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Genetic and Phenotypic Parameters of Jersey Cows Reproductive Traits in the Different Calving Numbers

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Abstract **– Genetic parameters of reproductive traits of dairy cows can be evaluated by considering it as the same trait over the calving numbers of a given animal or by treating reproductive performances over calving numbers as different traits. The objectives of this study were to estimate variances, heritabilities genetic as well as phenotypic correlations of some reproductive (calving interval, CI and service per conception, SPC) traits of Jersey cows during their first, second, third, fourth and fifth calving/lactation numbers in Ethiopia considering each calving number as separate trait. Genetic parameters were estimated using multi-variate analysis via AI-REML algorism of the Wombat software. The pedigree file which used to compute the numerator relationship matrix were 782 and 1061, 602 and 787, 458 and 604, 368 and 455 and, 277 and 366 animals for first, second, third, fourth and fifth calving numbers of CI and SPC traits, respectively. Year as a fixed effect and animal and error/residual as random effects were assigned in the model of analysis. The analyzed results showed that higher additive, residual and phenotypic variances of calving interval (CI) were found at the third calving number. For service per conception (SPC), the variances were increased across calving numbers. The estimated heritabilities of CI in the five consecutive calving numbers were 0.15, 0.05, 0.23, 0.22 and 0.08, respectively somewhat higher than the reviewed literature reports. For SPC, the estimates were not different from zero but slightly increased across calving numbers with the values of 0.003, 0.006, 0.01, 0.016 and 0.02, respectively which were lower than the reviewed literature results. Genetic correlations of CI in first and fourth, first and fifth, second and third and, fourth and fifth calving numbers were higher (0.73-0.99) than the other respective calving numbers (-0.33-0.14) whereas, the phenotypic correlations were tended to be of close to very low and some negative values (-0.05-0.19). On the other hand, there were great genetic (0.98-0.99) and phenotypic (0.96-0.99) associations among calving numbers of SPC trait.**

Keywords **– Calving Number, Fertility Trait, Genetic and Phenotypic Parameter, Jersey Cow.**

I. Introduction

Female fertility is an outstanding importance in contributing the dairy herd profitability. The continual genetic improvement in milk production trait undertaking in most dairy cattle population around the world ultimately causes reducing fertility [1, 2, 3]. These traits, however, have relatively high additive genetic variances and low heritabilities and therefore the chance of improvements are through selection [4].

Calving interval (CI) and service per conception (SPC) are the two repeated measurement of fertility traits and influences the lifetime milk production, calf crop and total cost of production in the dairy sector. Calving interval can be a good indicator of cows fertility because of high correlation between calving interval and several direct measures of fertility traits. Furthermore, calving interval is possibly the single reproductive index which provides most information on reproductive efficiency, whether in an individual cow or on herd basis as the trait is a function of open period, service period, service repetition, gestation length, dry period and lactation period [5]. As a trait which is expressed repeatedly in animals' life, the fertility performance is affected by genetic and environmental factors. In addition, as fertility performance is affected by age, parity, physiological developments and changes, genetic correlations in later parities are not necessarily of the same magnitude as those within the first parity [6]. Genetic and phenotypic parameters of a trait measured in different parities are essential to know the true heritabilities and relationships in different parities in different periods and used for management decision in every calving or service period.

Genetic parameters of female fertility can be evaluated by considering it as the same trait over the parities of a given animal or by treating reproductive performances over parities as different traits [7, 8]. As mentioned above, the differences in the physiological status of early lactating compared with advanced lactating cows are assumed, and factors affecting fertility are supposed to be of different magnitude over lactations. Moreover, results on genetic correlations for the same fertility trait on early lactation and advanced lactation cows are controversial [9]. From a practical point of view, the choice of considering fertility as the same trait or as different traits over parities for its inclusion in merit indices is having a great value [9].

No studies were found in the literatures about variance, heritability and correlation estimates for CI and SPC involving five calving numbers treating it as a separate trait in Jersey cattle in Ethiopia. Genetic correlations between a trait measured in the same way in different periods indicate whether the trait can be handled as the same trait or not. Therefore, the aims of this study were to estimate genetic parameters for CI and SPC traits in Jersey cows in different parities/calving numbers considering as different traits, and to estimate correlations among different parities/calving numbers.

II. Materials and Methods

Breeding information of Jersey dairy cattle from 1984 to 2019 were obtained from Adea Berga sub dairy research farm, central Ethiopia. The following data were obtained from individual animal card history and from the center database for analysis;

- ✓ Identification number of each animal, sire and dam.
- ✓ Date and year of calving of the animals.
- ✓ Calving interval and service per conception.
- ✓ Calving numbers/parities.

