Effects of Season, Housing and Physiological Stage on Drinking and Other Related Behavior of Dairy Cows (*Bos taurus*)

Marielena Moncada Laínez and Liang Chou Hsia*
Institute of Tropical Agriculture and International Cooperation, Taiwan, ROC

ABSTRACT : The objective of the paper was to study the drinking and other related behavior of dairy cows (*Bos taurus*). There were 142 Holstein dairy cows observed and compared in this study. The experiment was designed on the basis of two different housing systems (wet pad with forced ventilation cooling house and open house); two different seasons (winter and summer); four different stages (high milk yielding cows, low milk yielding cows, dry cows, and heifers); and grouping (home and visitor animals). All cows had free access to water. Dairy cows spent 13.8 min/day drinking in wet-pad house and 11.7 min/day in open house. However, there was no significant difference in the duration of water drinking between these two housing systems ($p>0.05$). The water consumption was significantly higher in wet-pad housed animals (68 L/day) than open-housed animals (31.5 L/day) ($p<0.05$). A significant interaction between housing and grouping ($p<0.05$) was found. Home and visitor animals spent more time drinking in open house, wet-pad house, respectively. A highly significant interaction was found between housing and drinking time during the day ($p<0.001$). Animals in open house drank more during the morning (6:00 to 10:00 h), whereas wet-pad housed animals drank in the afternoon (14:00 to 15:00 h) and evening (18:00 to 20:00 h). The average time a cow spent in drinking in summer was not significantly different from that of drinking in winter. However, the water intake was significantly higher in summer (61.9 L/day) than in winter (38.6 L/day) ($p<0.05$). Drinking activity showed a highly significant interaction between season and physiological stage ($p<0.01$). High milk yield cows spent more time drinking in summer than in winter, whereas cows in all other stages followed the opposite drinking pattern. Grouping exchange did not influence the drinking behavior of dairy cows in either season ($p>0.05$); both home and visitor animals spent almost the same time in drinking water. A strong significant interaction between season and time during the day was found ($p<0.01$), suggesting that animal's high drinking frequency occurred during the daytime for both seasons, with a peak midday in winter and two peaks at 10:00 h in the morning and 19:00 h in summer. Thus, drinking behavior was associated with the cooler time of day in summer and with the warmer hours of day in winter. High and low milk yielding cows and heifers spent 15.3 min/day, 14.3 min/day, and 12.8 min/day, respectively, in water drinking activity, but there was no significant difference among them ($p>0.05$). There was, however, a significant difference in water drinking activity found in dry cows, which spent less time in drinking at 8.2 min/day ($p<0.05$). ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 10 : 1417-1429)***

Key Words : Drinking Behavior, Dairy Cows, Season, Housing System, Physiological Stages

INTRODUCTION

Drinking behavior is a very important indication to assess productivity in dairy cattle especially under tropical conditions because water is the main component of milk. Animals exposed to thermal stress generally show a decline in productivity. An analysis of drinking behavioral patterns of cattle exposed to these conditions may indicate potential methods of alleviating this decreased performance (Ray and Roubicek, 1971). Among farm animals, lactating dairy cows require the greatest amount of water in proportion to their size, primarily because of the volume of water secreted in their milk. Restriction in water intake caused by water quality or supply might be expected to affect primary milk production (National Research Council, 2001). Yoon et al. (2004) indicated that dairy cattle produced more milk in winter and spring than in summer. It is important to understand the relationship between water intake and different dairy cattle house in different seasons.

* Corresponding Author: L. C. Hsia. Dept. of Animal Science, National Pingtung University of Science and Technology, 1 Hsueh-Fu Road, Lao-Pi, Nei-Pu, Pingtung 912, Taiwan, ROC. Tel: +886-8-7701094, Fax: +886-8-7700984, E-mail: lchsia@mail.npust.edu.tw

Received September 1, 2003; Accepted January 14, 2004

By understanding the above needs, one can improve the cows' productivity. Access to fresh, clean water is an important issue, because water intake can affect feed intake (Castle and Thomas, 1975; Stockdale and King, 1983; Sekine and Asahida, 1987; Murphy, 1992; Holter and Urban, 1992), performance, and milk yield. The study of animal drinking behavior can help us to improve our dairy cattle production system.

This study investigated the animal drinking and other related behavior of cattle in two different seasons (winter and summer) and housing designs (open house and wet pad with forced ventilation cooling system) and compared animals' drinking behavior among different stages of the animals (high milk yield cows, low milk yield cows, dry cows, and heifers) to determine the effect of grouping exchange on drinking behavior, as well as the effect of drinking behavior on water intake.

As mentioned, water represents an important role in dairy cattle due to milk production. Thus, drinking behavior

Table 1. Animal distribution during winter and summer experiment in both housing systems

Season	Classification	Open house	Wet-pad house	Total
Winter	High milk yielding cows	5	5	10
	Low milk yielding cows	3	3	6
	Dry cows	9	9	18
	Heifers	19	19	38
Summer	High milk yielding cows	11	12	23
	Low milk yielding cows	11	12	23
	Dry cows	6	6	12
	Heifers	6	6	12
Total		70	72	142

represents an important key to understanding animals' needs according to the environment provided for the animals in many different circumstances. In our experiment we attempted to investigate the influence of the housing designs on drinking behavior in tropical areas, especially the effects or advantages of acquiring the wet pad and forced ventilation cooling system as an effective house to keep animals under well-controlled conditions and avoid heat stress in the cows (Hsia, 2002). The present experiment also would like to study the other factors, which might influence on drinking behavior. They are season, physiological stage ad social factor. The social factor here was group exchange. Group exchange happened quite frequently in dairy farms, e.g., non-lactational cows being moved to dry cow pen and moved lactational cows into milking cow group. All these factors will interact with housing design then influence on water intake, e.g., when dairy cows move to another group usually may eat less due to move into a new physical and social environment.

MATERIALS AND METHODS

The research was done at the Animal Farms of the National Pingtung University of Science and Technology (NPUST). A group of 142 Holstein breed animals were used in the experiments, of which 72 animals were observed during the winter season and 70 of the same breed and group animals were observed in the summer season. The animals were classified according to their age and physiological stage. The animals were divided according to their production stage and age in both seasons and were classified in four different groups as follows: High milk-yielding cows, low milk-yielding cows, dry cows, and heifers (Table 1).

Before starting the behavioral observations, the cows in both open and wet-pad housing systems were split into two sub-groups, one subgroup from one of the houses would be exchanged with a subgroup in the other house according to their physiological stage. The subgroup transferred was denominated as visitor animal, while the other subgroup, which stayed in the same house, was denominated home animal. This was done to observe the effect of grouping exchange on the behavior of dairy cows. Observations were done during two different seasons, winter (January, 2002) and summer (August, 2002). The behavioral observations were recorded during 24 h for each physiological stage. The experiment was conducted in the following two housing designs which were compared in both seasons:

Table 2. Composition of TMR fed to milking cows

Ingredients	Proportion (%)	Amount (kg)
Hay (*Digitaria eriantha*)	28	200
Napier grass (*Pennisetum purpureum*)	51	360
Concentrate	14	100
Molasses	5.6	40
$NaCO_3$	1.4	10

i) The dimensions of loose open house was 29.2 m× 60.4 m. The pen size was 29.2 m×15.0 m. The floor was made of concrete with a fence made of iron bars separating each pen. In this system the cows had free movement and also free access to feeding, water and resting area under partially sheltered conditions. Drinking water was provided in the water troughs, which were located in strategic positions in all pens.

ii) The dimensions of wet pad and forced ventilation house was 13.8 m×56.6 m. The principle of this system was to use an evaporative cooling system to lower the environmental temperature by using high-speed air movement to remove heat from both lung area as well as convection from the body (Hsia, 2001). The housing design included a feeding area with one stall per animal. The resting area was designed as a free-stall system; the bedding material was made of rubber mattresses 3 cm in depth. Each animal had access to any area in the pen, two drinkers of the water bowl type were located in the feeding area, and at the side of the free stalls rows, in each pen, was located a water trough.

Milking cows were fed Total Mixed Ration (TMR) as shown in Table 2. The amount offered to the cows was standardized according to milk yield and was maintained constant throughout the experiment. The feeds provided were measured according to the average milk yield for each group. The amount of feed for milking cows was 55 kg/cow/day. The dry cows and heifers were fed with hay made of Pangola grass (*Digitaria eriantha*). 10 kg for heifers and 13 kg for dry cows in both housing and seasons.

In both housing systems the cows had to put their heads through the feeding barrier to reach their food. The feeding barrier had a horizontal, adjustable bar and was separated by vertical bars, which defined a feeding space. Immediately after feed was delivered, most of the cows proceeded to the feeding barrier and started eating. During certain periods, many cows stood close together at the feeding barrier and all put their heads through the barriers.

