Indian Journal of Animal Sciences **83** (9): 948–952, September 2013/Article

Estimate of genetic and non-genetic parameters and trends for age at first calving in Sahiwal cows

SIVAMANI BALASUBRAMANIAM[1], MOHAN SINGH[2], G R GOWANE[3] and S KUMAR[4]

Chhattisgarh Kamdhenu Vishwavidyalaya, Durg, Chhattisgarh 491 001 India

Received: 10 March 2011; Accepted: 8 April 2013

ABSTRACT

Age at first calving (AFC) records (403) of Sahiwal cows sired by 30 bulls, spread over 50 years (1948–1997) maintained at Government Cattle Breeding Farm, Anjora, Durg were utilized to study the factors affecting age at first calving and its estimate of heritability by using least squares technique. The period of birth and sire effects were significant and the season was nonsignificant. The estimate of heritability was moderate (0.43). AFC showed negative association with first lactation milk yield, however, the relationship was positive in later cumulative milk and lifetime traits. Overall phenotypic and genetic trends for AFC were in the desired direction, except poor performance in the second to fourth periods. Genetic trend can further be improved if the available additive genetic variability in the herd is properly exploited through selection.

Key words: Age at first calving, Genetic factors, Heritability, Non genetic factors, Sahiwal

Age at first calving (AFC) is an important reproductive trait as well as an economic trait in cattle. Decrease in age at first calving decreases the cost of raising the animals to productive life, increases the annual genetic gain and raises the average productive life of the animal. The estimate of additive genetic variability for traits of economic importance gives an idea about the scope of genetic improvement of the trait through selective breeding. The selection and evaluation of breeds to be used as the parental stock is an important step for the success of any animal breeding program. An estimate of the genetic progress achieved by selection programs is necessary to describe the genetic changes progress, to assess the benefits of the selection program and to introduce necessary adjustments (Euclides Filho *et al.* 1997). The present investigation was undertaken to study the influence of various genetic and non-genetic factors on age at first calving along with estimation of genetic parameters for AFC and its relationship with other important traits. Holistic analysis of the genetic and phenotypic trends over the entire period of study was also performed for better evaluation of the genetic improvement program.

Present address: [1]Scientist (drsivamani@gmail.com), [4]Senior Scientist, Division of Animal Genetics. [2]Professor and Head, Department of Animal Genetics and Breeding, College of Veterinary Science and Animal Husbandry, Durg. [3]Scientist, CSWRI, Avikanagar.

MATERIALS AND METHODS

The data were collected on Sahiwal cows (403) maintained at the Government Cattle Breeding Farm and Bull Mother Experimental Farm, College of Veterinary Science and Animal Health, Anjora, Durg, over a period of 50 years from 1948 to 1997. The cows with the history of abortion, premature birth, still-birth, abrupt termination of lactation, abnormally short lactation length and chronic illness were excluded. The data were classified on the basis of period of birth, season of birth and sire.

The number of observations from 1948–57 were limited hence these 10 years were clubbed into one period. The subsequent periods comprised 5 years each. Thus the entire data were classified into 9 periods viz. P1: 1948–57, P2: 1958–1962, P3: 1963–1967, P4: 1968–1972, P5: 1973–1977, P6: 1978–1982, P7: 1983–1987, P8: 1988–1992 and P9: 1993–1997. The data were cross classified into 4 seasons. They are summer (April to June: S1), rainy (July to September: S2), winter (October to January: S3) and spring (February to March: S4). The age at first calving was also classified sire wise. Only those sires with 4 or more progenies were considered for the analysis. The number of progeny per sire ranged from 4 to 51. The data for age at first calving were classified into 30 groups on the basis of sires. The least squares analysis of variance technique using Mixed Model Maximum Likelihood Computer Programme PC-2 developed by Harvey (1990) was applied to study the effect of various factors on AFC. In the model, AFC was responding on dependent variables, period and season of birth being the fixed effects and sire a random effect.