The lower and upper limit records for calving interval were 330 and 1500 while 1 and 13 for service per conception. Lactation/calving numbers from 1 to 5 were used for analysis.

A. *Statistical Analysis*

Multi-trait analysis of an animal model was used for estimation of (co) variance components and the resulting genetic parameters (heritabilities, genetic and phenotypic correlations) of calving interval and service per conception across five calving numbers with AI-REML algorithm of the WOMBAT software [10]. Each parity was considered as different traits for analysis of both fertility traits in the genetic evaluation. Two fixed effects (year and season) were identified as fixed effects and analyzed by [11] to determine the level of significance. The preliminary analysis showed that year was the only significant source of variation in all parities/calving numbers for CI and NSC and fitted in to genetic parameter analysis. Additive genetic and residual/error effects were assumed as random. The animal model for analysis of genetic and phenotypic (co) variances in the five consecutive calving numbers were described as follows:

$Y_i = X_i b_i + Z_i a_i + e_i$

For $_i$ = 1, 2, 3, 4, 5 representing the i^{th} calving number;

Y_i, is the vector of observations (CI and NSC) on the i^{th} calving number;

b_i, includes vector of fixed effect (year in this case) on the i^{th} calving number;

a_i, is random direct animal (additive) genetic effect on the i^{th} calving number;

e_i, is the vector of random residual effects on the i^{th} calving number; and

X_i and Z_i are matrices of the fixed and random animal (additive) genetic effects on the i^{th} calving number, respectively. Genetic and phenotypic correlations were calculated by using the following formulas;

$$rg = \frac{\sigma_{aij}}{\sqrt{\sigma^2 ai\, \sigma^2 aj}} \quad (1)$$

$$rp = \frac{\sigma_{pij}}{\sqrt{\sigma^2 pi\, \sigma^2 pj}} \quad (2)$$

Where,

rg: genetic correlations,

rp: phenotypic correlations

σ_{aij} : additive genetic covariance between calving number i and j of CI or NSC,

σ_{pij} : phenotypic covariance between calving number i and j of CI or NSC,

$\sigma^2 ai$: additive genetic variance for calving number i of CI or NSC,

$\sigma^2 aj$: additive genetic variance for calving number j of CI or NSC,

$\sigma^2 pi$: phenotypic variance for calving number i of CI or NSC,

$\sigma^2 pi$: Phenotypic variance for calving number j of CI or NSC.

Heritability is the proportion of additive genetic variance to total phenotypic variance and calculated as follows;

$$h2 = \frac{\sigma a\ 2}{\sigma p\ 2} \quad (3)$$

Table 1. Number of records and average performances of CI and SPC in the five consecutive lactations/calving numbers.

Variables	Observed Data in Different Calving Numbers				
	1	2	3	4	5
Number of records (animals) for CI	782	602	458	368	277

Variables	Observed Data in Different Calving Numbers				
	1	2	3	4	5
Average CI	529.8	493.2	469.8	479..7	471.5
Number of records (animals) for SPC	1061	787	604	455	366
Average SPC	1.84	1.77	1.78	1.75	1.90

Table 2. Pedigree structure of CI and SPC for genetic analysis in different calving numbers.

Animal Pedigree	CI	SPC
Original number of animals	1007	1299
Number of animals after pruning	895	1202
Number of animals w/out offspring	498	667
Number of animals with offspring	397	535
Number of animals with unknown sire	344	376
Number of animals with unknown dam	385	413
Number of animals with both parents' unknown	321	355
Number of sires with progeny in the data	79	96
Number of dams with progeny in the data	318	439
Number of animals with paternal grandsire	0	0
Number of animals paternal granddam	0	0
Number of animals maternal grandsire	194	342
Number of animals maternal granddam	171	313

III. Results and Discussions

The performances of both traits (CI and SPC) and fixed effects of various factors (year, season and parity) were studied using analysis of variance and published earlier [12]. No further discussion is needed about Table 1. As mentioned earlier, the aims of this study were estimation of variances, heritabilities as well as genetic and phenotypic relationships among calving numbers of Jersey cows' fertility (CI and SPC) traits.

A. *Variances and Heritabilities of Calving Interval across Calving Numbers*

The heritabilities and variances of calving interval estimated from the five calving numbers are presented in Table 3. Variances (error and total phenotypic) were noticeably increased until third calving number. Additive genetic variances (6173 and 4595 days^2) and Heritabilities (0.23 and 0.22) were comparable and high in the third and fourth calving numbers and low in the second and/or fifth calving numbers (1058 and 1797days^2 additive genetic variances) and (0.05 and 0.08 heritabilities), respectively.

