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Full Length Article

Correlation between Behavior and Milk Yield of Dairy Cows

Shan Chun-hua[1†], Guo Jian-jun[2†], Sun Xin-sheng[1], Yang Xin-yu[1], Zhao Juan-juan[1], Wang Chao[1], Qiu Dian-rui[2], Wang Ya-nan[2], Feng Man[2] and Gao Yu-hong[1*]
[1]*College of Animal Science and Technology, Hebei Agricultural University, Baoding 071001, China*
[2]*Animal Husbandry Research Institute of Chengde, Chengde 067000, China*
[*]For correspondence: 10986369922@qq.com
[†]These authors contributed equally to this work

Abstract

The objective of this study was to evaluate correlation between four behaviors (lying, standing, feeding and drinking) of dairy cows and milk yield using principal component regression method. For each behavior, daily occupied time, daily frequency, daily occupied time for a single behavior, and percentage of cows with each behavior to all cows were investigated for 7 d in the middle of each month. The results showed that both the lying time and lying percentage were higher than other three behaviors. During whole year, the lying, standing, feeding and drinking time were 735.5, 347.6, 232.6 and 18.3 min per day, respectively and the percentages were 57.9, 25.1, 14.9 and 2.1%, respectively. Additionally, four behaviors demonstrated their seasonal characteristic. The low lying time and low lying frequency occurred in winter months, averaged 644.1, 724.3, 686.0 min and 8.4, 13.3, 8.0 times per day; low feeding time and low feeding frequency occurred in summer months, averaged 309.7, 315.7, 335.4 min and 12.0, 11.0, 16.3 times per day. The drinking time and drinking percentage were highest in summer months, averaged 23.8, 25.0, 24.2 min and 3.9, 4.8, 2.4% per day. On the other hand, a significant negative correlation was observed between the standing time and feeding time or feeding percentage ($P<0.05$). Besides, the milk yield of dairy cows was significantly positively correlated with the lying time ($P<0.05$, $r = 0.686$) or feeding frequency ($P<0.05$, $r = 0.595$) during a whole year. Based on our investigated data, two regression equations, between the milk yield and time distribution of the four behaviors, and between the milk yield and behaviors percentage, were also established, suggesting the lying time had a crucial effect on milk yield. Therefore, the results would provide important information for improving milk performance for dairy cows.

Keywords: Cowshed; Dairy cow; Behavior; Correlation; Milk performance

Introduction

Dairy cows may change their behaviors (*e.g*., lying time, standing time, feeding and drinking time) when exposed to adverse environment conditions, such as heat stress, cold stress and strong wind, and cause the reduction of milk performance. For example, dairy cows would rather stand than lie in cubicle beds under uncomfortable environment conditions (Han *et al*., 2011; Fernandes *et al*., 2017). Early studies involving behaviors of dairy cows have been reported worldwide. An automatic sensing system for monitoring cows behavior have been commercialized in developed countries (Apinan *et al*., 2015; Borchers *et al*., 2016). However, limited information is available for cow behaviors in Asian countries such as China. The lying behavior plays an important role in milk performance (Munksgaard and Lovendahl, 1993; Jensen *et al*., 2004; Munksgaard *et al*., 2005; Gao *et al*., 2014). It have been demonstrated that dairy cows spend 12 to 14 h daily to lie in cubicle beds for the rest as well as rumination (Jensen *et al*., 2005). Also, the length of lying time depended on beddings type, the design of cubicle beds and management strategies, as well as indoor environment (Javorova *et al*., 2014). High ambient temperature often results in a small quantity of cows lying in beds (Bao *et al*., 2004).

The feeding and drinking behavior of dairy cows (*e.g*., feeding and drinking time) were affected by many factors, such as feed and water quality, environment condition, management strategies and so on (Fu *et al*., 2015). Particularly, ambient temperature may influence feeding and drinking time for cows. Under high temperature, feeding, rumination and drinking time for cows were shortened (Acatincai *et al*., 2009; Moallem *et al*., 2010; Soriani *et al*., 2013), resulting in the decrease of feed intake and drinking water intake (Arias and Mader, 2011). Similarly, the low temperature also affected feeding and drinking time for cows; however, the influence caused by cold stress was weak relative to heat stress (Ihsanullah Qureshi *et al*., 2017). Previous studies suggested that cows prolonged standing time in summer by staying at the pool or sink to mitigate heat stress (Du *et al*., 2007). Thus, the behavior changes for cows responses well to their

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production performance. Until now, little information was available for correlation with multiple behaviors and milk performance for dairy cows, despite some studies on the correlation between single behavior and milk performance. The objectives of the present study were to investigate four behaviors (lying, standing, feeding and drinking) of dairy cows for a whole year and the quantitative relationship between milk performance and these behaviors.

