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THE EFFECT OF SELECTED FACTORS ON CHANGES IN BODY CONDITION IN HIGH-YIELD COWS

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Abstract. An analysis was conducted of 644 body condition assessments made in 2011 in a herd of 52 Black-and-White Polish Holstein-Friesian cows with annual milk yield exceeding 10,000 kg. Body condition was assessed once a month according to the 5-point BCS system, accurate to within 0.25 points. Changes in body condition and the frequency of particular scores were found to be significantly influenced by lactation number (first or subsequent), the season in which calving took place, daily milk yield, milk urea level, and the period after calving. The highest average scores were noted in multiparous cows, in cows that calved in the summer, and in those with the lowest daily milk yield. The lowest scores were observed in cows with the highest milk urea level and in the period from the 5th to 7th month after calving. In addition, primiparous cows were found to begin lactation with lower fat reserves than multiparous cows, and had lower body condition scores in all periods after calving.

Key words: body condition, cows, milk urea, milk yield, multiparous cows, primiparous cows

INTRODUCTION

Selection aimed at increasing production entails the risk of behavioural, physiological, and immunological problems in populations of many species of farm animals, including dairy cattle [Słoniewski 2003]. In high-yield cows, milk production is the main energy expenditure, far exceeding the energy expended on other

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bodily functions [Borkowska et al. 2004]. In the initial period of lactation, energy uptake is not sufficient to meet requirements, so the cow draws energy from its own tissues [Borkowska and Januś 2002, Słoniewski 2003, Nogalski et al. 2009]. During the first 60–80 days after calving, a loss of 70 kg of fat reserves in an adult cow can produce nearly 500 kg of milk in excess of the amount ensured by energy uptake from feed [Guliński et al. 1994]. Thus proper preparation of cows for lactation allows their production potential to be fulfilled [Januś and Borkowska 2002]. In order to obtain satisfactory milk yield, proper body condition must be maintained over the entire production cycle and dry period, which can be achieved with rational feeding [Borkowska and Januś 2002, Słoniewski 2003]. Adamski and Kupczyński [2005] emphasize that proper feeding of cows, particularly during the dry period, is also the key to avoiding health problems.

The extent to which feed rations for dairy cows are properly balanced can be evaluated with various relatively simple tools, e.g. by determining the level of urea in the milk and its total protein content. Another method for evaluating nourishment of cows and the depletion or replenishment of their energy reserves, particularly fatty tissue, is the use of body condition scores (BCS). This is a subjective, non-invasive method for determining the level of energy accumulated in fat and muscle tissue [Nogalski et al. 2009]. Body condition should be assessed routinely in dairy herds during the dry period, after calving, and on days 45, 90, 180, and 270 of lactation [Guliński et al. 1994].

The aim of the study was to evaluate the effect of selected non-genetic factors on changes in the body condition of Polish Holstein-Friesian cows.

MATERIAL AND METHODS

The study was carried out on a family farm which in 2011 kept 52 Polish Holstein-Friesian cows with average milk yield of 10,729 kg, containing 4.37% fat and 3.44% protein [PFCBDF 2012]. The cows were tethered and milked in stalls with a pipeline milking machine. Feed rations during both the summer and winter periods included hay, grass silage, and silage from maize and alfalfa. In winter the cows were also fed sugar beet pulp. Concentrate feed, in amounts determined individually depending on daily yield, consisted of grain meal, bran, sunflower meal, and rapeseed meal. The cows also received vitamin and mineral supplements.

On test-day milking days in 2011 the body condition of the cows was evaluated according to the 5-point BCS system [Wildman et al. 1982], accurate to within 0.25 points. A total of 644 body condition scores were determined, 37 of which were for dry cows. In addition, calving dates for each cow and the dates

and results of test-day milking were obtained from breeding documentation kept by the farm. The data were used to analyse the influence of the following factors on the body condition of the cows:

- lactation number (first – primiparous cows, or subsequent – multiparous cows);
- feeding season (summer: May–October, winter: November–April);
- season of calving (spring: March–May, summer: June-August, autumn: September–November, winter: December–February);
- daily milk yield (up to 20.0 kg; 20.1–30.0; 30.1–40.0; > 40.0 kg);
- milk urea level (up to 140, 141–250, > 250 mg·l^{-1});
- successive periods after calving (up to month 4 of lactation; months 5–7; months 8–10, month 11 and later; dry period).