Table 3. Management action plans during the experiment

Time	Activities
05:15	Flush milking machine
05:30	Start milking: ①WHM, ②WLM, ③OHM, ④OLM (milking order)
	Run pedometer: ①WH, ②OH (run pedometer order)
	Scrape out manure
	First feeding time
07:30	Push roughage against the feeding barrier channel
09:00	Push roughage against the feeding barrier channel
	Lock neck stable
09:30	Release neck stable
11:00	Push roughage against the feeding barrier channel
14:00	Second feeding time
	Lock neck stable
14:30	Release neck stable
16:00	Push roughage against the feeding barrier channel
17:15	Flush milking machine
17:30	Start milking: ①WHM, ②WLM, ③OHM, ④OLM (milking order)
	Run pedometer: ①WH, ②OH (run pedometer order)
	Scrape out manure
19:30	Push roughage against feeding barrier channel
22:30	Push roughage against feeding barrier channel
	Scrape out manure

WHM: High milk yield cows in wet-pad house.
OLM: Low milk yield cows in open house.
OHM: High milk yield cows in open house.
WLM: Low milk yield cows in wet-pad house.
WH: Heifers in wet-pad house.
OH: Heifers in open house.

All activities and management practices carried out during the experiment are listed in Table 3.

The scraper was operated in wet pad and forced ventilation cooling system house. Water was not used for cleaning purposes in this system to reduce the water usage on the farm and improve the efficiency of waste treatment. The animals were provided light for 24 h a day throughout the experiment in both open and wet pad house. The lamps used were fluorescent.

Every four hours had four observers on duty to record the behaviour and the location and activity of each animal every minute during each period of 24 h; behavioral patterns of individual animals were recorded. Behavior was classified as: standing, lying, moving, eating, drinking, milking, defecating, urinating, sleeping and licking salt. The description of each behavior is detailed as follows:

· Standing : The animal stood without movement.

· Moving : The animal showed forward or backward steps.

· Eating : The animal put its head through the feeding barrier until withdrawal from feeding trough.

· Drinking : When the animal puts its mouth into the water bowl or water trough until withdrawing its head.

· Defecating : The animal raised its tail and the feces were seen coming out, until the animal stopped the action.

· Urinating : The animal raised its tail, arched its back, ceased any other activity, and splayed its legs until the urine came out, and until the time the animal returned to the normal standing position.

· Sleeping : The animal lay down and closed its eyes.

· Licking salts : When the animal started lapping the salt block until it stopped the action.

· Front leg on bed : When the animal kept its front legs on the free stall's floor.

Drinking behavior of the herds was studied for a 24 h period in each housing system in both seasons. The quantity of water drunk each day was measured every hour using water bowls and water troughs equipped with a water meter. Intakes and the time spent drinking by individual cows were recorded. All water consumption was recorded once every hour, the same as for environmental temperatures and relative humidity. Drinking behavior of cows was observed once every minute during the whole experiment.

The experiment was set up in a complete randomized design (CRD). The animals were randomly selected after confirming their milk production. Every animal was considered a replication. Statistical analyses were performed by using the general linear models procedure for the analysis of variance (ANOVA), and LSD test was used for mean comparisons in the Statistical Analysis System SAS 2000®.

Table 4. Average maximum and minimum environmental temperatures in winter and summer during the experimental period (Unit: °C)

Temperature	Winter		Summer	
	Wet-pad house	Open house	Wet-pad house	Open house
Maximum	25.2	24.3	30	36
Minimum	13.6	13	25	27.1

RESULTS AND DISCUSSION

The average environmental temperature is shown in Table 4, which shows that the temperature difference between the two seasons was about 12°C. Temperatures were higher in the wet-pad house during the winter, whereas in summer higher temperatures were recorded in the open house.

Cows spent more time drinking during summer (13.1 min/day) than winter (12.4 min/day). The higher temperatures to which the animals were exposed led the animals to drink more frequently and as a means to maintain their body temperature. However, the effect of the season had no significant difference ($p>0.05$). These results agree with those found by other authors (Mullick et al., 1952; Winchester and Morris, 1956; Hoffman and Self, 1972; Little and Shaw, 1978; Stockdale and King, 1983;

Table 5. Behavior of cows during winter and summer

Behavior	Season (min/day)		MSE
	Winter	Summer	
Standing	279.8[b]	340.4[a]	129.9
Lying down	701.3[a]	639.6[b]	157.2
Front leg on bed	16.2	23	37.1
Moving	35.6[b]	42[a]	15.3
Eating	294.6[a]	264.6[b]	72.1
Drinking	12.4	13.1	6.9
Defecating	7.1[a]	3.9[b]	2.6
Urinating	3.7	4.1	2.1
Sleeping	43.9[b]	79.4[a]	38.3
Licking salt	32.4[a]	2.9[b]	21.9

Means followed by different letters in the same row are significantly different by the Duncan's multiple range test (p<0.05).
MSE: Standard error of mean.

Table 6. General behavior comparison between two different housing systems: wet pad and open house

Behavior	House (min/day)		MSE
	Wet-pad house	Open house	
Standing	302.9	316.6	129.9
Lying down	657.5	684.7	157.2
Moving	29.1[b]	48.7[a]	15.3
Eating	300.8[a]	258.2[b]	72.1
Drinking	13.8	11.7	6.9
Defecating	5.5	5.5	2.6
Urinating	3.7	4.1	2.1
Sleeping	59.9	63	38.3
Licking salt	13.9[b]	21.8[a]	21.9

Means followed by different letters in the same row are significantly different by the Duncan's multiple range test (p<0.05).
MSE: Standard error of mean.

Chesworth, 1992; Ali et al., 1994; Fraser and Broom, 2002). Redbo et al. (2001) found that drinking was not significantly influenced by any climatic variable.

Eating activity was significantly different ($p<0.05$) between seasons, demonstrating that animals have higher feed intake during winter (294.6 min/day) than summer (264.6 min/day); this difference indicated that lower temperatures do induce the animals to eat more so that it could use more energy and thermoregulate themselves, as suggested by previous studies (Church and Pond, 1982; Chen et al., 1993). Similar figures were reported by Wierenga and Hopster (1990), who reported an eating time of 235.8 min/day. These results agree with those found by some other studies (Ray and Roubicek, 1971; Lanham et al., 1986; Alhassan and Kabuga, 1988; Krohn et al., 1992), who reported a marked reduction in feed intake under hot weather.

Defecation time appeared to be higher ($p<0.05$) in winter than summer, approximately 7.1 and 3.90 min/day, respectively. The defecation time appeared to be associated with a higher feed intake in winter than in summer. Young (1983) pointed out that cold temperatures stimulated the animals to eat more. A similar pattern was observed in urination. The animals tended to spend a longer time at the drinking trough during the summer as compared to winter. However, this difference was not significant ($p>0.05$).

It was noticed that the cows spent more time standing during summer (340.4 min/day) than winter (279.8 min/day). This is due to the fact that the animal had to dissipate more heat from the body as indicated by Phillips (1993). He suggested that animals tend to expose more of their body surface for effective evaporative cooling. The same behavior was seen in lying activity, which was greater in winter at 701.3 min/day than summer 639.6 min/day ($P<0.05$). This behavior appeared to be longer than those times observed by Phillips (1993) in a range of 420 to 600 min/day. Also, moving activity was significantly different ($p<0.05$), obtaining a higher value in summer (42.0 min/day) than winter (35.5 min/day).

Time spent sleeping was significantly ($p<0.05$) higher during the summer than (49.4 min/day) in winter (43.9 min/day). Longer sleeping time could be attributed to the mechanism of the animal to reduce its activity that reduces heat production associated with high-energy metabolism. It was reported that cows tended to reduce their exposure to the sun in order to reduce their body temperatures (Phillips, 1993). This was an indirect evidence to show that cows try to reduce heat production in summer.

Licking of salt was observed to be higher during winter (32.4 min/day) than summer (2.9 min/day). This may be due to the animal increasing its mineral requirement in winter due to higher feed intake (Table 5).

By comparing both housing systems it was observed that time spent in drinking by the cows was higher in wet pad (13.7 min/day) than open house (11.6 min/day). This result was not significantly different ($p>0.05$).

Cows in wet-pad house spent a longer time (300.8 min/day) eating. The controlled environment was comfortable, agreeing with studies reported by Chesworth (1992) and Church (1974). They suggested that when animals are kept under thermoneutral zone temperatures, they are less stressed and therefore are stimulated to greater feed intake.

