ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 18(1) 2019, 3–10

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2019.18.1.01

ORIGINAL PAPER

Received: 10.01.2019
Accepted: 28.02.2019

EFFECT OF SELECTED FACTORS ON THE BODY CONDITION OF DAIRY COWS MANAGED IN THE FREE-STALL AND TIE-STALL HOUSING SYSTEMS

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ABSTRACT

The analysis involved results of 6891 body condition evaluations carried out on 680 Polish Holstein-Friesian Black-and-White cows from two herds belonging to the same owner, although managed in different husbandry systems. The evaluation was carried out within two years using a 5-point scale, with an accuracy of 0.25 points. It was found that the most frequent score was 3.0 BCS (more than 24% of cows), in the tie-stall system, and 3.25 BCS (over 26%), in the free-stall housing system. The distribution of BCS scores of the cows with different daily productivity, of different ages and evaluated in different seasons of the year was significantly correlated with the applied housing system. Cows with the highest daily milk yield (>35 kg), younger cows (in the second lactation) and those evaluated in the summer had the least favorable distribution of body condition scores and their average values as compared to other groups. It was shown that cows kept on tether were more often receiving extreme body condition scores, i.e. not more than 2.0 points or 4.0 and more BCS points, as compared to cows managed in the free-stall housing system.

Key words: dairy cows, BCS, housing system, milk yield, Holstein-Friesian breed

INTRODUCTION

The progress in dairy cattle genetics and dairy production technology has resulted in a significant increase in milk yields. Higher milk production, in consequence, escalates cow's requirements in terms of nutrition and welfare. A dairy producer has become highly exposed to pitfalls and errors when deciding about the feeding strategies and farming methods and systems. As a consequence, there is a higher risk of metabolic diseases, reproduction disorders and a resulting drop in productivity [Holtsmark et al. 2008]. Therefore, it is crucial that the modern dairy farmer use rapid and effective methods to evaluate the physiological condition of cows. One of these evaluation methods is the Body Condition Score, commonly abbreviated as BCS. The method combining palpation and visual examination of the body fatness was developed by Wildman et al. [Wildman et al. 1982]. However, Edmonson et al. [1989] proposed a significant simplification. Later, Ferguson et al. [1994] clarified the methodical side of condition evaluation, which is now widely used worldwide, and the body condition score is included in many breeding indices of individual cattle breeds.

Many authors confirm there exists a significant relationship between the cow's body condition score and the animal's production and functional characteristics. Such dependencies involve a number of parameters, including age [Guliński et al. 1994, Kertz et al. 1997, Borkowska et al. 2012], milk yield and composition [Borkowska 2000, Berry et al. 2003, Mao et al. 2004, Bouška et al. 2008, Jílek et al. 2008, Stádník and Atasever 2015], or reproduction parameters [Januś 2003, Jílek et al. 2008, Stádník et al. 2017]. Other authors [Kowalski et al. 2003,

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Jankowska et al. 2012] also demonstrate that a dairy cow's health heavily depends on the housing system the animal is reared in, its physiological state, the phase of the production cycle and the season of the year.

The aim of this study was to determine the effect of housing systems and the interaction between the housing system and selected non-genetic factors in relation to the body condition score in dairy cows.

MATERIAL AND METHODS

The research was carried out in West Pomerania, Poland, in two dairy farms located approximately 10 km from each other, both belonging to the same owner. Both herds consisted of Polish Holstein-Friesian Black-and-White cows. In the first herd (farm I), cows were kept in a tie-stall barn, while the other farm (farm II) applied a free-stall housing system. Over the period of our study, the average individual milk yield exceeded 10,000 kg per year in both herds, with a fat and protein content of 4.1–4.2% fat and 3.2–3.3%, respectively. The cows were assigned to technological groups and fed by the TMR system. The mix included maize silage, grass silage, a meaty mix, a mineral-vitamin mix and pickled pulp. The proportions of the feed components and the total ration were adjusted to the yield and physiological state of the cows.

