Relationships among body condition score, milk yield and sires' breeding value for beef production efficiency in Czech Fleckvieh cattle

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ABSTRACT: The objective of this study was to analyze the relationships among cows' body condition score before calving, subsequent BCS changes, milk yield, lactation characteristics and their sires' relative breeding value for net daily gain. Increasing the relative breeding value of net daily gain in the sires was associated with increased BCS in their daughters. The differences ranged between 0.02 and 0.18 points in the particular lactation periods, but they were not statistically significant. The group of cows with the highest BCS before calving showed the highest BCS decrease (–0.25 points) after calving ($P < 0.01$); the BCS loss lasted for 3 months. The analysis of the relationship between the relative breeding value of sires for net daily gain and milk yield of their daughters showed a negative effect of RBV NG ≤ 89 on the daughters' milk yield ($P < 0.05$), while the negative differences were up to – 279.12 kg of fat-protein corrected milk. The effect of this trait on the lactation curve was also analyzed.

Keywords: body condition score (BCS); relative breeding value (RBV); net daily gain (NG); milk yield; Czech Fleckvieh

Increasing the economic efficiency in dairy cattle breeding, which was made necessary by the severe competition of both breeders and breeding countries, has led to strong and one-sided selection for milk yield traits in recent decades. These traits were highly preferred by commonly used breeding programs, so that the selective preference for other economically important traits and parameters did not reach the necessary optimum (Philipsson et al., 1994). Genetic improvement of milk yield in dairy cattle is accompanied by many economically negative trends, mainly by a marked decline in longevity, which is connected with impaired health and reproduction.

In the Czech dairy cattle population analyses of the relationship of the impact of diseases on reproduction and milk yield were also performed (Němcová et al., 2007; Vacek et al., 2007).

It is commonly known that selection for increased milk production is connected with unfavourable reproduction (Evans et al., 2002; Royal et al., 2002) and poorer health (Pryce et al., 1998). It is necessary to limit the trend of continual improvement of milk yield in such a way that will allow optimizing the improvement of those nonproductive traits and parameters that markedly influence the effectiveness of dairy cattle breeding.

One of the indicator traits for evaluating the nutritional state of the organism, which is connected with fertility and health, is the body condition and body weight level and especially their changes during lactation (Berry et al., 2003). Body condition scoring can be used as the basic tool for effective management of dairy cow breeding. It is easy to measure by a given point scale and accurate enough to determine body reserves and energetic state of

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the organism (Veerkamp et al., 2001). BCS changes during the calving interval reflect those processes that are related to energy balance and consequently could be critical for metabolic stability (Coffey et al., 2001), health (Collard et al., 2000) and fertility of the animals (Veerkamp et al., 2001). Hence, effective and objective indicators of these nonproductive traits and parameters closely connected with energy balance are being sought.

For this purpose, body condition scoring is an easy and inexpensive tool for effective selection in relation to reproduction indexes because its heritability reaches a similar level to that in milk yield and h^2 ranges between 0.25 and 0.35 (Veerkamp et al., 2001; Dechow et al., 2002; Kadarmideen a Wegmann, 2003; Lopez-Gatins et al., 2003). The body condition level is phenotypically connected with milk yield, health and reproduction performance (Domecq et al., 1997; Shaver, 1997). The economic efficiency of dairy cattle breeding is largely dependent on these traits, so the interrelationships among these indexes are intensively studied. The results of these studies are inconsistent in the reported relationship between BCS and milk yield. Some authors determined genetic correlations between these traits as slightly negative (Berry et al., 2002; Pryce et al., 2002), whereas others found slightly positive correlations (Dechow et al., 2001).

There was no effect of BCS level at calving, but its changes influenced both milk yield and the trend of the milk yield curve (Ruegg, 1994). It was demonstrated that cows with higher BCS at calving showed a higher BCS loss during lactation. This could negatively influence both reproduction and production performance (Domecq et al., 1997).

