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Original study

Factors affecting lactation length and effect of current lactation length on the subsequent production and reproduction in Iranian Holsteins

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Abstract

Calving records of Holstein cows from January 1983 to December 2006 comprising 1 190 herds with 385 102 calving events were used to evaluate factors affecting the length of lactation and effect of current lactation length on the next productive and reproductive performances of Iranian Holsteins. Statistical analyses of productive and reproductive traits in this study were performed as linear mixed models. Lactation length (LL) of cows was grouped into 10 classes from <100 days to ≥500 days. Average LL was 314 days in Iranian Holsteins. Primiparous cows had the greatest LL and the mean of LL increased over the years from 1983 to 2006 and spring calvers had the longest LL (P<0.05). Cows within the LL class of ≥500 had the greatest unadjusted milk yield, adjusted milk yield, adjusted protein yield and adjusted fat yield and also the longest calving intervals (P<0.05). Cows within the LL classes of 150-199 and 200-249 had the greatest values of adjusted protein percentage. Additionally, age at calving was the lowest for the LL class of 250-299 (P<0.05). There were linear and increasing trends for unadjusted milk yield, adjusted milk yield, adjusted protein yield and adjusted fat yield over the LL classes in this study, but a linear but decreasing trend was observed for adjusted protein percentage over LL classes. On the other hand, there were non-linear relationships between adjusted fat percentage, calving interval and age at calving with LL classes in the current study.

Keywords: dairy cow, lactation length, productive performance, reproductive performance

Abbreviations: AAC: age at calving; AFP: 305-d adjusted fat percentage of milk; AFY: 305-d adjusted fat yield; AMY: 305-d adjusted milk yield; LL: lactation length; APP: 305-d adjusted protein percentage of milk; APY: 305-d adjusted protein yield; CI: calving interval; RMY: unadjusted milk yield

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Introduction

With the increase in population worldwide, there is a need to increase milk productivity for the tropics. An interesting aspect of milk production in tropical dairy cattle is the length of lactation. Variability appears much greater in tropical than in temperate dairy cattle with the former having relatively high proportions of short lactations. Most European dairy cattle in temperate zones produce milk at profitable levels for 305 days. This length is the most common for evaluating performance of dairy cows and it corresponds to a 12-month calving interval. In Zebu cattle, however, lactations are usually shorter than 305 days (Rehman & Khan 2011, Bajwa *et al.* 2004); this often has resulted in the recording of total lactation yields without limiting the period of production. One management strategy to enhance the economic returns of the dairy farm might be the manipulation of the lactation length. A fresh cow usually will produce more milk per day than a cow that is several months in lactation. This suggests that there will be an increase in cash flow if the ratio of fresh cows to late lactation cows is greater. A larger percentage of fresh cows, in theory, produce more daily milk and increase cash flow while the operation remains at its current number of cows in milk. As a result, however, there will be more dry cows than normal. If the fresh cows can produce enough milk to sustain their costs as well as the costs of extra dry cows, there is an increase in economic efficiency (Lissow 1999).

Lactation length in high-producing cows has increased over the last decade (Van Raden 2005, Steri *et al.* 2010) and presently in many countries cows have lactations extended beyond 305 d (Vargas *et al.* 2000). For example, in dairy herds of Costa Rica, more than 25 % of cows are dried-off after 330 d of lactation and the average lactation length is about 328 d (Vargas *et al.* 2000). It results from extending days open, mainly because of reproductive difficulties. So, extending lactations become a part of contemporary management strategy (Tarazon-Herrera *et al.* 2000, González-Recio *et al.* 2006, Dematawewa *et al.* 2007). Recent studies show that over 55 % of US Holstein cows exhibited lactations longer than 305 d (Tsuruta *et al.* 2005, VanRaden *et al.* 2006). The undesirable trend that exists with loss of fertility and reproductive failures in dairy cattle (Butler 1998, Silvia 2003) is a well-known contributor to extended lactations. Aisbett (1984) reported that among 305 d lactations there was a strong correlation between lactation yield and lactation length. Increases in 305 d yields were associated biologically with longer lactation. The biological association between lactation yield and length is strengthened further by management practices of culling and selection. Low yields were typically associated with lactations where daily yield became low shortly after calving. The aim of this study was to determine factors affecting the length of lactation and the effect of current lactation length on the next productive and reproductive performances of Iranian Holsteins.

