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Lifetime Production and Reproduction Performances of *Bos taurus* x *Bos indicus* Crossbred Cows in the Central Highlands of Ethiopia

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Abstract

Lifetime reproduction and production records of 170 Boran crossbred cows belonging to six genetic groups that were born between 1974 and 1995 at the Holetta Agricultural Research Center (HARC) were used in this study. The genetic groups were F_1 Friesian x Boran (F_1FBo), F_1 Jersey x Boran (F_1JBo), F_2 Friesian x Boran (F_2FBo), F_2 Jersey x Boran (F_2JBo), 75% Friesian inheritances (FxBoF), and 75% Jersey inheritances (JxJBo). Reproductive traits studied were age at first calving (AFC, n=170), calving interval (CI, n=844) and days open (DO, n=844). Productive traits studied were lactation milk yield (LMY, n=1011) and lactation length (LL, n=1010). Fixed effects included in the model were birth year, birth season, calving year, calving season and parity. The overall least square means (s.e) was 43.20 (0.84) months for AFC, 200.13 (25.55) days for DO and 481.30 (25.73) days for CI. AFC was significantly affected (P<0.01) by genetic groups and birth year. However CI and DO were not affected by any of the fixed effects considered. The overall least square means (s.e) was 1919.60 (103.21) liters for LMY and 360.76 (16.11) days for LL. Both traits were significantly affected (P<0.05) by genetic groups, birth year, calving year and parity. In general, F_1 crosses produce significantly more average LMY of 2150.03(1.92) liters and had longer LL of 365.01(12.56) days as compared to F_2 crosses with average LMY and LL of 1553.96(106.35) liters and 346.30(16.52) days, respectively. Likewise average AFC, DO and CI were 41.39 (1.92) months, 189.16(19.13) days and 469.25(20.27) days, respectively for F_1 crosses. However, AFC, DO and CI were found to be 49.02(0.9) months, 213.26(26.56) and 494.36(26.75) days, respectively for F_2 crosses. Therefore, results showed that when productive and reproductive performances were simultaneously considered, F_1 crosses were superior to the second-generation crosses in all the traits considered.

Keywords: lifetime, lactation length, lactation milk yield, age at first calving and calving interval

Introduction

Two different types of factors are responsible for the differences between individual animals within a breed. First, there are environmental factors such as climate, nutrition, health and overall management. Second, there are genetic factors, which are due to the genes received from the two parental gametes.

The genetic and environmental factors interact, so that the total variations between animals are equal to the sum of the effects of the entire environment and genetics, and the interaction between them (Syrstad, 1990).

Poor productive and reproductive performances of cattle breeds, which are indigenous to tropical climates, have mainly originated from influences of these two factors. On one hand, they have poor inherent genetic potential to produce sufficient milk and on the other hand, the natural environments in which they survive are stressful and as a result, even if milk production potential exists, they cannot perform to their maximum capacities.

Several reports (Kiwuwa *et al*., 1983; Beyene Kebede, 1992; Sendros Demeke, 2002) showed that cattle breeds indigenous to Ethiopia are characterized by extended age at first calving, which ranges from 3½ to 4 years, longer calving interval and inter-calving period. Lactation milk yield also hardly exceeds 600 liters in a shorter lactation length of less than 200 days.

On the other hand, improved dairy breeds imported to tropical environments showed unsatisfactory result compared to their performances in their home environment. Study conducted by Vaccaro (1973, 1974a, 1975a, 1990), Mason (1974), Nagarcenkar (1982), Taneja and Bhat (1986) confirmed that the performances of temperate breeds imported to tropical climates showed disappointing results such as low growth rate, high mortality rate of calves and low fertility of the cows.

As a result, crossbreeding of improved breeds of *Bos taurus* with the indigenous cattle of the tropics (*Bos indicus*) was popularized as an option to improve milk production potential of tropical breeds. Review works have been done in several tropical countries by a number of expatriates (Buvanendran and Mahadevan, 1975; Vaccaro, 1973; McDowell, 1985b) and all unanimously concluded that crossbred cows have marked superiority over indigenous cattle breeds in dairy traits.

