Iranian Journal of Applied Animal Science

Criteria Verification of Adaptability in Dairy Cattle of Iran's Industrial Holstein Mega-Farms

Research Article

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Received on: 17 Oct 2024
Revised on: 1 Jan 2025
Accepted on: 17 Jan 2025
Online Published on: Mar 2025

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Online version is available on: www.ijas.ir
https://doi.org/10.71798/ijas.2025.1202947

ABSTRACT

One of the main tools of genetic improvement in developing countries is the importation of semen from elite bulls for special characteristics. As the biggest challenge is the adaptability of the semen progeny to new environmental conditions, this study was designed and carried out to investigate the effects of the environment on the productive life of dairy cows at industrial mega-dairy farms in Iran. Data of 113584 culled cows from 20 industrial Holstein mega dairy farms located in 14 provinces of Iran (March 2006 to February 2022) were collected and analyzed using the chi-square method in SAS 9.4. The results showed that the true productive life (TPL) was significantly affected by the amount of milk production (305/Day/3x) and the peak of milk production (kg/day) and a high degree of positive regression was observed. Ranchers seem to be more careful in keeping highly productive cows because this is a cost-effective measure. To verify the performance of the imported semen, 70 sires with the highest number of daughters were selected. These sires had 23,222 daughters (20.44% of the data) in their covered herds. It is concluded that whatever is mentioned in sire catalogues for the PL and the TPL in the daughters' performance is different based on climate and functional conditions. Thus, it is recommended that a reference population for PL and milk production be created based on the local farm conditions to get optimum adaptability.

KEY WORDS adaptability, genetics and environment interaction, Holstein, mega-dairy farm.

INTRODUCTION

The criteria for cows' adaptation to milk production technology are the realization of the genetic potential of productivity and its retaining under extreme stimuli, the ability to reproduce healthy offspring, the time of economic use, and the resistance to diseases (Ulimbashev and Alagirova, 2016). The productive life (PL) and milk production (3x/305/kg/day and peak of milk production) had the main role in investigating adaptability in two different climates and management and because of that these were designed and done. The productive lifespan of dairy cows in the United States, the leading country in the dairy industry, averages approximately 3 years after the first calving (De-Vriest, 2020), which means that some animals do not have the opportunity to develop their production potential, which is observed in the 3rd or higher lactation. The USDA selection indexes from USDA included yield traits beginning in 1971, productive life and somatic cell score beginning in 1994, conformation traits in 2000, and cow fertility and calving ease in 2003 (VanRaden, 2004). Cow longevity is recognized as an important trait for improving farm economic performance, while concurrently reducing environmental and social impacts. However, there is an economic trade-off between longevity and herd genetic improvement, which may influence dairy farm efficiency and productivity growth over time (Beshir, 2021). Sasaki *et al.* (2018) reported that economic value was linearly correlated with herd-life length, the linear regression coefficients between these factors could be used to estimate the economic value of herd-life length which longer herd life means a higher benefit. Lurdes Kern *et al.* (2016), assess the most important factors that influence the PL of Brazilian Holstein cows and estimate genetic parameters for PL. Since the quality of the PL of the animal is calculated after the end of the life of the animal, VanRaden and Wiggans (1995) suggested that multi-trait evaluations might produce higher reliabilities for PL by including correlated traits measured earlier in life, such as yield, type, and somatic cell score.

Stevenson and Lean (1998) reported that the age at first calving was not a significant risk factor for culling. Milk production in the first lactation was greater than the population mean and did not influence the length of productive life overall but was associated with a greater risk of removal of disorders of the udder. The risk of culling for reproductive failure differed significantly between farms and was not related to events in the previous lactation period, such as calving to first service interval or calving-to-conception interval. Shorter calving intervals were associated with an increased risk of removal due to low milk production and disorders of the udder. The main aim of this study was to investigate the real performance of the daughters of used sires in our mega dairy farms and compare it with what was mentioned in the sire's catalogue, especially for the PL trait, to find a proper breeding strategy for having more profitable and low-difficulty cows that have a longer stay ability in the farms.

Litwińczuk *et al.* (2016) investigated the length of life and milk production efficiency in cows with varying lactation persistency and reported that lactation persistency significantly influenced (P≤0.01) the length of life and milk production efficiency in the analyzed cow population. Cows with a yield of over 30 kg at the peak of lactation followed by a moderate decrease (40%) lived the longest (over 6 years) and produced the most milk (nearly 28000 kg). The yield of primiparous cows at the peak of lactation and its course was found to have a significant effect on the length of life and lifetime of milk production. The long period of high peak yield (over 30 kg of milk) in the primiparous cows in group I (with the best lactation persistency) in the long term proved to be detrimental, as these cows had the shortest productive life (2.3 lactations on average) and lifetime milk yield about 4,000 kg lower than in the cows in groups II and II (with poor lactation persistency).