Defecation duration seemed to be the same for animals in both housing systems (5.52 min/day), even though eating time was higher in wet-pad housed animals. Urination activity was not significantly different ($p>0.05$) between the animals of either housing systems.

Time spent standing was not significantly different ($p>0.05$). However, moving activity appeared to be greater ($p<0.05$) in open system (48.7 min/day) than in wet pad (29.1 min/day). This may be due to the larger space of the open house that allowed more free movement. This data agrees with those of Haley *et al.* (2000) but differs from those found by Wierenga and Hopster (1990), who reported that animals stood for 250 min/day.

For dairy cows, lying down is generally seen as an important behavior, as it enables the cows to rest. Allowing dairy cattle adequate opportunity to lie down and rest is considered important for maximizing production as well as cow comfort and well-being. It suggested that both systems were comfortable for the animals to lie down in because enough space was provided for them in both houses; thus, no stress was observed. Cows followed the same pattern as to the time spent sleeping in both systems where no significant difference ($p>0.05$) was observed (Table 6).

Drinking activity of dry cows was significantly less than the other three groups ($p<0.05$). High milk producer cows have a higher metabolic rate; thus, more heat is produced. For this reason, they demanded more water. Similar results were found by Andersson (1987), who reported that high milk yielding cows drank more frequently than the low milk yielding cows. The literature mentions that high milking cows have greater water intakes (Murphy et al., 1983; Chesworth, 1992; Maltz et al., 1994; Grant and Albright, 2001). The lowest drinking activity in the dry cows may be due to no milking, the animals in that stage having slower movements and tending to rest most of the time. Holter and Urban (1992) found that dry cows tended to show decreased water intake.

Times spent eating by the animals were higher for high milk yielding cows (316.2 min/day) and dry cows (298.5 min/day) than for the low milk yielding cows (290.9 min/day) and heifers (261.3 min/day) ($p<0.05$). This is because they have greater requirements; these data agree with those of Grant and Albright (2001). They pointed out that higher producing and older cows consumed more feed and ate their feed more quickly than low producers.

Defecation time was greater for high milk yielding cows (7 min/day) ($p<0.05$), but no differences were found among the other physiological stages. Urination results showed a marked effect of water intake on urination since urine is mainly composed of water (Church and Pond, 1982; Chesworth, 1992; Phillips, 1993). The same pattern was found between the two behaviors at each physiological stage.

Standing time was higher in both high (313 min/day) and low milk yielding cows (334 min/day), but no significant difference was found compared with the other stages ($p>0.05$). These results agree with those of Wierenga and Hopster (1990), who reported that standing time was higher at the beginning of lactation.

Time spent lying was the highest for heifers 708.6 min/day, followed by dry cows 694.8 min/day ($p<0.05$). This may have been due to the fact that the dry cows tended to rest more because of their great body weight. It is not easy for them to move all the time compared with other animals as mentioned above. Low milk yielding cows spent less time lying down (588.2 min/day) compared with all other stages ($p<0.05$). Time spent lying by heifers differed from those reported by Grant and Albright (2001), who found 461 min/day. For adult cows they reported 424 min/day, which are lower times that the ones found in this experiment.

Moving behavior was found higher for low milk yielding cows, 56.5 min/day ($P<0.05$), than for the other stages, followed by heifers (38 min/day) and low milk yielding cows (32 min/day). The dry cows showed least movement (30.16 min/day) due to their heavy weight. However, the sleeping time was higher by low milk yielding cows 124.4 min/day than all other stages with a significant difference ($p<0.05$). Dry cows (61.1 min/day) and heifers (44 min/day) spent more time sleeping than did high milk yielding cows (32.1 min/day) ($p<0.05$).

Time spent on salt licking activity was more for heifers (38.3 min/day) followed by dry cows (17.3 min/day), high milk yielding cows (1.7 min/day), and low milking cows (1.4 min/day). This result is quite interesting because there was no concentrate provided for heifers and dry cows; thus, they had to lick salts for a longer time to supply part of the minerals they required (Table 7).

Regrouping may disturb the social hierarchy; that is, change the dominance rank of individuals in the herd, which may distress cattle and have adverse effects on

Table 7. General behavior comparison between different physiological stages in dairy cows

Behavior	Physiological stage (min/day)				MSE
	High milk yield cows	Low milk yield cows	Dry cows	Heifers	
Standing	313.5	334.5	295.9	301	129.9
Lying down	664.5^{a}	588.2^{b}	694.8^{a}	708.6^{a}	157.2
Front leg on bed	24.5	30.2	18.1	10.9	37.1
Moving	32.0^{bc}	56.6^{a}	30.2^{c}	38.0^{b}	15.3
Eating	316.2^{a}	250.9^{b}	298.5^{a}	261.3^{b}	72.1
Drinking	15.3^{a}	14.3^{a}	8.2^{b}	12.8^{a}	6.9
Defecating	7.0^{a}	5.4^{b}	4.8^{b}	5.1^{b}	2.6
Urinating	5.0^{a}	4.3^{ab}	2.5^{c}	3.8^{b}	2.1
Sleeping	32.1^{c}	124.2^{a}	61.1^{b}	44.5^{bc}	38.3
Licking salt	1.7^{c}	1.4^{c}	17.3^{b}	38.3^{a}	21.9

Means followed by different letters in the same row are significantly different by the Duncan's multiple range test ($p<0.05$).

MSE: Standard error of mean.

Table 8. General behavior comparison between different seasons and grouping exchange

Behavior	Grouping (min/day)				MSE
	Winter		Summer		
	Home	Visitor	Home	Visitor	
Standing	277.1[b]	282.8[ab]	344[a]	336.9[ab]	129.9
Lying down	706.6	695.4	635.9	643.1	157.2
Moving	32.1[b]	39.4[ab]	44.7[a]	39.1[b]	15.3
Eating	299.1[a]	289.5[ab]	267.5[ab]	261.9[b]	72.1
Drinking	12.8	11.9	13.3	12.9	6.9
Milking	1.4[b]	1.4[b]	16.2[a]	15.8[a]	3.3
Defecating	7.2[a]	7.1[a]	3.6[b]	4.2[b]	2.6
Urinating	3.7	3.8	4.2	3.9	2.1
Sleeping	45[b]	42.6[b]	77.5[a]	81.3[a]	38.3
Licking salt	33.1[a]	31.6[a]	4.1[b]	1.7[b]	21.9

Means followed by different letters in the same row are significantly different by the Duncan's multiple range test ($p<0.05$).
MSE: Standard error of mean.

production. When a cow moves from one group to another, she is subjected to both social and nutritional stress. Lactating dairy cows showed that member exchange between groups increased aggression and that behavioral time and patterns could also be altered. In the present study, on the first day of observation after re-grouping the animals showed aggressive behavior in establishing a new hierarchy.

Drinking activity was slightly higher for home animals in both seasons; however, no significant difference was found ($p>0.05$). This might be because home animals kept their dominance over the visitors animals. However, it seems that the visitor animals tried to find a proper time to drink water when the dominant animals could not disturb them. If forced to compete for feed and water, the animals can be easily injured or suffer reductions in feed intake. Similar results were found by Andersson et al. (1984), who reported that dominant cows consume more water than submissive cows. Results differed from those of Grant and Albright (2001) who reported around 18 min/day drinking.

Although data are scarce, it is clear that grouping strategy can have an impact on the feeding behavior and feed intake of dairy cattle. Grouping is a component of the cow's feeding environment that can modulate intake as a result of its impact on cow comfort and competition for feed and other resources as suggested by Grant and Albright (2001). The time cattle spent eating was highest for home animals in winter (299.1 min/day) and least for visitor animals in summer (261.9 min/day). These results had a difference of ($p<0.05$). These eating times agree with those reported by Grant and Albright (2001), who suggested a range from 180 to 300 min/day. These results suggested that aggressive behavior was observed just after re-grouping. Other reports show similar values (Tennenssen et al., 1985; Wierenga, 1990; Albright and Arave, 1997; Hasegawa et al., 1997; Phillips, 1993; Phillips and Rind, 2001; Phillips, 2002). The decrease in eating time of visitor animals may be due to the confrontations between animals after the first day of re-grouping. Hasegawa et al. (1997) found that lower-ranking animals were more often disturbed at feeding; however, in the present experiment, enough space and an individual stall were provided for the animals. Whereas some differences might be present when feeding animals in-group rather than individually, continued competition among the in-group animals causes adverse results, even with the provision of adequate feeding space and ration as reported by Brakel and Leis (1976).

Defecation time was higher in winter for both home and guest animals, about 7 min/day than for summer season, at 3.5 and 4.2 min/day for home and visitor animals, respectively. No significant difference was seen between home and visitor animals within season ($p>0.05$), but a significant difference was found for home and visitor animals when comparing different seasons ($p<0.05$). No difference in urination time was found comparing both home and visitor animals in either season ($p>0.05$). This result can be supported indirectly by the animals, which did not reveal any difference in total drinking time.

