The Skinfold Thickness and Its Association with Body Condition Score and Milk Production Traits in Holstein Friesian Cows

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Abstract
A series of successive skinfold measurement over the neck and the last rib of dairy cows were made in the Holstein Friesian herd at Agriculture Research and Development Station (ARDS) Șimnic-Craiova, Romania. In the summer of 2017 and 2018, skinfold thickness over the neck (STN) and the last rib (STR), body condition scores (BCS) and test-day records of milk production traits were available from 127 lactating cows. We then estimated the heritability of skinfold thickness and its association with BCS, milk yield, milk fat percentage and milk protein percentage in dairy cows. The heritability of skinfold was 0.15 for STN and 0.30 for STR. Genetic correlation between skinfold thickness and BCS were low to moderate and with milk production traits were very low (0.02 to 0.1). Skinfold thickness was sensitive to changes in body condition across parity and lactation stage in dairy cows. The use of skinfold thickness and BCS is beneficial to monitor changes in body fat deposition with increasing days in milk of the cows. These results could facilitate further exploration in the use of skinfold thickness for management precision in dairy cattle.

Keywords: body condition score, genetic correlation, heritability, skinfold thickness.

1. Introduction

Skinfold thickness is used to evaluate nutritional status in humans. This method has bear used in dairy cattle [1]. Thickness is one of the critical characteristics of skin. There are two general methods to measure the thickness of skin in live cattle: skinfold measurement [2], and ultrasound measurement [3].

It is known that skinfold thickness includes the subcutaneous fat [1].

Subcutaneous back fat thickness (BFT) is mostly measured in beef animals. The proportion of lean-to-fat is important to predict carcass components [4]. In addition, measurement of BFT might be used to predict energy reserves in dairy cows as a tool to confirm body condition scoring (BCS) systems.

Adipose tissue is partitioned across four major fat depots: subcutaneous, perinephric omental, and intra as well as intermuscular fat depots [5]. The proportion of total fat in each fat depot varies between species and between breeds within species. Breeds of dairy cattle tend to have proportionally less subcutaneous fat and more omental fat than breeds of beef cattle [6]. During lactation the subcutaneous fat depots, including rib subcutaneous fat, is the most sensitive to mobilization.

Skinfold thickness measured over the neck and rib is used because of the advantages of high repeatability and convenience of measurement for these regions compared with other regions.

Skinfold thickness is reported to be related to immune response [7], body fat [1], heat tolerance

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[7], tick resistance [8, 9], reproduction [10] and milk yield [11] in cattle.

In the literature, one report [9] rated that skinfold thickness in beef cattle was moderately heritable (0.12 ± 0.02, in the region posterior to the scapula).

The objective of this study was to estimate the heritability of skinfold thickness and its association with BCS, milk yield, milk fat percentage and milk protein percentage in dairy cows.

2. Materials and methods

Skinfold thickness, BCS and test-day records of milk production traits were available from the dairy herd of ARDS Șimnic-Craiova, Romania. Skinfold thickness was measured in the summer of 2017 and the summer of 2018. The measurer used left hand to pull the skin to form a fold and used right hand to measure the folded thickness with a Vernier calliper. The skinfold thickness over the neck (STN) and skinfold thickness over the last rib (STR) were measured on the left-hand side of the body of dairy cows. At the same time BCS was evaluated using a scale from 1 to 5 with 0.5-unit increments (1=thin, 5=fat [12]). Test-day milk yield (MY), milk fat percentage (MF %) and milk protein percentage (MP %) records were available from official dairy herd improvement services.

The linear procedure of SAS software was used to test the significance of parity and lactation stage on STN, STR, BCS and on MY, MF% and MP%. The parities of cows were grouped into 4 levels, 1, 2, 3 and over 4, and lactation stages were divided into 4 levels, including 1-50 days, 51-100 days, 101-200 days, 201-305 days. The significant effects ($p<0.05$) were used in genetic analysis.

3. Results and discussion

The descriptive statistics for the traits are presented in Table 1.

Table 1. Descriptive statistic of skinfold thickness over neck and last rib, BCS, and milk production traits

Trait	n	Mean	SD	CV	Minimum	Maximum
STN	127	7.23	1.32	0.18	4.7	11
STR	127	12.41	2.42	0.19	7.8	18
BCS	127	2.98	0.72	0.24	1.5	5
MY kg	127	28.05	8.22	0.29	21	40.6
MF %	127	3.98	0.92	0.23	2.2	6.8
MP %	127	3.15	0.28	0.09	1.6	8.3

STN = skinfold thickness over the neck (mm); STR = skinfold thickness over the las rib (mm); MY = milk yield (kg/day); MF% = milk fat percentage; MP% = milk protein percentage.

The STN (7.23 ± 1.32 mm; mean ± SD) was thinner than STR (12.41 ± 2.42 mm). The difference (5.18 mm) between STR and STN was strongly significant using paired t-test ($P<0.01$).

Estimates of parity effects on skinfold thickness are presented in Table 2. The STN decreased with increasing parity, declining, an average by 0.31 mm from parity 1 to parity 4 or greater, which coincided with the decline in STR by 0.54 mm from parity 1 to parity 4 or greater (Table 2).

The estimates of the lactation stage effect on skinfold thickness are shown in Table 3.

