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A study on the lactation and reproductive performances of purebred Jersey stock: implications for introducing European dairy breeds in the tropical environment

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ABSTRACT

To fulfil market demand, high-yielding temperate dairying breeds have been introduced to the tropics to boost dairy production. The tropical environment may impact the expression of the genetic potential of improved European breeds. Jersey breed has certain valued traits, i.e., small body size, low maintenance requirement, and milk quality. However, there is lack of empirical evidence on the performance of the Jersey breed, despite their huge dairy potential and contribution in East Africa. This study was carried out to investigate milk production and reproductive performance of Jersey dairy stock and related environment factors at Wolaita Sodo dairy breeding center. Data from 1164 records from 2008 to 2023 of purebred Jerseys were used and summarized by descriptive statistics, and General Linear Models of SPSS to analyze the effects of different factors on the performance parameters. The results revealed that the overall means for lactation milk yield (LMY), milk yield (DMY), and lactation length (LL) were 1852.5±21.5 litres, 5.5±0.07 litres and 337.2±2.5 days, respectively. LMY, LL and DMY were influenced by calving year and parity. There was a significant interaction among year, season of calving, and parity on LMY. Environmental influence (milking season, and period), and stage of lactation were significantly affected milk yield. The overall means of age at first service (AFS), age at first calving (AFC), calving interval (CI), days open (DO), and number of services per conception (NSPC) were 23.2±0.4 months, 34.9±0.5 months, 462.7±8.1 days, 186.9±7.0 days, and 1.89±0.05, respectively. All reproductive performance traits were significantly influenced by the year of birth/service. CI and DO were influenced by the calving season and parity. Management inconsistency and climate fluctuation appear to have a significant impact on cow productivity and reproductive efficiency. Performance levels such as AFC and NSPC are comparable with other results for Jersey herds in tropical countries but far below the genetic ability of the breed, particularly in terms of LMY. Therefore, improvements in management practices, feeding levels, and health management would be critical. Moreover, the study implied that farm-bred/adapted pure European or crossbred dairy cows are appropriate for the highlands and mid-altitudes in the tropical climate.
Keywords: Jersey breed, Milk production, Reproduction, Temperate breed, Tropics

INTRODUCTION

By 2050, emerging countries are projected to contribute 61% of global milk production, many of which are in tropical regions (Alexandratos and Bruinsma, 2012). Over 925 million smallholders rely on livestock for food and income, most residing in Sub-Saharan Africa or South Asia (McDermott *et al.*, 2010). Eastern Africa is the most promising area for dairy production (Ngigi, 2005). The region is the leading milk-producing region in Africa, accounting for 46 percent of milk output, estimated at 23.3 million tonnes (in milk equivalents) in 2022 (FAO, 2024). Generally, Eastern Africa dominates cow milk production, accounting for 68% of the continent's total, with Ethiopia, Kenya, and Tanzania among Africa's leading dairy producers (Sere, 2020; Bingi and Tondel, 2015).

Dairy production is an essential part of livestock farming in Ethiopia. The (Peri)-urban dairy production system includes both commercial and smallholder dairy farms, primarily concentrated in major cities and most towns in Ethiopia. These farms possess most of the improved or crossbred dairy cattle and are the primary suppliers of milk to urban markets. FAO (2022) reported, the Holstein Friesian x indigenous crosses produced an average of 19.22 ± 6.68 liters per cow per day, with peak yields reaching up to 27 liters. Indigenous cattle are also valuable genetic resources in remote rural, lowland, (agro)-pastoral, areas for their dual purpose. Jersey cows in Ethiopia have shown lactation yields of 2155 kg over 336 days (Hunde *et al.*, 2015) and 1691.59 kg over 318.42 days (Habtamu *et al.*, 2009). The country's dairy cattle improvement started with the first importation of dairy cattle after World War II by the United Nations Relief and Rehabilitation Administration (UNRRA).

Ethiopia benefits from a large dairy cow population, favorable and relatively disease-free agroecological zones—especially in the highlands—ample feed resources, and strong market demand in (peri)-urban areas (Tegegne *et al.*, 2013). However, to meet the growing demand for dairy products in tropical developing countries, productivity must be enhanced through the introduction of high-yield temperate breeds along with suitable management practices. Farming systems in these locations differ significantly from those in temperate countries. Genetic adaptation, which includes including thermal load resilience as a functional feature in breeding programs, could be a long-term approach for dairy cattle (Al-Kanaan *et al.*, 2015). Nonetheless, several breeding programs have yielded mixed success in improving dairy productivity.

Sustainability in the performance of animals is potentially challenged by climate change, particularly since dairy breeds have been selected (Marumo *et al.*, 2022). Ethiopia is one of Africa's most vulnerable countries to climate change and variability, with climate-related concerns having a persistent impact on people's lives and livelihoods (Belay *et al.*, 2017). Jerseys are disease-resistant, thermotolerant, and well-suited to the problems of the tropical environment, such as insufficient water, suboptimal nutrition, pest infestations, vector-borne diseases, heat stress, and other issues (Porter *et al.*, 2016). The same authors disclosed that Jersey cattle are recognizedss to adapt well to a variety of climates, environments, and management approaches. The Jersey breed is said to be sturdy, tenacious, and adaptable to a variety of meteorological and geographical situations (Berry and Buckley, 2016) and varied production systems (Huson *et al.*, 2020; Effa *et al.*, 2013).

