RELATIONSHIP BETWEEN BODY CONDITION SCORE, MILK PRODUCTIVITY AND LIVE WEIGHT OF DAIRY COWS

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Abstract
Live weight and body condition are indicators for dairy cow's (*Bos taurus*) health, milk productivity and reproduction. Live weight and body condition are defined by genetic and non-genetic factors. These factors are dependent on dairy cows growing and welfare. The aim of research was to analyze body condition relationship with milk productivity and live weight. Data were collected from 49 different breed and lactation dairy cows. Research location was Latvia University of Agriculture Research and Study farm 'Vecauce'. Data were collected from October 2013 to January 2014. Body condition score of all cows decreased from 2.8 ± 0.05 to 2.5 ± 0.04 points in research period. Milk yield increased from 35.6 ± 0.79 kg in the 1st recording to 40.9 ± 1.12 kg in the 2nd recording. Milk yield decreased in the 3rd recording ($p<0.05$). Fat content was the lowest in the 2nd recording (35.5 ± 0.09 g kg^{-1}). Protein content was significantly different in the 1st and 2nd recordings ($p<0.05$). Somatic cell changes were not significant. Body condition decreased of older lactation cows, but milk yield increased at the same time. Milk yield was significantly the greatest in red breed group, compared with Holstein black and white cows (51.1 ± 3.21 kg vs. 41.4 ± 0.78 kg; $p<0.05$). Body condition score significantly affected live weight in such body condition score groups: <2.5 points, 2.75 to 3.0 points. Effect was not significant on live weight in body condition score 3.25< group. Milk productivity and quality traits were not affected by the body condition score ($p<0.05$).
Key words: body condition score, live weight, milk yield.

Introduction

Metabolic processes increase if milk productivity increases. It promotes an increase of metabolic stress. Milk productivity and reproduction traits decrease then. Indicators, which characterize dairy cows metabolic processes, are body condition score (BCS) and live weight. It is very important to evaluate the changes of these indicators. BCS is a visual parameter, which characterizes backfat thickness. Dairy cows cannot intake enough feed in an early stage of lactation and the result is a negative energy balance. According to other researchers, BCS and live weight start to decrease after the 30th lactation day (Banos et al., 2004; Bewley et al., 2008; Yamazaki et al., 2011). Locker S. et al (2011) found out that BCS is the lowest from the 40th to 80th lactation day. In this period BCS decreases to 2.45 points. According to previous studies, the risks to become ill with milk fever, ketosis and fatty liver increases if BCS is greater than 3.5 points after calving and the loss of BCS is great. BCS has been researched since 1970. Researchers started to search for BCS relationship between animal health and milk productivity (Roche et al., 2013). BCS is defined by genes, and heritability coefficient of BCS is average (mean h^2 is 0.26). Genetic correlation between BCS and mastitis is negative. The risk to become ill with mastitis and metabolic diseases is greater for thinner cows (Loker et al., 2012). BCS is a visual indicator, but changes in BCS are related to changes in blood content. Glucoses and triglycerides decrease, if BCS decreases. Cholesterol content increases in this case (Mouffok et al., 2013). BCS has higher influence on milk productivity and reproduction traits for high yielding cows compared to low productivity cows. It is explained with metabolism intensiveness of high yielding cows (Pryce et al., 2002).

The aim of research was to analyze body condition relationship with milk productivity and live weight.

