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PHENOTYPIC AND GENETIC PARAMETERS OF REPRODUCTIVE TRAITS IN TUNISIAN HOLSTEIN COWS

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Abstract: Various factors influencing reproduction in dairy Holstein cows were routinely evaluated and genetic parameters were estimated for four traits for assessing fertility of artificially inseminated cows: Calving to first service interval (CFSI), calving interval (CI), calving to conception interval (CCI), and number of services per conception (NSC). Data used in this investigation consisted of records of insemination and calving events on Tunisian Holstein cows. Records were registered from 1994 to 2003 in 150 herds to study the effects of non-genetic factors and estimate the heritabilities of those fertility traits. The factors examined were: month and year of calving, herd, parity, and year-month of calving. The effect of month and year of calving (or insemination), herd, parity and year-month of calving were included in the model and were significant ($P < 0.01$) except for the number of lactations that does not have an effect on the number of services per conception. A decreasing efficiency in cow fertility was observed over the last years, with a longer day for first service interval. Heritability for fertility traits was low ranging from 0.027 for NSC to 0.067 for CI. The results suggested that more attention should be paid to herds with too low fertility traits and that monitoring/alert and intervention schemes should be tested in research/action approaches.

Key words: fertility, heritability, repeatability, Tunisian Holstein, cattle

Introduction

Knowledge of reproductive performance in Tunisian dairy herds is limited. Selection for higher yields of dairy cattle has led to a decline in fertility due to unfavorable genetic correlations between yield and fertility *(Pryce et al., 2004)*. On a herd basis, fertility in Tunisian dairy herds is not well defined and is poorly managed. It appears difficult to correct, as the levels of the standards used to measure many of the fertility indices are declining. *Ben Hamouda et al.* (2005) on Tunisian data showed that the reproductive performance of Holstein herds is poor. Tunisian Holstein is the main exotic breed used for milk production in Tunisia *(Ben Salem et al., 2006)*. During the last two decades, the dairy sector in Tunisia went through major development programs to increase dairy production in order to improve farmer's life's whose income comes from milk sale and to ensure the national self-sufficiency in milk and dairy products. In fact, these development programs are not in favor of reproductive performances of Holstein which remain low. The deterioration of the fertility in dairy cows during the last two decades today constitutes a major difficulty confronted by the dairy breeders. This tendency has concerned many countries *(Barbat et al., 2005; Bosio, 2006)*. The results of reproductive performances conditioned largely the breeding economic profitability and its improvement is a part of the common imperatives for all types of production. The actual determination of the type of traits to be included in genetic evaluation for fertility is difficult. Earlier studies on cow reproduction possessed only calving dates from which calving intervals or days open could be computed assuming a standard gestation length *(Jansen, 1986)*. The availability of insemination data has allowed the calculation of intervals between calving and each insemination as well as the number of inseminations. Age at first insemination, age at conception, and the intervals from calving to first service and first service to conception in each lactation have been important traits in several studies *(Averill et al., 2004; Jamrozik et al., 2005; Biffani et al., 2005)*. *Averill et al. (2004)* affirmed that reproductive performance of a cow is an array of several traits. The heritabilities of most reproductive traits were generally below 0.10 *(Kadarmideen et al., 2003; Wall et al., 2003)*. The objectives of this study were to identify non-genetic factors strongly associated with reproductive performance and to estimate genetic parameters for Tunisian Holstein female reproduction traits.

Materials and Methods

Data Source. Data on reproductive traits were obtained from the National Center for Performance recording of Dairy Cattle under guardian of The Tunisian Livestock and Pasture Office, (OEP). These comprised insemination records collected by OEP from 1994 to 2003 that were matched to pedigree, lactation, and calving performance information to be able to calculate the traits of interest. Pedigree records for individual cows were verified with records from OEP. Pedigree file of all participating animals was available and contained the ancestry of approximately 80,000 animals (about 66,000 animals and 4000 bulls). Fertility traits were defined based on data availability in a way that would describe a complete picture of a reproductive history for a cow. In order to describe herd fertility retrospectively, four fertility parameters were calculated for each cow from the insemination recording data: Calving to first service interval (CFSI), calving interval (CI), Calving to conception interval (CCI), and number of services per conception (NSC). Interval traits were expressed in days. The file contain herd, number of cows, day-month-years of birth, day-month-years of insemination, day-month-years of calving, age at calving, number of lactations, number of inseminations, and genetic group (the origin of the animal).

