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RELATIONSHIPS BETWEEN MILK PERFORMANCE AND BEHAVIOUR OF COWS UNDER LOOSE HOUSING CONDITIONS

Krzysztof Adamczyk[1], Anna Słania[1], Zygmunt Gil[1], Andrzej Felenczak[1], Jozef Bulla[2]

[1]University of Agriculture in Krakow, Department of Cattle Breeding, al. Mickiewicza 24/28, 30-059 Kraków, Poland
[2]Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic
Corresponding author: Krzysztof Adamczyk, email: rzadamcz@cyfronet.pl, tel./fax + 48 12 6624162

Abstract

The aim of the study was to determine relationships between the milk performance and behaviour of cows under the loose-housing system. Forty-nine Holstein-Friesian cows from the same technological group were investigated. The following parameters were analysed: milk yield and milking time at 4 successive milkings, body weight, age and health, hornedness/hornlessness, days from cow placement in the group, number of days from last calving, number of days from last oestrus, and number of days of pregnancy. The behavioural traits analysed were walking activity, the speed of cow approaching the feeding table, the order of cow entry into the milking parlour during milking, and cow temperament. Considerable repeatability was found for the order of the cows at different milkings, with no correlation between this trait and cows' milk yield. The speed of cow approaching the feeding table was not repeatable.

Key words: milk performance, cow behaviour

Considerable individual variation in animal behaviours and their interpretation are a significant problem in behavioural studies of cattle regardless of housing and environmental conditions and the animals' natural behavioural patterns (Phillips and Denne, 1988; Phillips, 2002). On the other hand, the behavioural observations of cattle are increasingly accurate and their analysis more and more objective with advances in animal production technology (Tucker et al., 2004; Lipiński, 2009). This is crucial for breeding practice, which is not only interested in understanding cattle behaviour but also places particular emphasis upon its relationship with production traits at phenotypic and genetic levels (Schutz and Pajor, 2001; Berry et al., 2005; Brouček et al., 2008).

Research in this area concentrates on evaluating the relationship between cattle behaviour and:
– health, especially the incidence of lameness and metabolic diseases (Fregonesi and Leaver, 2001; Edwards and Tozer, 2004; Cook and Nordlund, 2009);
– traits of reproductive performance, especially in oestrous and periparturient cows (López-Gatius et al., 2005; Yániz et al., 2006; Bicalho et al., 2007);
– meat performance, mainly with regard to body weight gains and beef quality (Voisinet et al., 1997; Müller et al. 2006; Behrends et al., 2009).

This cited research has generally shown significant correlations between the behaviour and performance of animals.

The most debatable issue is the relationship between milk production traits and behaviour of cattle (Schein and Fohrman, 1955; Wieckert, 1971; Rathore, 1982; Schutz and Pajor, 2001). Phillips (2002) observed, for instance, that the research to date shows no conclusive evidence on how far the order of cow entry into the milking parlour depends on the social relations in a given group of animals and to what extent on daily milk yield of the cows.

Therefore, the aim of this study was to investigate relationships between the milk performance and some behavioural traits of cows under the loose housing system.

Material and methods

Experimental animals and housing conditions

A total of 49 Holstein-Friesian cows were investigated. The overwhelming majority of the cows (41) were in their first and second lactations, with 8 in their third to seventh lactation cows. They formed one technological group that included animals past the 100th day of lactation. Daily milk yield of the cows averaged 24 kg with considerable variation (s = 3.3 kg). Of the experimental cows, 8 were horned and 41 hornless. Twenty-one cows were pregnant and no oestrus was detected in the other cows examined during the study. The status of the cows did not change over the 7 days preceding the observations and during the observations.

Cows were kept in a single-row loose house and were under zootechnical and veterinary care. The feeding table could accommodate 53 cows and there were 52 individual lying stalls. Cows had free access to automatic waterers. Animals were milked twice daily (morning and evening) in a 2×10 herringbone milking parlour. Afifarm v.3.04D software (A-Lima-Bis Ltd.) was used for herd management.

Cows were fed total mixed rations (TMR). TMR diets contained approximately 41% silages (from maize, grass, maize grain and lucerne) and 59% brewers' grains, concentrates and mineral supplements. Daily ration was 51.6 kg TMR per cow. TMR was fed once daily at milking.