Table 2. Estimates of the parity effects on skinfold thickness

Parity	STN		STR	
	n	$BLUE^2$ ± SE	n	BLUE ± SE
1 -	50	0.54 ± 0.07	50	0.54 ± 0.12
2 -	45	0.44 ± 0.07	45	0.24 ± 0.12
3 -	20	0.36 ± 0.08	20	0.06 ± 0.12
≥ 4	12	0.23 ± 0.07	12	0

STN = skinfold thickness over the neck; STR = skinfold thickness over the last rib. BLUE = best linear unbiased estimator.

Table 3. Estimates of lactation stage effects on skinfold thickness

Lactation stage	STN		STR	
	h	BLUE^2 ± SE	n	BLUE ± SE
1-50 days	120	0.32 ± 0.05	120	0.30 ± 0.08
51-100 days	119	0.16 ± 0.05	119	0.08 ± 0.02
101-200 days	115	-0.1 ± 0.06	115	-0.12 ± 0.08
201-305 days	110	0.7 ± 0.05	110	0

STN = skinfold thickness over the neck; STR = skinfold thickness over last rib, 2 BLUE = best linear unbiased estimate.

In the normal lactation period, both STN and STR, decreased with increasing days in milk (DIM). At the time of calving the STN and STR were the thickest and in the third stage of lactation were the thinnest (Table 3).

The estimates of the variance components and heritability are shown in Table 4.

Table 4. Estimates of additive genetic variance (6^2a), residual variance (6^2e), phenotypic (6^2p) and heritability (h^2) of skinfold thickness over the neck and last rib, BCS and milk production traits

Trait	**6^2a**	**6^2e**	**6^2p**	**h^2**
STN	0.16	0.9	1.05	0.15
STR	0.78	1.8	2.58	0.3
BCS	0.06	0.44	0.5	0.12
M.Y.	74 160	129 040	203 200	0.36
MF %	0.06	0.07	0.13	0.46
MP %	0.02	0.07	0.09	0.22

STN = skinfold thickness over the neck (mm); STR = skinfold thickness over last rib (mm); MY = milk yield (kg); MF % = milk fat percentage; MP % = milk protein percentage; BCS = body condition score.

The additive genetic variance and phenotypic variance of STR were larger that of STN (Table 4). The heritability for STN was 0.15 and lower than that for STR (0.30). The estimated heritability for BCS, MY, MF % and MP % were 0.12; 0.36; 0.46 and 0.22 respectively (Table 4).

The genetic and phenotypic correlation among all traits is presented in Table 5.

Table 5. Genetic correlation (above the diagonal) and phenotypic correlation (below the diagonal) for STN, STR, BCS and milk production traits

Trait	**STN**	**STR**	**BCS**	**MY**	**MF %**	**MP %**
STN	-	0.68	0.3	0.14	0.13	0.04
STR	0.36	-	0.16	-0.03	0.03	0.02
BCS	0.13	0.15	-	-0.32	0.16	0.32
MY	0.01	-0.02	-0.22	-	-0.66	-0.55
MF %	0	-0.01	0.02	-0.09	-	0.62
MP %	-0.01	-0.01	-0.01	-0.14	0.26	-

STN = skinfold thickness over the neck (mm); STR = skinfold thickness over last rib (mm); MY = milk yield (kg); MF % = milk fat percentage; MP % = milk protein percentage; BCS = body condition score.

A positive genetic correlation (0.68) was detected between STN and STR. The genetic correlation between STN and BCS was positive (0.33) and higher than that between STR and BCS (0.16). The genetic correlation between BCS and MY was negative (-0.32). The genetic correlation between BCS and MF % was positive (0.16), and between BCS and MP % also was positive and higher (0.32), than that between BCS and MF % (Table 5).

The average STN in this study (7.23 mm) was reported in previous study [2]. The force used to pinch the fold affects the measurement of skinfold thickness. The average STR in this study (12.41 mm) was higher than the reported mean range of Holstein and Friesian populations (1.4 – 12.16 mm; [2, 13]). The differences in skinfold thickness among dairy populations may be due to difference of genetics, nutrition level or measurer.

The heritability's of skinfold thickness in the current study (0.15 and 0.30) for STN, and for STR respective were higher than that previous

reported by Maiorano et al., 2016 [9], in Nellore cattle (0.12 of the region posterior to the scapula).
A high genetic correlation between skinfold thickness over the neck and last rib was detected (0.68). Skinfold thickness over one convenient region could be sufficient for management purposes.
After calving, reduction in skinfold thickness was pronounced and remained low until the period of 101 to 200 DIM. Whereas the lowest BCS were measured during the period of 51 to 100 DIM (not showed in this study).
In this study the genetic correlation between skinfold thickness and BCS were low (0.16 for STR) and medium (0.30 for STN). The skinfold thickness and BCS provide complementary information about the nutrition status of dairy cattle. The complementary use of skinfold thickness and BCS is beneficial to identify change in the body fat and to monitor changes in body fat deposition to achieve greater management precision in dairy cattle.

4. Conclusions

Skinfold thickness can be easily measured and is sensitive to changes across parities and lactation stages in Holstein Friesian cows.
Skinfold thickness is a trait with moderate heritability.
The skinfold thickness over one convenient position (either over the neck or over the last rib) is sufficient when skinfold thickness is used for management purposes.
The use of skinfold thickness and BCS is beneficial to monitor changes in body fat deposition with increasing DIM of the cow.
This result could facilitate further exploration in the use of skinfold thickness for management precision in dairy cattle.

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