Materials and Methods

Research location was Latvia University of Agriculture Research and Study farm 'Vecauce'. Data was collected from October 2013 to January 2014. Data were analyzed from 49 dairy cows. By a breed factor dairy cows were grouped in 3 groups – Holstein Black and White (HBW, n=12), Red breeds (Latvian Brown, Danish Red, Holstein Red and White; RB, n=30) and milk breed-crosses (F1 HBW×RB; XP, n=7). By lactation cows were grouped in 3 groups – the 1st lactation (n=17), 2nd lactation (n=12), 3rd and older lactation (3rd<, n=20). Cows were kept in a loose housing farm. Cows had *at libidum* access to total mixed ration (TMR). TMR ingredients were 20.0 kg grass silage (*Leguminoseae*, *Phleum pretense* L., *Lolium perenne* L., *Poa pratensis* L., *Dactylis glomerata* L.), 20.0 kg maize silage (*Zea mays* L.), 1.0 kg hay (*Leguminoseae*, *Phleum pretense* L., *Lolium perenne* L., *Poa pratensis* L., *Dactylis glomerata* L.), 6.5 kg grains (*Hordeum vulgare* L), 2.0 kg rapeseed meal (*Brassica napus* L.), 2.0 kg sunflower meal (*Helianthus annuus* L.), 2.0 kg soybean meal (*Glycine max* L.), 0.5 kg sugar beet pulp (*Beta vulgaris* L.), 1.0 kg molasses, 0.2 kg Biotin plus, 0.15 kg baking soda, 0.08 kg salt, 0.07 kg living yeast, 0.07 kg chalk. BCS was evaluated 3 times for each cow in milk recording days. The 1st recording was on average 14 ± 0.66 day after calving, the 2nd recording was on average 47 ± 0.57 day after calving, 3rd recording was on average 80 ± 0.63 day after calving. Body condition was evaluated in 5 points system (1-thin, 5-fat). Live weight was measured at the same time. Live weight was measured with a special printed tape (with values of live weight). Measures were done at heart girt.

Recording data was collected from Agricultural data center database from the heard recording data. Monthly control milk samples were analyzed for fat, protein and somatic cells count. All of these parameters were analyzed in accredited milk quality laboratory SIA ‘Piensaimnieku Laboratorija’ with FOSS instrument CombiFoss FC.

Somatic cell count was calculated to somatic cell score (SCS) by formula:

$$SCS=\log_2(\text{Somatic cell count}/100000)+3 \quad (1)$$

Dairy cows were grouped by BCS in 3 groups – the 1st BCS group from 2.0 to 2.5 points (n=94), the 2nd BCS group from 2.75 to 3.0 points (n=47) and the 3rd BCS group from 3.25< points (n=6).

For data analysis SPSS and MS Excel software were used. For traits characterization mean values and standard error, minimal and maximal values were used. To examine BCS, live weight and milk productivity changes according to recording time and BCS group, ANOVA single factors were performed. To analyze breed and lactation influence on these traits, ANOVA Two factors were performed. Bonferroni test was performed to determine significance. The factor was significant if $p<0.05$. Significant differences were marked by different letters ($^{a;b;\ c}$ and $^{A;B;C}$) with superscript.

Results and Discussion

The mean live weight after calving was 639 ± 8.76 kg, but the lowest live weight was on the 47th lactation day, analyzed live weight changes in 90 lactation days. The lowest live weight was 612.6 ± 8.84 kg. Live weight increased in the 3rd recording on average by 9.0 kg, but BCS decreased if compered changes between recordings. Mean of BCS was 2.8 ± 0.05 points in the 1st recording. BCS decreased to 2.5 ± 0.04 points in the 3rd recording (Table 1). A change of live weight was not significant, while BCS varied significantly when compered the 1st and 3rd recording ($p<0.05$). According to researchers of the United Kingdom, BCS characterized dairy cows reproduction traits. The lowest live weight by the UK researchers was found in the 12th lactation week (average 84th lactation day). The UK researchers found out that mean BCS Holstein cows decreased from 2.60 points (after calving) to 2.39 points (Pryce et al., 2001). We obtained similar results. In our case the lowest BCS was on the 80th lactation day. Somatic cell count is an indicator of udder health. Somatic cell count was from 99 ± 32 to 219 ± 104 thousands mL^{-1}.

Foreign scientists concluded that the lowest live weight is from the 10th to 50th lactation day. Live weight increases after this period. BCS changes are similar to those of live weight (Berry et al., 2011). We obtained similar results.