The majority of the studies concerning the relationships among BCS, milk yield and economically important nonproductive traits were performed on Holstein cattle. There are no similar analyses in other breeds, especially in dual-purpose cattle. In this type of cattle the Czech Fleckvieh belongs to, appropriate beef production efficiency (Bouška et al., 2003) and longevity (Bouška et al., 2006) are required. It is obvious that it is necessary to cover up another factor in the study of BCS impact. This is genetic merit, or more precisely, the value of the animal for beef production efficiency. This trait may be connected not only with BCS but also with productive and reproductive performance. It is also necessary to identify the relationship between cows' BCS and their sires' breeding value for beef production efficiency. These findings are required for an efficient use of body condition scoring in management of Czech Fleckvieh herds. Within genetic studies, BCS and measurement of its changes could be used for the prediction of Holstein cows' longevity (Coffey et al., 2001). Therefore, for both dairy and dual-purpose cattle, it is highly important to have objective knowledge of the relationship of this basic energy balance indicator and economically important traits. The objective of this study was to analyze the relationships among cows' body condition score before calving, subsequent BCS changes, milk yield, lactation characteristics and their sires' relative breeding value for net daily gain.

MATERIAL AND METHODS

A semi-field observation performed in two commercial Czech Fleckvieh herds was aimed at determination of the relationships between body condition level and milk yield. At the same time, changes in BCS during lactation in relation to the milk yield curve were monitored. The objective of this research was also to study relationships among sires' genetic merit for beef production efficiency, their daughters' milk yield, BCS and changes in these two traits during lactation.

More than 1 500 lactations were included in the observation. Body condition score was periodically measured, and the level of milk yield in similar stages of lactation was recorded. Body condition score classification was performed according to a five-point scale to the nearest 0.5 point from 2 months before calving, immediately after calving and then regularly in monthly intervals.

Data on milk yield were collected from the A4 model of milk performance, also recording in monthly intervals. The milk yield for each cow was adjusted to kilograms of 3.8% fat and 3.2% protein (FPCM).

Relative breeding value for net daily weight gain was used as an indicator of the genetic merit of the cows' sires for their offspring's beef production efficiency. This indicator denotes primarily the growth intensity of the animals and is connected with the utilization of nutrients from feedstuffs for the formation of body tissues. In dual-purpose cattle, where these analyses are performed, it is necessary to know the relation of this indicator to the daughters' BCS, BCS changes and milk yield. This information is important for subsequent effective selection. Hence, the following relationships were analyzed:

– a relationship between the relative breeding value of cows' sires for net weight gain and their daughters' BCS, milk yield per entire lactation and in the particular phases of lactation;
– a relationship between BCS in the 2nd and 1st month before calving and its subsequent development in the particular lactation phases;
– a relationship between BCS in the 2nd and 1st month before calving and subsequent milk yield of the cows.

For the analysis of these relationships the dataset was classified in groups:
according to sires' RBV for net gain:
(1.) RBV ≤ 89
(2.) RBV 90–110
(3.) RBV 111 and more
according to BCS before calving:
(1.) BCS 3.5 points and less
(2.) BCS 4.0 points
(3.) BCS 4.5 points and more

The dataset was analyzed by multifactorial analysis of variance with the use of procedures COOR and GLM through the statistical program SAS (SAS, 2001). The following basic model with fixed effects was used for subsequent estimation:

$$y_{ijkl} = \mu + HYS_i + A_j + B_k + \beta x_1 + e_{ijkl}$$

where:
μ = average value of dependent variable
HYS_i = fixed effect of i-herd – year – season of calving
A_j = fixed effect of j-lactation number
B_k = alternative effect
βx_1 = regression on the age at the first calving
e_{ijkl} = residual effect (random error)

These alternative effects were used in the model:
– effect of k-RBV for sires' net gain (NG)
– effect of k-BCS two months before calving of the cows
– effect of k-BCS one month before calving of the cows

Residual Pearson's correlation coefficients were used to estimate the closeness of the relationship between BCS before and after calving in the observed cows.