In the literature review regarding heritabilities of CI trait considering different calving numbers as different traits reported different values in the different regions and breeds of dairy cows. Wall et al. (2003) [3] reported lower heritability (0.033) in the first calving number of UK dairy cows. Navid (2011) [13] reported lower heritabilities of calving interval in the three lactations of Iranian Holstien cows. Muir et al. (2004) [14] and [15] also reported lower value of heritability in the first lactation of Canadian Holstein and Turkish Brown Swiss cattle (0.07), respectively. Heritabilities of calving interval in the four consecutive calving reported by [16] were 0.03-0.04 which were lower than the present study. Ilatsia et al. (2007) [17] also found 0.05, 0.02 and 0.03 heritabilities in the first three consecutive calving of Kenyan Sahiwal cattle. Ali et al. (2018) [18] also reported lower heritabilities (0.01, 0.00 and 0.08) in the three lactations of Brazilian Girolando cattle. The present study was higher than the above literature reports and this difference might be associated with several factors like breed/genotype of the animals, management and environment, population and/or data size, data management and statistical procedure for analysis.

Table 3. Variances and heritabilities of CI trait in Jersey cows across calving numbers.

Parameters	Calving numbers				
	1	2	3	4	5
σa^2	3090 ± 1168	1058 ± 1543	6173 ± 3138	4595 ± 3488	1797 ± 4155
σe^2	17464 ± 129	20087 ± 1798	21040 ± 3010	16703 ± 3368	20401 ± 4424
σp^2	20554 ± 983	21145 ± 1165	27212 ± 1925	21298 ± 1862	22197 ± 2385
h^2	0.15 ± 0.055	0.05 ± 0.07	0.23 ± 0.11	0.22 ± 0.15	0.08 ± 0.18

B. *Variances and Heritabilities of Service Per Conception across Calving Numbers*

The variances and heritabilities of SPC in the five calving numbers are presented in Tale 4. Additive genetic variance was low (0.047) at first calving number and increased slightly and reached high (0.32) at fifth calving number but no constant trends across calving numbers were observed in the residual and phenotypic variances. Liu et al. (2017) [4] reported constant (0.1) and similar additive genetic variances in the three consecutive lactations of Chinese Holstien cows. The estimated heritabilities across calving numbers were found to be in the lower range of (0.003 to 0.02) and there was slight increment from first to fifth calving numbers. It can be concluded that the estimated heritabilities in all calving numbers were close to zero which could be due to lower proportion of additive genetic variances. Furthermore, the higher proportion of residual variances which could be arises from unmeasurable environmental and managemental factors (nutrition, semen quality, inseminator efficiency, heat detection, time of insemination, reproductive health condition of animals, etc.), the heritabilities across calving numbers were became low. Low heritability estimates are common in reproductive traits of dairy cows as the trait is very sensitive to different environmental and managemental conditions.

In comparison to the present study, authors were reported higher heritabilities of SPC in different calving numbers. Raheja et al. (1993) [19] reported 0.03, 0.04 and 0.06 heritabilities in the first, second and third lactations which were an increasing trend in Canadian Holstien cows. Bagnato and Oltenacu (1993) [20] found constant trend of heritability in the three calving numbers (0.1). Wall et al. (2003) [3] reported heritability of 0.02 in the first parity of UK dairy cows. Ilatsia et al. (2007) [17] found a constant values of 0.3 in the three consecutive calving of Sahiwal cattle in Kenya. Tiezzi et al. (2012) [9] also found 0.046 and 0.045 heritability in the first and second calving of Italian Brown Swiss cattle, respectively. Study by [15] the heritability of service per conception in the first calving for Turkish Brown Swiss dairy cattle had 0.03. Other study done by [4] in Chinese Holstien cows considering three consecutive calving numbers and reported 0.029, 0.027 and 0.027 whi-

-ch were higher than the present results.

The lower heritabilities of SPC across calving numbers in the present study compared to the literatures might be, the SPC trait of Jersey cows at different calving numbers are more or less affected by different environmental and managemental factors.

Table 4. Heritabilities and variances of SPC trait in Jersey cows across calving numbers.

Parameters	Calving Numbers				
	1	2	3	4	5
σa^2	0.047	0.085	0.15	0.25	0.32
σe^2	14.99	14.71	14.76	15.19	15.56
σp^2	15.04	14.79	14.91	15.44	15.88
h^2	0.003 ± 0.010	0.006 ± 0.011	0.01 ± 0.003	0.016 ± 0.010	0.02 ± 0.010

C. *Genetic and Phenotypic Correlations of Calving Interval in Different Calving Numbers*

Genetic and phenotypic correlations of calving interval for Jersey cows estimated from five consecutive calving numbers are presented in Table 5. Genetic correlations in first and fourth, first and fifth, second and third and, fourth and fifth calving numbers were higher (0.73-0.99) than the other respective calving numbers (-0.33-0.14) whereas, the phenotypic correlations were tended to be of close to very lower and some negative values were found across calving numbers. There were no apparent trends in genetic and phenotypic correlations from first to fifth calving numbers. The higher genetic correlations implies that calving interval performance during first calving number may be very repeatable in the fourth and fifth calving numbers than other calving numbers. However, unfavorable genetic associations between first and second, second and fourth, second and fifth and, third and fourth calving numbers were found. These negative values in the respective calving numbers were repeated over phenotypic correlations.