Materials and Methods

All animal procedures were approved by the Animal Care Committee at Agricultural University of Hebei in accordance with the university's guidelines for animal research.

Cowshed and management: The study was conducted in a free-stall cowshed without playground in a dairy farm in Chengde city of Hebei province, China. A total of 200 lactating primiparous Holstein cows (450 ± 40.0 kg of initial BW) were used in the study. The proportion of cubicle bed number and cow number was approximately 1.5: 1. The roller blinds were put down to close the cowshed in winter, and fans (1.5 KW) at 2.2 m height and 12 m interval were run daily to mitigate heat stress in summer. Automatic manure scrapers were run for 5 to 6 times daily. All cows were housed in the cowshed and offered a total mixed ration (TMR) with corn-soybean meal as concentrate and corn silage as forage three times daily after milked. The nutritional level in TMR was as follows: 15.3% of crude protein, 36.0% of neutral detergent fiber, 28.2% of acidic detergent fiber, 0.6% of calcium, 0.4% of phosphorus, and 35.1 MJ/d of net energy lactation. Cows had ad libitum access to TMR and water.

Environmental parameters measurement: The study was performed for 12 consecutive months from 2016 to 2017. Seven consecutive days with were chosen to investigate indoor and outdoor ambient temperature (AT), relative humidity (RH) and wind velocity (WV) using KTH-350-I temperature and humidity data-logger (Kimo Industry Co., French) and WFWZY-1wind data-logger (Kimo Industry Co., French) at 30 min intervals over 24 h in the middle of each month. The data-loggers were installed at 1.5 m vertical height, and the sampling sites for above three parameters were showed in Fig. 1. The curve graphs for AT, RH and WV over 24 h per month were obtained and analyzed.

Cow behavior parameters measurement: Four behaviors, including lying, standing, feeding and drinking, were measured using video recorder for 7 d in the middle of each month for a total of 12 months. For each behavior, total occupied time per day, daily frequency, occupied time for a single frequency per day, and percentage of cows with each behavior to all cows were evaluated. A big stall holding 50 cows were used to measure these behaviors, and a total of 6 cameras were installed to ensure that the four behaviors for all experimental cows can be recorded clearly. Ten cows were randomly chosen per month, marked with crayons, and kept track of 7-d behaviors for daily occupied time, daily frequency and occupied time of a single frequency. The percentage of each behavior mentioned above was measured by the method of screenshots at 30 min intervals for 7 d in the middle of each month throughout a whole year. The location for experimental cows and installed cameras are shown in Fig. 1.

Milk yield measure: A total of 30 cows in the cowshed were used to analyze daily milk yield for 12 months. The milk yield of each milking was recorded (Waikato Milking Systems NZ Ltd., Hamil-ton, New Zealand) in the middle of each month for 7 d to calculate the average daily milk yield per month.

Statistical Analysis

Correlation among the four behavioral parameters, and correlation between four behaviors and milk yield was analyzed using the person procedure of statistical software SPSS (Statistics Version 19.0). The quantitative relationship between milk yield and four behavioral parameters was analyzed using the method of principal component regression, and the regression equation between behavior and milk yield are established.

Results

Thermal Environment in Cowshed

The curve patterns of indoor and outdoor AT, RH and WV for 12 months were shown in Fig. 2. In January and February, the indoor and outdoor AT was below 0°C, and subsequently increased with increasing months, peaked with 25.2°C in the cowshed in August, and then decreased gradually from September to December. During 3 months from October to March, the indoor AT was higher compared with the outdoor AT, whereas the indoor AT had a lower tendency than the outdoor AT during other months from April to September. The indoor RH in March, April and June was lower than 50%; however, the indoor RH in December was over 80%. Besides, the indoor RH was higher than the outdoor for one year, except for May.

