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Relationships between production and fertility traits in first lactation and life time performances of Holstein cows under subtropical condition

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Abstract

The objective of this study was to determine the relationships between milk yield and calving interval in first lactation and breeding efficiency, herd life and length of productive life of 1 293 Holstein cows maintained at Ceylanpinar State Farm in Southeast Anatolia from 1990 to 2002.

The least-squares means of first lactation milk yield, lactation length and calving interval were 5 620.1±76.6 kg, 315.5±2.0 and 386.9±2.6 days. The values for breeding efficiency, herd life and length of productive life were 94.9%, 2 095.9±34.7 and 1 257.2±34.4 days. The year of first lactation had significant effect ($P<0.05$) on all traits except for calving interval and lactation length, and breeding efficiency was only affected by age at first insemination and age at first calving ($P<0.05$).

Heritabilities were 0.27±0.08 for milk yield, 0.02±0.05 for lactation length, 0.06±0.05 for calving interval, 0.05±0.05 for breeding efficiency, 0.30±0.08 for herd life and 0.29±0.08 for length of productive life. Genetic and phenotypic correlations between different traits ranged from −0.49 to 0.99 and −0.37 to 0.99 respectively.

Keywords: milk yield, calving interval, breeding efficiency, herd life, length of productive life, Holstein cows

Zusammenfassung

Beziehungen zwischen Milch- sowie Fruchtbarkeitsleistungen in der ersten Laktation und Lebensleistung von Holsteinkühen unter subtropischen Bedingungen

Untersucht wurden bei 1 293 Holsteinkühen der staatlichen Ceylanpinarfarm in Südostanatolien die Beziehungen zwischen der Erstlaktationsleistung, mehreren Fruchtbarkeitsmerkmalen und der Nutzungsdauer. Die durchschnittliche Laktationsleistung lag bei 5 620 kg Milch bei eine Laktationsdauer von 316, einem Kalbeintervall von 387, einem Lebensalter von 2 096 und einem Nutzungsalter von 1 257 Tagen. Außer dem Kalbeintervall, dem Alter bei Erstbesamung und dem Kalbealter beeinflusste die Erstlaktationsleistung sämtliche anderen Merkmale signifikant. Die Heritabilitätsschätzwerte sowie die genetischen und phänotypischen Korrelationen werden dargestellt und diskutiert.

Schlüsselwörter: Erstlaktationsleistung, Fruchtbarkeitsmerkmale, Kalbeabstand, Lebensalter, Nutzungsdauer, Holstein Kühe

Introduction

High milk yield, regular fertility, and improved herd and length of productive lives are desired traits for dairy animals. Latter two ones have significant effect on economic advantage by reducing replacement and increasing the number of cows producing at mature levels in a herd (SZAJKO 1987, KALM 2002). These characters are influenced by several factors such as inheritance, year, season, parity, feeding, management and age at first calving. Lower age at first calving and the ability to produce longer years are charming for high yielding cows. VUKASINOVIC *et al.* (2001) reported that age at first calving did not have a significant influence on the length of productive life. However, some researchers (PIRLO *et al.* 2000, MARTINEZ *et al.* 1983) emphasized that the reduced age at first calving decrease the generation interval and feed costs, but may also reduce calf liveability at the same time because of dystocia.

According to various studies herd life and length of productive life ranges from 1716 to 3737 and 903 to 2792 days in different breeds. (NIEUWHOF *et al.* 1989, HARRIS *et al.* 1992, SETTAR and WELLER 1999, FREYER and ERHARDT 2000, RIZZI *et al.* 2002, NILFOROOSHAN and EDRISS 2004, TSURUTA *et al.* 2005, GOSHU 2005, DAKAY *et al.* 2006)

Heritability estimates ranged from 0.22 to 0.40, 0.03 to 0.09, 0.04 to 0.14, and 0.03 to 0.12 for first lactation milk yield, calving interval, herd life and length of productive life respectively. Genetic and phenotypic correlations of production traits with herd and length of productive lives were from −0.08 to 0.91 and 0.04 to 0.55 (VAN DOORMAL *et al.* 1985, HARRIS *et al.* 1992, JAIRATH *et al.* 1995, VOLLEMA and GROEN 1996, SETTAR and WELLER 1999, CRUICKSHANK *et al.* 2002, ROXSTRÖM and STRANDBERG 2002, HAILE-MARIAM *et al.* 2003a, HAILE-MARIAM *et al.* 2003b, SEELAND and HENZE 2003, NILFOROOSHAN and EDRISS 2004, KHATTAB *et al.* 2005, TSURUTA *et al.* 2005, GADER *et al.* 2007).

