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Lying behaviour of dairy cows under different housing systems and physiological conditions

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Abstract

Rest and activity are fundamental and complementary indices of animal behavior. Monitoring lying behaviour (LB) for individual dairy cows can advance precision dairy farming by indicating animal's comfort in different housing .conditions and physiological status

The objectives were: 1) to study diurnal lying behaviour (LB) of dairy cows under normal commercial management routine; 2) to compare the effects on LB of different housing systems; 3) to study LB in relation to activity, normally and .during oestrus

A leg-mounted sensor to monitor and register lying times was developed, tested, .and found reliable. Data were downloaded during milking times

In a first trial 12 multiparous cows in a roofed no-stalls barn, under comfortable ± h per day. Lying periods ranged from 3.7 1.6 ± thermal conditions. lay for 8.8 .h, between 13:00 and 20:00 0.8 ± h, between 20:00 and 05:00, and 2.3 1.3

In a second trial, 8 first-calving cows were housed in each of two adjacent completely roofed barns: one no-stall and the other free-stall; the third trial repeated the second trial, with 4 cows from each group interchanged. In both trials, cows of both groups demonstrated diurnal lying patterns similar to that of trial 1, except that those in the no-stall barn lay for 2 h more then those in the .free-stall barn

The free-stall cows were more active; there was a significant negative correlation between activity and lying time in the free-stall barn, and no correlation in the no-stall barn. Lying time was significantly shorter in cows that were in oestrus, in .accordance with the increase in activity

The lying sensor can indicate the suitability of housing conditions for animal comfort, can improve oestrus detection, and probably can provide early .indication of health problems

Lying behaviour, dairy cows, comfort, welfare :**Key words**

Introduction

Rest and activity are fundamental and complementary components of animal behaviour. In ruminants in general, and dairy cows in particular, lying behaviour (LB) reflects the rumination activity as well as resting patterns. The LB may be affected by the daily routine activities such as feeding and milking, and by individual temperaments; it is often considered as an indicator of cow comfort in comparisons between different housing environments (Metz 1985, Singh et al., 1993; Ketelaar de Lauwere et al., 1999; Sonck et al., 1999; Fregonesi & Leaver, 2001; Haley et al. 2001; Horning et al., 2001). LB measurements may be used to reveal physiological changes in dairy cows, such as onset of oestrus (Phillips & Schofield, 1990; Brehme et al., 2004) or health problems (Galindo & Broom, 2002). In the cited studies the LB data were obtained through visual observations whereas in the present study, a leg-mounted sensor was developed and was used to monitor, record and transmit lying times.

The objectives of the present study were: 1) to study diurnal LB under normal commercial management; 2) to compare the effects of two different housing systems on LB; and 3) to relate LB to activity in regular and in oestrous cows.

Materials and methods

A leg-mounted sensor to monitor and record lying times and periods was developed in the Institute of Agricultural Engineering, The Volcani Center. The sensor is based on ability to measure the angle of the leg and can store and transmit data. Ongoing patenting prevent the disclosure of technical details of the sensors at present. The sensor was tested by comparison with parallel visual observations and by comparing data obtained by two sensors fitted to the same cow (Fig. 1). The power source (commercial batteries) was sufficient to run the sensor for at least one month. Collected data were downloaded during milking.

Trial 1: The sensor was used to monitor and analyze the LB of 12 Israeli Holstein multiparous cows for 3 weeks. The cows, which produced an average of about 35 kg milk/d, were housed in a completely roofed, no-stall barn in the research dairy of the Volcani Center. The weather conditions were comfortable. Feeding (total mixed ration – TMR) and food nearing were performed once daily (09:00-10:00, and 16:30 respectively), and milking thrice daily (05:30, 13:30, 20:30).