The WV was shown in Fig. 3. Both indoor and outdoor WV began to rise from January, and reached a peak of approximately 0.8 m/s in June or in July, followed by a gradual decrease. The indoor WV was higher during summer months (June, July and August) than that during other months because of the fans' cooling. Particularly, the indoor WV in both July and August was higher than the outdoor WV. However, during winter months (December, January and February), the indoor WV was lower (almost zero) compared with other months.

Time Allocation and Percentage of Four Behaviors

Time allocation for four behaviors: The time distributions over 24 h of four behaviors per month during a whole year were shown in Table 1. The daily occupied time for lying,

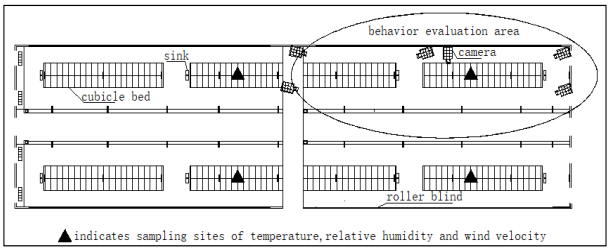

Fig. 1: The sampling sites of ambient temperature, relative humidity and wind velocity in the cowshed

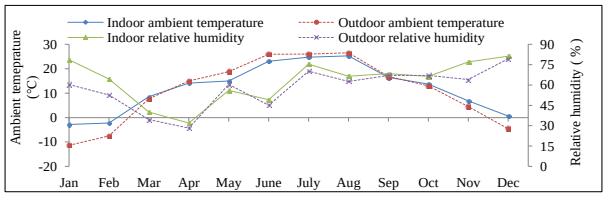

Fig. 2: The change of ambient temperature and relative humidity in the cowshed for 12 months

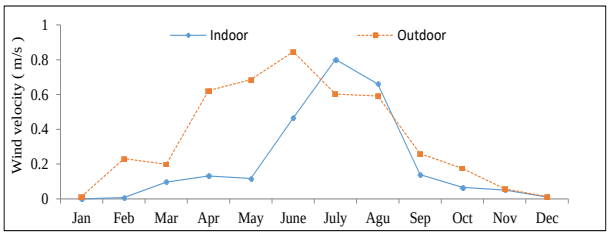

Fig. 3: The change of wind velocity in the cowshed for 12 months

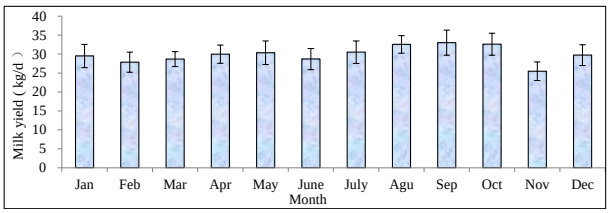

Fig. 4: The change of milk yield for dairy cows for 12 months

standing, feeding, and drinking ranged from 644.1 to 780.9 min (average 735.5 min), 173.9 to 288.6 min (average 232.6 min), 315.7 to 417.8 min (average 347.6 min), and 11.7 to 25.0 min (average 18.3 min) during a whole year, respectively. Among four behaviors, the lying time reached 3.2, 2.1 and 41.0 folds of standing time, feeding time, and drinking time, respectively. For the daily frequency for each behavior, feeding frequency was the highest among four behaviors, whereas drinking frequency was the lowest, with an average value of 15.3 times daily for feeding and 8.6 times daily for drinking. In addition, the occupied time for a single frequency also depended on behaviors types. The single time for lying, standing, feeding, and drinking was 79.3 min, 25.1 min, 22.7 min and 2.1 min, respectively, which was in accordance with the daily occupied time for each behavior. The daily lying time and single lying time were the longest among all behaviors. Besides, among all months, the longest lying time occurred in the fall months (from September to November), averaged 780.9, 766.4 and 757.4 min, whereas the shortest lying occurred in the winter months, averaged 644.1, 724.3 and 686.0 min. The longest standing time occurred in the summer months, averaged 261.1, 288.6 and 288.6 min, and the shortest occurred in the fall months, averaged 214.7, 193.4 and 231.6 min; similarly, the longest drinking time was also in the summer months with an average value of 24.3 min, and the shortest was in the winter months with an average value of 13.2 min. Also, the longest and shortest feeding time were in the spring months (from March to May) and in the summer months, respectively, averaged 311.5, 332.9, 417.8 min and 309.7, 315.7, 335.4 min.