The heritability of age at first calving was calculated by paternal half-sib correlation method. Mixed Model Least squares and Maximum Likelihood Computer Programme PC-2 developed by Harvey (1990) was used for the analysis of variance.

The traits examined in this study include first lactation milk yield for 300 days (FLMY 300), life time milk yield (LTY3 and LTY5: total milk yield in 3 and 5 lactations respectively), productive life (PL3 and PL5: period from the day of first calving to the day of completion of 3 and 5 lactations respectively) and herd Life (HL3 and HL5: period from the day of birth to the day of completion of 3 and 5 lactations respectively). Genetic, phenotypic and environmental correlations of AFC with all the above traits were calculated. The component of variance and co-variance between AFC and other traits were obtained for the estimation of correlations.

Estimation of genetic, phenotypic and environmental trends: The phenotypic trend (ΔP) was estimated as the regression (b_{PT}) of population performance (P) on time (T). The population performance is the period wise average (least squares means) of age at first calving. The rate of change per period, obtained by the above procedure, was converted into the rate of change per year.

The genetic trend was estimated by Henderson's principle (Henderson 1973) which consisted of regression of the weighted average transmitting abilities of the sires for each period on time (period). The fixed effect models comprising period, season, and sire effects were run for age at first calving and the least squares constants for the sires were obtained. The Expected Breeding Values (EBV) of each sire was obtained by the formula given by Lush (1935).

$$EBV = \frac{0.5nh^2}{1+(n\text{-}1)t} \text{ (LSC)}$$

where, EBV, expected breeding value; h^2, heritability; t, intra class correlation (0.25 h^2 for the half sib progeny); n, number of half sib progeny; LSC, least squares constant.

The expected transmitting abilities (ETA) were obtained by dividing the respective EBVs by 2. The weighted averages of sires transmitting abilities for periods were then regressed on periods. The regression value, thus obtained, was multiplied by 9 (as there were 9 periods) to get the total genetic change and then divided by 50 (as there were 50 years in 9 periods) to get the annual genetic change.

The environmental trends were obtained by subtracting the genetic trend from the phenotypic trend.

RESULTS AND DISCUSSION

Effect of period, season and sire on AFC: The least squares analysis of variance for age at first calving (AFC) revealed that AFC was significantly (P<0.01) affected by period of birth as well as sire effects whereas the season of birth was nonsignificant (Table 1). The sire and period effects contributed 13 and 12% respectively to the variability of AFC.

Table 1. Least squares mean for age at first calving

Effect	N	AFC (LSM± SE)
μ±SE	403	1250.07 ± 17.40
Period **		
1948–57	38	1140.04^{a} ± 60.35
1958–62	39	1299.27^{b} ± 65.58
1963–67	31	1365.92^{b} ± 55.41
1968–72	34	1485.00^{f} ± 42.50
1973–77	47	1223.82^{c} ± 49.86
1978–82	76	1257.67^{bcd} ± 42.04
1983–87	58	1175.25^{ace} ± 43.11
1988–92	31	1215.36^{acde} ± 55.33
1993–97	49	1088.28^{a} ± 70.74
Season NS		
Summer	88	1233.26 ± 23.79
Rainy	98	1241.71 ± 23.33
Winter	138	1282.34 ± 21.26
Spring	79	1242.97 ± 24.49

**, Significant at 1% level; NS, nonsignificant; N, number of records; values bearing different superscripts indicate they differ significantly from each other as per DMRT.

The significant effect of sire indicated that through the selection of sires with better breeding values for age at first calving, the genetic change in the trait can be effected in the desirable direction. The significant effect of period is the reflection of differences in the feeding and fodder availability during different periods influencing the growth rate and age at first calving in the heifers. The nonsignificant effect of season clearly indicates that the Sahiwal is adaptable to the area (Durg) and is not susceptible to the seasonal changes in the temperature and humidity. The results are in close agreement with Kushwaha *et al.* (2002). In divergence with the present findings, nonsignificant effect of period was reported by Wakchaure and Meena (2010). The significant effect of season was reported by Anilkumar *et al*. (2009).