Trial 2: In a commercial dairy farm in which 550-600 cows were milked thrice daily (04:00, 12:00, 20:00), two adjacent barns at equal walking distances from the milking parlor were used for this trial. Both were completely roofed; one was a no-stall barn, the other free-stall. Each barn housed about 100 cows. Sixteen first-calvers were selected (eight in each barn) and each was paired with a counterpart in the other barn, with similar time after calving, milk yield (MY) and body weight (BW) (Table 1). LB, activity, and performance were monitored for 10 days, starting on the 5th day carrying the sensors. The cows were fed four times daily (04:00, 07:00, 11:00 and 18:00) with a TMR, and food nearing five times daily (03:00, 08:00, 12:00, 17:00 and 01:00). Activity and performance were monitored with an Afifarm Management System (S.A.E. Afikim, Israel). Significance of differences was evaluated with Student’s t-tests: unpaired, between groups; and paired, between periods and between treatments in the same cows.

Trial 3: Eight cows that participated in Trial 2 – four cows from each of the two barns were switched over to the other barn. After the transferred cows had been allowed one week to adaptat to the new conditions, performance activity and LB were monitored for 11 successive days and analyzed.

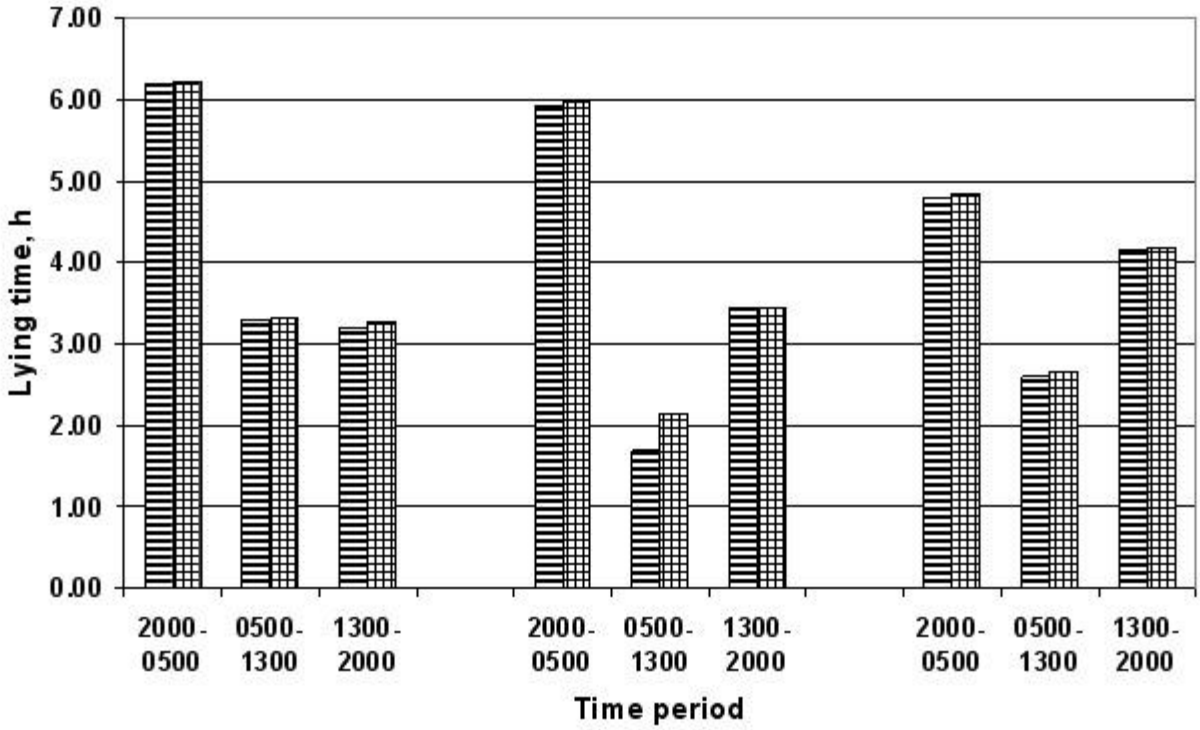

Figure 1. Diurnal lying times during between-milking intervals of one cow measured by two different sensors (different bar shadings) each fitted to a hind leg.