Yamazaki *et al.* (2014), investigated genetic correlations among female fertility, 305-day milk yield and persistency during the first three lactations of Japanese Holstein cows and concluded that when selecting to increase lactation persistency, indicators of female fertility must be included in the genetic evaluation to reduce undesirable side effects on fertility in cows.

Sowula-Skrzyńska *et al.* (2023), inquire thermal stress influence on the productive and economic effectiveness of Holstein-Friesian dairy cows in temperate climate and reported that with a change in microclimate conditions in the barn, a decrease in the daily production and changes in the milk chemical composition were noted, and the economic efficiency of the studied activity decreased. From the results of this study, it can be concluded that daughters of the same sperm in different climatic conditions will have different functions, and their economic efficiency will be different.

Prastowo *et al.* (2019) investigated the milk production of imported Holstein cows in different environments and reported that imported cows underwent extreme adaptation processes to be able to live optimally in a new environment that would modify their physiology. We suspect that environmental changes and resource differences between tropical and subtropical climates trigger different trait expressions to explain this phenomenon.

Clasen *et al.* (2024) investigated the effects of herd management decisions on dairy cow longevity, farm profitability, and emissions of enteric methane, a simulation study of milk and beef production, which reported that reducing the number of replacement heifers needed to improve cow reproductive performance is thus key to increasing cow longevity and profitability while reduction enteric CH_4 emissions from the herd without compromising milk and meat production.

Because the calculation of PL is calculated after removing the cow from the herd, most studies have been carried out as an estimate of the PL trait using the correlation of this trait with other traits. In this study, the true productive life (TPL) was calculated using a large amount of data (113584 removed cows), and its correlation with the amount of PL estimated in sperm catalogues was compared. In other words, in this study, the amount of TPL in a different climate (Iran's industrial mega-dairy farms) was compared with the PL estimated in sperm catalogues; a higher TPL in cattle indicates a higher adaptability of the cow, increasing profitability.

MATERIALS AND METHODS

The data of culled cows from 20 industrial mega-dairy farms (Holstein Frisian cows) in Iran during the past 16 years (March 2006 to February 2022) were collected, and finally, 113584 culled cows were analyzed.

The average herd size was 2179 Holstein-Frisian cows (maximum: 5200, minimum: 385 cows), and the farms were located in 14 provinces in Iran. The average standard 3x/305/kg/day milk yield was 12342 kg in the 3rd lactation, and the average age of culled cows was 1890 days, with an average of 997 milking days. The data from 113584 culled cows were descriptively analyzed. Currently, 18 under-analyzed herds have more than 1000 productive animals, and the average number of animals in the herds under analysis was 2179. The total number of breeding cows in the 20 herds was 43,587. The breeds of animals in these herds are all Holstein Friesians of North American origin, which produce industrial milk with 100 percent HF blood-line or can be registered as purebred. Cows were kept in completely semi-closed barns and managed professionally. Currently, the average milk production of herds is > 40 kg per head of dairy cows.

The method of calculating the true productive life (TPL) of animals is to calculate the number of days the animal has been in the herd and given milk, which has been reported for each animal (Kharitonov *et al*. 2022). In other words, all the days after the first calving of the animal until the time of removal from the herd by removing the dry days of the animal in each lactation period were calculated using computerized software, and the output was reported as the TPL of the animal. In international reports, the lifespan of livestock is reported in units of months, as in this report.

RESULTS AND DISCUSSION

The descriptive statistics for the TPL of livestock as a main factor of adaptability were obtained by the univariate command in SAS 9.4 software (SAS, 2014) as shown in Table 1.

Table 1 Descriptive statistics of the true productive life (month)

Moments			
N	113584	**Sum weights**	113584
Mean (month)	33.6	**Sum observations**	3813436
Std deviation	20.8	**Variance**	432
Skewness	0.80	**Kurtosis**	0.650
Uncorrected SS	177049714	**Corrected SS**	49018536
Coeff variation	61.9	**Std error mean**	0.0616

As shown in Table 1, 113584 data points were analyzed, and there were no missing data. The average TPL of the animals under investigation was 33.57 ± 20.77 months, which shows that the animals had an average of 33.57 months of milk production (not counting dry days during the milk production period) till they were removed from the herd.

