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# Day and night grazing by cattle in the Sahel

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## Abstract

**The influence of night grazing on feeding behavior, nutrition and performance of cattle was studied. Twenty-four steers weighing 367 kg (SD = 76) grazed either from 0900 to 1900 (day grazers), 2100 to 0700 (night grazers) or 0900 to 1900 and 2400 to 0400 (day-and-night grazers) during 13 weeks. Four esophageally fistulated steers were used in a cross-over design to sample the diet selected during the day and at night. No differences (P > 0.05) were observed in the diet selected in the day or at night. As the season progressed the fiber components of the diet increased (P < 0.01) significantly while nitrogen and in sacco dry matter disappearance declined (P < 0.01). Actual grazing time (min day$^{-1}$, SE = 16) were 352, 376, and 476 for day, night, and day-and-night grazers, respectively. Day-and-night grazers had a higher intake of organic matter than either day or night grazers. Night grazers had the lowest forage intake and also the slowest rate of consumption. Steers that grazed in the night had the lowest water intake: 22.7 liter day$^{-1}$ (SE = 1.5) in week 4; 19.9 liter day$^{-1}$ (SE = 1.1) in week 8. Average weight changes (g day$^{-1}$, SE = 62) were -435, -548 and -239 for day, night, and day-and-night grazers, respectively. These results show that during the dry season, grazing exclusively in the night cannot substitute for day time grazing, but that it is rather complementary to the latter. Timing (day or night) of grazing did not affect diet selection but nocturnal grazing decreased the need for water.**

## Resumen

**El objetivo del presente trabajo fue estudiar la influencia del pastoreo nocturno sobre el comportamineto alimenticio, el consumo de forraje, la excreción fecal y los cambios de peso en bovinos. Veinticuatro novillos con un peso inicial de 367 kg (desviación est·ndar = 76) pastorearon de 0900 a 1900 (pastoreo diurno), 2100 a 0700 (pastoreo nocturno) o de 0900 a 1900 y de 2100 a 0700 (pastoreo dìa y noche) durante 13 semanas. Cuatro novillos con fÌstula esof·gica fueron utilizados en un diseÒ reversible para muestrear la dieta seleccionada durante el dÌa y en la noche. No se observaron diferencias (P > 0.05) en la dieta seleccionada en el dÌa o en la noche. A medida que la estación seca avanzó los componentes de fibra de la dieta aumentaron (P < 0.01), mientras que el contenido de nitrógeno y la desaparición *in sacco* de la materia seca disminuyeron (P < 0.01). El tiempo de pastoreo propiamente dicho (i.e. tiempo de consumo) fue 352, 376 y 476 min dìa$^{-1}$ (SE = 16) para novillos con pastoreo nocturno, pastoreo diurno o con pastoreo el dÌa y la noche, respectivamente. Los novillos con pastoreo el dÌa y la noche tuvieron un mayor consumo de materia org·nica que aquellos que pastorearan el dÌa o la noche. Los novillos con pastoreo nocturno tuvieron los niveles y tasas de consumo de forraje m·s bajos. El consumo de agua fue tambiÈn m·s bajo en los novillos que pastorearon durante la noche 22.7 liter dÌa$^{-1}$ (SE = 1.5) en la semana 4 y 19.9 liter dÌa$^{-1}$ (SE = 4) en la semana 8). El cambio promedio de peso fue –435, –548 y –239 g dìa$^{-1}$ (SE = 62) para los novillos con pastoreo nocturno, pastoreo diurno o con pastoreo el dÌa y la noche, respectivamente. Estos resultados indican que durante la estación seca el pastoreo exclusivamente durante la noche no puede ser substituto, sino m·s bien complemento del pastoreo durante el dia. El momento (dÌa o noche) de pastoreo no affectó la selección de la dieta, pero el pastoreo nocturno disminuyó el requerimiento de agua.**