Material and methods

Calving records from the Animal Breeding Centre of Iran, collected from January 1983 to December 2006 and comprising 385 102 calving events of Holsteins from 1 190 dairy herds were included in the data set. The characteristics of dairy herds used in this study were described in the previous studies (Ghavi Hossein-Zadeh *et al.* 2009, Ghavi Hossein-Zadeh & Ardalan 2011).

The data included animal registration number, herd, calving date, parity, calving age, unadjusted milk yield (RMY), 305-d adjusted milk yield (AMY), 305-d adjusted fat yield (AFY), 305-d adjusted fat percentage of milk (AFP), 305-d adjusted protein yield (APY), 305-d adjusted protein percentage of milk (APP), calving interval (CI), age at calving (AAC) and days in milk. 305-d yields were calculated through multiplying a correction factor based on days in milk and two times milking per day by unadjusted yields of milk. Records were eliminated when no registration number was present for a given cow. Records were also deleted from the analyses when there was no information on the productive and or reproductive performances. Months of calving were grouped into four seasons: April through June (season 1=spring), July through September (season 2=summer), October through December (season 3=autumn), and January through March (season 4=winter). In addition, calving years were grouped into four classes: 1983 to 1988, 1989 to 1994, 1995 to 2000 and 2001 to 2006. Also, lactation length (LL) of cows was grouped into 10 classes: <100 (class 1), 100-149 (class 2), 150-199 (class 3), 200-249 (class 4), 250-299 (class 5), 300-349 (class 6), 350-399 (class 7), 400-449 (class 8), 450-499 (class 9), and ≥500 (class 10). The abovementioned LL classes represented 0.5, 1.8, 3.2, 7.9, 33.9, 26.1, 13.4, 6.6, 3.4 and 3.2 % of total observations.

Statistical analyses of productive and reproductive traits in this study were performed as linear mixed models (Proc Mixed) with the best fitted covariance structure of SAS 2002 (SAS Institute Inc., Cary, NC, USA). The least square means were estimated by Restricted Maximum Likelihood (REML) method. The final models used to analyse RMY, AMY, AFY, APY, APP and AAC included the fixed class effects of herd, calving year, calving season, parity of dam, lactation length, and interaction effects of year by parity, year by season, year by lactation length, season by parity, season by lactation length and parity by lactation length. In addition, AFP was analysed in a model in which the following variables were included: herd, calving year, calving season, parity of dam, lactation length, and interaction effects of year by parity, year by season, year by lactation length and season by lactation length. The final model used to analyse CI included the fixed class effects of herd, calving year, calving season, parity of dam, lactation length, and interaction effects of year by season, year by lactation length, season by lactation length and parity by lactation length. The final model used to analyse LL included the fixed class effects of herd, calving year, calving season, parity of dam, and interaction effects of year by parity, year by season and season by parity. Animal effect was considered as a random variable in all models of analysis for productive and reproductive traits.

Results

Average LL was 314±83.2 d. Table 1 shows productive and reproductive performances at different lactation length groups. Cows within the LL class of ≥500 had the greatest RMY, AMY, APY and AFY, and cows within the LL classes of 150-199 and 200-249 had the lowest values of RMY and AMY ($P<0.05$). The cows within the calving year period of 2001-2006 and LL class of ≥500 had the greatest RMY, AFY, AAC and AMY ($P<0.05$). Also, winter-calved cows within the LL class of ≥500 had the greatest RMY, AFY and AMY ($P<0.05$). Cows in their second parity and within the LL class of ≥500 had the greatest RMY, AFY, APY and AMY ($P<0.05$). The cows within the calving year period of 2001-2006 and LL class of 100-149 had the greatest AFP ($P<0.05$). Also, autumn-calved cows within the LL class of 100-149 had the greatest

Table 1
Productive and reproductive performances at different lactation length groups in Iranian Holsteins