Table 1

Live weight, body condition score (BCS) and milk productivity changes in recordings (n=49)

Trait	1st recording			2nd recording			3rd recording		
	$\bar{x} \pm s_{\bar{x}}$	min	max	$\bar{x} \pm s_{\bar{x}}$	min	max	$\bar{x} \pm s_{\bar{x}}$	min	max
Live weight, kg	616.6 ± 7.47	496	721	612.6 ± 8.84	478	750	621.3 ± 8.39	486	742
BCS	2.8 ± 0.05 ^{a}	2	4	2.7 ± 0.05 $^{a\,b}$	2.0	3.5	2.5 ± 0.04^{b}	2.0	3.5
Milk yield, kg	35.6 ± 0.79 ^{a}	23.6	47.5	40.9 ± 1.12^{b}	22.8	56.4	40.4 ± 0.92 ^{b}	21.1	55.0
Fat, g kg^{-1}	45.4 ± 0.09 ^{a}	31.6	62.9	35.5 ± 0.09^{b}	24.3	50.5	39.2 ± 0.11^{c}	21.9	55.0
Protein, g kg^{-1}	33.1 ± 0.03^{a}	29.6	40.2	34.1 ± 0.03^{b}	29.9	37.7	33.9 ± 0.03 ^{ab}	28.2	39.9
Somatic cell score	2.5 ± 0.22	-0.1	7.6	1.8 ± 0.22	-1.1	6.9	2.0 ± 0.28	-0.8	8.43
Somatic cell count, thousands mL^{-1}	154 ± 50	12	2422	99 ± 32	6.0	1513	219 ± 104	7	4317

$^{a;b;c;}$ – traits with different letters significantly different by recordings ($p < 0.05$)

Milk yield was significantly lower in the 1st recording (35.6 ± 0.79 kg) compered the 2nd (40.9 ± 1.12 kg) and 3rd (40.4 ± 0.92) recording results ($p<0.05$). Other scientists found out that correlation between milk yield and BCS is negative, respectively, milk yield decreases if BCS increases. Correlation is positive between milk yield and live weight. It is due to the fact that cows with greater live weight can intake more feed (Berry et al., 2003). According to results of foreign researchers, negative energy balance period is from calving to the 9th week of lactation. Milk yield increased to the 6th week of lactation, but BCS and live weight decreased in this period (Gross et al., 2011). We found out that phenotypic correlation was negative between milk yield and BCS (r_p = -0.150), while positive correlation was between live weight and milk yield (r_p = 0.191).

Milk fat content was significantly greater in the 1st recording (45.4 ± 0.09 g kg^{-1}) compared with the 2nd and 3rd recording, but protein content was greater in the 2nd recording (34.1 ± 0.03 g kg^{-1}).

Data was analyzed from different lactation HBW, red breeds and cross-breed cows. Significantly greater live weight (643.8 ± 7.15) was in the 3rd< lactation HBW cows group. Live weight of HBW was the lowest in the 2nd lactation group. We found out similar trend also in red breed and crossbreed groups, too. The greatest live weight was found in red breed 3rd< lactation group (690 ± 29.49 kg; Table 2).

BCS was the greatest in HBW 1st lactation and cross-breed 3rd < lactation groups (3.0 ± 0.13 points in both groups). According to previous studies, BCS is greater in the 1st lactation if compared with the 2nd and 3rd lactations. BCS decreases after the 4th lactation to the same level as in the 1st lactation. This process may be affected by cows' age (Kadarmideen, 2004).