Standing was significantly higher ($p<0.05$) in home animals (344 min/day) in summer compared with those in winter (277.1 min/day). There was no significant difference found between the visitor groups in either season. These results agree with those of Hasegawa et al. (1997), who reported that frequency of standing and lying decrease after re-grouping during the first few days, whereas in the present study no difference was found between home and visitor animals between seasons. Moving was significantly higher ($p<0.05$) for home animals (44.7 min/day) during the summer than home animals during the winter (32.1 min/day). There was also a significant difference found in summer between home and visitor animals, 44.7 and 39.1 min/day, respectively ($p<0.05$).

There was a difference found in time spent sleeping in summer between home and visitor animals, 77.4 and 81.2 min/day, respectively, compared with those in winter, 45.0 min/day for home animals and 42.6 min/day for visitors ($p<0.05$). This suggests an effect of season on re-grouping the animals. Cattle tended to sleep more during summer; as a consequence, they could reduce heat production and heat stress.

Licking salt was found to be higher in winter than summer ($p<0.05$), but no difference between home and visitor animals in either season was observed ($p>0.05$) (Table 8). It has been reported that drinking is synchronized with feeding and milking (Andersson et al., 1984; Andersson, 1985; Andersson, 1987). A highly competitive time at the feed bunk or manger coincides with the return of cows from milking when fresh feed is delivered (Friend and Polan, 1973; Friend and Polan, 1974; Wierenga and Hopster, 1990). The present study showed that most of the drinking

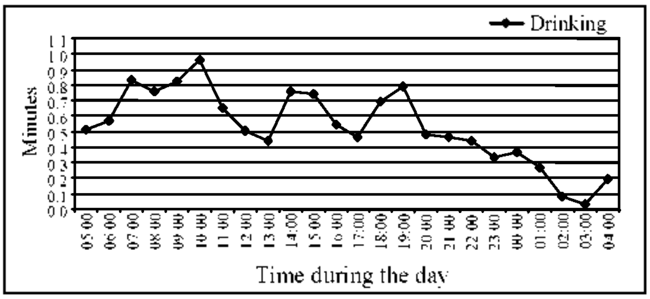

Figure 1. Drinking behavior during 24 h.

occurred from 7:00 to 10:00 h soon after the milking time. The first meal was provided at 5:30 h, and the cows spent eating actively. The remaining feed was pushed against the feeding channel at 7:30 h. They drank after the meal. Usually the submissive or low-ranking animals started to eat at this time after the dominant animals had eaten their meals. However, at 9:00 h, the feed was pushed again, and this stimulated the animals to eat more. At this time the stall bars at the feeding trough were locked to force the animals to continue eating for half an hour. This management practice helped the animals to eat the amount of feed that they needed, particularly the submissive animals that were given the opportunity to continue eating freely. The neck lock was released at 9:30 h, and the animals drank water again. It was observed that the peak of water consumption occurred at 10:00 h ($p<0.05$). A similar pattern of drinking activity occurred in the afternoon when the second meal was provided at 14:00 h. The cows started drinking when the neck bar was released during the drinking period from 14:00 to 15:00 h. The second peak of drinking activity occurred after the second milking. There were two other periods of drinking bouts, when the feed was pushed at 19:30 and at 22:30 h. The cows even drank until midnight but seldom at dawn. This result was also similar to studies reported earlier (Phillips, 1993; Albright and Arave, 1997; Grant and Albright, 2001; Phillips, 2001). However, the animals usually drank no more than one minute in each hour (Figure 1). Milking time was set at 5:30-7:00 h and 17:30-19:00 h. The same watering management was followed every day.

The time spent on eating was obviously higher when feed was provided (5:00 h), particularly when the neck bar was locked at 7:00 and 14:00 h ($p<0.05$); eating peaked during this period followed by the 6:00 h feeding. This result agrees with that of Albright and Arave (1997), Phillips (1993), and Fraser and Broom (2002), who suggested that animals started eating at sunrise and stopped at sunset. Andersson (1987) mentioned that the animals used to eat more when food was readily available. The cows ate the least at dawn.

In the present study the cows were stimulated to eat, and it was observed that cows started to move to the feeding barrier as soon as they heard the feeder (tractor). Another important factor was the pushing of the feeds, which encouraged the animals to eat frequently. This is a clear example of learning behavior when the animals get used to the same management; thus, we can see the importance of always keeping the same management in order not to alter animal behavior or affect their performance. When cows were eating at the feeding bunk, they regularly changed feeding places before all the food at a previous place was consumed. This behavior was obvious among the dominants animals. This fact leads the submissive animals to find another activity before eating their meal.

Defecation and urination occurred almost at the same time. The cows urinated, followed by defecation. Urination peaked at 16:00 h (0.30 min/h), whereas defecation pecked at 12:00 h (0.38 min/day).

Standing time was significantly higher at 17:00 h (21.4 min/h) and 6:00 h (21.9 min/h) compared with all other hours during the day ($p<0.05$). It was also observed that at 16:00 h the animals kept standing for a long time. The main period of standing occurred at dawn, coinciding with the lying time. However, it should be mentioned that the standing time values excluded those when the animals were

Table 9. General behavioral interaction between seasons and physiological stages

Behavior (min/day)	Winter								Summer								MSE	Level of Significance
	High milk cows	SD	Low milk cows	SD	Dry cows	SD	Heifers	SD	High milk cows	SD	Low milk cows	SD	Dry cows	SD	Heifers	SD		
Standing	203.5	84.1	395.7	112.8	256.6	123.9	292.6	144.5	361.3	141.3	318.5	110.7	354.8	148.6	327.7	136.1	129.9	**
Lying	742.8	139.2	568	161	755.4	138.3	685.8	170.5	630.5	160.3	593.7	184.8	604	189.8	780.8	138.1	157.2	**
Moving	31.1	7	38.8	19.6	32.1	18.7	37.9	17.1	32.4	9.7	61.2	37.9	27.3	4.7	38.3	13.4	15.3	*
Eating	344.0	35.2	314.0	40.9	299.6	93.9	276.1	63.1	304.2	71.1	234.4	70.7	297	52.5	214.4	130.4	72.1	NS
Drinking	10.2	3.7	15.7	7.7	8.9	3.4	14	7.7	17.6	10.2	14	6.8	7	3.1	9	4.5	6.9	**
Milking	5.9	1.9	5.7	0.5	0.0	0	0.3	0.4	27	7.9	19.8	11.3	3	2.1	0.5	0.5	3.3	***
Defecation	11.1	3.5	11.3	1.9	6	2.8	5.9	3.1	5.2	2.2	3.9	2.4	2.9	1.9	2.3	2.1	2.6	**
Urination	4.3	1.7	5.0	2.6	2.5	1.5	4	2.7	5.3	2.1	4.1	1.7	2.6	1.6	3.1	2.4	2.1	NS
Sleeping	45.3	24.5	33.5	32.1	46.2	36.7	44.1	38.6	26.3	32.1	147.9	60	83.5	55.1	45.8	26.4	38.3	***
Licking salt	5.7	5.4	2.2	2.8	25.4	19.8	47.4	39	0	0	1.2	2.5	5	5.8	9.3	13.9	21.9	**

MSE: Standard error of mean. NS: No significant difference. SD: Standard deviation.

* Significant difference $p<0.05$. ** Highly significant difference $p<0.01$. *** Strongly significant difference $p<0.001$.

eating, drinking, or any other general behavior activities. Moving peaked in the early morning at 6:00 h (3.9 min/h) and in the evening at 17:00 h (4.2 min/h), corresponding to the time when the cows were taken to the milking parlor (milking time) and returned to the pens. For the heifers, this occurred when they were taken to run the pedometer to measure their conductivity.

Most of the lying time was in the early morning, where they tended to rest, with the peak observed at 2:00 h (40 min/h) ($p<0.05$). Generally the cows tended to lie between 21:00 to 4:00 h. They tended to lie down least during the day, especially from 9:00-12:00 h after they had fed and drunk. Similar results were reported by Wierenga and Hopster (1990), who found that cows spent more time lying during nighttime than during the day. Sleeping time occurred mostly at dawn, usually at the same time as the cows were lying, with the peak occurring at 3:00 h (10 min/h). However, the period of sleeping was from 1:00 to 4:00 h.

During the experiment we observed some interactions between the treatments in each behavior activity. Table 9 shows that the drinking activity had a significant ($p<0.05$) interaction between season and physiological stage of the animals. High milk yielding cows spent more time drinking in summer than winter, whereas all other physiological stages followed the opposite pattern. This is explained by the fact that high producer cows have a higher metabolic rate and higher heat production, resulting in higher water demand compared with all other stages.