Body condition of cows was evaluated about every two months for a period of two consecutive years. In all, 6891 body condition scorings were performed on 680 cows in both herds, of which 254 were kept in farm I (tethered) and 426 in farm II (free-stall). Body condition was assessed on a 5-point scale according to Wildman et al. [1982], rounded up to 0.25 point. Each assessment was carried out by two independent experts. In addition, the following data were retrieved from the farm records (stored in the *Obora* and *Afifarm* farm database systems): daily milk yield (kg) on the evaluation day, cow's age, physiological state and lactation phase. The research material obtained was grouped in subgroups considering the following factors:

1. Age and the order of lactation (in-calf heifers, primiparous, and multiparous in second, third, fourth and fifth and higher lactation)
2. Daily milk yield (dry cows, up to 15.0 kg, 15.1–25.0 kg, 25.1–35.0 kg and more than 35.0 kg)
3. Season of assessment (winter: December through February, spring: March through May, summer: June through August, fall: September through November)
4. Housing system (tie-stall and free-stall)

The resulting data were processed using the Statistica PL package. The analysis involved the distribution of body condition scores in each subgroup by the chi-squared test for independence with respect to the housing system, and also within the housing system: daily milk yield, season of evaluation and lactation number.

RESULTS AND DISCUSSION

Average body condition scores of cows kept in tethers and in the free-stall system were similar, 3.08 and 3.10, respectively (Table 1). In both systems, the distribution of BCS fitted the shape of the Gaussian curve, with its peak in the range 2.75–3.5. The most often noted score was 3.0 BCS (769 cases – more than 24%), in the tie-stall system, and 3.25 BCS (974 cases – more than 26%), in the free-stall system. A better distribution of individual condition scores was found in the herd kept in the free-stall system. In this group, over 66% of scores were within the range of 2.75–3.25 points, i.e. in the optimal range for the Holstein-Friesian breed. On the other hand, the cows that were tethered attained only 57% of the scores in this range. Bewley and Schutz [2008] indicate that the condition of dairy cows should remain in the range of 2.5–3.5 points. The authors report that the percentage of BCS in this range was from over 83% in the tether system to over 90% in the case of cows kept without tethers in the herds they had studied. The above results should be considered very good, demonstrating the correct and balanced nutrition of cows in both herds. The cow's condition, which, according to the owner's assurances, was routinely performed in both herds, could also have a positive impact on the results.

It was shown that cows kept tethered were more likely to receive extreme condition scores, i.e. no more than 2.0 BCS points (72 scores, 7.2%) or 4.0 and more BCS points (136 scores, 4.31%), compared to free-stall cows (respectively: 29 scores, 0.78%, and 72 scores, 1.93%). The chi-squared test value indicates that the cow's management system significantly influenced the distribution of condition values to the benefit of the free-stall system. In the studies of Kowalski et al. [2003] and Jankowska et al. [2012] no such relationship was found. Also Sablik et al. [2014] did not show a significant impact of the housing system on body condition in cows. In the studies of these authors, more scores with lower values were found, and the percentage of optimal values (60%) was significantly lower than in our research.

Table 2 presents the distribution of body condition scores in two housing systems for heifers and cows in subsequent lactations. The mean BCSs in individual cow subgroups were within the range 2.97–3.26 points, and – except for cows in the fourth lactation – were higher in cows kept on tether, in comparison to those that were kept loose. The chi-squared test results decreased with an increase in parity and indicated that (with the exception of cows in the fifth and subsequent lactations) the

Table 1. BCS distribution in cows in various housing systems

Tabela 1. Rozkład BCS u krów w różnych systemach utrzymania

Housing system System utrzymania		Body condition, BCS points – Kondycja, pkt BCS								
		≤2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	≥4.0
Tie-stall – Uwięziowy N = 3158, $\bar{x}$ = 3.08	n	72	73	333	556	769	477	507	235	136
	%	2.28	2.31	10.54	17.61	24.35	15.10	16.05	7.44	4.31
Free-stall – Wolnostanowiskowy N = 3733, $\bar{x}$ = 3.10	n	29	65	297	605	919	974	543	229	72
	%	0.78	1.74	7.96	16.21	24.62	26.09	14.55	6.13	1.93

Chi^2 = 177.48; P = 0.000.

