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Relationships between Body Weight and Milk Yield, and Factors Affecting Related Traits in Holstein cows

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Abstract: This study was conducted to investigate the relationships between body weight (BW) and milk yield, and post-partum BW and their changes during parity and stage of lactation in Holstein cows. This study was conducted on a private dairy cattle farm in Kastamonu province in the Mid-Black Sea Region of Turkey. The study material included 2133 records from 273 Holstein cows calved between 2016 and 2017 years. Parity (from 1 to 5) and stage of lactations (from 1 to 10) were used to be environmental factors affecting traits. The effect of parity and stage of lactation on BW and milk yield were significant (P<0.05). BW and milk yield increased with advancing lactation until the fourth parity, then declined in the fifth parity. The lowest BW was observed in the first two months of lactation, and it increased linearly with following lactation periods. Milk yield was low in the first month of lactation and then decreased linearly until the end of lactation. Correlations between BW and milk yield were all positive and ranged from 0.201 to 0.588. BW changes in early to mid-lactation were phenotypically correlated with milk yield. Finally, based on the findings in present study, it is suggested that monitoring BW change in early and mid-lactation can be used as a management tool to improve the milk yield in dairy herds.

Key words: Holstein, body weight, milk yield, parity, stage of lactation

Holstein İneklerde Canlı Ağırlık ile Süt Verimi Arasındaki İlişkiler ve İlgili Özellikler Üzerine Etkili Faktörler

Öz: Bu çalışma Holstein ineklerde canlı ağırlık (CA) ile süt verimi ve doğum sonrası CA arasındaki ilişkileri ve bunların laktasyon sırası ve laktasyon dönemlerindeki değişimlerini araştırmak amacıyla yapılmıştır. Bu çalışma, Türkiye'nin Orta Karadeniz Bölgesi'nde Kastamonu ilinde bulunan özel bir süt sığırcılığı çiftliğinde yürütülmüştür. Çalışma materyalini, 2016 ve 2017 yılları arasında buzağılayan 273 Holstein ineğinin 2133 kaydını oluşturmaktadır. Laktasyon sırası (1-5 arası) ve laktasyon dönemi (1-10 arası) özellikleri etkili çevresel faktörler olarak kullanılmıştır. CA ve süt verimi üzerine laktasyon sırası ve laktasyon döneminin etkisi önemlidir (P<0.05). CA ve süt verimi laktasyonun ilerlemesiyle dördüncü laktasyona kadar artmış, ardından beşinci laktasyonda düşmüştür. En düşük CA laktasyonun ilk iki ayında gözlenmiş ve sonraki laktasyon dönemleri ile doğrusal olarak artmıştır. Süt verimi laktasyonun ilk ayında en düşük ve daha sonra laktasyonun sonuna kadar doğrusal olarak azalmıştır. CA ve süt verimi arasındaki korelasyonların tümü pozitiftir ve 0.201 ile 0.588 arasında değişmiştir. Erken ve orta laktasyon dönemindeki CA değişimleri süt verimi ile fenotipik olarak ilişkilidir. Sonuç olarak, bu çalışmadaki bulgulara dayalı olarak, erken ve orta laktasyonda CA değişiminin izlenmesinin, süt sığırcılığı sürülerinde süt verimini iyileştirmek için bir yönetim aracı olarak kullanılabileceği önerilmektedir.

Anahtar kelimeler: Holstein, canlı ağırlık, süt verimi, laktasyon sırası, laktasyon dönemi

1. Introduction

High-producing dairy cattle cannot provide a positive dietary balance and must mobilize their body fat reserves during early lactation. However, energy balance measurement in a population with a larger scale is certainly not easy. Therefore, the use of other traits such as body condition scores (BCS) or body weight (BW), having indicators of the energy balance of the cow, has increased (Santolaria et al., 2012).

BCS is a subjective method to assess the nutritional status of dairy cows (Kul et al., 2020). However, BCS is not practice due to the failure assessment of inexperienced herd managers. Nonetheless, daily cow body-weighting is available in commercial farms and BW can be observed during critical periods of lactation (Santolaria et al., 2012).

BW is not currently included in most breeding recordings in dairy cows. A suitable method of recording must be available to include BW in an intensive breeding program (Veerkamp and Brotherstone, 1997). BW in selection decisions is hindered by limited knowledge on procedures for data recording and can therefore be used to be a tool to improve productivity as well (Koenen, 2001).