Many Ethiopians consume dairy products, either fresh (48%) or fermented; 47% are used to make butter, and only 5% are marketed (Shapiro *et al.*, 2017). Butter is made from around 62% of Ethiopia's total milk production (Gebremedhin *et al.*, 2014). When the market need for butterfat is high and marketing fluid milk is challenging, the Jersey breed offers additional benefits.

Dairy stock output could be improved by improving the animals' environmental conditions, increasing the population's mean breeding values, or combining the two ways. Environmental influences often hide the animal's genetic capacity. Missanjo *et al.* (2011) observed that selection in the best environment resulted in increased gene expression, which boosted selection responses. Environmental variance, which includes all variations of non-genetic origin, is a source of error that affects precision in genetic investigations. Genetic and environmental factors influence productive and reproductive traits. The evaluation of these parameters offers the foundation for developing appropriate breeding strategies to promote the genetic improvement of the animal population. It aids in identifying animals with better genetic merits based on their high breeding values. In addition to improving animal genetics, the relevance of optimal environmental conditions in increasing animal production is becoming more widely understood (Cunha *et al.*, 2008).

Therefore, this study aimed to investigate the milk production and reproductive performance of Jersey dairy cattle and associated factors at the Wolaita Sodo Cattle Breeding Centre—one of the southern region's major dairy clusters.

MATERIALS AND METHODS

Study Area

The study was carried out at the Wolaita Sodo Cattle Breeding Centre in the Wolaita area, South Ethiopia, at 6°49' N latitude and 39°47' E longitude (WZFEDD, 2003). Wolaita Sodo, the administrative town, is located 332 km south of Addis Ababa in Ethiopia. The altitude of the area is 1854 meters above sea level. The rainfall pattern is bimodal, with a short rainy season from March to May and a primary rainy season from July to October.

The Wolaita sodo dairy cattle breeding farm is historical, established in 1986 by the Wolaita Agricultural Development Unit (WADU), which is among the first livestock improvement programs supported by the World Bank. The farm is one of the three farms/ranches in Ethiopia with exotic breeds (pure breeding). The center is also located in one of the southern region's two key dairy clusters (Ndambi *et al.*, 2018; Wytze *et al.*, 2012) in terms of conductive highland agroecology, market demand and the southern butter trade channel.

Study Animal Mmanagement

Feeding management

Animals were grouped by age, sex, and production category. Feed sources included natural pastures and improved forages such as elephant grass, Rhodes grass, and tree lucerne. During the summer, animals grazed on fresh grass; in the winter, dry grass was provided. Clean tap water was available at all times. Cows and heifers grazed for five hours daily before returning to the barn.

Concentrates were offered during the long dry season, subject to budget availability, and composed of wheat bran, middling, maize, and oilseed cake. According to Fekede *et al.* (2015), the concentrate had the following composition (per kg DM): DM 892.8 g, CP 187.9 g, ME 10.1 MJ, Ash 100.2 g, NDF 440.1 g, ADF 156.8 g, and Lignin 43.5 g.

Housing management

The farm has a conventional barn with four-sided concrete walls and a tail-to-tail housing arrangement. There is a separate house for calves, heifers, bulls, and milking cows. Cows were milked by hand twice a day in their barn, around 7:00-8:30 in the morning and 3:30-5:30 in the afternoon.

Health management

Disease control is achieved by a combination of health management methods, including frequent immunizations administered by full-time veterinarians on the farm. Internal parasites, pneumonia, and coccidiosis are all issues that calves face, according to health technicians.

Vaccinations against blackleg, anthrax, bovine pasteurellosis, foot and mouth infections, and lumpy skin diseases were administered on a regular basis. Animals are dewormed for internal parasites and treated for infectious diseases based on their preliminary diagnosis.

Breeding Program

Artificial insemination is the only method for breeding the animals. Heat detection is performed by herdsmen, who subsequently report to an AI technician. Age, mastitis, abortion, and fertility difficulties are among the reasons for culling farm animals. Another management practice is keeping records (breeding, production, finances and health). Calves within 24 hours of birth, ear tagging, and weighting were also implemented.

Study Population and Study Design

The study population consisted of Jersey cows raised on the farm over the last 16 years (2008-2023). A retrospective study was conducted to assess the milk production and reproductive performance of the Jersey breed on the farm.

Data Source and Number of Data Collected

The data used for production and reproductive performance analysis were gathered from records of the pure Jersey breed kept at the Wolaita Sodo Cattle Breeding Center. A total of 262, 104, 94, 143, 461, and 100 data were used to evaluate LMY, DMY, LL, AFS, AFC (CI and DO), and NSPC, respectively. In addition, the farm record books and individual animal card histories were also used to collect information on cow age and parity (1-6), calving period (2008-2010, 2011-2013, 2014-2016, 2017-2019, 2020-2023) and season (long rain, long dry, short rain). Animals have not been used for scientific purposes while gathering data.

