INFLUENCE OF ENVIRONMENTAL AND ANIMAL FACTORS ON DAY AND NIGHT GRAZING ACTIVITY OF IMPORTED HOLSTEIN-FRIESIAN COWS IN THE HUMID LOWLAND TROPICS OF NIGERIA

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The grazing activity of 14 Holstein-Friesian cows was observed at 21 day intervals for one year at the University of Nigeria Dairy farm. Overall mean grazing activity accounted for 7.9 hours daily of which 59% took place at night. The mean total dry season grazing activity accounted for 7.4 hours and that of the wet season 8.4 hours, per 24 hour period. The mean period of wet season daytime grazing activity was longer than that of the dry season, while the period of nighttime grazing activity was shorter. Significant relationships were found between hours of grazing activity and environmental temperatures, hours of sunshine, level of milk production, concentrate supplementation level and age.

Key words: Holstein - Friesian cows, grazing activity, humid tropics

The comfort zone for milk production of Holstein-Friesian cows has been found to be in the region of 4!- 21°C with a slow decline occurring in milk yields until about 27°C after which a sharp fall sets in (Johnson 1965). At environmental temperatures of 21°C and above, the feed consumption of Holstein-Friesian cattle has been found to decline, stopping entirely at 40°C (Bianca 1965).

At an altitude of 430 m above sea level, the Nsukka mean monthly maximum and minimum temperatures range from 32°- 27°C and between 23°- 20°C respectively (Ezedinma 1976). These temperature ranges indicate that the Holstein-Friesian cows at Nsukka would experience temperatures above the comfort zone most of the time.

On this background it was decided to study the distribution of grazing activity between day and night, daytime being considered as being the period from 06,00 to 17.40 and nighttime being from 18.00 to 05.40 hours local time.

Materials and Methods

A 3.6 ha mainly Cynodon spp paddock containing adequate tree-shade, was set aside for this study. 14 cows were observed every third Saturday throughout the observational year of November 13th 1976 to November 5th 1977. The total milk yield of the observed cows during the period was 64,663 kg, corresponding to a mean daily yield per cow in herd of 12.9 kg.

All cows in milk were given the same amount of concentrate on each observation day. Dry cows were fed concentrate during the dry season only. Type of concentrate and amount given varied between observation days.

At the start of the observational year, the age of the cows ranged between 3.3 and 4.2 years. The mean liveweight was 508 kg on October 24th 1976 rising to 593 kg on the same date in 1977. The cows were milked between 06.04 and 08.20 hours and between 16.40 and 18.20 hours. Water was available in the paddock.

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The herbage was sampled on every Friday preceding observation days. The paddock we, split into 42 equally-sized sampling plots. In each of these a 0.065m^2 sized quadrant was thrown at random four times. Herbage within was cut to a stubble height of 4 cm and herbage rooted within the quadrant collected.

Meteorological data were collected from the University Meteorological Station

A total of 504 summaries of grazing time within 12 hour periods were obtained. These were made up of 14 cows, nine dry season dates, nine wet season dates, nighttime and daytime. The dry season was considered to be those 6 months of the lowest precipitation means, namely November to April inclusive, the remaining 6 months being considered the wet season.

The effects of 14 variables on grazing activity were studied, viz:- cows, dates, nightime, daytime, dry season, wet season, maximum temperature, minimum temperature, mean temperature, hours of sunshine, pasture availability, milk yield, concentrate supplementation level and age of animal.

Results

Means and levels of significance of differences for the meteorological data are shown in Table 1.

Table 1:
Summary of meteorological station means and significant levels of difference

Meteorological data	Means	t-test degree of significance of difference
Air temperature, °C[a]		
1. Dry season, maximum	31.4 ± 0.75	1 and 2 ***
2. " " , minimum	21.9 ± 0.70	1 and 4 ***
3. " " , mean	26.7 ± 0.60	3 and 6 ***
4. Wet season, maximum	28.0 ± 0.77	4 and 5 ***
5. " " , minimum	21.0 ± 0.48	2 and 5 NS
6. " " , mean	24.5 ± 0.44	7 and 8 ***
7. Whole year, maximum	29.7 ± 0.67	10 and 11 NS
8. " " , minimum	21.4 ± 0.42	13 and 14***
9. " " , mean	25.6 ± 0.45	
Sunshine, hours daily[a]		
10. Dry season	4.9 ± 1.10	
11. Wet season	4.9 ± 1.08	
12. Whole year	4.6 ± 0.76	
Monthly rainfall, mm[b]		
13. Dry season	32.1 ± 8.95	
14. Wet season	182.9 ±21.98	
15. Whole year	107.5 ±25.42	

*** P <.001; ** P <.01; * P< .05 ; NS = Not significant
[a] Observation days; [b] Dry season Nov - Apr. Wet season May - Oct.