Table 2. BCS distribution in cows of different ages and housing system

Tabela 2. Rozkład BCS u krów w różnym wieku i systemie utrzymania

Age of lactation Wiek – laktacja	Housing system* System utrzymania*			Body condition, BCS points – Kondycja, pkt BCS								
				≤2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	≥4.0
Calf heifers Jałówki cielne Chi^2 = 17.798 P = 0.0227	I	$\bar{x}$ = 3.06 N = 156	n	–	3	12	24	37	32	29	10	9
			%	–	1.92	7.69	15.38	23.72	20.51	18.59	6.41	5.77
	II	$\bar{x}$ = 3.26 N = 211	n	–	–	13	10	49	66	41	24	8
			%	–	–	6.16	4.74	23.22	31.28	19.43	11.37	3.79
First Pierwsza Chi^2 = 115.63 P = 0.0000	I	$\bar{x}$ = 3.12 N = 1264	n	18	18	115	206	340	174	242	115	36
			%	1.42	1.42	9.1	16.3	26.9	13.77	19.15	9.10	2.85
	II	$\bar{x}$ = 3.11 N = 1621	n	7	19	105	272	416	458	239	91	14
			%	0.43	1.17	6.48	16.78	25.66	28.25	14.74	5.61	0.86
Second Druga Chi^2 = 48.876 P = $7 \cdot 10^{-8}$	I	$\bar{x}$ = 2.97 N = 738	n	30	24	105	153	162	119	97	35	13
			%	4.07	3.25	14.23	20.73	21.95	16.12	13.14	4.74	1.76
	II	$\bar{x}$ = 3.07 N = 734	n	8	12	53	139	212	173	91	29	17
			%	1.09	1.63	7.22	18.94	28.88	23.57	12.40	3.95	2.32
Third Trzecia Chi^2 = 37.398 P = $9.72 \cdot 10^{-6}$	I	$\bar{x}$ = 3.06 N = 406	n	9	13	44	77	109	51	49	26	28
			%	2.22	3.20	10.84	18.97	26.85	12.56	12.07	5.40	6.90
	II	$\bar{x}$ = 3.09 N = 599	n	8	14	65	94	124	153	78	49	14
			%	1.34	2.34	10.85	15.69	20.70	25.54	13.02	8.18	2.34
Fourth Czwarta Chi^2 = 24.161 P = $2.15 \cdot 10^{-3}$	I	$\bar{x}$ = 3.26 N = 286	n	5	4	17	40	52	47	48	33	40
			%	1.75	1.40	5.94	13.99	18.18	16.43	16.78	11.54	13.99
	II	$\bar{x}$ = 3.14 N = 266	n	2	9	21	35	58	68	40	23	10
			%	0.75	3.38	7.89	13.16	21.80	25.56	15.04	8.65	3.76
Fifth and more Piąta i więcej Chi^2 = 3.705 P = 0.882	I	$\bar{x}$ = 3.01 N = 308	n	10	11	40	56	69	54	42	16	10
			%	3.25	3.57	12.99	18.18	22.40	17.53	13.64	5.19	3.25
	II	$\bar{x}$ = 3.04 N = 302	n	4	11	40	55	60	56	54	13	9
			%	1.32	3.64	13.25	18.21	19.87	18.54	17.88	4.30	2.98

For tie-stall: chi^2 = 190.603; P = 0.0000; for free-stall: chi^2 = 137.566; P = 0.0000; sum of lactation: chi^2 = 495.384; P = 0.0000.
* I – tie-stall system; II – free-stall system.
Dla uwięziowej: chi^2 = 190.603; P = 0.0000; dla wolnostanowiskowej: chi^2 = 137.566; P = 0,0000; ogółem dla laktacji: chi^2 = 495.38; P = 0.0000.
* I – system uwięziowy; II – system wolnostanowiskowy.

housing system had a significant impact on the distribution of body condition scores for the benefit of the tie-stall housing system. However, in the group of the oldest cows (fifth and further lactations), the percentage distribution of scores was comparable in both housing systems. In all evaluation groups falling within the range of 2.75–3.5 BCS points were most common. Their percentage ranged from 65.38 to 85.43%. On the other hand, in each of the groups, a higher proportion of assessments in this range was recorded in animals that were kept free. It was also found that with the increase in the number of lactations in cows, the frequency of scores between 2.75 and 3.5 points decreased. The most often noted score in tethering in all age groups was 3.0 BCS, while in the free-stall system in most groups, cows were assessed at 3.25 points. Higher numbers and higher shares of extremely low and high scores were recorded in groups of cows that were kept on tether.

