GENETIC AND PHENOTYPIC TRENDS OF CALVING INTERVAL AND AGE AT FIRST CALVING IN A COMMERCIAL HOLSTEIN HERD

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SUMMARY

Reproductive records of Holstein cows raised at a commercial farm during the period from 1991 to 2006 were used. A total of 3656 records of 1611 cow daughters of 413 sires and 588 dams were used to study genetic and phenotypic trends of age at first calving (AFC, mo) and calving interval (CI, d). Two animal models were applied to estimate the genetic parameters and breeding values of the two traits using VCE program.

Genetic trend was estimated for the studied traits. Regression analyses by XLSTAT- Pro (2009) procedures were used to estimate genetic and phenotypic trends.

Means of CI and AFC were 484 d and 27.5 mo, respectively. Heritability estimates for CI and AFC were 0.07 ± 0.01and 0.12 ± 0.04, respectively, while the corresponding estimate for repeatability of CI was 0.08.

Genetic trends were 0.06 d/yr and 0.02 mo/yr for CI and AFC, respectively. Phenotypic trends were -0.48 d /yr for CI -0.04 mo/yr for AFC.

Keywords: Reproductive traits, genetic trend, phenotypic trend, Holstein

INTRODUCTION

Animal improvement has been achieved by selection based on either phenotype or genetic merit of the superior animals for production traits. The practice of intensive selection programs for higher milk yields of dairy cattle has resulted in a significant reduction in reproductive efficiency caused by unfavorable genetic correlations between yield and fertility traits (Pryce *et al.*, 2004; Ojango and Pollott, 2001; VanRaden *et al.*, 2004; and Atil and Khattab, 2005).

Fertility traits may be economically more important than production traits (Berry and Cromie, 2009). Reproductive efficiency has a considerable impact on the overall profitability of dairy cattle production. Poor fertility increases costs due to fertility treatments and multiple inseminations, prolongs calving interval, and leads to a high replacement rate due to involuntary culling (Boichard, 1990; Dekkers, 1991; Gonzalez-Recio *et al.*, 2004 and González-Recio and Alenda, 2005). To determine the effectiveness of breeding schemes, genetic trends in dairy cattle populations should be calculated. The estimation of genetic trend represents the best tool to follow genetic changes in a population (Falconer and Mackay, 1996 and Atil and Khattab, 2005).

Heritability estimates of reproductive traits in dairy cattle are generally low (often less than 5%), making selection for those traits difficult (Lucy, 2001; Biffani *et al.*, 2003; Amimo *et al.*, 2006 and Abdelharith, 2008). Even though most reproductive traits have low heritabilities, monitoring reproductive performance has merit because after low milk yield, poor fertility is the leading reason for culling dairy cows (Berger *et al.*, 1981).

The objective of this study was to estimate the genetic and phenotypic trends of CI and AFC of Holstein cows in a commercial farm.

MATERIAL AND METHODS

Reproductive records of Holstein cows raised at the International Company for Animal Wealth located at Giza Governorate during the period from 1991 to 2006 were used. The data included 3656 records of 1611 cow daughters of 413 sires and 588 dams. All cows were artificially inseminated by imported Holstein frozen semen from USA and Canada.

The traits selected for this study were age at first calving (AFC) and calving interval (CI) of Holstein cows.

Statistical Analysis:

Two statistical models were applied to estimate the genetic parameters and breeding value of reproductive traits using VCE 6.0.2 (Groeneveld *et al.*, 2008) program. The repeatability animal model used for CI trait was as follow:

$$Y_{ijklmn} = \mu + S_i + Y_j + PI_k + A_l + Per_m + e_{ijklmn} \quad (1)$$

Where,

Y_{ijklmn} is the observed CI,

μ is the overall mean,

S_i is the fixed effect of i^{th} season of calving (i= 1, 2, 3 , and 4), where 1= 1991-1994, 2= 1995 - 1998, 3= 1999- 2002 and 4= 2003 - 2006.

Y_j is the fixed effect of j^{th} year of calving group (j= 1, 2, 3, and 4), where 1= winter (December - February), 2= spring (March, - May), 3= summer (June - August) and 4= autumn (September - November).