Traits observed

Milk yield and milking time at 4 successive milkings were analysed. In addition, the cows were weighed once using platform scales before TMR feeding and before

the observations made to determine speed of cow approaching the feeding table. The following parameters were also accounted for: age and health, hornedness/hornlessness, days from cow placement in the group (day 1 of observations), number of days from last calving, number of days from last oestrus, and number of days of pregnancy (for pregnant cows).

The behavioural traits analysed were:

– walking activity, which was recorded using a pedometer and automatically read during each milking;

– speed of cow approaching the feeding table, which was recorded over 3 successive days during TMR feeding directly after the morning feeding, when all the animals left the milking parlour (Table 1);

– the order of cow entry into the milking parlour at milking (after cow's entry to the milking parlour, but before occupying the milking stall); it was registered over 4 successive milkings; the animals entering the parlour were not encouraged by handlers or equipment;

– cow temperament, which was evaluated during weighing as a cow's response to the novel environment and situation. Each cow was scored by 4 evaluators and a mean score was calculated for each animal (Table 1).

Table 1. Evaluation of cow temperament and speed of cow approaching the feeding table during TMR feeding

Score	Cow temperament	Speed of cow approaching the feeding table
1	animal very difficult or impossible to weigh because of aggression towards handlers	animal waiting at the feeding table before feed dispensation
2	animal restless, unwilling to enter the scales, leaving it quickly and nervously, showing fear and excessive excitability when weighed	animal quickly approaching the feeding table at feed dispensation
3	animal showing little fear when entering, standing on and exiting the scales	animal slowly approaching the feeding table within 10 minutes of feed dispensation
4	animal calm, calmly entering and exiting the scales, showing positive interest in handlers when weighed (e.g. calmly sniffing the handlers)	animal failing to visit the feeding table within 10 minutes of feed dispensation

Statistical analysis of the results

The following statistical procedures were performed:

– chi-square test to evaluate the goodness of fit of different variables with normal distribution;

– one-way analysis of variance and the Kolmogorov-Smirnov test to evaluate the effect of hornedness/hornlessness;

– Spearman's rank correlation coefficients to evaluate the relationships between the analysed traits.

The calculations were made using Statistica v.7.0.

Results

Tables 2 to 4 compare the behaviour of hornless and horned cows. There were no significant differences between the means, which may have been largely due to considerable variation of the observations, as evidenced by the difference between the maximum and minimum values.

Walking activity of the cows during the evening milkings was higher by 18% (hornless cows) and 8–36% (horned cows) compared to the readings taken at the morning milkings (Table 2). Horned cows were the first to enter the milking parlour during all milkings (Table 3).

Table 2. Walking activity of the cows

Item	Walking activity on day 1 (morning milking)		Walking activity on day 1 (evening milking)		Walking activity on day 2 (morning milking)		Walking activity on day 2 (evening milking)	
	HL	H	HL	H	HL	H	HL	H
Mean[1]	77.4	82.4	94.3	128.0	79.3	82.5	97.2	89.6
Minimum	44	56	36	61	11	65	44	60
Maximum	127	152	166	376	168	137	348	143

Note: HL – hornless cows, H – horned cows; [1] – specific units of cows walking activity used by Afifarm v.3.04D [UA].

Table 3. Order of cow entry into the milking parlour

Item	Order of cows at morning milking on day 1		Order of cows at evening milking on day 1		Order of cows at morning milking on day 2		Order of cows at evening milking on day 2	
	HL	H	HL	H	HL	H	HL	H
Mean (UA)	25.4	24.3	26.5	21.5	25.4	28.1	25.1	23.1
Minimum	3	1	3	1	2	1	3	1
Maximum	49	42	49	43	49	47	49	47

For explanations see Table 2.

Table 4. Speed of cow approaching the feeding table and cow temperament

Item	Speed of cow approaching the feeding table on day 1		Speed of cow approaching the feeding table on day 2		Speed of cow approaching the feeding table on day 3		Cow temperament	
	HL	H	HL	H	HL	H	HL	H
Mean	3.0	2.1	2.8	2.4	2.7	2.9	3.7	3.6
Minimum	1	1	1	1	1	1	2	2
Maximum	4	4	4	4	4	4	4	4

For explanations see Table 2.