**Key Words: cattle, forage intake, night grazing, Sahel**

Night grazing is a common herd management practice in the West African Sahel, especially at the end of the dry season (Dicko-Tourè 1980, Powell et al. 1996). This practice has also been reported for herded animals in the sub-humid zone of West Africa (Bayer 1986), East Africa (Wigg and Owen 1973, Nicholson 1987) and for free ranging sheep and cattle in the USA and Australia (Vallentine 1990). In addition to the advantage of increased grazing time, King (1983) reported that night grazing helps to reduce heat stress on the animals and may increase forage intake. It has the benefit of manure deposition on rangelands rather than in the enclosed sites (Wigg and Owen 1973). However, this is in conflict with the practice of corralling the animals on cropland for depositing manure (Powell et al. 1996). Previous research (Fernández-Rivera et al. 1996) on night grazing by cattle showed that diet selection during the day and at night were not different. However, the steers that grazed during the day consumed more forage and water than those that grazed in the night. Further studies on the influence of night grazing on feeding behavior, nutrition and performance of cattle are needed to improve understanding of the nutrition of grazing cattle and cattle's role in nutrient transfer processes in the landscape.

The objective of this study was to determine the effects of night grazing on diet selection, forage and water intake, fecal excretion, feeding behavior and performance of cattle.

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## Material and Methods

### Study site

The experiment was conducted over 13 weeks at the end of the dry season (February to May) of 1995 at International Crop Research Institute for the Semi-Arid Tropics (ICRISAT-SC) in Sadorè (13° 14' N 2° 16' E), Niger.

### Treatments, pasture and animals

Twenty-four intact steers with a body weight (W) of 367 (SD = 76) kg were randomly allotted to 3 treatments: grazing either from 0900 to 1900 (day grazing), 2100 to 0700 (night grazing) or 0900 to 1900 and 2400 to 0400 (day-and-night grazing). After return from the pasture, the steers were kept in individual pens in a barn located 150 m from the paddock. The animals grazed the same pasture in the day and at night, i.e. a fallow of 5.5 ha, dominated by annual grasses mainly *Ctenium elegans* Kunth, *Diheteropogon hagerupii* Hitchc., *Pennisetum pedicellatum* Trin. and forbs mainly *Borreria stachydea* (DC.) Hutch. & Dalz. and *Hibiscus sabdarifa* Linn. At the beginning of the trial, the standing herbage and litter mass of the pasture were estimated at 828 and 1,070 kg DM $ha^{-1}$, respectively (Table 1). The herbage mass consisted of standing hay composed of 59% grasses and 41% forbs.

The study included 2 periods of collection of feces and extrusa which started in weeks 4 and 8 of the experiment. Each period included 9 days of fecal collection.The animals were accustomed to carrying fecal collection bags during the last week before the collection started. In each collection period, fecal bags were emptied and the feces weighed, before and after grazing. Ten percent of the fecal excretion was sampled and frozen for subsequent analysis. Water intake was also measured in weeks 4 and 8 of the trial. All the animals were watered in the morning (0800) before grazing started. Water intake was measured daily during the collection periods, for which all animals had access to water for 30 min. In week 8 of the experiment the grazing activities of all steers were observed. Observation was made every 5 min (24 hour/day) for 3 consecutive days by 6 observers. The observation was instantaneous and the recording included one of the following activities: searching for food, prehending, masticating, ruminating, walking, drinking, sleeping, and idling. Grazing time was defined as the time spent prehending, masticating and searching for food. Idling included time spent neither for grazing, ruminating, sleeping, walking, nor drinking. Activities such as drinking, fighting, and socializing were referred to as 'other'.

In the 2 collection periods, four esophageally fistulated steers were randomly grouped into 2 pairs and were used in a cross-over design for sampling the diet selected during the day and at night. The 2 pairs either grazed in the day (0900 to 1900) or at night (2100 to 0700). During the data collection period in weeks 4 and 8, samples of the diet selected by the fistulated steers (extrusa) were collected in the morning (1000) and afternoon (1500) for the day grazing pair, and at night (2200) and at dawn (0300) for the night grazing pair, for 3 consecutive days. At the end of the 3 days collection period, the 2 groups were switched. After switching the grazing schedule, the animals were allowed 3 days for adaptation after which extrusa samples were collected for another 3 days following the same collection schedule. The extrusa samples were frozen immediately after collection.