Percentage of four behaviors: The percentage of each behavior (proportion of cows with each behavior to all cows) was showed in Table 2. For a whole year, the average percentage for lying, standing, feeding and drinking cows was 57.9, 14.9, 25.1 and 2.1%, respectively and the lying percentage was the highest and the drinking percentage was lowest. This was in agreement with daily occupied time of each behavior in this study. Among 12 months, high lying percentage and low lying percentage occurred in the fall months and the winter months, averaged 58.1 and 56.0%, respectively. The standing percentage was opposite to lying percentage, averaged 14.7% in the fall months and 16.6% in the winter months. The feeding percentage was high in average 26.6% in the spring months, and low in average 24.2% in the summer months. Besides, the high drinking percentage occurred in the summer months (average 3.7%).

Milk yield: The milk yield per month during a whole year was shown in Fig. 4. The highest milk yield occurred in September, with an average of 33.0 kg/d, and then gradually decreased to a minimum of 25.5 kg/d in November. Milk yields in February and June were lower compared to other months (except for November), reaching 27.8 and 28.7 kg/d, respectively.

Correlation coefficient among behaviors and between behaviors and milk yield: The correlation coefficient among four behaviors and correction coefficient between behaviors and milk yield were shown in Table 3. A significant negative correlation was observed between daily feeding time and standing time ($P<0.05$, r = - 0.656). Also, there was a significant negative correlation between the lying percentage and the standing percentage ($P<0.05$, r = - 0.703). Additionally, the daily standing time was negatively correlated with daily feeding time or feeding percentage, and positively correlated with the standing percentage or drinking percentage ($P<0.05$). It was also observed that the drinking percentage was negatively correlated with the feeding frequency ($P<0.05$), and had a significant positive correlation with daily drinking time or drinking frequency ($P<0.05$). Moreover, daily drinking time had a significant positive correlation with single drinking time ($P<0.01$); however,

Table 1: Time distribution of four behaviors for 12 months

Month	Lying			Drinking			Standing			Feeding		
	[1] T/min	[2] F/time	[3] St /min	[1] T/min	[2] F/time	[3] St/min	[1] T/min	[2] F/time	[3] St/min	[1] T/min	[2] F/time	[3] St/min
Jan	724.3 ± 80.0	13.3 ±1.8	62.3 ±10.9	12.1 ±2.0	7.0 ±1.0	1.7 ±0.1	203.2±33.6	13.3 ±1.8	18.1 ±1.5	337.7±58.1	12.8 ±2.0	27.8 ±4.2
Feb	686.0 ±12.7	8.0 ±1.7	90.4 ±9.7	14.6 ±1.8	9.1 ±0.7	1.5 ±0.1	253.8±33.7	8.0 ±1.1	30.7 ±1.5	382.5±62.4	19.4 ±7.0	25.3 ±4.4
Mar	741.9 ±88.7	10.1 ±2.8	80.9 ±12.7	19.9 ±3.5	8.2 ±1.2	2.4 ±0.3	244.3±33.5	10.1 ±1.3	25.8 ±1.2	331.5±35.5	14.2±2.6	24.1 ±2.8
Apr	765.1 ±78.2	9.4 ±17.3	81.1 ±9.3	11.8 ±2.0	8.1 ±0.7	1.5 ±0.2	236.5±39.4	9.4±1.3	25.1 ±2.2	332.9±31.8	18.9 ±2.2	17.6 ±1.8
May	740.9±78.4	8.0±2.2	104.8±18.6	19.1±1.2	8.3±1.3	2.5±0.1	173.9±30.4	8.0±1.2	30.4±1.4	417.8±55.7	13.2±2.4	34.0±4.0
June	741.4±111.8	8.5±2.0	91.2±12.4	23.8±2.4	10.4±1.5	2.3±0.3	261.1±38.9	8.5±1.0	34.2±1.8	309.7±55.5	12.0±1.5	27.0±3.3
July	727.3±101.6	10.4±1.5	71.2±14.0	25.0±3.8	9.9±1.1	2.5±0.4	288.6±42.0	10.4±1.5	27.7 ±1.4	315.7±55.9	11.0 ±1.3	29.5±4.2
Aug	750.1±81.3	8.9±0.8	84.4±11.2	24.2±1.2	8.1±1.2	3.0±0.4	288.6±38.5	8.9±0.8	25.7±1.9	335.4±54.2	16.3±3.0	21.4±3.3
Sep	780.9±36.9	8.7±1.0	90.8±10.5	21.4±2.4	8.5±1.0	2.5±0.3	214.7±28.6	8.7±1.0	25.0±7.1	331.2±36.5	18.4±2.4	19.5±2.9
Oct	766.4±89.0	8.7±0.8	89.4±15.6	18.5±1.7	7.6±1.2	2.4±0.2	193.4±29.7	8.7±0.8	22.1±0.5	385.4±62.1	18.2±3.2	22.4±2.5
Nov	757.4±121.6	8.8±1.6	88.8±10.4	11.7±1.0	10.0±1.8	1.2±0.2	231.6±44.4	8.8±1.6	28.0±12.0	356.2±49.8	19.0±4.4	19.7±3.6
Dec	644.1±88.6	8.4±2.5	83.0±10.5	12.8±1.9	8.4±0.8	1.6±0.3	261.2±36.7	8.4±1.5	33.7±1.6	335.0±32.1	14.3±2.0	24.8±2.9
Average	735.5±37.8	9.3±1.5	79.3 ±10.7	17.9±2.1	8.6 ±1.0	2.1 ±0.4	232.6±32.4	9.3±1.5	25.1±4.6	347.6±32.0	15.3±2.8	22.7±4.1