Lactation length	Trait							
	RMY	AMY	AFY	AFP	APY	APP	CI	AAC
<100	7 560.7±77.3^{g}	7 001.5±43.1^{g}	214.4±1.5^{g}	3.13±0.01^{d}	233.6±2.2^{f}	3.16±0.01^{b}	429.1±3.2^{e}	61.9±0.5^{bc}
100-149	7 295.1±37.7^{h}	6 810.6±22.6^{h}	212.8±0.8^{g}	3.20±0.01^{c}	228.6±1.1^{g}	3.16±0.01^{b}	422.2±1.5^{f}	60.8±0.3^{e}
150-199	6 855.1±27.4^{i}	6 558.4±16.7^{i}	207.4±0.6^{h}	3.22±0.01^{a}	220.0±0.8^{h}	3.18±0.005^{a}	409.9±1.1^{g}	62.4±0.2^{ab}
200-249	6 850.6±16.6^{i}	6 551.4±10.2^{i}	208.2±0.3^{h}	3.23±0.003^{a}	217.3±0.5^{i}	3.19±0.003^{a}	379.9±0.6^{i}	62.6±0.1^{a}
250-299	7 784.4±8.0^{f}	7 071.7±4.8^{f}	223.5±0.2^{f}	3.19±0.002^{c}	234.6±0.2^{f}	3.14±0.001^{c}	363.7±0.2^{j}	58.6±0.1^{g}
300-349	8 167.5±9.5^{e}	7 281.9±5.5^{e}	230.7±0.2^{e}	3.20±0.002^{c}	240.3±0.2^{e}	3.13±0.001^{d}	404.9±0.2^{h}	59.8±0.1^{f}
350-399	8 554.2±13.9^{d}	7 496.7±7.9^{d}	238.6±0.3^{d}	3.21±0.002^{bc}	245.4±0.3^{d}	3.11±0.002^{e}	458.1±0.3^{d}	61.1±0.1^{de}
400-449	8 895.6±21.0^{c}	7 651.3±11.4^{c}	244.1±0.4^{c}	3.22±0.004^{ab}	248.0±0.4^{c}	3.10±0.002^{e}	511.4±0.4^{c}	61.6±0.1^{cd}
450-499	9 166.7±30.7^{b}	7 783.3±16.1^{b}	249.1±0.6^{b}	3.22±0.005^{a}	251.5±0.6^{b}	3.08±0.003^{f}	562.8±0.6^{b}	61.8±0.2^{cd}
≥500	9 689.4±34.9^{a}	8 022.8±17.3^{a}	257.2±0.7^{a}	3.22±0.005^{ab}	258.2±0.6^{a}	3.06±0.003^{g}	660.5±0.9^{a}	62.0±0.2^{abc}

$^{a\text{-}j}$Means within a row that do not have a common superscript are significantly different ($P<0.05$). RMY: unadjusted milk yield, kg, AMY: adjusted milk yield, kg, AFY: adjusted fat yield, kg, AFP: adjusted fat percentage, APY: adjusted protein yield, kg, APP: adjusted protein percentage, CI: calving interval, day, AAC: age at calving, month

Table 2
Effect of different variables on the lactation length of Iranian Holsteins

Variable		Number of observations	Lactation length	*P-value*
Calving year	1983-1988	4 335	309.4±1.2^{c}	$P<0.0001$
	1989-1994	44 825	308.1±0.4^{c}	
	1995-2000	162 716	313.5±0.2^{b}	
	2001-2006	173 226	320.4±0.2^{a}	
Calving season	Spring	89 980	318.7±0.3^{a}	$P<0.0001$
	Summer	101 752	313.1±0.2^{d}	
	Fall	99 110	314.6±0.3^{c}	
	Winter	94 260	317.7±0.3^{b}	
Parity	1	132 491	328.0±0.2^{a}	$P<0.0001$
	2	99 477	312.7±0.3^{b}	
	3	65 926	307.7±0.3^{c}	
	≥4	87 208	307.6±0.3^{c}	

Means within a column that do not have a common superscript (a-d) are significantly different ($P<0.05$)

AFP (P<0.05). In addition, dairy cows in their second parity and LL class of 100-149 had the greatest AFP (P<0.05). Cows within the calving year of 1989-1994 and LL class of 450-499 had the greatest APY, but cows within the LL class of 150-199 which calved in 1995-2000 had the greatest APP (P<0.05). Autumn-calved cows within the LL class of ≥500 had the greatest APP (P<0.05). On the other hand, LL classes of 150-199 and 200-249 resulted in the greatest AFP and LL class of <100 had the lowest AFP (P<0.05). Cows within the LL class of ≥500

