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Full Length Research Paper

Relationships among milk production, reproductive traits, and herd life for Tunisian Holstein-Friesian cows

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The objective of this study was to link productive life of Tunisian dairy cows to their performances of milk, fat, and protein yields and fertility traits. Data included 128,652 records collected from 1990 to 2004 on 47,276 Holstein-Friesian cows in 142 herds. A linear model that included fixed effects of herd-calving year, calving season, parity, and age at first calving was used to study variations of milk production, fertility, and herd life. Relations among yield and fertility traits and herd life were examined by computing linear correlations between residuals from fitting respective linear models. Under Tunisian conditions, a dairy cow averages 5905, 180, and 167 kg of milk, fat, and protein, respectively. Intervals between successive calving and from calving to first service, and days open were 427, 90, and 163 days, respectively. True herd life was 41.99 (SD = 24.6) months. The optimal age at first calving ranged between 23 and 27 months. Cows with intermediate yields tended to stay longer in the herd than low or high producing ones. The mean lactation number was 2.6 with more than 57% of cows culled after the first two lactations and only 7.14% of them reached their fifth lactation. Phenotypic correlations of true herd life with milk, fat, and protein yields were 0.07, 0.11, and 0.09, respectively. Those with fertility parameters ranged from -0.04 (with days open) to 0.06 (with calving interval).

Key words: Milk production, reproductive traits, herd life, dairy cattle.

INTRODUCTION

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, the time from first calving to culling or death of a cow (Forabosco et al., 2004). Increased longevity reduces the direct costs of raising or purchasing replacement females (Forabosco et al., 2004). High culling rates are of a great concern for farmers, especially those who wish to expand their dairy herds but face a shortage of replacement heifers. Culling on an unsatisfactory production (unprofitable cows) is desirable; however, one must distinguish between volun-tary and involuntary culling. Voluntary culling occurs when the farmer chooses to remove from the herd a healthy and fertile cow due to low milk production. In-voluntary culling, on the other hand, occurs when the far-mer is forced to remove a productive cow due to illness, injury, infertility, or death (Weigel et al., 2003).

Longevity corrected for voluntary culling is called functional longevity, whereas actual observed longevity is called true longevity or true herd life. The reason for distinguishing between voluntary and involuntary culling is that the selection for true longevity is largely equivalent to selection for production (at least in dairy cattle) and does not necessarily lead to genetic improvement in the ability to withstand involuntary culling (Dekkers, 1993). Therefore, culling risk increases for low producing cows (Ducrocq, 1993), and decreases for high producing ones (Durr et al., 1999) . Highly producing cows seem to have longer productive life (Rogers et al., 1988) . However, increased yield productions in dairy cattle can have negative side effects on fertility traits (Winding, 2006). The objective of this work was to study the length of productive life of Tunisian dairy cows and to link it to milk yield and reproductive performances.

MATERIAL AND METHODS

Data

Data on culling, milk production, and fertility were provided by the National Center for Genetic Improvement at Sidi Thabet, in Tunisia. After editing for biologically unacceptable yield records (for examp-

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Table 1. Initial and final number of records by trait*.

Trait	Initiak data	Edited data
MY305	128562	110667
FY305	43320	34250
PY305	39521	31542
THL	25264	17027
CI	-	86175
CSI	-	65172
DO	-	64135

MY305: MILK yield IN 305 days; FY305: fat yield in 305 days; PY: protein yield in 305 days THLl: true herd life ci: calving interval; csi Calving to first service interval; and DO; days open

Table 2. Mean performances* of milk production, reproduction, and herd life of the Tunisian Holstein-Friesian cows.

	Traits	Number of records	Mean
Milk Production	MY305 (kg)	110667	5905 (1895)
	FY305 (kg)	34250	180.23 (75.9)
	PY305 (kg)	31542	167.83 (70.10)
Herd life	THL (month)	17000	41.99 (24.58)
	CI (day)	86175	427.01 (96.93)
Reproductive traits	CSI (day)	65172	90.22 (55.21)
	DO (day)	64135	163.34 (101.33)