There were significant differences between seasons in respect of maximum temperatures, mean temperatures and monthly rainfall. During both seasons the temperatures were above the upper limit of the comfort zone.

The pattern of grazing activity by cows, dates and seasons was analyzed using a factorial design regarding both days and cows as replicates. Table 2 shows the results in terms of number of recordings of grazing made at 20 minute intervals.

Table 2:

Summary of grazing activity of imported Holstein-Friesian cows at Nsukka

Period	Mean
Whole year, night and day	23.6 ± 0.32 [1]
" " , nighttime	14.0 ± 0.21
" " , daytime	9.7 ± 0.26
Dry season, night and day	22.2 ± 0.45
" " , nighttime	14.7 ± 0.31
" " , daytime	7.6 ± 0.31
Wet season, night and day	25.1 ± 0.40
" " , nighttime	13.3 ± 0.28
" " , daytime	11.8 ± 0.30

[1] Number of recordings of grazing made every 20 minutes

Significant differences (P <.001) were found in grazing activity amongst cows and dates. Overall mean calculated grazing activity accounted for 7.9 hours, that of the dry season for 7.4 hours and that of the wet season for 8.4 hours daily, the significance of the difference being at the P <.001 level. Table 3 summarizes the analysis made for the season and the time of day.

Table 3:

Mean grazing hours by season and time of day[1]

Season	Daytime	Nighttime	Difference
Wet	3.93	4.42	0.49***
Dry	2.52	4.88	2.36***
Difference	1.41***	0.46***	

[1] Estimated from observations of grazing activity made every 20 mins.

*** P<.001

Whole year analysis showed that nighttime grazing activity exceeded that of the daytime significantly in the case of 13 of the 14 cows and on 11 of the 18 observation dates. Nine of these dates occurred during the dry season, whereas daytime grazing activity significantly exceeded that of the nighttime on one date during the wet season.

Pasture clippings yielded a mean 6.0 ± 0.61 kg of herbage. This corresponds to a mean availability of some 5512 kg per ha.

In order to study which environmental factors were possibly associated with the differences in grazing activity between dates, an analysis was carried out as outlined in Table 4.

Table 4:

Correlation coefficients between various environmental factors and hours of grazing activity

Factor	Hours of grazing activity		
	Daytime	Nighttime	Total
Maximum temperature	$-.58^{*}$	$.48^{*}$	$-.23^{NS}$
Minimum temperature	$-.55^{*}$	$.01^{NS}$	$-.51^{*}$
Average temperature	$-.70^{**}$	$.37^{NS}$	$-.41^{NS}$
Hours of sunshine	$-.33^{NS}$	$.74^{***}$	$.19^{NS}$
Pasture availability	$.60^{**}$	$-.01^{NS}$	$.60^{**}$

*** P <.001; ** P <.01 ; * P <.05 ; NS = Not significant

High maximum temperatures were associated with a depressed daytime grazing activity. High minimum temperatures were associated with a low level of daytime grazing activity and total grazing activity. Average temperatures were negatively associated with daytime grazing hours.

Hours of sunshine were positively correlated with hours of nighttime grazing, Pasture availability was correlated with hours of grazing during daytime and in total.

In order to discover whether the environmental factors were correlated with one another, a further analysis was made as outlined in Table 5.

Table 5:

Correlation coefficients between various environmental factors

Factor	Hours of sunshine	Pasture availability	Minimum temperature
Maximum temperature	$.31^{NS}$	$-.45^{NS}$	$.29^{NS}$
Minimum temperature	$-.52^{*}$	$-.58^{*}$	
Average temperature	$-.01^{NS}$	$-.59^{*}$	
Pasture availability	$.00^{NS}$		

* P <.05; NS = Not significant

Pasture availability was significantly and negatively correlated with minimum temperatures and with average temperatures while the hours of sunshine negatively and significantly correlated with minimum temperature.

The analysis summarized in Table 2 showed that there were significant

differences between cows in grazing activity. Means and standard errors for variables believed to be associated with the differences are shown in Table 6.