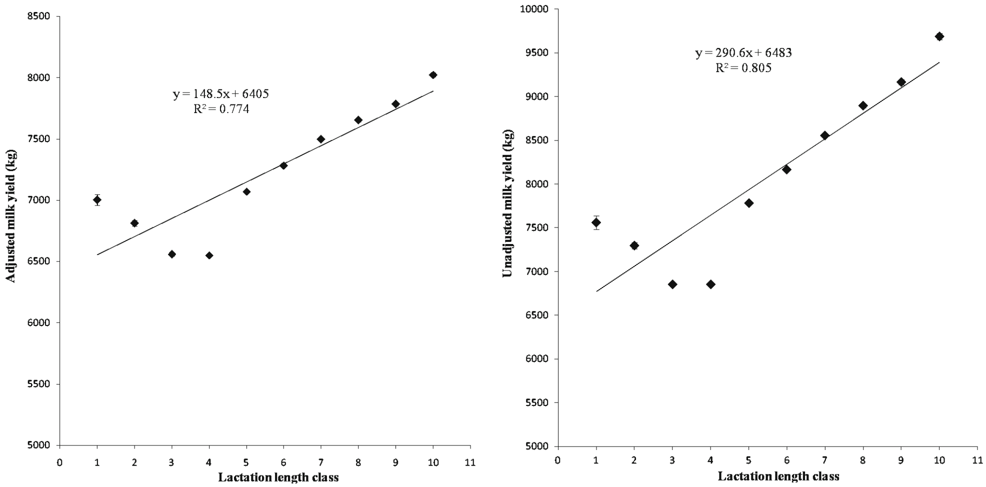

Figure 1
Distribution of unadjusted (above) and adjusted (below) milk yield over different lactation length classes in Iranian Holsteins

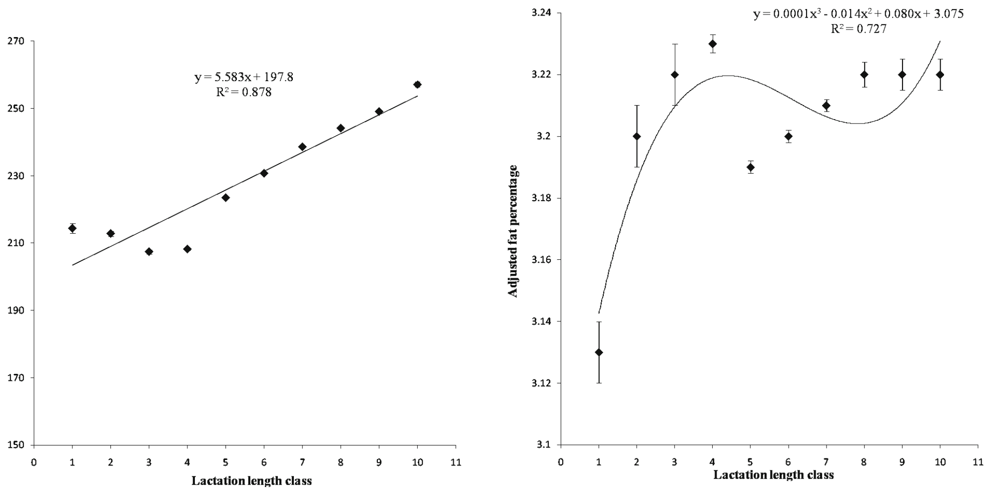

Figure 2
Distribution of adjusted fat yield (above) and adjusted fat percentage of milk (below) over different lactation length classes in Iranian Holsteins

