

Effect of shade on various parameters of Friesian cows in a Mediterranean climate in South Africa. 3. Behaviour

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The effect of a shade structure on the behaviour of lactating Friesian cows in open camps (dry lots) was determined over two consecutive summer periods. The daily activities of cows were observed and recorded on 9 separate 24-h periods. Shade cows spent more time ($P < 0.05$) feeding during the day than no-shade cows, while there was no difference in feeding time at night. More than 80% of the cows in both groups started to eat directly on returning from the milking parlour. Feeding lasted for approximately 2.5 h during the morning, whereas the first feeding period in the afternoon was shorter (probably owing to high ambient temperatures) and cows (60%) ate again at 19:00. No-shade cows spent more time ($P < 0.05$) standing during the day than shade cows and they also tended to crowd around the water trough. Shade cows tended to spend more time ($P < 0.10$) lying down (mainly in the shade) to ruminate or to sleep than cows without access to shade. Different behavioural patterns indicated responses by cows specifically aimed at alleviating heat stress during the day.

Die invloed van 'n skaduwee-afdak op die gedragpatroon van lakterende Frieskoeie in oop kampe is gedurende twee opeenvolgende somerperiodes bepaal. Die daaglikse aktiwiteite van koeie is op 9 afsonderlike 24 h-observasieperiodes waargeneem en aangeteken. Koeie met skaduwee het gedurende die dag meer tyd ($P < 0.05$) bestee om te vreet as koeie sonder skaduwee, terwyl die vreettyd gedurende die nag nie verskil het nie. Die meeste koeie (>80%) in beide groepe het direk na terugkoms vanaf die melkportaal begin vreet. Gedurende die oggend was die vreettyd ongeveer 2.5 h, terwyl dit na die middagmelking korter was (waarskynlik weens hoër omgewingstemperatuur) en ongeveer 60% van die koeie het weer om 19:00 begin vreet. Koeie sonder skaduwee het gedurende die dag langer gestaan ($P < 0.05$) as koeie met toegang tot skaduwee en het geneig om rondom die waterkrip saam te drom. Koeie met skaduwee het daarenteen geneig ($P < 0.10$) om langer, hoofsaaklik onder die skaduwee-afdak, te lê om te herkou of te slaap. Die gedragpatroon van koeie met of sonder skaduwee het aangetoon dat koeie bepaalde gedragsveranderinge toon in 'n poging om die invloed van hittedruk gedurende die dag te verminder.

Keywords: Behavioural pattern, dairy cows, heat stress, shade.

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Introduction

Studies concerning the behaviour of animals have long been regarded to be important in understanding the response of various treatments on physiology, nutrition, breeding and management (Hafez & Lindsay, 1965). Behavioural observations have often been secondary to the main aims of research projects. It has been pointed out (Taylor, 1962, as cited by Arave & Albright, 1981) that the nutritionist who ignores the behaviour of experimental animals may find differences measured on different rations to be confounded by crowding stress. A knowledge of the behaviour and daily activities of dairy cows may be useful mainly in two ways, namely:

- (i) a change in behaviour may indicate some problem in management or animal health; and
- (ii) it is possible to change and improve the herd routine as a result of studying the behavioural patterns of animals (Castle & Watkins, 1979).

There has been a trend towards more intensive dairy farming in many parts of South Africa, notably in the Western Cape. Cows are kept mainly in open camps (dry lots or corral confinement systems) according to milk production potential.

Feed is usually provided twice a day after milking. On most farms no protection against adverse climatic conditions is provided. The negative effect of high temperatures, solar radiation, relative humidity and wind speed on milk production during summer is a major concern.

Very little information concerning the daily behavioural pattern of dairy cows under local locations is available. The effect of a shade structure on the daily activity of cows is also not known. The objective of this study was to observe and record the behavioural pattern of cow activities during summer in open camps with or without a shade structure.

Materials and Methods

The study was conducted at the Elsenburg Experimental Station (altitude 177 m, longitude 18° 50', latitude 33° 51') of the Department of Agriculture during two consecutive summer periods. In behavioural studies, experimental designs which simulate ordinary farm conditions should be used. This usually include large groups (i.e. more than a pair of animals) and commercial-type pens, water and feed troughs as well as management practices (McGlone, 1986).

