Online Journal of Animal and Feed Research
Volume 4, Issue 4: 83-90 (2014)
ISSN 2228-7701

GENETIC AND NON-GENETIC PARAMETER ESTIMATES OF DAIRY CATTLE IN ETHIOPIA: A REVIEW

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ABSTRACT: Ethiopia is endowed with diverse ecosystems inhabited by an abundant diversity of animal, plant and microbial genetic resources due to the availability of diverse agro-ecology. The productivity of any species depends largely on their reproductive performance. Reproduction is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs. Reproductive performance does not usually refer to a single trait, but to a combination of many traits and is an indicator of reproductive efficiency and the rate of genetic progress. The main indicators of reproductive performance those are reported by many authors are age at first service, age at first calving, calving interval, days open and number of services per conception. The non-genetic factors like sex of calf, season, year, and parity had significant effect on reproductive performance traits. Knowledge on these factors and their influence on cattle performance are important in management and selection decisions. Development of breeding objectives and effective genetic improvement programs require knowledge of the genetic variation among economically important traits and accurate estimates of heritability, repeatability and genetic correlations of these traits. The estimates of genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as genetic gains. The reproductive performance of Ethiopian indigenous and exotic breeds producing in the country is low due to various environmental factors and absence of integrated record on the sector that leads a biased result and recommendations of the genetic parameter estimates. Selection and designing of breeding programs for improving the production and productivity of indigenous breed through keeping their native potentials should be based on the results obtained from accurate genetic parameter estimates like heritability, repeatability and correlation between traits.

REVIEW ARTICLE
Received 25 Jul. 2014
Accepted 20 Aug. 2014

Keywords: Genetic Parameters, Non-Genetic Parameters And Reproductive Performance

INTRODUCTION

Ethiopia is endowed with diverse ecosystems inhabited by an abundant diversity of animal, plant and microbial genetic resources. The country's geographical proximity to the historical entry point of many livestock populations from Asia and Europe to Africa and the diverse topographic and climatic conditions as well as the wide ranging production systems have further contributed to the existence of a large diversity of farm animal genetic resources (IBC, 2004; Mohamed et al., 2004). The country had also large potential for dairy development that is practiced almost all over the country involving a vast number of small or medium or large-sized; subsistence or market-oriented farms (Mohamed et al., 2004; Sintayehu et al., 2008; SNV, 2008).

The productivity of cattle depends largely on their reproductive performance. Reproduction is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs particularly in dairy and beef production (Nuraddis, 2011). Among the reproductive traits, age at first service (AFS), number of services per conception (NSC), days open (DO) and calving interval (CI) are the basis for profitable dairy farming (Enyew et al., 1998). An important prerequisite for the sustainability of a dairy production system is reproductive performance (Azage and Alemu, 1998).

Estimating genetic parameters for various livestock traits has been a main topic of animal breeding during the past half century. Advances in statistical animal breeding and broadening its range of application and traits of interest provide great opportunities for animal agriculture (Sang, 2003). The genetic composition of a population can be studied by considering the relative importance of heredity and environmental factors affecting the performance and overall phenotypic variance, which summarizes the nature of that population. The most commonly used parameters for estimating genetic parameters are repeatability, heritability and genetic correlation

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Scienceline/Journal homepages: http://www.science-line.com/index/; http://www.ojafr.ir

(Yibrah, 2008). Pertinent to the effective use, genetic variability is knowledge of the genetic and environmental relationships among the characters which include heritability and repeatability of the characters and the genetic, phenotypic and environmental correlations among them (Khalid et al., 2001).

Furthermore, development of breeding objectives and effective genetic improvement programs require knowledge of the genetic variation among economically important traits and accurate estimates of heritability, repeatability and genetic correlations of economically important traits (Abegaz et al., 2002; Juma and Alkass, 2006). In Ethiopia there are around 27 indigenous cattle breeds (Rege and Tawah, 1999) and above three introduced indigenous dairy breeds for improving the genetics and milk production (Addisu, 2013). Fogera cattle breed is one of the milk producing cattle in Ethiopia (Addisu et al., 2010). In Ethiopia there is no well-reviewed works on genetic parameter estimates of reproductive performances of dairy cattle breeds. This paper is a review of the genetic and non-genetic parameter estimates for dairy cattle in Ethiopia.

