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THE EFFECTS OF SOCIAL HIERARCHY IN A DAIRY CATTLE HERD ON MILK YIELD

Tomasz Sołtysiak, Zenon Nogalski

Department of Cattle Breeding and Milk Quality Evaluation
University of Warmia and Mazury in Olsztyn

K e y w o r d s: social hierarchy, dairy cattle, pasture feeding, behavioral observations.

A b s t r a c t

The objective of this study was to determine the effects of dominance hierarchy in a dairy cattle herd on milk yield. Observations of social behaviors in a group of 126 Polish Holstein-Friesian cows were carried out for seven days, starting from the first grazing day. In order to estimate the position of each animal in the herd, the interactions and relationships between cows were studied. The indices of aggression, dominance and social rank were calculated. These data were used to calculate the competitive index, which enabled to divide all animals into the following subgroups of dominance: dominant cows, subdominant cows, subordinate cows, submissive cows and marginal cows.

All dairy cows were at a similar age. Their social rank was found to be positively correlated with body weight and condition. Higher-ranking animals were characterized by a higher milk yield. Both social status and performance parameters may provide a basis for selecting animals and placing them into groups, so as to optimize milk production.

HIERARCHIA W STADZIE KRÓW A WYDAJNOŚĆ MLECZNA

Tomasz Sołtysiak, Zenon Nogalski

Katedra Hodowli Bydła i Oceny Mleka
Uniwersytet Warmińsko-Mazurski w Olsztynie

S ł o w a k l u c z o w e: hierarchia w stadzie, bydło mleczne, żywienie pastwiskowe.

A b s t r a k t

Celem pracy było poznanie hierarchii w stadzie krów oraz określenie jej związku z wydajnością mleczną. Obserwacje behawioralne dotyczące 126 krów rasy polskiej holsztyńsko-fryzyjskiej prowadzono przez siedem dni, począwszy od pierwszego wyjścia krów na pastwisko. W celu określenia miejsca w stadzie dla każdego osobnika sporządzono siatkę współzależności, a następnie na podstawie

Address: Zenon Nogalski, University of Warmia and Mazury, ul. Oczapowskiego 5, 10-958 Olsztyn, phone: +48 (89) 523 38 23, e-mail: zena@uwm.edu.pl

współczynników: agresywności, dominacji i wzajemnych współzależności obliczono współczynnik hierarchiczny, który pozwolił podzielić stado na krowy dominanty, subdominanty, osobniki podporządkowane, opanowane i marginesowe.

W zbliżonym wiekowo stadzie krów mlecznych wykazano dodatni wpływ masy ciała i kondycji na pozycję w hierarchii. Zwierzęta z wyższych poziomów hierarchii charakteryzowały się większą wydajnością mleczną. Informacje dotyczące hierarchii w stadzie i parametrów użytkowości mlecznej poszczególnych sztuk powinny być uwzględniane w czasie tworzenia optymalnych grup technologicznych, jak również prowadzenia selekcji.

Introduction

Production optimization requires a full understanding of complex behavioral patterns and responses of farm animals (JEZIERSKI 1987, PISULA 2006). The term "behavior" refers to the coordinated actions and reactions of an individual aimed at satisfying biological, psychological and social needs, affected by external factors or internal stimuli (SADOWSKI 2003). Forms of behavior include simple physical actions and complex motor acts, innate or learned, known as behavioral responses or functions. Animals exhibit nine main types of natural behavior related to feeding, excretion, mating (sexual reproduction), protectiveness, subordination, aggressiveness (social hierarchy in the herd), imitation, sense of self-preservation and cognition.