In Ethiopia, crossbreeding of indigenous cattle breeds with the commonly used exotic dairy breeds was started in 1974 by the then Institute of Agricultural Research (IAR) at four research stations, that represent different agro-ecological zones of the country with various outcomes (Mohammed *et al*., 1987 Sendros *et al*., 1987a, 1987b, Beyene Kebede, 1992).

However, some of the results presented on production and reproduction traits were based on few lactation records and might not reflect the actual lifetime production and reproduction performances of crossbred cows. This paper is therefore, designed to evaluate lifetime production and reproduction efficiencies of various crossbred dairy cows at Holetta Agricultural Research Center, Ethiopia.

Materials and Methods

Study area

This study was carried out at Holetta Agricultural Research Center (HARC). Holetta is one of typical highland areas of Ethiopia, which is conducive for dairying. It is located at 45km west of the capital Addis Ababa. It is located at an altitude of 2400 meters above sea level. Geographically, it is situated at 9^0 3'N latitude and 38^0 38' E longitudes.

Breeding plan and animal management

The data were obtained from a long-term crossbreeding program undertaken from 1974 to 1995. Semen from two exotic sire breeds; Friesian (F) and Jersey (J) were imported and crossed with local Boran (Bo) dams to produce F_1 crossbred calves. F_1 bulls in turn were selected based on dam milk yield, growth performances and physical appearances for the production of F_2 generations (Table 1). In addition, semen from exotic bulls was used to produce advanced generations like 75% exotic inheritances.

All animals were treated under similar feeding and management practices. They graze for approximately 7:00 hrs per day from 8:00 hour to 15:00 hour on native pasture except during the main rainy season when the herd is restricted limited grazing area. Upon return to the barn, they were supplemented with conserved hay and green grass from natural pasture or cultivated forage (elephant grass) depending on availability. Milking cows were supplemented with nearly 2 kg/head/day local concentrate feeds mainly constituting 30% wheat bran, 31% wheat middling, 35% noug seed cake (*Guizota absysinica*), 3% bone and blood meal and 1% salt during milking.

As the cows were kept for experimental purposes of various natures, there were no stringent culling procedures. Calves were immediately separated from their dams after birth and fed colostrum for five days. Bucket feeding of whole milk continued until weaning at 98 days of age. Two weeks from birth, calves were supplemented with additional hay and concentrate. Calves consumed a total of 260 liters of milk until weaning and further maintained in a calf-rearing pen until six months. After six months of age, female calves joined the breeding herd and were bred when they attained body weight of above 230kg.

Table 1. Mating design and genotype produced in the breeding programs †

Sire genotype	Dam genotype	Progeny produced
F	Bo	F_1 FBo
J	Bo	F_1JBo
F_1FBo	F_1FBo	F_2FBo
F_1JBo	F_1JBo	F_2 Bo
F	F_1FBo	3/4F:1/4Bo
J	F_1JBo	3/4J:1/4Bo

†Bo = Boran; F = Friesian; J = Jersey; F_1FBo = F_1 Friesian x Boran; F_1JBo = F_1 Jersey x Boran; F_2 Bo = Friesian x Boran F_2; F_2JBo = Jersey x Boran F_2; 3/4F:1/4Bo = 75% Friesian inheritances; 3/4J:1/4Bo = Jersey inheritances.

Treatment of the herd against any incidence of diseases was a routine practice. Seasonal outbreaks of major diseases of economic importance were identified and control measures were taken according to the disease control calendar set by the animal health research division of the HARC.

Traits studied

Two major types of dairy traits were considered in this study. These were productive traits, which include lactation milk yield (LMY) and lactation length (LL) and reproductive traits, which include age at first calving (AFC), calving interval (CI) and days open (DO) (Table 2).

