THE BODY CONDITION SCORE AND LIVE WEIGHT INFLUENCE ON PREDICTED NITROGEN EXCRETION WITH URINE

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Abstract
The purpose of research was to analyze dairy cows (*Bos taurus*) milk productivity according to the calving body condition score (BCS) and to predict the nitrogen output with urine according to BCS and live weight. The research was carried out at the Research and Study farm 'Vecauce' of Latvia University of Agriculture. Data were collected from 55 dairy cows during October 2013 to October 2014. Dairy cows were from different breeds (Holstein Black and White, red breed cows with Holstein blood more than 40% and crossbreeds) and different lactations. Cows were grouped in two groups for the estimation of BCS effect on the analyzed traits: BCS≤2.5 and BCS≥2.6. BCS was estimated at calving and in monthly recording control days. Nadir value of BCS≥2.6 group was 2.64 ± 0.06 points on the third control day, but 2.46 ± 0.08 points of BCS≤2.5 on the second control day. Calving live weight of BCS≤2.5 and BCS≥2.6 groups were 613.8 ± 13.3 kg and 651.1 ± 11.4 kg. The highest milk yield was observed in BCS≥2.6 group until the third control day, the highest fat content was observed in this group, but the highest protein content was in BCS≤2.5 group. Milk urea content was not significantly affected by calving BCS, but milk urea content of BCS≤2.5 group ranged from 23.2 ± 1.86 to 30.9 ± 1.98 mg dL^{-1}, and from 20.6 ± 1.53 to 30.2 ± 2.27 mg dL^{-1} in BCS≥2.6 group. A significantly higher urinary nitrogen output was observed from BCS≥2.6 group on the second control day – 237.8 ± 8.1 g day^{-1} ($p<0.05$).
Key words: body condition score, milk urea, nitrogen output.

Introduction

Balanced nutrition is a basic condition for good animal health and environmental protection. Dairy cows (Bos taurus) produce a high milk yield if nutrition is unbalanced. Negative energy balance can be observed in early lactation stage and it depends on nutrition. Excess nitrogen losses pollute environment if dairy cows intake too much protein. Total pollution is collected from feces, urine and various other types of nitrogen pollution. The dietary protein degradability efficiency is characterized by nitrogen losses in environment (Jordan et al., 1983). The risk of pollution increases and reproductive performance decreases when nitrogen metabolism is unbalanced. The ova viability is low when concentration of nitrogen in body is high (Kohn et al., 1997). The scientists recommend using special additive for balancing nitrogen metabolism and reduction of nitrogen losses (Chacher et al., 2014). The highest nitrogen output was observed from cows with highest live weight. Nitrogen output can be affected by milk yield, crude protein content in diet and intake nitrogen quantity (Yan et al., 2006).

Different formulas can be used for urinary nitrogen output calculation. Urine is one of the basic end products of nitrogen metabolism and it is very important to predict nitrogen output with urine. For calculation of urinary nitrogen output it is necessary to determinate the milk urea nitrogen (MUN). MUN can vary 9.50 – 19.50 mg dL^{-1} ant it can be affected by live weight, breed and other factors. Formulas were developed for predicted nitrogen output with urine calculation for Holstein, Jersey breeds and all breeds (universal formula) by scientists from The Ohio State University. The breed effect lost its significance when live weight is included as a factor in the model. The universal formula is with high determination – R2=0.98 (Whang et al., 2000; Kauffman and St-Pierre, 2001). Other scientists developed formulas, but the coefficient of determination was not so high (Jonker et al., 1998).

Scientists have observed low positive relationship between body condition score (BCS) and milk urea nitrogen. When BCS milk urea nitrogen increases, these traits also change and become opposite – both traits decrease. It has allowed to conclude that similar relationship is between BCS and predicted nitrogen output with urine (Miglior et al., 2007). According to the previous studies, the predicted nitrogen output with urine ranges from 150 – 225 g day^{-1} from Holstein cow (Castillo et al., 2001).

The purpose of the research was to analyze the dairy cows milk productivity according to the calving BCS and to predict nitrogen output with urine according to BCS and live weight.

Materials and Methods

The research was carried out at the Research and Study farm 'Vecauce' of Latvia University of Agriculture. Data were collected from 55 dairy cows during October 2013 to October 2014. Dairy cows were from different breeds (Holstein Black and White, red breed cows with Holstein blood more than 40% and crossbreeds – F1 progeny of Holstein Black and White, and red breeds) and different lactations. Cows were kept in loose house system and milked three times per day. Dairy cows were *at libitum* access for total mixed ration. Ingredients of total mixed ration 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.