The strong correlation between age and body condition has also been reported by other authors [Guliński et

Table 3. BCS distribution in cows depending on the daily milk production and housing system

Tabela 3. Rozkład BCS u krów w zależności od dobowej produkcji mleka i systemu utrzymania

Daily milk production, kg Dzienna produkcja mleka, kg	Housing system* System utrzymania*			Body condition, BCS points – Kondycja, pkt BCS								
				≤2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	≥4.0
Dry cows – Krowy zasuszone $Chi^2 = 35.879$ $P = 1.848 \cdot 10^{-5}$	I	$\bar{x} = 3.34$ N = 407	n	2	11	13	28	67	65	116	61	44
			%	0.49	2.70	3.19	6.88	16.46	15.97	28.50	14.99	10.81
	II	$\bar{x} = 3.32$ N = 394	n	1	6	9	32	39	130	96	56	25
			%	0.25	1.52	2.28	8.12	9.90	32.99	24.37	14.21	6.35
≤15.0 $Chi^2 = 111.635$ $P = 0.0000$	I	$\bar{x} = 3.33$ N = 178	n	4	–	10	15	25	39	32	29	24
			%	2.25	–	5.62	8.43	14.04	21.91	17.98	16.29	13.48
	II	$\bar{x} = 3.16$ N = 525	n	–	1	12	21	288	87	58	48	10
			%	–	0.19	2.29	4.00	54.86	16.57	11.05	9.14	1.90
15.1–25.0 $Chi^2 = 74.714$ $P = 0.0000$	I	$\bar{x} = 3.10$ N = 1221	n	16	21	108	202	326	201	216	89	42
			%	1.31	1.72	8.85	16.54	26.70	16.46	17.69	7.29	3.4
	II	$\bar{x} = 3.14$ N = 1216	n	4	17	75	198	254	362	216	69	21
			%	0.33	1.40	6.17	16.28	20.89	29.77	17.76	5.67	1.73
25.1–35.0 $Chi^2 = 55.498$ $P = 0.0000$	I	$\bar{x} = 2.92$ N = 999	n	39	38	148	227	274	123	97	38	15
			%	3.90	3.80	14.81	22.72	27.43	12.31	9.71	3.80	1.50
	II	$\bar{x} = 2.96$ N = 1044	n	18	27	145	261	228	235	102	23	5
			%	1.72	2.59	13.89	25.00	21.84	22.51	9.77	2.20	0.48
>35.0 $Chi^2 = 39.83$ $P = 3.45 \cdot 10^{-6}$	I	$\bar{x} = 2.87$ N = 197	n	11	–	42	60	40	17	17	8	2
			%	5.58	–	21.32	30.46	20.30	8.63	8.63	4.06	1.02
	II	$\bar{x} = 2.96$ N = 266	n	6	14	43	83	61	94	30	9	3
			%	1.75	4.08	12.54	24.20	17.78	27.41	8.75	2.62	0.87

For tie-stall: $chi^2 = 452.057$; P = 0.0000; For free-stall: $chi^2 = 729.21$; P = 0.0000; sum of milk yield: $chi^2 = 1386.313$; P = 0.0000.
* I – tie-stall system; II – free-stall system.
Dla uwięziowej: $chi^2 = 452.057$; P = 0.0000; dla wolnostanowiskowej: $chi^2 = 729.21$; P = 0.0000; ogółem dla wydajności mleka: $chi^2 = 1386.313$; P = 0.0000.
* I – system uwięziowy; II – system wolnostanowiskowy.

al. 1994, Borkowska et al. 1999, Borkowska 2000]. Kertz et al. [1997] found the lowest condition in cows after the second calving, which is consistent with the results obtained in our study. Also Busato et al. [2002] indicate that older cows are characterized by higher condition scores compared to younger cows.