The data were analysed using the SAS package [SAS® User's Guide 2006]. Duncan's test and the χ^2 test (test of independence) were used to determine the effect of the experimental factors on the body condition of the cows.

RESULTS AND DISCUSSION

The average calculated for all of the body condition scores was BCS 3.36 (Table 1). Most often noted in the herd (45.8% of the total) were scores in the range of BCS 2.50–3.00, while the scores occurring least often (2.2%) were those indicating that the cows were too thin (Table 2). As many as 20.2% of the body condition scores were too high (> 3.75 points). Changes in energy reserves in the cows and the frequency of different body condition scores were significantly affected by most of the factors analysed (evaluated using the χ^2 test). Scores for primiparous cows were 0.20 lower ($P \leq 0.01$) than those for multiparous cows. Scores that were too high (> 3.75) were noted less often (by 13.1%) in primiparous cows, as were scores in the 3.25–3.75 range (by 5.6%), while those in the 2.50–3.00 range occurred more often (by 18.9%). These differences may have resulted from the fact that primiparous cows began lactation with lower energy reserves. A significant association between the age of cows and their fat reserves has been indicated by other studies as well [Guliński et al. 1994, Borkowska et al. 1999, Borkowska 2000]. Kertz et al. [1997] noted the lowest body condition in cows after their second calving.

Average body condition scores calculated for the summer and winter feeding seasons did not differ significantly. This factor did, however, significantly affect the frequency of different scores ($P \leq 0.05$). The lowest scores (up to 2.25) were noted more often in the winter period (by 3.5%), as were those in the 2.50–3.00 range (by 1.4%), while higher scores were observed less often (by 4.9%).

Table 1. Changes in body condition of cows taking into account the effect of the factors analysed

Tabela 1. Kształtowanie się kondycji krów w obrębie analizowanych czynników

Factors – Czynniki	Number of scores Liczba ocen	Body condition scores (BCS) Oceny kondycji (pkt BCS)	
		$\bar{x}$	s
Lactation number – Kolejna laktacja			
– 1 (primiparous) – I (pierwiastki)	342	3.27^{A}	0.57
– >1 (multiparous) – >I (wieloródki)	302	3.47^{B}	0.57
Feeding season – Sezon żywienia			
– summer – letni	304	3.41	0.56
– winter – zimowy	340	3.32	0.61
Season of calving – Sezon wycielenia			
– spring – wiosenny	46	3.12^{A}	0.38
– summer – letni	248	3.49^{B}	0.60
– autumn – jesienny	204	3.27^{AC}	0.62
– winter – zimowy	146	3.35^{BC}	0.53
Daily milk yield, kg – Dobowa wydajność mleka, kg			
– ≤ 20.0	77	3.75^{A}	0.66
– 20.1–30.0	219	3.49^{B}	0.60
– 30.1–40.0	206	3.18^{C}	0.49
– > 40.0	105	3.15^{C}	0.53
Milk urea level, mg · l^{-1} – Poziom mocznika w mleku, mg · l^{-1}			
– ≤ 140	153	3.37^{A}	0.52
– 141–250	388	3.40^{A}	0.61
– > 250	66	3.12^{B}	0.66
Period of lactation – Okres po wycieleniu			
– up to month 4 – do 4. miesiąca	198	3.22^{A}	0.57
– 5–7	130	3.19^{A}	0.55
– 8–10	112	3.36^{A}	0.55
– 11th and later – 11. i dalsze m-ce	167	3.66^{B}	0.59
– dry period – zasuszenie	37	3.76^{B}	0.43
Total and average – Ogółem i średnio	644	3.36	0.59

Mean values within a factor designated with different letters differ significantly at P ≤ 0 .01.
Średnie w obrębie czynnika oznaczone różnymi literami różnią się istotnie przy P ≤ 0,01.

