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Effect of parity on service per conception, gestation length, milk yield, calving interval, and calf birth weight of crossbred dairy cows

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Abstract: A dairy cow in a stable herd will typically have 3.4 lactation numbers, and many dairy farmers do not keep their dairy cows for extended lactation number past the sixth lactation. As a result, there is limited study on the influence of later lactation number or parity (6–10) on lactation traits. In order to determine the effect of lactation number of crossbred Holstein Friesian cows on their calving interval, calves weight, gestation length, lactation milk yield, and number of services per conception, this study was carried out. The record data at the dairy farm operated by Haramaya University was gathered and organized. A retrospective analysis was conducted on the number of services per conception, gestation length, lactation length, lactation milk yield, calving interval, and calf birth weight of dairy cows using records of 1863, 1742, 1280, 1280, 1329, 1170, and 848, respectively. The numbers of lactations per conception and gestation length were not impacted by lactation number, but it did have a significant impact on the total lactation milk yield, lactation length, calving interval, and calf birth weight. According to the findings of this study, crossbred Holstein Friesian cows could continue to produce milk up until their eighth lactation without experiencing a discernible drop in yield. As a result, lactation number ought to be considered a crucial trait in dairy cattle performance. To determine how lactation number affects other lactation traits like dry period, days open, and milk composition, more research needs to be done.
Keywords: Birth weight; calving interval; gestation; lactation; milk yield; parity.

1. Introduction

One of the most crucial elements for the long-term viability of dairy cattle breeding is milk yield. Breed, age, the length and number of lactations, the properties of the cow's udder and teat, management, and animal nutrition techniques all have an impact on milk yield (Koç, 2006). Understanding the variables that influence milk production is a fundamental component of dairy farm management (Novak et al., 2009). Many reports indicate either the importance of lactation number on milk yield per lactation (Şahin and Ulutaş, 2010) or the insignificance of lactation number (Koçak et al., 2007).

Many studies have established that milk yield increases with increasing lactation number and is maximized in the fourth or fifth lactation in the conventional milking method (Ray et al., 1992; Cilek, 2009). According to Afzal et al. (2007), the first lactation's yield was not different from the fifth, sixth, and seventh lactations' yield, but it did significantly less than the yields in the second, third, and fourth lactations. Rios-Utrera et al. (2013) reported that milk yield traits showed a significant increasing trend from the first to the fourth lactation. Additionally, according to Vijayakumar et al. (2017), the milk yield decreased in the fourth lactation and increased from the first to the third. On the other hand, milk yield in Holstein Friesian crosses increased up to third parity, according to Koc (2011). Epaphras et al. (2004) most likely reported a positive correlation between parity and milk production, but they also pointed out those cows in their fourth and subsequent lactations were no longer producing more milk than those in their third lactation. Conversely, Johnson et al. (2002) found that older cows produced more milk than younger ones. This was anticipated because higher parity cows have physiologically more developed udders than lower parity cows. However, Epaphras et al. (2004) noted that older cows produced less milk, and they explained this by pointing out that the turnover rate of secretory cells was higher in dying than in newly produced active secretory cells. Furthermore, McNamara et al. (2008) observed that the number of lactations increased milk production, and they assumed that this was because the mammary glands frequently removed the feedback inhibitor of lactation (FIL) from them, increased cell activity, decreased apoptosis in MEC, and increased MEC numbers.

Lactation length was also significantly impacted by lactation number or parity (Licitra et al., 1990). Nonetheless, a number of researchers found that the length of lactation varied insignificantly amongst parities (Koc, 2011). According to Hoka et al. (2019), there was a statistically non-significant increase in calf birth weights when parity or lactation number increased. Adeneye et al. (2009) did observe that calves born to Friesian dams with three or more parties weighed significantly more than those born to younger dams.

The aforementioned background explains why milk yield, calves' birth weight, and lactation duration have all been positively correlated with lactation number or parity. A stable herd of Holstein Friesian dairy cows would, however, typically have 3.4 lactation numbers, and many farms do not maintain dairy cows for longer lactation numbers later than 6th parity (Muller and De Waal, 2016). As a result, the later lactation number (6–10 parities) and its impact on the number of services per conception, gestation duration, milk production, lactation duration, calving interval, and calve weight have been limited. For this reason, the impact of lactation number on crossbred Holstein cows' number of services per conception, gestation length, milk yields, lactation length, calving interval, and calf birth weight was investigated in this study.