Table 2. Production and reproduction records by genetic groups †

Genetic groups	Number of cows	Production records		Reproduction records		
		LMY	LL	AFC	CI	DO
F_1FBo	44	278	278	44	234	234
F_1JBo	44	299	299	44	256	256
F_2FBo	27	144	144	27	117	117
F_2JBo	31	148	148	31	117	117
¾ F:¼ Bo	11	54	54	11	45	45
¾J:1/4Bo	13	88	88	13	75	75
Total	170	1011	1010	170	844	844

†LMY= lactation milk yield, LL= lactation length, AFC= age at first calving, CI= calving interval, DO= days open

Statistical model and data analysis

The data were analyzed using linear additive model where the independent effects include genetic groups, birth year, calving season, parity and calving year. The dependent variables were subjected to the analysis of variance using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 1999).

Birth year from 1974 to 1997 inclusive was analyzed. However, because of few observations in 1995, 1996 and 1997, they were grouped together and analyzed as single year record denoted as 1995^+. Similarly, early calving year of 1977, 1978 and 1979 were grouped together and analyzed as single year record denoted as 1979^+. Lactation lengths of less than 50 and greater than 720 days and lactation milk yield of less than 70 liters were not included in the final data analysis.

The general linear models used were;

i) $Y_{ijklm} = \mu + B_i + Y_j + S_k + P_l + C_m + e_{ijklm}$

Where

Y_{ijklm} = lactation milk yield, lactation length, days open and calving interval of $ijklm^{th}$ cow

μ = Overall mean;

B_I = the effect of i^{th} genetic groups (I = 1 to 6) Y_j = the effect of j^{th} birth year (j=1974 to 1995^+)

S_k = the effect of k^{th} calving season (dry, short rainy and heavy rainy seasons)

P_l = the effect of l^{th} parity (l=1 to 8^+)

C_m = the effect of m^{th} calving year (m=1979^+ to 2000)

e_{ijklm} = random error associated with $ijklm^{th}$ observation assumed to normally and independently distributed with mean = 0 and variance δ_e^2.

ii) Age at first calving was analyzed by fitting the data to fixed effects of linear model that consists of genotype of the cow, birth year and birth season.

$Y_{ijk} = \mu + B_i + Y_j + S_k + e_{ijk}$ Where

Y_{ijk} = age at first calving of i^{jkth} heifer

μ = Overall mean

B_I = the effect of i[th] genetic groups (i= 1 to 6)

Y_j = the effect of j[th] birth year (j=1974 to 1995[+])

S_k = the effect of k[th] birth season (dry, short rainy and heavy rainy seasons)

e_{ijk} = random error associated with ijk[th] observation and assumed to be normally and independently distributed with mean =0 and variance δ_e^2.

Results

Productive performances

The overall LMY and LL for the genetic groups was 1919.6 (103.21) liters and 360.76 (6.11) days, respectively. Genetic group and parity were detected to be significant (*P*< 0.05) sources of variation in both traits. Lactation milk yield (LMY) and LL were also highly influenced (*P*<0.001) by birth year and calving year (Table 3). However, the effect of calving season was not significant (*P*>0.05). Crosses with 75% Friesian inheritance were found to be more productive per lactation though did not produce significantly more LMY than the F_1 crosses. However, they produce more LMY as compared to F_2 crosses and crosses with 75% J inheritance (Table 4).