The level of fat reserves in the cows and the frequency of different body condition scores were significantly influenced ($P \leq 0.01$) by the season in which calving took place. The lowest averages for this trait were calculated for cows that calved between March and May, and the highest for those that gave birth in the summer. The difference between these averages was 0.37 ($P \leq 0.01$). Also significant ($P \leq 0.01$) were the differences between body condition scores of cows that gave birth in spring and winter (0.23) and between summer and autumn (0.22). The percentage of scores in the 2.50–3.00 range was highest in cows that calved in the spring (73.0%). Scores exceeding 3.75 were noted most often (24.6%) in the case of summer calvings. The fact that the lowest percentage of the highest scores was noted in cows giving birth in spring (4.4%) may result from the fact that in these cows the last stage of lactation or the dry period was in late winter or early spring. During this time roughage feed is often of lower quality, which

means that the cows accumulate fat reserves at a slower rate, despite the fact that their bodies are predisposed for this during this period. The effect of the season of calving on changes in body condition was also confirmed by the χ^2 test, with a value of 41.0 ($P \leq 0.01$).

Table 2. Frequency of different body condition scores in cows taking into account the effect of the factors analysed

Tabela 2. Frekwencja różnych ocen kondycji krów w obrębie analizowanych czynników

Factors – Czynniki	Number (%) of different body condition scores (BCS) Liczba (%) różnych ocen kondycji krów (pkt BCS)				Value for χ^2 test Wartość testu χ^2
	≤ 2.25	2.50–3.00	3.25–3.75	> 3.75	
Lactation number – Kolejna laktacja					
– I (primiparous) – I (pierwiastki)	7 (2.1)	187 (54.7)	100 (29.2)	48 (14.0)	27.7**
– > I (multiparous) – > I (wieloródki)	7 (2.3)	108 (35.8)	105 (34.8)	82 (27.1)	
Feeding season – Sezon żywienia					
– summer – letni	1 (0.3)	137 (45.1)	103 (33.9)	63 (20.7)	9.9*
– winter – zimowy	13 (3.8)	158 (46.5)	102 (30.0)	67 (19.7)	
Season of calving – Sezon wycielenia					
– spring – wiosenny	–	34 (73.0)	10 (21.7)	2 (4.4)	
– summer – letni	–	104 (41.9)	83 (33.5)	61 (24.6)	41.0**
– autumn – jesienny	11 (5.4)	96 (47.0)	54 (26.5)	43 (21.2)	
– winter – zimowy	3 (2.1)	61 (41.8)	58 (39.7)	24 (16.4)	
Daily milk yield, kg – Dobowa wydajność mleka, kg					
– ≤ 20.0	–	21 (27.3)	15 (19.5)	41 (53.2)	
– 20.1–30.0	3 (1.4)	81 (37.0)	78 (35.6)	57 (26.0)	102.2**
– 30.1–40.0	8 (3.9)	109 (52.9)	73 (35.4)	16 (7.8)	
– > 40.0	3 (2.9)	70 (66.7)	22 (20.9)	10 (9.5)	
Milk urea level, mg · l^{-1} – Poziom mocznika w mleku, mg· l^{-1}					
– ≤ 140	–	73 (47.7)	51 (33.3)	29 (19.0)	37.6**
– 141–250	6 (1.5)	173 (44.6)	123 (31.7)	86 (22.2)	
– > 250	8 (12.5)	35 (53.0)	14 (21.2)	9 (13.7)	
Period of lactation – Okres po wycieleniu					
– up to month 4 – do 4. miesiąca	9 (4.5)	109 (55.1)	54 (27.3)	26 (13.1)	
– 5–7	5 (3.8)	74 (56.9)	37 (28.5)	14 (10.8)	83.7**
– 8–10	–	50 (44.6)	45 (40.2)	17 (15.2)	
– 11th and later – 11. i dalsze m-ce	–	48 (28.8)	52 (31.1)	67 (40.1)	
– dry period – zasuszenie	–	14 (37.8)	17 (46.0)	6 (16.2)	
Total – Ogółem	14 (2.2)	295 (45.8)	205 (31.8)	130 (20.2)	–