PI_k is the fixed effect of k^{th} parity (k= 1, 2, ..., and 6),

A_l is the random animal additive genetic effect,

Per_m is the random permanent environmental effect, and

e_{ijklmn} is the random error assumed NID $(0,\sigma^2 e)$

The second model was used for AFC trait:

$$Y_{ijkl} = \mu + S_i + Y_j + A_k + e_{ijkl} \quad (2)$$

Where,

Y_{ijkl} is the observation associated with the AFC trait,

μ is the overall mean,

S_i is the fixed effect of i^{th} season of birth (i= 1, 2, 3 , and 4), where 1= Winter (December - February), 2= spring (March - May), 3= summer (June - August) and autumn (September - November).

Y_j is the fixed effect of j^{th} year of birth group (j= 1, 2,3, and 4), where 1= 1989-1992, 2= 1993 - 1996, 3= 1997 - 2000 and 4= 2001 - 2005.

A_k is the random animal additive genetic effect, and
e_{ijkl} is the random assumed NID $(0,\sigma^2 e)$

The genetic trend was estimated as the linear regression coefficient of mean of breeding values on year of calving for CI and on year of birth for AFC, weighted by the number of animals in each year. Phenotypic trend was estimated by regressing phenotypic values on calving year for CI and on birth year for AFC. Genetic and phenotypic trends were estimated by XLSTAT (2009) procedures.

RESULTS AND DISCUSSION

Means and standard deviations for CI in days and AFC in months are shown in Table 1.

Table 1. Means and standard deviations (SD) for calving interval (CI) and age at first claving (AFC) of Holstein cows

Trait	Records (No.)	Mean	SD
CI, day	3656	484	131
AFC, month	1611	27.5	2.7

The present mean of CI was 484 d, which was longer than the optimal CI performance of 365 d. The average CI in the current study exceeded those obtained by Afifi *et al.* (2004), Salem *et al.* (2006) and Abdelharith (2008) on Friesian herds raised in Egypt. This result was comparable with means obtained from studies carried out in subtropical and tropical regions (Campos *et al.*, 1994 and Amimo *et al.*, 2006), but longer than those reported in temperate zones (González-Recio and Alenda, 2005 and Berry and Cromie, 2009) averaging 400 and 390 days, respectively. Ojango and Pollott (2001) indicated that the negative energy balance during early lactation in high-producing cows could affect the onset of estrus and hence result in longer calving intervals. Calving interval has a high economic weight as reduction in CI could improve the overall productivity of the herd.

Age at first calving in the present study averaged 27.5 mo, which was in close agreement with that reported by Abdelharith (2008). Afifi *et al.* (2004) found a younger average AFC (23.7 mo), while Salem *et al.* (2006) reported an older AFC (29.2 mo) compared to our study. Age at first calving in this study is lower than mean estimates of AFC in Italy (28.2 mo; Pirlo *et al.*, 2000), in Spain (28.6 mo; Perez *et al.*, 1999), and in Kenya (31 mo; Ojango and Pollott, 2001) for Holstein dairy herds. It has been reported that AFC of 22 months followed by a reduced CI has resulted in an increment in the productive life of dairy cows, which consequently has an influence on shortening the generation interval and accelerating the annual rate of genetic change through selection (Amimo *et al.*, 2006). Older cows at first calving had increased risk of being culled earlier post-first calving (Berry and Cromie, 2009). The same authors reported that the optimal AFC depends on the prevailing economic situation such as milk price, cull cow price, cost of feed and other inputs (e.g. labor, housing).

Table (2) illustrates heritability and repeatability estimates for the two studied traits. In general, low estimates of genetic parameters for reproductive traits were obtained in other studies (Campos *et al.*, 1994; Dematawewa and Berger, 1998; Ojango and Pollott, 2001; Amimo *et al.*, 2006; and Pozveh *et al.*, 2009).

Table 2. Estimates of heritability (h^2 ± SE), and repeatability (r) for calving interval (CI) and age at first calving (AFC) of Holstein cows.

Trait	h^2 ± SE	r
CI	0.07 ± 0.01	0.08
AFC	0.12 ± 0.04	–

Heritability estimate for CI was 0.07± 0.01 (Table 2), which was similar to that obtained by Pozveh *et al.* (0.07, 2009). This estimate was somewhat greater than 0.04 published by Wall *et al.* (2003) and González-Recio and Alenda (2005) and Amimo *et al.* (2006), and less than 0.09 reported by Campos *et al.* (1994) and Atil and Khattab (2005). Our estimate of heritability was greater than has previously been reported for different Holstein-Friesians herds in Egypt (Afifi *et al.*, 2004; and Abdelharith, 2008). In addition, Atil and Khattab (2005) suggested that a large proportion of the phenotypic variation in CI was mainly caused by differences in temporary environmental components and herds management systems.