Data preparation . Data consisted of recorded artificial insemination and calving events; however, data on several variables were missing in some cases or do not correspond to the reality. Edits performed for all traits included removal of animals having unreasonable value; 1) with more than eight lactations; 2) which calved before 1994 and after 2003; and 3) with incomplete records. Artificial inseminations before 1994 were eliminated to avoid errors at the beginning of the reproductive recording scheme. Calving intervals (CI) that were lower than 270 days or greater than 720 days were removed. Calving to a successful insemination and calving to first service intervals (CFSI) which were less than 30 days or greater than 450 days were deleted. A pedigree file of all participating animals was available and contained the ancestry of approximately 80,000 animals (about 66,000 animals and 4000 bulls).

After editing, records from 150 herds with 65,549 cows for the number of inseminations per conception, calving to first service interval and calving to conception interval, and 28,777 cows for calving interval were available for analysis.

Statistical of data analyses. The data were first analyzed by the least squares techniques using the GLM procedure of SAS (*SAS Institute Inc., 1989*) to determine the effects of the various factors on reproductive traits. CFSI, CCI and CI were analyzed using the following model.

$$Y_{ijklm} = \mu + p_i + h_j + y_k + s_l + e_{ijklm}$$

Where:

- $Y_{ijklm} =$ observations on variable of interest;
- μ = underlying constant,
- p_i = fixed effect of the i^{th} lactation number,
- h_j = fixed effect of j^{th} herd,
- y_k= fixed effect of k^{th} year of calving,
- s_l = fixed effect of l^{th} season of calving,
- e_{ikllm} = the random residual NID $(0,\sigma^2_e)$

The model to analyze NSC was:

$$Y_{jklm} = \mu + h_j + y_k + s_l + e_{ijklm}$$

$Y_{ijklm} =$ the observations on number of inseminations per conception.

- μ, h_j, e_{ijklm} = as described in the previous model.

From the preliminary analysis a suitable model was identified for the final estimation of the genetic parameters. The final statistical analyses were performed with the Derivative-Free Restricted Maximum Likelihood software (DF-REML) *(Meyer, 1989)* and multiple-trait animal model to obtain variance components for calving interval (CI), calving to first service interval (CFSI), calving to conception interval (CCI), and number of inseminations per conception (NSC). The animal model included additive genetic merit of each cow as the only random effect. To estimate repeatability for CI, CFSI and CCI, an animal model was used to account for permanent environmental effects common to the repeated records on the same animal. Estimation of phenotypic, genetic and environmental trends was carried out for CI, CFSI, CCI and NSC. The mean additive genotype in a particular year of birth was defined as the mean predicted breeding values of cows born in that year. Consequently, changes of mean additive genotype between the years reflected additive genotypic differences. The overall additive genetic trend in a trait was estimated by regressing the mean predicted breeding values on the respective year of birth in that trait. For phenotypic trends, the adjusted performance records were averaged within the year of birth and then regressed on years of birth *(Wakhungu, 1988; Rege and Mosi, 1989)*. The difference within years between the mean predicted breeding value and the mean of the adjusted phenotypic records reflected the component due to the non-additive genetics and the environmental parameters.

Results and Discussion

Tendency and dispersion of reproductive performance. Table 1 presents a descriptive summary of the edited data used in the present study. Heritabilities for the four traits shown in table 1; they are low and ranged from 0.027 for NSC to 0.063 for CI. The reproductive trait with the highest heritability (0.063) is CI.

Table 1. Descriptive statistics of reproductive indices of Tunisian Holstein herds

Traits	Records	Means (SD)	First quartile	Median	Third Quartile	H^2	R
NSC	65,549	2.55±1.7	1	2	3	0.027	0.034
CFSI	65,549	93.2±80.2	58	75	103	0.032	0.128
CCI	65,549	150.9±75.7	84	138	194	0.041	0.135
CI	28,777	444.2±101.5	445	445	445	0.063	0.152

NSC: Number of services per conception; CFSI: calving to first service interval; CCI: calving to conception interval; CI: calving intervals; H^2: Heritability; R: Repeatability; N: number of observations and SD: Standard Deviation.

Effect of non-genetic factors on reproductive performance. The analysis of variance (Table 2) showed that the number of lactations had significant effect on CFSI, CCI and CI (P< 0.0001) with f values of 149.68, 46.36, and 5.73 respectively, but no effect was reported for NSC (P= 0.0510). Effects of herd, calving year, calving month, and the interaction calving year-calving month and the genetic group on studied fertility traits were found to be statistically significant

(P< 0.0001). Herd had a significant influence (P<0.001) on traits related to time period (CI, CCI and CFSI) (Table 2).

Table 2. Effect estimates for selected factors included in final model.