calving cows tested in a completely roofed, no-stall barn or-Table 1. Average details of 16 1st
(free-stall barn (8 cows in each barn) (mean ± SD, and range

Pen type	Days in milk	Body weight, kg	Milk yield, kg/d
No-stall barn	141 ± 40 (74 - 186)	480 ± 41 (434 – 552)	35.5 ± 4.3 (26.0 – 39.5)
Free-stall barn	139 ± 42 (71 – 182)	482 ± 17 (461 – 510)	35.7 ± 3.1 (31.8 – 42.0)

Results

In the first trial, the cows spent 8.8 ± 1.6 h per day lying; the longest lying time (3.7 ± 1.3 h) was recorded between 20:00 and 05:00; the shortest (2.3 ± 0.8 h) between 13:00 and 20:00.
In the second trial, cows of both groups demonstrated qualitatively similar diurnal lying patterns to that observed in trial 1, but quantitatively there was a significant difference between the two groups (Table 2). On average the cows in the free-stall barn lay for approximately 2 h (20%) per day less than those in the no-stall barn. The greatest difference (1.5 h) was recorded between 13:00 and 20:00, and the smallest (0.5 h) during the morning.

Table 2. Lying times (means ± SD) during daily between-milking intervals of eight cows in a no-stall barn and eight in free-stall one

Time interval	Lying time (min)		Free-stall lying time, as % of no-stall	Significance (P<)
	No-stall	Free-stall		
04:30 - 12:30	157 ± 42	120 ± 43	76.4	0.01
12:30 - 20:30	118 ± 50	108 ± 49	91.5	ns
20:30 - 04:30	258 ± 51	199 ± 50	77.1	0.001
24h total	533 ± 87	427 ± 90	80.1	0.001

This pattern was fully confirmed by the switch-over results obtained in Trial 3 (Table 3): the cows that were transferred from one barn to the other adopted the lying behaviour characteristic of the cows that had always inhabited their destination barn (Table 2). Cows that had spent about 10 h lying in the no-stall barn, spend lying 3 h less diurnally after their transfer to the free-stall barn (Table 3), but maintained the same proportions of lying time between milkings (Table 4).
The activities of the cows that were transferred between the two barns were compared (Trial 3). The data in Table 3 are presented for individual cows in order to highlight the differences between individual cows as well as the diurnal uniformity of each cow's activity (Table 5). Whether cows were transferred from no-stall to free-stall conditions or vice ~~a~~ versa made no difference: in each case the activity level was higher and lying time lower in the free-stall barn (except for one cow, #6734, that did not change her lying time). The individual differences in lying times were much smaller than those in activity levels. There was a significant negative correlation between cows' activity levels and lying times in the free-stall barn (R^2 = 0.6663), and no correlation between these two variables in the no-stall barn. No significant changes in milk yield and body weight were recorded as a result of the transfer from one type of barn to the other.

Table 3. Lying times (means ± SD) during daily between-milkings intervals of two groups of four cows that were transferred from one type of barn (period 1) to the other type (period 2)

Time interval	Period 1		Period 2	
	No-stall	Free-stalls	No-stall	Free-stalls
04:30 - 12:30	153 ± 41*[a]	120 ± 39*	178 ± 55[a]	126 ± 55
12:30 - 20:30	110 ± 45*	113 ± 48*	148 ± 46[a]	78 ± 43
20:30 - 04:30	254 ± 51*[a]	180 ± 56*	259 ± 58[a]	200 ± 75
24h total	517 ± 73*[a]	414 ± 77*	585 ± 75[a]	404 ± 69

* Significant difference (*P* < 0.01, paired t-test) in lying behaviour of the same cows when transferred from one barn to the other in different periods.
[a] Significant difference (*P* < 0.01, unpaired t-test) in lying behaviour between groups (4 cows) inhabiting different barns within period.

