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Evaluation of Reproductive Performance of Jersey Cattle Raised under Semi-intensive Management in Ethiopia

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ABSTRACT

Background: The productivity and profitability of dairy cattle depend largely on reproductive performance. Thus, this study was intended to evaluate the reproductive performance of Jersey cattle raised under semi-intensive management system.

Methods: A retrospective analysis consisted of data collected for the last 33 years was conducted. The fixed effects fitted were birth period, calving period, service period, birth season, calving season, service season, parity and genetic group. The general linear model procedure of SAS was used for the statistical analysis of data.

Result: The overall least-square means for age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO) and the number of services per conception (NSPC) were 22.93±0.22 months, 32.95±0.22 months, 494.16±3.68 days, 221.09±3.73 days and 1.99±0.03, respectively. Year, season and parity had a significant effect on most of the investigated reproductive traits. Imported Jersey cows had an extended CI and DO than farm-bred cows. Besides, the inconsistency of management and variability of climatic variables across year and season seems to have a considerable influence on the reproductive efficiency of cows. Therefore, the improvement in the level of management and selection of parents based on their breeding value would be improve the reproductive performance of Jersey cows.

Key words: Age at first calving, Calving interval, Days open, Jersey, Non-genetic factors.

INTRODUCTION

Ethiopia has the largest livestock population in Africa and the subsector contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP (Metaferia *et al.* 2011). However, the productivity of livestock is low and the direct contribution of this sector to the national economy is limited compared to its potential. Thus, to enhance productivity and economic contribution, crossing with exotic breeds was considered a major option in Ethiopia since the 1950s and different cattle breeds were imported including Jersey.

Jersey breed is characterized by small mature body size, high feed conversion efficiency, low maintenance requirement, high milk fat content, docile temperament, good reproductive performance and heat tolerance. Due to these features, this breed has been selected for tropical development programs (Njubi, 1992). Thus, to use this breed as an additional option for intensive and large-scale dairy farms through crossing with indigenous breeds, Adea-Berga dairy farm was established at Adea-Berga wetland in 1986. The farm had been engaged in the production and rearing of pure Jersey breed for dairy development enterprises and also serve as a bull dam station for the national artificial insemination center (Hunde *et al.* 2015).

Reproductive traits are the most economically important traits contributing to the profitability of dairy production (Lobago *et al.* 2007). Evaluation of the breed for these economically important traits could indicate the existing situation or suitability of the breed and insight the future breeding program to be planned. However, there is limited information on the reproductive performance of pure Jersey breed under semi-intensive management systems in Ethiopia. Therefore, the objective of this study was to evaluate the reproductive performance of pure Jersey dairy cows raised semi-intensively.

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MATERIALS AND METHODS

Description of the farm

This study was conducted at Adea-Berga Dairy Research Center, West Shewa Zone, Ethiopia. Adea-Berga is located at 9°N latitude and 38°E longitude at an altitude of 2500 m.a.s.l. The area is characterized by a cool sub-tropical climate with the mean annual temperature of 18°C and rainfall of 1225 mm. The most common grass species in

the area are *Trifolium*, *Pennisetum* and *Andropogon* according to Hunde *et al.* (2015).

Herd management

The breeding program was pure breeding using the controlled mating system through natural mating and artificial insemination techniques. The numbers of imported and farm-bred cows were 398 and 792, respectively. The management of the herds was based on sex, physiology and age of animals. Calves were allowed to suckle their dam immediately after birth for about five days to receive colostrums. Then female calves were separated from their dams and offered fresh milk twice a day for about six months as they used as a replacement (Hunde *et al.* 2015). Unselected male calves were weaned within 98 days, while selected calves for sire were offered fresh milk twice a day for about six months. Weighing and ear tagging were conducted within 24 hours after birth. All animals were allowed to graze natural pasture for about four hours a day and supplemented with hay, silage and concentrate feeds upon return to the barn. The animals had free access to clean tap water all the time. All animals were restricted from grazing and managed indoor during the main rainy season. All animals were supplemented with hay and concentrate feeds constituting 60% wheat bran, 38% noug seed cake (*Guizotia abyssinica*) and 2% salt. The amount consumed is not exactly known, since it depends upon the amount of feed available on the stock. Vaccination was conducted against Blackleg, Anthrax, Pasteurellosis, Foot and mouth disease and Lumpy skin disease. In addition, animals were de-wormed against internal parasites and treated against other infectious diseases by tentative diagnosis (Hunde *et al.* 2015).

