dry, whereas it was comparable in the wet and cool dry season (Table 2).

Despite the relatively constant daily pasturing time (mean duration of the daily time spent on pasture) over the seasons, the time spent by cattle on walking, grazing, browsing and watering varied according to the season of the year (Fig. 2). Regardless of the season, the cows spent most of the time on grazing, followed by the time spent on walking and browsing. The time spent on grazing decreased from the wet to the cool dry season and was lowest during the hot dry season (all comparisons $p < 0.05$). For the time spent on browsing, the opposite trend was observed. Here, the time spent was low to negligible in the wet and the cool dry season, respectively, but increased significantly in the hot dry season ($p < 0.05$). According to the longer daily distance travelled by cattle in the hot dry season, cows spent more time on walking in that season as compared to the wet and cool dry season ($p < 0.05$). There was an increase in the time spent on watering from the wet season to the cool dry season ($p < 0.05$). The time spent on resting both with and without rumination, and for social activities did not differ between

Table 2: *Grazing itineraries of cattle herds in the outskirts of Ouagadougou.*

		distance	*duration*	*speed*
	Itineraries		*in mean*	
Season	*n*	*km/day*	*h/day*	*km/h*
Wet	37	8.9^a	7.1	1.2
Cool dry	39	8.3^a	7.3	1.1
Hot dry	16	11.4^b	7.2	1.6
SEM		3.30	1.11	0.35
P-value		< 0.05	0.89	-

SEM: Standard error of the mean. Means in the same column with different superscript letters significantly differ at $p < 0.05$.

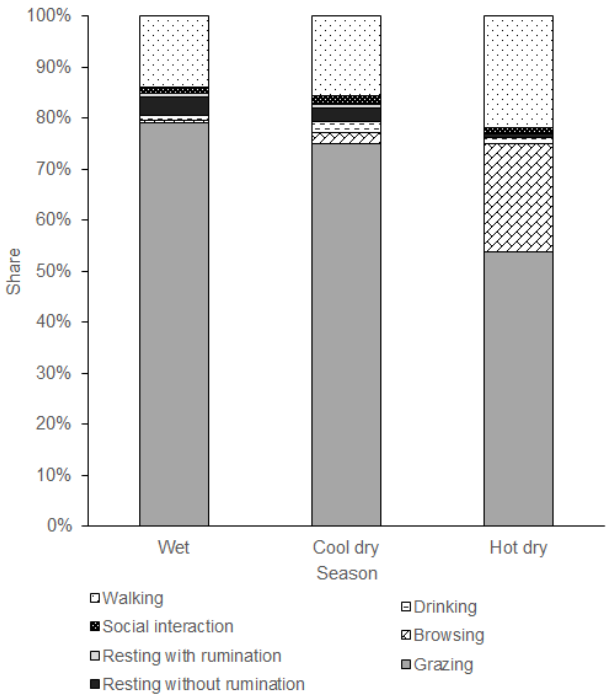

Fig. 2: *Seasonal variation in the time spent on activities by cattle on pasture.*

the study seasons ($p \geq 0.05$). The rest took place in a lying or standing position and depended on the shepherd who forced the cows to rest in the afternoon for his own needs.

4 Discussion

4.1 Vegetation study

Shallows and savannahs constituted the main land types grazed by cattle herds in the hot dry season. During that period of the year, shallows (mostly flooding plains and dry dams) with high residual moisture during the dry season allow the growth of young grasses which were available for cattle grazing. These are very high in nitrogen but low in dry matter at this stage (Breman & De Ridder, 1991). The savannahs offered woody plants, especially leaves and pods of *Guiera senegalensis* J.F.Gmel., *Piliostigma reticulatum* (DC.) Hochst. and *P. thonningii* (Schum.) Milne-Redh., *Acacia macrostachya* DC., and *Vitellaria paradoxa* C.F.Gaertn., that are also rich in nitrogen and quite rich in tannins and minerals (Ickowicz & Mbaye, 2001). With the cultivation of arable land in the wet season, cattle are kept away from the cropped fields to avoid conflicts with farmers (Vall & Diallo, 2009), and fallows remain the space in which animals could graze without constraint during this period of the year. After the crop harvest, during the cool dry season, cattle were allowed to graze millet, sorghum and maize stubble, as well as the haulms of legumes such as cowpeas and groundnuts (own data).