Source	DF	NSC		CFSI		CCI		CI	
		F	Pr>F	F	Pr>F	F	Pr>F	F	Pr>F
H	125	28.99	<0.0001	26.64	<0.0001	18.15	<0.0001	15.34	<0.0001
LN	7	2	0.0510	149.68	<0.0001	46.36	<0.0001	5.73	<0.0001
CY	9	77.79	<0.0001	83.03	<0.0001	43.70	<0.0001	74.72	<0.0001
CM	11	37.72	<0.0001	28.34	<0.0001	60.98	<0.0001	7.33	<0.0001
CY*CM	99	4.18	<0.001	9.92	<0.0001	12.65	<0.0001	2.29	<0.0001
GG	16	5.69	<0.0001	4.87	<0.0001	8.13	<0.0001	189.61	<0.0001

Herd (H), lactation number (LN), calving year (CY), calving month (CM) interaction calving year-calving month (CY*CM) and genetic group (GG)

The variation of CI from one herd to another could be attributed to differences in skills of heat detection. Effects of year of calving on CI, CCI, CFSI and NSC were significant (P<0.001). The year of calving is important source of variation. The main effect for the model was also significant (P<0.001). Calving first service (CFSI), calving conception (CCI) and calving interval (CI) were found to be very long at the firsts lactations (115, 210, and 478 days). The situation was changed during the next lactations. They range from 115 to 100 days and from 210 to 196 days for CFSI and CI, respectively, from parity one to parity four. A decrease was reported for these traits with the lactation number between the first and the last lactations from 486 to 387 for CI, from 168 to 135 for CCI, and from 88 to 76 for CFSI (Figure 1).

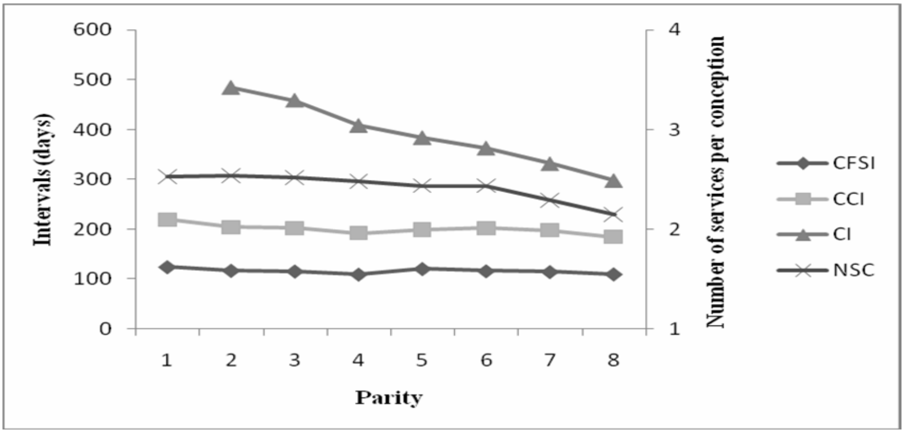

Figure 1. Evolution of calving first service, calving conception, calving intervals and number of services per conception with parity.

The numbers of services per conception were slightly decreased with the lactation number from an average value of 2.50 at first lactation to 2.11 at the eighth lactation (Figure 1). As per Figure 2, an elongation of CFSI, CCI and CI were observed for many years. Calving intervals was prolonged from 13 to 17 months from 1994 to 2003, with a noteworthy increase in 1997 (Figure 2). Fluctuation of calving first service interval (CFSI) showed that the number of cows inseminated at less than 50 days of postpartum decreased appreciably during the last years. It can partially explain the prolongation of calving interval. Hence there could be a factor that contributes to larger CI. It may be due to selection for yield or it may be due to poor management, such as poor conception rates, poor expression or detection of estrus and poor nutrition. An increase in the number of services per conception was noticed during the period from 1994 to 2003. The NSC ranges from 1.5 in 1994 to 2.5 at 2002 with a peak at 1996 when the NSC exceeds 2.7. A reduction has also been reported between 2002 and 2003 in which the NSC decreased again to reach a value lower than 2. (Figure 2)

