Tarım Bilimleri Dergisi
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Journal of Agricultural Sciences
Journal homepage:
www.agri.ankara.edu.tr/journal

TARIM BİLİMLERİ DERGİSİ — JOURNAL OF AGRICULTURAL SCIENCES 23 (2017) 464-471

Determination of the Body Condition Score and Its Relationship with Milk Yield in Turkish Holstein Cows

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ARTICLE INFO
Research Article DOI: 10.15832/ankutbd.385869
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Received: 23 June 2016, Received in Revised Form: 01 September 2016, Accepted: 01 September 2016

ABSTRACT

It is quite important to keep the condition of cows under surveillance due to conduct of nutritional programs in dairy herds as well as genetic relations with other traits. This study was conducted to estimate the heritability of body condition score (BCS) and genetic correlation with milk yield of Holstein cows. Also, the effects of herd, lactation period and calving age on BCS were investigated. For this aim, body conditions of 1001 cows were scored using the scale of 1-9. The average BCS was determined as 5.52±0.04 and its average was ranged from 4.54 to 6.58 at different periods of lactation. Results showed that body conditions were affected by the lactation period significantly (P<0.01), while the effects of herd and calving age on it were not statistically significant. Heritability estimate of BCS was 0.20±0.16 while the genetic correlation of BCS with milk yield was moderately negative (-0.41±0.17) indicating that high-producing cows tend to be leaner. Although with high standard errors, these results indicates that BCS is heritable at low-moderate level and can result in a progress in both traits by defining an appropriate index.

Keywords: Body condition score; Energy balance; Genetic parameter; Milk yield

Türk Siyah Alaca İneklerde Vücut Kondisyon Skoru ve Süt Verimi ile Arasındaki İlişkinin Belirlenmesi

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Geliş Tarihi: 23 Haziran 2016, Düzeltmelerin Gelişi: 01 Eylül 2016, Kabul: 01 Eylül 2016

ÖZET

Gerek işletmedeki besleme programının yürütülmesi, gerekse diğer özelliklerle olan genetik ilişkisi nedeniyle, ineklerin kondisyonlarının gözlem altında tutulması oldukça önemlidir. Bu çalışma, Siyah Alaca ineklerde vücut kondisyon skorunun (VKS) kalıtım derecesi ve süt verimi ile arasındaki ilişkinin belirlenmesi amacıyla yürütülmüştür. Ayrıca, işletme, laktasyon dönemi ve buzağılama yaşının VKS'ye etkisi araştırılmıştır. Bu amaçla 1001 ineğin vücut kondisyonları 1-9'luk ölçeğe göre puanlanmıştır. VKS'ye ait ortalama 5.52±0.04 olarak bulunmuş olup farklı laktasyon dönemlerinde VKS ortalamaları 4.54 ile 6.58 arasında değişmiştir. İçinde bulunulan laktasyon döneminin, hayvanların vücut kondisyonu üzerine önemli etkiler yaptığı (P<0.01), işletme ve ilk buzağılama yaşının etkilerinin ise istatistiksel olarak önemli olmadığı belirlenmiştir. VKS'ye ait kalıtım derecesi 0.20±0.16 iken, süt verimi ile arasındaki genetik korelasyon -0.41±0.17 olarak tahmin edilmiştir ki bu da yüksek süt verimine sahip ineklerin daha zayıf yapılı olma eğiliminde oldukları anlamına gelmektedir. Standart hataları yüksek olmakla beraber elde edilen bu sonuçlar, VKS'nin düşük-orta düzeyde kalıtsal olduğunu ve uygun indeks belirlenerek ele alınan her iki özellikte de ilerleme sağlanabileceğini göstermektedir.

Anahtar Kelimeler: Vücut kondisyon skoru; Enerji dengesi; Genetik parametre; Süt verimi

1. Introduction

Bovine meat and milk are essential to meet the need for animal protein that is indispensable for human beings. Holstein is globally the most widely reared cattle breed. For long years, a variety of studies on animal breeding have traditionally focused on the milk yield as well as the fat and protein content of the milk (Gallo et al 2001). Pushing animal health and reproduction into the background resulted in animals with high yield values but poor health and fertility (Grosshans et al 1997; Evans et al 2002; Royal et al 2002a; Berry et al 2003).

Energy balance in dairy cattle can be defined as the difference between the energy taken into the body and the energy being used for the functions of daily living and for yield (Koenen et al 2001). Energy balance is negative during the early stages of lactation, which is regarded as normal for mammals (Robinson 1986; Berglund & Danell 1987).