The least squares means (LSM) for various periods and seasons are presented in Table 1. The overall age at first calving was calculated as 1250.07 ± 17.40 days (3 years 5 months) which is in close agreement with Singh *et al.* (1990). The estimate is higher than Singh *et al.* (2001) and Wakchaure and Meena (2010). The maximum LSM for AFC (1485.00 ± 42.50) was noticed in the period P4 (1968–72) and the minimum (1088.28 ± 70.74) was in period P9 (1993–97). The season-wise least squares mean had very little variation. The higher AFC was noticed in winter and the lower was noticed in summer born calves.

Heritability of AFC: The heritability estimate for AFC was 0.43 ± 0.168, which is medium to high. The age at first calving, having bearing on reproductive efficiency is considered as one of the important reproductive traits. Reproductive traits, in general, have low heritability. In spite of being a reproductive trait the AFC showed medium to high heritability. The apparent contradiction can be explained by the fact that the AFC is highly dependent upon the growth rate, which generally has high heritability.

The estimate is higher than those observed by Khan *et al.* (1999) and Banik *et al.* (2010). Our estimate is in close agreement with the findings of Gore (1981), Kushwaha *et al. (*2002). The high estimate of heritability had also been reported by Singh *et al.* (2000). Banik *et al*. (2010) reported heritability of 0.5 under two-trait analysis and 0.193 under multi-trait analysis in Sahiwal cattle.

On the basis of the present finding and the literature cited above it may be inferred that there are large variations in the estimate of heritability from one herd to another. The high estimate of heritability found in the present study for the Sahiwal herd of Anjora farm is indicative of existence of large additive genetic variance for the trait. The individual selection for the trait would be highly effective with accuracy as high as 66%. Thus substantial reduction in age at first calving is possible through individual selection. The heritability estimate of 0.43 indicates that the magnitude of non-genetic variance is also very large (57%) and it should be given due attention to bring down the age at first calving.

Correlation between AFC and FLMY (300): The genetic and phenotypic correlation of AFC with FLMY (300) were –0.245 ± 0.30 and 0.027 ± 0.05 (Table 2) respectively. The genetic correlation was negative and the phenotypic correlation was positive; but both the estimates were nonsignificant and unreliable due to the high standard error, however, the environmental correlation (0.369) was positive and medium. The previous findings of Banik *et al.*(2010) reported the negative genetic correlation. However Singh *et al*.(2001) reported positive genetic and phenotypic correlations.

Correlation between AFC and LTY: The genetic correlation of AFC with LTY3 (total milk yield in first 3 lactations) was 0.633 ± 0.234. It was highly significant ($P<0.01$) and positive, and the same trend was noticed in terms of phenotype (0.313 ± 0.069) too. It indicated that genetic factors responsible for AFC are also responsible for change in LTY3. High phenotypic and genetic correlations between AFC and LTY3 found in our study indicated that the 2 traits are fairly controlled by the same genes and selection for high lactation milk yield will increase the age of the cow at first calving that is not advantageous for economical dairy production (Javed *et al*.2004). Positive nonsignificant correlation (0.05) of AFC and LTY3 was reported by Shinde *et al.*(2010) in Triveni crossbred cattle.

The genetic and phenotypic correlations of AFC though maintain the same positive trend with LTY5 (total milk yield in first 5 lactations), it is nonsignificant (0.11± 0.332). It might be due to that the effect of AFC is reflected only in the earlier lactations i.e. up to 3 lactations and it is nullified or reduced significantly in the later part of lactations as during this stage various other genetic factors such as lactation length and calving interval and environmental factors like management and nutrition play major role. However Gospal and Bhatnagar (1972) reported a negative and significant correlation.