In the outskirts of Ouagadougou, the woody vegetation of the different land types was mostly represented by the dominant families typical of the northern Sudanese zone, namely Fabaceae, Combretaceae and Anacardiaceae. These families are indicators of changes in the state of the woody vegetation (Ngom *et al*., 2013). Especially the development of species of the Combretaceae family, which dominated stratum A in our study, may point to a certain ecosystem degradation (Savadogo, 2002). This family has been reported to be well adapted to various stressors (Sarr *et al*., 2013), and has a high capacity for vegetation regeneration through stump release (Ngom *et al*., 2013), despite its systematic elimination during clearing operations (Sarr *et al*., 2013). According to Boussim (2010), the northern Sudanian zone is the most densely populated and the most intensely cultivated in Burkina Faso, hence a very stressed vegetation physiognomy is prevalent. Similarly, Béchir & Kaboré-Zoungrana (2012) confirmed for the Sudanian zone of Chad that *Anogeissus leiocarpus* (DC.) Guill. & Perr, *Combretum collinum* Fresen, *C. glutinosum* Perr. ex DC., and *Detarium microcarpum* Guill. & Perr. are the most represented species in terms of regeneration with high density. Despite the predominance of three families only, the low value obtained for Pielou's eveness (R) in our study indicated a high diversity of species of the woody flora, while Simpson index (D) was medium, showing a good distribution of individuals between species.

The herbaceous vegetation of the land types exploited by cattle herds in the outskirts of Ouagadougou during the wet season was dominated by Ga, especially of the family Poaceae. The predominance of Ga in the Sudanian savannahs has also been noted by Kagoné (2000). The abundance of Ga could indicate the low quality of fodder just after the period of maximum biomass. After this phenological stage, Ga in the form of straw provides a ration with low energy value and very low nitrogen content (Zampaligré *et al*., 2013). This predominance could be the cause of the fodder deficit in the North Sudanian savannah during the dry season because Ga are short-cycle plants. The high proportion of Poaceae can be explained by their very high possibility of tillering and regrowth after grazing, when environmental conditions become favourable (Kouassi *et al*., 2014). Therefore, the Ga contribute to the recovery of the herbaceous vegetation cover. However, the decrease in CS_i and FS_i of highly palatable species to the detriment of less palatable and invasive species with low quality indices such as *Microchloa indica* (L.f.) P.Beauv. could be an indicator of pasture degradation (Kiéma, 2002). On the contrary, perennials are very sensitive to rainfall variations The short duration of the rainy season and the low total rainfall are not sufficient to support the survival of many perennials. In addition, the way rangelands are exploited may negatively impact the presence of perennials (Savadogo *et al*., 2009). The numerical abundance of Fb in our study did not reflect their contribution to the recovery of herbaceous vegetation, as has been confirmed previously by Ouattara (2004) in the Sahel and Traoré (2015) in the classified forest of Dinderesso in the southern Sudanian zone. In fact, the number of Da species recorded in the outskirts of Ouagadougou was more than double that of La species, however the CS_i of the latter was four times that of the Fb. The pastoral value of the herbaceous layer in our study was clearly higher than the values reported by Yaméogo *et al*. (2013) for the same area. Nevertheless, our results indicate that pastures in the outskirts of Ouagadougou were not of good quality. Indeed, the PV of a pasture depends on the species encountered in the herbaceous layer. In general, it decreases with increasing pastoral pressure due to the decrease in the contribution of palatable forage species (Botoni Liehoun *et al*., 2006) which are over-exploited. In addition, bush fires have been cited as a factor in decreasing the PV of a pasture because they favour the development of annual broadleaf weeds to the detriment of Gp (Sawadogo *et al*., 2005).

The herbaceous biomass of pastures obtained in this study is much lower than that found by IUCN (2015) in the shrub and grass savannahs of the northern Sudanian zone in eastern Burkina Faso, and by Yaméogo *et al*. (2013) in the outskirts of Ouagadougou. The first report gave a variation in herbaceous biomass from 734 to 3465 kg DM ha^{-1}, and the second gave a biomass between 2205 kg DM ha^{-1} and 3335 kg DM ha^{-1}. The lower herbaceous biomass availability in the present study can be explained by several factors, including the structure of the herbaceous layer (Ouattara, 2004), and especially the strong contribution of Ga that we recorded. In addition, a drop in rainfall, the decrease in grazing land in favour of the expansion of the city and the cultivation of crops to meet the food and housing needs of a rapidly growing population (Obulbiga *et al*., 2015), negatively impact the length of fallow periods and increases the grazing pressure.