Milk yield was significantly greater in all breed groups for the 3rd < lactation dairy cows; the greatest milk yield was 51.1 ± 3.21 kg in red breed group. We found out that milk yield of older dairy cows increased. Foreign scientists got similar results, milk yield of older dairy cows increases. This tendency gets stronger if dairy cows have high genetic potential to produce milk (Short et al., 1990). Genes are factors of breed, respectively, majority genes, which are responsible for milk productivity traits, are located in the 14th chromosome. Milk productivity depends on these genes polymorphisms and interaction (Grisart et al., 2001). Genotype, which is responsible for high milk yield, is mostly in Holstien cow's genome. This genotype encodes lower fat and protein content in milk (Thaller et al., 2003).

Fat content varied from 29.3 ± 0.43 to 43.6 ± 0.10 g kg^{-1} and was significantly different between lactations in HBW and red breed groups ($p<0.05$). Protein varied from 31.7 ± 0.12 to 34.3 ± 0.09 g kg^{-1} and difference was not significant. We obtained inconsistent results if compared with other scientists, because in our research fat content was greater for Holstein breed cows.

BCS affects metabolism processes of dairy cows; respectively, metabolism stresses sensitivity changes by BCS. The level of BCS changes can affect metabolism processes, because body condition is connected with metabolism of lipids. Metabolism affected dairy cows' milk productivity (Bernabucci et al., 2005). A metabolism imbalance is greater for primiparous if compared with multiparous, because primiparous have difficulties to balance metabolism processes (Meikle et al., 2004). Fat cows were metabolically challenged during early lactation due to intense mobilization of body fat. Thin cows were associated with increased plasma indicators of body

Table 2

Live weight, body condition score (BCS) and milk productivity changes between breeds and lactations

Breed	Lactation	Live weight, kg	BCS	Milk yield, kg	Fat, g kg^{-1}	Protein, g kg^{-1}	Somatic cell score
HBW	1st	605.3 ± 20.85^{a}	3.0 ± 0.13$^{a; A}$	31.9 ± 2.27^{a}	41.9 ± 0.30^{ab}	34.3 ± 0.09	3.4 ± 0.69^{a}
	2nd	582.6 ± 8.89^{a}	2.7 ± 0.06$^{ab; A}$	39.9 ± 0.97^{b}	38.7 ± 0.13$^{a; A}$	33.9 ± 0.04	1.7 ± 0.30^{b}
	3rd<	643.8 ± 7.15^{b}	2.7 ± 0.05$^{b; A}$	41.4 ± 0.78$^{b; A}$	43.6 ± 0.10^{b}	34.0 ± 0.03	1.8 ± 0.24^{b}
RB	1st	601.9 ± 9.33^{a}	2.6 ± 0.06$^{a; B}$	34.4 ± 1.01^{a}	36.4 ± 0.14^{ab}	33.3 ± 0.04	2.3 ± 0.21
	2nd	551.7 ± 29.49^{a}	2.3 ± 0.19$^{ab; B}$	42.6 ± 3.21^{b}	29.3 ± 0.43$^{a; B}$	32.9 ± 0.12	1.8 ± 0.98
	3rd<	690.0 ± 29.49^{b}	2.0 ± 0.19$^{b; B}$	51.1 ± 3.21$^{b; B}$	37.6 ± 0.43^{b}	31.7 ± 0.12	2.7 ± 0.98
XP	1st	619.1 ± 13.19	2.8 ± 0.08^{AB}	33.0 ± 1.44^{a}	39.8 ± 0.19	33.9 ± 0.06	2.4 ± 0.44
	2nd	–	–	–	–	–	–
	3rd<	651.8 ± 20.85	3.0 ± 0.13^{A}	49.6 ± 2.27$^{b; B}$	41.5 ± 0.30	32.0 ± 0.09	3.1 ± 0.69

^{a,b} – traits are significantly different between different lactation groups in the same breed ($p<0.05$)

$^{A, B}$ – traits are significantly different between different breeds in the same lactation group ($p<0.05$)

– data were not found

protein mobilization during the first weeks of lactation, and lower milk protein secretion (Pires et al., 2013). Sirotkin et al. (2013) found out that indicators of blood were significantly different if compared two dairy cows research groups. Ca^{2+}, P_i, Mg^{2+}, Fe^{2+}, Cu^{2+}, leptin and insulin contents were different. These parameters of blood are connected with ovulation process.