### Sample processing and laboratory analyses

The daily fecal sub-samples were bulked by time of collection (before or after grazing) and analyzed for dry (DM) and organic matter (OM). The extrusa samples were dried at 55° C for 48 hours and were ground to pass a 1-mm screen. They were analyzed for DM, OM, nitrogen (N), ashless neutral detergent fiber (NDF), ashless acid detergent fiber (ADF) and ashless lignin (Van Soest et al. 1991). Hemicellulose and cellulose were calculated as the differences NDF-ADF and ADF-lignin, respectively. Samples ground to pass a 2-mm screen were incubated in duplicate for 48 hours in 3 ruminally fistulated steers to determine in sacco DM (DMD) and OM (OMD) disappearance, treating the residues from the nylon bags in a HCl-pepsin solution for 24 hours. Samples collected from vegetation mass measurement, representing the available feed, were subdivided by functional group (grasses or forbs) and dominant species within a group for standing herbage and litter separately. These were analyzed for DM, OM, N, phosphorus (P), DMD, and OMD.

### Animal measurements

Animals were weighed every two weeks for 3 consecutive days. Average daily gain (ADG) was estimated by regression of individual body weight (W) data over time. Individual animal feed intake was determined from individual data on fecal output and group (day or night schedule) means of OMD.

### Statistical analysis

Data analysis were performed with SAS (Statistical Analysis System Institute 1987) using the General Linear Model (GLM) procedure for the variance and regression analyses. An analysis of variance model including treatments as fixed effects, was used to analyze data on fecal output, forage and water intake, and animal behavior (time spent grazing, ruminating, idling, walking, sleeping, and drinking). The model for analysis of water intake included live weight and dry matter intake in addition to the treatments studied. Multiple comparisons of treatment means (Day vs Night grazing and Day vs Day-and-night grazing) within and between the collection periods (weeks 4 and 8) were performed by contrasts. Extrusa components of diet selected in the day and at night were analyzed using the Cochran procedure for the t-test. Unless it is specified differently, the level of significance was declared at $P < 0.05$.

**Table 1. Nutritional quality of standing herbage and litter mass at the beginning of the experiment (March 1995).**

| Component | Standing herbage | Litter | SE |
|---|---|---|---|
| | ---------- g $kg^{-1}$ DM ---------- | | |
| Organic matter | 949 | 938 | 6 |
| Nitrogen | 3.5 | 3.4 | 0.5 |
| Phosphorus | 1.2 | 1.1 | 0.2 |
| Dry matter digestibility | 426 | 412 | 18 |
| Organic matter digestibility | 400 | 391 | 19 |
| Digestible organic matter | 380 | 367 | 13 |

## Results

There were no differences in the quality of diet (extrusa) selected (Table 2) in the day or at night for both collection periods (weeks 4 and 8), the only exception was observed in week 4 when the NDF (SE =

Table 2. **Chemical composition of forage selected (extrusa) by esophageally fistulated steers grazing in the day or at night.**

| Component | Week 4 Day | Week 4 Night | Week 8 Day | Week 8 Night | SE |
|---|---|---|---|---|---|
| | ---------- | ---------- | g kg$^{-1}$ DM | ---------- | ---------- |
| Organic matter | 894 | 883 | 881 | 889 | 4 |
| Nitrogen | 9.0[a] | 8.1[a] | 7.5[b] | 7.1[b] | 0.4 |
| NDF | 649[a] | 675[a] | 817[b] | 821[b] | 6 |
| ADF | 507[a] | 521[a] | 635[b] | 637[b] | 6 |
| Lignin | 134[a] | 129[a] | 178[b] | 187[b] | 5 |
| Cellulose | 373[a] | 393[a] | 460[b] | 450[b] | 6 |
| Hemicellulose | 143[a] | 154[a] | 182[b] | 184[b] | 5 |
| DMD[2] | 533[a] | 524[a] | 486[b] | 478[b] | 8 |
| OMD[2] | 469 | 455 | 459 | 444 | 8 |
| DOM[2] | 419 | 402 | 404 | 395 | 6 |