Targeting high yield in animal breeding can lead to energy imbalances. It should be remembered that the duration and severity of such energy imbalances will cause problems on reproduction and health (Butler & Smith 1989; Veerkamp et al 2001). This is because the high yielding animals tend to make up this energy deficit to a large extent by activating their tissue reserves (Veerkamp & Emmans 1995; Dechow et al 2002; Loker et al 2012). What is ideal is to select the animals exercising satisfactory levels of yield, but in the meanwhile, not over using their tissue reserves. That may also mean the selection of animals which consume more feed to compensate the energy imbalance.

Body condition scoring is a method that is routinely used to assess the body fat and energy levels of the cows (Wildmann et al 1982; Kadarmideen 2004). It has gained popularity since it fosters indirect improvement of the reproduction performance and health indairy cows (Pryce et al 2000; Kadarmideen & Wegmann 2003). A variety of methods and scales are used for evaluating the body condition, the ultimate goal of which is to find out the amount of metabolic energy lying inert under the fat and muscle tissues of the animals. Assessing the body condition with ultrasound gives more accurate results, yet it is more expensive and less convenient to be used widely on the ground (Domecq et al 1995). Although it is a subjective method, visual evaluation is easily applicable, accurate enough to show the variations of body reserves among animals of the same breed, and it can be used to determine the ratio of the fat metabolization with reasonable accuracy (Waltner et al 1994; Enevoldsen & Kristensen 1997). Therefore, the subjective method for assessing the body condition score (BCS) was approved and recommended by the International Committee for Animal Recording (ICAR 2004).

There are very recent studies on the potential benefits of body condition scoring for breeding programs, which plays an important role to assess and regulate the caring and nutrition. The objective is to increase the frequency of genotypes in the population that have optimal condition and whose condition scores do not change significantly in the successive periods rather than the over-fat or underweight genotypes. According to Veerkamp & Brotherstone (1997), selection for increased milk yield while maintaining BCS at its current level results in a reduction of overall (economic) genetic gain by 5%. However, this study disregarded the reduction in cost that resulted from the improved health and reproduction.

Although the change in the body condition during lactation is slightly heritable, the heritability of the body condition level is around 0.20-0.50 (Koenen et al 2001; Loker et al 2012; Bastin & Gengler 2013). Several researchers estimated the correlation between BCS and yield, which generally turned out to be negative (Veerkamp et al 2001; Berry et al 2003; Dal Zotto et al 2007; Loker et al 2012). While it was found that the effect of BCS on embryo quality characteristics and milk composition was not important (Ayaşan et al 2012a; 2012b), Bastin & Gengler (2013) reported that the cows with higher BCS are also better in terms of reproduction.

BCS is expected to become more important in animal breeding programs because the heritability is medium, and it shows low to medium genetic correlation with economically important traits. The findings of the studies on this topic have revealed that selection might be based on the body condition without a significant negative impact on the milk yield. Therefore, any information about the genetic variation in terms of body condition and its correlation with the milk yield can be helpful to plan breeding programs for dairy cattles. This study aims to discover the heritability of BCS and itsrelationship with milk yield as well as some environmental factors affecting the BCS.

2. Material and Methods

This study used the data regarding the Holstein cows from 3 herds, all of which are the members of Cattle Breeders' Association of Antalya, Turkey. The records of the animals-i.e, date of birth and calving-were taken from the database of the Cattle Breeders' Association of Antalya. 1001 animals in the herds were scored by the same person using 1-9 scale as recommended by ICAR (Figure 1). All the cows within a herd were scored on the same day. When estimating the heritability, scores of 965 animals whose age at first calving ranges from 20 to 40 months were evaluated (Table 1). Moreover, 668 of these animals with lactation milk yield ≥ 1,000 kg were used to discover the correlation between BCS and lactation milk yield.

SPSS was used to estimate the descriptive values and the effects of fixed environmental factors. The model used for this is shown in Equation 1.