RESULTS AND DISCUSSION

In addition to good milk production, appropriate beef production is required from dual-purpose cattle the Czech Fleckvieh belongs to. Czech Fleckvieh bulls are tested for basic indexes of beef production efficiency in the progeny control. This fact could largely influence BCS and milk yield of the daughters and the changes in these two indicators during lactation. Table 1 presents results of the analysis of the relationship between RBV of sires' net gains and their daughters' BCS in the particular phases of lactation. It is obvious that increasing sires' RBV for net gain causes higher BCS of their daughters in the particular phases of lactation. However, the differences are not statistically significant and range from 0.02 to 0.18 points in the particular phases

Table 1. A relationship between the relative breeding value of sires for corrected net gain and their daughters' body condition score in the particular periods of calving interval

Meantime periods	RBV for sire's corrected net gain (%)						$P < 0.05$
	1 (≤ 89) n = 259		2 (90–110) n = 770		3 (≥ 111) n = 151		
	LS mean	SE	LS mean	SE	LS mean	SE	
2 months before calving	3.97	0.05	3.99	0.03	4.04	0.07	
1 month before calving	3.97	0.05	3.99	0.03	4.10	0.06	
After calving	3.49	0.06	3.55	0.05	3.57	0.07	
1 month after calving	3.39	0.05	3.41	0.04	3.41	0.06	
2 months after calving	3.33	0.05	3.35	0.04	3.36	0.06	
3 months after calving	3.39	0.05	3.40	0.04	3.42	0.07	
4 months after calving	3.40	0.06	3.46	0.04	3.50	0.07	
5 months after calving	3.50	0.06	3.59	0.05	3.65	0.07	
6 months after calving	3.57	0.06	3.68	0.05	3.75	0.07	
7 months after calving	3.65	0.07	3.72	0.06	3.83	0.07	

Table 2. A relationship between BCS 2 months before calving and BCS changes after calving in Czech Fleckvieh cows

Period of BCS evaluation	BCS 2 months before calving						$P < 0.01$
	1 (≤ 3.5 points) n = 212		2 (4 points) n = 358		3 (≥ 4.5 points) n = 189		
	LS mean	SE	LS mean	SE	LS mean	SE	
After calving	3.22	0.05	3.56	0.04	3.88	0.05	1:2.3; 2:3
1 month after calving	3.13	0.05	3.46	0.04	3.72	0.05	1:2.3; 2:3
2 months after calving	3.16	0.05	3.41	0.04	3.64	0.06	1:2.3; 2:3
3 months after calving	3.23	0.07	3.45	0.06	3.63	0.08	1:3
4 months after calving	3.23	0.08	3.48	0.07	3.69	0.09	1:2.3
5 months after calving	3.37	0.08	3.65	0.08	3.84	0.09	1:2.3
6 months after calving	3.50	0.09	3.73	0.10	3.94	0.10	1:3
7 months after calving	3.55	0.08	3.75	0.07	3.98	0.10	1:3

of lactation. The highest BCS loss – 0.75 points – during lactation in comparison with BCS before calving was recorded in the 3rd group (highest sires' RBV for NP). In the other two groups, the BCS loss was 0.64 points, and the lower BCS during lactation was in the 2nd month after calving.

In Table 2, the relationship between BCS two months before calving and its development is presented. The largest differences in the respective lactation phases between group 1 (BCS ≤ 3.5) and group 3 (BCS ≥ 4.5) were from 0.43 to 0.66 points and they were in all statistically significant. The average BCS of the 1st group (BCS ≤ 3.5) differed from the 2nd (BCS = 4) group by 0.20–0.34 points. During the evaluation of BCS loss, shorter duration of BCS loss (one month after calving) was shown in the 1st group with the lowest BCS before calving. In the second (BCS = 4) and third group (the highest BCS before calving), the BCS loss lasted for two and three months after calving, respectively. The largest differences in BCS changes during lactation also increased depending on increased BCS before calving. While in the first group the BCS change was – 0.09 points, the second and third groups showed a higher BCS loss: –0.25 points. These findings are in agreement with results of other authors (Domecq et al., 1997). The same trend was recorded in the analysis of the relationship between BCS one month after calving and its changes in the particular lactation phases (Table 3). The largest differences among the evaluated groups ranged between 0.4 and 0.68 points, and they were also statistically significant.