Table 3. Least squares means analysis of variance of different genetic groups of Boran crossbred cows by fixed effects †

Traits	Genetic groups	Birth year	Calving year	Calving season	Parity	Birth season
LL (days)	*	***	***	NS	*	-
LMY (days)	***	***	***	NS	**	-
AFC (months)	**	**	-	-	-	NS
CI (days)	NS	NS	*	NS	NS	-
DO (days)	NS	NS	*	NS	NS	-

†LL = lactation length; LMY = lactation milk yield; AFC = age at first calving; CI = calving interval; DO = days open; NS (p>0.05); * = p<0.05; ** = p<0.01; *** = p<0.001 and - = fixed effect in a column was not used to analyze trait in a row

Parity had no significant influence on both LL and LMY up to the sixth parity, but its effect was considerable beginning from the seventh parity. LMY tended to increase from the first through to the forth parity where peak LMY was attained in the fourth parity. However, it showed a declining trend after reaching a peak at the fourth parity (Table 4).

Birth year and calving year were detected to be significant sources of variation for both LL and LMY (*P*<0.001). However, no clear yearly trend can be detected. Rather it showed inter-annual fluctuation in both traits. However, it was noted that earlier and later years of birth and calving had better response than the intermediate years.

Table 4. Least squares means (s.e.) of LMY and LL of Boran crossbred cows by genetic groups, calving season and parity based on lifetime records

Effects	LMY (s.e.) (liters)	LL (s.e.) (days)
Genetic groups		
F_1FBo	2149.67 (85.86)^{a}	359.11 (13.46)^{b}
F_1JBo	2150.39 (75.42) ^{a}	371.00 (11.67)^{b}
F_2FBo	1765.25 (111.4) ^{b}	360.41 (17.3)^{ab}
F_2FBo	1342.66 (101.3)^{c}	332.19 (15.73)^{c}
3/4F:1/4Bo	2342.90 (136.9)^{a}	392.66 (21.61)^{a}
3/4J:1/4Bo	1766.77 (108.3)^{b}	349.17 (16.94)^{b}
Calving season		
Dry season	1900.92 (80.01)	358.35 (13.26)
Short rainy	1910.72 (88.15)	365.28 (14.02)
Rainy season	1947.18 (91.81)	358.64 (13.11)
Parity		
1	1833.26 (72.61)^{a}	367.79 (11.37)^{a}
2	1993.37 (64.14)^{a}	375.40 (10.07)^{a}
3	1974.91 (71.90)^{a}	355.42 (11.29)^{a}
4	2035.54 (89.62)^{a}	384.77 (14.02)^{a}
5	2022.69 (113.63)^{a}	369.30 (17.70)^{a}
6	1965.48 (136.11)^{a}	373.14 (21.25)^{a}
7	1946.98 (168.73)^{a}	349.61 (26.27)^{a}
8^{+}	1584.62 (194.43)^{b}	310.62 (30.35)^{b}
Overall mean	1919.60 (103.21)	360.76 (16.11)
CV	0.3953	0.3311

Means with the same superscript within columns are not significantly different from each other (P>0.05)

Reproductive performances

The overall least squares means (s.e.) for AFC (months) CI (days) and DO (days) for the entire genetic group was 43.20 (0.84), 481.30 (25.73) and 200.13 (25.55), respectively. Genetic group had significant influence on AFC (P<0.01) where as CI and DO were not influenced by any of the fixed effects considered (P>0.05). F_1JBo and crosses with 75% Friesian inheritance had shorter AFC than the second generation crosses (Table 5).

Though the fixed effects considered had no significant influence (P>0.05) on CI and DO, least squares means analysis of variance showed a progressive improvement in CI and DO with the advancement in parities. At earlier parities, all the cows had longer CI and DO than the later parities.

Though the overall effect of birth year and calving year were significant sources of variation for all reproductive traits (P<0.05), no clear trend was found except for AFC. Graph 1 showed that almost constant AFC was observed during the early periods of crossbreeding program and the longest AFC was observed during the years of 1981 through 1984.