Data Analysis

Data on milk production and reproductive performance traits were analyzed using the Statistical Package for Social Science version 26 software procedure (SPSS, 2020). The collected data were analyzed using a Mixed Model procedure. Differences between least squares means of traits were tested using the Duncan test based on the ANOVA result. Fixed effects that are significant (P<0.05) were fitted into the models.

1. Model used for the analysis of LMY, and LL was $Y_{ijkl} = \mu + Pc_i + P_j + Cs_k + (Pc*P)_{lj} + (Pc*Cs)_{ik} + (P*Cs)_{jk} + (P*Cs*Pc)_{jki} + e_{ijkml}$
2. Model for AFS and AFC (season of birth): $Y_{ikj} = \mu + Pc_i + Cs_k + (Pc*Cs)_{ik} + e_{ikj}$
3. Model for NSPC, CI and DO (season of last calving/service, parity): $Y_{ijkl} = \mu + Pc_i + P_j + Cs_k + (Pc*P)_{ij} + (Pc*Cs)_{ik} + (P*Cs)_{jk} + (P*Cs*Pc)_{jki} + e_{ijkl}$

Where:

Y_{ijkl} = observation in each trait
μ = the overall mean common to all observations
Pc_i = the effect of i^{th} period of calving (period of calving, with i = 5)
P_j = the effect of j^{th} parity of the cow (j = 6)
Cs_k = the effect of k^{th} calving/last service season (k=3)
Pc*P = interaction between periods of calving/service and parity
P*Cs = interaction between parity and calving/service seasons
Pc*Cs = interaction between periods of calving/service and calving/service seasons
P*Cs*Pc = interaction between periods of calving/service, calving/service seasons and parity
e_{ijkl} = random error associated with $Y_{ijkl}{}^{th}$ observation.

RESULTS AND DISCUSSION

Milk Production Performance

Environmental influence (milking season, and period), and stage of lactation significantly affected milk yield. The mean and standard error values for lactation milk yield (LMY) and lactation length (Table 1). The average lactation milk

Table 1. Least squares means (LSM) and standard errors (SE) for LMY, DMY & LL

Factors	N	Least square means ± SE		
		LMY (Liters)	LL (days)	DMY (Liters)
Overall Mean	262	1852.5±21.5	337.5±2.5	5.5±0.07
calving period				
2008-2010	33	1970.7±52.1^{b}	372.8±6.6^{c}	5.3±0. 16^{a}
2011-2013	66	1783.1±38.1^{a}	332.6±4.9^{ab}	5.4±0.12^{a}
2014-2016	58	1989.7±51.9^{b}	332.8±6.6^{ab}	6.03±0.16^{b}
2017-2019	44	1766.1±49.4^{a}	339.4±6.3^{b}	5.25±0.15^{a}
2020-2023	61	1815.4±48.1^{a}	318.2±6.1^{a}	5.7±0.15^{b}
P-value		(0.01)*	(<0.0001)***	(0.005)**
Season of calving				
Long rainy	87	1852.6± 37.6	338.3±4.8	5.5±0.1
Long dry	119	1839.8±32.4	335.4±4.1	5.6±0.1
Short rainy	56	1866.6±41.9	338.9±5.3	5.51±0.1
P-value		0.8	0.59	0.74
Parity				
1	57	1879.8±47.3^{b}	351.4±6.02^{c}	5.36±0.1^{ab}
2	64	1973.5±41.7^{b}	342.2±5.3^{bc}	5.80±0.13^{c}
3	51	1966.0±47.3^{b}	347.7±6.0^{bc}	5.68±0.15^{bc}
4	37	1908.6±53.1^{b}	340.1±6.7^{bc}	5.7±0.2^{bc}
5	25	1659.8±66.9^{a}	321.7±8.5^{b}	5.22±0.2^{a}
≥6	28	1646.9±61.9^{a}	315.8±7.9^{a}	5.3±0.2^{ab}
P-value		(<0.0001)***	(0.006)**	(0.03)*

LSM with different letters within a factor differ significantly, ** (p<0.01), *(p<0.05); LMY=lactation milk yield; LL=lactation length; DMY= daily milk yield; N =number of observations.

output for Jersey cows in this study was 1852.5±21.5 kg. This study's result was lower than those reported by Direba *et al.* (2015) (2155±16.4 kg), Adebayo and Oseni (2016) (2160±34.9 kg) in Nigeria, and Beneberu *et al.* (2020) (2166.82±26.70 kg). A lower lactation value was reported by Habtamu *et al.* (2009) (1691.59±27.55 kg) in the previous study on the same dairy farm. This might be dairy experience gained, and some management improvements have been made over the years.