Data source and data collection

The data were collected from 1986 to 2019. The investigated traits were age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO) and number of service per conception (NSPC). AFS was determined from the difference between the date of birth and the date of first service. AFC was determined from the difference between the date of birth and the date of first calving. The CI was determined from the difference between two consecutive calvings. The DO is also known as calving-to-next conception interval which is the period between calving and conception in cows. Service required for successful conception was used as the NSPC.

Data analysis

Preliminary data analysis like checking for outliers and normality tests were employed before conducting the main data analysis. Least squares analysis was carried out to examine fixed effects using the general linear model procedures of SAS (2002). Tukey-Kramer test was used to separate least squares means with more than two levels. The models for investigated reproductive traits are presented as follows:

Model 1: Statistical model for analysis of AFS and AFC:

$$Y_{ijk} = \mu + Y_i + S_j + e_{ijk}$$

Where:

Y_{ijk} = AFS and AFC
μ = Overall mean
Y_i = The fixed effect of i^{th} period of birth (i= 1986 to 2019)
S_j = The fixed effect of j^{th} season of birth (dry, short rain and main rain season).
e_{ijk} = Random error associated with each observation.

Model 2: Statistical model for analysis of CI, DO and NSPC:

$$Y_{ijkl} = \mu + Y_i + S_j + G_k + P_l + e_{ijkl}$$

Where:

Y_{ijkl} = CI, DO and NSPC
μ = Overall mean
Y_i = The fixed effect of i^{th} period of calving (i= 1986 to 2019)
S_j = The fixed effect of j^{th} season of calving (dry, short rain and main rain season)
G_k = The fixed effect of k^{th} animal group (imported and farm bred).
P_l = The fixed effect of 1^{th} parity (l = 1, 2, 3, 4, 5 and ≥6)
e_{ijkl} = Random error associated with each observation.

For NSPC trait, fixed effect of year and season of service were substituted instead of year and season of calving in the model.

RESULTS AND DISCUSSION

Reproductive performance and the effect of non-genetic factors

The main traits used to assessing reproductive performance of dairy cows are age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO) and number of services per conception (NSPC). The overall least-squares mean for AFS, AFC, CI, DO and NSPC were 22.93±0.22 months, 32.95±0.22 months, 494.16±3.68 days, 221.09±3.73 days and 1.99±0.03, respectively.

Age at first service (AFS)

The least-square means and standard errors for AFS are summarized in Table 1. The AFS in this study is comparable with the report of Tadesse (2006) for pure Jersey breed. However, it is lower than the report of Lemma *et al.* (2010) for Jersey breed, Eshetu (2015) for Jersey x Horro and Dinka (2013) for Horro x Jersey F1. The early AFS in this study could be due to the selection of replacement heifers and special care given for them to make a replacement of the nucleus breeding herd.

Year and season of birth had a significant (P<0.0001) effect on AFS. This result is in line with the finding of Getahun *et al.* (2019). The lowest AFS was recorded for animal born during 2015-2016 followed by 1985-1987 and 1994-1996 (Table 1). Cows that born during 2006-2008 require 11 more months to attain AFS than those during 1985-1987 period. This might be due to selection, environmental effect and inconsistency of management level across the years. Birth

season exerted a significant (p<0.0001) influence on AFS. On the contrary, a non-significant influence of birth season on AFS was reported elsewhere (Tadesse, 2006; Haile *et al.* 2009; Lemma *et al.* 2010; Getahun *et al.* 2019). In this study, cows born during the dry and main rainy seasons attained AFS of 2.34 and 1.45 months earlier than those born during the short rainy season, respectively (Table 1). This could be explained by the environmental effect and inconsistency of management (variability of forage quality and quantity across the season as natural pasture is the main source of feed).