Table 5 Least squares means (s.e) of reproductive performances of Boran crossbred cows by genetic groups, calving season and parity based on lifetime records

Effects	Reproductive performances		
Genetic groups	AFC (months)	DO (days)	CI (days)
F_1FBo	44.02 (0.72)[b]	195.24 (21.55)	474.25 (21.70)
F_1JBo	38.76 (0.60)[c]	183.08 (16.71)	464.21 (18.84)
F_2FBo	49.80 (0.96)[a]	206.10 (27.73)	486.46 (27.92)
F_2FBo	48.24 (0.84)[a]	220.41 (25.40)	502.56 (25.57)
3/4F:1/4Bo	38.52 (1.44)[c]	227.42 (33.52)	509.55 (33.75)
3/4J:1/4Bo	39.72 (1.08)[c]	168.55 (26.42)	450.30 (26.60)
Calving season			
Dry season	-	183.56 (20.06)	465.08 (20.20)
Short rainy	-	207.66 (22.24)	488.87 (22.40)
Rainy season	-	209.18 (22.62)	489.97 (22.78)
Parity			
1	-	242.87(16.70)[a]	520.80(16.81)[a]
2	-	218.83(14.64)[a]	496.14(14.75)[a]
3	-	202.45 (17.25)[a]	483.94 (17.37)[a]
4	-	210.82 (22.21)[a]	491.62 (22.37)[a]
5	-	200.25 (28.53)[a]	482.37 (28.73)[a]
6	-	184.45 (35.86)[a]	468.76 (36.11)[a]
7	-	185.38 (43.50)[a]	462.82 (43.80)[a]
8^+	-	156.01 (50.08)[b]	439.00(50.42)[b]
Overall	43.20 (0.84)	200.13 (25.55)	481.30 (25.73)
CV	0.2169	0.7511	0.33

Means with the same superscript within columns are not significantly different from each other (P>0.05)

Discussion

The overall mean of LMY observed in the present study for Boran crosses is within the ranges of LMY reported by different authors. Schaar *et al*. (1981), Alberro (1983), Kiwuwa *et al*. (1983) and Chernet *et al*. (1999) reported LMY of 1885, 2031, 1977 and 1478 liters, respectively for different crossbred cows in Ethiopia. As expected, variability in these reports and the present findings could perhaps stemmed from dam breed differences that comprised the crosses, agro-ecological variations or management differences implemented by individual farms. In addition, LMY in the reports is entirely based on few records, which may not clearly reflect actual lifetime performances.

Higher productivity per lactation obtained in crosses with 75% Friesian inheritances could be due to relatively longer lactation length observed in this cross and/or it may have arisen from high proportion of Friesian genes as Friesians are known for high milk production. For instances, Million Tadesse, (2001); Million *et al*. (2004) reported that LMY increased as the proportion of Holstein Friesian blood increased from 0 to 15/16. In this study, though the level of LMY in 75% Friesian inheritances is relatively better than the rest of genetic groups, it was realized to be unsatisfactory. This indicates that raising the level of exotic inheritance (upgrading) alone would not improve LMY unless the level of management is simultaneously improved.

The relatively better productive performance noticed in F_1 crosses of both Friesian and Jersey is consistent with several other reports. McDowell (1988b) revised crossbreeding results from 25 countries of the tropics involving 57 genetic groups, 15 native breeds and 7 European breeds and reported that F_1 crosses had considerable benefits. They calved earlier, yielded more milk (147%), were milked for more days, and had slightly shorter calving interval. Other researchers (e.g. Kiwuwa *et al*., 1983; Vacarro, 1973; Beyene Kebede, 1992) also reported the superiority of F_1 over the rest of genetic groups.

The consistently better rank of F_1 crosses could be attributed to maximum heterotic effect obtained by crossing the two diverse populations. Apparently, lower LMY exhibited by F_2 crosses in the present study might be in part due to reduction in hybrid vigor as explained by McDowell (1988b) and Falconer and Mackay (1996). On the other hand, lower selection intensity of F_1 bulls or cows for the production of F_2 crosses because of small population size may have resulted in low LMY. Besides, the decline in performance from F_1 to F_2 or backcross generation in tropical environments could be due to recombination losses than other factors (McDowell 1985; Cunningham and Srystad 1987; Srystad, 1989).

