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# ESTIMATION OF GENETIC PARAMETERS FOR REPRODUCTIVE TRAITS OF FOGERA AND HOLSTEIN FRIESIAN CROSSBRED CATTLE AT METEKEL RANCH, AMHARA REGION, ETHIOPIA

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**ABSTRACT**: The study was carried out at Metekel ranch, Amhara region, Ethiopia, with the objective of estimating genetic parameters for reproductive traits of Fogera and Holstein Friesian crossbreed cattle. The data used in the study included pedigree records and reproductive performance records of animals born from 1990 to 2012.The parameters were estimated by using Variance Component Estimation (VCE 6.0) software. Four models were used Viz. Model1: $Y= X_b+Z_1a + e$; Model2:$Y=X_b+Z_1a+Z_3c + e$; Model3: $Y=Xb+Z_1a+Z_2m+ e$; cov a,m=0 and Model4: $Y= X_b + Z_1a + Z_2m+ Z_3c + e$; cov a, m=0.Traits like Gestation Length (GL), Calving Interval (CI) and Days Open(DO) were estimated using model2 and 4 which fit permanent environmental effect due to repeated records per cow. Whereas, age at first service (AFS) and age at first calving (AFC) were estimated using model 1, 3, and 4. Estimates of direct heritability of the studied traits ranged from 0.01±0.05 for DO to 0.26±0.21 for AFS, besides high error variance was observed. The phenotypic correlations between traits ranged: 0.33 to 0.99 between CI and DO and GL and DO respectively. And genetic correlations ranged from -1.0 to 1.0 between GL and CI between CI and DO respectively. The result in this study indicates there were low heritability estimates high environmental variances which imply selection based on phenotypic performance of animals was unlikely to bring genetic progress in the studied herd because of the low estimate of heritability of the trait. Besides, The result showed there was moderate to high correlation that indicated selection for one trait will affect the correlated traits. Thus, selection method, in addition to individual records, should incorporate pedigree and progeny information in the form of an index to get optimum genetic progress in the studied population. In addition, selection for any particular trait(s) must be carried out with caution as it could have an adverse effect due to correlated response on the correlated traits.

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**Abbreviations**: AFC=age at first calving, AFS= Age at first service CI= calving interval=DO Days Open GL= Gestation Length

## INTRODUCTION

The total cattle population of Ethiopia is estimated to be 53.39 million. Out of this population, about 98.95% are local breeds while hybrids and exotic breeds account only for about 0.94% and 0.11%, respectively (CSA, 2013). From the total milk production in Ethiopia 81.2% came from cattle, whereas; 6.3%, 7.9% and 4.6% come from camels, goats and ewes, respectively (CSA, 2008). Of the total milk produced from cattle 97% of the milk is produced by the indigenous stock and the remaining 3% from improved crosses and pure grade (exotic) cattle. The dairy production in Ethiopia is based largely on indigenous breeds of cattle and breed improvement and development programs, have been directed mainly on crossbreeding activities through research stations, government stock multiplication centers and private farms (MOARD, 2007).

Economically important traits in animals are affected by both genetic and environmental factors. The genetic factors are due to a random sample of genes received from the two parental gametes whereas the environmental factors include influences of climate, nutrition, health and management (Bourdon, 1999). Genetic analysis of animal genetic resources most often aims at separating genetic and environmental effects (Falconer and Mackay, 1996). Genetic parameter estimates are needed for implementation of breeding programs and assessment of progress of ongoing programs where accuracy of their estimation is of paramount importance (Wasike, 2006). The



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genetic and phenotypic parameters in quantitative genetics include heritability, genetic and phenotypic correlations and repeatability, which play a vital role in the formulation of any suitable breeding plan for genetic improvement program (Aynalem, 2006).

The reliability of phenotype depends upon the heritability of the trait. Heritability is critically important for selection of polygenic traits. When selection is made for trait(s), heritability decides how much genetic improvement is expected in the trait(s) while genetic correlation between traits selected and other correlated trait (s) decides how much response to selection can be expected for traits not selected in addition to the response for the selected traits (Rao and Bhatia, 2002). The response to selection is the combined result of direct selection for each trait and indirect selection caused by the genetic correlation between the traits (Bourdon, 1999).