$$Y_{ijkl} = \mu + h_i + lp_j + ca_k + e_{ijkl} \quad (1)$$

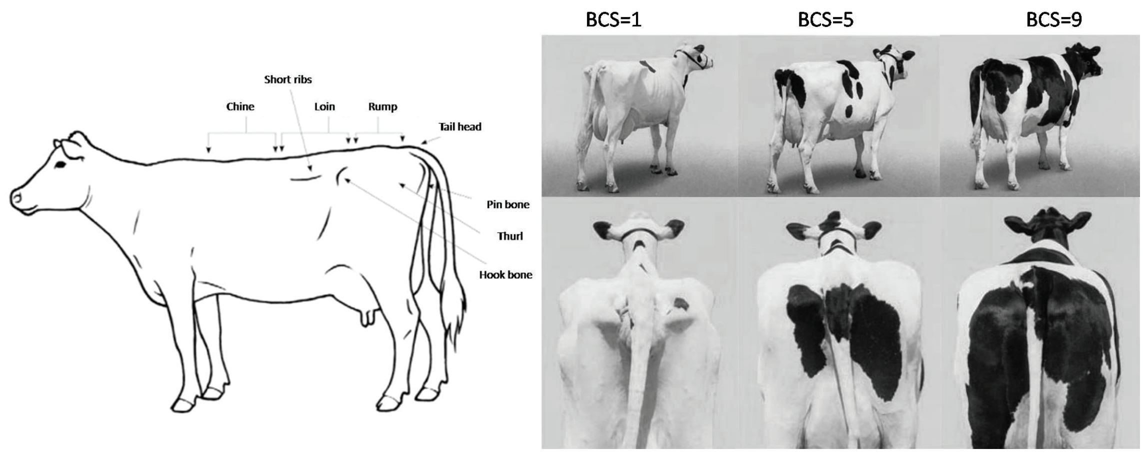

Figure 1- Anatomic regions used to evaluate body condition and examples of cows with different conditions (NFACC 2016; Kellogg 2016)

Where; Y_{ijkl}, body condition score; μ, mean; h_i, herd effect; lp_j, lactation period (month) effect; ca_k, calving age effect; e_{ijkl}, the random residual.

Table 1- Details about the file used to estimate the heritability of BCS

Parameter	*Value*
Number of records	965
Number of dams	951
Number of sires	669
Total number of animals	2478
Average number of daughter per sire	1.44
Number of inbred animals	1
Average of inbreeding coefficient	0.25

MTDFREML was used to estimate the heritability of BCS and the relationship with milk yield. Univariate animal model were used to estimate the heritability while multivariate animal models were used to estimate the correlation. Such models are given in Equation 2 and 3 (Mrode 1996).

$$y = Xb + Za + e \quad (2)$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \ldots \quad (3)$$

(1= BCS, 2= milk yield)

Where; *X*, fixed design matrix; *Z*, random design matrix; *b*, fixed factors that are the herd and the month of lactation when the scoring was exercised, in which the age at first calving is excluded since it does not contribute to the reliability of the model; *a* and *e*, additive genetic effect vector and the error vector-which are random factors, respectively.

3. Results and Discussion

Figure 2 displays the distribution of animals included in this study by their BCS. The most common score was 5. No animal was scored with 1 and only 2% of the animals were scored with 2 and 9. Neither on 1-5 scale nor on 1-9 scale, the cows were supposed to be scored lower than 2. Besides, almost 77% of 1001 cows were scored in 4-6 range, which means that the body condition of the cows are neither underweighted nor fat. This can be interpreted as a very positive finding of the study.

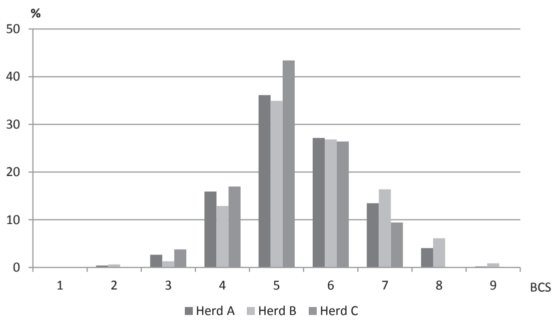

Figure 2- Distribution of animals' BCS according to the herds

The analysis showed that the average scores of the herds were very close to each other. Similarly, there was a slight difference in the body conditions of the animals that have different ages at first calving; however, this difference was not statistically significant. On the other hand, a statistical significance was discovered regarding the effect of the period of lactation at the time of scoring on the BCS ($P<0.01$). Average BCS by months ranged from 4.54 to 6.58 (Table 2). The means of lactation milk yields were also given at the Table. It was sure to have the lowest score in the early stages of lactation, considering the negative energy balance that the cows are in inevitably because they failed to meet the energy need caused by high milk yield after calving. Cows have loss of condition because they regulate the energy imbalance with their body fats. This situation disappears progressively resulting in an increase in BCS. In this study, the score also improved in the later stages of lactation despite small fluctuations. The extreme variations in the latest stages are considered to be associated with the low number of animal in the groups and the extreme values that these animals display. On the other hand, the difference between the highest and the lowest BCS in the lactation period was supposed to be no bigger than 4 on 1-9 scale (Staples et al 1992; Ruegg & Milton 1995; ADLIB 2001a). Table 2 shows that this difference is around 2 only in the study material.