BW is also affected by parity (Oni et al., 2001; Bayram et al., 2006). Higher-parity dairy cows in early lactation lose more BW (Roche et al., 2007a), and the period with minimum BW increased with parity in Holstein cows (Koenen et al., 1999). Banos et al. (2005) reported that BW in first-parity cows is provided reliable predictions according to the changes in total body energy estimated on the basis of weekly and subsequent parities as well. However, the authors emphasized the further research to elucidate the relationships between BW changes and milk production (Řehák et al., 2012). Also, BW also changes during the early lactation period (Veerkamp and Brotherstone, 1997; Berry et al., 2002; Berry et al., 2007). Lose more BW in early lactation and tend to gain more BW in late lactation was determined by Uribe and González (2018). Also, BW in dairy cows is affected by animal size, degree of fatness, and gut fill, all of which are dependent on the stage of pregnancy, stage of lactation, and age-dependent growth (Berry et al., 2002).

BW in dairy cows and its changes contribute to increasing economic and biological efficiency. Consideration as a genetic selection of BW might be a tool for improving economic response (Koenen, 2001). Information of the cow's individual BW changes throughout the lactation and its adjustment factors is limited. The importance of BW in dairy cattle has been researched by many research. Phenotypic and genetic relationships between BW and milk production have been investigated by several studies (Koenen et al., 1999; Berry et al., 2002; Oni et al., 2001), but the results have been inconsistent.

In Turkey, BW in dairy cows is not routinely recorded in dairy farms. Therefore, the data needed to study the potential associations between BW and production traits are not available. Our objectives therefore were to evaluate relationships between BW and milk yield, and also post-partum BW and its changes during lactation and parity in Holstein cows.

2. Material and Methods

This study was conducted in Kastamonu province in the Mid-Black Sea Region of Turkey. The study material included 2133 records from 273 Holstein cows calved on a private dairy cattle farm between 2016 and 2017 year. The cows were milked three times per day by milking machines. They were kept in free-stall barns during the whole year. The cows were fed a total mixed ration (TMR) and ad libitum twice a day. All cows were milked three times a day and yields were recorded automatically recorded on a computer via transponders. BW was measured electronically by a walking scale in the milking parlor three times a day after milking, and average daily BW was calculated automatically and recorded. All records were taken ten times from 30±15 to 300±15 of lactation.

According to their mean BW and milk yield, the cows were grouped five parity (from 1 to 5) and ten stage of lactations' group (from 1 to 10).

The fallowing model was used to determine the parity and stage of lactation on BW and milk yield;

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$$

where Y_{ijk} = dependent variable, μ = overall mean, α_i= parity effect with i = 1 to 5, β_j = stage of lactation with j = 1 to 10, e_{ijk}= random residual.

The statistical analysis was performed using SPSS 21.0 for Windows. The values were

presented as means ± standard error (SE). The Duncan multiple range test was used to determine the significance of differences between means. In addition, Pearson's Correlation method was employed to compute the correlations between the BW and milk yield.

3. Results and Discussion

The effect of parity on BW was significantly important (P<0.05). The lowest BW was found in first parity compared to other parities (P<0.05). The highest BW was determined in fourth parity, but there were no significant differences between the fifth lactation (Table 1). High BW in older cows than younger cows may be explained by continued growth with the advancing age. This result is similar to previous research (Oni et al., 2001; Bayram et al., 2006). Koenen et al. (1999) determined BW increased with parity, because cows gain weight until they reach maturity.

Table 1. Effect of parity on body weight and milk yield
Çizelge 1. *Laktasyon sırasının canlı ağırlık ve süt verimi üzerine etkisi*

Parity	n	Body weight (kg)	Milk yield (kg/day)
First	878	539.80±1.88 ^{d}	28.82±0.22 ^{c}
Second	575	624.09±2.56 ^{c}	35.65±0.36 ^{b}
Third	348	634.32±3.50 ^{b}	36.71±0.54 ^{ab}
Fourth	164	645.37±4.45 ^{a}	37.11±0.73 ^{a}
Fifth	168	643.15±4.82 ^{ab}	35.73±0.75 ^{b}
Mean	2133	594.18±1.63	33.13±0.20

$^{a, b, c, d}$: Different letters on the same line indicate statistically significant differences (P<0.05)

Milk yield is related to the parity of the cows (P<0.05). The lowest milk yield was found in the first parity (P<0.05). Milk yield increased linearly with advancing lactation until the fourth parity, then declined in the fifth parity (Table 1). In other words, when the parity increased, the milk yield also increased; but thereafter, a gradual declined in milk yield then set in. As the animal advances in age, there is a concomitant increase in milk production and yield until a limit is reached and beyond which an inverse relationship comes into effect (Oni et al., 2001). Also, increased milk production in subsequent lactations is explained by development of the mammary gland and maturation (Pawar et al., 2012). Similar results were presented by Cinar et al. (2015) and Kul et al. (2019) who concluded that milk yield was significantly affected by parity. The result of this study also confirms the earlier findings of Cobanoglu et al. (2019) who detected milk yield was found to be considerably high in the second lactation month (P<0.01). Similarly, Mostert et al. (2001) reported that cows calving in first and second lactations had less milk than cows calving at older ages.

