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Influences of Milk Yield and Fertility Traits in the First Lactation on the Length of Productive Life of Holstein Dairy Cows in Iran

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Abstract: The objectives of this study were to evaluate the influences of milk yield and fertility traits in the first lactation on the Length of Productive Life (LPL) of Holstein dairy cows in Iran. Records of Holstein-Friesian cows born from 1993-2006 on 7 large-scale farms were analyzed. The length of productive life was defined as the number of days from first calving to the date of death or culling on the farm. The dependent variable analyzed was LPL. The model included herd, sire, milk yield and fertility traits in the first lactation and also culling year and culling category. Data were analyzed using General Linear Models using the statistical software package JMP. Length of productive life averaged 3.52±0.03 year. The result showed that sire, herd and culling year impacted LPL ($p<0.01$). Length of productive life was impacted by 305-day adjusted milk yield ($p<0.001$) and the LPL was decreased in high producing cows compare with the average cows. The LPL was higher in the cows with eutocia compare with dystocia and stillbirth groups in the first calving ($p<0.01$). Age at first calving had significant effect on LPL ($p = 0.035$). The LPL was impacted by the culling groups ($p<0.001$). LPL for cows which culled due to sold for dairy purposes was the lowest and for reproductive problems was the greatest compare with the other categories. The result of this study demonstrated that in addition to sire and herd effects some other variables had significant impact on LPL.

Key words: Dairy cows, productive life, longevity, milk yield, fertility traits

INTRODUCTION

Herd life or longevity is a measure of the success of the cow to delay both voluntary and involuntary culling. It combines traits related to production, health and fertility. Herd life is the second most important trait after milk production used in selection indices all over the world. It is an easy trait to record. One common way to measure longevity is length of productive life. Productive herd life is the length of time that individual cows remain in herds after their first calving. The length of productive life of the dairy cow is a trait of economic importance for the dairy farmer. If a cow lived 800 d, during that time, she was considered by the dairy producer to be more profitable than her potential replacement. With an improved length of productive life the scope for voluntary culling is improved, the costs for replacements are reduced and the proportion of mature and high producing cows in the herd increases, all of which is beneficial for the farm economy (Essl, 1998). The length of productive life of the dairy cow is a complex trait, influenced by biological and management factors (Petersson *et al*., 2005). Conceptually, the trait productive life is made up of subtraits such as disease resistance, a complex trait in its turn, productivity, reproduction, temperament etc. The relative importance of those sub-traits most probably depends on which environment the cow encounters (Petersson *et al*., 2005). If the complex trait productive life has a different composition in different types of environments, interaction effects between genotype and environment are expected.

Little information is available about survival of dairy cattle in tropical countries, where the adverse environmental conditions result in climatic stress to cattle and affect herd life. The Holstein-Friesian is the most widely used exotic dairy breed in all farming sectors of Iran. Iranian dairy production has undergone significant and considerable structural changes during the last two decades with creation of larger herds. The increased prices for replacement heifers in the last several years have increased the interest in increasing productive life. Information on the productive herd life of these animals in the Iran environment is scarce, yet Length of Productive Life (LPL) is a trait of considerable economic impact.

The objectives of this study were to evaluate the influences of milk yield, fertility and health in the first lactation on the length of productive life of Holstein dairy cows in Iran.

MATERIALS AND METHODS

Records of Holstein-Friesian cows born from 1993-2006 on seven large-scale farms identified as Holstein-Friesian breeders in Iran and registered by the Animal Breeding Center of Iran (ABCI) were analyzed. Farms were located in eastern north of Iran and were enrolled in the official milk-recording scheme. The farms are classified as having medium to high potential for agricultural production. In the selected farms, calving occurred throughout the year. The farm selection was done among those affiliated with at least one of dairy cooperatives and was also based on the farmer's willingness to cooperate in the study. Each farmer had dairy management software in farm to collect the data and manage all dairy operations. Farmers have recorded information about all existing and culled cows. Each cow has been characterized by demographic data (birth date, sire, first calving date), 305 days adjusted milk yield and reproduction data (calving class, sex of calf at calving, next breeding information, days open). Collected data were checked for consistency of data.

Because single sire progeny groups had variable observations to provide a meaningful baseline, sires were grouped into various categories depending on their area of origin. In total, four groups were defined; Iran, Canada, USA and others which include sires originating from European countries. Because of low number of sires originating from European countries, this group was omitted from final data for the statistical analysis.