The mean body condition scores were highest in the group of dry cows, 3.34 points, in the tie-stall system, and 3.32 points, in the free-stall system (Table 3). The values decreased with an increase in daily milk production to 2.87 points, in the tie-stall system, and to 2.96 points, in the free-stall system. It was found that with a daily milk yield exceeding 15 kg (i.e. 15.1–25.0, 25.1–5.0 and > 35 kg), average body condition scores were higher in free-stall cows, which may suggest that this system allows easier nutrition balancing, especially in cows producing high milk yields. Analysis of body condition distribution of cows with different daily yields and dry cows in two housing systems showed that 62.36 to 86.48% of the scores remained in the range of 2.75–3.5. The lowest BCS was recorded in the group of tethered cows with the yield up to 15 kg per day, and the highest in cows in the same productivity group, but managed in the free-stall system. Untreated cows were given 8–14% more assessments of optimal condition, compared to those assessed in the tether system, which indicates that free-stall housing of dairy cows fosters favorable body condition scores. The values of the chi-squared test decreased along with an increase in the daily milk yield, but the distribution of BCS values was better under the free-stall housing system. Another noticeable relationship, confirming the previous statement, was that in the tie-stall system the value of the most frequently noted score decreased from 3.5 points in dry cows to 2.75 points in cows with a yield of > 35 kg of milk. On the other hand, free-stall cows did not have such a tendency, and the most frequent score was 3.25 BCS in the majority of groups.

The relationship between body condition of dairy cows and milk yield has been subject of many studies. Confirming our findings, other authors report that the highest body condition scores are the case if the milk yield is lowest [Guliński et al. 1994, Borkowska et al. 1999, Borkowska 2000, Januś and Borkowska 2002, Loker et al. 2012]. Borkowska et al. [2016] showed a significant correlation between the size of changes in condition after calving and milk yield.

Year season can significantly affect many of dairy cows' production and functional characteristics. In our

Table 4. BCS distribution in cows depending on the assessment season and husbandry system

Tabela 4. Rozkład BCS u krów w zależności od sezonu oceny i systemu utrzymania

Season Sezon oceny	Housing system* System utrzymania*			Body condition, BCS points – Kondycja, pkt BCS								
				≤2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	≥4.0
Winter – Zima $Chi^2 = 25.949$ P = 0.00107	I	$\bar{x} = 3.11$ N = 750	n	5	10	71	124	210	122	118	59	31
			%	0.67	1.33	9.47	16.53	28.00	16.27	15.73	7.87	4.13
	II	$\bar{x} = 3.09$ N = 853	n	6	9	70	136	234	208	130	48	12
			%	0.70	1.06	8.21	15.94	27.43	24.38	15.24	5.63	1.41
Spring – Wiosna $Chi^2 = 52.197$ $P = 2 \cdot 10^{-8}$	I	$\bar{x} = 3.12$ N = 743	n	12	22	82	106	172	98	149	64	38
			%	1.62	2.96	11.04	14.27	23.15	13.19	20.05	8.61	5.11
	II	$\bar{x} = 3.14$ N = 919	n	11	12	71	124	215	242	141	74	29
			%	1.20	1.31	7.73	13.49	23.39	26.33	15.34	8.05	3.16
Summer – Lato $Chi^2 = 72.976$ P = 0.000	I	$\bar{x} = 2.99$ N = 958	n	40	31	128	206	206	123	124	62	38
			%	4.18	3.24	13.36	21.50	21.50	12.84	12.94	6.47	3.97
	II	$\bar{x} = 3.04$ N = 1210	n	11	29	126	248	293	276	146	65	16
			%	0.91	2.40	10.41	20.50	24.21	22.81	12.07	5.37	1.32
Autumn – Jesień $Chi^2 = 55.513$ P = 0.000	I	$\bar{x} = 3.11$ N = 707	n	15	10	52	120	181	134	116	50	29
			%	2.12	1.41	7.36	16.97	25.60	18.95	16.41	7.07	4.10
	II	$\bar{x} = 3.16$ N = 751	n	1	15	30	97	177	248	126	42	15
			%	0.13	2.00	3.99	12.92	23.57	33.02	16.78	5.59	2.00