Correlation between AFC and productive life: The correlation of AFC with productive life is positive and highly significant in both ways genetic and phenotypic (Table 2). It indicated that cows with more AFC would have more productive life. But this would not offer any advantage as revealed by the poor correlation between AFC and LTY5 (0.11). Further study on the components of productive life i.e. lactation length and calving interval may reveal the real relationship between AFC and productive life.

Correlation between AFC and Herd life: The genetic correlations of AFC with HL3 and HL5 were respectively 1.043 ± 0.062 and 0.935 ± 0.107. The correlations were positive and highly (more than 93%) significant ($P<0.01$), but the genetic correlation of HL3 was beyond the parametric space. The phenotypic correlation was also

Table 2. Genetic, phenotypic and environmental correlations of AFC with FLMY (300) and lifetime traits

Trait 1	Trait 2	r_G±SE	r_P±SE	r_E
AFC	FLMY (300)	–0.245±0.301	0.027±0.050	0.369
AFC	LTY3	0.633±0.234**	0.313±0.069**	–1.925
AFC	PL3	†	0.80±0.028**	†
AFC	HL3	1.043±0.062	0.729±0.036**	1.397
AFC	LTY5	0.11±0.332	0.119±0.094	–0.102
AFC	PL5	0.768±0.325**	0.320±0.086**	0.820**
AFC	HL5	0.935±0.107**	0.645±0.056**	–1.580

** -Significant at 1% level; †, inestimable.

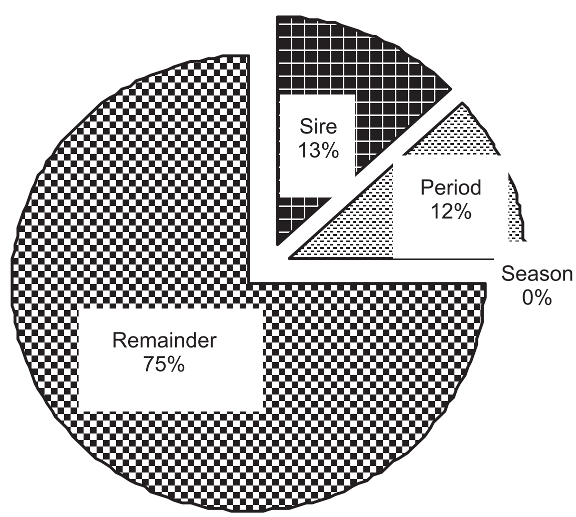

Fig. 1. Contributions of different effects on AFC.

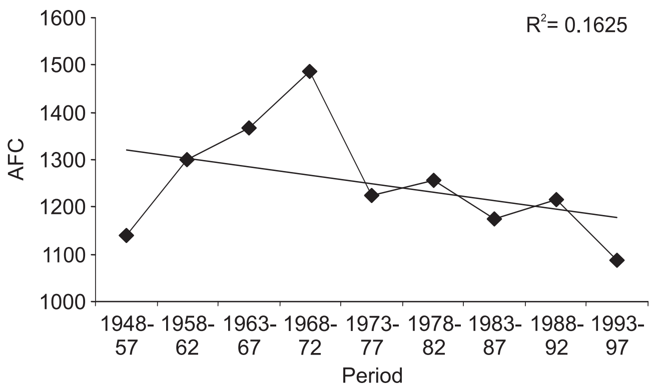

Fig. 2. Linear phenotypic trend of AFC.