[1]Values with different superscripts denote significant difference ($P < 0.05$) between means within rows.
[2]DMD=Dry matter digestibility; OMD = Organic matter digestibility; and DOM = Digestible organic matter (i.e. OMD x OM).

6) of the diet selected by night grazers (675 g kg$^{-1}$ DM) was significantly higher than that of the day grazers (649 g kg$^{-1}$ DM). As the dry season progressed (week 4 vs week 8, Table 2) diet's NDF, ADF, cellulose, hemicellulose and lignin increased significantly ($P < 0.01$) while nitrogen concentration (SE = 0.4) declined from 8.5 in week 4 to 7.3 g kg$^{-1}$ DM in week 8 and DMD (g kg$^{-1}$ DM, SE = 8) also declined significantly (week 4 = 529; week 8 = 482).

Steers grazing in the day, night, and day-and-night spent 352, 376, and 476 min day$^{-1}$ respectively for grazing (Table 3). Night grazers spent less time ruminating and walking than day grazers. Day-and-night grazers spent 124 minutes grazing more than day-grazers. The hourly distribution of time expenditure (Fig. 1.) for different activities showed that day grazers had 2 distinct grazing periods with the first in the morning till mid-day and the second before the sunset. The second grazing period accounted for over 60% of total time spent grazing. Day-and-night grazers also had 2 grazing periods in the day similar to day grazers with one additional period in the night of about 2 hours. Night grazers had 2 grazing periods with the initial period accounting for about 75% of the total grazing time. Steers that grazed in the day-and-night had lower time for resting (time spent sleeping + idling) than steers that grazed in the day (421 vs 560, SE = 25, $P < 0.05$) but there was no difference in resting time by day grazers compared to night grazers (560 vs 614, SE = 25).

Day, and day-and-night grazing steers consistently consumed more forage (g DM kg$^{-0.75}$ W) than steers that grazed at night (Table 4). In weeks 4 and 8, day-and-night grazers consumed daily 93.2 and 67.1 g DM kg$^{-0.75}$ W respectively whereas night grazers consumed 62.5 g DM kg$^{-0.75}$ W in week 4 and 53.6 g DM kg$^{-0.75}$ W in week 8. Day grazers consumed significantly more digestible organic matter (g DOM kg$^{-0.75}$ W) than night grazers (Week 4: 30.2 vs 20.4, SE = 1.6; week 8: 22.7 vs 18.3, SE = 1.4), but the differences between day grazers and day-and-night grazers were not statistically significant. Forage intake declined significantly from week 4 to week 8 for day grazers, and day-and-night grazers. Intake rate (mg OM kg$^{-0.75}$ W min$^{-1}$) in week 8 (SE = 7) were 142 for day grazers, 110 for night grazers and 113 for day-and-night grazers.