Reproductive performances of dairy cattle in Ethiopia

Reproductive traits describe the animal's ability to conceive, calve down and suckle the calf to weaning successfully (Davis, 1993); these traits are important since they affect the herd size. Reproductive performance is commonly evaluated by analyzing female reproductive traits (Aynalem et al., 2011) of a combination of many traits (Olawumi and Salako, 2010). Reproduction is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs particularly in dairy and beef production (Mukassa-Mugerewa and Azage, 1991). High reproductive efficiency is necessary for efficient milk production and has an important influence on herd profitability (Pryce et al., 2004). Reproductive efficiency is expressed by the extent of reduction of reproductive wastage and it affects lifetime milk and meat production (Nuraddis, 2011). The main indicators that would be considered in assessing reproductive performance are age at puberty, age at first calving, calving interval, days open and number of services per conception (Yifat, 2009; Habtamu et al., 2010; Aynalem et al., 2011; Demissu et al., 2013).

Age at first calving (AFC): Age at first calving is the period between birth and first calving and influences both the productive and reproductive life of the female, directly through its effect on her lifetime calf crop and milk production and indirectly through its influence on the cost invested for up-bringing (Gebrekidan et al., 2012). Age at first calving is closely related to the rearing intensity, and in a breeding program has impact on generation interval and response to selection. It is affected by nutrition, year and month of birth (Kelay, 2002).

Calving interval (CI): It is the period between successive parturitions and is a function of postpartum anestrus period (from calving to first estrus), service period (first postpartum estrus to conception) and gestation length (Tewodros, 2008). Estimates of calving interval in zebu cattle range from 12.2 to 26.6 months (Mukassa-Mugrewa, 1989; Gebrekidan et al., 2012). Nutritional conditions that vary seasonally and yearly and parity (Prabhakar and Addisu, 2004) have major effect on calving interval (Hailemariam and Kassa, 1994). The effectiveness of estrus detection and conception rate has a great impact on the calving interval. Calving interval is probably the best indicator of cattle reproductive efficiency. It is fertility traits that can be used in selection programmes to minimize the negative effects that selection for production have on fertility (Mostert et al., 2010).

Number of services per-conception (NSPC): Number of services per conception, which is defined as the number of services (natural or artificial) required for a successful conception, depends largely on the breeding system used, the reproductive health status of the animal, the management and feeding practices in a farm and the semen quality of AI or natural service bulls (Tewodros, 2008). Values of NSPC greater than 2 should be regarded as poor (Mukassa-Mugrewa, 1989). Number of service per conception is influenced by season; that is related to availability of feed, placenta expulsion time, lactation length and milk yield and parity (Hailemariam and Mekonnen, 1996; Gebeyehu et al., 2005; Gebrekidan et al., 2012).

Days open (DO): Days open (also called calving-to-conception interval) is the period between calving and conception in cows (Tewodros, 2008). Days open is influenced by the length of time for the uterus to completely involutes, resumption of normal ovarian cycle, occurrence of silent ovulation, accuracy of heat detection, management, semen quality and skill of inseminator or efficiency of bull (Yosef, 2006; Melaku et al., 2011). Days open affect lifetime production and generation intervals, and hence the annual genetic gain (Yosef, 2006).

Getenet and Addisu (2006) and Ayenalem (2006) summarizes the reproductive performances of Fogera and Boran cattle, respectively in Ethiopia that was conducted by different authors in different years sourcing the data both at on-station and on-farm level. The authors summarize the performances of the respective breeds got decline from year to year and this decline, even in the same ranches, may be due to the deterioration of feed quality and invasion by unpalatable weeds of the grazing lands of the production sites; shrinkages of grazing land due to shift in farming system; lower level of selection of the best performing breeds. The report of Aynalem et al. (2011) indicated that, Fogera breed had better daily milk yield and longer lactation length than other indigenous cattle breeds in Ethiopia like Boran of Ethiopia, Horro, and Bagait; that classifies the breed as one of the known milk producer breed in Ethiopia.