During TMR feeding, cows most often approached the feeding table either quickly or within 10 minutes of feed dispensation (mean score: 2.1–3.0) (Table 4). During weighing, hornless and horned cows did not show much fear when entering, standing on and exiting the scales; they were calm and responded positively to the handlers, as evidenced by the mean temperament score of 3.6–3.7.

There were significant (P<0.01) positive correlations between the order of cows during individual milkings (Table 5). The coefficients of correlation were around 0.4–0.7, which shows good repeatability of the analysed trait.

Table 5. Relationships between the order of cow entry into the milking parlour at successive milkings

Item		Day 1		Day 2	
		morning milking	evening milking	morning milking	evening milking
Day 1	morning milking	1.00			
	evening milking	0.68**	1.00		
Day 2	morning milking	0.58**	0.53**	1.00	
	evening milking	0.46**	0.39**	0.55**	1.00

** Spearman's rank correlation coefficients significant at P<0.01.

Table 6. Relationships between the speed of cow approaching the feeding table on successive days

Item	Day 1	Day 2	Day 3
Day 1	1.00		
Day 2	0.08	1.00	
Day 3	0.09	0.19	1.00

Table 7. Relationships of milk yield with cow walking activity and order of entry into the milking parlour

Milk yield (kg)	Cow walking activity (UA) Order of entry into the milking parlour			
	Day 1		Day 2	
	morning milking	evening milking	morning milking	evening milking
Day 1 – morning milking	–0.14 –0.18	–0.11 –0.07	–0.02 –0.03	–0.18 –0.07
Day 1 – evening milking	–0.18 –0.07	–0.10 0.07	–0.12 0.10	–0.17 0.07
Day 2 – morning milking	–0.08 –0.26	–0.08 –0.08	–0.17 –0.12	–0.22 –0.09
Day 2 – evening milking	–0.02 –0.03	–0.06 0.15	–0.06 0.07	–0.21 –0.02

Moreover, the correlation coefficients in Table 6 (r = 0.08 to 0.19) showed no repeatability for the speed of cows approaching the feeding table in the analysed time period.

Table 8. Relationships of milking time with cow walking activity and order of entry into the milking parlour

Milking time (s)	Cow walking activity (UA) Order of entry into the milking parlour			
	Day 1		Day 2	
	morning milking	evening milking	morning milking	evening milking
Day 1 – morning milking	0.12 0.30	0.01 0.15	0.35* 0.38**	0.13 0.20
Day 1 – evening milking	0.07 0.17	–0.05 0.06	0.21 0.21	0.09 0.06
Day 2 – morning milking	0.05 0.25	–0.11 0.17	0.14 0.28	–0.04 0.16
Day 2 – evening milking	0.14 0.21	–0.01 0.12	0.25 0.23	0.03 0.07

* Spearman's rank correlation coefficients significant at $P<0.05$.
** Spearman's rank correlation coefficients significant at $P<0.01$.

Table 9. Relationships of milk yield with cow temperament and speed of cow approaching the feeding table

Milk yield (kg)	Temperament	Speed of cow approaching the feeding table		
		Day 1	Day 2	Day 3
Day 1 – morning milking	0.07	0.01	0.23	–0.16
Day 1 – evening milking	0.07	–0.05	0.12	–0.28
Day 2 – morning milking	0.29*	0.02	0.16	0.00
Day 2 – evening milking	0.04	0.05	0.13	–0.18

For explanations see Table 8.

Table 10. Relationships of cow walking activity and order of entry into the milking parlour with some reproductive traits, number of days after cow placement in the group, age and body weight

Item	Cow walking activity (UA) Order of entry into the milking parlour			
	Day 1		Day 2	
	morning milking	evening milking	morning milking	evening milking
Days from last calving	–0.06 –0.28	–0.08 –0.05	–0.06 –0.28	–0.06 –0.11
Days from last oestrus	0.18 –0.22	0.15 –0.09	0.08 –0.05	0.09 –0.16
Days of pregnancy	0.33 –0.27	0.10 –0.41	0.12 –0.33	0.12 –0.46*
Days from cow placement in the group	–0.13 0.09	–0.11 0.00	–0.28 0.16	0.03 0.18
Age (months)	–0.28* –0.09	–0.38* –0.11	–0.47** 0.01	–0.21 0.14
Body weight (kg)	–0.26 0.01	–0.21 0.13	–0.17 0.08	–0.11 0.07

For explanations see Table 8.