In addition to genetic factors, reproductive traits are mainly affected by environmental factors (climate, nutrition, health and other factors which are not of genetic origin). Relatively poor performances in measure of reproductive efficiencies such as AFC, DO and CI observed in this study (Table 5) could be attributed to the fact that level of management practices that could support optimum performances in these traits was unmet at the center.

The overall least square means for AFC, CI and DO in this study were longer than the voluntary waiting periods of each trait. This expected to affect the lifetime productivity and, therefore, profitability of diary cows. A study conducted by Mukasa-Mugerwa (1989) also revealed that the lifetime productivity of a cow is influenced by age at puberty, age at first calving, inter-calving period and calving interval.

Several reports (Kiwuwa *et al*., 1983; Enyew Nigussie, 1999; Tawah *et al*., 1999; Sendros Demeke, 2002) showed that the effect of birth year on AFC and calving year on CI and DO were significant for grazing animals under tropical conditions. The trend of influence was, however, irregular and not similar for all traits. In this study too, the inter-annual variation on reproductive traits may indicate a failure to maintain uniform management practices over the years.

Shorter AFC observed in the present study for Jersey crosses is in agreement with most other reports (Beyene Kebede, 1992; Sendros Demeke, 2002). However, shorter AFC noticed in crosses with 75% F inheritances was inconsistent with most of the results reported under tropical conditions. This could be attributed to the smaller sample size in this study and/or due to the faster growth rate in the early traits of Friesian breeds as the level of inheritance increased. Though there were no significant differences in CI and DO, high variability has been observed in these traits.

The relative superiority of F_1 crosses in all traits compared to their F_2 crosses are reported in several studies. Buvanendran *et al.* (1981); McDowell, (1985b); Tawah *et al.* (1999) and Sendros Demeke (2002) noted that F_1 crosses ranked first in all the traits considered. In particular, decline in performance from F_1 to F_2 and later generations are common phenomenon because of reduction in heterozygosity in F_2 (McDowell, 1985b; Syrstad, 1989).

Both CI and DO showed a decreasing tendency with advancing lactation number even though they were not influenced by any of the factors considered in the study. Several reports (Silva *et al.,* 1992; Tawah *et al*., 1999; Saha *et al*., 2000) noted that CI and DO tended to decrease with increases in the number lactation completed. Though there is no hard fact to justify this trend, results suggest that reproductive efficiency of dairy cows show tendency of improvement with increasing lactation number.

Conclusion

In general, results of this study showed that F_1 crosses in particular, that of Jersey were superior in all production and reproduction traits considered. Second generation crosses were inferior in all the traits studied.

Productivity per lactation was high for crosses with 75% Friesian inheritance. However, they completed fewer numbers of lactations in their lifetime, which has a negative impact on the total lifetime milk yield. Therefore, improvement in the level of overall management has to be considered before designing to increase the level of Friesian inheritance.

In Ethiopia, where there is no clear crossbreeding program, careful decision should be made in selecting appropriate exotic breed and the level of their inheritances. In addition, the crossbreeding program should take into account of dairy production systems and available resources since these factors influence the types of crossbred cow to be maintained.