The above two tables indicate that the reproductive performances of the cross breeds had better performances with their respective indigenous cattle breeds. This is because of the improvement of crossbreeding

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through the improvement of the lower performing traits of the local breeds (Belay, 2014). Additionally, in the second and third generation of crossbreeding summarized for Fogera × Holstein Friesian (Belay, 2014) and Boran × Holstein Friesian (Ayenalem et al., 2010) there is a lowering of performance from the first generation. This lowering in the performance as the exotic blood increases is due to the negative effects of Heterosis, which is the non-additive effect of crossbreeding that indicates the amount by which merit of crossbreds' deviates from the additive component (Belay, 2014).

Table 1 - Summary of reproductive performances (in month) of Ethiopian Indigenous breeds

Breed	CI	AFC	DO	NSC	Source
Fogera	19.3	52.4	298.4	1.62	Almaz (2012); Gebeyehu et al. (2005)
Horro	12.2	50.0	152	1.69	Hailemariam and Mekonnen (1996)
Arsi	14.6	32.8	211	2	Mulugeta et al. (2008)
Boran	20.7	57.6	339	1.61	Yifat et al. (2012)
Barka	13.2	30.3	253	1.11	Hailemariam and Mekonnen (1996); Million and Tadelle (2003)
Highland zebu	15.1	53	148	2.2	Niraj et al. (2014)
Ogaden	16.4	50.3	195	2	Getinet et al. (2009)
Metema highland zebu	19.2	46.1	204.1	1.74	Tesfaye (2007)

Calving Interval (CI), Age at First Calving (AFC), Number of Service per Conception (NSC) and Days Open (DO) of dairy cattle in Ethiopian

Table 2 - Reproductive performances (in month) of some crossbreed dairy cattle in Ethiopia

Breed	CI	AFC	DO	NSC	Source
Jersey	15	34.5	174.68	1.79	Habtamu et al. (2010)
Zebu x Holstein-Friesian	21.36	36.6	155.7	1.56	Belay et al. (2012)
Fogera x HF	-	52.3	-	1.54	Gebeyehu et al. (2005); Belay (2014)
Friesian x Arsi zebu	11.9	29.2	-	-	Negussie et al. (1998)
Boran x HF	14.06	39.1	127	2.17	Aynalem et al. (2010)
Crossbreed cattle	12.4	34.8	85.6	1.52	Hunduma (2012)

Non-genetic factors influencing reproductive performance in dairy cattle

Non-genetic factors such as age of dam, sex of the calf, gestation length, parity, and cow weight influenced birth weight in cattle, which is useful in selection criterion for increased production and reproductive efficiency of dairy cattle (Olawumi and Salako, 2010); and they had significant effect on reproductive traits. Knowledge on these factors and their influence on cattle performance are important in formulation of management and selection decisions (Goyache et al., 2003). In various studies, a number of factors have been included in analyses as main factors or their two- and/or three-way interactions either as fixed effects or as continuous effects to account for environmental sources of variation in animals' performance (Wasike, 2006). These factors, which can be assisted as fixed effect (Wasike, 2006) and other stress causing factors affect the performance of individual growth performance (Almaz, 2012) and reproductive performances intern affect the productivity of a given farm.

Table 3 - Non-genetic factors influencing pre-weaning and reproductive performance of dairy cattle in Ethiopia

Factor	Traits						Source
	BW	WW	AFC	CI	DO	NSC	
Sex	**	NS					Melaku et al. (2011)
	***	**		NS			Almaz (2012)
Parity	**			*			Getinet et al. (2009)
	NS	*					Melaku et al. (2011)
	***	**		***		NS	Habtamu et al. (2010)
				NS	**	***	Yifat et al. (2009)
	***	*	NS	***	***		Almaz, (2012)
Year	**		**	**			Getinet et al. (2009)
	**	**					Melaku et al. (2011)
	***	***	***	***		***	Habtamu et al. (2010)
	***	***	***	***	***		Almaz (2012)
Season	NS		NS	NS			Getinet et al. (2009)
	**	*					Melaku et al. (2011)
	*	***	NS			*	Habtamu et al. (2010)
				***	**	**	Yifat et al. (2009)
	**	***	NS	***	***		Almaz, (2012)

***P<0.001; **P<0.01; *P<0.05; NS=Not Significant. BW=birth weight; WW=weaning weight; AFC=age at first calving; CI=calving interval; DO=days open; NSC=number of service per conception; AFS = age at first service.