Table 2 shows that the repeatability estimate for CI was 0.08. This estimate was close to that obtained by Abdelharith (0.07, 2008) and less than that obtained by Silva *et al.* (0.1, 1992). It can be concluded that the low estimate of repeatability in this study is an indication that CI is more affected by temporary environmental factors, rather than genetic and permanent environmental ones. Therefore, it would be thus possible to shorten the length of CI by improving reproductive management strategies within dairy herds.

The estimate of heritability for AFC was 0.12, which was in agreement with that obtained by Abdelharith (0.13, 2008). Age at first calving is known to be as a trait with small genetic variation. However, in the current study it is more heritable trait compared to calving interval (Table 2).

Genetic improvement of reproductive traits is slow and does not reduce the need for appropriate management techniques. Genetic improvement could reduce breeding costs because of isolation, treatment, culling and replacement of problem cows. Adequate methods of selecting dairy cattle and of improving herd reproductive efficiency depend on how genetic progress for milk yield influences reproductive performance. The cow's genetic merit for milk can affect reproductive performance, perhaps by increasing stress (Campos *et al.*, 1994).

Genetic and phenotypic trends of the studied traits:

The phenotypic trend of CI, as shown in Figure 1, was non-significantly negative (- 0.48±0.96 d/yr, $P>0.05$). The corresponding genetic trend for CI was significantly positive 0.06±0.02 d/yr, $P<0.015$, indicating a genetic increase in calving interval over time (Figure 2). Our result was comparable with that obtained by Abdelharith (2008), who reported estimates of genetic and phenotypic trends 0.03 ± 0.03 d per year and -0.09 ± 0.17 d per year, respectively, for CI. In addition, Atil and Khattab (2005) estimated the genetic trends for CI and 305 d milk yield to be -0.95 d/year and 44.85 kg/yr. They concluded that selection objective focused on choosing the best sires and cows to be the next generation parents would lead to increase in milk traits and decrease in reproductive traits simultaneously. Numerous publications confirmed that selection for milk production with little or no emphasis on reproduction has led

to a decline in reproduction performance in dairy populations (Ojango and Pollot 2001; Weller and Ezra, 2004; González-Recio and Alenda, 2005; and Berry and Cromie, 2009).

The genetic trend in AFC was positive (Fig. 3), indicating a genetic increase in AFC over time. The regression of breeding value for AFC on year of birth was significant positive (0.02±0.003 mo/yr, P=0.000). The results obtained in the current study correspond to previous results for the Israeli Holstein population (Weller and Ezra, 2004) and for Simmental breed in Slovenia (Potoenik *et al.* 2000), but disagree with other studies that have mentioned negative genetic trend for AFC (Amimo *et al.*, 2006; Abdelharith, 2008). In contrast, phenotypic trend (Fig. 4) in AFC was non-significantly negative (-0.04±0.06 mo./yr, P>0.05). This decrease is due to better management of calves and heifers and realization of the economic importance of earlier first calving.