A significant interaction ($p<0.05$) could be seen between housing systems and grouping, where greater values were reported by home and visitor animals in wet-pad house than those in open house. Home animals tended to spend more time drinking in open house, whereas visitor animals had higher times in wet pad house. This interaction was more clearly observed during the winter where home animals spent more time on drinking activity. This may be attributed to the stress and frustration of the new animals in the herd; thus, they tried to drink more water as a displacement behavior. In the summer, this difference was not obvious because all animals demanded more water due to higher environmental temperatures (Table 10).

Table 10. General behavioral interaction among seasons, housing systems and grouping exchange

Behavior (min/day)	Wet-pad house								Open house								MSE	Level of significance
	Winter				Summer				Winter				Summer					
	Home	SD	Visitor	SD	Home	SD	Visitor	SD	Home	SD	Visitor	SD	Home	SD	Visitor	SD		
Standing	246.8	122.6	305.7	209.5	334.8	151.6	327.6	140	307.5	83.6	259.9	101	354.4	88.9	346.2	139.6	129.9	NS
Laying	724.7	140.8	644.8	218.5	621.2	191	634.8	196.0	688.4	136.7	746.1	143.9	652.4	169.8	651.4	173.2	157.2	NS
Moving	26.6	9.6	32.3	13.4	29.3	7.9	28.3	10.1	37.6	12.0	46.6	23.6	62.1	40	50.5	22.3	15.3	NS
Eating	327.3	82.7	307.9	57.6	292.6	95.9	274.4	85.5	270.8	59.6	271.1	67.8	239.2	68.6	249.4	96.1	72.1	NS
Drinking	12.2	4.3	15.8	6.8	13.8	7.0	13.4	6.7	13.4	8.6	8	4.2	12.6	7.8	12.4	11.5	6.9	*
Milking	1.5	3.1	1.6	3.0	20.7	14.7	21.6	16.3	1.3	2.0	1.3	1.8	11.3	9.2	9.9	6.9	3.3	NS
Defecating	7.5	4.2	6.9	3.3	3.6	2.1	4.2	2.5	6.8	3.4	7.2	4.1	3.6	2.3	4.3	2.7	2.6	NS
Urinating	3.1	2.2	3.8	1.3	4.3	1.8	3.6	1.7	4.3	2.7	3.8	3.2	4.1	2.5	4.3	2.8	2.1	NS
Sleeping	46.9	36.3	43.1	38.1	77.1	62.4	72.2	65.5	43.1	33	42.2	37.7	77.9	81.4	90.3	71.9	38.3	NS
Licking salt	19.6	22.2	29.6	34.5	5.1	12.1	2.1	4.8	46.6	44.2	33.5	30.7	3	4.1	1.3	2.9	21.9	**

MSE: Standard error of mean. NS: No significant difference. SD: Standard deviation.
* Significant difference $p<0.05$. ** Highly significant difference $p<0.01$.

Table 11. General behavioral interaction between housing systems and physiological stages

Behavior (min/day)	Wet-pad house								Open house										
	High milk cows	SD	Low milk cows	SD	Dry cows	SD	Heifers	SD	High milk cows	SD	Low milk cows	SD	Dry cows	SD	Heifers	SD	MSE	Level of significance
Standing	278.8	144.1	323.6	117.7	321.4	190	295.8	174.6	350.4	141.9	346.1	112.2	270.4	59.0	306.2	103.0	129.9	NS
Lying	669.5	175.4	631.7	201.7	611.2	194.8	692.6	187.9	659.2	149.2	541.9	140.4	778.5	101.9	724.6	145.4	157.2	**
Moving	28.3	7.5	36	12.7	22	4.1	29.6	10.6	36.0	8.7	78.6	39.7	38.3	17.2	46.4	16.6	15.3	***
Eating	329.9	74.9	241.8	95.2	325.5	85.2	301.6	61.4	301.7	49.7	260.6	38.3	271.5	63.7	221	90.7	72.1	**
Drinking	16	6.7	14.1	7.1	9.4	3.7	14.7	5.6	14.6	11.7	14.6	6.9	6.9	2.5	11	8.4	6.9	NS
Milking	26.1	12.3	24	11.9	0.4	0.5	0.2	0.4	14.8	8.2	9.3	4.0	2	2.5	0.4	0.5	3.3	***
Defecation	5.6	3.2	5.7	4.4	5.1	2.8	5.6	3.8	8.4	4	5.1	3.2	4.4	3	4.6	2.7	2.6	**
Urination	4.2	1.5	3.6	1.7	2.5	1.6	4.1	1.9	5.8	2.3	5.1	1.9	2.6	1.5	3.4	3.3	2.1	**
Sleeping	25.8	27.8	99.3	66.5	91.1	48.9	40.8	33.7	38.8	33.6	150.9	71	31.1	20.4	48.3	38.1	38.3	***
Licking salt	1.2	3	0	0	15.2	19.3	30.2	30.2	2.3	4.7	2.9	3	19.3	18.3	46.4	44	21.9	NS

MSE: Standard error of mean. NS: No significant difference. SD: Standard deviation.
** Highly significant difference $p<0.01$. *** Strongly significant difference $p<0.001$.

Eating activity seemed to be affected by the housing system stage and lactation ($p<0.01$) (Table 11). At all stages, cows in wet pad spent more time eating as compared to open house, except the low milk yielding cows, which spent a longer time eating in the open house.

Urination presented a highly significant interaction between housing systems and physiological stages ($p<0.01$) (Table 11). This result suggests that animals tended to urinate more in open house than in wet-pad house. However, heifers spent more time in urinating activity while in wet-pad house.

Defecation was found to be influenced by several factors. The season and physiological stages highly affected the behavior of defecation ($p<0.01$) (Table 9). Defecation appeared to be higher during winter for all physiological stages; this may be due to the higher feed intakes of animals during the cold season. A highly significant interaction was observed between housing system and physiological stage of the animals ($p<0.01$) (Table 11). This result suggested that animals tended to defecate more in wet-pad house. However, defecation for high milk yielding cows was higher in the open house.

Milking activity showed a highly significant interaction between season and stage ($p<0.001$) and house and stage ($p<0.001$). There was a marked tendency of the animals to spend more time during the summer in both housing systems compared with those of winter (Table 12). This can be explained because summer is the milking season because of the market demand. Season and stage interaction (Table 9) showed that the milk producer animals spent more time in milking during summer than winter; the same pattern was followed also by dry cows, and heifers. However, no milk is produced by them, but they are taken to run the pedometer. House and stage interaction demonstrated that milking time was higher for wet-pad animals in both low and high milk yielders ($p<0.001$).

Standing activity showed a season and stage interaction at a highly significant level ($p<0.01$) (Table 9). The results suggest that cows with high milk yield, dry cows, and heifers spent more time standing during the summer, whereas for low milking cows spent more time on standing activity in winter. A significant interaction between season and house was found ($p<0.05$). Data suggest that animals stand more in summer than winter. However, animals stood more in the open house in both seasons (Table 13).

Moving activity showed four interactions: season and house, season and stage, house and stage, and stage and group. A very strong and significant interaction was found in season and house ($p<0.01$) (Table 13). These results suggest that moving was higher in open house in both systems; this might be related to the bigger area that the animals had in open house (loosing housing) compared to wet-pad house (free stall). There was a significant interaction between season and stage ($p<0.05$). According to Table 9, a tendency to spend more time moving during the winter was observed for dry cows; milking cows did this during summer and heifers showed similar times spent moving in both seasons. House and stage showed a strongly significant interaction ($p<0.001$) (Table 11). This result suggested that all animals independent of their physiological stage spent more time moving in the open house. There was a slight interaction in stage and group ($p<0.05$). Data suggest that home animals spent more time moving. Dry cows and heifers of the visitor animals had more moving activity. Those animals may have had more confrontation after re-grouping, thus more movement (Table 12).