Notes: [1] T=daily occupied time
[2] F=daily frequency
[3] ST=daily occupied time for a single behavior

Table 2: The change of four behaviors percentage of dairy cows for 12 months

Month	Lying (%)	Standing (%)	Feeding (%)	Drinking (%)
Jan	56.6 ±3.6	14.6± 1.7	27.3±1.9	1.5±0.2
Feb	55.2±2.6	19.2±2.9	24.0±2.0	1.6±0.1
Mar	56.4±0.9	16.5±1.3	25.5±1.7	1.7±0.1
Apr	56.7±1.6	16.0±2.5	25.6±2.3	1.7±0.3
May	56.5±1.7	12.5±1.1	28.7±1.4	2.4±0.3
June	55.6±1.3	15.7±1.5	24.8±1.1	3.9±0.4
July	56.8±1.6	15.2±0.6	23.2±2.3	4.8±0.5
Aug	56.4±1.5	16.5±1.0	24.7±1.1	2.4±0.2
Sep	59.0±3.1	14.2±3.0	24.5±1.6	2.2±0.2
Oct	59.5±1.0	12.7±1.3	26.0±1.9	1.8±0.2
Nov	55.7±1.4	17.1±1.9	25.7±0.6	1.6±0.2
Dec	56.3±0.7	16.1±0.9	25.7±0.8	1.9±0.2
Average	57.9±4.0	14.9±2.1	25.1±2.4	2.1 ±0.1

Table 3: Correlation coefficient of cow behaviors as well as the correlation coefficient between behaviors and milk yield