The length of productive life was defined as the number of days from first calving to the date of death or culling on the farm. Animal records used for analysis had to have a date of first calving and a date of death or culling from the herd. To describe the reasons for culling, the open-ended answers were grouped into 99 groups of primary culling reasons. On account of the small numbers of the observations for some of the primary groups, categories were combined into 8 logical groups including sold for dairy purposes, low milk production, feet and legs problems, reproductive problems, death, mastitis, disease and udder problems. After editing and discarding record with incomplete information, records on 5757 animals were retained for analysis from 6057 animal cards. This study was mainly concerned with looking at the first lactation production and reproduction records.

The dependent variable analyzed was LPL. The model included herd with seven levels, sire with three levels (Iran, Canada and USA), the first parity 305-day adjusted milk yield, first calving class with three levels (eutocia, dystocia and stillbirth), first calving calf sex with 3 levels (male, female, twin), number of insemination to conception after the first calving with three levels (once, twice and three times and more), first calving season with four levels (spring, summer, autumn and winter), the Age at First Calving (AFC) with 23 levels (from 17-40 month, one per month), season of non-return insemination in the first-parity cows with 4 levels (spring, summer, autumn and winter), days from first calving to conception (days open), culling year and culling category with the 8 levels described former. Data were analyzed using General Linear Models. The distribution analyze for the variables was done using the statistical software package JMP (SAS Institute Inc., NC, USA). The means were separated using Tukey HSD multiple range test. Least squares means are reported throughout and significance was declared at $p<0.05$.

RESULTS

Length of productive life averaged 3.52±0.03 year. The upper and lower bounds of a 95% confidence interval were 3.46 and 3.59 year, respectively. The median was 3.1 year and 25 and 75% quartiles were 1.7 and 5.0 year, respectively. Its distribution showed almost a bimodal shape and a progressive decrease (Fig. 1).

First-parity days open averaged 133.93±1.28 days. The upper and lower bounds of a 95% confidence interval were 131.42 and 136.43 day, respectively. The median was 106 day and 25 and 75% quartiles were 72 and 167 days, respectively. Its distribution showed a sharp increase and gradual decrease.

The 305-days adjusted milk yield averaged 6947.61±29.01 kg. The upper and lower bounds of a 95% confidence interval were 6890.73 and 7004.48 kg, respectively. The median was 7061 kg and 25 and 75% quartiles were 5731 and 8239 kg, respectively. Its distribution showed almost a bell sharp (Fig. 2).

Culling year had significant impact on LPL ($p<0.001$) and farmer had different policy in the years to keep or exit the cows. To have a better picture of the year effect, culling year was discretised in two groups, the first 7 years, 1993 until 1999 and recent 7 years, 2000 until 2006. Statistical analysis showed that LPL was decreased in the recent 7 years compare with the preceding 7 years ($p<0.05$, Fig. 3).

The LPL was different among the herds ($p<0.001$). Sire had significant impact on LPL ($p<0.001$) and cows from Canadian sires had greatest LPL. American sires were in the middle and finally Iranian sires had lowest LPL (Fig. 4).

Length of productive life was impacted by 305-day adjusted milk yield ($p<0.001$) and the LPL was decreased with increase in the first-parity milk yield (Fig. 5). The

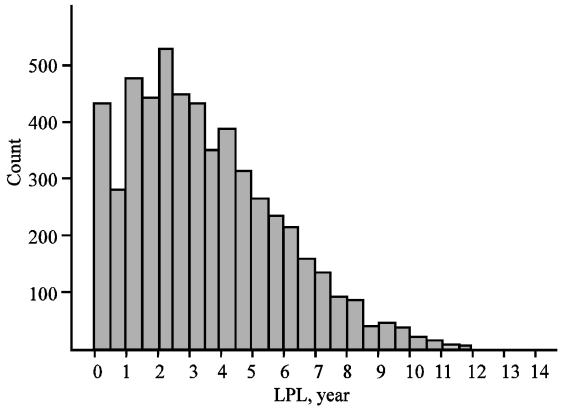

Fig. 1: Length of Productive Life (LPL) in year in the Iranian Holstein cows (SE = 0.03)

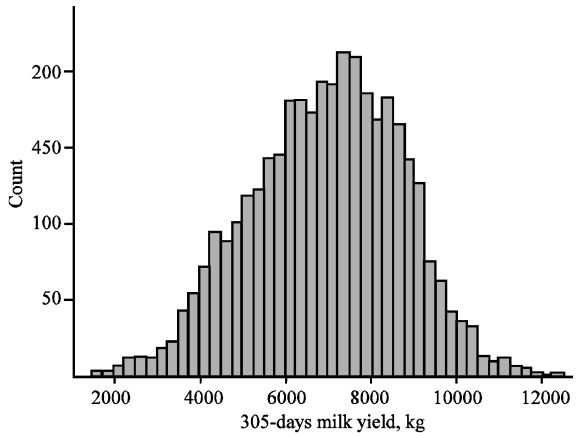

Fig. 2: First-parity 305-days milk yield in the Iranian Holstein cows (SE = 29)