In dairy herds kept in tie-stall barns the order of entry is determined by dominance hierarchy. Cattle are social animals and dominance hierarchy is an important consideration for management decisions. Animals that are to form a herd should be selected based on such factors as their breed, age, sex, height, body weight, the presence of horns and physiological condition (NOWICKI 1978). In order to establish their social position in the herd, animals adopt different strategies indicating dominance or submission, i.e. threatening or avoiding. High dominance rank is associated with certain privileges, including priority of access to the feeder and lying area. In extreme cases animals fight for dominance status in the herd. Social hierarchy in the herd may be determined by observing the attitudes taken by animals (ROGALSKI 1972). In the social hierarchy, individuals are assigned to different (three to five) classes or ranks in the group or herd (KOWALSKI 2000). The most common linear structure comprises five classes: I – dominant cows that displace other animals from feeding and resting areas, and are never harassed by subordinates; II – subdominant cows that often aspire to become leaders, but always lose in direct competition; they show submissive behaviors towards dominants but demonstrate their superiority over lower-ranking animals; III – subordinate cows, servile towards superiors and aggressive towards inferiors; IV – submissive cows, subordinate to representatives of the above classes, aggressive only against the lowest-ranking individuals; in this group submissive and servile

attitudes dominate over threatening and aggressive behaviors; V – marginal cows, subordinate to all other animals.

Grazing on pasture gives cows the opportunity to relearn their herd instinct and ability to survive in the natural environment (SKRIJKA 1999). A better understanding of cattle behavior in pasture contributes to implementing a rational grazing system and adjusting rations to the nutritional needs of animals, thus positively affecting the reproductive performance and health status of cows. In view of the recent trends to increase herd size and pasture stocking density, the results of studies of animal behavior may provide a basis for proper organization and intensification of dairy cattle production (WROŃSKI et al. 1988).

The objective of this study was to determine the effects of dominance hierarchy on milk yield in a herd of Polish Holstein-Friesian cattle.

Materials and Methods

The experimental materials comprised 126 Polish Holstein Friesian (PHF) cows (94 primiparous cows and 32 cows in their second lactation) which had their horns removed, kept in a free-stall barn. The basal diet fed to cows was composed of maize and grass silage. Feed was offered immediately after the morning milking (7.00 a.m.) and evening milking (6.00 p.m.). Cows were fed supplemental concentrate via automatic feeding stations, so as to meet their nutrient requirements. From the middle of June until the end of September, the animals could graze the pasture situated at a distance of around 70 m from the barn. The cattle were grazed rotationally, they were moved from one paddock to another each day, and had free access to water.

Behavioral observations were carried out by four persons for seven consecutive days starting from the first grazing day, between 9.00 a.m. and 3.00 p.m. The persons made every effort not to interfere in herd behavior – they stayed at the edge of the pasture and used binoculars to monitor the cattle. All cows had neck straps with identification numbers.

In order to estimate the position of each animal relative to social rank, the interactions and relationships between cows were studied and described using appropriate codes. Particular attention was paid to aggression and submissiveness. All cases of aggressive interactions in the herd were noted, including those related to access to the resources (feed, water, resting place) and non-competitive situations. Depending on their intensity, aggressive interactions were divided into threatening (1 point), pushing (2 points) and violent attacks (3 points). The index of aggression was calculated based on the total score for each animal, obtained over the entire period of observation (JEZIERSKI 1987):

$$\text{index of aggression} = g + 2o + 3a$$

where:
g – threatening,
o – pushing,
a – violent attack.

The aggression index was presented so as to reflect the position of each animal in the dominance hierarchy. The cows were placed in ascending order, from the lowest score to the highest score, and social hierarchy rank was assigned to each animal. The final result was divided by the number of positions in the herd, as follows:

$$\text{index of aggression in the herd} = \frac{\textit{position of a cow} \text{ in } \textit{the herd} \text{ (}\textit{score}\text{)}}{\textit{number of positions} \text{ in } \textit{the herd}}$$

Based on the number of acts of dominant and subordinate behavior in social interactions, the index of dominance was calculated for each animal (JEZIERSKI 1987):

$$DV = \frac{n_1}{n_1 + n_2}$$

where:
DV – index of dominance,
n_1 – number of animals subordinate to a given individual,
n_2 – number of animals dominant over a given individual.

Subordinate cows would avoid aggression by moving out of the way of dominant partners, standing up from the lying position to let the dominants pass, searching for another place to rest if a given resting area had been chosen by a higher-ranking cow, giving dominant cows their space at the feeder.