Table 4. Cows lying time distribution (percentage of 24-h total) in between-milkings diurnal intervals of two groups of four cows that were transferred from one type of barn (period 1) to the other type (period 2)

Time of day	Period 1		Period 2	
	No-stall	Free-stalls	No-stall	Free-stalls
04:30 - 12:30	29.5	29.0	30.5	31.2
12:30 - 20:30	21.3	27.4	25.2	19.3
20:30 - 04:30	49.2	43.6	44.3	49.4
24-h total	100.0	100.0	100.0	100.0

Table 5. Maximal diurnal activity level (steps/h, average ± SD, and range of 11 successive days) of two groups of 4 cows transferred from one type of barn

to the other. The first group of 4 cows were moved from a no-stall barn to an adjacent free-

Cow	Activity* (steps/h)		Lying time* (min)	
	No-stall	Free-stall	No-stall	Free-stall
6634	179 ± 26 151 - 237	237 ± 33 190 - 307	601 ± 50 542 - 669	446 ± 96 251 – 531
6734	237 ± 21 201 - 284	346 ± 34 285 - 402	417 ± 77 305 - 547	449 ± 63 354 – 517
6736	137 ± 17 126 - 184	165 ± 19 153 - 216	492 ± 87 356 - 595	341 ± 74 263 – 458
6738	75 ± 10 59 - 88	142 ± 13 113 - 155	576 ± 38 528 - 648	383 ± 42 318 – 446
6655	147 ± 15 128 - 180	169 ± 11 153 - 194	647 ± 62 523 - 720	365 ± 55 301 – 448
6677	124 ± 24 94 - 159	187 ± 25 151 - 234	511 ± 51 460 - 600	400 ± 70 268 – 508
6684	151 ± 23 115 - 185	180 ± 31 114 - 229	624 ± 95 481 - 718	461 ± 95 303 – 633
6811	142 ± 13 122 - 164	156 ± 17 134 - 196	579 ± 58 479 - 650	444 ± 82 344 - 536
Average	149 ± 46	201 ± 65	556 ± 77	411 ± 45

stall one, and vice-versa for the second group.

* Significant difference in activity and lying time between treatments (*P* < 0.005, paired t-test)

There were only three cases of oestrus that could be monitored in relation to LB and activity level. In all of them the lying time dropped significantly during the day of detection of oestrus, similarly to the increase in activity in timing and magnitude (Fig. 2).

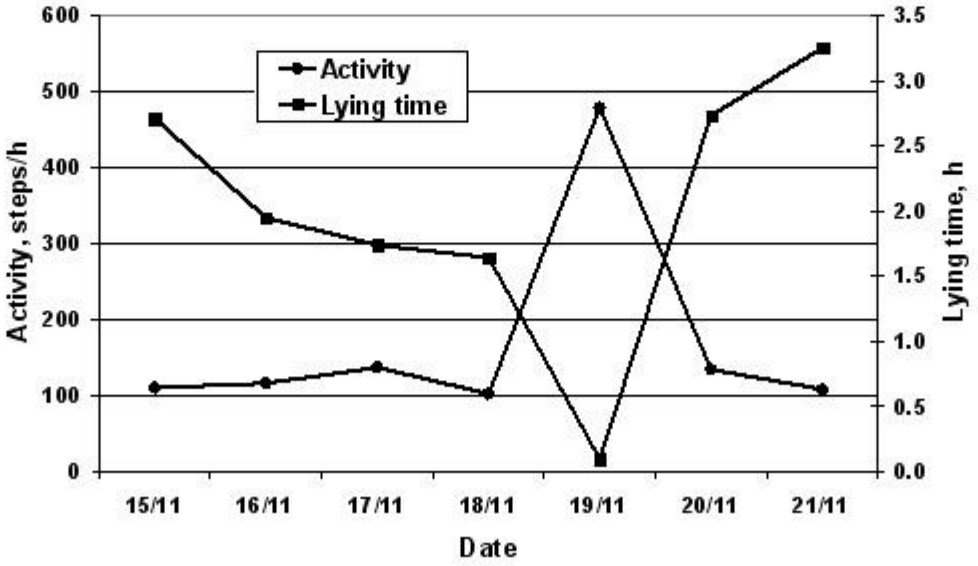

Figure 2. Lying time and activity of a cow in oestrus.