Analyzing BCS influence on live weight and milk productivity, we found out that BCS affected live weight. Live weight was the greatest (636.3 ± 7.40 kg) for the dairy cows whose BCS was 2.75 to 3.0 points. Milk yield was the greatest (39.3 ± 0.72 kg) for the dairy cows with BCS 2.0 to 2.5 points (Table 3).

According to Hungarian scientists, milk fat, protein and lactose decreased from the week 2nd to 8th. Those milk content parameters are affected by lactation and BCS and are very important for reproduction traits – first ovulation and pregnancy parameters (Adrien et al., 2012).

Milk fat decreased in research group with the highest BCS, and it could be the result of lipid metabolism. Lipid metabolism is a cumbersome process. Researchers of Serbia indicated the importance of environment conditions: high temperature and humidity are important factors, which affected BCS. Adaption process is difficult for dairy cows with BCS 4.0 and more points. Milk yield, fat content decreases, when temperature and humidity are too high. Milk yield, fat content and protein content could be lower of our research in the summer time. Body temperature was the highest for dairy cows with the highest BCS, because stress level of metabolism was high when humidity increased (Cincovic et al., 2011).

Other researcher found out that BCS does not affect somatic cell count. Phenotypic correlation was low between somatic cell count and BCS. It could be explained by the fact that somatic cell count is affected by environment factors and udder form (Kadarmideen, 2004).

We analyzed live weight relationship with milk yield and fat according to BCS and recording (1st R, 2nd R, 3rd R – 1st, 2nd, 3rd recordings; Figure 1.).

Milk yield was greater in the 2nd recording 1st and the 2nd BCS groups and in the 3rd recording 3rd BCS

Table 3

Body condition score (BCS) influence on live weight and milk productivity traits

Traits	BCS group		
	2.0 – 2.5	2.75 – 3.0	3.25 <
BCS	2.4 ± 0.02	2.9 ± 0.03	3.7 ± 0.11
Live weight, kg	606.0 ± 6.10	636.3 ± 7.40	633 ± 16.87
Milk yield, kg	39.3 ± 0.72	38.6 ± 1.06	36.5 ± 2.76
Fat, g kg^{-1}	40.0 ± 0.08	40.5 ± 0.11	37.8 ± 0.35
Protein, g kg^{-1}	33.7 ± 0.02	33.5 ± 0.03	34.9 ± 0.11
Somatic cell score	2.0 ± 0.17	2.2 ± 0.26	2.3 ± 0.69

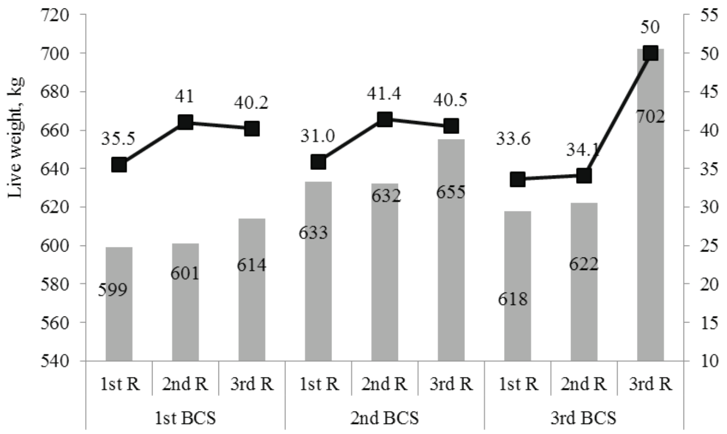

Figure 1. Live weight relationships with milk yield according to body condition score (BCS) in 1st recording: ■ live weight, kg; ▬ milk yield, kg.