Table 3. A relationship between BCS 1 month before calving and BCS changes after calving in Czech Fleckvieh cows

Period of BCS evaluation	BCS 1 month before calving						$P < 0.01$
	1 (≤ 3.5 points) n = 233		2 (4 points) n = 373		3 (≥ 4.5 points) n = 225		
	LS mean	SE	LS mean	SE	LS mean	SE	
After calving	3.19	0.04	3.56	0.03	3.87	0.04	1:2.3; 2:3
1 month after calving	3.17	0.05	3.46	0.04	3.69	0.05	1:2.3; 2:3
2 months after calving	3.18	0.05	3.39	0.04	3.67	0.05	1:2.3; 2:3
3 months after calving	3.21	0.07	3.37	0.05	3.73	0.07	1:2.3; 2:3
4 months after calving	3.25	0.08	3.42	0.06	3.75	0.08	1:2.3; 2:3
5 months after calving	3.41	0.08	3.52	0.07	3.88	0.08	1:3; 2:3
6 months after calving	3.50	0.08	3.57	0.07	3.96	0.08	1:3; 2:3
7 months after calving	3.59	0.06	3.68	0.06	3.99	0.08	1:3; 2:3

Table 4. The closeness of a relationship between BCS before and after calving in Czech Fleckvieh cows (Pearson's correlation coefficient)

BCS	BCS before calving	
	2 months	1 month
After calving	0.565	0.848
1 month after calving	0.372	0.628
2 months after calving	0.143	0.416
3 months after calving	–0.003	0.265
4 months after calving	–0.095	0.135

Table 4 documents the closeness of the relationship between BCS of Czech Fleckvieh cows before calving and during lactation, which is presented by Pearson's correlation coefficient. A more significant relation was recorded between BCS two months before calving and BCS after calving and BCS one month after calving (r = 0.565 and r = 0.372). No significant effect was found in the other periods. The correlation coefficients between BCS one month before calving and BCS after calving and in the others periods of lactation were higher, ranging from r = 0.135 (BCS four months after calving) to r = 0.848 (BCS after calving).

One of the most important analyses is that of the relationship between RBV of sires for net gain and milk yield per lactation of their daughters. Table 5 presents the results of this analysis. The most favourable results were shown in the group of cows with their sires' RBV from 90 to 110%. This group (2) was characterized by higher milk yield (273.14 and 173.52 kg of milk more) than the other groups 1 (RBV ≤ 89) and 3 (RBV ≥ 111). In FPCM production, the difference between groups 2 and 1 was 279.12 kg, and it was statistically significant. Generally, it may be concluded that it is possible to cull Czech Fleckvieh bulls with RBV for net gain lower than 90 from subsequent utilization in breeding.

The relationship between BCS of cows two months before calving and their subsequent milk yield within the lactation is shown in Table 6. The first group with the lowest BCS two months before calving produced the highest milk, FPCM, fat and protein yield. The differences between the 1st and 2nd and 3rd group were 354.30 kg and 678.67 kg respectively in milk yield and 305.19 kg and 664.70 kg respectively in FPCM yield. The fat and protein amount in milk was quite balanced, and the maximum differences were 0.07% in percentage amount of fat and 0.02% in percentage amount of protein. The relationship between cows' BCS one month before calving and their subsequent milk yield during lactation is shown in Table 7. It may be stated that the former tendency was sustained, while the differences in milk yield were lower in this analysis (cows' BCS measured one month before calving) than in

Table 5. A relationship between the relative breeding value of sires for corrected net gain and their daughters' milk yield

Milk yield index	Sire's RBV for corrected net gain (%)						$P < 0.05$
	1 (≤ 89) n = 259		2 (90–110) n = 770		3 (≥ 111) n = 151		
	LS mean	SE	LS mean	SE	LS mean	SE	
Milk (kg)	6 698.51	134.34	6 971.65	86.38	6 798.13	166.96	
FPCM (kg)	7 131.08	121.94	7 410.20	78.41	7 238.56	151.56	1:2
Fat (%)	4.15	0.03	4.19	0.02	4.16	0.04	
Protein (%)	3.37	0.02	3.35	0.01	3.37	0.02	
Fat (kg)	275.75	4.90	288.04	3.15	279.95	6.09	1:2
Protein (kg)	223.42	3.77	230.66	2.42	226.74	4.68	

Table 6. A relationship between BCS 2 months before calving and subsequent milk yield per lactation in Czech Fleckvieh cows