Table 2. Effect of stage of lactation on body weight and milk yield
Çizelge 2. *Laktasyon döneminin canlı ağırlık ve süt verimi üzerine etkisi*

Stage of Lactation	n	Body weight (kg)	Milk yield (kg/day)
1	265	578.23±4.75 ^{g}	33.34±0.61 ^{c}
2	265	574.27±4.54 ^{g}	37.78±0.55 ^{a}
3	265	581.18±4.43 ^{gf}	36.76±0.54 ^{a}
4	265	587.42±4.45 ^{efg}	35.00±0.54 ^{b}
5	265	594.17±4.54 ^{ef}	33.23±0.50 ^{c}
6	255	599.26±4.53 ^{de}	31.86±0.50 ^{cd}
7	219	608.94±4.96 ^{cd}	30.41±0.50 ^{de}
8	172	620.82±5.64 ^{bc}	28.91±0.59 ^{e}
9	113	624.91±6.83 ^{ab}	26.55±0.71 ^{f}
10	55	634.11±9.89 ^{a}	25.95±0.82 ^{f}

$^{a, b, c, d}$: Different letters on the same line indicate statistically significant differences (P<0.05)

BW was significantly affected by stage of lactation (P<0.05) in Table 2. The lowest BW was detected in the first and second lactation months and it increased linearly with following lactations periods. Decreasing BW in the early lactation period can be explained because of the negative energy balance (NEB). As is known, during the early postpartum period, the energy demand for maintenance and production exceeds and dairy cows enter a period of NEB during which they due to mobilize body reserves from milk production. Thus, dairy cows must consume enough feed to meet energy demand during the early period (Spicer et al., 1990; Kul and Erdem, 2018). Thus, BW is decreased in early lactation when cows are in peak milk yield, BW increase advancing lactation period. Calculated lowest BW means belonging to the first lactation period might be explained by an intensive body reserve mobilization related to milk production at the beginning of lactation and regaining reserves with dropping milk yield in later periods. Koenen

et al. (1999) stressed that cows lose BW due to the typical NEB during early lactation, and later in lactation, BW increases when new tissue reserves are built up. Actually, this case could be assumed as an expected change for lactation physiology of cows (Erdem et al., 2015).

The effect of the stage of lactation on milk yield was significant (P<0.05) in Table 2. Milk yield was the highest in two and three lactation months. Milk yield, which was low in the first month of lactation, was highest in the second and third lactation months, then decreased linearly until the end of lactation, and the lowest was found in the ninth and tenth lactation months. Çobanoglu et al. (2017) concluded that the effects of the lactation period on the milk yield were significant (P<0.01). Kul et al. (2020) determined that the highest milk yield was found in the first two lactation months, and it gradually decrease with the progress of lactation (P<0.05). The change at the milk yield in the early lactation period is a result of the physiological change in cows (Domecq et al., 1997). This could be due to the dilution effect of increased milk yield during early lactation (Kul et al., 2020). Cows undergo a period of NEB in this period and require extra energy. Therefore, the milk yields of dairy cows are expected to increase in the peak period when they enter a period of NEB (Çobanoglu et al., 2017). Differently, Krovvidi et al. (2013) determined that milk yield was unaffected by lactation periods in Holstein cows.

Figure 1 also demonstrates that the BW of first parity cows for all lactation periods was the lowest than other parity cows. BW reduced their second month more rapidly except fourth parity cows and reached the highest in tenth except for fifth parity cows. Roche et al. (2007a) found similar results that the highest weight loss is seen in fifth parity, and first and second-parity cows lose less weight than older cows. Higher parity dairy cows in early lactation lose more BW (Berglund and Danell, 1987). Řehák et al. (2012) stressed that older cows had a more extended period and lost more BW in NEB. It might vary with age or lactation stage as changes in BW are related to various biological processes such as growth, lactation, and body tissue mobilization. BW increase: It can be explained by still ongoing the growth stage of cows in the first lactation and, therefore, exhibit a flow of energy and nutrients during their growing process (Gallo et al., 1996).