Discussion

The range of diurnal lying times recorded in the present study was similar to those recorded in other studies of dairy cows (Singh et al. 1993). Although the longest lying periods occurred during the night, a substantial part of the cows' daily lying time occurred during daytime. There was a range of differences of only 20%, approximately, between individuals in their daily lying times, whereas the difference in activity levels could exceed 100%. The lying behaviour can, therefore, be considered as a relatively stable parameter, similar to feeding (Halachmi et al., 2004), indicating its significance in the natural diurnal behaviour pattern of the dairy cow.

First-lactation cows were selected to evaluate the effectiveness of the sensor as a device for measuring lying times in two different housing systems, in order to eliminate the possible effects of size, hoof problems and acquired lying behaviour habits, especially in the free-stall system. The cows were selected to be in a lactation stage in which they were well adapted to the daily routines, and therefore, the variations in milk production over the measuring period were very moderate (Maltz et al. 1991). The lying behaviour as measured diurnally was found to be a powerful tool for indicating differences in the cows' comfort in two different housing systems. One of the definitions of animal comfort is the freedom to persist in its natural behaviour, therefore, the fact that a cow spent about 8-10 h diurnally lying in a no-stall barn and 20% less in the other housing system indicates that something is wrong with the latter system. It is impossible to claim at this stage that the no-stall barn is a superior housing system to the free-stall in every case, even though shorter lying times have been recorded in the latter systems (Singh et al. 1993, Fregonesi & Leaver, 2002). Such a conclusion would require more measurements under similar controlled conditions in more dairies, especially since contrary evidence has been reported as well (Horning et al. 2001). However, in the case of the particular two systems in the present study, we conclude that the no-stall system provides more comfortable conditions for dairy cows than the free-stall one. The fact that the milk production and body weight were not affected by the housing conditions does not necessarily lead to a contrary conclusion. Indeed, MY in Jersey cows was not affected by restriction of lying-time (Verkerk et al. 1999). However, it can be suggested that the driving force for milk production is strong enough to maintain performance despite less comfortable conditions. Rumination also takes place while cows stand. It is possible that the "payment" for overcoming this discomfort is, in the long run, reduced resistance to the extreme physiological demands of lactation, which leads to a higher replacement rate. The cows in the free-stall

barn were significantly more active than those in the no-stall barn, perhaps because they were more restless. This is confirmed by the negative correlation between lying time and activity level that was observed in the free-stall barn but not in the no-stall one.
The effect of housing conditions on LB indicates that LB monitoring could be used for evaluating and improving animal welfare. For this purpose it might be sufficient to monitor the LB of a few cows in order to evaluate suitability of facilities or management routines. Monitoring the LB of cows transferred from one facility to another, or monitoring the changes in LB that follow a change in a routine could be a useful tool in the adoption of animal-friendly routines and facilities.
In addition, this sensor could contribute to more efficient oestrus detection, in parallel to other existing methods. In tied stalls, this is likely to be the most efficient single sensor for detecting standing heat. The stability of LB, on the one hand, and its sensitivity to physiological changes, on the other hand, suggest that this sensor could also indicate deterioration in animal health.

Conclusions

The lying sensor which was developed for research purposes was found to be useful for accurately and continuously monitoring the lying behaviour of dairy cows in different housing environments, as well as their physiological conditions.
It was concluded that an LB sensor could serve as an indicator of the cow's welfare and for use in comparing different housing conditions. The sensor has the potential to improve oestrus detection, and it is likely that it can indicate health problems, and this is an objective of our future work.

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