Milk productivity and quality data for the study were obtained from the state agency 'Lauksaimniecības datu centrs'. Milk samples were analyzed in 'Piensaimnieku laboratorija', Ltd. Milk yield (kg), fat content (g kg^{-1}), protein content (g kg^{-1}), milk urea content (mg dL^{-1}) and somatic cell score were analyzed in the paper. Fat content, protein content, milk urea content was analyzed according to ISO 9622 / IDF 141:2013, but somatic cell count according to LVS EN ISO 13366-2:2007. The first control day was on 17.9 ± 0.72 day of lactation, second control day – 48.4 ± 0.65 day of lactation, third control day – 80.7 ± 0.64 day of lactation, fourth control day – 110.8 ± 0.88 day of lactation. Live weight and BCS were measured at calving and on the monthly recording control days. Live weight was measured with verified type. BCS was evaluated in 5 point system with increment of 0.25 (1 point – extremely thin, 5 point – very obese). Body condition measuring system was described by J.M. Bewley and M.M. Schutz (2008), but developed by B.G. Lowman et al., (1976).

Somatic cell score (SCS) was calculated by formula (Schutz and Powell, 1993):

$$SCS = \log 2 \text{ (Somatic cell count/100000)} + 3 \quad (1)$$

For the calculation of predicted nitrogen output with urine, the milk urea nitrogen (MUN) has to be calculated. MUN was calculated using formula (Spiekers and Obermaier, 2012):

$$MUN = \text{Milk urea content} \times 0.46 \quad (2)$$

The predicted nitrogen output with urine (UN) was calculated using MUN and live weight traits. Two formulas were used for the result comparison. Formula (3) included two factors – MUN and live weight (LW), but formula (4) included only factor MUN. Formula (4) was developed for Holstein breed.

Formula (3) was as follows (Kauffman and St-Pierre, 2001):

$$UN = 0.0259 \times LW \times MUN \quad (3)$$

Formula (4) was:

$$UN = 17.6 \times MUN \quad (4)$$

Cows were grouped in two groups for the estimation of BCS effect on the analyzed traits: BCS≤2.5 (n=20) and BCS≥2.6 (n=35), without the use of lactation as factor, because calving BCS of primiparous (2.78 points) and multiparous (2.86 points) was not significantly different. T-test for independent samples was used for significance determination ($p<0.05$). Pearson correlation was used for analyzing relationship between live weight, BCS and predicted nitrogen output with urine. SPSS and MS Excel software was used for data mathematical processing.

Results and Discussion

Differences between BCS at calving and on the first, seconding and third control days were significant ($p<0.05$). BCS values range from 2.47 ± 0.08 to 2.79 ± 0.06 points in BCS≤2.5 group, but BCS observed from 2.64 ± 0.06 to 2.99 ± 0.05 points in BCS≥2.6 group. After having analyzed the changes of BCS, we found that BCS had decreased a little in BCS≤2.5 group. Calving BCS was 2.47 ± 0.08 points in this

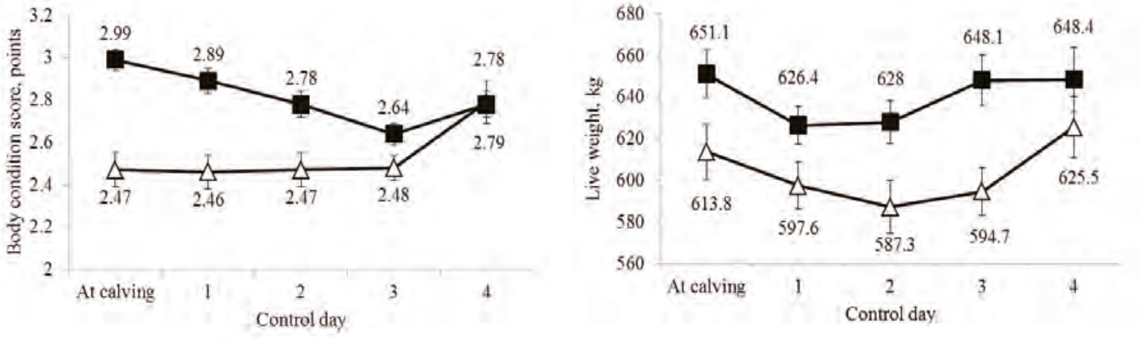

Figure 1. Body condition score and live weight changes: Δ – BCS≤2.5; ■ – BCS≥2.6.