*MY305: milk yield in 305 days; FY305: fat yield in 305 days; PY305: protein yield in 305 days; THL: true herd life; CI: calving interval; CSI: calving to first service interval; and DO: days open.
(.): Standard deviation

le milk is less than 3 kg or greater than 80 kg), 110,667 lactation records remained for milk yield (Table 1). These records were collected on 47,276 Holstein-Friesian cows calving from 1990 to 2004 in 142 herds. Herds belong to four production sectors and farms are located in the north and central Tunisia (Rekik et al., 2003). Available records on fat, protein, and fertility were lower than those on milk yield (Table 1). Differences in effective numbers of records among various traits are due to lags between expressed interests for recording various traits. The Tunisian Livestock and Pasture Office, (OEP), begun by recording milk yield followed by fat, protein, and recently somatic cells. Recording system has been an A4 (each 4 weeks) scheme and has been changed to an A6 scheme, to lower expenses and cover greater areas. Actual yields of milk, fat, and protein were standardised to a lactation length of 305 days. MY305, FY305, and PY305 in Table 1 represent milk, fat, and protein yields in 305 days, respectively. Only 8 lactations were kept for the analysis. Days open (DO), the interval from calving to a successful insemination and calving to first service intervals (CSI) which were less than 21 days or greater than 500 days were deleted. Calving intervals (CI) that were lower than 300 days or greater than 900 days were also removed. True herd life (THL) was defined as the number of days from first calving until culling or death. Editing on all data left the fewest records for longevity among all traits (Table 1).

Variation of milk, fertility, and longevity traits

The linear model used to study variations of yields reproductive traits, and herd life was:

$Y_{ijklmn} = + HY_j + S_k + NL_l + Age_m + e_{ijklmn}$ (I),

Where Y_{ijklmn} : is MY305, FY305, PY305, THL, CI, CSI, or DO, : is an overall mean,
HY_j : is the fixed effect of herd by calving year j,
S_k : is the fixed effect of calving season k (k= spring, summer, autumn, and winter),
NL_l : is the fixed effect of lactation number l (l=1,…,8),
Age_m : is the fixed effect of age at first calving (C_1<23 months, 23 months C_2<27 months, 27 months C_3 <30 months, 30 months C_4 <35 months, and C_5 > 35 months), and
e_{ijklmn} : is a residual effect with $e_{ijklmn} \sim N(0, {}_e^2)$.

True herd life variations were analysed for the last lactation of a cow. Residuals from fitting model (I) to various traits were used to compute linear correlations.

RESULTS

The mean and standard deviation for each trait estimated across all parities are given in Table 2. Milk, fat, and protein yields adjusted to 305 days were lower than most of recent estimates in the USA and Canada (World Holstein- Friesian Federation, 2006). Mean CI (Table 2) was also lower than those reported on US Holstein (Silva et al., 1992 ; Garcia-Peniche et al., 2005) but greater than those found in Ireland (Pool et al., 2003) . Mean CSI (Table 2) was greater than that estimated on Florida Holstein data (Silva et al., 1992). Mean estimate for DO

Table 3. Mean square of environment effects on herd life for the Tunisian Holstein-Friesian cows.

Effect	Degrees of freedom	Mean square	Significance level	Contribution
Herd-calving year	688	4814,2	0,0001	4,15%
Calving season	3	1306,7	0,0074	1,13%
Parity	7	108319,12	0,0001	92,48%
Age at first calving	4	1433,1	0,0015	1,23%
R^2	0,48			

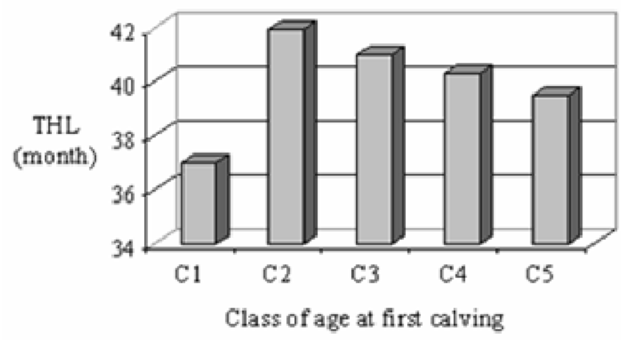

Figure 1. Least squares means of THL by age at first calving (C1 < 23 months, 23 months ≤ C2 < 27 months= C3 < 30 months, 30 months ≤ C4 < 35 months, and C5 :> 35 months) for the Tunisian Holstein-Friesian cows