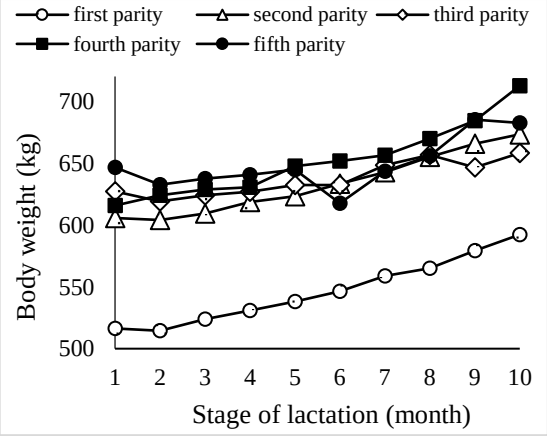

Figure 1. Body weight change of different parity in Holstein cows

Şekil 1. *Holstein ineklerde farklı laktasyon sırasında canlı ağırlık değişimi*

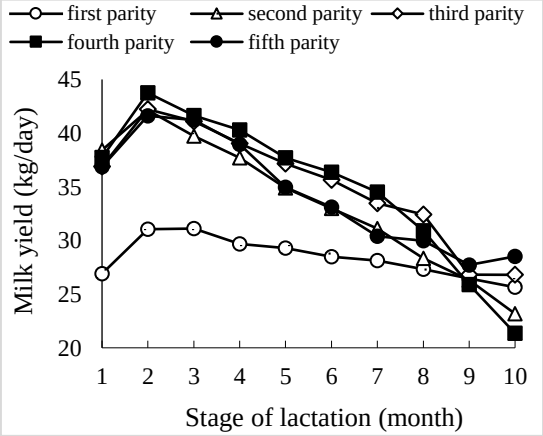

Figure 2. Milk yield change of different parity in Holstein cows

Şekil 2. *Holstein ineklerde farklı laktasyon sıralarında süt verimi değişimi*

As seen in Figure 2, multiparous cows had high milk yield than those primiparous cows. Cows with second and subsequent parities produce more milk compare with first-lactation ones (Poncheki et al., 2015). Řehák et al. (2012) determined that first-parity cows in the first 30 weeks of lactation exhibited lower milk yields than greater-parity cows and the differences between older parity cows were reduced in size, which is similar to the result of present study.

Relative changes (%) in the milk yield and BW are shown in Figure 3. The highest change was observed for milk yield compared with BW. The highest milk yield change was determined (13.3%) in the second month of lactation, after that this change was decreased linearly during the lactation period. The highest percentage decrease (-22.2%) for milk yield was determined in the tenth month of lactation. However, more raid BW loss (-0.5%) was observed in the second lactation month and increased linearly during lactation. The highest BW increase (9.9%) was found to be in the tenth lactation month. At the end of the analyzed period, the most distinctive differences for both milk yield and BW were determined at the end of the lactation. Normally, milk yield in dairy cows increases, while BW decreases in the early lactation weeks. Kul et al. (2020) stressed that the BW loss in the early period of lactation is associated with peak production to sustain their milk production.

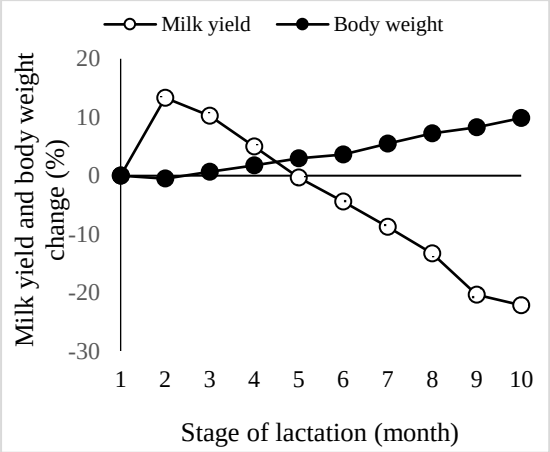

Figure 3. Milk yield and body weight change in Holstein cows
Şekil 3. *Holstein ineklerde süt verimi ve canlı ağırlık değişimi*

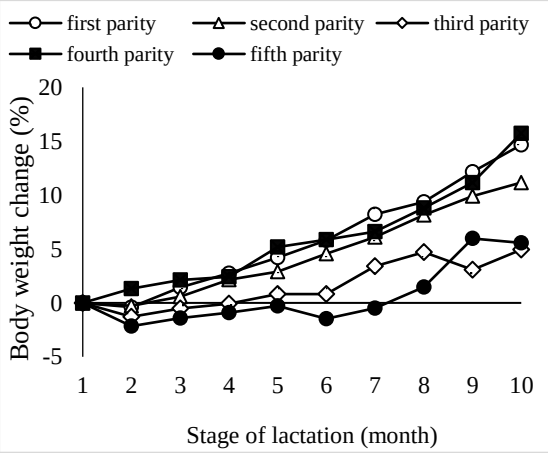

Figure 4. Body weight change of different parity in Holstein cows
Şekil 4. *Holstein ineklerde farklı laktasyon sırasında canlı ağırlık değişimi*