parameters	percentage of four behaviors				time allocation of four behaviors										
	[1] Fr	[2] Sr	[3] Dr	[4] Lr	[5] Ft	[6] St	[7] Dt	[8] Lt	[9] Fc	[10] Dc	[11] Lc	[12] SFt	[13] SSt	[14] SDt	[15] SLt
Sr	-0.46														
Dr	-0.412	-0.097													
Lr	-0.106	-0.703*	-0.127												
Ft	0.575	-0.26	-0.415	0.04											
St	-0.798**	0.629*	0.596*	-0.386	-0.656*										
Dt	-0.285	-0.217	0.672*	0.104	-0.247	0.214									
Lt	0.291	-0.397	-0.113	0.276	-0.013	-0.463	0.254								
Fc	-0.001	0.076	-0.617*	0.286	0.224	-0.361	-0.413	0.466							
Dc	-0.411	0.413	0.648*	-0.514	-0.243	0.610*	0.285	-0.06	-0.168						
Lc	0.096	-0.152	0.005	0.091	-0.478	0.046	-0.106	0.104	-0.329	-0.363					
SFt	0.344	-0.309	0.436	-0.212	0.283	-0.029	0.286	-0.382	-0.858**	0.056	0.101				
SSt	-0.250	0.374	0.404	-0.463	-0.022	0.498	0.072	-0.468	-0.205	0.592*	-0.650*	0.183			
SDt	-0.039	-0.419	0.38	0.300	-0.066	-0.125	0.904**	0.323	-0.299	-0.123	-0.039	0.266	-0.161		
SLt	0.295	-0.081	-0.16	-0.074	0.562	-0.345	0.006	0.232	0.408	0.176	-0.847**	-0.082	0.526	0.025	
[16] My	0.203	-0.062	-0.49	0.193	-0.128	-0.316	-0.198	0.595*	0.686*	-0.279	-0.095	-0.707*	-0.113	-0.049	0.382

Notes: [1] Fr=daily feeding percentage, [2] Sr=daily standing percentage, [3] Dr=daily drinking percentage, [4] Lr=daily lying percentage
[5] Ft=daily feeding time, [6] St=daily standing time, [7] Dt=daily drinking time, [8] Lt=daily lying time
[9] Fc=daily feeding frequency, [10] Dc=daily drinking frequency, [11] Lc=daily lying frequency
[12] SFt=daily single feeding time, [13] SSt=daily single standing time, [14] SDt=daily single drinking time, [15] SLt=daily single lying time
[16] My=daily milk yield
* indicates significant, ** indicates extremely significant

there was no significant correlation between daily drinking time with drinking frequency (P>0.05). On the other hand, a significant positive correlation was found between daily lying time or daily feeding time and milk yield (P<0.05), whereas there was a significant positive correlation between the single feeding time with milk yield (P<0.05).

Establishment of regression equation between behaviors and milk yield: During the entire experimental period, the

structure of cows group, management system and feed nutrient levels were basically unchanged. By Bartlett's sphericity test, there was a significant different ($P<0.01$), and the principal component regression analysis was performed. Two regression equations, between milk yield and time allocation of behaviors (1), and between milk yield and behaviors percentage (2), have been established, respectively, as follows:

My =25.73+0.01402 Lt -0.01542 St-0.00170 Ft-0.03539 Dt -0.04843 Lc+0.08522 Fc
-0.24431 Dc+0.01562 SLt-0.04 790 SSt-0.03300 SFt+0.11017 SDt (1)

Where Lt = lying time, St = standing time, Ft = feeding time, Dt = drinking time, Lc = lying frequency, Fc = feeding frequency, Dc = drinking frequency, SLt = single lying time, SSt = single standing time, SFt = single feeding time, and SDt = single drinking time.

My =21.93 + 0.523 Lr - 0.457 Sr - 0.4 449 Fr - 1.669 Dr (2)

Where My = milk yield, Lr = lying percentage, Sr = standing percentage, Fr = feeding percentage, and Dr = drinking percentage.

Discussion

The behaviors of dairy cows affect milk performance to some extent. In this study, the daily occupied time for the four behaviors was inconsistent with the percentage of cows with each behavior to all cows. Both daily lying time and the percentage of lying cows were the highest among all behaviors, whereas both daily drinking time and percentage of drinking cows were the lowest. This may be due to physiological property of dairy cows and maintaining internal balance from survival competition. Also, these behaviors characteristics were linked to management strategies in the dairy farm.