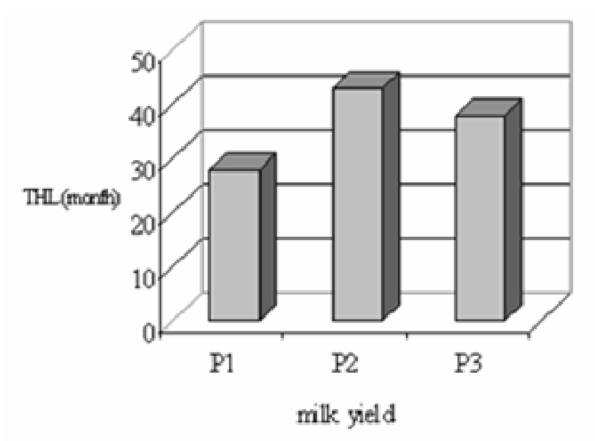

Figure 2. Means of THL by production level of milk yield for the Tunisian Holstein-Friesian cows. P1 < 3000 kg milk; 3000 ≤ P2 < 8600 kg milk, and P3 ≥ 8600 kg milk.

was 163.34 days (SD = 101). This value is greater than those found by Silva et al. (1992), but lower than others (Dematawewa and Berger, 1998).

Variation of herd life

Mean squares for the most important environment effects on herd life (Model I) are given in Table 3. The relative importance of each factor is determined by its contribution to the total variability of herd life. The coe-fficient of determination [1 – (error sum of squares/total sum of squares)] of model I was 48%. The effects of herd by year of calving interaction, season of calving, parity, and age at first calving were statistically significant (p<0.01). The significant effects of the interaction of herd by calving year and season of calving may be explained by various management conditions among herds (herds belong to four different production sectors) as well as annual climatic changes. Impacts of all the effects from model I on farmer breeding decisions, as a result of productive, reproductive, and health conditions of cows, dictate culling decisions and consequently affect longevity.

The effect of age at first calving on THL was highly significant (p<0.01) . Age at first calving is an important economic criterion. It does allow not only for time winning and then an increased production but also affects the lifespan of a cow in the herd. For Tunisian Friesian-Holstein cows, the mean age at first calving was 29.28 months (SD = 4.01) while an age at first calving between 23 and 27 months seemed to be an optimum for increased herd life (Figure 1). These results are similar to those found in most of the literature (Ben Gara, 1998; Essl, 1998; Dürr et al., 1999; Rogers et al., 2004) but differed from that of Ducrocq (1994) on the Normandy breed.

Relationships of THL with production traits

Figure 2 shows the length of productive life for three classes of 305d milk production recorded during the last lactation (P1 < 3000 kg milk; 3000 P2 < 8600 kg milk, and P3 ≥ 8600 kg milk). Cows with low milk yield production seemed to be culled earlier than the others (voluntary culling). The mean THL for the latter class was 28.48 months. Cows with the highest yields were also unexpectedly removed early from the herd. The mean THL computed for these cows was 38.95 months. While cows with intermediate yields stayed longer in the herd; their mean THL was 43.54 months. Table 4 shows phenotypic correlations between milk yields and THL. They were 0.07, 0.11, and 0.09 with MY305, FY305, and PY305, respectively. These correlations are comparable to most of those reported in the literature (Ben Gara,

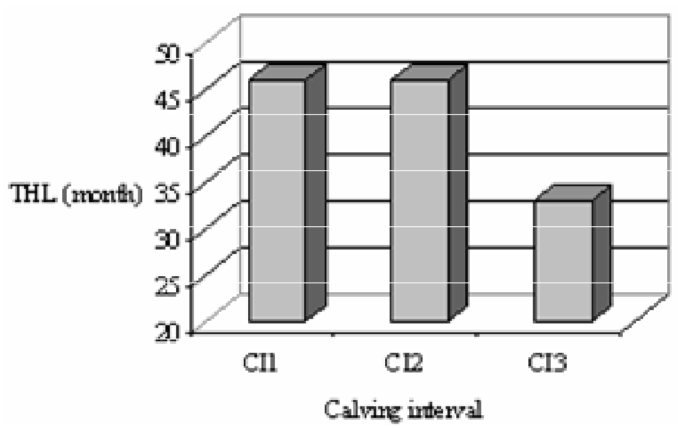

Figure 3. Means of THL by calving interval (CI) level for the Tunisia Holstein-Friesian cows. 300 ≤ CI1< 370 days, 370 ≤CI2 < 475 days, and 475≤ CI3 < 900 days.