The purpose of this investigation was to determine relationships of first lactation milk yield and calving interval with breeding efficiency, herd and length of productive lives of Holsteins in subtropical conditions.

Material and methods

Records of 1 293 Holstein cows maintained at Ceylanpınar State Farm from 1990 to 2002 were used in this study. The area has subtropical climate conditions and geographical coordinates are 36.84 °N and 40.02 °E. The climate of area is characterized by hot summers. The meteorological data are given in Figure 1.

Milk yield, lactation length and calving interval in first lactation, and breeding efficiency, herd life and length of productive life were examined.

The breeding efficiency (BE) (WILCOX *et al.* 1957) was estimated as

$$\%BE = \frac{365(N-1)\cdot 100}{D} \quad (1)$$

where is N the total number of parturitions and D the number of days from first to last parturition.

Herd life was defined as the number of days from date of birth to date of culling. Length of productive life was defined as the number of days from first calving to date of culling.

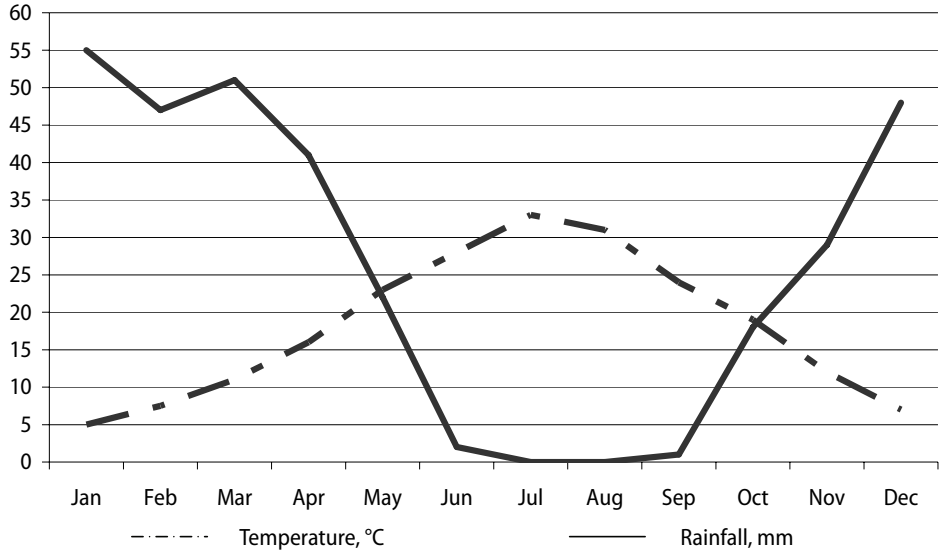

Figure 1
Temperatures and rainfall for Ceylanpınar State Farm
Temperaturen und Regenmenge im Untersuchungsbetrieb

Data were analyzed using linear mixed model least squares and maximum likelihood (LSMLMW) computer program of Harvey's (HARVEY 1987). The traits were analyzed with a model that included 1 random (sire), 4 fixed effects (first calving year and season, age at first insemination [AFI], age at first calving [AFC]). Calving years were grouped into 3 periods *viz.* (1) 1990-1994, (2) 1995-1998 and (3) 1999-2001. Calving months were classified into 4 seasons *viz.* (1) winter: December-February, (2) spring: March-May, (3) summer: June-August, (4) fall: September-November. AFI were classified into 3 group *viz.* (1) 15-17th month, (2) 18-19th month and (3) 20-25th month, and AFC were subdivided into three groups *viz.* (1) 24-26th month, (2) 27-28th month and (3) 29-34th month.

Only 82 sires with greater than or equal to 5 cows were included in the analysis. Heritabilities (h^2), genetic (r_G) and phenotypic (r_P) correlations by paternal half-sib method were computed by LSMLMW program of Harvey's (HARVEY 1987).

Results

Least-squares analysis of different traits

The least-squares means are presented in Table 1. Calving year had significant effect ($P<0.05$) on all traits except for lactation length and calving interval. The effect of season on milk yield, lactation length and breeding efficiency were significant ($P<0.05$). Age at first calving were significant ($P<0.05$) for only breeding efficiency. The over all means for milk yield, lactation length, calving interval, breeding efficiency, herd life and length of productive life were 5 620.1±76.6 kg, 315.5±2.0, 386.9±2.6, 94.9±0.5%, 2 095.9±34.7, and 1 257.2±34.4 days, respectively.