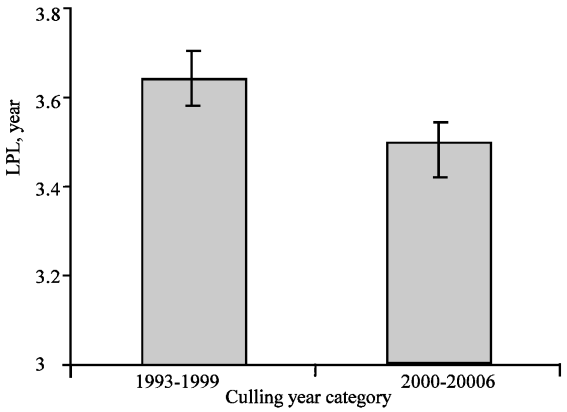

Fig. 3: Length of Productive Life (LPL) in the Iranian Holstein cows during the years

305-day adjusted milk yield was grouped in 3 classes including less than 3500 kg milk, 3500-7600 kg milk and more than 7600 kg milk. The LPL was impacted with the

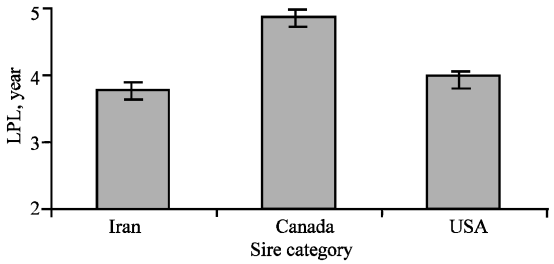

Fig. 4: Length of Productive Life (LPL) in year in the Iranian Holstein cows for sires from Iran, Canada and USA

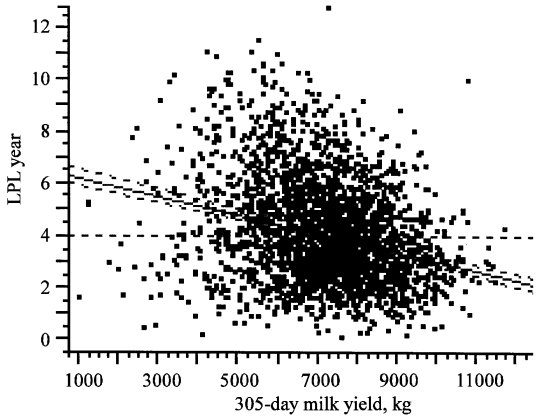

Fig. 5: Length of Productive Life (LPL) in year in the Iranian Holstein cows in relation with 305-d adjusted first-parity milk yield

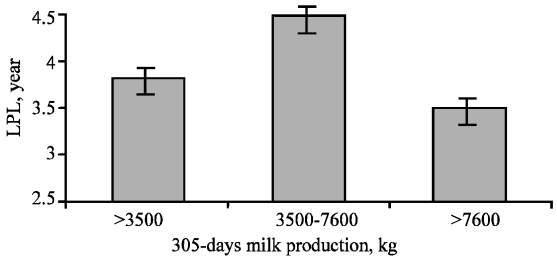

Fig. 6: Length of Productive Life (LPL) in year in the Iranian Holstein cows for different 305-days adjusted milk yield classes in the first calving

milk production groups ($p<0.01$). Statistical analysis showed that cows in low milk production class were culled earlier than the middle class. Cows with the highest yields were also unexpectedly removed early from the herds compare with the middle class (Fig. 6).

First calving class had significant impact on the cow's LPL ($p<0.001$, Fig. 7). The LPL was higher in the cows with eutocia compare with dystocia and stillbirth groups.