Table 6:

Means of animal factor variables, observation day totals

	Dry season mean	Wet season mean	Whole year mean
Kg milk yield	102.5 ± 14.86	131.0 ± 11.27	233.5 ± 11.27
Kg concentrate fed	73.1 ± 5.61	65.1 ± 3.26	138.3 ± 6.72
Age at project start, years			3.8 ± 0.07

Growth rate and days in milk were not included as the former was confounded with pregnancy and parturition and the latter was directly related to level of concentrate feeding. The relationship between the factors of Table 6 and grazing hours are shown in Table 7.

Table 7:

Correlation coefficients by season and for the whole year between grazing activity of individual cows and milk yield, amount of concentrate fed and age at the beginning of the observational year.

	Dry season			Wet season			Whole year		
	D	N	N+D	D	N	N+D	D	N	N+D
Milk yield	$-.68^{**}$	$.07^{NS}$	$-.54^{*}$	$.36^{NS}$	$.55^{*}$	$.52^{NS}$	$-.39^{NS}$	$-.30^{NS}$	$-.42^{NS}$
Concentrate	$-.73^{**}$	$.06^{NS}$	$-.59^{*}$	$.44^{NS}$	$.19^{NS}$	$.37^{NS}$	$-.37^{NS}$	$-.23^{NS}$	$-.37^{NS}$
Age	$-.62^{*}$	$-.05^{NS}$	$-.55^{*}$	$-.50^{NS}$	$-.32^{NS}$	$-.47^{NS}$	$-.76^{**}$	$-.15^{NS}$	$-.55^{*}$
Night grazing	$.01^{NS}$			$.54^{*}$			$.41^{NS}$		

** P < .01; * P < .05; NS = Not significant; D = daytime grazing activity; N = Nighttime grazing activity

It appears that almost all of the variables studied were significantly correlated with the pattern of grazing activity for at least part of the yea' and/or part of the day. Milk yields were significantly and negatively correlated with both daytime and total grazing activity during the dry season only, whereas they were significantly and positively correlated with nighttime grazing activity during the wet season. Level of concentrate feeding was significantly and negatively correlated with both daytime and total grazing hours during the dry season only.

This indicates that it is difficult to disentangle the effect of milk yield and concentrate on grazing activity. The analysis of the data indicated that the younger animals grazed significantly more than the older animals during daytime and in total during the dry season and over the whole year. During the wet season only, daytime and nighttime grazing hours were significantly and positively correlated with one another. A separate analysis showed that milk yield was highly significantly and positively correlated with concentrate feeding level during the dry season and less so during the wet season (r= .92 (P <.001) and .59 (P <.05) respectively).

Discussion

The observation interval of 20 minutes is considered to be representative of the true time spent grazing, as other workers have found that grazing time estimated from 5, 15 and 30-minute intervals were insignificantly different from total grazing time (Hull et al 1960). The overall means hours of grazing activity of 7.9 hours is in line with that reported for Bos taurus in temperate areas (6.1 to 9.0 hours daily) (Atkeson et al 1942; Johnstone-Wallace and Kennedy 1944; Gary et al 1970; Stricklin et al 1976), Tropical findings range between 7.4 (Wilson 1961)and 13.6 hours daily (Stobbs 1970).

Nighttime grazing activity was significantly higher than daytime grazing during both seasons, Studies in temperate areas have shown hours of darkness grazing to account for between 16% and 40% of total grazing time (Atkeson et al 1242; Gary et al 1970; Johnstone-Wallace and Kennedy 1944; Stricklin et al 1976).

In Queensland lactating Jersey cows were found to spend between 24% and 37% of their total grazing time at night (Stobbs 1970) and Shorthorn Steers were found to do all their grazing at night during the hottest season (Larkin 1956). During hot days in Luisiana, *Bos taurus* lactating dairy cows' daytime grazing activity accounted for about 22% of the total, rising to about 505 on cooler days (Seath and Miller 19462, Payne et 81 (1951) in Fiji found a mean of 67% of the grazing of the lactating Friesian cows to take place at night. The findings of the present study, that between 53% and 66% of grazing takes place at night, depending on season, are broadly in line with other tropical findings regarding exotic cattle. (1951) in Fiji found a mean of 67% of the grazing of the lactating Friesian cows to take place at night, depending on season, are broadly in line with other tropical findings regarding exotic cattle.