Milk yield index per lactation	BCS 2 months before calving						$P < 0.01$
	1 (≤ 3.5 points) $n = 212$		2 (4 points) $n = 358$		3 (≥ 4.5 points) $n = 189$		
	$\mu + a_i$	$s_{\mu + ai}$	$\mu + a_i$	$s_{\mu + ai}$	$\mu + a_i$	$s_{\mu + ai}$	
Milk (kg)	7 371.73	136.38	7 017.43	110.66	6 693.06	144.77	1:3
FPCM (kg)	7 798.33	135.89	7 493.14	110.26	7 133.63	144.25	1:3
Fat (%)	4.13	0.03	4.17	0.03	4.20	0.04	
Protein (%)	3.33	0.02	3.35	0.02	3.34	0.02	
Fat (kg)	302.42	5.52	290.58	4.48	277.52	5.85	1:3
Protein (kg)	243.47	4.17	233.92	3.39	221.84	4.43	1:2.3

the previous one (cows' BCS measured two months before calving). The differences were 364.40 kg and 477.19 kg respectively in milk yield and 274.22 kg and 322.84 kg in FPCM yield. The negative relationship was proved whereas the levels of Pearson's correlation coefficient were $r = 0.041$ and $r = -0.110$. Kadarmideen and Wegmann (2003) reported the genetic and phenotypic correlation between BCS and milk yield $r_g = -0.12$ and $r_p = -0.69$, respectively. These findings fully correspond with previous

Table 7. A relationship between BCS 1 month before calving and subsequent milk yield per lactation in Czech Fleckvieh cows

Milk yield index per lactation	BCS 1 month before calving						$P < 0.01$
	1 (≤ 3.5 points) $n = 248$		2 (4 points) $n = 397$		3 (≥ 4.5 points) $n = 233$		
	LS mean	SE	LS mean	SE	LS mean	SE	
Milk (kg)	7 345.21	141.97	6 980.81	113.92	6 868.02	146.48	1:3
FPCM (kg)	7 681.31	130.24	7 407.09	104.50	7 358.47	134.38	
Fat (%)	4.11	0.03	4.15	0.03	4.21	0.03	
Protein (%)	3.31	0.02	3.34	0.02	3.34	0.02	
Fat (kg)	297.85	5.28	287.15	4.24	286.85	5.45	
Protein (kg)	239.84	3.99	231.37	3.20	228.23	4.12	

Table 8. A relationship between sires' RBV for corrected net gain and FPCM production in kg/day (3.8% of fat; 3.2% of protein) in their daughters during the particular monitored periods of lactation

Monitored period for FPCM production	Sire's RBV for corrected net gain (%)						$P < 0.05$
	1 (≤ 89) $n = 259$		2 (90–110) $n = 770$		3 (≥ 111) $n = 151$		
	LS mean	SE	LS mean	SE	LS mean	SE	
1 month after calving	31.29	0.56	31.21	0.39	31.66	0.67	
2 months after calving	29.76	0.49	30.50	0.35	29.99	0.60	
3 months after calving	27.72	0.48	29.05	0.34	28.36	0.58	1:2
4 months after calving	26.01	0.49	26.77	0.35	26.26	0.59	
5 months after calving	24.26	0.55	24.97	0.41	24.62	0.64	
6 months after calving	21.36	1.12	22.45	1.04	21.78	1.16	

Table 9. FPCM yield (kg/day) development in the particular months of lactation according to BCS 1 month before calving

Months of lactation	BCS 1 month before calving		
	1 (≤ 3.5 points)	2 (4 points)	3 (≥ 4.5 points)
1	31.06	31.96	33.51
2	32.34	31.69	31.97
3	31.39	31.50	31.43
4	29.69	29.13	29.06
5	27.03	27.02	27.00
6	25.82	25.24	24.19
7	23.35	22.15	20.87
8	22.55	21.46	19.65
9	21.00	19.82	18.36

studies. Dechow et al. (2002) found the phenotypic correlation between BCS before calving and BCS loss after calving, and between BCS loss after calving and milk yield: $r_p = -0.69$ and $r_p = 0.10$, respectively. It means that higher BCS before calving is associated with lower milk yield after calving. In the study of Contreras et al. (2004) the group of cows with BCS 3.0 points and less had higher milk yield (+1.25kg) in the first five months of lactation than the group with BCS 3.25 points and more. Pryce and Harris (2006) and Dal Zotto et al. (2007) also confirmed the negative relationship between BCS and milk protein production; the genetic correlation ranged from –0.03 to –0.22.