These results were supported by those reported by Hare *et al*. (2006). As is clear from the data distribution diagram of the real lifespan of livestock (Figure 1), the distribution of this data is different from the bell diagram, and the expectation of complete normality of these data may not be a good expectation owing to the large volume of data and the fact that one side of the diagram is broken. Therefore, the measures taken to normalize the data were not successful. Figure 1- Distribution of true productive life (months). To investigate adaptability, linear regressions between TPL, milk production (3X/305/kg/day) and peak milk production (kg/day) (Table 2) were performed.

In this analysis, the variable of TPL was considered as a dependent variable, and the variables of milk production (3x/305/kg/day) and peak milk production (kg/day) were considered as independent variables. The amount of R square for this analysis was calculated as 12.15%, which according to the high amount of data under analysis and the number obtained from the data output shows the rejection of the null hypothesis that the variable of TPL is independent, as well as the production of milk (3X/305/kg/day) and the peak of milk production (kg/day). In other words, TPL is significantly affected by the amount of milk produced and peak milk production.

As seen in Figure 1, there is a high degree of regression between TPL (as a dependent variable) and milk production and the peak of milk production. The regression formula is calculated as below:

TPL= 1.8058 + 0.0017 Milk Production + 0.2905 peak of Milk Production.

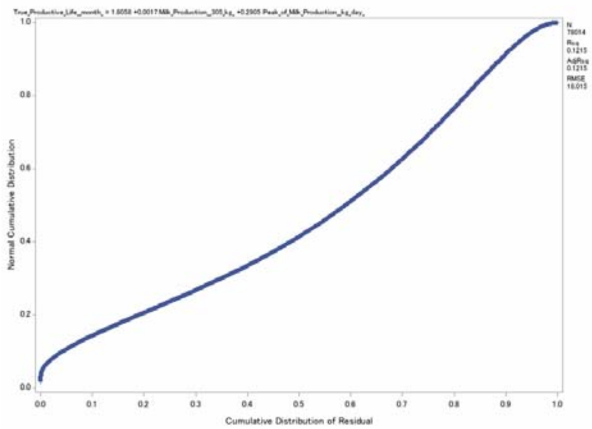

Figure 1 Regression between the TPL (as a dependent variable) and milk production (3x/305/kg/day) and the peak of milk production (3x/305/kg/day)

The TPL of livestock production increases with a higher amount of standard milk production (3x/305/kg/day) and also with a higher peak of milk production (kg/day, Table 2).

Table 2 Linear regression between TPL, milk production (3x/305/kg/day) and peak of milk production (kg/day)

Variable	df	Parameter estimate	Standard error	t Value	Pr > |t|
Intercept	**1**	1.81	0.382	4.72	<0.0001
Milk production (3X/305/kg/day)	**1**	0.0017	0.0000	44.3	<0.0001
Peak of milk production (kg/day)	**1**	0.291	0.0099	29.4	<0.0001

Table 3 Correlation between the TPL with milk production of 305 days, and peak of milk production

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	Milk Production 3x/305/kg	Peak of milk production kg/day	True productive life month
Milk production (3x/305/kg/day)	1.00	0.747	0.333
		<0.0001	<0.0001
	78036	78014	78036
Peak of milk production (kg/day)	0.747	1.00	0.479
	<0.0001		<0.0001
	78014	111276	111276
True productive life (month)	0.333	0.479	1.00
	<0.0001	<0.0001	
	78036	111276	113584

In other words, cows with higher milk production (3x/305/kg/day) and higher peak milk production (kg/day) will have a longer TPL. To investigate the effect of interaction between environment and genetics in the data under investigation, the number of 70 sires that had the highest number of daughters were selected. These sires had 23222 daughters (20.44% of data) in the covered herds. The average number of daughters in these sires in the data was 332 (maximum 798 and minimum 220 daughters), as shown in Table 3. The latest evidence of these sires (CDCB & HA-USA Genetic Evaluations 12/2023) was gathered. TPL data were classified into 22 classes (8 to -13), and the PL data in the catalogue were classified into nine classes (3-5). The difference between the daughters' performance and PL claimed in the catalogue was analyzed using SAS 9.4 software with the chi-square method. As shown in Table 4, daughters' performance under the climatic and functional conditions of the industrial herds of dairy cows in Iran is significantly different from the figures mentioned in the sire catalogues.

The high correlation between the TPL and the peak of milk production indicates that the animal that had a higher production peak also had a higher PL in the herd, and this is contrary to the claim made regarding the reduction of livestock longevity due to pressure on production.