Genetic parameter estimates for dairy cattle in Ethiopia

The potential for genetic improvement of a trait largely depends upon genetic variation existing in the population. The genetic composition of a population can be studied by considering the relative importance of

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heredity and environmental factors affecting the performance of an individual in that population (Gebeyehu et al., 2014). Precise and accurate knowledge of genetic parameters are of paramount importance for planning appropriate selection and breeding strategies for the genetic improvement programs (Choudhary et al., 2003; Wasike et al., 2006; Edward et al., 2013; Gebeyehu et al., 2014). The estimates of genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic gains (Wasike, 2006; Edward et al., 2013; Gebeyehu et al., 2014). Even though, there is limited information on the genetic parameter estimates of dairy cattle in Ethiopia, the available information's are summarized.

Heritability (h^2): Heritability is the measure of the degree to which a trait is genetically determined. Obviously heritability is important among the several factors determining how much genetic improvement can be made in any trait (Aynalem, 2006). Heritability estimates show a high level of variability that is a result of the differences in the population structure of the herds that provided the data, the model fitted for the analysis, the breed and the environment where the data was obtained (Wasike, 2006). The low heritability is caused not only by a low genetic variance but also by a higher phenotypic variance due to small size of the herd and by random or unidentified environmental factors (Khalid et al., 2001). Heritability estimation can be increased by providing uniform environment, use of multiple measurements, adjustment of records, and accurate measurement of data (Aynalem, 2010). Different estimates of heritability may be found for the same trait in different populations or in one population at different times.

Heritability of reproductive traits: Calving interval has a very low heritability (Cassell, 2001). Million and Tadelle (2003), reported that, heritability value of 0.03 for first calving interval in Holstein dairy cattle; Haile-Mariam and Kassa (1994) reported a heritability value of 0.03 and 0.04 for Ethiopian Boran from original and selected data; Gebeyehu et al. (2014) reported a heritability of 0.28 for Holstein Friesian cattle in Ethiopia; Haile-Mariam et al. (2003) also reported a heritability value of 0.04 and 0.03 in the first and second parity for CI, respectively. Kefena and his colleague (2011) reported a heritability value of 0.17 for calving interval of dairy cattle in Ethiopia. Almaz Bekele (2012) also reported a heritable value of 0.02 for Fogera cattle at Metekel Fogera cattle conservation ranch. For tropical cattle herds, average heritability value of 0.11was reported by Lobo et al. (2000). Aynalem (2006) reported heritability values of CI estimated for Ethiopian Boran and crosses were 0.0014±0.04 and 0.1±0.05, respectively.

Heritability of age at first calving is generally low, indicating that this trait is highly influenced by environmental factors. Cassell (2001) reported a heritability value of 0.14 for age at first calving in Holstein cattle while Hailemariam (1994) reported a respective heritability value of 0.06 and 0.07 for Ethiopian Boran cattle from original and selected data. Gebeyehu et al. (2014) and (Kefena Effa et al., 2011), also reported a respective heritability value of 0.53 and 0.40 for dairy cattle in Ethiopia. Almaz Bekele (2012) also reported a heritable value of 0.07 for Fogera cattle at Metekel Fogera cattle conservation ranch. Additionally, a heritability value of 0.263 was reported by Mohamed (2004) for Holstein Friesian in Ethiopia.

A respective heritability value for Days Open of 0.0006 and 0.1 for Boran and Boran × HF was reported by Ayenalem et al. (2009). Yosef (2006) reported a heritability value for day's open of 0.15 for Holstein and 0.07 for Jersey breed in Ethiopia. Mohamed (2004) also report a value of 0.224 for days open for Holstein Friesian in Ethiopia.