Values for the χ^2 test significant * – at $P \leq 0.05$; ** – at $P \leq 0.01$
Wartości testu χ^2 istotne: * – przy $P \leq 0{,}05$; ** – przy $P \leq 0{,}01$

The association between body condition of cows and milk production has been the subject of many studies. Like the present study, they have found that the highest body condition scores occur when milk yield is lowest [Guliński et al. 1994, Borkowska et al. 1999, Borkowska 2000, Januś and Borkowska 2002, Loker et al. 2012]. In the present study, daily milk yield significantly ($P \leq 0.01$) influenced both average body condition scores and the frequency of different scores. When daily milk yield was ≤ 20.0 kg, the average body condition score was 3.75. No

scores from the lowest range (up to 2.25) were noted in this group, while over half of them (53.2%) exceeded BCS 3.75. Daily milk yield within the 20.1–30.0 kg range was associated with an average BCS of 3.49, and 26.0% of the scores were in the highest range. The 0.26 difference between the average body condition scores for these groups was significant at $P \leq 0.01$. Moreover, both of these averages were significantly higher ($P \leq 0.01$) than in cows whose milk yield exceeded 30.0 kg. The average score in the case of yield of 30.1–40.0 kg was BSC 3.18, which was only 0.03 higher than for the highest daily milk yield. Differences between these groups in the frequency of the highest and lowest scores were small (1.7 and 1.0%, respectively). Negative correlations between body condition of cows at different stages of lactation and milk production were noted by Berry et al. [2003]; the genetic correlation coefficients for these traits ranged from –0.51 to –0.14.

Loker et al. [2012] estimated genetic correlations between body condition of cows and their productivity and the chemical composition of the milk. These showed that BCS was not correlated with milk urea level. In the present study, in the case of urea levels indicating protein deficiencies in the feed rations (up to 140 mg·l^{-1}) and those indicating proper protein levels (141–250 mg·l^{-1}), average body condition scores were similar (3.37 and 3.40). However, these values were significantly ($P \leq 0.01$) higher than the average for cows whose milk had the highest urea levels (> 250 mg·l^{-1}). This factor was also significantly ($P \leq 0.01$) associated with the frequency of different body condition scores, which is indicated by the result of the χ^2 test – 37.6. This association was mainly due to the fact that where the urea level in the milk was over 250 mg·l^{-1}, as many as 65.5% of scores were $\leq$ 3.00. In the remaining groups, the percentage of these scores was 47.7% (up to 140 mg·l^{-1}) and 46.1% (141–250 mg·l^{-1}). It is worth noting that in the case of urea levels up to 140 mg·l^{-1}, there were no scores $\leq$ 2.25.

The body condition of cows should vary in different periods of the production and reproduction cycle [Borkowska et al. 1999, Berry et al. 2003, Borkowska et al. 2004. Jílek et al. 2008, Loker et al. 2012]. In the present study, the average BCS for the first four months of lactation was 3.22, and nearly 60% of these scores were $\leq$ 3.00. In the next period of lactation, the average score decreased by 0.03, and then increased by 0.17 (insignificant differences). Greater variation was noted in the frequency of different scores in the first three periods after calving. The lowest range of scores ($\leq$ 2.25) occurred only up to the 7th month after calving. In the first two periods after calving (up to month 4 and months 5–7), scores in the 2.50–3.00 range were noted with nearly equal frequency (55.1% and 56.9%). This was also true in the case of BCS 3.25–3.75 (27.3% and 28.5%) and > 3.75% (13.1% and 10.8%). In the last three months of standard lactation no scores in

the lowest range were noted, whereas the percentage of scores in the 3.25–3.75 range and the highest range (> 3.75) increased (by 11.7–12.9%). During lactations extended beyond the 305-day standard, there was a significant ($P \leq 0.01$) increase in the average BSC (0.30–0.47) and in the percentage of excessively high scores, i.e. > 3.75. The average BCS for the dry period (3.76) was only slightly higher than the score considered optimal during this period, and scores > 3.75 were noted in only 16.2% of cases. An increase in energy reserves in dairy cows in the last months of lactation and during the dry period has been observed in other studies [Guliński et al. 1994, Borkowska and Januś 2002].