The calving period significantly affected LMY ($p<0.05$) in this study, which is consistent with that of Direba *et al.* (2015) and Beneberu *et al.* (2020). The lowest lactation milk yield was recorded in 2017–2019 (1766.1±49.4 kg) and had significant differences with periods of 2008–2010 and 2014–2016. Cows that calved between 2017 and 2019 may have underperformed. The variation in lactation milk yield from one calving period to the other could be related to inconsistent management (feeding) strategies implemented from year to year. The relatively lower rainfall, higher environmental temperature fluctuations, and elevated Temperature-Humidity Index—particularly in January, February, and March (Figures 1a,b and 2)—may have contributed to the situation. Housing cows and ensuring a reliable water supply are primary strategies for mitigating the negative effects of heat on cow performance in such farms. Additionally, feed supplementation strategies, such as improved forage crops and farm-made concentrates, should be implemented as solutions.

Parity had a significant effect on LMY ($p<0.001$). This strong influence of parity on LMY was in agreement with the findings of Beneberu *et al.* (2020) for the Jersey breed in Ethiopia's central highlands. In contrast, Yosef (2006) found that parity had no significant influence on LMY. Lactation milk output was higher in parities one through four, but lower in parities five (1659.8±66.9 kg) and ≥6 (1646.9±61.9 kg). Lactation milk output appears to increase linearly from the first to fourth parity, likely due to increased body weight with maturity, as larger cows have more udder tissue and a larger digestive tract. However, milk yield was higher in the second parity than in the third, and lactation milk showed a decreasing tendency after the fourth parity, coinciding with a shorter lactation period. The disparity between the current results and those of other authors may be attributed to differences in animal management systems and climate factors influencing how the animals were maintained.

Lactation Length

The mean and standard error of LL for pure Jersey cows in this investigation were 337.5 ± 2.5 days (Table 1). This finding is similar to the figure of 336.17 ± 2.3 days reported by Direba *et al.* (2015). A higher value was reported by Vijayakumar *et al.* (2019) (364.21±9.52 days) for Jersey crossbreds in India, and Beneberu *et al.* (2020) (344.89±3.81 days) in Ethiopia. Nandolo (2015) observed lower values (307 days) in Malawi, while Adebayo and Oseni (2016) reported lower values (302±1.96 days) for Nigeria's Jersey breed. For a typical modern dairy cow, lactation length is defined as 305 days—it is important to note that this period reflects dairy management practices designed to have animals concurrently pregnant and re-initiating lactation approximately every year. Longer lactations can be realized if milk harvesting is continued (Russell, 2018).

The calving period had a considerable effect on lactation length ($P<0.001$) (Table 1). This result is similar to the reports of Beneberu *et al.*

Table 2. P-values of interaction effects of fixed effect on LMY, LL & DMY

Interaction effect	LMY	LL	DMY
Season*calving year	0.39	0.5	0.75
Season*parity	0.43	0.18	0.66
calving year *parity	0.09	0.24	0.4
Calving year*parity*Season	(0.01)*	0.42	0.08

LMY= Lactation Milk Yield; LL= Lactation Length; DMY= Daily Milk Yield

(2020) and Direba *et al.* (2015). The highest lactation length was recorded during 2008–2010 (372.8±6.6 days), which had a significant difference from other periods of calving. The variation in lactation length across different calving seasons may be influenced by annual fluctuations in rainfall, which directly or indirectly impact feed availability.

Parity did show a significant influence on lactation length (Table 1). This finding was in agreement with the findings of Kefale *et al.* (2020) and Direba *et al.* (2015). There was a significant interaction effect ($p<0.05$) between calving year, calving season, and dam parity on LMY (Table 2). The interaction highlights the complex interplay of biological and environmental factors in determining milk production. This emphasizes the need for multiple considerations in optimizing dairy management practices. The effect of one factor—such as calving year—on milk yield may depend on the levels of other factors, including calving season and dam parity. For instance, the impact of calving season on milk yield may vary depending on the year and the