Primi- and multiparous cows from the Elsenburg Friesland herd were divided into two groups of at least 15 cows each, according to stage of lactation and average daily milk yield during a 3-week preliminary period. During 1985/86 and 1986/87 seven and five cows respectively from each treatment were paint-branded on both sides to allow individual identification. Cows were kept in two adjacent dry lots. A surface area of 75 m²/cow was provided in each camp. A fence-line feeding trough providing feeding space of 700 mm/cow was used. Cows received a complete diet twice a day. While the cows were in the milking parlour, fresh feed was supplied in the troughs after refusals of the previous feeding were removed. An overhead shade structure, providing an unbroken area of shade of 4.1 m²/cow, orientated lengthwise in a north-south direction, was erected near the centre of one of the camps. The shade structure was 4.5 m wide, 16.5 m long and 3.5 m high. In the same camp another shade structure of 2.7 m wide and 2.9 m high was erected over the feed trough to provide a further 2.5 m² shade per cow.

Continuous observations of cows in the shade and no-shade camps were done by the same observers on separate 24-h periods during February 1986 (3 days) and from February to March 1987 (6 days). Each cow's daily activities concerning feeding, standing and lying down were observed and noted down to the nearest minute. Additionally, on every hour of each 24-h period, the number of animals engaged in a particular activity was determined. The percentage of cows engaged in feeding, standing and lying down, was calculated for each experimental group. Data for the main activities were plotted on time of day to determine changes in behavioural patterns.

Data on the activities of cows were pooled over the two experimental periods. Differences in times spent eating, standing and lying down between shade and no-shade cows, were compared by analysis of variance by using the Genstat-5 statistical package. Differences between number of feedings, standing and lying-down periods as well as duration of parameters were similarly analysed.

Results and Discussion

Meteorological conditions

The meteorological conditions on observation days during the two experimental periods are presented in Table 1. Conditions were representative of the season. Maximum temperatures on all test days were higher than 25.0°C (mean 31.5 ± 2.5°C) with cool night temperatures (14.5 ± 2.2°C). The number of stress hours (ambient temperature ≥ 25.1°C) was on average 8.5 ± 2.0. This indicates that animals were subjected to high temperatures during the day with relatively cool conditions at night.

Feeding activities

The daily feeding activities of shade and no-shade cows on test days during the two experimental periods are presented in Table 2. As expected, shade cows spent more ($P < 0.05$) time feeding during the day than no-shade cows, probably due to the fact that a shade structure was provided over the feed trough. There was no difference ($P > 0.05$) in feeding time at night between the shade and no-shade cows. Although shade cows spent more time feeding per 24 h (238.4 vs. 209.4 min),

Table 1 Meteorological conditions on observation study days

Year	Days	Temperature (°C)			Stress hours ^b (h:min)
		Maximum	Minimum	Mean ^a	
1985/86	1	33.0	11.8	23.67	10:26
	2	28.6	14.0	21.00	07:46
	3	36.2	12.3	25.39	12:09
1986/87	1	33.3	12.8	20.50	06:04
	2	31.0	16.8	21.70	07:24
	3	28.8	17.1	21.85	07:43
	4	32.0	17.8	23.58	09:51
	5	29.4	14.5	21.03	06:19
	6	30.9	13.6	23.23	08:34

^a Mean of 24-hourly values.

^b Number of hours at ambient temperature ≥ 25.1°C.

Table 2 Daily feeding activities of shade and no-shade cows on test days

Parameter	Time	No		SE _d	Significance level (P)
		Shade	shade		
Total feeding time (min)	Day	114.1	94.6	8.0	0.02
	Night	124.3	114.8	12.1	0.44
	Total	238.4	209.4	17.9	0.12
Number of feedings	Day	5.3	6.1	0.45	0.08
	Night	6.0	6.8	0.79	0.36
	Total	11.3	12.8	0.98	0.12
Duration of feedings (min)	Day	23.1	16.6	1.49	0.001
	Night	22.4	18.4	1.39	0.01
	Daily mean	22.7	17.3	1.23	0.001

SE_d = Standard error of difference.

this difference was not significant ($P = 0.12$). Both shade and no-shade cows tended to spend more time feeding at night, ($P < 0.10$). Webb *et al.* (1963) observed that cows went more often to hay feeders at night, but spent the same time eating during the day and night.