Crossbreeding allows us to use hybrid vigor which affects the heritability of the traits. Though crossbreeding in Ethiopia had been initiated in the early 1950s, the formal breed improvement research was started in early 1970's at Bako, Melka Werer, Adami Tulu and Holleta Agricultural Research Centers. Metekel ranch was established in 1986 for the purpose of Fogera cattle conservation and improvement program. Under the improvement program Fogera x Holstein Friesian crosses have been produced. With the view to evaluate performance of these crossbreds, growth and reproduction traits have been recorded and being recorded since the establishment of the ranch. Hence, the present study was intended to contribute its part in filling the gaps. Thus, this study was initiated with the following objective:

- Estimating genetic parameters of reproductive traits of Fogera and Holstein Friesian crossbred cattle population.

## MATERIALS AND METHODS

### Description of the study Area

Metekel Cattle Breeding and Improvement Ranch is found in the Guangua district of Awi zone in Amhara National Regional State, and is situated about 505 km North-west of Addis Abeba, 200 km from Bahir Dar town on the road to Guba. Its altitude ranges from 1500-1680 m.a.s.l. The annual mean relative humidity is 61.7% and it reaches high from June to October (76.7- 83.8%). The ranch receives an average annual rainfall of 1730.0 mm; average temperature ranges from 13.7 to 29.5$^0$C. The area has three rainy seasons; long rainy season (June-October), short rainy season (March-May) and dry season (November-February). The ranch has three types of soils viz. Red, brownish red (Latosols) and dark brown. The vegetation is mostly composed of perennial and annual grasses and a few scattered trees.

### Herd management

The Ranch has been engaged in maintenance of Fogera cattle population outside their adapted environment (*ex-situ conservation*). The cattle herded based on breed and age. During the day time animals graze on natural pasture and were provided with hay in addition to grazing during dry season. Crossbred female calves above three months of age and sick animals were supplemented with Desmodium (*Desmodium triflorum*), Rohodus (*Chloris gayana*) and Elephant grass (*Pennisetum purpureum*) both in wet and dry seasons through cut and carry system. The main source of water was a year-round river. Tap-water has been provided to lactating Fogera cows, crossbred stock and sick animals. Health management practice includes the prevention and control scheme. The prevention scheme focused on vaccination against anthrax, blackleg and pasturollosis once in every 6 to 8 months and once per year for CBPP. Whereas, control measure focused on internal and external parasites. De-worming was conducted twice a year, at the start and end of the rainy seasons.

### Breeding program

The breeding program has two components: selection and crossbreeding. The establishment of the pure breed unit was meant for the improvement of the Fogera breed and for providing heifers for cross- breeding to exotic dairy sires (by Artificial insemination). In the selection program of pure breed unit, the tradition was Fogera bulls were allowed to run together with Fogera cows. The selection activity undertaken at Metekel ranch had never been based on quantitative traits; instead the visual appraisal had been used. But recently they have been trying to study and include background of the animal during selection. According to the breeding plan of the ranch, heifers available for mating for the first time should attain a minimum body weight of 250 kg. If the heifer didn't attain the minimum body weight its mating time will be extended. At around three to six months of pregnancy, the F1 heifers were sold to farmers for milk production (Melaku et al*.,* 2011). Very recently the ranch has started to distribute non pregnant F1 heifers to minimize rearing costs.



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### Study design, source and nature of the data

A retrospective type of study was carried out to evaluate the reproductive performances of Fogera X Holstein Friesian crossbred cattle in the ranch. At the ranch, records of individual animals were kept on individual animal cards. Therefore, in this study, a 23 year old farm records (i.e. All records of animals born and cows that calved between 1990 and 2012 were included). The main problem encountered was the challenge of the pedigree record screening procedure. Therefore, consistency checks were performed on identification of animals and their pedigrees.

### Data management and Data analyzed

Records with irregularity in pedigree information and dates were discarded. The animals that have abnormal calving, i.e., abortion and stillbirths were not included in the analysis. After clearing the data for consistency of pedigree information a final data set comprising of 526, 44, 105, 92 and 52 records of AFS, AFC, CI, GL and DO respectively, were used for analysis.