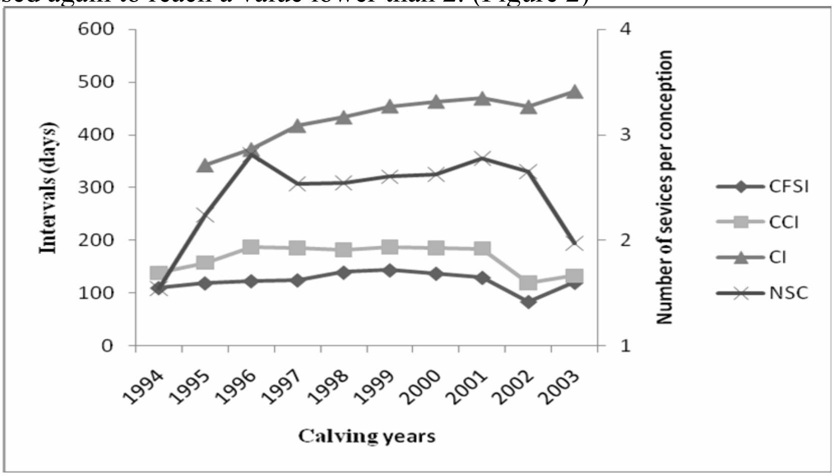

Figure 2. Evolution of calving first service, calving conception, calving intervals and number of services per conception during ten years

Variation of fertility traits according to calving season. During the same year, changes in management and feeding systems, temperature, humidity, and photoperiod were observed. Figure 3 showed that intervals increased during the hottest and the coldest periods of the year. An elongation of all intervals was observed from June to August and from the first fifteen days of November to the first fifteen days of February. Figure 3 showed a fluctuation in the number of inseminations during the year, an increase in the NSC during two periods; colder and hotter when NSC reached 3.5 and 3 services, respectively. In the temperate regions, fertility is maximal in spring and minimal in summer and winter. (Figure 3).

The results of this study are not in agreement with the results of Vallet et al. (1997) who put standard objectives for CFSI of 70 days, with a percentage of cows having CFSI > 80 days greater than 15 %, CCI (90 days) with a percentage of cows having CCI > 110 days greater than 15 %, and CI (365 days) with a percentage of cows having CI > 365 days was greater than 15%. Heritabilities are low and in agreement with previous studies which are weak and ranged from 0.01 to 0.05 *(Maijala, 1987; Hanset et al., 1989; Jamrozik et al., 2005; Biffani et al., 2005)*. However, genetic improvement of reproductive traits is very hard to achieve because their low heritability using linear model. Although, some differences do exist between traits related to time period (CI, CCI and CFSI) and score traits (NSC). *Averill et al. (2004)* reported a heritability of 0.028 for female fertility using longitudinal binary data with Bayesian methodology. Our estimates for reproductive traits and most estimates of other researchers are comparable and low. The reproductive trait with the highest heritability (0.063) is CI. Considering this value and the lower repeatability of reproductive traits (<0.03 to 0.13) *(Hayes et al., 1992)*, it is recognized that the reduction of one day on the delay of first service is accompanied by an equivalent reduction of CCI *(Schneider et al., 1996)*. Effects of herd, calving year, calving month, and the interaction calving year-calving month and the genetic group on studied fertility traits were found to be statistically significant (P< 0.0001). Herd had a significant influence (P<0.001) on traits related to time period (CI, CCI and CFSI) which is confirmed by *(Kaya, I. 1996; Amimo et al., 2006)*.

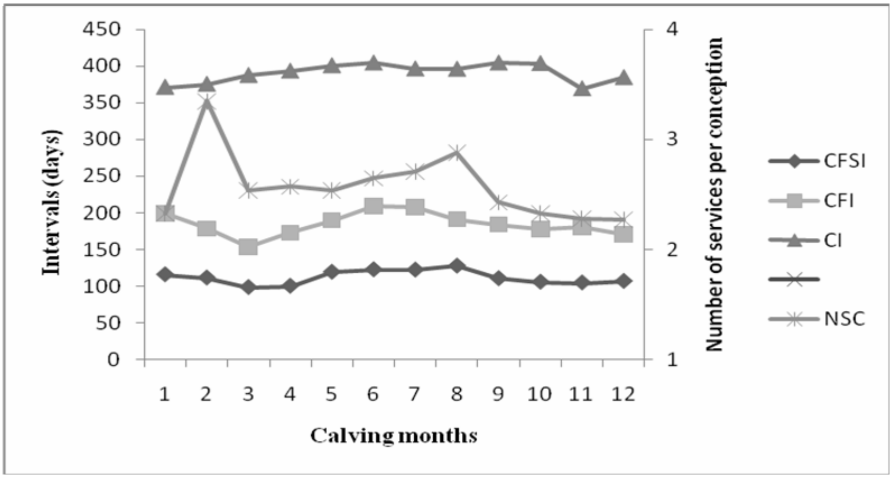

Figure 3. Seasonal variations of calving first service, calving conception, calving intervals and number of services per conception.