Comparison of the total daily feeding times of dairy cows is difficult owing to the fact that the type of feed offered, has a great influence on the duration of feeding times. Rate of feeding is affected by many factors such as the physical and chemical characteristics of feeds, the amount offered, the age and the size of the cow. Feeds of a fibrous, bulky and dry nature are normally eaten at a slower rate than less fibrous, moist feeds, whereas pelleted feeds are eaten most rapidly (Campling & Morgan, 1981). Considering the nature of the experimental diet in which the roughage was ground and mixed with the concentrate in a complete diet, it was to be expected that the total duration of feeding should be less than that of feeds such as long hay and silage. Metz (1975) as cited by Campling & Morgan (1981) noted that dry, non-pregnant cows offered hay wafers *ad libitum*, spent between 248 to 392

min/day eating. Freer and Campling (1965) as cited by Campling & Morgan (1981) found that when different feeds were offered *ad libitum*, total feeding time on hay was 263 min, feeding time on chopped, dried grass hay was 194 min and that on concentrate pellets was 66 min only. It seems that grinding and pelleting of forages cause an appreciable reduction in feeding time.

No-shade cows tended ($P = 0.08$) to have more feedings than shade cows during the day, while there was no difference ($P > 0.05$) in number of feedings at night. Shade cows had longer ($P < 0.01$) feedings both during the day and night. Campling (1966a) as cited by Campling & Morgan (1981) kept dairy cows in individual stalls with hay available throughout the day and two meals of concentrate pellets per day. It was found that cows spent on average 7.4 h daily eating hay, divided into 12 meals. This is in agreement with number of meals provided for shade and no-shade cows in the present study. Webb *et al.* (1963) noted that Guernsey cows which had access to hay and silage simultaneously, ate on 18.6 occasions per day for a total feeding time of 6.3 h/day.

Figure 1 shows the daily activities of shade and no-shade cows during the day and night. From this it seems that in both groups of cows, most cows (>80%) ate directly after returning from the milking parlour. This is in agreement with results of Shultz (1985), who found that more than 60% of cows inside intensive housing systems ate within the first 30 min post-milking period. At 08:00, approximately 17% of shade cows

in the present study were still eating, while more than 39% of no-shade cows were eating ($P < 0.05$). At 09:00, most cows in both groups were finished eating. From 12:00 to 15:00, more ($P < 0.05$) shade cows were eating than no-shade cows. This is probably due to the shade provided over the feed trough. This is in agreement with general behavioural patterns of shade cows in Florida, USA (Roman-Ponce *et al.*, 1977). During daylight cows remained under the shade structure, while at night cows spent their time in an open camp.

Fewer than 20% of the shade cows ate at any time after 08:00, which resulted in an under-utilization of the shade structure over the feed trough. Wiersma & Armstrong (1985) found only a modest increase in cattle performance by providing shade over the feed trough. This makes economic justification for a structure of this kind questionable. Providing shade over 30% to 50% of the length of the feed trough is likely to be as effective as complete shade.

On returning from the milking parlour during the afternoon, most cows (72% of shade and 80% of no-shade cows) started eating immediately. The time spent feeding, however, was not as long as the post-milking feeding period in the morning. More than 60% of shade and no-shade cows ate again at 19:00 when the average ambient temperature was below 24°C. Shultz (1984) also found that in commercial dairies in California, fewer ($P < 0.05$) cows ate at the afternoon feeding period owing to hot weather conditions. This reduction was highly significant ($P < 0.01$) in dairies without shade