The correlation coefficients of around –0.2–0.2 are evidence that cows' milk yield is not related to their walking activity and the order of entry into the milking parlour (Table 7). Only the walking activity of cows during the morning milking and the order of cows during the morning milking on day 2 were significantly correlated ($P<0.05$ and $P<0.01$, respectively) with milking time during the morning milking on day 1, with positive correlation coefficients of 0.35–0.38 (Table 8).

In addition, significant ($P<0.05$) coefficients of correlation were found between cow temperament and milk yield during the morning milking on day 2 ($r = 0.29$) (Table 9).

In most cases, cows' age was significantly ($P<0.05$; $P<0.01$) negatively correlated with their walking activity at successive milkings ($r = –0.28$ to $–0.47$) (Table 10). No correlations were found between cows' age and the order of entry into the milking parlour ($r = –0.11$ to 0.14).

Table 11. Relationships of cow walking activity with order of entry into the milking parlour, speed of cow approaching the feeding table and cow temperament

Item	Cow walking activity (UA)			
	Day 1		Day 2	
	morning milking	evening milking	morning milking	evening milking
Order of cow entry into the milking parlour:				
Morning milking – day 1	–0.28	–0.28	–0.11	–0.06
Evening milking – day 1	–0.22	–0.25	–0.14	–0.08
Morning milking – day 2	–0.38*	–0.44**	–0.09	–0.13
Evening milking – day 2	–0.42**	–0.39**	–0.26	–0.40**
Speed of cow approaching the feeding table				
Day 1	0.21	0.07	0.05	0.02
Day 2	–0.19	–0.35*	–0.11	–0.30*
Day 3	0.00	–0.10	–0.02	–0.06
Cow temperament	0.07	0.03	–0.05	–0.05

For explanations see Table 8.

Table 12. Relationships of order of entry into the milking parlour with speed of cow approaching the feeding table and cow temperament

Speed of cow approaching the feeding table	Order of cow entry into the milking parlour			
	Day 1		Day 2	
	morning milking	evening milking	morning milking	evening milking
Day 1	–0.14	0.00	–0.22	–0.18
Day 2	0.23	0.21	0.23	0.26
Day 3	–0.13	–0.13	0.09	–0.02
Cow temperament	–0.24	–0.30*	–0.15	–0.05

For explanations see Table 8.

Among the relationships between individual behavioural traits, it was found that cows' walking activity on day 1 during morning and evening milking was significantly ($P<0.05$; $P<0.01$) correlated with the order of entry into the milking parlour on day 2 (Table 11). The coefficients of correlation were around –0.4. The same level was noted for the correlation between cows' walking activity recorded at the evening milking on day 2 and the order of entry into the milking parlour in the evening.

A significant ($P<0.05$) correlation was also found between cow temperament and the order of cows at the evening milking on day 2 ($r = –0.30$) (Table 12).

Discussion

In general, our study showed no or weak correlations between the analysed milk production traits and cow behaviour, especially social behaviour. Without doubt, one of the major underlying factors was the assurance of welfare conditions in loose housing of the cows (compared to tie-stalls, loose housing allows for more natural animal behaviour) (Hultgren, 2003).

Social relationships among cattle (e.g. dominance/submissiveness) are most apparent in situations where animals have limited access to things such as feed (Krohn and Munksgaard, 1998; Phillips, 2002; Val-Laillet et al., 2008). For this reason, when animal welfare standards are met (sufficient number of feeding places, *ad libitum* access to feed, etc.) it is difficult to observe any regularities in the order of cows at feed dispensation. This is confirmed by our study, which demonstrated no or poor repeatability for this trait ($r = 0.08$ to 0.19) and a weak correlation between cows' milk yield and speed of cow approaching the feeding table during feed dispensation ($r = –0.28$ to 0.23).

Our study also revealed that the order of cow entry into the milking parlour was influenced more by behavioural traits (e.g. dominance relations) than milk yield or even hornedness/hornlessness, time spent in the group and physiological status, as evidenced by good repeatability of the order of cow entry into the milking parlour ($r = 0.39$ to 0.68) and no or weak correlations between daily milk yield and the order of entry into the milking parlour at successive milkings ($r = –0.26$ to 0.15). This can be attributed to the fact that cows were allowed limited access to the milking parlour and thus had to wait their turn, which triggered a number of behaviours associated with dominance/submissiveness and manifestation of temperament (Stricklin, 2001). This type of behaviour may occur even in cows milked with a milking robot (Halachmi, 2009).