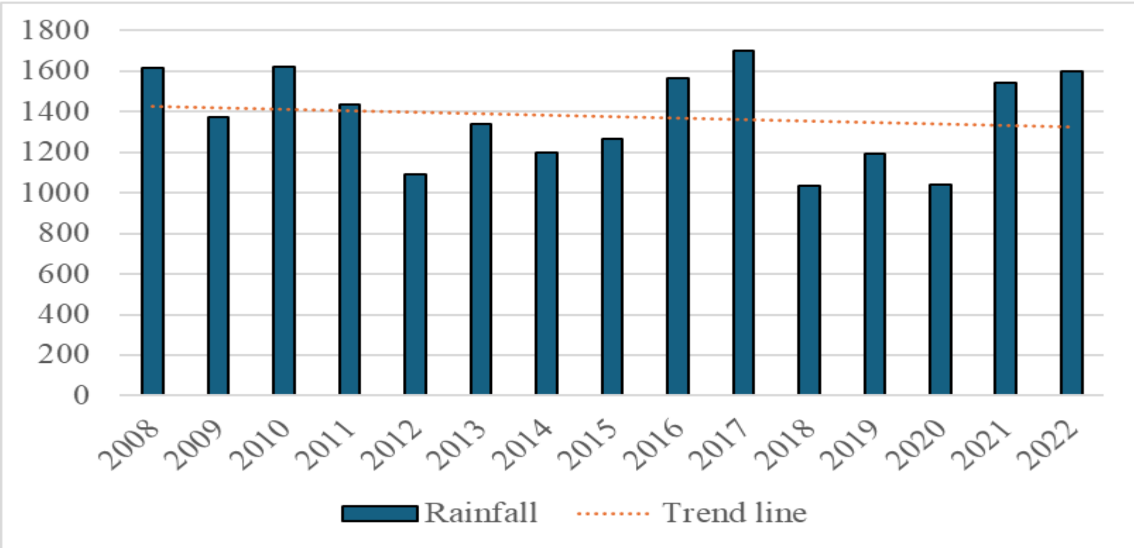

Figure 1a. Rainfall trends in the studied years

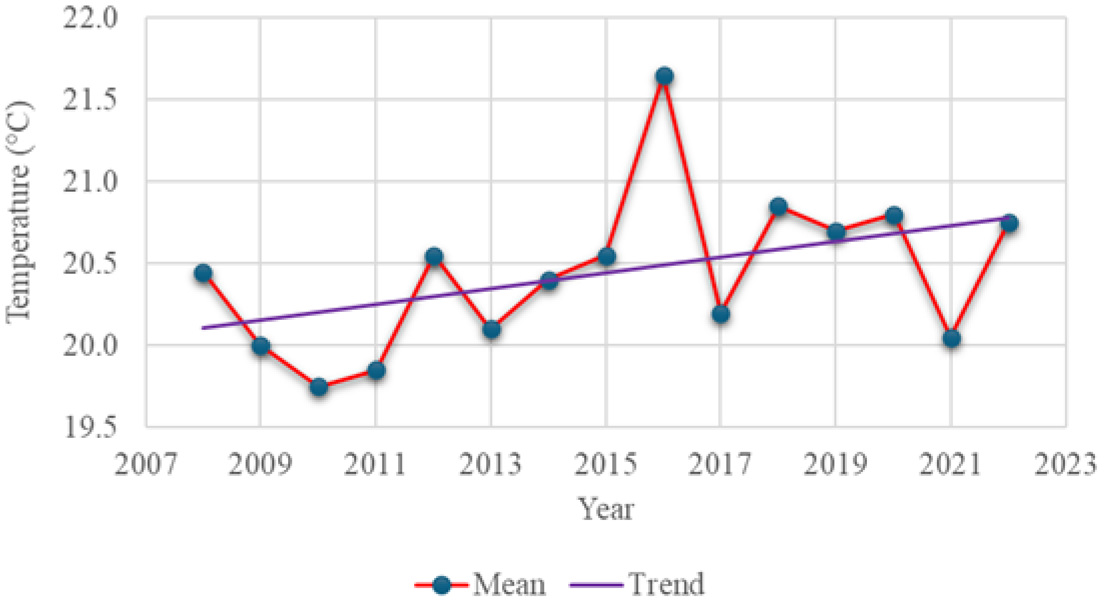

Figure 1b. Temperature trends in the studied years

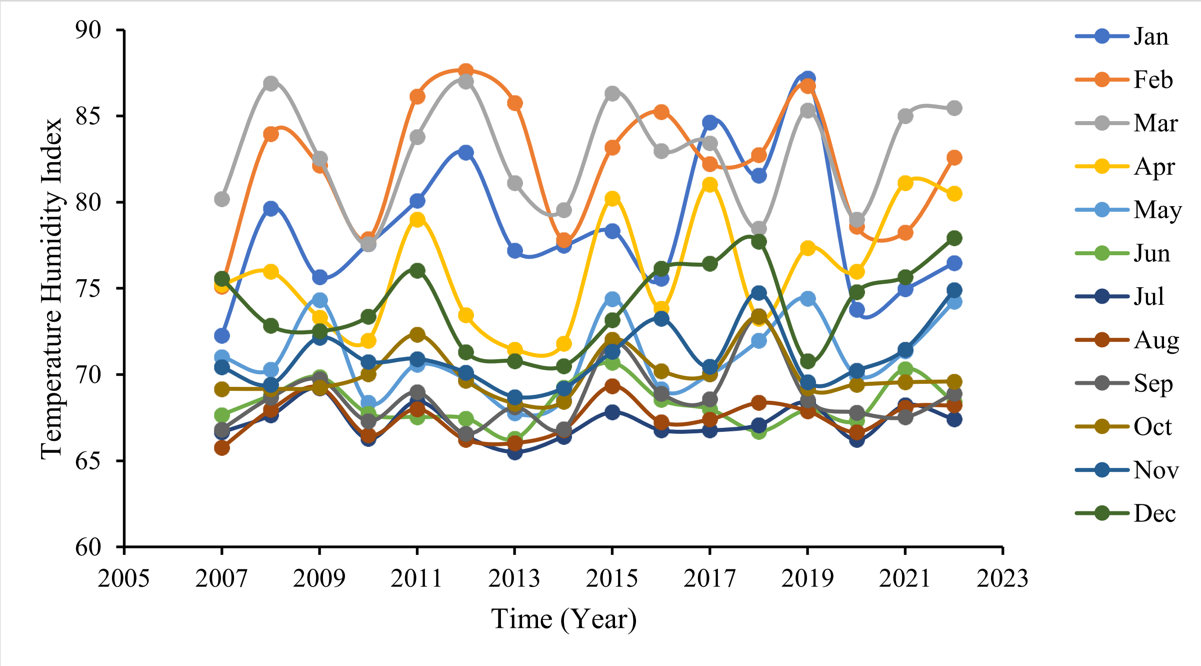

Figure 2. Temperature Humidity Index (THI) of Wolaita Sodo City (2007–2022)

dam's parity. Understanding these interactions is crucial for enhancing management strategies to improve milk production.

Reproductive Performance

All reproductive performance traits were significantly influenced by the year of birth/ service. Calving Interval (CI) and Days Open (DO) were influenced by the calving season and parity.

Age at first service

The mean and standard error for Age at First Service (AFS) of Jersey cows in this study were 23.2±0.4 months (Table 3). This study's result is comparable to Beneberu *et al.* (2021) report of 22.93±0.22 months for jerseys. However, Demissu *et al.* (2013) reported a higher value of 33.25 months for Jersey-Horro crosses, while Beshatu *et al.* (2023) reported 27.9±0.52 months for Jersey crossbreds. The disparity between the current results and those published elsewhere may be due to differences in feed management, heat detection by herders, health control measures, and climate fluctuations.

Birth year significantly affected AFS ($P<0.01$) (Table 3). This result is consistent with the findings of Beshatu *et al.* (2023) and Beneberu *et al.* (2021). Animals born in 2020-2021 had the lowest AFS (18.5 ± 1.3 months), which had a significant difference from other periods of birth. The variation in AFS from year to year may be influenced by environmental factors and inconsistencies in management practices over time. Farm management strategies, including the timing of breeding and the use of reproductive technologies, can fluctuate annually, impacting the age at first service.

Age at first calving

The mean and standard error for the Age at First Calving (AFC) of the Jersey breed in this study were 34.9±0.5 months (Table 3). The result of this study is comparable to the 35.5 months reported by Nandolo (2015) in Malawi, but higher than Beneberu *et al.* (2021) (32.95±0.22 months), and Direba *et al.* (2015) (29.92±0.17 months). Higher AFC was reported by Beshatu *et al.