Additive genetic correlations of calving interval reported in the literature were higher than the present study [13, 16] who reported in the range of 0.67-0.98 across lactations. Olori et al. (2003) [21] reported high genetic correlation between first and second (0.94), first and third (0.85) and second and third (0.90) lactations. These differences might be associated with data structures, number of observations, genetic profile and physiological status of the animals and, environmental and managemental situations. The overall genetic and phenotypic correlations far from unity among different calving suggested that calving interval in different calving numbers would be evaluated differently and the number, interction and function of genes in each calving could be different. Furthermore, managemental and environmental factors were influenced differently.

D. *Genetic and Phenotypic Correlations of Service Per Conception in Different Calving Numbers*

The average values and standard errors of genetic and phenotypic relationships for measures of SPC in the different calving numbers are given in Table 5. The genetic and phenotypic correlations among all calving numbers of SPC were higher and greater than 0.9 which implies that the same genes control the trait in different calving numbers. All correlations were favorable, the same and can be interpreted as single trait. The genetic and phenotypic performances of Jersey cows in the first calving number would be repeated over the rest of five successive calving numbers. In other word, Jersey cows have conceiving with a single or two inseminations in the first calving may be repeated the same in the later calving numbers.

In the literature review, authors reported high genetic correlations among calving numbers of service per conception trait which were similar to the present study. Bagnato & Oltenacu (1993) [20] estimated genetic correlations in Italian Friesian cattle and reported somewhat close to the present study (0.78 between the first and second and 0.92 between second and third lactations). The genetic correlations between first and second and, second and third lactations of SPC in Swedish red and white dairy cattle reported by [22] were 0.94 and 0.93, respectively. Tiezzi et al. (2012) [9] found 0.93 correlation between first and second calving. Liu et al. (2017) [4] reported 0.92, 0.92 and 0.94 genetic correlations between first and second, first and third and second and third lactations of SPC trait, respectively.

Table 5. Genetic and phenotypic correlations of CI and SPC traits in the different calving numbers.

Calving Numbers	Genetic Correlations		Phenotypic Correlations	
	CI	SPC	CI	SPC
1 & 2	-0.33 ± 0.52	0.99 ± 0.002	0.02 ± 0.045	0.98 ± 0.001
1 & 3	0.02 ± 0.31	0.99 ± 0.002	0.02 ± 0.05	0.98 ± 0.002
1 & 4	0.99 ± 0.45	0.98 ± 0.005	0.13 ± 0.06	0.96 ± 0.003
1 & 5	0.98 ± 0.0	0.98 ± 0.005	0.19 ± 0.08	0.96 ± 0.003
2 & 3	0.73 ± 0.67	0.99 ± 0.001	0.12 ± 0.05	0.99 ± 0.002
2 & 4	-0.32 ± 0.78	0.99 ± 0.003	0.05 ± 0.06	0.98 ± 0.002
2 & 5	-0.28 ± 0.0	0.99 ± 0.003	-0.02 ± 0.08	0.97 ± 0.002
3 & 4	-0.07 ± 0.44	0.99 ± 0.002	-0.04 ± 0.06	0.98 ± 0.001
3 & 5	0.14 ± 0.8	0.99 ± 0.002	0.08 ± 0.08	0.98 ± 0.001
4 & 5	0.95 ± 0.0	0.99 ± 0.002	-0.05 ± 0.08	0.99 ± 0.001

IV. Conclusion

Heritabilities of CI and SPC in the different calving numbers were low. Especially, for service per conception the estimates were not different from zero as a result of small proportion of genetic variances. The genetic and phenotypic correlations of SPC in the different calving numbers were close to unity suggested that all calving numbers were the same and analyzed as the same trait over calving numbers. However, such evaluation was not applicable for CI as the variances, heritabilities and correlations were different across calving numbers. The values of heritabilities of CI in the five consecutive calving numbers were higher than the literature average reports. For SPC, the present results were lower than those in other studies. This difference might be associated with several factors like breed/genotype of the animals, management and environment, population and/or data size, data management and statistical procedure for analysis. On the other hand, the genetic and phenotypic correlations of both traits in the respective calving numbers were comparable to the literature average reports.

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Conflict of Interest

No potential conflict of interest is reported regarding the subject matter of this manuscript.

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