Table 1

Milk productivity and quality traits

Group	Control day			
	1.	2.	3.	4.
	Milk yield, kg			
BCS≤2.5	34.8 ± 1.07	39.3 ± 1.78	40.3 ± 1.45	43.0 ± 2.67
BCS≥2.6	37.2 ± 1.12	42.6 ± 1.34	41.3 ± 1.28	40.5 ± 2.27
×	Fat content, g kg^{-1}			
BCS≤2.5	46.4 ± 1.51	33.9 ± 1.24	38.0 ± 1.72	32.2 ± 1.82
BCS≥2.6	44.1 ± 1.04	36.4 ± 0.99	39.5 ± 1.23	34.8 ± 1.65
×	Crude protein content, g kg^{-1}			
BCS≤2.5	33.3 ± 0.39	34.1 ± 0.43	34.0 ± 0.49	32.3 ± 0.51
BCS≥2.6	32.9 ± 0.36	33.8 ± 0.32	33.6 ± 0.42	33.1 ± 0.39
×	Milk urea content, mg dL^{-1}			
BCS≤2.5	23.2 ± 1.86	26.7 ± 0.71	27.7 ± 1.62	30.9 ± 1.98
BCS≥2.6	20.6 ± 1.53	29.3 ± 0.98	28.8 ± 0.92	30.2 ± 2.27
×	SCS			
BCS≤2.5	2.50 ± 0.33	1.66 ± 0.34	2.33 ± 0.49	1.06 ± 0.55
BCS≥2.6	2.40 ± 0.27	2.04 ± 0.30	1.80 ± 0.30	2.37 ± 0.36

1. control day – 17.9 day of lactation, 2. control day – 48.4 day of lactation, 3. control day – 80.7 day of lactation, 4. control day – 110.8 day of lactation.

group, but BCS increased to 2.79 ± 0.06 points on the forth control day. Calving BCS of other group was 2.99 ± 0.05 points, bud nadir value was observed on the third control day.

Live weight was significantly different at calving and third control day ($p<0.05$). Calving live weight of BCS≤2.5 group was 613.8 ± 13.3 kg, bur nadir value was observed on the second control day. Calving live weight of BCS≥2.6 group was 651.1 ± 11.4 kg and nadir value was found on the first control day when it decreased to 626.4 ± 9.1 kg (Figure 1).

According to the Irish researchers, the average calving BCS and live weight of Holstein dairy cows was 3.14 ± 0.42 points and 564 ± 77.9 kg, respectively (Berry et al., 2011).

M.D.P. Komaragiri et al. (1998) concluded that dairy cows lose major part of BCS by the fifth lactation week and further reduction is small. Other researchers, similar to Irish scientists, found that calving BCS of Holstein cows varied from 3.00 to 3.25 point, but it decreased to 2.60 points by the seventh lactation week (Roche et al., 2006; Yamazaki et al., 2011).

We did not find calving BCS significant influence on milk quantity and quality traits. Variation of average milk yield had a different trend between the control days. The milk yield of BCS≤2.5 group was 34.8 ± 1.07 kg on the first control day, but it increased with each next control day until the fourth recording or 110.8 lactation day when the milk yield was 43.0 ± 2.67 kg. The highest milk yield of BCS≥2.6 group was found on the second control day (42.6 ± 1.34 kg), but milk yield insignificantly decreased over the next control days. According to D. P. Berry et al. (2007), it was concluded that milk yield was highest from dairy cows with the highest BCS. We found similar result by the third control day or 81st lactation day.

Analyzing milk fat content we found a trend that fat content was highest in BCS≥2.6 group, except on the first control day when a peak of milk fat 46.4 ± 1.51 g kg^{-1} was observed. Lower fat content of both groups was observed on the fourth control day.

The highest crude protein content was found from BCS≤2.5 group by the third control day, but highest crude protein content of BCS≥2.6 group was observed on the fourth control day.

Milk urea content of BCS≤2.5 group ranged from 23.2 ± 1.86 to 30.9 ± 1.98 mg dL^{-1}, but from 20.6 ± 1.53 to 30.2 ± 2.27 mg dL^{-1} in BCS≥2.6 group. Milk urea content depends on the season, parity and lactation stage. Researchers from Latvia found that milk urea varied from 12.6 to 52.9 mg dL^{-1}, but average value was 28.3±1.25 mg dL^{-1} and it means that our results are close to the previous papers (Jonkus and Paura, 2011; Ruska and Jonkus, 2014).