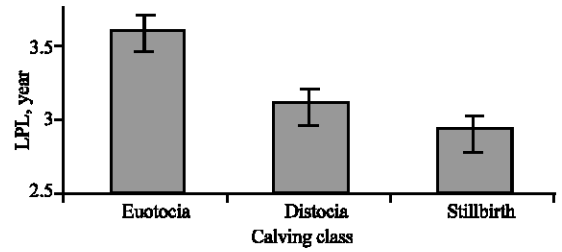

Fig.. 7: Length of Productive Life (LPL) in year in the Iranian Holstein cows for different calving class in the first calving

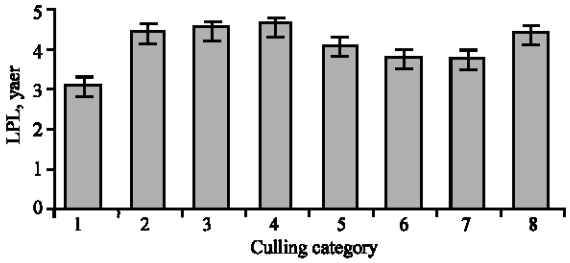

Fig. 8: Length of Productive Life (LPL) in year in the Iranian Holstein cows for different culling category (1= sold for dairy purposes, 2 = low milk production, 3 = feet and leg problems, 4 = reproductive problems, 5 = death, 6 = mastitis, 7 = diseases, 8= udder problem)

Calf sex, season of first conception and first calving and also days open had no impact on LPL. Age at first calving had significant effect on LPL ($p = 0.035$) and the LPL was maximum for cows with the age of first calving at 23 month and then decreased with increase in age at first calving.

The LPL was impacted by the culling groups ($p<0.001$, Fig. 8). LPL for cows which culled due to sold for dairy purposes was the lowest and for reproductive problems was the greatest compare with the other categories.

DISCUSSION

The result of this study showed that the mean LPL was 1285 day and the median was 1131 day. The mean value is larger than reported previously by Nieuwhof *et al.* (1989) or recently by Hare *et al.* (2006) for American Holstein (1050 and 1080 day, respectively). The median value reported in the present study is less than that reported by Terawaki *et al.* (2006) for Japanese cows (1250 day) and larger than that reported by Durr *et al.* (1999) for Canadian Holstein (1078 day). The diverse management systems and economic contexts are, of course, largely responsible for these differences. Result of the present study also showed that the herd had significant impact on LPL. Length of productive life is influenced not only by the cow's production ability but also by the herd management policy. This management policy has a larger influence on longevity than on production traits. Therefore, it is expected that the suitable model differ over countries and regions that have different dairy production systems (Terawaki *et al.*, 2006).

Our result showed that the LPL was decreased during recent years. In agreement with our results Nieuwhof *et al.* (1989) found declines in productive herd life during the years. Another study by Vanraden and Wiggans (1995) showed that mean Productive Life (PL) decreased by approximately 2 month for cows born during the 1980s compared with mean PL during previous decades. Rizzi *et al.* (2002) also showed that both lifetime and production performances decreased over the years in Venezuelan Holstein cows. Decrease in LPL was also reported in other breeds. In one of these studies it was shown that LPL decreased over years in Brown Swiss cows (Vukasinovic *et al.*, 1997). The effect of year on LPL is not consistent in the literature. A recent study by Hare *et al.* (2006) showed that productive herd life began to increase slightly during the most recent years. Decreased LPL in the present study means that cows were culled earlier during recent years which could impacted the farm profitability. The largest effect of longer productive life is decreased replacement costs. Longer productive life also leads to a higher proportion of cows that are in later, high producing lactations. This allows the cow an opportunity to achieve mature production levels (Essl, 1998). An increase in length of productive life from three to four lactations increases milk yield per lactation and profit per year by 11-13% (Strandberg, 1996). Herd life has higher economic value than many traits currently evaluated and may be about one-third as important as yield, based on an average of recent estimates (Vanraden and Wiggans, 1995). More studies needed to evaluate the impact of early culling on economy of Iranian farms. On the other hand, decreased in LPL during the recent years also showed that, in general, the mean risk to cull cows tends to increase slightly from one year to the next. This increase could be explained by more intensive selection in the recent years. As cows have improved, culling standards have been raised. A downward environment trend has occurred because cows that once were competitive now would be culled.

The result of this study showed that age at first calving impacted LPL. The LPL was increased with age at first calving and reached the maximum at 23 month and then decreased. Ducrocq (1994) also reported negligible

effects of the age at first calving on the length of productive life in dairy cows. Other study on Brown Swiss cows also showed similar result (Vukasinovic *et al*., 1997). They showed that the change in log likelihood that was associated with the age at first calving was very small compared with that of the other effects. Therefore, this effect was considered to be unimportant. Another recent study showed a negative linear regression of mean productive herd life on year of first calving (Hare *et al*., 2006). Decreased LPL with increase in age at first calving after 23 month of age at the present study is in agreement with Sewalem *et al*. (2005) study which found that heifer older at first calving were at a higher risk of being culled than those calving at intermediate ages. Ojango *et al*. (2005) recently also showed that animals that calved very early and those that calved late were at a higher risk of being culled than those in the other classes. Very early breeding of animals may have negative consequences on the LPL due to complications of difficult calving, lower milk production and poor general body condition (Ojango *et al*., 2005).