Based on the number of acts of dominant and subordinate behavior in the monitored herd, the index of social rank was calculated for each animal:

$$\text{index of social rank} = \frac{a - u}{N}$$

where:
a – number of acts of dominant behavior,
u – number of acts of subordinate behavior,
N – number of cows in the herd.

The values of the indices of dominance and social rank were put in ascending order, and social hierarchy rank was assigned to each animal. The final results were divided by the number of positions in the herd, as follows:

$$\text{index of dominance in the herd} = \frac{\textit{position of a cow} \text{ in the } \textit{herd} \text{ (}\textit{based on DV}\text{)}}{\textit{number of position} \text{ in the } \textit{herd}}$$

$$\text{index of social rank in the herd} = \frac{\textit{position of a cow} \text{ in the } \textit{herd} \text{ (}\textit{based on a–u}\text{)}}{\textit{number of positions} \text{ in } \textit{the herd}}$$

The values of the indices of aggression, dominance and social rank were used to calculate the competitive index, which is the outcome of the above indices:

$$\text{competitive index} = \frac{\textit{index of aggression} + \textit{index of dominance} + \textit{index of social rank}}{3}$$

The competitive index, in the above form, objectively reflects dominance hierarchy in the herd and the social position of each cow. Based on the values of this index, the herd was divided into five social groups, according to the relevant definitions (Table 1).

Table 1

Herd division based on the values of the competitive index (KOWALSKI 2000)

Social group	*N* (%)	Competitive index
Dominant cows (I)	3 2.38	0.000–0.100
Subdominant cows (II)	23 18.25	0.101–0.400
Subordinate cows (III)	38 30.16	0.401–0.600
Submissive cows (IV)	58 46.03	0.601–0.850
Marginal cows (V)	4 3.18	0.851–1.000

Milk yield, milk fat content and milk protein content were determined based on milk yield records. The body weights of cows were determined using an electronic scale. Body condition score (BCS) was calculated using a five-point scale proposed by WILDMAN et al. (1982) on the fifth grazing day.

A statistical analysis of the data was performed using STATISTICA 7.0 software. The effects of body weight, body condition and age on the position of cows in dominance hierarchy were determined by a one-factor analysis of variance in a non-orthogonal design. The significance of differences between mean values was estimated by Tukey's test.

Results and Discussion

Social hierarchy in the cattle herd may be determined by observing the attitudes taken by individual cows. Pasture is the best place to monitor manifestations of the natural herd instinct and to recognize dominance relationships in the herd. In the present study, social hierarchy in the herd was determined based on the values of the competitive index and the relevant definitions of social groups (Table 1). Only three cows (2.38%) were found to be dominant. Submissive cows formed the largest group (46.03%) in the herd. Four individuals were classified as marginal. According to NOWICKI (1978), marginal cows cannot use their full production potential. Almost identical social relationships were reported by SAMBRAUS (1975) – in his study eight dominant cows accounted for only 1.52% of the herd. In an experiment conducted by ROGALSKI (1972), the herd was divided into social groups as follows: group I – 13%, group II – 27%, group III – 7%, group IV – 40%, group V – 13%.

The social status of animals in the herd is dependent on the perception and manifestation of their physical traits, and the attitudes they adopt towards one another, rather than on their actual strength. Only animals with appropriate physical attributes and mental capacities can hold a high social position in the herd. There exists a close interdependence between the age, body weight and intelligence of an individual and its social rank. An important role may be also played by the length and sharpness of horns, agility, stress resistance and courage (ROGALSKI 1972). SCHEIN and FOHRMAN (1955) demonstrated a strong correlation between the social position in the herd and the age ($r = 0.93$) and body weight ($r = 0.87$) of cows. In our study the social rank of animals was found to be positively correlated with their age, body weight and condition (Table 2). The average body weight of dominant cows was 587.7 kg, and it was on average by 82.2 kg higher than the body weight of marginal cows. Body condition also exerted a significant effect on the position of cows in social hierarchy. Differences between dominant and submissive cows reached 0.6 points on average. Although all cows in the analyzed herd were at a similar age (first and second lactation), the oldest, most experienced and heaviest ones performed the role of leaders. Dominant cows were significantly older ($p \leq 0.05$) than submissive cows.