Age at first calving (AFC)

The overall least squares mean AFC was 32.95±0.22 months (Table 1). The result obtained in this study is comparable with the report of Tadesse (2006) for Jersey breed. However, it is lower than the report of Lemma *et al.* (2010) for Jersey, Tadesse (2006) for Holstein Frisian (HF), Mengistu *et al.* (2016) for HF and Goshu *et al. (*2014) for HF. This variation could be due to breed differences, variability in feeding management, heat detection and the time of insemination especially for heifers, health control and climate variation. According to Kumar and Tuki (2014), the desirable AFC in local breeds is 3 years and 2 years in crossbred cattle. The AFC in this study is prolonged than this standard and this could influence both the productive and reproductive life of the female due to less number of calving.

Age at first calving (AFC) was significantly (p<0.0001) affected year and season. This result is in agreement with the finding of Hunde *et al.* (2015) and Getahun *et al.* (2019). The earlier AFC was recorded for animals born during 2015-2017 followed by 1985-1987 and 1994-1996. In this study, cows born during the dry and main rainy seasons attained AFC of 2.67 and 2.03 months earlier than those born during short rain season, respectively (Table 1). However, a non-significant influence of birth season on AFC was reported in previous studies (Haile *et al.* 2009; Lemma *et al.* 2010; Tadesse *et al.* 2010; Yalew *et al.* 2011; Belay and Chakravarty, 2014; Getahun *et al.* 2019).The influence of year and season in this study could be due to management fluctuation among years and seasons.

Calving interval (CI)

The least-squares mean of CI for the levels of fixed effects are summarized in Table 2. The CI in this study is lower as compared to the report of Tadesse (2006) for Jersey breed, Hunde *et al.*(2015) for Jersey breed, Getahun *et al.* (2019) for 50% F2 Friesian x Boran and Effa *et al.* (2006) for 75% Jersey crossbreds. However, this result is higher than the finding of Lemma *et al.* (2010) for Jersey breed, Haile *et al.* (2009) for Holstein Friesian x Boran and Getahun *et al.* (2019) for Holstein Friesian x Boran. In general, the average CI in this study is higher than the optimum values (356 days) desirable for profitable milk production. The differences could be explained by breed genetic potential, seasonal availability and quality of feed, climate and other management factors like heat detection, the skill of AI technicians and the quality of semen used for insemination.

Farm-bred cows had a shorter calving interval (466.68±3.66 days) than the imported cows (521.64±8.42 days) (Table 2). This result is in agreement with Lemma *et al.* (2010) for Jersey breed. The superiority of farm-bred cows

Table 1: Least square means (±SE) for effects of non-genetic factors on AFS and AFC.

Sources of variation	AFS (months)		AFC (months)	
	N	LSM ± SE	N	LSM ± SE
Overall mean	753	22.93±0.22	885	32.95±0.22
CV (%)		18.58		15.20
Birth period		****		****
1985-1987	389	17.03±0.22^{e}	328	26.37±0.29^{f}
1988-1990	58	21.79±0.50^{cd}	80	32.90±0.54^{d}
1991-1993	11	25.21±1.10^{abc}	34	34.92±0.80^{bc}
1994-1996	47	20.88±0.54^{d}	71	29.87±0.56^{e}
1997-1999	51	22.04±0.51^{cd}	65	32.30±0.58^{d}
2000-2002	49	22.87±0.52^{cd}	74	33.36±0.54^{cd}
2003-2005	51	26.20±0.51^{ab}	86	36.36±0.51^{b}
2006-2008	25	28.84±0.73^{a}	51	38.56±0.66^{a}
2009-2011	14	24.50±0.98^{bc}	33	35.41±0.81^{b}
2012-2014	46	26.28±0.54^{ab}	49	36.46±0.67^{b}
2015-2016	12	16.61±1.06^{e}	14	25.97±1.25^{f}
Birth season group		****		****
Dry season	441	21.85±0.25^{c}	489	31.84±0.26^{b}
Short rain season	102	24.19±0.39^{a}	137	34.51±0.41^{a}
Main rain season	210	22.75±0.31^{b}	259	32.49±0.32^{b}

N= number of observations, ****= P<0.0001, CV= coefficient of variation, Least square means with different superscripts within the same fixed effect indicate statistical difference.

Table 2: Least square means (±SE) for effects of non-genetic factors on CI and DO.