The result of present study demonstrated that the LPL of cows culled because of sold for dairy purposes was the lowest among the other groups. In agreement with our study other research also showed that low producing cows are at higher risk than their herdmates with average production and high producing cows are less likely to be culled (Vukasinovic *et al*., 1997). Other studies also showed the detrimental impact of low milk production on LPL (Ducrocq *et al*., 1988; Ducrocq, 1994; Beaudeau *et al*., 1995). Durr (1997) showed that the greatest risk of being culled due to low production was in the first lactation. Reduction of production costs can allow profitability of dairy farms to be maintained. The lower risk of culling for high producing cows might also be caused by the preferential treatment of these top cows (Essl, 1989). More attention is now given to health management to minimize losses from health disorders. The contribution of culling to disease-related losses can be high. In many cases, involuntary cullings are related to health disorders. In agreement with our result, Beaudeau *et al*. (1995) showed that health disorders occurring in lactation 1 had a high impact on longevity, especially in the first few months following occurrence. All the udder disorders investigated were significantly related to LPL. They also showed a particularly high impact of these disorders when they occur in first lactation.

Our result showed that LPL was higher for the reproductive problems. There was a consistent increase in the risk of being culled due to fertility problems with increasing parity, indicating that older cows are more likely to be culled for this reason than their younger counterparts (Roxstrom and Strandberg, 2002).

The result of the present study showed that cows with mastitis in their first lactation had lower LPL compare with the cows with reproduction problem. In contrast with our results, Roxstrom and Strandberg (2002) showed that in first parity risk of being culled due to mastitis was low and the overall risk of being culled due to mastitis was less than the risk of being culled due to fertility problems. The discrepancy between the results might be because of the price of replacement. Farmers, in Iran, prefer to keep cows with reproduction problem in herd for a longer period but in case of mastitis and because of the significant impact of mastitic cows on farm economy, cows with repeated mastitis would prefer to be culled in lower LPL.

Our result showed that with increase in first parity 305-day milk yield, the LPL was decreased. The analysis on the 305-day milk yield classes revealed that the cows in the middle group were remained longer than the cows in lower and upper groups. It seems that cows with the lowest 305-day milk production were removed voluntarily. A shorter than expected stay of high producing cows in the herd may be explained by culling for reasons other than production such as health disorders and unsatisfactory reproductive performances (involuntary culling). These results are comparable to findings by Ducrocq (1994), Weigel *et al*. (2003) and Ajili *et al*. (2007). On the other hand, harsh conditions in the summer (Heat stress) and food shortages in some cases may compromise performances of cows with high potentials for milk production (Ajili *et al*., 2007).

According to our results, first-parity days open and number of AI to conception had no significant impact on LPL. Erb *et al*. (1985) and Milian-Suazo *et al*. (1989) investigated days to first AI and number of AI as risk factor for culling. In another study the risk of cows being culled increased when days open increased, regardless of the lactation number. The high risk associated with days open = 210 day, regardless of lactation number, stressed that farmers probably consider high losses caused by excessive calving interval in making culling decision but also seek compromise accounting forage and milk production of the cows (Beaudeau *et al*., 1995). The mean days open in the present study for first-parity cows was 134 days which was not considered as a risk factor for culling.

The result of present study showed that variable LPL of Iranian Holstein was obtained according to the area from which sires originated. Daughter of Iranian Holstein bred sires were at the highest risk of being culled earlier relative to those from USA and Canada. Similar results were observed in another study comparing Kenyan bulls to other regions (Ojango *et al*., 2005). This could show preferential preferences for treatment of daughter of

Canadian and American sires relative to those of Iranian born sires. On the other hand, a proper genetic evaluation of Iranian sires would lead to prolonged LPL in the herds for their daughters.

CONCLUSION

Result of the present study demonstrated that in addition to sire and herd effects some other variables had significant impact on LPL. Among them first-parity production and reproduction variables including 305-day adjusted milk yield, first calving class and age at first calving significantly impacted LPL. Culling year and reason also had significant effect on LPL. Multitrait evaluation might produce higher reliabilities for productive life by inclusion of correlated traits measured earlier in life such as yield and some reproductive traits.

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