Repeatability of reproductive traits: In dairy cattle, the measure of repeatability estimate refers to the correlation between records of the same cow in the same herd and this may be utilized to assess the real producing ability of individual cows in a population (Olawumi and Salako, 2010). Basically repeatability value is greater than heritability value since repeatability estimates include the permanent maternal environmental variance in addition to the additive genetic variance component (Solomon and Gemeda, 2000). The low repeatability values indicate that an animal evaluation for the traits based on repeated observations is more reliable than evaluation on a single observation. Cows should not be culled on single (or only few) initially available records. Lower repeatability estimate for traits could be also due to higher influence of specific environmental effects on a given record that may inflate within animal records variability.

Repeatability estimation result of 0.39 for Jersy breed was reported by Edward et al. (2013). As indicated by Amin et al. (2013), repeatability estimates were low for days open and calving interval, 0.08 and 0.09, respectively for indigenous zebu. Repeatability estimates were reported as, 0.14±0.02 for calving interval, 0.14±0.02 for days open and 0.08±0.01 for services per conception for dairy cattle in the tropical highlands of Ethiopia (Ayenalem, 2006).

Genetic correlation among reproductive traits: The genetic correlation expresses the extent to which two characters are influenced by the same genes and it is important when selecting for net merit involving several traits. Estimates of genetic correlation between any pair of traits suggest that selection for one trait can lead to an indirect genetic response in the other trait (Edward et al., 2013; Gebeyehu et al., 2014).

As reported by Wasike et al. (2006), estimates of direct-maternal genetic correlation were highly negative. Genetic correlation estimates of -0.54, -0.57 and –0.80 was reported for South African Bonsmara, Ethiopian Boran and Kenan Boran. The antagonistic genetic correlation between mean MY and CI increased from 0.43 in the first

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to 0.58 in the second parity while that of persistency of MY (parity 1 and 2) with CI (0.04 to 0.18) and Surv (0.06 to 0.18) were close to zero (Haile-Mariam et al., 2003). Almaz (2012) reported a phenotypic and genotypic correlation between CI and DO as 0.32 and 0.83 for Fogera cattle, respectively. And a high genetic correlation for AFC with growth traits were; 0.77 ± 0.24, 0.82 ± 0.02 and 0.87 ± 0.03 respectively for AFC with BWT, AWWT and PADG. A phenotypic and genetic correlation value between AFS and AFC was reported 0.85 and 1, respectively and between CI and DO 0.99 and 1 respectively for Fogera × Holesien Fresiean cattle at Metekel ranch (Belay, 2014). A value for genetic correlation between CI and DO for Holstein and Jersey breeds was reported as 1 (Yosef, 2006).

CONCLUSION AND RECOMMENDATION

The reproductive performances of Ethiopian indigenous and exotic breeds producing in Ethiopia shows lower result because of various environmental factors (mainly of the changing climate) and absence of integrated record on the sector that leads a biased result and recommendations of the genetic parameter estimates. Development of effective genetic evaluation and improvement programs requires knowledge of the genetic parameters (genetic variance of each trait and covariance among traits) for economically important production traits. Accurate estimation of these genetic parameters requires data to be corrected to accommodate differences in known environmental effects that influence the production and reproductive performances of livestock. To increase the estimates of genetic parameter, uniform environment, use of multiple measurements, adjustment of records and accurate measurement of data are the basics need to be considered. Thus, implementation of these basic points for known environmental effects has an important role in reducing the non-genetic or environmental components of phenotypic variance. On the basis of this review result, the following recommendations were done.

- It is clearly reviewed that there is works done on estimation of genetic parameter for indigenous cattle breeds in Ethiopia; therefore, future focus should be given for the estimation of genetic parameters for productive and reproductive traits.
- As genetic parameters are estimated from the available recorded data of a given breed, it is necessary to keep well developed and designed record keeping system.
- Selection and designing of breeding programs for improving the production and productivity of indigenous breed through keeping their native potentials should be based on the results obtained from genetic parameter estimates viz. heritability and repeatability.
- Genetic parameters estimate from control breeding need to be updated regularly due to the changing of environmental and breeding factors.

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