Sources of variation	Calving interval (days)		Days open (days)	
	N	LSM ± SE	N	LSM ± SE
Overall mean	2497	494.16±3.68	2650	221.09±3.73
CV (%)		23.78		60.08
Animal group		****		****
Imported	835	521.64±8.42^{a}	896	254.69±8.52^{a}
Farm-breed	1662	466.68±3.66^{b}	1754	187.50±3.74^{b}
Calving period		****		****
1989-1991	557	414.97±8.64^{d}	600	128.84±8.72^{f}
1992-1994	200	568.15±8.71^{a}	210	296.09±8.86^{a}
1995-1997	227	522.31±7.57^{b}	249	245.82±7.51^{bc}
1998-2000	261	473.08±8.02^{c}	287	195.29±8.02^{de}
2001-2003	287	463.47±8.43^{c}	308	186.05±8.49^{e}
2004-2006	261	481.21±8.80^{c}	278	204.72±8.87^{de}
2007-2009	170	468.85±10.19^{c}	177	191.58±10.35^{de}
2010-2012	164	530.49±10.19^{b}	165	269.10±10.50^{ab}
2013-2015	172	497.08±10.07^{bc}	173	222.82±10.38^{cd}
2016-2019	198	522.02±9.59^{b}	203	270.64±9.82^{ab}
Calving season group		*		**Ns**
Dry season	1139	488.38±4.57^{b}	1207	214.99±4.62
Short rain season	647	491.66±5.23^{ab}	694	220.47±5.28
Main rain season	711	502.44±5.07^{a}	749	227.82±5.11
Parity		**Ns**		*
2	818	497.49±5.97	879	226.22±5.99^{a}
3	599	497.97±6.08	646	228.10±6.15^{a}
4	399	493.22±6.36	419	222.17±6.46^{ab}
5	268	497.93±7.28	280	224.45±7.37^{ab}
≥ 6	413	484.21±5.81	426	204.54±5.95^{b}

N= number of observations, Ns (not significant) = P>0.05, ****= p<0.0001, *= P<0.05, CV= coefficient of variation, Least square means with different superscripts within the same fixed effect indicate statistical difference.

could be attributed to the sample size used, genetic to environmental interaction and adaptation problem as the animals were exposed to a new environment which may affect the expression of their genetic potential.

The significant (p<0.0001) influence of the calving period on CI observed in this study is in agreement with Tadesse (2006) and Hunde *et al.* (2015) for Jersey breed. The lowest CI (414.97±8.64 days) was observed for cows calved during 1989-1991 followed by cows calved during 2001-2003 (463.47±8.43 days). An extended CI (568.15±8.71 days) was observed for cows calved during 1992-1994 than those other years. The calving season was a significant (p<0.05) sources of variation for CI. This result is in line with the report of Birhanu (2014) and Getahun *et al.* (2019) for Holstein Friesian x Boran. However, a non-significant influence of calving season on CI was noted in literature (Tadesse, 2006; Tadesse *et al*. 2010; Hunde, 2012). Parity did not have a significant effect on CI. The differences across season and year could be attributed to differences in management practices and climatic variables.

Days open (DO)

The overall least square mean of DO was 221.09±3.73 days (Table 2). The DO in this study is lower than the report of Getahun *et al.* (2019) for 75% F1 Friesian crossbreds (244±14.0 days), but higher than Mengistu *et al.* (2016) for HF (139.58±7.91 days) and report of Haile *et al.* (2009) for Boran and its crossbred with Friesian in Ethiopia (141±19 days). In general, the DO in this study is higher than the optimum values (85 days) desirable for profitable milk production. Feed shortage, lack of proper heat detection and silent estrus could be the possible reason for longer days open.

Days open was significantly affected by animal group. Farm bred cows had shorter days open (187.50±3.74 days) than the imported animals (254.69±8.52 days). This could be attributed to the sample size used, genetic to environmental interaction and adaptation problem as the animals were exposed to a new environment which could create more difficulty to express their genetic potential.

The significant effect of the calving period observed in this study is in agreement with Hunde *et al.*(2015) for Jersey breed and Getahun *et al.* (2019) for HF x Boran. Animals calved during 1989-1991 had shortest DO followed by 2001-2003 and 2007-2009 (Table 3). The longest DO was observed for cows calved during 1992-1994. This is due to

Table 3: Least square means (±SE) for effects of non-genetic factors on NSPC of Jersey cattle.