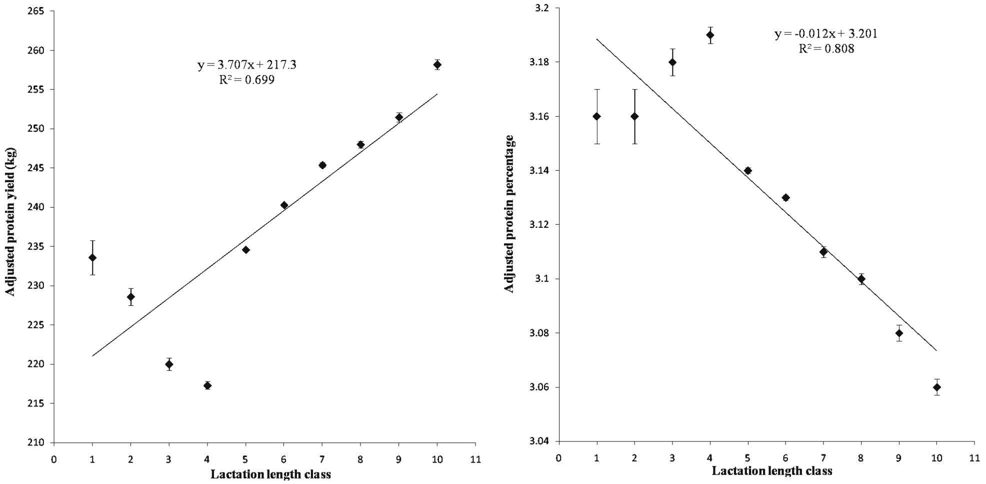

Figure 3
Distribution of adjusted protein yield (above) and adjusted protein percentage of milk (below) over different lactation length classes in Iranian Holsteins

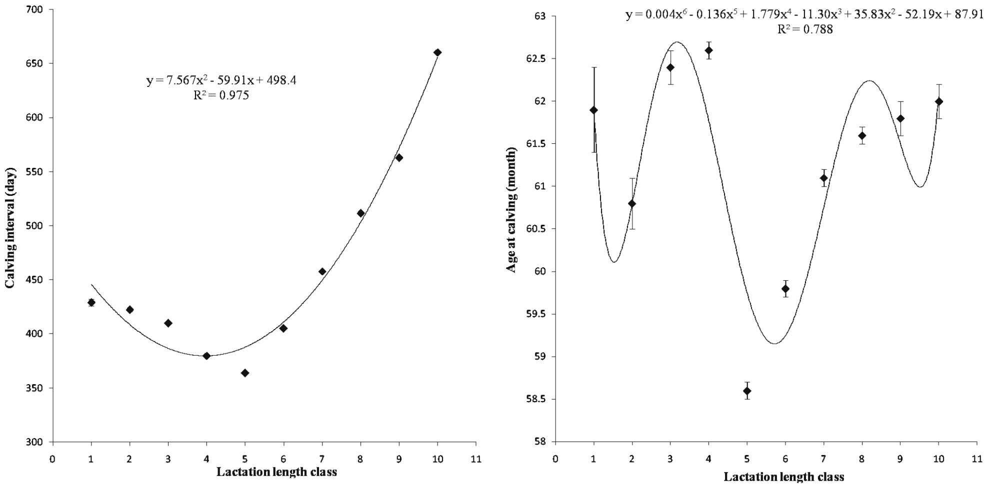

Figure 4
Distribution of calving interval (above) and age at calving (below) over different lactation length classes in Iranian Holsteins

had the greatest APY, and cows within the LL class of 200-249 had the lowest values of APY (*P*<0.05). Cows within the LL class of ≥500 had the lowest APP, and cows within the LL classes of 150-199 and 200-249 had the greatest values of APP (*P*<0.05). The calving intervall was the longest for the LL class of ≥500 and it was the shortest for the class of 250-299 (*P*<0.05). Also, the AAC was the lowest for LL class of 250-299 (*P*<0.05). The cows which calved within summer or within the calving years of 1989-1994 and LL class of ≥500 had the longest CI (*P*<0.05). Also, dairy cows in their third parity and within the LL class of ≥500 had the longest CI (*P*<0.05). Winter-calved cows within the LL class of 450-499 had the greatest AAC (*P*<0.05). Also, cows in their fourth and greater parities and within the LL class of ≥500 had the greatest AAC (*P*<0.05).