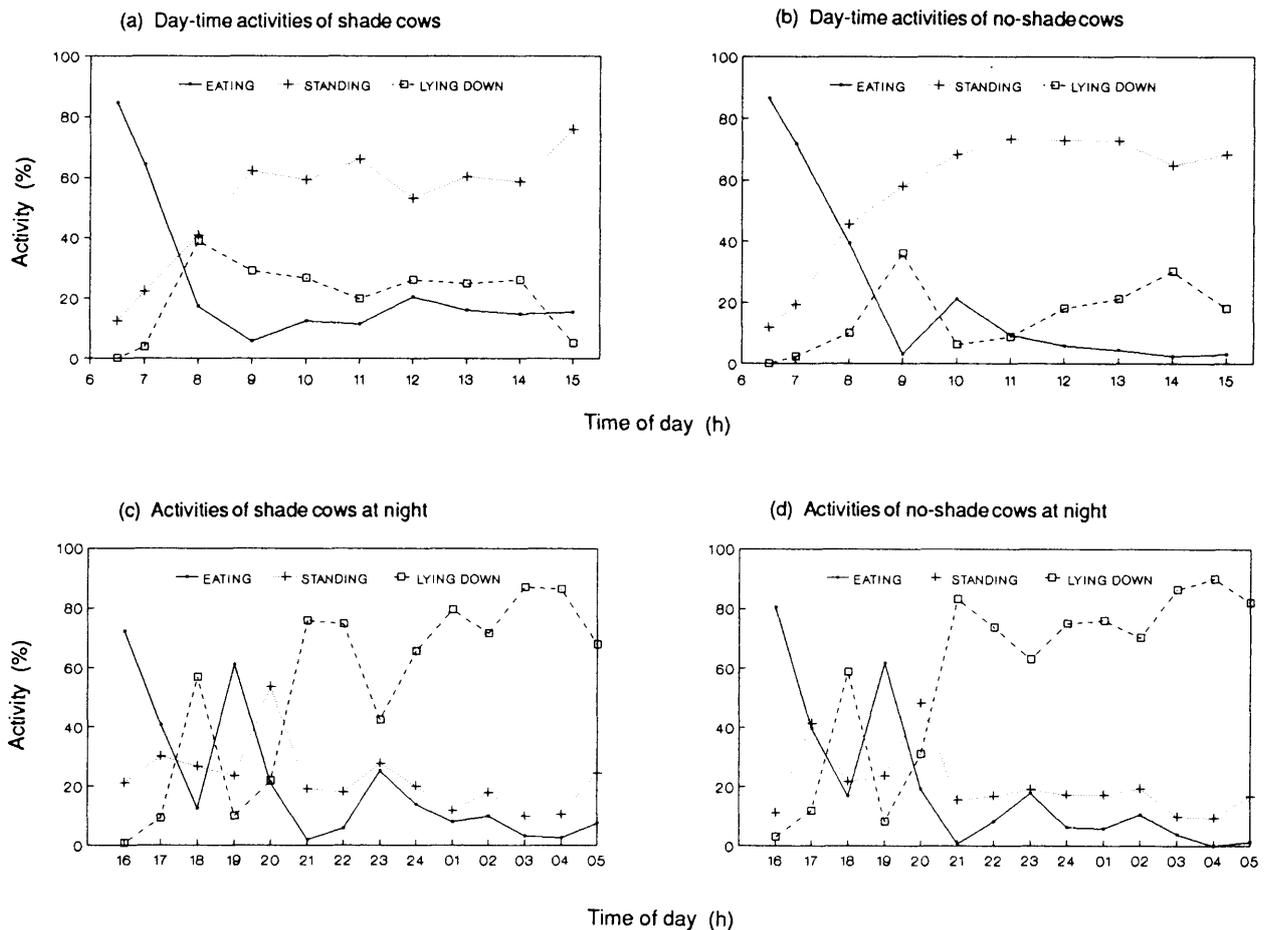


Figure 1 The daily activities of shade and no-shade cows during the day and night.

structures over the feed troughs. The better responses with shaded feed troughs were probably due to maintaining feed palatability as well as protecting cows from heat. It seems therefore that early morning and evening feedings are important for maintaining desired feed intakes.

There was another feeding period at 23:00 when 25% of shade and 18% of no-shade cows were eating. Very few cows ate between midnight and 05:00. Webb *et al.* (1963) noted that cows stopped eating at about 18:30 after being fed at 16:00. Cows ate again at 23:00 with some activity up to midnight. Krohn & Konggaard (1976) as cited by Campling & Morgan (1981) found that dairy cows which ate grass silage *ad libitum* and restricted amounts of sugar-beet pulp as well as concentrate in the milking parlour, tended to concentrate the eating of silage from 06:00 to 09:00 and again from 15:00 to 18:00.

Standing activities

Cows usually spend considerable time each day standing around, ruminating or resting (idling). According to Castle & Watkins (1979) idling time is approximately 9.5 h per 24 h for grazing dairy cows. Rumination usually occurs during this time. The daily standing activities of shade and no-shade cows on test days are presented in Table 3. No-shade cows spent more time ($P < 0.05$) standing during the day than shade cows, possibly to increase radiation from the body in an effort to keep body temperature down. It was also noted that no-shade cows crowded around the water trough with some cows even standing with their front feet in the water, trying to splash water from the trough over their backs. This is in agreement with results reported by Shultz (1984). He observed that under hot conditions in California, more ($P < 0.05$) cows were lingering near (but not drinking) water. This was specifically noted ($P < 0.05$) on dairy farms where no protection against summer heat was provided (5.9 vs. 1.8% of no-shade and shade cows). Cooling ponds for dairy cattle are used by dairy farmers in some hot regions of the USA to alleviate heat stress (Beede *et al.*, 1987).