The highest somatic cell logarithm was observed on the first control day from groups 2.50 ± 0.33 of BCS≤2.5 group and 2.40 ± 0.27 of BCS≥2.6 group, respectively (Table 1).

Analyzing the predicted nitrogen output with urine using formula (3) we ascertained that the highest value of the first control day was in BCS≤2.5 group – 168.1 ± 12.9 g day^{-1}. Predicted nitrogen output of both groups increased in each next control day. Difference was significant between groups on the second control day when nitrogen values of BCS≤2.5 and BCS≥2.6 groups were 219.3 ± 7.8 and 187.3 ± 7.4 g day^{-1}, respectively. Using formula (4), we observed that values of predicted nitrogen output were higher.

Table 2

Predicted nitrogen output with urine, g day^{-1}

Group	Control day		
	1.	2.	3.
	Formula (3)		
BCS≤2.5	168.1 ± 12.9	187.3 ± 7.4[a]	195.2 ± 11.7
BCS≥2.6	150.8 ± 11.6	219.3 ± 7.8[b]	223.3 ± 8.5
×	Formula (4)		
BCS≤2.5	192.1 ± 14.8	215.6 ± 5.5[a]	222.9 ± 12.5
BCS≥2.6	164.2 ± 13.4	237.8 ± 8.1[b]	233.7 ± 7.6

[a,b] –trait is significantly different between BCS groups using the same formula (p<0.05)
1. control day – 17.9 day of lactation, 2. control day – 48.4 day of lactation, 3. control day – 80.7 day of lactation.

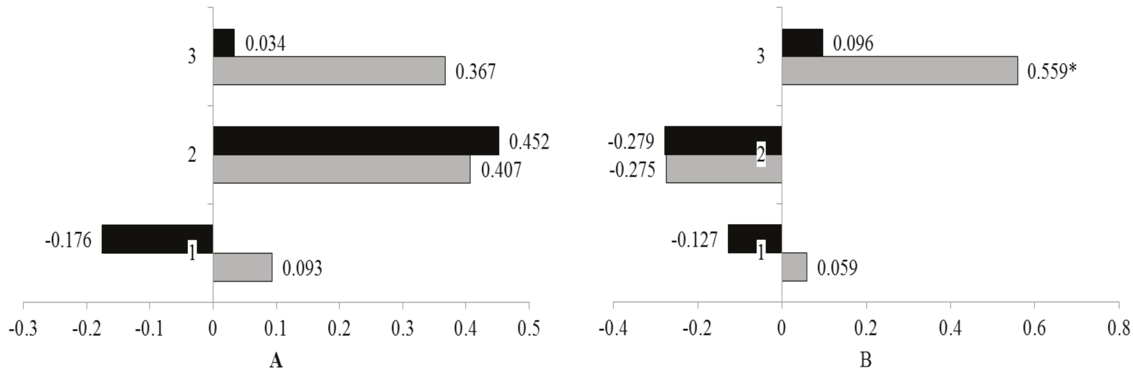

Figure 2. Phenotypic correlation between live weight and predicted nitrogen output with urine in BCS≤2.5 group (A) and BCS≥2.6 group (B) for calculation using: ■ Formula (3); ■ Formula (4) (* p<0.05).

Scientists accented that predicted nitrogen output with urine is affected by animal nutrition but not so much by BCS (Noftsger and St-Pierre, 2003). Researchers from China found that nitrogen output with urine depending on animal diet can range from 123 to 196 g day^{-1} (Zhai et al., 2007). Estimation of urinary nitrogen can be predicted by using formula (3), because the target MUN have decreased from 8.5 to 11.5 mg dL^{-1} for most dairy herds compared with the previous target concentrations of 12 to 16 mg dL^{-1} (Kohn et al., 2002). However, models are very sensitive, because nitrogen output can be affected by different factors, for example, nitrogen intake, crude protein content and degradability of protein in diets (Kebreab et al., 2002). Taking into account the nutrition recommendations, the recommended nitrogen output should be 168 g day^{-1}, but, on average, farmers appeared to feed 6.6% more nitrogen and it resulted in increase of nitrogen output with urine, milk and feces (Jonker et al., 2002).