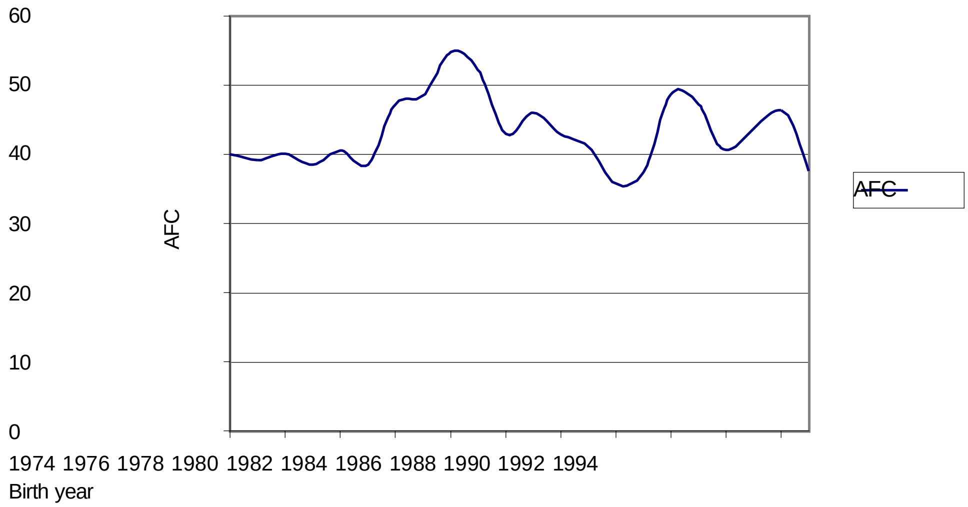

Figure 1. Yearly variation of age at first calving

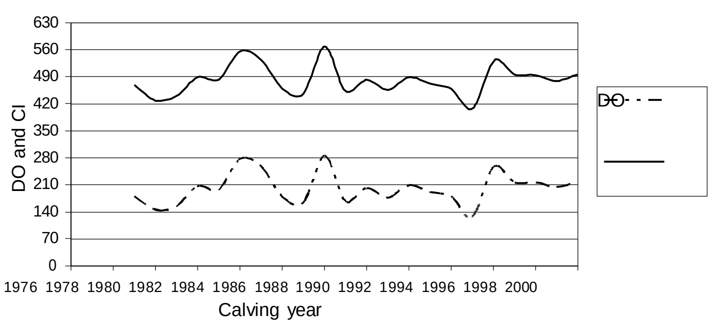

Figure 2.Yearly variation of calving interval (CI) and days open (DO)

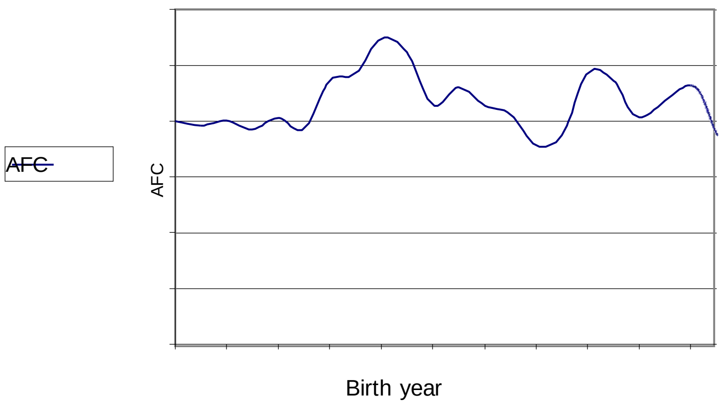

Figure 3. Yearly variation of age at first calving

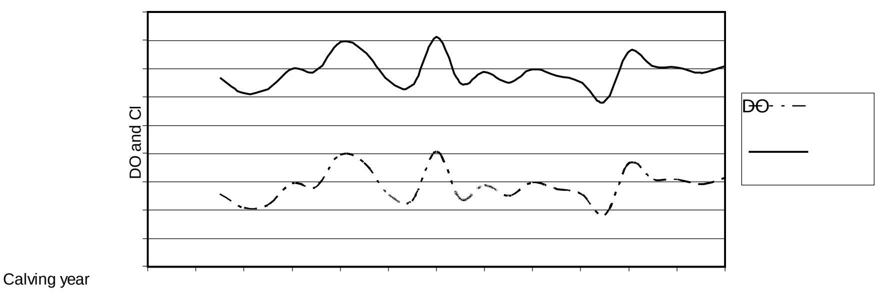

Figure 4.Yearly variation of calving interval (CI) and days open (DO)

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