Table 2

Body weight, body condition and age of cows representing different social groups

Social group	Statistical measure	Body weight (kg)	Body condition (points)	Lactation (1–5)
I	$\bar{x}$	587.7	3.13	2.00
	SD	63.8	0.75	0.0
II	$\bar{x}$	564.5^{A}	2.93^{AB}	1.21^{a}
	SD	57.6	0.22	0.42
III	$\bar{x}$	524.7	2.60^{A}	1.21
	SD	49.1	0.26	0.41
IV	$\bar{x}$	507.2^{A}	2.53^{B}	1.10^{a}
	SD	51.6	0.29	0.31
V	$\bar{x}$	505.4	2.50	1.25
	SD	49.4	0.18	0.50

Mean values in columns followed by the same superscript letters differ significantly: capital letters – $p \leq 0.01$, small letters – $p \leq 0.05$.

In a newly formed herd, most of the dominance/subordination relationships develop during the first hour. As shown by BOUISSON (1974), 84% of relationships in a group of cattle are established within the first five minutes, and within two hours animals form stable social subgroups. However, it should be stressed that certain parameters of social behavior (e.g. those related to physiological condition or disease occurrence) are relatively variable and may affect dominance hierarchy over time. According to SAMBRAUS (1975), older, usually heavier cows hold higher positions in the social structure and maintain their status even at an older age, when their physical activity is largely reduced. In-calf heifers and juvenile cattle occupy the lowest-ranking position in the herd. Ill animals are always dominated by healthy individuals, even if the latter were subordinate to the former prior to disease occurrence. Temporary isolation or displacement of leaders is ineffective since on coming back they quickly regain their former dominant position (NOWICKI 1978). The removal of the most dominant individual from the herd results in taking the leadership by the next highest-ranking animal. In addition, a herd without a leader is likely to fall apart and is difficult to manage in open spaces.

Higher-ranking cows were characterized by a higher milk yield during lactation of standard length (Table 3). Differences in the average milk yield between groups ranged from 8 to 20%. In the groups of dominant and subdominant cows, milk yield exceeded 6 000 kg in standard-length lactation. The difference in average milk production between dominants and marginal cows reached 1092 kg, but it was statistically non-significant due to a too low number of group I cows. Significant differences were noted between groups II and IV with respect to milk protein content. SCHEIN and FOHRMAN (1955) observed a 5% decrease in milk production in cows that were losers in

aggressive interactions. Similar results were reported by JEZIERSKI (1987), who noted an average decrease in milk yield of 4.36% due to factors other than social stress within five days after the exchange of cows between groups. According to SYME and SYME (1979), aggressive interactions and competitive situations should be avoided in cattle herds although there is no unequivocal evidence to support the hypothesis that dominance in the herd can be associated with milk performance traits. The results of the present study, which are consistent with the findings of FRIEND and POLAN (1978), suggest that both social status and performance parameters may provide a basis for selecting animals and placing them into groups, so as to optimize milk production.

Table 3

Effect of dominance hierarchy on milk yield

Social group	Statistical measures	Milk yield for 305 days (kg)	Milk protein content (%)	Milk fat content (%)
I	$\bar{x}$	6580	3.22	4.04
	SD	832	0.40	0.78
II	$\bar{x}$	6105	3.59^{A}	4.60
	SD	1063	0.36	0.60
III	$\bar{x}$	5890	3.36	4.36
	SD	924	0.29	0.58
IV	$\bar{x}$	5460	3.29^{A}	4.19
	SD	658	0.24	0.42
V	$\bar{x}$	5488	3.22	4.05
	SD	756	0.22	0.41

Mean values in columns followed by the same superscript letters differ significantly: capital letters – $p \leq 0.01$.

Conclusions

1. In a herd composed of dairy cows at a similar age, the social rank of animals was found to be positively correlated with their body weight and condition.

2. Higher-ranking cows were characterized by a higher milk yield during lactation of standard length.

3. Both social status and performance parameters may provide a basis for selecting animals and placing them into groups, so as to optimize milk production.

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