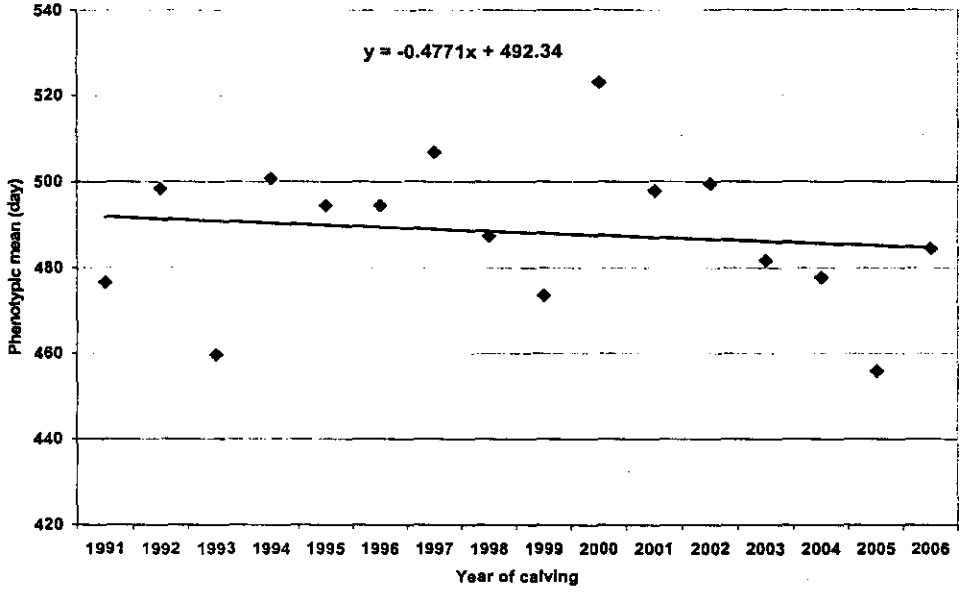

Figure 1. Phenotypic trend of CI of Holstein cows

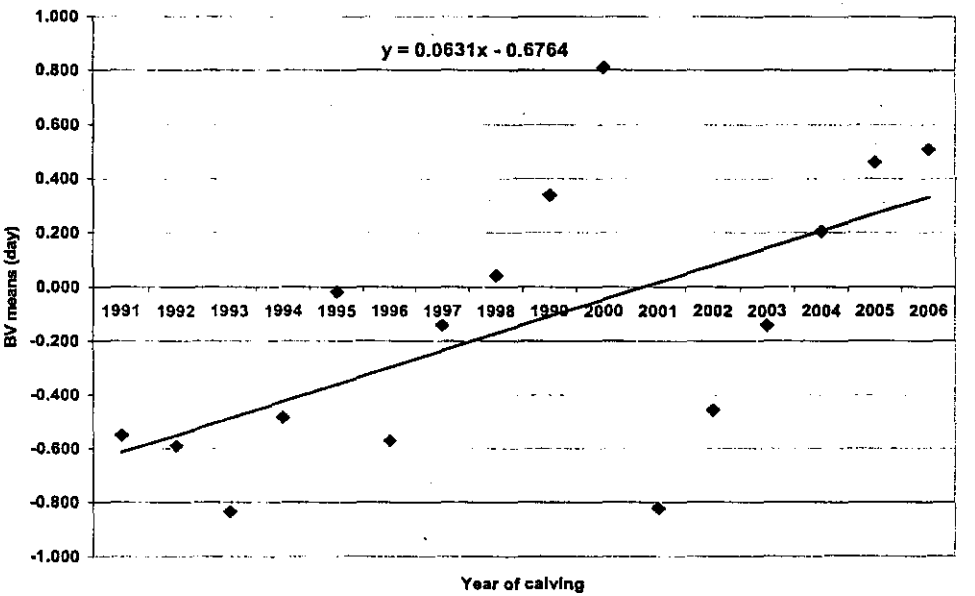

Figure 2. Genetic trend for CI of Holstein cows

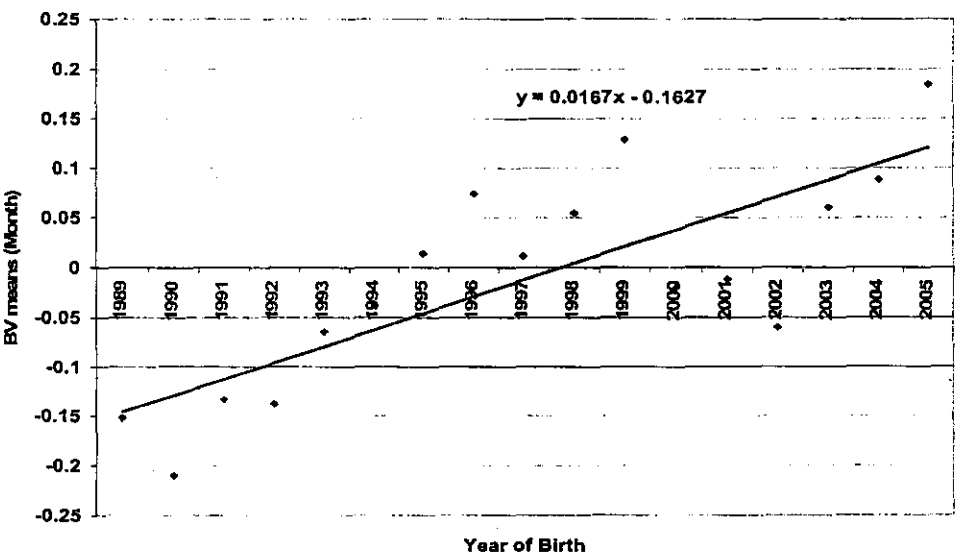

Figure 3. Genetic trend for AFC of Holstein cows

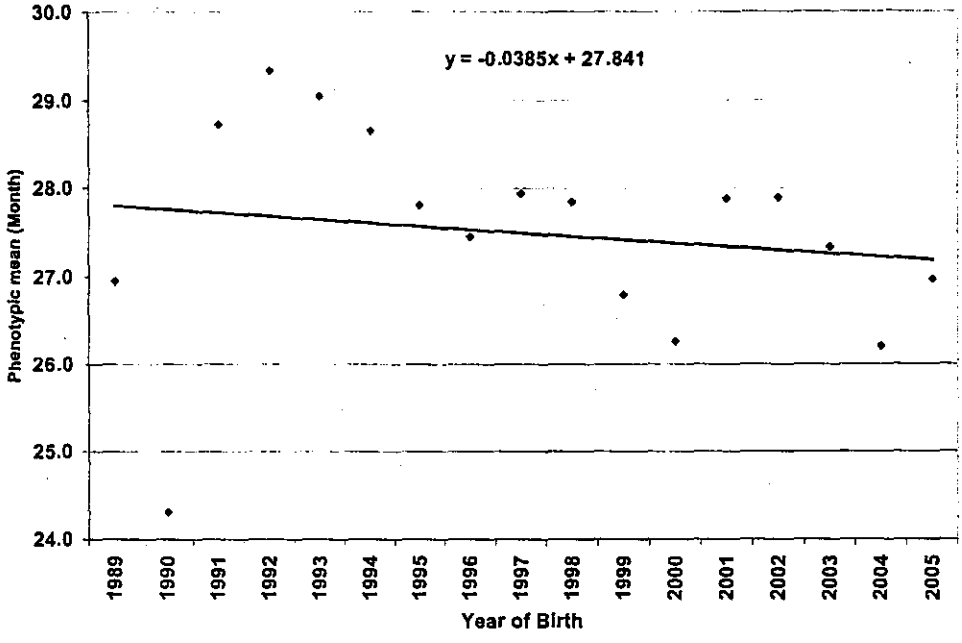

Figure 4. Phenotypic trend for AFC of Holstein cows

CONCLUSIONS

Heritability and repeatability estimates for CI and AFC were in the range of those previously reported in the literature. Low estimates of reproductive traits in this study support the idea that genetic selection to improve reproductive traits is probably unwarranted.

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الإتجاهات الوراثية و المظهرية لصفة الفترة بين ولادتيين و العمر عند أول ولادة لابقار الهولستين فى قطيع تجارى

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تم إستخدام 3656 سجلا لـــــ 1611 بقرة هولستين (بنات 413 طلوقة و 588 أم) تابعة لمزرعة الشركة العالمية للثروة الحيوانية بمحافظة الجيزة، لدراسة تقدير الإتجاهات الوراثية