Lying behavior presented three interactions. Table 9 shows the significant interaction between season and stage ($p<0.05$). Data suggest that high milk yield cows and dry

Table 12. General behavioral interaction among seasons, grouping exchange and physiological stages

Stage	Season	Group	Behavior (min/day)																					
			Standing	SD	Lying	SD	Front leg on bed	SD	Moving	SD	Eating	SD	Drinking	SD	Milking	SD	Defecating	SD	Urinating	SD	Sleeping	SD	Licking salt	SD
High milk yielding cows	Winter	Home	245.8	63.4	659.5	165.7	58.3	96.8	31.8	7.4	359.3	40.0	12.8	2.2	6.8	1.9	11.3	2.9	4.0	0.8	40.0	20.7	3.0	4.8
		Visitor	175.3	89.0	798.3	95.6	10.5	19.0	30.7	7.4	333.8	31.1	8.5	3.6	5.3	1.8	11.0	4.2	4.5	2.2	48.8	28.1	7.5	5.5
	Summer	Home	339.0	134.5	661.1	156.0	14.5	22.1	33.7	11.0	308.6	97.1	17.5	6.9	28.8	6.3	4.3	2.1	5.0	1.8	19.7	25.1	0	0
		Visitor	381.8	150.2	602.4	165.7	29.6	76.8	31.3	8.7	300.1	38.8	17.7	12.9	25.3	9.1	6.1	2.0	5.6	2.4	32.3	37.6	0	0
Low milk yielding cows	Winter	Home	408.0	139.3	608.8	190.0	0	0	31.8	19.7	302.0	29.5	12.5	5.8	5.5	0.6	11.5	2.4	4.8	3.3	46.8	31.3	3.3	2.9
		Visitor	371.0	59.4	486.5	37.5	131.0	36.8	53.0	12.7	338.0	63.6	22.0	8.5	6.0	0.0	11.0	0	5.5	0.7	7.0	9.9	0	0
	Summer	Home	358.6	109.2	545.3	157.2	28.7	49.6	67.5	48.3	235.6	65.6	15.8	6.2	19.5	9.3	4.2	2.1	4.5	2.0	144.7	69.4	2.0	3.3
		Visitor	281.7	102.8	638.0	203.3	24.8	57.2	55.4	26.1	233.3	77.9	12.3	7.1	20.2	13.2	3.7	2.7	3.8	1.5	150.8	53.0	0.5	1.2
Dry cows	Winter	Home	295.5	137.2	717.1	149.3	3.6	9.3	29.0	14.0	307.9	117.0	9.2	3.9	0	0	6.3	3.0	2.0	1.8	45.5	41.5	23.9	20.5
		Visitor	208.0	90.7	803.4	114.3	11.8	22.7	36.0	23.9	289.1	59.8	8.6	2.8	0	0	5.6	2.6	3.1	0.8	47.0	32.5	27.4	20.0
	Summer	Home	376.7	179.0	609.5	221.0	18.2	33.7	26.3	2.7	296.3	57.5	6.0	2.0	3.0	2.2	3.5	2.1	3.5	1.4	72.8	65.3	5.7	7.3
		Visitor	333.0	124.1	598.5	174.1	50.7	64.6	28.2	6.2	297.7	52.5	8.0	3.8	3.0	2.2	2.3	1.6	1.7	1.2	94.2	46.3	4.3	4.4
Heifers	Winter	Home	248.1	72.2	730.3	115.8	6.3	9.2	33.9	10.6	282.1	58.7	14.7	8.0	0.3	0.4	5.9	3.4	4.3	2.6	45.5	35.2	49.7	42.0
		Visitor	342.1	186.2	636.4	208.2	19.5	32.1	42.4	21.7	269.5	68.8	13.3	7.5	0.3	0.5	5.9	2.9	3.7	3.0	42.6	43.1	44.9	36.4
	Summer	Home	293.8	74.9	782.0	138.8	6.7	13.1	41.7	10.0	221.5	99.7	8.2	5.5	0.5	0.5	1.2	0.8	3.0	3.0	64.7	21.9	13.8	17.9
		Visitor	361.5	179.9	779.5	150.5	4.8	6.4	35.0	16.4	207.3	165.5	9.8	3.7	0.5	0.5	3.5	2.3	3.2	2.0	27.0	14.2	4.8	7.4
MSE			129.9		157.2		37.1		15.3		72.1		6.9		3.3		2.6		2.1		38.3		21.9	
Level of significance			NS		*		NS		*		NS		NS		*		NS		NS		NS		NS	

MSE: Standard error of mean. NS: No significant difference. SD: Standard deviation. * Significant difference $p<0.05$

Table 13. General behavioral interaction between seasons and housing systems

Behavior (min/day)	Winter				Summer				MSE	Level of significance
	Wet-pad house		Open house		Wet-pad house		Open house			
	Min/day	SD	Min/day	SD	Min/day	SD	Min/day	SD		
Standing	274.6	169.4	285.0	94.0	331.2	143.9	350.1	116.9	129.9	*
Laying	687.0	183.5	715.6	141.2	628.0	190.9	651.9	168.9	157.2	NS
Moving	29.3	11.7	41.9	18.7	28.8	9.0	56.0	31.9	15.3	**
Eating	318.1	71.6	271.0	62.6	283.5	90.0	244.6	83.2	72.1	NS
Drinking	13.9	5.8	10.8	7.3	13.6	6.7	12.5	9.8	6.9	NS
Milking	1.6	3.0	1.3	1.9	21.1	15.3	10.6	8.0	3.3	***
Defecating	7.2	3.8	7.0	3.7	3.9	2.3	3.9	2.5	2.6	NS
Urinating	3.4	1.8	4.1	2.9	3.9	1.7	4.2	2.6	2.1	NS
Sleeping	45.1	36.6	42.7	34.8	74.7	63.1	84.4	75.6	38.3	NS
Licking salt	24.3	28.7	40.4	38.5	3.6	9.2	2.1	3.6	21.9	**

MSE: Standard error of mean. NS: No significant difference. SD: Standard deviation.
* Significant difference $p<0.05$. ** Highly significant difference $p<0.01$. *** Strongly significant difference $p<0.001$.

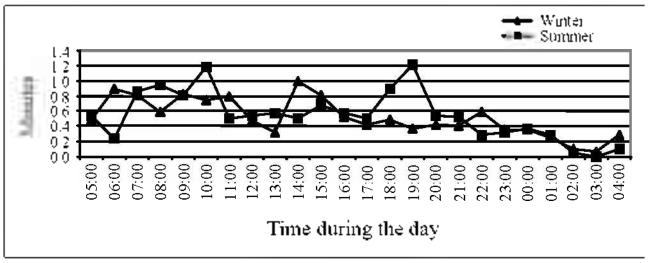

Figure 2. Drinking activity interaction between seasons and time.

cows spent less time lying during the summer. This might be due to the high temperatures. However, low milking cows and heifers had higher values in the summer. There are two reasonable explanations for this. Dry cows during the summer try to stand to expose their body surface to dissipate heat. For low milk yield cows and heifers, it was more efficient to lie down in summer season to try to save energy spent in moving as a better means of heat dissipation. A strongly significant interaction between housing and stage was found ($p<0.001$). These data (Table 11) show that high and low milking cows spent more time lying in wet-pad house; this might be due to the bedding material in the comfortable stalls. However, dry cows and heifers spent more time lying in the open house. This result suggests that both housing systems were comfortable for all animals, but it should be pointed out that dry cows needed more space to lie down, thus more lying time was observed in the open house. Another reason may be because dry cows and heifers may not produce too much heat. Stage and grouping interaction ($p<0.05$) suggest that home animals tended to spend more time in lying activity for high and low milk yield cows and heifers, whereas visitor animals showed more time spent lying for dry cows (Table 12).

Sleeping followed the same pattern as lying, since the same interactions were found. A strongly significant interaction was found between season and stage ($p<0.001$). Most animals tended to sleep more during the summer, except high milking cows who exhibited the pattern opposite (Table 9). There was a strongly significant interaction between house and stage ($p<0.001$). Data suggested that high milk yield cows, low milk yield cows, as well as heifers spent more time sleeping in the open system, whereas dry cows did so in wet pad (Table 11).

Drinking activity was fairly irregular, the highest frequency occurring during the daytime in both seasons. Even though total time spent drinking was almost the same, it can be noted that the frequency distribution differed between hours, suggesting that animals tended to modify their drinking pattern according to the season or environmental temperatures, thus supplying their demands. In summer there were two marked peaks, at 10:00 h in the morning and 19:00 h in the evening. In winter most of the drinking activity was in the morning. However, the peak was in the afternoon from 14:00 h to 15:00 h. These results agree with previous studies (Ray and Roubicek, 1971; Andersson et al., 1984; Andersson, 1985; Andersson, 1987) (Figure 2).

For both seasons the morning peak of eating activity occurred between 6:00 h and 7:00 h after providing the meals. However the summer peak had a higher frequency than the winter. It can be noted that during the midday the time spent eating during the summer was markedly decreased, whereas in winter this was opposite, as cows tended to spend more time eating in midday in winter. Compensatory consumption in the warmest hours in winter and reduced eating in the highest temperatures in summer have been reported in previous studies (Phillips, 1993; Albright and Arave, 1997; Phillips, 2001; Fraser and Broom, 2002). The eating activity was more concentrated in the three major peaks during summer (7:00, 14:00 and 18:00 h), and winter (12:00, 16:00 and 20:00 h).