Table 8 presents the analysis of the effect of sires' RBV NG on the lactation curve, which is expressed by average FPCM yield (kg) in the particular lactation periods. Altogether, the differences in FPCM yield among the particular periods of lactation were not statistically significant. Within the 6-month period of observation, the highest decrease in FPCM production was shown in the first group (RBV NG ≤ 89) – 9.93 kg. The decrease in the third group (RBV NG > 111) was 9.88 kg of FPCM, and in the second group (sires' average RBV NG 90–110) it was 8.76 kg. These findings correspond only partly with the results of Jakobsen et al. (2000), who determined that the level of genetic correlations between sires' breeding value for live weight gain and their daughters' milk yield were $r_g = 0.42$ for milk production and $r_g = 0.34$ for fat production in Red Danish cattle.

The lactation curve development (FPCM production) and its relationship to BCS one month before calving are shown in Table 9 and Figure 1. Group 1 with BCS 3.5 and less points one month before

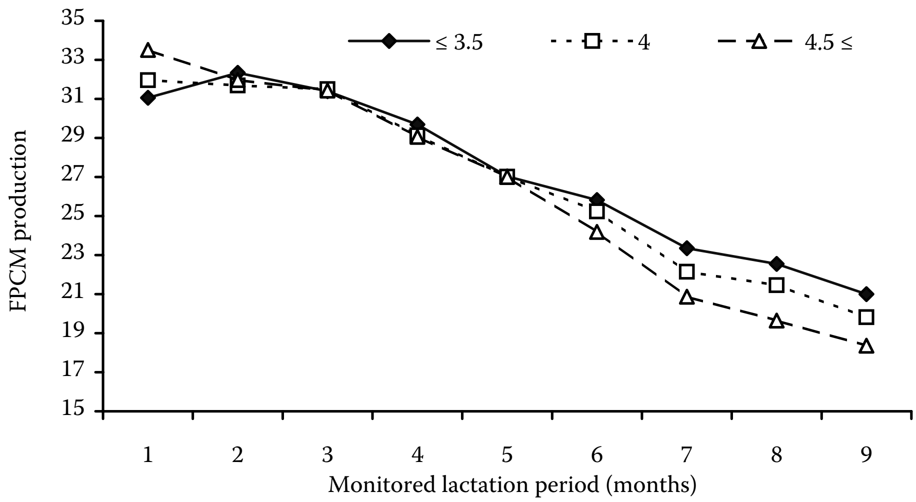

Figure 1. Lactation curve development (FPCM production in kg) in relation to BCS one month before calving in Czech Fleckvieh cows

calving showed the most favourable lactation curve development. The total FPCM decrease in the first nine months of lactation was 10.06 kg, with a milk yield increase in the first three months of lactation of 0.33 kg; in the periods from 4th to 6th and from 7th to 9th months of lactation the FPCM yield decrease (–3.78 kg and –2.35 kg, respectively) was noted. In the second group (BCS = 4 points) the total FPCM production decrease was 12.14 kg and the differences in the particular periods of monitoring were –0.96 kg (1st–3rd month), –3.89 kg (4th to 6th month) and –2.33 kg (7th–9th month). In the third group (the highest BCS before calving), the same tendency in FCPM production changes was noted: –14.95 kg in total, –2.08kg (1st to 3rd month), –4.87kg (4th–6th month) and –2.51 kg (7th–9th month). In general, it was stated that the milk yield of the monitored cows during lactation markedly decreased with their increasing BCS before lactation. The same conclusions were reported in the previous study of Berry et al. (2003), who also evidenced the negative relationship between BCS and milk yield during lactation. The negative genetic correlations increased with the progressing lactation; from r_g = –0.33 after calving to r_g = –0.50 on day 240. Dechow et al. (2001) also reported the negative relationship between BCS and milk yield, which was characterized by the estimated value of r_g; it ranged from –0.27 to –0.31.

CONCLUSION

Regarding our results, it may be stated that BCS measurement can be an effective tool for general management improvement also in dual-purpose herds. The genetic merit of cows' sires for beef production efficiency did not have a statistically significant effect either on BCS development in the particular lactation periods or on the milk yield of their daughters. It can be recommended to include BCS evaluation in the exterior classification in Czech Fleckvieh cows similarly like it is used in other countries with the advanced breeding of Holstein cattle. These results show that it is also possible to select the Czech Fleckvieh population for good BCS and optimal milk yield.

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