For tie-stall: $chi^2 = 96.185$; P = 0.0000; For free-stall: $chi^2 = 103.067$; P = 0.0000; Sum of milk yield: $chi^2 = 383.794$; P = 0.000.
* I – tie-stall system; II – free-stall system.
Dla uwięziowej: $chi^2 = 96.185$; P = 0.0000; dla wolnostanowiskowej: $chi^2 = 103.067$; P = 0.0000; ogółem dla wydajności mleka: $chi^2 = 383.794$; P = 0.000.
* I – system uwięziowy; II – system wolnostanowiskowy.

research, an attempt was made to answer the question whether the season when scoring takes place could have an effect on BCS value and distribution (Table 4). It was found that the average condition score in both housing systems was distinctly lower in the summer compared to the other seasons, in which it was at a similar level (3.09–3.16 BCS). Our study shows that winter and autumn BCS assessments were more often in the range of 2.75–3.5, compared to spring and summer. In the spring and summer seasons, more extreme evaluations were recorded, i.e. cows that were too thin or extremely fat. Similarly to the previously discussed factors, also in different seasons body condition scores were more often within optimal range in the case of free-stall system. Differences between the two systems ranged from 6% in the winter season to nearly 11% in the summer. The calculated values of chi-squared test again showed a significant impact of housing system on the distribution of body condition scores, and the free-stall system was better in terms of the proper condition of dairy cows. In most subgroups, the value of 3.0 BCS was most frequently reported, except for the subgroups of cows kept in the free-stall system evaluated in the spring and autumn season, for which 3.25 points were most common. Sablik et al. [2014] found a significant impact of season on the average body condition score. However, in contrast to the results presented in this study, the authors mentioned claim that cows evaluated in summer had the highest average BCS. Borkowska et al. [2012], who analyzed the effect of calving season on the body condition, stated that cows calved in summer demonstrated a higher condition score compared to those calving in the other seasons of the year.

CONCLUSIONS

It was shown that the distribution of body condition scores of cows with different daily productivity, of different ages and evaluated in different seasons of the year, was significantly related to the housing system. Cows with the highest daily milk yield (> 35 kg), younger (in the second lactation) and evaluated in the summer season had the least favorable distribution of condition scores and their average value compared to other groups. It was shown that cows kept on tether were more often receiving extreme body condition scores, i.e. no more than 2.0 points or 4.0 and more BCS points, as compared to cows from free-stall system. The obtained results also indicate that the free-stall system of housing dairy cows fed TMR was significantly more beneficial in terms of maintaining the proper condition in the cows of various milk yields, age and season of the assessment. To obtain these benefits, constant and systematic evaluation of BCS in dairy cows is necessary.

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WPŁYW WYBRANYCH CZYNNIKÓW NA WYNIKI OCENY KONDYCJI KRÓW MLECZNYCH W WOLNOSTANOWISKOWYM I UWIĘZIOWYM SYSTEMIE UTRZYMANIA

STRESZCZENIE

W analizie wykorzystano 6891 ocen kondycji, dokonanych u 680 krów rasy polskiej holsztyńsko-fryzyjskiej odmiany czarno-białej z dwóch gospodarstw, należących do jednego właściciela, różniących się systemem utrzymania zwierząt. Ocenę kondycji krów przeprowadzano w ciągu dwóch lat w skali 5-pkt, z dokładnością do 0,25 pkt. Stwierdzono, że najczęściej przyznawaną oceną w systemie uwięziowym było 3,0 pkt BCS (ponad 24%), a w wolnostanowiskowym 3,25 pkt BCS (ponad 26%). Rozkład ocen kondycji krów o różnej dobowej wydajności, będących w różnym wieku i ocenianych w różnych sezonach roku istotnie był związany z systemem utrzymania. Krowy o najwyższej dobowej wydajności mleka (>35 kg), młodsze (w drugiej laktacji) oraz oceniane w sezonie letnim miały najmniej korzystny rozkład ocen kondycji i ich średnią wartość w porównaniu do pozostałych grup. Wykazano, że krowy utrzymywane na uwięzi częściej otrzymywały skrajne oceny kondycji, tj. nie więcej niż 2,0 pkt lub 4,0 i więcej pkt BCS w porównaniu do krów z chowu wolnostanowiskowego.

Słowa kluczowe: krowy mleczne, BCS, system utrzymania, wydajność mleka, rasa holsztyńsko-fryzyjska

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