There were obviously seasonal differences in the standing activity. During the summer there was a high tendency for the cows to stand more in each hour compared

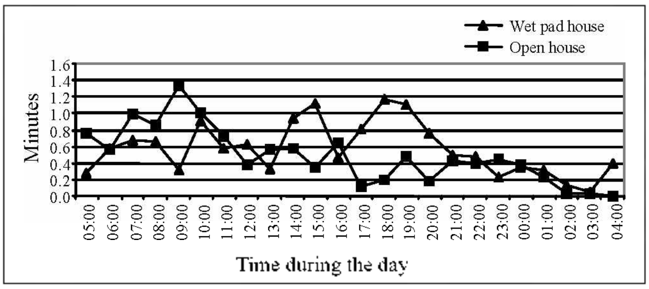

Figure 3. Drinking activity interaction between housing and time.

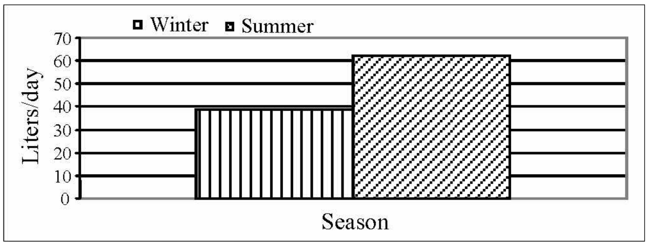

Figure 4. Total water intake in winter and summer season. Means followed by different letters are significantly different by the Duncan's multiple range test (p<0.05).

with the winter season. There were two major peaks in standing activity, at 6:00 h and 17:00 h in summer. Standing activity was lowest at 7:00 h, coinciding with the peak of eating activity. There was also a reduction in time spent standing during the midday and 12:00 h, which was the peak of lying during the daytime. This suggests that cows tended to dissipate heat from their bodies during the summer by increasing their surface exposed to the surrounding environment or could be due to the fact that in the open house they tried to stand in the shelter to protect themselves from solar radiation. The peak standing activity was at 6:00 h, one hour after the end of the milking time in the winter. The other peak was from 8:00 to 10:00 h in winter. The highest peak of standing activity was at 17:00 h. The lowest point was between 21:00 h and 4:00 h, whereas in the summer the frequency dropped at 22:00 h to minimum activity during the night and up to 3:00 h.

The highest time of lying activity was observed at 20:00 h and 4:00 h. The lowest time was at 17:00 h, coinciding with the milking time. This issue was observed in both seasons. The time spent lying was higher in winter than in summer. The highest peak of lying was from 1:00 to 3:00 h in winter.

It can be noted that cows tended to spend more time drinking during the morning in the open house whereas during the afternoon and evening in the wet pad. The maximum range spent drinking in the open house was from 6:00 to 10:00 h. The highest frequencies occurred from 14:00-15:00 h and 18:00-20:00 h in the wet-pad house. However, the distribution of drinking activity in the open house seemed to be continuous, whereas in the wet-pad house this occurred intermittently during the day. However, most of the activity was recorded in the daytime in both systems (Figure 3).

In both systems, the cows showed peak eating behavior in the morning after the feed was pushed to the feeding channel at 7:00 h, whereas the afternoon peak of eating activity occurred from 14:00 to 20:00 for the wet pad. It was also noted that the minimum frequency for eating activity occurred in the evening time after 21:00 h in both housing systems. However, the animals tended to spend more time eating in wet pad. Also, lowest frequency occurred at dawn from 1:00 to 4:00 h in both systems. It can be said that the wet pad and forced ventilation systems provided a comfortable environment for the animals. These differences were more marked during the hot climate (summer).

The first peak-time standing by the animals was reached at 6:00 h in both houses. However, animals in wet pad spent more time than in the open house. during the second peak in the evening (17:00 h) the opposite situation occurred. The open housed animals spent more time standing than those in the wet pad. Standing activity was higher in frequency during the daytime for the open system.

Lying activity had a higher frequency during the evening period. There was a low frequency in the morning between 6:00 h and 7:00 h (the peak of eating activity) and the evening milking time at 17:00 h in the open house. On the other hand, those in the wet-pad house had a higher frequency during the daytime at 12:00 h compared to the open system. Cows tended to rest most of the time in the evening and dawn periods. At dawn the major activity was lying in both housing systems.

Animals drank more water during summer than winter. This can be explained by the effect of environmental temperatures upon water intake. The time spent in drinking activity in both seasons was not different. However, the water intake in both seasons differed significantly (p<0.05). Animals in summer drank 61.9 L/day and 38.6 L/day in winter. These results suggest that animals in summer had more drinking activity motivation. Cows tended to drink more water per minute on each occasion they visited the water source (Figure 4).

Water intake was significantly higher in wet pad house (68 L/day) than in open house (31.5 L/day) (p<0.05) although there was no difference in the time spent in drinking in either house. The results suggest that the time spent drinking did not determine the amount of water that the animals drank. Another reason could be the fact the animals were just playing with water as a displacement behavior (Figure 5).

Low milk yielding cows drank more water (69.1 L/day) than dry cows (65.4 L/day) or high milk yielding cows (50.75 L/day), whereas heifers drank the least (32.37

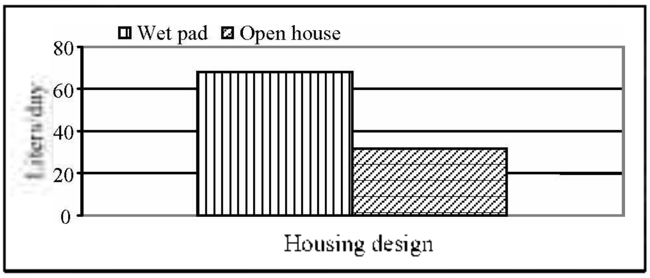

Figure 5. Total water intake in wet pad and open house. Means followed by different letters are significantly different by the Duncan's multiple range test ($p<0.05$).

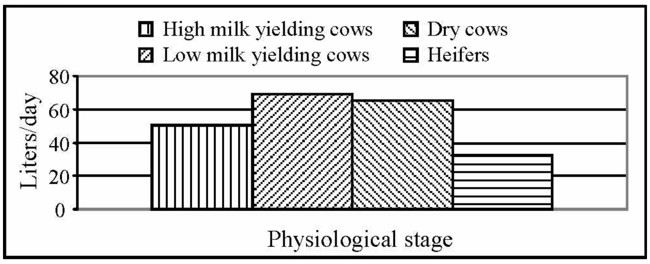

Figure 6. Total water intake for each physiological stage. Means followed by different letters are significantly different by the Duncan's multiple range test ($p<0.05$).

min/day) ($p<0.05$). The lower intake of high milk yield cows can be related to their eating behavior because they ate more and therefore obtained more feed. The water intake in dry cows suggests that they were able to drink more water per unit of time as a mechanism to supply their higher water requirements as an effect of the hay since they spent less time drinking but they had a high water intake, whereas heifers drank less water although they spent more time in drinking activity. This suggests that heifers frequently visited the water source, but did not necessarily drink water or that they had lower water intake flow rates (Figure 6).

CONCLUSIONS

Drinking activity occurred mostly during the daytime. Animals drank in the evening up to 19:00 h. There was a marked decline in drinking activity from 20:00 to 5:00 h. However, the cows seldom drank at night or dawn. There was a marked influence of milking and feeding times upon drinking behavior of dairy cows. Animals proceeded to drink after each milking and after they ate each meal.

Season and time interaction on drinking activity clearly showed that in the summer there were two main peaks of drinking, at 10:00 h and 19:00 h, suggesting that the animals tried to avoid drinking from 11:00 to 16:00 h, corresponding to times that the cows were having a rest. The drinking activity in winter appeared to be irregular, varying throughout the day. This suggests that dairy cows modified their drinking pattern according to the season and environmental temperature: in winter animals drink in the hottest periods of time of the day, whereas in summer they do so in the coolest times.

Animals concentrated their drinking activity during the morning in the open house, whereas in wet-pad house, drinking activity was more evenly distributed throughout the day. However, in both housing systems the animal seldom drank at dawn. Total water intake of dairy cows in wet-pad house was double the amount of cows in open house, suggesting that wet pad with forced ventilation cooling system was an important implement for dairy cattle husbandry to achieve animal comfort and well-being. Animals housed in wet-pad system tended to be less stressed. The drinkers' type and arrangement were appropriate for the cows' needs and could support milk production due to higher water intake.