و المظهرية لصفة الفترة بين ولادتيين و العمر عند أول ولادة لابقار الهولستين. إشتمل النموذج الإحصائى الأول لصفة لصفة الفترة بين ولادتيين على تأثير موسم و سنة الولادة و ترتيب الوضع كتأثير ثابت و تأثير الحيوان و البيئة الدائمة كتأثير عشوائى. بينما اشتمل النموذج الثانى على تأثير موسم و سنة الميلاد كتأثير ثابت بالأضافة الى الأثر العشوائى للحيوان. إستخدم برنامج VCE لتقدير المقاييس الوراثية و القيم التربوية.

كانت النتائج على النحو التالى :

1- متوسط كلا من صفة الفترة بين ولادتيين و العمر عند أول ولادة هو 484 يوم و 27.5 شهر، على الترتيب.
2- قية العمق الوراثى لكل من صفة الفترة بين ولادتيين و العمر عند أول ولادة هو 0.07 و 0.12 ، على الترتيب. بينما كانت قيمة معامل التكرار لصفة الفترة بين ولادتيين هى 0.08 .
3- أظهر الإتجاه المظهرى لصفة الفترة بين ولادتيين اتجاها سالبا غير معنوى قيمته -0.48 يوم/سنة ولادة. بينما كان الإتجاه الوراثى موجباً و معنوياً و قيمته 0.06 يوم / سنة و لادة.
4- كان الإتجاه المظهرى لصفة العمر عند أول ولادة اتجاها سالبا غير معنوى قيمته – 0.04 شهر/سنة ميلاد. بينما كان الإتجاه الوراثى موجبا معنويا (0.02 شهر/سنة ميلاد).