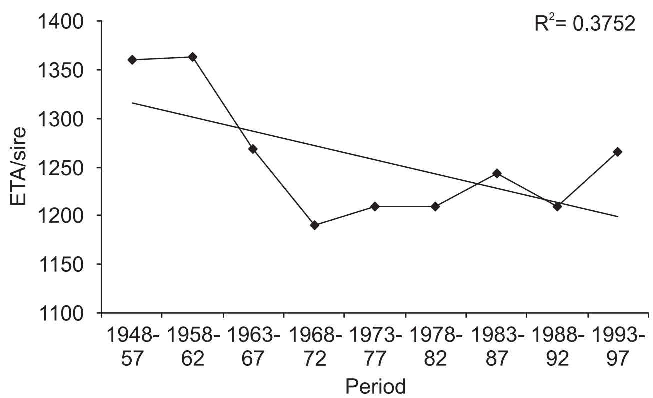

Fig. 3. Linear genetic trend of AFC.

positive and highly significant. This is because AFC is one of the components of these 2 traits. The findings suggest that cows with lower AFC would be able to complete their third and fifth lactations at an earlier age and thereby there is possibility of having still more number of lactations during their entire life. This is a desirable trend and suggests that an effort to decrease AFC is likely to pay dividends in the long run. Dalal *et al.* (2002) reported negative correlation of AFC with PL and HL (–0.21± 0.71 and –0.41 ± 0.87) in Hariana cattle, but they were imprecise due to the high standard error, whereas a study in Nili-Ravi buffaloes (Afzal *et al.* 1999), revealed negative and significant correlation with PL and HL.

Trends of AFC: The phenotypic, genetic and environmental trends were –17.79, –14.43 and –3.36 days respectively. The phenotypic genetic and environmental changes per annum were –3.2, –2.5 and –0.6 days respectively. Though the observed trends are in desirable direction i.e. negative, they were low in magnitude. It is possibly because the AFC has not changed in linear fashion with the periods. In fact the AFC increased from 1948–72 and then it started to decline gradually. The periods (P2, P3 and P4) showed poor performance by the individuals in terms of phenotypic trend for AFC. However, genetic trend was fairly well throughout the period of study except some incline in the later half duration. The phenotypic trend (Fig. 2) does not exactly match with genetic trend (Fig. 3) which indicated importance of several other factors such as management, nutrition, health, etc. in controlling the phenotype of the animals. The environmental trend counts for the residual change from genetic to phenotypic trend. It may be concluded that the apparent decline in AFC from 1972 onwards might be due to the improvement in the environmental factors such as feeding and effective management of the herd. The decline in the genetic trend after 1972 calls for necessary steps to improve the AFC genetically through stringent selection of sires and dams.

Our findings are in agreement with that of Tirpude *et al*. (1995) who reported the negative and significant trend as against the nonsignificant ones estimated in our study. Kumar and Narain (1979) and Pundir (1999) both reported the desirable trend (negative) in Sahiwal and Hariana cattle respectively. Some undesirable trends (positive) were also reported by Gupta and Tripathi (1994) and Yadav *et al*. (1983) in Red Sindhi cattle and Murrah buffaloes respectively.

Period of birth and sire had a significant effect on AFC, whereas season showed nonsignificant effect. Moderate to high magnitude of heritability indicates lot of scope for selection in the farm. All the life time traits were positively correlated with AFC which indicated that as the AFC increased, life-time milk yield also increased along with the increase in productive life and herd life. Positive genetic correlation of milk yield traits with AFC needs to be explored properly, as it suggests undesired results. A reduction in age at first calving can be achieved through better feeding, management, disease control and efficient heat detection and timely service programme. However, the FLMY300 negative correlation with AFC indicates that early age at calving may result in higher potential for milk production. Overall trend for AFC was in the desired direction, however, poor performance by the animals in second to fourth periods declined their overall gain. Looking at the additive variability in the herd, the genetic trend for AFC can further gain momentum with intensive selection and breeding programme.

ACKNOWLEDGEMENTS

Authors thank the In-Charge, Bull Mother Dairy Farm, Durg, for providing Data and thanks are also expressed to the Dean, College of Veterinary Science and Animal Husbandry, Durg, for all other necessary facilities.

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