Producer animals (high and low milk yielding cows) spent more time drinking than did dry cows and heifers, this mainly due to milk production. However, we observed that the feed type also influenced the drinking behavior and water intake of the cows. The effect of re-grouping (grouping exchange) on behavior of cows was noticeable; cows altered their behavior when new members entered the group, mainly in the form of aggressive behavior in order to find a new hierarchy position in the herd. As to drinking and feeding activities, usually dominant cows ate and drank first, then submissive animals, but the latter tried to find a more appropriate time to supply their requirements.

REFERENCES

Albright, J. L. and C. W. Arave. 1997. The Behaviors of Cattle. CAB International. United Kingdom at the University Press, Cambridge. p. 306.

Alhassan, W. S. and J. D. Kabuga. 1988. Dry and wet seasonal studies on the grazing behavior of native N'dama and imported Friesian bulls in a humid tropical environment. Appl. Anim. Behav. Sci. 19:245-254.

Ali, S., L. A. Goonewardene and J. A. Basarb. 1994. Estimating water consumption and factors affecting intake in grazing cattle. Can. J. Anim. Sci. 74.551-554.

Andersson, M 1985 Effect of drinking water temperatures on water intake and milk yield of tied-up dairy cows. Livest. Prod. Sci. 12:329-338.

Andersson, M. 1987. Effects of number and location of water bowls and social rank on drinking behavior and performance of loose-housed dairy cows Appl. Anim Behav Sci. 17:19-31.

Andersson, M., J. Schaar and H. Wiktorsson. 1984. Effects of drinking water flow rates and social rank on performance and drinking behavior of tied-up dairy cows. Livest Prod Sci 11:599-610.

Brakel, W. J. and C. Leis. 1976. Impact of social disorganization on behavior, milk yield, and body weight of dairy cows. J Dairy Sci. 59:716-721.

Castle, M. E. and T. P. Thomas. 1975. The water intake of British Friesian cows on rations containing various forages. Anim. Prod. 20:181-189.

Chen, K. H., J. T. Huber, C. B. Theurer, D. V. Armstrong, R. C. Wanderley, J. M. Simas, S. C. Chan and J. L. Sullivan. 1993. Effect of protein quality and evaporative cooling on lactational performance of Holstein cows in hot weather. J. Dairy Sci. 76:819.

Chesworth, J. 1992. Water in: Ruminant Nutrition. The McMillan Press Ltd., London, England. pp. 18-24.

Church, D. C. 1974. Water metabolism and requirements in: Digestive physiology and nutrition of ruminants. Vol. II. O & B books. Corvallis, Oregon, USA. pp. 401-411.

Church, D. C. and W. G. Pond. 1982. Water in: Basic Animal Nutrition and Feeding. Second edition by John Wiley & Sons, Inc. United States of America. pp. 50-58.

Fraser, A. F. and D. M. Broom. 2002. Farm Animal Behavior and Welfare. Third edition. CABI Publishing, United Kingdom. p. 437.

Friend, T. H. and C. E. Polan. 1973. Effects of social rank on feeding behavior and free stall utilization by cows. J. Dairy Sci. 56:668.

Friend, T. H. and C. E. Polan. 1974. Social rank, feeding behavior, and free stall utilization by dairy cattle. J. Dairy Sci. 57:1214-1222.

Grant, R. J. and J. L. Albright. 2001. Effect of animal grouping on feeding behavior and intake of dairy cattle. J. Dairy Sci. 84:156-163 (suppl.).

Haley, D. B., J. Rushen and A. M. de Pasillé. 2000. Behavioral indicators of comfort: activity and resting behavior of dairy cows in two types of housing. Can. J. Anim. Sci. 80:257-263.

Hasegawa, N., A. Nishiwaki, K. Sugawara and I. Ito. 1997. The effect of social exchange between two groups of lactating primiparous heifers on milk production, dominance order, behavior and adrenocortical response. Appl. Anim. Behav. Sci. 51:15-27.

Hoffman, M. P. and H. L. Self. 1972. Factors affecting water consumption by feedlot cattle. J. Anim. Sci. 35:871-876.

Holter, J. B. and W. E. Urban. 1992. Water portioning and intake in dry and lactating Holstein cows. J. Dairy Sci. 75:1472-1479.

Hsia, L. C. 2001. Dairy cattle management by automatic facilities. The 9th dairy seminar among Japan, Korea and Taiwan. pp. 53-58.

Hsia, L. C. 2002. How to release heat stress from dairy cattle. International training on strategies for reducing heat stress in dairy cattle. Taiwan Livestock Research Institute, ROC. pp. 128-140.

Krohn, C. C., L. Munksgaard and B. Jonasen. 1992. Behavior of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments. 1. Experimental procedure, facilities, time budgets-diurnal and seasonal conditions. Appl. Anim. Behav. Sci. 34:37-47.

Lanham, J. K., C. E. Coppock, K. Z. Milam, J. M. Labore, D. H. Nave, R. A. Stermer and C. F. Brasington. 1986. Effects of drinking water temperature on physiological responses of lactating Holstein cows in summer. J. Dairy Sci. 69:1004-1012.

Little, W. and S. R. Shaw. 1978. A note in the individuality of the intake of drinking water by dairy cows. Anim. Prod. 26:225-227.

Maltz, E., N. Silanikove, U. Shalit and A. Berman. 1994. Diurnal fluctuations in plasma ions and water intake of dairy cows affected by lactation in warm weather. J. Dairy Sci. 77:2630-2639.

Mullick, D. N., V. N. Murty and N. D. Kehar. 1952. Seasonal variations in the feed and water intake of cattle. J. Anim. Sci. 11:42.

Murphy, M. R. 1992. Water metabolism of dairy cattle. J. Dairy Sci. 75:326-333.

Murphy, M. R., C. L. David and G. C. McCoy. 1983. Factors affecting water consumption by Holstein cows in early lactation. J. Dairy Sci. 66:35-38.

National Research Council. 2001. Nutrient requirements of dairy cattle. 7th rev. ed. National Academy Press. Washington, DC. USA. p. 381.

Nielsen, L. H., L. Mogensen, C. Krohn, J. Hindhede and J. T. Sorensen. 1997. Resting and social behavior of dairy heifers housed in slatted floor pens with different sized bedded lying areas. Appl. Anim. Behav. Sci. 54:307-316.

Phillips, C. J. C. 1993. Cattle Behavior. Farming Press Books. United Kingdom. p. 212.

Phillips, C. J. C. 2001. Principles of cattle production. CABI Publishing. United Kingdom. p. 278.

Phillips, C. J. C. 2002. Cattle Behavior and Welfare. Second edition. Blackwell publishing. United Kingdom. p. 263.

Phillips, C. J. C. and M. I. Rind. 2001. The effects on production and behavior of mixing uniparous and multiparous cows. J. Dairy Sci. 84:2424-2429.

Ray, D. E. and C. B. Roubicek. 1971. Behavior of feedlot cattle during two seasons. J. Anim. Sci. 33:72-76.

Redbo, I., A. Ehrlemark and P. Redbo-Torstensson. 2001. Behavioral responses to climatic demand of dairy heifers housed outdoors. Can. J. Anim. Sci. 81:9-15.

Rossi, R., E. Del Petre, J. Rokitzky and E. Scharrer. 1999. Circadian drinking during ad libitum and restricted feeding in pygmy goats. Appl. Anim. Behav. Sci. 61:253-261.

SAS. 2000. SAS/STAT User's Guide. SAS Institute, Cary, NC.

Sekine, J. and Y. Asahida. 1987. A note on the effect of the dry matter concentration in forages on water consumption of yearling steers. Anim. Prod. 45:527-529.

Stockdale, C. R. and K. R. King. 1983. A note in some of the factors that affect the water consumption of lactating dairy cows at pasture. Anim. Prod. 36:303-306.

Tennenssen, T., M. A. Price and R. T. Berg. 1985. The social interactions of young bulls and steers after re-grouping. Appl. Anim. Behav. Sci. 14:37-47.

Wierenga, H. K. 1990. Social dominance in dairy cattle and the influences of housing and management. Appl. Anim. Behav. Sci. 27:201-229.

Wierenga, H. K. and H. Hopster. 1990. The significance of cubicles for the behavior of dairy cows. Appl. Anim. Behav. Sci. 26:309-337.

Winchester, C. F. and M. J. Morris. 1956. Water intake rates of cattle. J. Anim. Sci. 15:722.

Yoon, J. T., J. H. Lee, C. K. Kim, Y. C. Chung and C. H. Kim. 2004. Effects of milk production, season, parity and lactation period on variations of milk urea nitrogen concentration and milk components of Holstein dairy cows. Asian-Aust. J. Anim. Sci. 17 (4):479-484.

Young, B. A. 1983. Ruminant cold stress: Effect on production. J. Anim. Sci. 57:1601-1607.