There was a significant difference in water intake between steers that grazed in

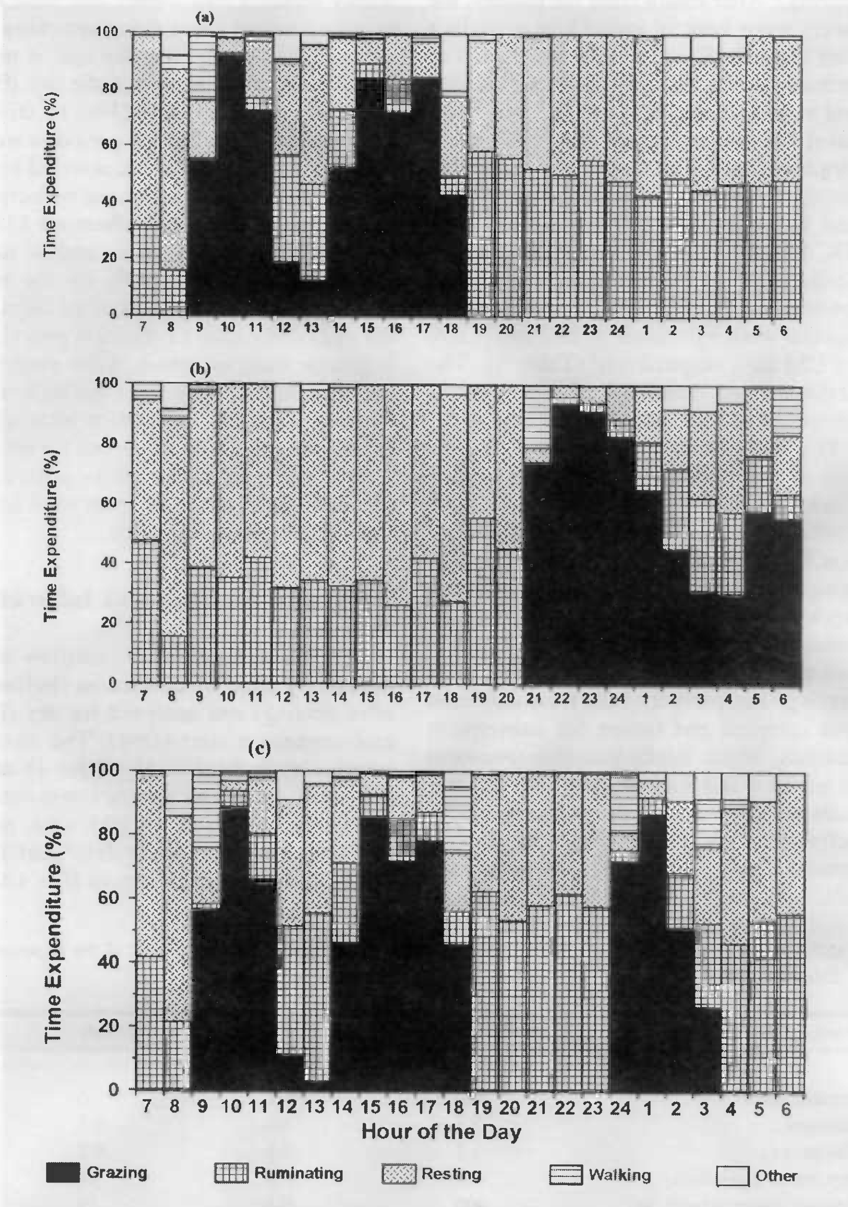


**Fig. 1. Hourly distribution of time expenditure for different activities by (a) day, (b) night, and (c) day-and-night grazing steers in the dry season in the Sahel.**

**Table 3. Time expenditure on different activities in Week 8 (May 1995) of the experiment by day, night, and day-and-night grazing steers.**

| Activity | Day | Night | Day-and-night | SE |
|---|---|---|---|---|
| | -(min $day^{-1}$)[1] | | | |
| Grazing[2] | 352[a] | 376[a] | 476[b] | 16 |
| Ruminating | 463[a] | 389[b] | 447[a] | 21 |
| Sleeping | 88[a] | 99[a] | 50[b] | 12 |
| Walking | 37[a] | 28[a] | 55[b] | 3 |
| Idling[2] | 472[a] | 519[a] | 371[b] | 27 |
| Other | 30 | 29 | 43 | 10 |

[1]Values with different superscripts denote significant difference (P < 0.05) between means within rows.
[2]Grazing includes prehension, mastication and search for food; Idling includes time spent neither for grazing, ruminating, sleeping, walking nor drinking; and Other includes activities such as drinking, fighting and socializing.