* (2023) (38.5±0.53 months) and Kefena *et al.* (2013) (43.21± 0.9 months) for the Jersey crossbred. The observed AFC differs from reports by other authors and may be attributed to variations in feeding management, heat detection, insemination timing—particularly for heifers—health control, and climate fluctuations. With proper nutrition, heifers are expected to grow rapidly and gain weight at an early age (Million *et al.*, 2010).

Age at first calving was significantly

Table 3. Least squares means and standard error for AFS and AFC

Source of variation	N	AFS mean± S.E (months)	N	AFC mean± S.E (months)
Overall	104	23.2±0.4	94	34.9±0.5
Year of birth				
2008-2010	16	$23.27{\pm}0.4^{b}$	15	$35.33{\pm}1.3^{bc}$
2011-2013	24	$24.05{\pm}0.9^{b}$	20	$33.63{\pm}0.97^{ab}$
2014-2016	18	$24.2{\pm}0.82^{b}$	17	$35.28{\pm}1.1^{abc}$
2017-2019	14	$24.32{\pm}9.4^{b}$	14	$36.58{\pm}1.3^{c}$
2020-2021	19	$18.5{\pm}1.3^{a}$	13	$31.2{\pm}1.6^{a}$
P-Value		(0.004)**		(0.03)*
Season of birth				
Long rainy season	37	24.3±0.7	29	35.92±0.9
Long dry season	51	23.3±0.45	48	34.8±0.6
Short rainy season	16	21.7±0.77	17	35.05±1.2
P-Value		0.12		0.16
Birth year *birth season				
P-Value		0.75		0.72

N= number of observations, *= p<0.05; AFC= age at first calving; AFS= age at first service

Table 4. Least square means and standard errors for NSPC of Jersey stock

Sources of variation	N	NSPC (LSM ± SE)
Overall mean	461	1.89±0.05
Service period		
2008-2010	68	$2.10{\pm}0.13^{c}$
2011-2013	99	$1.59{\pm}0.89^{a}$
2014-2016	105	$2.15{\pm}0.13^{c}$
2017-2019	72	$1.97{\pm}0.13^{bc}$
2020-2023	117	$1.74{\pm}0.95^{ab}$
P-value		(0.016)*
Season of service		
Long rainy season	135	$1.96{\pm}0.99^{b}$
Long dry season	212	$1.96{\pm}0.79^{b}$
Short rainy season	114	$1.68{\pm}0.85^{a}$
P-value		0.16
Parity		
1	109	$2.11{\pm}0.12^{c}$
2	96	$1.95{\pm}0.12^{bc}$
3	81	$1.67{\pm}0.1^{ab}$
4	73	$2.12{\pm}0.15^{c}$
5	48	$1.44{\pm}0.11^{a}$
≥6	54	$1.76{\pm}0.12^{abc}$
P-value		(0.001)**
Season*service year		0.26
Season*parity		0.36
service year *parity		0.93
Service year*parity*season		0.92

N= number of observations; NS= non-significant (p>0.05); *= p<0.05; **=p<0.01; NSPC= Number of services per conception.