Table 2- Body condition scores and average lactation milk yields of animals in different periods of lactation

Lactation period	*Body condition score*				*Lactation milk yield*	
(month)	*N*	*Mean±SE**	*Minimum*	*Maximum*	*N*	*Mean*
1	45	5.04±0.159 [ab]	3	7	31	9,444.58
2	70	4.54±0.116 [a]	2	7	43	8,633.42
3	107	4.94±0.084 [ab]	2	7	73	8,419.89
4	95	5.08±0.101 [ab]	2	8	74	8,515.30
5	82	5.13±0.099 [b]	3	8	50	8,450.56
6	73	5.16±0.107 [b]	3	7	46	9,440.43
7	39	5.31±0.152 [b]	3	7	26	8,743.19
8	41	5.27±0.140 [b]	3	7	31	9,238.35
9	53	5.40±0.143 [b]	3	8	42	9,598.17
10	49	6.12±0.122 [cd]	4	8	34	9,121.50
11	60	5.98±0.125 [c]	4	8	39	9,919.05
12	70	6.11±0.126 [cd]	4	9	50	9,676.68
13	51	6.39±0.146 [cd]	4	8	34	9,922.56
14	43	6.58±0.174 [d]	4	9	30	10,567.60
15	24	5.96±0.299 [c]	3	9	13	9,914.31
16	16	6.44±0.288 [cd]	4	8	11	10,506.64
17	83	6.29±0.134 [cd]	4	9	41	8,957.78

[a,b,c], means with different superscripts letter differ significantly at P<0.01; [*], standard error

The changes reported in different stages of lactation were parallel to the findings of various other studies (Gallo et al 1996; Dechow et al 2001; Çoban 2006; Şahin 2011; Karslıoğlu Kara 2015). Having a BCS of 5.04 at the beginning of the lactation was slightly below the optimal values that were reported by various other researchers (Staples et al 1992; ADLIB 2001b; Karslıoğlu Kara 2015). However, in the subsequent months when the animals had peak lactation, the body condition scores were at the required level, which implies the absence of a general problem.

Table 3 shows the parameters derived from the analysis. Heritability of BCS was 0.20±0.16. This was smaller than the values reported as 0.33, 0.38, and 0.28 by Gallo et al (2001), Veerkamp et al (2001) and Royal et al (2002b), respectively but bigger than the values reported as 0.07-0.09 for dry period by Dechow et al (2001). The heritability was similar to the estimates of Koenen et al (2001) as 0.24, Dechow et al (2004) as 0.20 and Vallimont et al (2010) as 0.26. On the other hand, the genetic correlation in the analysis was -0.41±0.17 between BCS and milk yield. This value was higher than the values reported as -0.12 by Kadarmideen & Wegmann (2003) and as -0.28 by Loker et al (2012). However, it was very similar to the values reported as -0.39 and -0.40 by Battagin et al (2013) and Dal Zotto et al (2007), respectively. Bastin & Gengler (2013) discovered a negative correlation that ranges from -0.63 to -0.12 in their review article. In other words, the cows with genetically high yield tend to have low BCS particularly in the lactation period. The differences reported by the above-mentioned studies can be related to the data source (field data-research data), the scale used to evaluate the body condition, the statistical model used, the number and period of lactation, breeds, the number of records per animal, and the procedures of data editing (Dal Zotto et al 2007; Bastin & Gengler 2013).

Table 3- Some parameters related to BCS

Parameter	*Value*
Additive genetic variance	0.20
Error variance	0.72
Phenotypic variance	0.92
Heritability	0.22
Additive genetic correlation with milk yield	-0.41
Phenotypic correlation with milk yield	-0.10

4. Conclusions

Compared to other traits, BCS has an advantage in terms of acceptability by the breeders. Because they usually do not favor breeding programs that either intend to improve reproduction through selection on the basis of low milk yield or take into account the characteristics such as body depth, rump angle, and front udder attachment. Therefore, BCS is a trait that can be used indirectly to improve lactation milk yield and reproduction. Studies on the subject discovered that there is generally a high correlation among the BCS evaluated within and between parity. Therefore, a selection that is based on the BCS at the first lactation is also effective on the subsequent lactations (Bastin & Gengler 2013).

The results showed that, 22% of phenotypic variation of BCS is due to genetic factors. This means that it is not impossible to achieve a change in the desired direction at BCS with selection of proper parents. Moreover, since the correlation between the two traits is not 1:1 (absolute), this can result in a progress in both traits by defining an appropriate index. What is prominent here is that the standard error associated with the genetic correlation is high. This is possibly related to the small dataset and the absence of some data about pedigree particularly about sires. BCS data should be collected and analysed more extensively and for longer time period to have more reliable estimates. Evaluating the body condition of each animal at different stages of lactation will not only increase reliability but also give a clue about the changes in body condition during lactation.

Acknowledgements

This study was financially supported by the Scientific Research Projects Unit of Akdeniz University under the project number of 2014.01.0104.006.

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