the night and those that grazed either in the day or in the day-and-night in both periods of measurement (Table 4). As the season progressed water intake of day grazers (week 4 = 35.5, week 8 = 27.6 liter $day^{-1}$) and day-and-night grazers (week 4 = 35.5, week 8 = 27.6 liter $day^{-1}$) declined significantly but that of night grazers (week 4 = 22.7, week 8 = 19.9 liter $day^{-1}$) remained fairly constant. Relative to forage intake water consumption (liter $kg^{-1}$ forage DM) was constant for all treatments regardless of the period of measurement. Regression analyses of water intake on metabolic weight ($W^{0.75}$) and dry matter intake (DMI, kg DM $day^{-1}$) showed that water intake (ml $day^{-1}$) was correlated with metabolic weight in all treatments and with DMI for day grazers (equation 1), and day-and-night grazers (equation 3) but not for night grazers (equation 2). The following regression equations were estimated from the pooled data of weeks 4 and 8:

$$\text{water intake} = 148\ (SE = 26)\ W^{0.75} + 3243\ (SE = 343)\ DMI\ (r^2 = 0.99, P < 0.01) \quad \textbf{(1)}$$

$$\text{water intake} = 263\ (SE = 6)\ W^{0.75}\ (r^2 = 0.99, P < 0.01) \quad \textbf{(2)}$$

$$\text{water intake} = 126\ (SE = 34)\ W^{0.75} + 3412\ (SE = 429)\ DMI\ (r^2 = 0.99, P < 0.01) \quad \textbf{(3)}$$

In week 4, fecal excretion by day grazers, night grazers, and day-and-night grazers were 9.3, 6.9, and 10.3 g DM $kg^{-1}$ W $day^{-1}$ (SE = 0.7), respectively. In week 8 (SE = 0.6), day grazers excreted 7.6 g DM $kg^{-1}$ W $day^{-1}$, the fecal output by night grazers was 6.9 g DM $kg^{-1}$ W $day^{-1}$ and day-and- night grazers voided 8.3 g DM $kg^{-1}$ W $day^{-1}$. A significant decrease in fecal excretion was observed in day grazers, and day-and-night grazers as the season progressed, whereas that of night grazers remained essentially the same.

Average weight changes (g $day^{-1}$, SE = 62) was –435 for day grazers, –548 for night grazers and –239 for day-and-night grazers. There was no significant difference in weight changes between day grazers and night grazers.

**Table 4. Daily intake of dry matter (DM), digestible organic matter (DOM) and intake rate, and water intake by day, night, and day-and-night grazing steers in the dry season in the Sahel.**

| Variable | Day | Night | Day-and-night | SE |
|---|---|---|---|---|
| **Week 4** | | | | |
| Forage intake | | | | |
| g DM $kg^{-0.75}$ W | 86.3[a]† | 62.5[b] | 93.2[a]† | 4.8 |
| g DOM $kg^{-0.75}$ W | 30.2[a]† | 20.4[b] | 31.9[a]† | 1.6 |
| Water intake | | | | |
| liter $animal^{-1}$ $day^{-1}$ | 36.0[a]† | 22.7[b] | 35.5[a]† | 1.5 |
| liter $kg^{-1}$ forage DM | 5.1[a] | 4.4[b] | 4.9[a] | 0.2 |
| ml $kg^{-1}$ W $day^{-1}$ | 100[a]† | 62[b] | 105[a]† | 5 |
| **Week 8** | | | | |
| Forage intake | | | | |
| g DM $kg^{-0.75}$ W | 62.9[a] | 53.6[b] | 67.1[a] | 4 |
| g DOM $kg^{-0.75}$ W | 22.7[a] | 18.3[b] | 24.3[a] | 1.4 |
| Intake rate | | | | |
| g DM $min^{-1}$ | 14.4[a] | 11.2[b] | 11.0[b] | 0.7 |
| mg OM $kg^{-0.75}$ W $min^{-1}$ | 142[a] | 110[b] | 113[b] | 7 |
| Water intake | | | | |
| liter $animal^{-1}$ $day^{-1}$ | 27.1[a] | 19.9[b] | 27.6[a] | 1.1 |
| liter $kg^{-1}$ forage DM | 5.5[a] | 4.8[b] | 5.3[a] | 0.3 |
| ml $kg^{-1}$ W $day^{-1}$ | 80[a] | 59[b] | 82[a] | 3 |

[1]Values with different superscripts denote significant difference (P < 0.05) between means within rows.
[2]Different symbols (†) following the same variable in Weeks 4 and 8 within a treatment group (column) denote significant difference (P < 0.05) between values in the 2 periods.