Similar conclusions were made by other authors. For instance, Wieckert (1971) summarized the results of research studies conducted in 1950–1960 concerning the relationships between cows' milk yield and their social behaviour. He noted high correlations ($r = 0.93$ to 0.98) between dominance values calculated for different types of behaviour (including butting and avoidance of other animals). However, there were no correlations between milk yield and dominance values. Likewise, no relationships were found between cows' milk yield and temperament. Also Law-

stuen et al. (1988) found low correlations of FCM milk yield and milking speed with cow temperament (r = 0.11 to 0.12).

Rathore (1982) showed a high positive correlation between the order of cow entry into the milking parlour at successive days of milking (r = 0.57 to 0.94), with no or weak correlations between the order of entry into the milking parlour and cows' age and milk yield (r = –0.07 to 0.36 and r = –0.43 to 0.02, respectively). Unfortunately, the same author did not examine the relationships between the order of cow entry into the milking parlour and cattle behaviour (e.g. temperament). Also Dobicki et al. (2003) reported good repeatability for cows' entry into the milking parlour (r = 0.55) and even for the choice of milking stall by the cow (r = 0.45). However, the same authors failed to determine the relationship between these traits and milk production traits of the cows (e.g. milk yield and milking time).

When discussing the effect of different factors on the order of cow entry into the milking parlour, Phillips (2002) noted that most often weak correlations are found between the order of cow entry into the milking parlour and milk yield, or between the order of cow entry into the milking parlour and dominance rank. It is therefore difficult to determine if the order of cow entry into the milking parlour is affected more by production traits (e.g. daily milk yield) or behavioural traits (e.g. dominance relationships in a group of animals) even after accounting for other factors that may have some influence (e.g. health status).

Our study generally showed no significant correlations between milk performance traits (e.g. daily milk yield or milking time) and walking activity of the cows. A weak negative correlation was found between this trait and cows' age (r = –0.21 to –0.47), which was only to be expected.

Similarly, Budzyńska et al. (2004) suggested that the relationships between walking activity and milk performance of cattle are lower than those between walking activity and meat performance traits or traits of reproductive performance. On the other hand, changes in cows' walking activity may be a very good indicator of their welfare, including health status (Edwards and Tozer, 2004).

In conclusion, our findings indicate that the behaviour of loose-housed cows depends on whether their behavioural needs have been met. Once the animals were provided with a sufficient number of feeding places and *ad libitum* access to good quality feed, no social behaviours associated with temperament or dominance/submissiveness relationships at the feeding table were observed. Whereas the fact that cows have to wait to be milked probably increases the manifestation of dominance/submissiveness behaviours expressed by the order of entry into the milking parlour. This is indicated by considerable repeatability of this trait at successive milkings on the one hand, and by the low correlation between the order of cow entry into the milking parlour and daily milk yield on the other.

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KRZYSZTOF ADAMCZYK, ANNA SŁANIA, ZYGMUNT GIL, ANDRZEJ FELENCZAK, JOZEF BULLA

Współzależności między użytkowością mleczną krów a ich behawiorem w warunkach chowu wolnostanowiskowego

STRESZCZENIE

Celem pracy było zbadanie współzależności między użytkowością mleczną krów a ich behawiorem w warunkach chowu wolnostanowiskowego. Badaniami objęto 49 krów rasy holsztyńsko-fryzyjskiej należących do tej samej grupy technologicznej. W pracy uwzględniono następujące cechy: wydajność mleka krów i czas doju podczas kolejnych 4 dojów, masę ciała zwierząt, ich wiek, zdrowotność krów, ich rożność/bezrożność, czas przebywania krów w grupie, liczbę dni od ostatniego wycielenia, liczbę dni od ostatniej rui oraz liczbę dni aktualnej ciąży. Z kolei wzięto pod uwagę takie cechy behawioru, jak: aktywność ruchową krów, szybkość podchodzenia krów do stołu paszowego, kolejność wchodzenia krów do hali udojowej podczas doju oraz temperament krów. Stwierdzono między innymi znaczną powtarzalność kolejności krów podczas poszczególnych dojów przy braku korelacji między tą cechą a wydajnością mleka krów. Natomiast wykazano brak powtarzalności szybkości podchodzenia krów do stołu paszowego.