In successive periods after calving, changes in fat reserves varied between multiparous and primiparous cows (Fig. 1). In cows who had calved for the first time, the average BCS increased (by 0.05) in the second period (months 5–7 of lactation) compared to the first period (months 1–5), while in multiparous cows the average BCS decreased by 0.09. Average body condition scores rose in both groups in successive periods after calving, with significantly higher scores noted in multiparous cows (except for months 5–7). These results may suggest that primiparous cows utilized feed components more for growth and development, which was reflected in their lower body condition scores (compared to multiparous cows). Similar associations were noted in a study by Januś and Borkowska [2005], which determined that multiparous cows began lactation with larger fat reserves than primiparous cows. These animals had higher body condition scores during the entire lactation period and dry period.

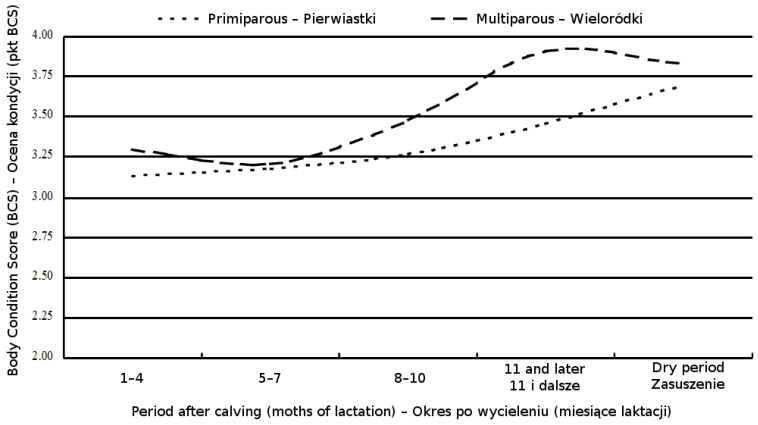

Fig. 1. Changes in body condition in successive periods after calving in primiparous and multiparous cows

Rys. 1. Kształtowanie się kondycji pierwiastek i wieloródek w kolejnych okresach po wycieleniu

CONCLUSIONS

Changes in the body condition of cows and the frequency of different body condition scores was significantly influenced by lactation number, season of calving, daily milk yield, milk urea level, and the period after calving. The highest average scores were observed in multiparous cows, cows that gave birth in the summer, and those with the lowest daily milk yield. The lowest scores were noted for the highest milk urea levels and in months 5–7 after calving. It was also determined that primiparous cows began lactating with lower fat reserves than multiparous cows and had lower body condition scores in all periods after calving.

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WPŁYW WYBRANYCH CZYNNIKÓW NA KSZTAŁTOWANIE SIĘ KONDYCJI KRÓW WYSOKOWYDAJNYCH

Streszczenie. W analizie wykorzystano 644 oceny kondycji, dokonane w 2011 roku w stadzie liczącym 52 krowy rasy polskiej holsztyńsko-fryzyjskiej o przeciętnej rocznej wydajności powyżej 10 tys. kg mleka. Ocenę kondycji krów przeprowadzano raz w miesiącu, w skali 5-punktowej, z dokładnością do 0,25 pkt. Stwierdzono, że na kształtowanie się kondycji krów oraz frekwencję różnych ocen istotnie wpływała kolejna laktacja, sezon wycielenia, dobowa wydajność mleka, poziom mocznika w mleku oraz okres po wycieleniu. Najwyższe średnie oceny stwierdzono u wieloródek, u krów wycielonych w okresie letnim oraz charakteryzujących się najniższą dobową wydajnością mleka. Najniższe oceny zanotowano przy najwyższym poziomie mocznika

w mleku oraz od 5. do 7. miesiąca po wycieleniu. Stwierdzono także, że pierwiastki, w porównaniu z wieloródkami, rozpoczynały laktację z mniejszymi zapasami tłuszczu i we wszystkich fazach po wycieleniu charakteryzowały się niższymi ocenami kondycji.

Słowa kluczowe: krowy, kondycja, mocznik w mleku, pierwiastki, wieloródki, wydajność

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