### Statistical analysis

The genetic parameters estimated were heritability and correlation. They were estimated using variance component estimation (VCE) procedure which is a software program package to estimate dispersion parameters under a general linear model for quantitative genetic analysis of continuous traits, fitting a linear mixed model for estimation of covariance components. The resulting genetic parameters were obtained by restricted maximum likelihood. It is assumed that traits analyzed were continuous and had a multivariate normal distribution.

The variance components and heritability were estimated by Uni-variate, bi-variate and multivariate animal model using four models which fitted direct additive, dam's (maternal) additive genetic and permanent environmental effect as a random effect and the fixed effects. Parameter for GL, CI and DO were estimated using model 2 and 4 which fit permanent environmental effect due to repeated records per cow. On the other hand AFS and AFC were estimated using model 1, 3, and 4. The Likelihood ratio tests were conducted to determine the most suitable model.

The model equations used for the analysis of reproductive traits (viz. AFS, AFC, GL, CI and DO) were:

Model1 $Y= Xb + Z_1a + e$;

Model2 $Y= Xb + Z_1a + Z_3c + e$;

Model3 $Y= Xb + Z_1a + Z_2m + e$ ($cov_{a,m} = 0$);

Model4 $Y= Xb + Z_1a + Z_2m + Z_3c + e$ ($cov_{a,m} = 0$)

Where, Y = vector of records; b = vector of fixed effects; X = incidence matrix of fixed effects a = vector of direct additive genetic effect; m = vector of maternal additive genetic effect; c = vector of permanent environmental effect; and $Z_1$, $Z_2$ and $Z_3$= incidence matrix for direct additive genetic effect, maternal additive genetic effect and permanent environmental effects respectively; e = vector of random errors.

Correlations (genetic and phenotypic) among the different traits were estimated from bi-variate analysis by using different models. Comparison of the different models was made by using the log-likelihood ratio tests to determine the best model.

## RESULTS AND DISCUSSIONS

### Heritability and correlation estimates for reproductive traits

The result of heritability estimation for reproductive traits is summarized in Table 1. Except AFS and AFC, the other traits (GL, CI and DO) are repeated per cow and permanent environmental effect must be fitted in the model. Therefore, estimates were not possible from model 1 and 3 for these traits. Hence, based on the Likelihood ratio tests the best model for all repeated reproductive traits was Model 2 which includes the permanent environmental effect.

Table 1 Heritability (diagonal), phenotypic correlations (above diagonal) and genetic correlations (below diagonal) from five traits

| Parameters | AFS | AFC | CI | GL | DO |
|---|---|---|---|---|---|
| AFS | 0.26±0.214 | 0.85463 | – | – | – |
| AFC | 1.00 | 0.15±0.23 | – | – | – |
| CI | – | – | 0.05±0.09 | -0.21969 | 0.99657 |
| GL | – | – | -1.00 | 0.079±0.131 | -0.32678 |
| DO | – | – | 1.00 | -0.4662 | 0.010±0.05 |

AFC=age at first calving, AFS= Age at first service CI= calving interval=DO Days Open GL= Gestation Length



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**Age at first service (AFS):** The heritability estimate of AFS was 0.26 which was lower than 0.42±0.05 (Yosef, 2006) for Holstein breeds, 0.61±0.15 (Aynalem, 2006) for Ethiopian Boran X Friesian and 0.316 ± 0.074 (Deb et al., 2008)for Bangladesh Cattle Breed-1. Moderate heritability of present study implied that AFS may be shortened in subsequent generations following the selection of breeding animals based on their individual performances.

**Age at first calving (AFC):** The heritability of direct genetic effect for AFC was 0.15. It was comparable with those reported by Yosef (2006) of 0.16 ± 0.06 for Jersey breed; 0.19±0.00 by Hadi et al. (2011) for Iranian Holstein; 0.21 ± 0.03 by Oyama et al. (2002) for Wagyu cattle. However, it was lower than 0.404 ± 0.069 (Deb et al., 2008), 0.53±0.116 (Gebeyehu, 2014) for Holstein; 0.61±0.15 (Aynalem, 2006) for Boran x Holstein; 0.39 ± 0.28 (Gaikward and Narayankedkar, 2000) for Gir X Holstein Friesian and Gir X Jersey cattle; 0.406±0.23 (Choudhary et al., 2003) for Sahiwal cattle. The current result was higher than the finding of Ilatsia et al. (2007) (0.04) for Sahiwal; Wasike (2006) (0.04) and Wasike et al. (2009) (0.04 ± 0.06) for Kenyan Boran.