Table 1
Least squares means and standards errors for different traits
Mittelwerte nach der Methode der kleinsten Quadrate und Standardfehler der untersuchten Merkmale

Classification	*N*	Milk Yield, kg	Lactation length, days	Calving interval, days	Breeding efficiency, %	Herd life, days	Length of productive life, days
		$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$
μ	1 293	5 620.1±76.6	315.5±2.0	386.9±2.6	94.9±0.5	2 095.9±34.7	1 257.2±34.4
Calving year		**			**	**	**
1990-1994	370	5 006.0±156.7^{b}	305.2±6.0^{a}	371.3±7.1^{a}	99.1±1.3^{a}	2 487.1±69.1^{a}	1 651.8±69.0^{a}
1995-1998	693	6 070.9±122.6^{a}	315.9±4.4^{a}	391.8±5.3^{a}	94.0±1.0^{b}	2 002.9±54.4^{b}	1 165.0±54.2^{b}
1999-2001	230	5 783.4±169.0^{a}	325.5±6.5^{a}	397.4±7.8^{a}	91.5±1.4^{b}	1 797.6±74.5^{c}	954.8±74.4^{c}
Season		**	*		*		
Winter	334	5 822.2±101.4^{a}	317.6±3.4^{ab}	389.2±4.1^{a}	95.3±0.7^{a}	2 118.6±45.3^{a}	1 280.8±45.0^{a}
Spring	405	5 843.4± 96.4^{a}	321.7±3.1^{a}	392.2±3.8^{a}	93.4±0.7^{b}	2 110.5±43.1^{a}	1 273.0±42.9^{a}
Summer	288	5 317.8±104.5^{b}	310.2±3.6^{b}	385.5±4.3^{a}	94.8±0.8^{ab}	2 070.5±46.6^{a}	1 230.5±46.4^{a}
Autumn	266	5 497.0±107.8^{b}	312.6±3.7^{b}	380.6±4.4^{a}	96.0±0.8^{a}	2 083.9±47.7^{a}	1 244.5±47.5^{a}
Age at first insemination, month							
15-17	602	5 738.4±124.1^{a}	318.0±4.5^{a}	390.6±5.4^{a}	93.2±1.0^{a}	2 078.6±55.0^{a}	1 266.4±54.9^{a}
18-19	477	5 564.8±106.4^{a}	314.5±3.7^{a}	384.1±4.4^{a}	94.3±0.8^{a}	2 100.3±47.4^{a}	1 268.3±47.2^{a}
20-25	214	5 557.1±162.8^{a}	314.0±6.3^{a}	385.8±7.4^{a}	97.1±1.4^{a}	2 108.8±71.8^{a}	1 236.8±71.7^{a}
Age at first calving, month					*		
24-26	504	5 489.9±140.6^{a}	310.5±5.3^{a}	376.6±6.3^{a}	96.8±1.1^{a}	2 059.0±62.1^{a}	1 261.8±62.0^{a}
27-28	509	5 566.5±109.4^{a}	314.6±3.8^{a}	386.2±4.6^{a}	95.8±0.8^{a}	2 106.3±48.7^{a}	1 275.3±48.5^{a}
29-34	280	5 803.8±136.8^{a}	321.4±5.1^{a}	397.7±6.1^{a}	92.1±1.1^{b}	2 122.4±60.5^{a}	1 234.5±60.4^{a}

^{a,b,c} subclass means followed by different superscripts are significantly different ($P<0.05$), *$P<0.05$, **$P<0.01$

Heritabilities, genetic and phenotypic correlations

Heritabilities, genetic and phenotypic correlations among investigated traits are shown in Table 2.