The estimated effect of factors affecting the LL of Iranian Holsteins is shown in Table 2. Herd had significant effect on LL (*P*<0.05). LL varied from 89 to 524 d among the dairy herds in this study. Lactation length was the greatest for the period of 2001-2006. Spring-calved cows had the greatest LL but summer-calved cows had the lowest (*P*<0.05). On the other hand, primiparous cows had the greatest LL and cows in their third parity and greater had the lowest LL (*P*<0.05; Table 2). There was a significant interaction effect of year by season on the LL and cows which calved during the spring season and years 2001-2006 had the greatest LL (*P*<0.05). Also, primiparous cows which calved during 2001-2006 or spring season had the greatest LL (*P*<0.05). There were linear and increasing trends for RMY, AMY, AFY and APY over the LL classes in this study (Figures 1 to 3). Also, a linear but decreasing trend was observed for APP over LL classes (Figure 3). Therefore, APP decreased with increasing LL in Iranian Holsteins. In addition, there were non-linear relationships between AFP, CI and AAC with LL classes in this study (Figures 1 and 4). The calving intervall decreased from the first through fourth class of LL and increased thereafter.

Discussion

Average LL in Iranian Holsteins was greater than that in the reports of Bajwa *et al.* (2004) and Ojango & Pollott (2001) who reported on a LL of 248 (in Sahiwal cows of Pakistan) and 300 days (in Holstein-Friesian cattle of Kenya), respectively. Modern Holstein cows have poorer fertility and so extended lactations occur because farmers cannot get cows back into calf early enough to achieve an annual calving interval. In this case, cows with longer lactation periods should have higher yields (Pollott 2011). The other option is that farmers manage the modern higher yielding cow to maximize milk output without regard to annual calving intervals (Pollott 2011). In this case, longer lactations would have greater yields throughout lactation (Pollott 2011). Dematawewa *et al.* (2007) and Pollott (2011) reported that milk yield was higher for longer lactations than usual lactation lengths, but Auldist *et al.* (2007) observed negative relationships between lactation length and annual production of milk and milk solids (milk fat and protein). Aisbett (1984) reported that among 305-d lactations there was a strong correlation between lactation yield and lactation length. Increases in 305-d yields were associated biologically with longer lactation. The biological association between lactation yield and length is strengthened further by management practices of culling and selection. Low yields were typically associated with lactations where daily yield became low shortly after calving.

Longer CI was observed for longer LL in this study and it seems that this could be due to the positive correlation between milk yield and CI, implying that animals that produce more milk have longer calving intervals. Longer CI can occur if higher-yielding animals produce fewer replacements, due to the correlation between calving interval and milk production. Also, a negative energy balance during early lactation in high-producing cows could affect the onset of estrus and hence results in longer CI (Ojango & Pollott 2001). Pollott (2011) proposed that several effects might contribute to longer lactations: greater negative energy balance in early lactation, better persistency and higher daily milk yields at around 305 d of lactation. Similar to the results of this study, Bajwa *et al.* (2004) reported on an increasing trend for LL over the years and primiparous cows had the greatest LL compared to advanced parities in Sahiwal cattle. Also, contrary to the results of current study, Bajwa *et al.* (2004) observed longer LLs for cows calved in summer compared to those calved during winter. Similar to this study, Amasaib *et al.* (2008) reported on a positive and linear relationship between milk yield and lactation length in dairy cows of Sudan. Wilson *et al.* (1987) reported on a correlation coefficient of only 0.08 between lactation length and calving interval in Kenana cattle. Also, Lobo *et al.* (1980) observed that within lactation older cows had longer lactations. Modern Holstein cows have poorer fertility and so extended lactations occur because farmers cannot get cows back into calf early enough to achieve an annual calving interval (Pollott 2011). In this case, cows with longer lactations should have higher peak yields and possibly faster daily increases in milk yield early in lactation; these two factors might contribute to the deeper negative energy balance (Pollott 2011). Cows with longer lactations had a slower rate of increase in milk yield and all lactation lengths had similar maximum secretion potentials. The slower increase in milk yield in early lactation in longer lactations may be due to inadequate energy supply, which may also have caused a later day of peak yield (Pollott 2011). Also, dairy farmers can manage the higher yielding cows to maximize milk yields without regard to annual calving intervals. In this case, longer lactations would have greater yields throughout lactation.

Similar to other countries, concurrent with the increase in milk yield, lactation length increased in dairy herds in recent years mostly due to selection on animals with superior genetics for milk production. Also, increase in the length of lactation in high producing dairy cows could result in poorer reproductive performance and fertility in Iranian Holsteins. Therefore, it seems that the recommendation of either the strategy of extending lactation or standard 305 d lactation lengths depends on the economic considerations in dairy herds.

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