## Discussion

The results on diet (extrusa) quality show that the time (day or night) of grazing had no significant influence on dietary selection, which supports the findings by Arnold (1966) that sight does not play a major role in the selection of plant parts by grazing animals. Similar results were observed by Fernández-Rivera et al. (1996). However, there may be differences between the quality of diet selected during the day and at night if the grazing sites and species composition are different, which is often the case when the animals are herded during night grazing. The declining quality of the diet selected as the season progressed, as observed in this study, has also been reported by Schlecht (1995) for steers and by Becker et al. (1996) for zebu cows grazing natural pastures in the region. Nitrogen concentration (7.1–9.0 g $kg^{-1}$ DM) in the diet selected was similar to values reported in the dry season by Schlecht (1995) in Mali (53–82 g CP $kg^{-1}$ OM) and Becker et al. (1996) in Niger (64 –75 g CP $kg^{-1}$ OM) for extrusa samples taken in the same season. The digestibility of OM (444 - 469 g $kg^{-1}$ DM) was similar to that observed by the latter authors and by Fernández-Rivera et al. (1996) in the region.

Regardless of the time of grazing, the steers spent about 60% of the time allowed for grazing (i.e. prehension, mastication, and searching for food). The actual grazing times of 5.9, 6.3, and 7.9 hours for day, night, and day-and-night grazing, respectively, compare well with reported values in the dry season of 6.3 hours for a day grazing herd in Kenya by Coppock et al. (1988); 7 to 8 hours for day-and-night grazers in Uganda by Harker et al. (1954) and 7.4 to 10.4 hours reported by Dicko-Tourè (1980) for day-and-night grazers in Mali. The ruminating time (6.5 to 7.7 hours) also agrees with those reported by Dicko-Tourè (1980) and Harker et al. (1954). Night grazers spent less time ruminating than either day grazers or day-and-night grazers, because they had a lower forage intake. This might also be associated with the natural inclination to ruminate in the night. The lower walking time for steers that grazed in the night compared to the other groups, even though they grazed in the same pasture, supports the findings of Arnold (1966) that sight impairment (poor visibility) causes orientation problems, which limits the area for selective grazing by the animals. The cost of grazing in the night in addition to day grazing is a reduction in resting time as observed for day-and-night grazers. The general pattern of 2 grazing periods during the day, separated by a mid-day rest observed in day grazers, and day-and-night grazers has also been reported by Coppock et al. (1988) for Turkana cattle in Kenya. Night grazers had a longer initial grazing period (4.5 vs 2.7 hours) than day grazers, probably because they were not constrained by heat and high radiation. Resting between the grazing periods by night grazers may likely be induced by rumen fill or fatigue. Similar findings were reported by Fernández-Rivera et al. (1996) in a preliminary study on nocturnal grazing by cattle in the region.