The year of calving is important source of variation. Significant year of calving effects on fertility traits have been reported in several studies *(Amimo et al., 2006; Muasya, 2005)*. The elongation of CFSI, CCI and CI observed in this study may be due to selection for yield or it may be due to poor management, such as poor conception rates, poor expression or detection of estrus and poor nutrition. These results agree with those of *Sewalem et al. (2002)* in Canadian dairy herds.

Shrestha et al. (2004) explained that higher intervals by the absence of heat detection at the onset of appropriate reproduction period. On the contrary, an elongation of these intervals with lactation number has been reported by *Erb et al. (1985)*. Interval between calving and first insemination decreased *(Ogan, 2000)* or increased *(Çilek and Tekin, 2007)* with lactation number. Others noticed the same trend in dairy cattle compared to beef cattle *(Gregory et al., 1999)*. Fertility was known to decrease with the increase of lactation number in dairy cattle *(Weller and Ron, 1992)* which was the case in this study.

The analysis of seasonal variation of reproductive performances must be interpreted in the light of the reciprocal influences. In temperate regions, fertility is maximal in spring and minimal in summer and winter. This was in agreement with the finding of *Çilek (2009)*. *Westwood et al. (2002*) noticed that the length of the anoestrus of the post-partum was longer when cows calved in winter, but *Eldon and Olafsson (1986*) confirmed that it was shorter for dairy cows calving in autumn. Fertility may be affected (*Gregory et al., 1999b)* or may not be affected *(Hageman et al., 1991)* as per seasonal variations. In tropical and subtropical areas, many authors reported a reduction in fertility in summer usually coinciding with the prolonged periods of elevated temperature *(Weller and Ron, 1992)*. According to *Hansen and Aréchiga (1999)*, the effect of temperature on cow reproductive performance would be translated by a decrease of heat. The modifications of the photoperiod were not alien to the variations of reproductive performances. *Berthelot et al. (1991)* mentioned the specificities of species, mechanisms of action as well as its effects on the puberty, calving, uterine involution and anoestrus postpartum.

Conclusion

Female fertility is a complex set of traits related to genetic and environmental factors. This study provides genetic parameters estimate inconformity with the literature data: fertility traits present a low heritability. Reproductive performances changed with the age of the cow often depending on previous performances. Heritability estimates for NSC, as a trait of the cow being inseminated was 2.7 % and was 3.2%, 4.1% and 6.3% for CFSI, CCI and CI, respectively. The results of reproductive performance in Tunisian herds were not exceptional. The deterioration of the non return rates and the elongation of the calving interval for several years were often mentioned by several authors in many countries. Months during the year, lactation number, and herd affected fertility traits. In order to improve or at least stop the deterioration trend in fertility, more emphasis on fertility traits in selection is necessary. Finally, high hopes exist for the use of genomic selection as an aid in genetic improvement for fertility.

Fenotipski i genotipski parametri reproduktivnih osobina holštajn krava u Tunisu

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Rezime

Različiti faktori koji utiču na reprodukciju mlečnih holštajn krava su ocenjivani, kao i genetski parametri za četiri osobine koje se koriste za ocenu plodnosti veštački osemenjenih krava: interval od teljenja do prvog pripusta (CFSI), interval između teljenja (CI), interval of teljenja do koncepcije (CCI), i broj pripusta po koncepciji (NSC). Podaci koji korišćeni u ovom istraživanju se sastoje od evidencije o inseminaciji i teljenju kod holštajn krava u Tunisu. Evidencija postoji od 1994 do 2003 u 150 zapata kako bi se ispitali efekti ne-genetskih faktora i ocenili heritabiliteti navedenih osobina plodnosti. Ispitani faktori su bili: mesec i godina teljenja, zapat, teljenje po redu, i godina-mesec teljenja. Uticaj meseca i godine teljenja (ili osemenjavanja), zapata, teljenja po redu i godina-mesec teljenja su uključeni u model i bili su signifikantni ($P < 0.01$) osim za broj laktacija gde nema uticaja na broj pripusta/povađanja po koncepciji. Smanjenje efikasnosti kod plodnosti krava je registrovano tokom prethodnih godina, sa intervalom do prvog pripusta koji je duži za jedan dan. Heritabilitet za osobine plodnosti je bio nizak i varirao od 0.027 za NSC do 0.067 za CI. Rezultati upućuju na to da više pažnje mora da se posveti zapatima sa niskim vrednostima za plodnost i da bi trebalo testirati sheme monitoringa/uzbune i intervencije u istraživačkim/akcionim pristupima.

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