Table 3 Daily standing activities of shade and no-shade cows on test days

Parameter	Time			SE_d	Significance level (P)
		Shade	No shade		
Total time standing (min)	Day	267.6 ^a	331.9 ^a	25.7	0.02
	Night	182.4 ^b	178.4 ^b	27.0	0.88
	Total	450.0	510.3	45.4	0.20
Number of standing periods	Day	12.7	12.6	0.89	0.99
	Night	14.2	14.3	0.92	0.99
	Total	26.9	26.9	1.20	0.99
Duration of standing periods (min)	Day	23.1 ^a	29.0 ^a	3.80	0.13
	Night	13.1 ^b	12.3 ^b	1.80	0.66
	Daily mean	17.5	19.9	2.30	0.31

^{a, b} Columns with different superscripts differed significantly ($P < 0.01$).
 SE_d : Standard error of difference.

In the present study, no-shade cows also stood in a line along the boundary fence with their heads held low in the shade provided by the first cow's body. Standing in a line like this, also enabled cows to be cooled by any air movement. Shade cows on the other hand, stood mainly under the shade structure during the day. Roman-Ponce *et al.* (1977) also observed that cows remained under the shade structure and only went outside at night. Ray & Roubicek (1971) noted that feedlot cattle in Arizona remained under a shade structure from 07:00 until 18:00, while at night very few (5%) of these cattle remained there.

The percentage of shade and no-shade cows which were standing during the day and night time periods is presented in Figure 1. It seems that only 12% of cows were standing (not eating) on returning from the milking parlour in the morning. By 09:00 almost 60% of cows were standing, which indicated an end to the morning feeding period. Only at 12:00 a greater percentage ($P < 0.01$) of no-shade cows was standing compared to shade cows (72.9 vs. 53.1%). At night-time the standing patterns of shade and no-shade cows were very similar. At 17:00, 30% of shade cows and 41% of no-shade cows were standing, possibly due to the heat experienced at that time of day (ambient temperature of 27.5°C). At 20:00, 54% of shade cows and 48% of no-shade cows were standing – which possibly indicated cows resting and ruminating after the second feeding period at 19:00. No information concerning the standing activity of dairy cows is available from the literature. It seems that researchers concentrate on the feeding and lying-down activities of cows. It was concluded that the standing activity of cows is mainly influenced by weather conditions and their feeding activities.

Lying-down activities

The lying-down activities of shade and no-shade cows on test days are presented in Table 4. Shade cows tended ($P < 0.10$) to spend more time lying down during the day than no-shade

Table 4 Daily lying-down activities of shade and no-shade cows on test days during the two experimental periods

Parameter	Time			SE_d	Significance level (P)
		Shade	No shade		
Total time lying down (min)	Day	128.7 ^a	87.1 ^a	23.5	0.09
	Night	448.9 ^b	462.5 ^b	31.8	0.67
	Total	577.6	549.6	47.3	0.56
Number of lying-down periods	Day	3.68 ^a	3.02 ^a	0.61	0.29
	Night	6.91 ^b	6.82 ^b	0.54	0.88
	Total	10.59	9.84	0.81	0.36
Duration of lying-down periods (min)	Day	36.6 ^a	27.5 ^a	4.2	0.04
	Night	67.4 ^b	69.0 ^b	6.3	0.80
	Total	56.2	56.8	4.5	0.90

^{a, b} Values in columns with different superscripts differed significantly ($P < 0.01$).

SE_d : Standard error of difference.

cows (128.7 vs. 87.1 min). There was no significant difference ($P > 0.05$) in lying time at night and total lying time per 24 h between shade and no-shade cows (9.6 vs. 9.2 h, respectively). Castle & Watkins (1979) noted that cows spent on average from 9 to 12 h per 24 h lying down to ruminate and rest or sleep. About 80% of rumination occurs when cows are lying down. Cattle do not exhibit true sleep as in humans, except for very short periods. They rest without loss of vigilance and probably without loss of consciousness. An animal may lie with its eyes closed, but any noise or movement will cause an immediate response (Merrick & Scharp, 1971). An analysis of the power density function of electroencephalograms indicated three behavioural states, viz. (i) standing with eyes open, (ii) lying down with head erect and eyes open, and (iii) lying down with head supported and eyes partially closed. True sleep (REM) is only experienced by cows in short, 2 to 8-min intervals (Ruckebusch & Bueno, 1978). According to Castle & Watkins (1979) cows rarely rest flat on their sides owing to the fact that the thorax must be kept in a vertical position to enable the proper functioning of the rumen. When resting, cows will stand for a few minutes from time to time and will lie down again at the same place but usually on a different side.