Forage intake, in both weeks 4 and 8, was lower for night grazers than day grazers, which supports previous findings by Fernández-Rivera et al. (1996). This was due to a slow intake rate. Forage intake by day grazers (64.6 g OM $kg^{-0.75}$ W), and day-and-night grazers (69.0 g) in week 4 falls within the range of 63–83 g reported by Schlecht (1995) for unsupplemented steers in Mali and the values reported by Becker et al. (1996) for unsupplemented cows in Niger. The intake values in week 8, however, are lower than those reported by these authors. Day-and-night grazers spent longer time grazing than day grazers but intake was not significantly different. This means that in the day-and-night grazing group, intake (and intake rate) during the day decreased due to night grazing. The fecal excretion values found in this study (6.3–11.0 g DM $kg^{-1}$ W $day^{-1}$) is similar to those reported by Schlecht (1995). Collectable manure, i.e. the amount of feces excreted while not in the pastures (manure excreted while in the corralling site), was higher than the feces deposited in the rangelands by day grazers (week 4: 1,786 vs 1,521, week 8: 1,322 vs 1,236 g DM $animal^{-1}$ $day^{-1}$). The reverse was the case for the animals that grazed in the night, i.e. night grazers (week 4: 1,058 vs 1,385, week 8: 953 vs 1,304 g DM $animal^{-1}$ $day^{-1}$) and day-and-night grazers (week 4: 1,126 vs 2,326, week 8: 932 vs 1,836 g DM $animal^{-1}$ $day^{-1}$). This shows that more manure could be collected from animals that did not graze in the night compared to those that did. The amounts of collectable manure estimated in this study fall within the range of 600 to 1,500 g DM $TLU^{-1}$ (TLU is Tropical Livestock Unit, animal of 250 kg body weight) reported by Khombe et al. (1992) and Fernández-Rivera et al. (1995).

Consumption of water relative to forage intake (liter $kg^{-1}$ forage DM) found in this study agrees with the value of 4.5 liter $kg^{-1}$ forage DM reported by King (1983). The day, and day-and- night grazers, that consumed more forage drank more water than the night grazers. High water consumption by the former could also be associated with high temperatures during the day, as reported by Nicholson (1987) and King (1983), the latter suggesting an extra water cost of 0.35 liter $km^{-1}$ for walking in high solar heat. The range in water consumption (56–110 ml $kg^{-1}$ W $day^{-1}$) observed in this study is below the theoretical maximum (160 ml $kg^{-1}$ BW $day^{-1}$) suggested by King (1983) for cattle grazing tropical pastures. The lower water intake observed in the second period of measurement (week 8) could be attributed to an unexpected rainfall during the period and the concomittant fall in daily temperature for some days and the low ingestion of forage. Low water consumption by the night grazers observed in this study and the previous one (Fernández-Rivera et al. 1996) suggests that during a period of water scarcity, the water needs of grazing cattle could be reduced if nocturnal grazing is practiced without day grazing and the animals are restricted and protected from sunlight during the day.

Steers that grazed in the day-and-night had lower weight loss (239 g $day^{-1}$) than either day grazers (435 g $day^{-1}$) or night grazers (548 g $day^{-1}$). Similar results were reported by Wigg and Owen (1973) and Khombe et al. (1992) for steers that grazed day and night. These findings and that of the present study show that grazing exclusively in the night cannot substitute for day grazing. It rather complements day grazing and leads to better animal performance especially in the dry season. From the data on weight change and intake, day-and-night grazers lost significantly less weight than day grazers but had the same diet quality and intake, whereas day grazers had higher intake than night grazers but had the same weight loss. This discrepancy could be due to differential gut fill which might have influenced live weight measurement (t' Mannetje et al. 1976). The differential gut fill could be associated with the time of the day (0730 to 0800) at which all the animals were weighed. This implies that the night grazers were weighed almost immediately after grazing, about 4 hours after night grazing for day-and-night grazers and 12 hours after grazing for day grazers. Perhaps, the weight loss for night grazers and day-and-night grazers could have been higher than the reported values if they had been weighed at the same time difference after grazing as the day grazers. However, this is not feasible due to the experimental design.

The results also show that the traditional practice of night corralling (i.e. no night grazing) of cattle in West African Sahel put a nutritional stress on the animals (by decreasing forage intake), thereby increasing weight losses especially in the dry season. It also increases the needs for supplementation. To resolve the conflict between night grazing and night corralling, it is necessary to determine the optimum use of the animal's time for grazing and manuring. Therefore, further research on combinations of timing (day and/or night) and duration of grazing is needed to identify practical and feasible recommendations on how to resolve the conflict.

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