Similar to the herbaceous biomass of pastures grazed by cattle herds in the outskirts of Ouagadougou, the CC obtained in our study was lower than that reported in Yaméogo *et al*. (2013) for the same area (0.48-0.73 TLU ha^{-1}). The low CC in our study was linked to the low biomass availability of the pastures, which limits their capacity to support livestock. CC is a good indicator of a sustainable management of natural pastures. Nevertheless, it is difficult to calculate the real CC of pastures in tropical areas (Traoré, 2015), as the concept of CC presupposes that pastures have well-defined limits, which are rarely found for extensive farming systems characterised by mobility of herders in search of good pastures. Hence, the size of the area grazed by extensively managed livestock herds is difficult to assess. In addition, the number of animals grazing communal land is unknown. Finally, livestock consume only a fraction of the biomass produced, hence the need to calculate the CC from this fraction, known as the "carrying capacity of qualified forage biomass", which considers the palatability of herbaceous plants.

4.2 Grazing itineraries and behaviour

The smallest daily distances covered by cattle herds in the outskirts of Ouagadougou were observed in the wet and cool dry season. In fact, after the establishment of the rains and the growth of herbaceous plants, the vegetation cover of the natural rangelands becomes relatively abundant, homogeneous and continuous in the wet season. The herds moved less, while devoting more time to grazing in that season. This is in accordance with Zampaligré & Schlecht (2017) who recorded a higher proportion of time spent on grazing in the wet season compared to the hot dry season in the northern Sahelian zone of Burkina Faso. In the cool dry season, after harvest, cows grazed mostly crop residues in the post-harvest fields (when not picked up by farmers), which reduced the need for long journeys in search of fodder. Similar observations were made by Ngom & Rippstein (2005) in Senegal as well as Béchir & Kaboré-Zoungrana (2012) in Chad, while Zampaligré & Schlecht (2017) observed no seasonal difference in the walking distance of cattle in the northern and southern Sahelian zone of Burkina Faso. Due to the presence of crop residues in the fields during the cool dry season, the time spent on grazing remained comparably high as compared to the hot dry season, when the time spent on grazing gradually decreases with the disappearance of herbaceous biomass and crop residues (Sanon & Sanou, 2012). Instead, cattle increased the time spent on browsing in the present study, either through direct feeding on shrubs or with the help of the shepherd by pruning or picking pods (Diarra, 2010). This confirms observations made in previous studies, e.g. Zampaligré & Schlecht (2017), Béchir & Kaboré-Zoungrana (2012) and Onana & Devineau (2002). Furthermore, the walking distance and hence the time spent on walking by the cattle herds in the outskirts of Ouagadougou significantly increased, while the time spent on drinking water decreased as compared to the other seasons. This was due to the shortage and dispersion of forage and of watering points in that season (Zampaligré & Schlecht, 2017), leading cattle to take long walks to explore a greater diversity of environments in order to have enough to graze (Sangaré, 2009) and drink. While surface water and water holes for watering cattle herds dried out in the hot dry season, no water problem was observed in the wet season because of the spread of surface water points. In addition, the grass grazed by cattle during this period has high moisture content which reduces the need for drinking water.

In contrast to the mean daily distances travelled by cattle herds, no seasonal variation was observed for the mean time spent outside the farm for grazing. This is consistent with the study of Zampaligré & Schlecht (2017) in the northern and southern Sahelian zone in Burkina Faso. In terms of travel speed, the results indicate that during the hot dry season, the speed of grazing cattle herds was higher due to the fact that there are increasingly wide and frequent bare patches without fodder on the rangelands as the dry season progresses. Between these bare patches the animals walked faster and without grazing to reach the places with fodder. Travel speed is a good indicator of fodder availability and the quality of the rangelands. When it is low, it indicates abundant pasture rich in palatable species. Conversely, high travel speed indicates low forage availability and poorly palatable plants (Kagoné, 2000).

5 Conclusions

It is concluded that pastures in the outskirts of Ouagadougou are subject to high anthropisation and overgrazing, as indicated by the species composition and biomass availability of the grazed lands. It is therefore becoming urgent for rural development actors and herders to consider reducing the animal burden on pastures and adopting alternative feeding strategies for peri-urban cattle herds.

Supplement

The supplement related to this article is available online on the same landing page at: https://doi.org/10.17170/kobra-202007291510 .

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Conflict of interest

The authors declare that they have no conflict of interest.

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