Table 2
Heritabilities, genetic and phenotypic correlations among different traits[1]
Heritabilitätsschätzwerte, genetische und phänotypische Korrelationen der untersuchten Merkmale

Traits	Milk yield	Lactation length	Calving interval	Breeding efficiency	Herd life	Length of productive life
Milk yield	0.27±0.08**	0.70±0.47	0.16±0.36	−0.49±0.54	0.08±0.21	0.08±0.21
Lactation length	0.63	0.02±0.05	0.64±0.44	<−1†	0.10±0.53	0.107±0.54
Calving interval	0.51	0.88	0.06±0.05	<−1†	−0.22±0.37	−0.21±0.37
Breeding efficiency	−0.37	−0.61	−0.72	0.05±0.05	0.19±0.41	0.17±0.41
Herd life	0.06	−0.01	−0.01	−0.11	0.30±0.08**	0.99±0.00*
Length of productive life	0.05	−0.02	−0.01	−0.11	0.99	0.29±0.08**

[1]Diagonals are heritabilities, upper-off diagonals are genetic correlations, lower-off diagonals are phenotypic correlations. †The estimates of these genetic correlations are outside the parameter limits of −1 and +1 in our data. **$P<0.01$, *$P<0.05$ Significance levels were seen by ANOVA in heritabilities and calculated as by ZAR (1984) in genetic correlations.

Discussion

Least-squares analysis of different traits

Significant ($P<0.05$) effects of calving year and least-squares means showed that while the milk yields increased breeding efficiency, herd life and length of productive life decreased with the advancing years. The fact that the fertility and longevity may be depressed while trying to boost milk production by changing feeding and management conditions throughout the years may explain this phenomenon. First lactation milk yield and breeding efficiency were found to be higher in relatively cool season calvers. In addition to green fodder and first-cut silage, low ambient temperatures during these seasons may result in improved performance. Heifers that freshened at younger ages had better herd life and length of productive life. The average for first lactation milk yield was between the values of OJANGO and POLLOT (2001) and JAIRATH *et al.* (1995) for Holsteins. The mean for breeding efficiency (94.87%) was higher than the values reported by AGEEB and HAYES (2000), GOSHU (2005), and WILCOX *et al.* (1957) in dairy herds. Different breeds, feeding, management, climatic conditions and calculation methods might cause this.

The averages for herd life (2 095.9 days) and length of productive life (1 257.2 days) were in the range of 1 716-3 737 and 903-2 792 days described by early research (LIN *et al.* 1988, NIEUWHOF *et al.* 1989, HARRIS *et al.* 1992, SETTAR and WELLER 1999, RIZZI *et al.* 2002, NILFOROOSHAN and EDRISS 2004, TSURUTA *et al.* 2005, GOSHU 2005, DAKAY *et al.* 2006).

Heritabilities, genetic and phenotypic correlations

The heritabilities were moderate for milk yield (0.27 ± 0.08), and low for lactation length (0.02 ± 0.05) and calving interval (0.06 ± 0.05). This is in agreement with the findings of various workers (HOEKSTRA *et al.* 1994, OJANGO and POLLOT 2001, HAILE-MARIAM *et al.* 2003a, DEMATAWEWA and BERGER 1998, CAMPOS *et al.* 1994, JAIRATH *et al.* 1995). Heritability for breeding efficiency (0.05) was lower than that of WILCOX *et al.* (1957). This could be due to the influence of some non-tangible environmental factors that may be specific to each animal besides the factors included in the least squares model. The moderate heritabilities were also estimated 0.30 and 0.29 for herd life and length of productive life. These findings were higher than the values announced by several researchers (VAN DOORMAL *et al.* 1985, HARRIS *et al.* 1992, JAIRATH *et al.* 1995, VOLLEMA and GROEN 1996, SETTAR and WELLER 1999, ROXSTRÖM and STRANDBERG 2002, NILFOROOSHAN and EDRISS 2004, TSURUTA *et al.* 2005, MESZAROS *et al.* 2008) except WILCOX *et al.* (1957). Correlations of first lactation production and fertility traits with longevity were relatively lower than the findings of several researchers (VAN DOORMAL *et al.* 1985, HARRIS *et al.* 1992, JAIRATH *et al.* 1995, VOLLEMA and GROEN 1996, SETTAR and WELLER 1999, ROXSTRÖM and STRANDBERG 2002, NILFOROOSHAN and EDRISS 2004, TSURUTA *et al.* 2005). This may be from the methods of estimation.

In conclusion, some environmental factors had significant effects ($P<0.05$) influence on life long performance in this study. This must be considered when breeding values are computed. First lactation milk yield, herd life and length of productive life were found to be more heritable. Therefore, these traits may be preferred by breeders as selection

criteria. Although correlations of the first lactation production and reproduction with longevity traits were non-significant, larger investigations would be useful due to undesirable way correlations of calving interval with milk yield, breeding efficiency, herd life and length of productive life.

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