Early study has indicated that dairy cows need to spend approximately 50 to 60% of time to rest and ruminate every day (Jensen *et al*., 2005). When dairy cows are lying, the blood flowing into mammary gland would increase by 25 to 50%, which helped to increase milk production (Rulquin and Caudal, 1992). In this study, the daily lying time for dairy cows was more than 50% in 83% of months during a whole year. Only in February and December, the lying time failed to reach 50%, with daily lying time was 686.0 and 644.1 min, respectively. Our present result also demonstrate that there was a significant positive correlation between the milk yield and the lying time (r=0.595), which was consistent with previous results (Rulquin and Caudal, 1992; Jensen *et al*., 2005); however, there was also some opposite reports by Norring *et al.* (2012), Stone *et al.* (2017). Moreover, our present result suggests that the lying time and frequency of cows depended on weather conditions in different months. The daily lying time and single lying time were the shortest in winter months; however, the lying frequency in winter months increased compared to other months. It may be explained that cubicle beddings of fermented cow manure with high water content were uncomfortable for dairy cows under cold winter, resulting that cows changed lying position frequently or stood up frequently. In this work, daily lying time, single lying time and daily lying frequency ranged from 644.1 to 780.9 min, 62.3 to 104.8 min and 8.0 to 13.3 times, respectively which were inconsistent with previous reports. The latter two parameters were higher compared to previous results (Zhang and Yang, 2008; Devries *et al*., 2012; Huang *et al*., 2016). The recent result reported by Huang *et al*. (2016) suggested that single lying time in spring, summer, fall and winter were 59.1, 55.8, 59.1 and 60.3 min, respectively (Huang *et al*., 2016). Another early study reported that lying time for dairy cows was 486.5 min per day (Geng *et al*., 1994). The inconsistent results may be due to improvement of management level in our study relative to previous studies, leading to long lying time. When appropriate feed and water were offered, dairy cows would rather lie down for a rest to increase their health level and milk production (Sahn and Ugurlu, 2015).

It is well known that standing behavior is associated with performance and healthy status of animals. The daily standing time for dairy cows averaged 232.6 min for a whole year in this work, which was lower than previous result ranged from 803.9 to 847.1 min per day (Zhang and Yang, 2008). A negative correlation was observed between standing percentage and lying percentage, which was in agreement with the occupied time for standing and lying. Besides, our results suggest that the daily standing time was the shortest in fall while lying time was the longest in this season during a whole year, and standing time was the longest in both winter and summer. The low ambient temperature in winter and uncomfortable bedding may result in the standing for a long time for dairy cows. Similarly to the behavior response to cold environment, the summer heat would cause a discomfort for cows. Published literatures suggested that cows would increase the standing time to defend from the heat stress by increasing skin area for losing heat (Moallem *et al*., 2010; Arias and Mader, 2011; Soriani *et al*., 2013).

On the other hand, the behaviors of feeding and drinking are important for milk performance. Our present result of daily feeding time ranged from 315.7 to 417.8 min was higher than the result from Zhang and Yang (2008). The increased feed intake helped to improve milk yield, and reduced the incidence of mastitis and hoof disease (Bjerre-Harpoth *et al*., 2012). Analysis of our data in this case indicates that the milk yield showed a significant positive correlation with feeding frequency (r=0.686). Thus, increasing feeding frequency would contribute to improving milk yield of dairy cows. Similarly to lying and standing behaviors, the feeding and drinking behaviors exhibited the seasonal characteristic, with the long feeding time and high feeding frequency in the spring and fall months in this study. It is also observed that the drinking time in the summer months was the longest, and the shortest in winter months.

Several studies involving drinking behavior also indicated that water intake and drinking frequency were related to ambient environment such as temperature, humidity, sunlight and so on. Another study confirmed that the daily drinking time of cows in summer was higher than that of other seasons (Arias and Mader, 2011). Based on these findings, the quantitative relationship between milk yield and behavioral parameters was established by method of principal component regression in this study. This quantitative relationship suggests that the lying time and lying percentage had greater influence on milk yield of dairy cows compared to other behavioral parameters, and the contribution rates of lying time and lying percentage to milk yield ranged from 9.03 to 10.95 and from 28.88 to 31.12, respectively, during 12-month period. Although the regression coefficient for drinking behavior was high relative to other parameters; however, because of lower values for drinking time, drinking frequency, and drinking percentage, the drinking behavior had little effect on milk yield.

Conclusion

The behavior change of dairy cows reflected basically their milk yield, and the four behaviors had seasonal characteristic. The low lying time and frequency occurred in winter months, and low feeding time and frequency occurred in summer months. Besides, a significant correlation was observed between milk yield and lying time or feeding frequency. Particularly, lying time had a crucial effect on milk yield.

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