Analyzing phenotypic correlation between live weight and predicted nitrogen output with urine of BCS≤2.5 group using formula (3) we found that correlation was moderate positive in the second and third recording, respectively, rp= 0.407 and 0.367. Using formula (4) moderate positive correlation was found only in the second recording. We observed significant correlation between live weight and predicted nitrogen output in the third recording ant it was moderate (rp = 0.559; p<0.05). Quite opposite situation was in the second recording, compared with BCS≤2.5 group, the correlation between live weight and predicted nitrogen output was negative, furthermore, it was low. The first recording results were quite similar as in BCS≤2.5 group; using formula (3) for predicted nitrogen output with urine calculation correlation was positive, but using formula (4) – negative. Relationships are illustrated in Figure 2.

Phenotypic correlation between BCS and predicted nitrogen output of BCS≥2.6 group was different compared with BCS≤2.5 group. Correlation between BCS and predicted nitrogen output of this group was positive in the first recording, but negative in the third recording using both formulas. Using formula (3) correlation was positive, but using formula (4) it was negative in the second recording. Significantly correlated BCS and predicted nitrogen output in the second recording using formula (3) and (4). Both relationships were positive, but using formula (3) it was strong (rp = 0.840; p<0.05), while using formula

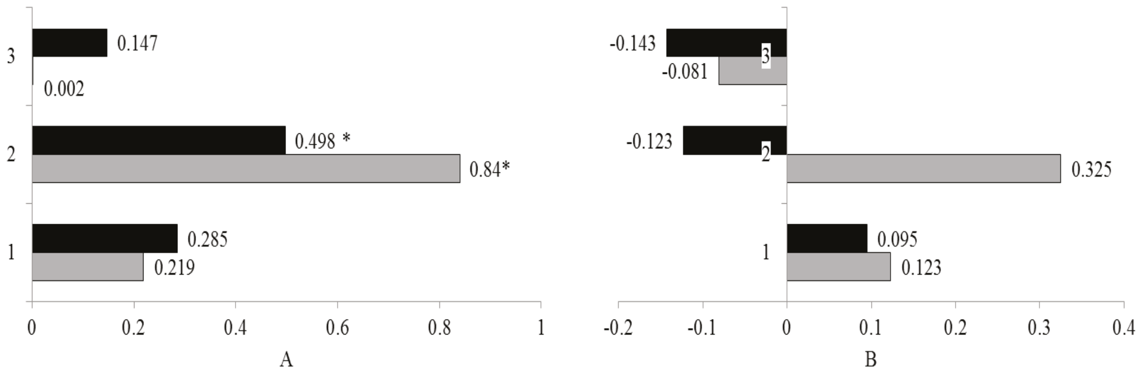

Figure 3. Phenotypic correlation between body condition score and predicted nitrogen output with urine in BCS≤2.5 group (A) and BCS≥2.6 group (B) for calculation using: ■ Formula (3); ■ Formula (4) (*$p<0.05$)

(4) it was moderate (rp = 0.498, $p<0.05$). These relationships are showed in Figure 3.

Balanced diets for dairy cows and correct management of manure help improve nitrogen utilization efficiency in farms. Recycling of nitrogen is very important for environment (Gourley et al., 2012). According to the calculations done by the researchers, dairy cows intake 0.33 to 0.67 kg nitrogen, but utilization efficiency varies from 0.21 to 0.42 (Whelan et al., 2013).

Conclusions

Nadir value of BCS≥2.6 group was 2.64 ± 0.06 points in the third recording, but 2.46 ± 0.08 points of BCS≤2.5 in the second recording.

Calving live weight of BCS≤2.5 group was 613.8 ± 13.3 kg, bur nadir value was observed in the second recording. Calving live weight of BCS≥2.6 group was 651.1 ± 11.4 kg and nadir value was found in the first recording when it decreased to 626.4 ± 9.1 kg.

BCS did not affect milk productivity traits significantly, but the highest milk yield was observed in BCS≥2.6 group until the third recording, the highest fat content was observed in this group, but the highest protein content was in BCS≤2.5 group.

Milk urea content was not significantly affected by calving BCS, but milk urea content of BCS≤2.5 group ranged from 23.2 ± 1.86 to 30.9 ± 1.98 mg dL^{-1}, and from 20.6 ± 1.53 to 30.2 ± 2.27 mg dL^{-1} in BCS≥2.6 group.

Using formula (3) and formula (4), the highest predicted nitrogen output with urine was observed in BCS≥2.6 group, furthermore, significant differences were in the second recording between groups.

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