Table 4. Phenotypic correlations between true herd life and milk and reproductive traits for Holstein-Friesian cows in Tunisia.

	Milk traits			Reproductive traits		
	MY305	FY305	PY305	CSI	DO	CI
THL	0,07**	0,11**	0,09**	0,04**	-0,03*	0,06**

MY305: milk yield in 305 days; FY305: fat yield in 305 days; PY305: protein yield in 305 days; THL: true herd life; CI: calving interval; CSI: calving to first service interval; and DO: days open. **: P<0.01, *: P<0,1

1998; Van Raden et al., 2003). Positive correlations show that yield is the most important trait for culling and cows with satisfactory yields tend to stay longer in the herd (Ben Gara, 1998; Van Raden et al., 2003; Tsuruta et al., 2004).

Relationships of THL with fertility parameters

Figure 3 presents the length of true longevity for three classes of last CI (300 CI1< 370 days, 370 CI2 < 475 days, and 475 CI3 < 900 days). Mean THL (around 46 months) was similar for the first two classes of calving intervals (CI1 and CI2). However, that corresponding to the third calving interval class was the lowest and did not exceed 36 months. This result suggests that herd managers wait too long for a cow to get pregnant. In fact, DO and CSI intervals and contrary to milk yield were high during the winter and spring (166.5 and 92.1 days, and 174.7 and 94.4 days, respectively) seasons but low during the fall and summer (158.6 and 87.7 days, and 155.8 and 87.4 days, respectively) seasons. And the cow is culled for reproductive reason only when her milk production becomes low and probably the cost for keeping her in the herd become very high. Phenotypic correlations between reproductive traits and THL (Table 4) were low and ranged from –0.03 (THL with days open) to 0.06 (THL with CI). The negative coefficient of THL with DO implies that an empty cow is culled which reduces her stay in the herd. While the positive correlation coefficient of THL with CI shows that when a cow is producing milk she may not be culled even if she is empty.

DISCUSSION

Phenotypic performances of Friesian-Holstein cows for milk yield, reproductive traits, and longevity were estimated under Tunisian conditions. Results may imply that Holstein-Friesian cows in Tunisia are not producing up to their potential probably because of shortcomings in management and relatively harsh climatic conditions. The mean THL of Tunisian Holstein-Friesian cows was 41.99 months (SD = 24.58) corresponding to 3.5 years of productive life. This result is greater than estimates on Spanish dairy population (Ben Gara, 1998). Estimates on Spanish cow population (Ben Gara, 1998) were computed as the difference between ages at first and last calving. The mean lactation number was 2.6 (SD =1.7). It is less than estimates in some studies (Ben Gara, 1998; Jennie and Brotherstone, 1999; Madgwick and Goddard, 1989). The percentage of cows culled after the first two lactations was 57%, and only 7.14% of cows reached their fifth lactation which may partly explain the limited number of realised lactations. As a result, 18.4% of cows had 43 months of productive life which is less than most of values reported in the literature (Rekik and Allaire, 1993; Ben Gara, 1998).

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) and Weigel et al. (2003). The latter authors worked on cows that attained production levels greater than those found under Tunisian conditions. In fact, the highest productions in Tunisia were obtained early in the cow's career, during the third lactation (6188 kg). Such a performance is still lower than 8600 kg recorded in more favourable conditions for all lactations (World Holstein-Friesian Federation, 2006). Holsteins produce the maximum of milk in the fourth and fifth lactations in their countries of origin (World Holstein-Friesian Federation, 2006). On the other hand, harsh conditions in the summer (Heat stress) and food shortages in some cases may compromise performances of cows with high poten-tials for milk production. Mean milk production in the summer season in Tunisia was only 5807 kg. Poor management may hamper the restitution of cows' corpo-ral reserves and consequently affect performances in subsequent lactations. That is, the length of the cow's productive life is reduced.

Conclusion

cows in Tunisia are lower than those performed in more favourable areas. Mean THL was 41.99 months. It allows for only 2.6 lactations. More than 57% of cows are culled after the first two lactations and only 7.14% of them reached their fifth lactation. Environment (Year of calving, season of calving) and management (herd) factors are all important sources of variation of milk production, reproductive traits, and consequently herd life. Clearly defined breeding goals associated with better management (culling on low production, selection on traits other than yields, varied feed resources, etc.) would improve Friesian-Holstein cows' performances and reduce costs in Tunisia.

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