BW was only increased in fourth lactation cows (1.3%) compared to all other lactation cows (-2.2 to -0.3%). Then, BW generally increased linearly during lactation except for the fifth lactation. The highest increase was observed at the first (14.7%) and fourth (%15.7%), and the lowest in the third (4.9%) and fifth lactation cows (4.6%) (Figure 4).

As seen in Figure 5, the highest milk yield change was determined at the second lactation month, and this occurs similarly to all parity groups. The highest milk yield losses were determined in the ninth lactation month for third and fifth parity cows and the tenth lactation month for first, second and fourth parity cows, respectively.

The phenotypic correlations between BW and milk yield changes throughout lactation are given in Figure 6. Correlations between milk yield and BW were all positive and ranged from 0.20 to 0.59. BW in early to mid-lactation showed moderate to high positive correlations with milk yield (0.45 to 0.59). In other words, BW changes in early to mid-lactation were phenotypically correlated with milk yield and this result indicates that those cows with high BW in early lactation had high milk yield. However, there is a low correlation between BW and milk yield changes in late lactation. Similarly, Koenen et al. (1999) determined that BW during lactation was highly correlated with estimated lactation BW. Berry et al. (2002) found that BW throughout lactation had a moderate positive genetic correlation with milk yield (0.22 to 0.34). In a trial conducted by Roche et al. (2007b), results suggested that cows with greater milk production had higher weight loss. Research reported showed that selection for increased BW may

result in increased milk yield. Differently, Oni et al. (2001) determined that the phenotypic correlations between post-partum body weights and milk yield were small and negative.

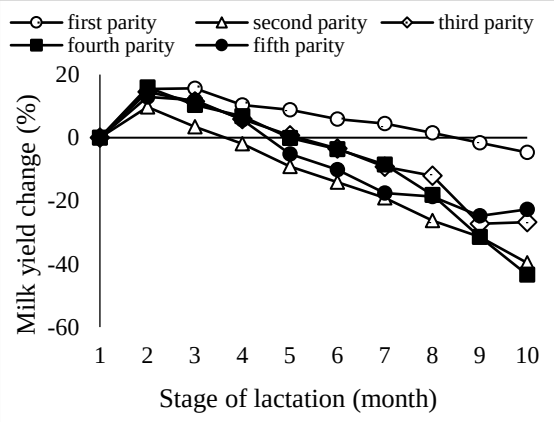

Figure 5. Milk yield change of different parity in Holstein cows
Şekil 5. *Holstein ineklerde farklı laktasyon sırasında süt verimi değişimi*

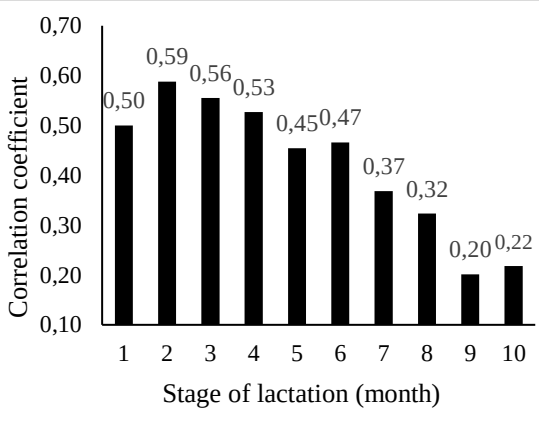

Figure 6. Correlations between milk yield and body weight during stage of lactation
Şekil 6. *Laktasyon dönemi süresince süt verimi canlı ağırlık arasındaki ilişkiler*

4. Conclusions

Milk yield and BW were significantly affected by parity and stage of lactation ($P<0.05$). Milk yield and BW increased with advancing lactation until the fourth parity, then declined in the fifth parity. The lowest BW was determined in the first two months of lactation, and it increased linearly with following lactations periods while milk yield was low in the first month of lactation and then decreased linearly until the end of lactation. BW changes in early to mid-lactation were phenotypically correlated with milk yield. It can be concluded that environmental factors affecting milk yield and BW should be considered, and monitoring BW change in early and mid-lactation can be used as a management tool to improve the milk yield in top production dairy herds.

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