The fact that the cows grazed less in the dry, compared with the wet season, mainly on account of a reduced level of daytime grazing, is explained by the finding-that the dry season is associated with the highest maximum temperatures, which were negatively correlated with nighttime grazing activity, High minimum temperatures also depressed daytime grazing and total grazing,

A separate study (Breinholt 1977, unpublished) showed that the mean rectal temperature of lactating cows of the same herd were a maximum of 39.4°C between 13.00 and 16.00 hours and a minimum of 38.6°C at 04.00 h. The normal rectal temperature for cattle has been found to be 38.5 ± 0.5°C (Seigmund 1979).

Lactating Holstein cows exposed to ambient temperature cycles responded by showing a rise in rectal temperature when ambient temperatures exceeded 21°C. The rectal temperature rise lagged behind that in ambient temperature by 1 - 2 hours and the fall to normal levels with falling ambient temperature required about 9 hours (Kibler and Brody 1956). The rise in rectal temperature is accompanied by a decreased feed intake (Worstell and Brody 1953).

Considering this, it is speculated that high minimum temperatures adversely affect the nighttime cooling-off process of the cow, so that it becomes unwilling to increase its nighttime grazing activity beyond normal levels and so that the heat-load carried over to daylight hours, will cause it to curtail daytime grazing relative to what would have been the case had nighttime temperatures been lower.

It was noted that, during sunshine periods, the animals tended to graze in the shade where pasture availability appeared to be low. This may have resulted in a

lower intake of herbage under conditions of sunshine compared with overcast, and hence more fill may have had to be obtained at night on sunny days compared with those of less sunshine. Therefore, perhaps, nighttime grazing increased on sunny days without any reduction in daytime grazing occurring simultaneously.

Pasture availability was positively correlated with both daytime and total grazing. This is at variance with findings elsewhere suggesting that a lowered availability of herbage will result in an increased grazing time (Hancock 1953). Hence it is believed that correlation found between pasture availability and grazing activity was confounded by climatic factors.

Hours of daytime grazing activity and total grazing activity were negatively associated with milk production and concentrate feeding levels during the dry season. Concentrate feeding of lactating cows elsewhere in the tropics also has been found to be negatively associated with grazing activity (Stobbs 1970).

It appears that under conditions of restricted grazing or of low herbage availability, milk production becomes more dependent upon the level of concentrate fed than what would have been the case under a restricted feeding regime or under conditions of herbage abundance. In the latter case it seem-e that the main effect of concentrate supplementation would be a decrease in herbage consumption (Leaver et al 1968), This would seem to explain why milk yields and concentrate feeding levels were more closely related during the dry season than during the wet season of less climatic restrictions.

The reduction in feed intake of *Bos taurus* cows occurring under conditions of thermal stress takes place in the roughage fraction at first (McDowell 1972). A high level of milk production is associated with a high level of heat production. This depresses heat tolerance, and therefore high yielding cows are less heat tolerant than low producing cows (Bianca 1965). Increased rectal temperatures are associated with lowered feed intakes and a consequent decline in the heat increment (Kibler and Brody 1956). These factors would seem to be involved in the reduction of grazing activity associated with higher milk production during the day time of the dry season.

During the wet season, nighttime grazing activity was positively corr- elated with milk production, but not with concentrate feeding level. Feeding of concentrate being at the same level for all cows in milk, it appears that the animals producing the highest levels of milk also were the most active grazers at night, daytime being the period of comparative climatic restrictions. Moreover there was a tendency for those cows being the most active grazers at night also to be so during daytime.

Findings elsewhere suggest that heat-tolerance increases with age up to four years (Bianca 1965) and this would seem to result in an increased grazing activity with age under thermal stress, the opposite of the Nsukka findings, Therefore it is believed that the lower levels of grazing activity of the alder animals were associated with lower nutritive requirements for growth.

Implications

The general picture emerging from this study is that the climatic factors at Nsukka are such that varying degrees of thermal stress, depending on season and time of day, are imposed on Boa taurs cows, and, as a result thereof, the grazing activity of

such cows is curtailed (tiring the daytime generally and during the dry season in particular, Compensatory grazing takes place at night.

Pasturing the animals day and night will allow cows to adjust their grazing activity to the environmental factors of the day, and it is speculated that the low-milk yields generally produced in the tropics partially, are on account of denying the animals access to night grazing. The fact that cows hardly sleep (Belch 1955) is not generally appreciated in the tropics.

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