Sources of variation	N	NSPC (LSM ± SE)
Overall mean	2968	1.99±0.03
CV (%)		58.19
Animal group		**Ns**
Imported	1080	2.08±0.07
Farm breed	1888	1.91±0.03
Service period		****
1987-1989	688	1.34±0.08^{d}
1990-1992	369	1.92±0.06^{c}
1993-1995	192	2.71±0.08^{a}
1996-1998	223	2.24±0.08^{b}
1999-2001	310	2.05±0.07^{bc}
2002-2004	286	2.10±0.08^{bc}
2005-2007	286	2.13±0.08^{bc}
2008-2010	133	1.86±0.10^{c}
2011-2013	202	1.99±0.09^{bc}
2014-2016	181	1.85±0.09^{c}
2017-2018	98	1.77±0.12^{c}
Service season group		**
Dry season	1240	1.94±0.04^{b}
Short rain season	954	1.95±0.04^{b}
Main rain season	774	2.10±0.05^{a}
Parity		****
1	798	1.71±0.06^{c}
2	753	2.16±0.06^{a}
3	506	2.02±0.05^{ab}
4	340	1.95±0.06^{b}
5	232	2.05±0.07^{ab}
≥ 6	339	2.08±0.06^{ab}

N= number of observations, Ns (not significant) = P>0.05, ****= p<0.0001, **= P<0.01, CV= coefficient of variation, Least square means with different superscripts within the same fixed effect indicate statistical difference.

inconsistent management across calving years. The calving season did not have a significant effect on days open. This result is agreed with other findings (Tadesse, 2006; Haile *et al.* 2009; Tadesse *et al.* 2010; Hunde, 2012; Mengistu *et al.* 2016). The significant effect of parity on DO observed in the present study is consistent with the study of Tadesse (2006), Lemma *et al.* (2010) and Hunde (2012) for Jersey breed. Days open in the sixth parity was significantly shorter than the second, third, fourth and fifth parities.

Number of service per conception (NSPC)

According to Mukasa-Mugerewa (1989), the NSPC higher than 2 is considered poor. The mean NSPC for Jersey cattle in this study was 1.99±0.03 (Table 3). This result is slightly higher than the report of Mengistu *et al.* (2016) for HF, Teketay *et al.* (2015) for HF x Arsi and the report of Lemma *et al.* (2010) for Jersey. However, it was lower than the report of Tadesse (2006) for Jersey breed and Haile *et al.* (2009) for Boran and Boran x Friesian. Herd management and performance of cows are associated with lower services per conception and could be the possible reason for the inconsistency of results across studies.

The NSPC was significantly affected by service period (p<0.0001), parity (p<0.0001) and service season (p<0.01). The lowest NSPC was observed in animals served in during 1987-1989 followed by those served in during 2017-2018. However, the highest service per conception recorded was during 1993-1995. The difference across periods of service could be due to variation of heat detection, skill of inseminator, time of insemination, inconsistent management and environmental variability.

Cows inseminated during the main rain season required more service than dry and short rain seasons. The significant effect of service season on NSPC was agreed with the report of Deberga *et al.* (2009) and Teketay *et al.* (2015). Shortage of feed might be the main reason for repeat breeding of cows during the main rain season. The significant effect of parity on NSPC observed in the present study is in agreement with the finding of Hunde (2012) for Jersey breed. The lowest NSPC was observed in the first parity (1.71±0.06) and the highest NSPC was recorded on 2nd parity (2.16±0.06). However, statistically there were no significant differences between 3rd, 5th and ≥ 6th parity (Table 3).

CONCLUSION

The calving interval and days open of farm-bred cows were shorter than the imported pure Jersey cows. The extended calving interval and days open exhibited poor reproductive performance of imported Jersey cows. The inconsistency of management and variability of climatic variables across year and season seems to have a considerable influence on the reproductive efficiency of cows. Therefore, the improvement in the level of feeding and health management and selection of parents based on their estimated breeding value would be improving the reproductive performance of Jersey cows.

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