Shade as well as no-shade cows spent more time ($P < 0.01$) lying down at night than during the day. Castle & Watkins (1979) also noted that the main lying-down period is at night. The number of lying-down periods during the day and night did not differ between shade and no-shade cows. However, shade cows lay down for longer periods ($P < 0.05$) during the day. Shade and no-shade cows had more ($P < 0.01$) lying-down periods at night and the duration of these periods was longer ($P < 0.01$) at night than during the day for shade and for no-shade cows (67.4 vs. 36.6 min and 69.0 vs. 27.5 min, respectively).

The percentage of cows lying down during the day and night is presented in Figure 1. About 40% of shade cows were resting at 08:00 while 36% of no-shade cows were resting at 09:00. This difference in resting time is possibly due to the fact that more ($P < 0.05$) no-shade cows were still eating at 08:00. From 09:00 onwards, only about 25% of shade and 20% of no-shade cows were lying down. Cows were mainly standing at this stage, possibly to increase heat loss. According to Roman-Ponce *et al.* (1977), cows with no shade lay down in wet areas during the hot hours of the day to alleviate heat stress. Shultz (1984) also reported an increase ($P < 0.05$) in the percentage of cows resting with increasing hot conditions, especially for cows with no protection against heat. At 18:00, 57% of shade and 59% of no-shade cows were lying down. From 21:00 onwards, with the exception of a late-evening feeding period by some cows at 23:00, most cows (76% of shade and 80% of no-shade cows) were lying down. Castle & Watkins (1979) noted that 80% of cows studied lay down at night, especially in the early hours of the morning. Gonyou & Stricklin (1984) noted that more than 95% of feedlot steers in their study lay down in the early morning (post 01:00) up to about two hours before sunrise.

From the combined daily activity budget of shade and no-shade cows during the day and night (Figure 1) it is clear that both groups of cows started to eat immediately on returning

from the milking parlour. A third major feeding period was observed at 19:00, possibly due to high temperatures at approximately 17:00. Most cows stood to ruminate after a meal, while only approximately 20% of cows lay down during the day. Shade cows lay down under the shade structure, while no-shade cows stood to alleviate heat stress. From 21:00 onwards, most cows lay down to ruminate and/or sleep. This behavioural pattern of dairy cows was similar to that of feedlot cattle studied in Arizona (Ray & Roubicek, 1971). The major portion of the 24-h period is one of inactivity, broken only by two major peaks in eating activity at sunrise and sunset, respectively. By mid-morning most eating activities had stopped, and similarly less than 10% of animals ate after 21:00. Very few animals remained under the shade structure at night. As milking times and the natural time of feeding of dairy cows usually correspond with sunrise and sunset, it is obvious that fresh feed should be available when cows return from the milking parlour. Fresh feed will ensure a high feed intake, thereby reducing the negative effect of high temperatures.

Conclusions

Shade cows spent more time ($P < 0.05$) feeding during the day than no-shade cows, whereas there was no difference in feeding time at night. Shade cows had longer ($P < 0.01$) feeding periods during both the day and night. Most (80%) of the shade and no-shade cows ate directly on returning from the milking parlour. During the morning, the cows were usually finished eating after approximately 2.5 h. After the afternoon milking, cows ate again at 19:00, possibly due to high temperatures at 17:00. Less than 20% of shade cows ate from 12:00 to 15:00, which results in an under-utilization of the shade structure over the feed trough. No-shade cows spent more time ($P < 0.05$) standing during the day than shade cows. No-shade cows crowded around the water trough while this behaviour was not observed among shade cows. There was no significant difference in number and duration of standing periods between shade and no-shade cows.

Shade cows spent more time ($P < 0.10$) lying down during the day than no-shade cows, although both groups of cows spent more time lying down at night than during the day. The number of lying-down periods was greater ($P < 0.01$) at night than during the day. The cows mainly lay down at night. With the exception of a short feeding period at 23:00, there was very little activity after midnight.

These observations seem to indicate different behavioural patterns between shade and no-shade cows, specifically aimed at alleviating heat stress during the day. This is a further indication that attempts should be made to reduce heat stress during summer by providing shade to dairy cows.

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