Table 4 Descriptive statistics of the number of sire daughters

Moments			
N	70	**Sum weights**	70
Mean	332	**Sum observations**	23222
Std deviation	113	**Variance**	12751
Skewness	1.52	**Kurtosis**	2.93
Uncorrected SS	8583558	**Corrected SS**	879825
Coeff variation	34.0	**Std error mean**	13.5

Table 5 Chi-Square of difference between TPL and PL in the catalogue

Statistics for Table of NAAB code by CLASIFIED_DIFFERENCE			
Statistic	**df**	**Value**	**Prob**
Chi-Square	552	2812	<0.0001
Likelihood Ratio Chi-Square	552	3188	<0.0001
Mantel-Haenszel Chi-Square	1	3.40	0.0651
Phi coefficient		0.329	
Contingency coefficient		0.123	
Cramer's V			
Sample size= 23222			

The results of this research are consistent with those of VanVleck (1964), Mendes *et al.* (2021), Jenko *et al.* (2015),and Rodríguez-Godina *et al.* (2021), but conflict with those of Dallago *et al.* (2021), Ulimbashev and Alagirova (2016), and Ajili *et al.* (2007). De Vries and Marcondes (2020) also reported other factors that affect the productive life of cows. However, the following factors can be considered influential in this regard:

• Paying more attention to the ration and quality of the feed along with the comfort of the high-producing cows
• More diagnosis and more appropriate treatment for high-yielding cows.
• More attention in deciding to remove cows with high milk production.

The high correlation between TPL and milk production shows the animals with better milk persistency, as a result, have a higher milk production in a lactation period and have a higher TPL. The result of this review can lead to the recommendation that when the milk production in cows is high, she will have higher adaptability or TPL too. However, the reason for this can be attributed to the following:

- In commercial milk production herds, keeping cows with high milk production is the main goal of that herd.
- Considering the high production of these cows, spending on good nutrition and animal welfare is economically justified.
- Faster detection of sick and estrous cows in the pens of cows with high milk production

From the results of this study, it can be concluded that the adaptability of sires' offspring is low and claim in the sire catalogues for the PL performance of the cows under investigation has a significant difference with the real TPL observed in the performance of the daughters of those sires in the climate and functional conditions of the industrial dairy herds of Iran. In other words, the interaction between the environment and genetics causes significant differences between figures mentioned in the sire catalogues and their true performance in different geographical and managemental conditions like industrial dairy farms of Iran. This result was supported by Sowula-Skrzyńska *et al.* (2023). This study is one of the few studies in which the real adaptability of more than 110000 removed cows was calculated and evaluated with the claim made in the catalogues for the PL trait. Because the number of sperms used in the herds under investigation was very high, only the sperms that had the highest number of daughters in the herds and had a minimum performance of 200 daughters were used in the performance comparison with the catalogues.

Toledo *et al.* (2024) mentioned that increasing cow comfort by making management adjustments to decrease exposure to high temperatures during the hot months allows farmers to decrease culling risk factors and possibly increase cow productive life. Perhaps the warmer climatic conditions of Iran are one of the main reasons for the difference between the calculated TPL and the PL claimed in the catalogues.

Based on the obtained results, it can be suggested that to evaluate the adaptability and better performance of sire in the conditions of industrial herds of dairy cows in Iran, it is advisable to repeat the study with more data which led to having a safe margin with higher accuracy when choosing a sire for proper traits viz, TPL as a national reference base or index. VanRaden (2004) advised that breeding programs should estimate future costs rather than current costs and prices. De-Vriest (2020) was advised that increases in genetic gain, reproductive efficiency, cow comfort, and health care will increase the opportunity for herd managers to change true productive life to increase profitability, improve societal acceptance of dairy production, or both. Adamczyk *et al.* (2018), he suggested taking milking temperament into account in breeding practice, as this trait is closely related to the longevity characteristics of dairy cows.

CONCLUSION

From this study, it can be concluded that with the idea of more pressure selection on milk production in cows, the PL of cows will decrease, not only is it not correct, but cows with high milk production will also have a longer PL. From the high positive regression between milk production and the peak of milk production with TPL, it can be concluded that farmers are more careful in keeping highly productive cows because this is a cost-effective measure for them. Due to the low heritability of the adaptability trait, it is suggested to determine a special selection index in future studies by using traits related to adaptability, so that by using it in the selection of future sperms, it is possible to increase the improvement in adaptability of the next generation of cows.

ACKNOWLEDGEMENT

The authors thank Pars Holding Company in Iran for supporting this article with farm data. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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