Table 4

Fat and protein content changes according to body condition score (BCS) in 1st recording

BCS group	Recording	Fat, g kg^{-1}	Protein, g kg^{-1}	Fat-protein ratio
1st BCS	1st	45.6	33.3	1.41
	2nd	33.2	33.9	0.97
	3rd	38.1	34.0	1.09
2nd BCS	1st	45.0	32.4	1.39
	2nd	35.3	34.4	1.03
	3rd	38.4	34.8	1.10
3rd BCS	1st	39.6	36.1	1.10
	2nd	37.7	34.0	1.11
	3rd	32.3	33.0	0.98

group. Live weight increased in all groups. Analyzing results of the 1st and 2nd recordings, we concluded that our results are similar to those of foreign scientists. Milk yield was the greatest by cows with average BCS value – 2.5 points (Kadarmideen, 2004). Live weight and BCS changes are connected with the length of dry period. Live weight changes were greater for dairy cows with a longer dry period. Dry period affects milk yield and milk content (Gulay et al., 2003).

Fat, protein and fat-protein ratio (FPR) were different between recordings and BCS groups (Table 4).

Analyzing milk fat and protein content, we found out that these parameters were the lowest in the 2nd recording. Fat and protein content was greater in the 1st recording, but FPR was the lowest in the 2nd recording 1st and the 2nd BCS groups (0.97 and 1.03). FPR increased in the 3rd recording 1st and 2nd BCS groups. FPR of the 3rd BCS group increased between the 1st and 2nd recordings, but in the 3rd recording decreased. According to scientists of Czech Republic, FPR of Holstein cows decreased during the whole lactation time. FPR value was 1.91 on the 25th lactation day, but on the 45th lactation day it was 1.45. Fat and protein content was the lowest on the 45th lactation day (Čejna and Chládek, 2005). FPR value was the greatest in the first lactation week; it is connected with milk chemical content (Toni et al., 2011). Optimal FPR value of red breed cows is 1.25 to 1.45 in lactation time (Negussie et al., 2013). FPR was lower of the 2nd lactation dairy cows compared with the 1st lactation cows (Reksen et al., 2002). Low values of FPR usually are connected with low fat content in milk. Farmers can avoid low fat syndrome, by feeding dairy cows on TMR which contains high level of fat acids and neutral detergent fiber. Positive effect is by linseeds that are used in TMR; respectively, fat content increased when linseeds (Suksombat et al., 2013) were used.

Body condition is an, important factor which affected milk productivity and reproduction. Dairy cows cannot be very thin or fat. Incomes of dairy business decrease if cows are thin or fat because BCS affects milk yield, reproduction. Lactation gets longer, but daily milk yield decreases and the period between parturitions becomes longer. Farmers cannot grow next dairy cows – heifers (Kashfi et al., 2011; Mushtaq et al., 2012; Jaakson et al., 2013). Feed for high productivity dairy needs to be balanced. Body condition does not decrease to feeding cows with balanced feed (Tamadon et al., 2011). Body condition is a trait with good heritability by a sire. Making a selection, the body condition is a trait by which farmers can select sires. Body condition needs to be in harmony with milk productivity and reproduction (Kadarmideen and Wegmann, 2003).

Conclusions

Body condition score decreased from 2.80 ± 0.05 to 2.54 ± 0.04 points in 90 days after calving, live weight increased from 616.6 ± 7.47 to 621.3 ± 8.39 kg, but milk yield was the greatest in the 2nd recording or the 47th lactation day (40.9 ± 1.12 kg per day).

Body condition score of the 1st lactation of Holstein Black and White was 3.0 ± 0.13 points, and it was the greatest if compared with red breed and cross-breed cows ($p<0.05$). Milk yield was the greatest in red breed 3rd< lactation group (51.1 ± 3.21 kg; $p<0.05$). Body condition score significantly affected live weight, but other traits did not affect ($p<0.05$) it.

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