(p<0.05) affected by year of birth (Table 3). This result is in agreement with the findings of Beshatu *et al.* (2023); Beneberu *et al.* (2021), Direba *et al.* (2015) for the Jersey breed, and Kefale *et al.* (2019) for crossbreed stock. The earlier AFC was recorded for animals born during 2020–2021 (31.2±1.6 months) and had a significant difference from other periods of birth. The temperature was also gradually falling until 2021 (Figure 1). The lowest AFC observed in this study may be attributed to improved management practices, the Jersey breed's adaptability to the current environment, climatic conditions affecting heifers, and effective heat detection when heifers reach puberty.

Number of services per conception

The overall mean and standard error for the number of services per conception (NSPC) of the Jersey breed in this study were 1.89±0.05 (Table 4). The finding obtained in this study is comparable to Eshetu (2015), who stated a value of 1.75±0.11 for the Horro-Jersey cross. Higher values were reported by Direba *et al.* (2015) (2.02±0.02); Beneberu *et al.* (2021) (1.99±0.03) for the Jersey breed; and Vijayakumar *et al.* (2019) (3.19±0.20) for the Jersey crossbred in India. A lower value (1.6±0.1) was reported by Beshatu *et al.* (2023) for Horro-Jersey crosses. McDowell *et al.* (1976) reported, high environmental temperature and reduced efficiency of inseminators contribute to the higher rate of number of services per conception.

The NSPC was strongly influenced by service period (p<0.05) and parity (p<0.01) (Table 4). The current study found a significant effect of the service period on NSPC, which is consistent with the findings of Beshatu *et al.* (2023). The lowest NSPC was found in animals bred in 2011–2013, followed by those served in 2020–2023. There was a substantial disparity between service-periods (2011–2013). The age of the cow and different health problems can also affect NSCP (Bello *et al.*, 2012). The service period can influence fertility. A longer service period may enhance conception rates by allowing cows sufficient time to recover from calving and return to estrus in optimal condition. Parity also plays a significant role, as first-calf heifers often exhibit lower conception rates than older cows due to the ongoing maturation of their reproductive systems.

Calving interval

The mean and standard error for the calving interval (CI) in this study were 462.7±8.1 days (Table 5). The CI in this study is lower than that reported by Beneberu *et al.* (2021), Vinothraj *et al.* (2016), Direba *et al.* (2015), and Nandolo (2015). The CI in this study exceeds the normal range of 12 to 13 months (365 days). Based on the evidence gathered, the extended CI appears to be primarily due to prolonged Days Open (DO), which may result from environmental factors, ineffective heat detection, inadequate nutrition before and after calving, and poor health conditions.

This study found a significant (p<0.001) (Table 5) influence of the calving period on CI, which is consistent with Beshatu *et al.* (2023), Beneberu *et al.* (2021), Direba *et al.* (2015) and Million *et al.* (2006). The lowest CI (384.2±12.1 days) was observed o from 2020 to 2023, which had significant deference from other periods of calving. An extended CI (523.3±26.4, 499.8±14.3, and 494.7±16.8 days) was observed for cows calved during 2008–2010, 2011–2013, and 2014–2016, respectively, compared to those other years. The progressive decline in CI observed in this study may indicate improvements in the farm's ability to manage its dairy stock, as well as the breed's adaptation to the prevailing environmental conditions over time.

The calving season significantly influenced CI (p < 0.05) (Table 5), which is consistent with the report of Beneberu *et al.* (2021). Beshatu *et al.* (2023) found no statistically significant effect. The highest CI was obtained in the long rainy season (515.2±1139 days), which had a significant difference from other seasons of calving. The variations across seasons and years could be related to differences in management approaches and climate variables. The current study found a significant influence of parity (p<0.05) on CI, which is similar to Beshatu *et al.* (2023); Direba *et al.* (2015) and Million *et al.* (2006). The lowest CI was recorded in cows of parity six or higher, showing a significant difference from other parities. This may be due to the lower DO values observed during this period. The decreasing trend in CI up to parity six could be attributed to advancements in reproductive management and the physiological maturity achieved by older cows.