**Calving interval (CI)**: The estimated value was 0.05 and it was comparable with 0.05±0.02 reported by Ojango and Pollot (2002) from Kenya; 0.04±0.00 by Hadi et al. (2011) for Iranian Holstein; 0.08±0.05 by Yosef (2006) for Holstein breed and 0.08 ± 0.03 by Demeke et al. (2004). However, the result was lower than Gogoi et al. (1992) 0.25 for Jersey x Sindhi crossbreds; Rahumathulla et al. (1993) also estimated 0.37 for Jersey x Tharparker cattle in India and Islam et al. (2004) 0.38±0.05 for Local zebu x Frisian.

**Days open (DO):** The direct heritability for DO was 0.01 which is comparable to 0.01 ± 0.03 reported by Almaz (2012) and 0.224±0.082 Mohamed (2004). But lower than 0.041 Mhamdi et al. (2010). Although the estimated value of the current study was low, it was within the range of estimates reported in the literature for tropical cattle (Lobo et al., 2000 and Cammack et al., 2009).

**Gestation length (GL):** The estimated direct heritability (0.08) for GL was lower than 0.26±0.57 0.14±0.28, 0.25±0.45 for Sahiwal x Friesian, Sahiwal x Pabna, Friesian x Pabna respectively (Das et al., 2003). From multivariate analysis, the permanent environmental effect for the trait was found to be higher than direct genetic effect. This shows the presence of maternal genetic effect (permanent environmental effect) on GL. Similar pattern was observed by Almaz (2012).

### Correlations

Since livestock are usually bred for multiple rather than single traits to bring about production efficiency in their lifetime, there is always bound to be a relationship between traits. This relationship can be shown through the correlation of trait values positively or negatively on the individual of a population Falconer (1989).

As indicated in table 1 there was a positive phenotypic correlation between Age at first service (AFS) and Age at first calving (AFC) (0.85). In addition, the strong positive phenotypic correlation was observed between Calving interval and Days open (0.99). However, negative correlations were observed between CI and GL. Consistently, low phenotypic correlations among reproductive traits were reported by Oyama et al. (2004); 0·00 for GL and CI and -0·03 for DO and GL. Except between DO and GL which showed moderate negative genetic correlation (-0.4662) strong genetic correlations were observed among reproductive traits in the current study, which ranged from strong positive 1.00 between AFS and AFC, between CI and DO to strong negative -1.00 between CI and GL (Table 1). The strong negative correlation showed that as calving interval increase the dam gets more time to build her body which could help for better fertility and fast growth of the fetus, as a result, the gestation length became short.

Due to the strong genetic relationship between these traits, selection of one of them could have high effect on the other through correlated responses. Similarly strong positive genetic correlation reported by Oyama et al. (2004) and Goyache et al. (2005) between DO and CI. The same authors (Oyama et al., 2004 and Goyache et al., 2005) reported a negative genetic correlation between GL and DO similar to the present study.

## CONCLUSIONS

The low direct heritability estimate for reproductive traits in this study indicates that there is low additive genetic variance in the study population. It indicates that the observed phenotypic variation is largely attributable to environmental effect. In other words the low heritability estimates indicate low genetic control of the expression of the traits. This is indicative of the fact that selection based on phenotypic performance of animals could not be effective in the population studied or the population has low response to selection. Therefore, one may decide on for a long-term strategy of achieving change in these traits firstly through improvement of the production environment and then by gene transfer through crossbreeding.

Based on the result of the present study the recommendations are as follows

- Accuracy of genetic parameter estimation is dependent on the availability and quality of records on animal's pedigree and performance. Thus the record keeping of the ranch should be improved and a standard record keeping practice on reproductive traits should be established.



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- The selection method of the ranch especially for heifers since the ranch gets semen from National Artificial Insemination Center (NAIC) based on the physical appearance of the animals need to be updated and must be based on the phenotypic and genetic evaluation result rather than on the basis of qualitative traits.

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**Competing interests**

The authors confirm and declare that they have no competing interests exist.

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