Table 1. Least square means and standard errors for CI and DO

Sources of variation	N	CI (days)	DO (days)
Overall mean	143	462.7±8.1	186.9±7.0
Calving period			
2008-2010	15	523.3±26.4[c]	229.0±24.8[c]
2011-2013	33	499.8±14.3[c]	224.0±14.5[c]
2014-2016	34	494.7±16.8[c]	214.9±15.1[c]
2017-2019	25	446.8±13.1[b]	169.8±10.3[b]
2020-2023	36	384.2±12.1[a]	120.5±6.1[a]
P-Value		(<0.0001)***	(0.005)**
Calving season			
Long rainy season	48	515.2±1139[b]	240.6 ±11.4[b]
Long dry season	64	43.8±1.5[a]	158.7±11.1[a]
Short rainy season	31	442.2±14.1[a]	161.4±11.7[a]
P-Value		(0.04)*	(0.003)**
Parity			
1	34	511.9±18.9[c]	214.6±16.8[b]
2	38	472.7±15.6[c]	199.9±13.6[b]
3	24	476.5±18.6[c]	186.1±14.9[b]
4	20	447.2±19.3[bc]	190.3±17.1[b]
5	17	419.4±18.01[ab]	139.2±14.2[a]
≥6	10	383.4±13.6[a]	118.4±7.6[a]
P-Value		(0.03)*	(0.029)**
Season*service year		0.59	0.6
Season*parity		0.97	0.98
service year *parity		0.3	0.26
Service year*parity*season		0495	0.9

N= number of observations; *= p<0.05; **=p<0.01; ***=p<0.0001; CI=Calving Interval; DO= Days Open

Days open

The overall mean of Days Open (DO) was 186.9±7.0 days (Table 5). This study's DO is lower than that of Beneberu *et al.* (2021), who reported 221.09±3.73 days. A lower value was reported by Beshatu *et al.* (2023) (99.9±7.6 days) for Horro-Jersey F1 crosses and Wondossen *et al.* (2018) (105.86±20.44 days) for Jersey crossbred cows. DO is a reliable metric for assessing a dairy herd's reproductive efficiency and achieving an optimal CI of 12–13 months. Ideally, cows should conceive within 85 to 110 days after parturition. Variations in DO may be influenced by different dairy cow management techniques.

The study found a significant effect of the calving period on DO (Table 5), which is consistent with Beneberu *et al.* (2021) and Direba *et al.* (2015). Beshatu *et al.* (2023) found no statistically significant effect. Animals calved during 2020–2023 had the shortest DO, which had a significant difference from other periods of calving. The longest DO was observed for cows calved from 2008 to 2010, 2011–2013, and 2014 –2016.

The study found a significant effect of the calving season (p<0.01) (Table 5) on DO, which is consistent with Kefale *et al.* (2019) findings for Holstein Friesian (HF) x Boran. In contrast, Wondossen *et al.* (2018), Destaw *et al.* (2016) for the HF breed, and Beshatu *et al.* (2023) for the Jersey stock found no significant effects of the calving season on DO. Animals calved during the long-wet season had the highest DO, which differed significantly from other calving seasons. The current study found a significant influence of parity (p<0.01) (Table 5) on DO, which is similar to findings by Beshatu *et al.* (2023), Beneberu *et al.* (2021), and Direba (2012).

The highest DO was observed in parity one, showing a significant difference between parity five and parity six or higher. Conversely, the lowest DO was recorded in cows of parity six or greater, which differed significantly from the other parities. DO levels declined until parity ≥6, possibly due to improved reproductive management and the physiological maturity of older cows. Additionally, as parity increases, the DO period decreases because older animals heal their uterus faster than heifers. Several factors influence DO, including the time required for uterine involution, the restoration of the normal ovarian cycle, the occurrence of silent heat, the accuracy of heat detection and control, semen quality, and the inseminator's expertise (Fikre, 2007).

CONCLUSION

This study assessed the performance of farm-bred Jersey dairy stock, taking into account environmental variables and their interactions. This generated evidence to the potential of the adapted pure European or crossbred dairy cows in terms of their appropriateness for the highlands and mid-altitudes in the tropical climate. The calving year and dam parity both influenced lactation milk yield (LMY). There was a significant interaction effect between calving year, calving season, and dam parity on LMY. This reveals a complex connection of various factors in determining milk production, stressing the importance of manifold considerations in improving performance. The year of birth had a significant influence on all reproductive performance parameters. Calving interval and days open were affected by the calving season and parity. Dairy farm management inconsistency and seasonal fluctuation appear to have a significant impact on cow reproductive efficiency. Therefore, it is necessary to improve or optimize the genetic potential of Jersey cows through additional interventions in improved husbandry practices and an overall breed management plan. Collaborations or knowledge-sharing platforms with other Jersey cattle breeders or researchers could help improve breed performance and management practices. Further research, such as genotype-environment interactions is required.

Implications

This study on the performance of farm-bred Jersey dairy stock in a tropical climate holds significant practical relevance, particularly in optimizing dairy management and breeding strategies under environmental constraints. Key implications include adaptation and productivity enhancement, feed and nutritional optimization, reproductive performance and breeding strategies, climate-resilient farm management, economic sustainability and dairy industry development. By integrating environmental variables into dairy management and breeding strategies, this research contributes to more sustainable and profitable dairy farming, ensuring Jersey cattle remain productive under tropical conditions.

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CONFLICT OF INTEREST

The authors declared no potential conflicts of interest.

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