2. Materials and Methods

2.1. Description of study farm

The study was carried out at the main campus of Haramaya University, which is situated approximately 510 kilometers from Addis Ababa in the eastern region of the country in the Hararghe zone of the Oromia Regional State. The campus is located 5 km from the nearby town of Haramaya, which is accessible via the main road that links the eastern city of Harar and the capital, Addis Ababa. It is located at latitude 90 26' N and longitude 4203' E, at an elevation of about 2010 meters above sea level. The site's mean annual minimum and maximum temperatures are 8.25 and 23.4 0C, respectively. It receives 741.6 mm of annual rainfall on average (Ewonetu and Gemechu, 2019). Cattle on the farm were Holstein Friesian crosses (a crossbreed between Holstein Friesian and zebu). The animals were given unlimited access to maize silage and kept intensively within paddock. The cattle were fed a supplemented concentrate ration while being milked. Two times a day, at 12:00 am and 12:00 pm, milk was collected. The animals bred naturally using a pen mating system.

2.2. Study design and sampling

Based on the documentation kept at the dairy farm run by Haramaya University, a retrospective study was carried out. To evaluate the effects of lactation number or parity, record data on the number of services per conception (NSPC), gestation length (GL), lactation length (LL), lactation milk yield (LMY), calving interval (CI), and calf birth weight (CBW) were gathered and compiled. One (1) to ten (10) lactation or calving numbers with complete information were used in the study. For NSPC, GL, LL, LMY, CI, and CBW, a total of 1863, 1742, 1280, 1329, 1170, and 848 data were used, respectively. Table 1 displays the samples that were used to evaluate each parameter for each lactation number.

The sample size used to estimate each trait under each lactation number.

LN	NSPC	GL	LL	TMY	CI	CBW
1.	335	332	303	235	91	116
2.	294	294	258	224	291	90
3.	223	229	214	350	232	92
4.	184	163	140	111	171	65
5.	170	114	91	132	114	86
6.	166	117	77	37	65	124
7.	139	143	62	75	53	95
8.	122	119	68	72	64	90
9.	117	118	40	45	56	48
10.	113	113	27	48	33	42
Total n	1863	1742	1280	1329	1170	848

Table 1 – n=sample size; NSPC= number of service per conception, GL= gestation length, LN= Lactation number; LL=lactation length; LMY=Lactation milk yield; CI=Calving interval; CBW=Calf birth weight.

2.3. Data analysis

The recorded data were organized, summarized, and analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS version 9.4). The following model was used:

$$Y_{ij} = \mu + P_i + e_{ij}$$

Where:

Y_{ij} = dependent variables (NSPC, GL, LL, TMY, CI, CBW);
μ = overall mean;
P_i = effect of parity (Parity 1 to 10);
e_{ij} = random error

3. Results and discussions

3.1. Effect of lactation number on total milk yield

Effect of lactation number on NSPC, GL, TMY, LL, CI, and CBW (Least mean square).

LN	NSPC	GL(days)	TMY(litter)	LL(Days)	CI(Days)	CBW(kg)
1.	1.35^{a}	276.54^{a}	4426.0^{a}	350.13^{a}	396.44^{ab}	33.66^{d}
2.	1.36^{a}	277.69^{a}	4022.4^{ab}	336.58^{ab}	432.21^{a}	34.90^{c}
3.	1.30^{a}	286.76^{a}	4208.6^{ab}	324.45^{ab}	413.68^{ab}	36.34^{ab}
4.	1.37^{a}	277.79^{a}	4258.2^{ab}	325.29^{ab}	424.22^{a}	37.15^{a}
5.	1.39^{a}	276.57^{a}	4136.4^{ab}	308.14^{ab}	416.82^{a}	36.59^{ab}
6.	1.38^{a}	281.35^{a}	4202.5^{ab}	311.45^{ab}	426.35^{a}	36.75^{ab}
7.	1.36^{a}	276.72^{a}	3918.4^{b}	306.15^{ab}	398.92^{ab}	36.58^{ab}

8.	1.50^{a}	281.37^{a}	4365.0^{ab}	306.26^{ab}	443.06^{a}	35.67^{bc}
9.	1.57^{a}	276.50^{a}	2777.2^{c}	287.81^{b}	431.63^{a}	36.83^{ab}
10.	1.67^{a}	280.67^{a}	1590.2^{d}	158.67^{c}	367.67^{b}	36.67^{ab}
P-value	0.922	0.9476	<.0001	<.0001	0.0121	<.0001

Table 2 – LN=Lactation number, GL=Gestation length, TMY=Total lactation milk yield, LL=Lactation length, CI=Calving interval, CBW=calf birth weight.

The total lactation milk yield was significantly (P<0.0001) impacted by the number of lactations (Table 2). This is consistent with the findings of Rios-Utrera et al. (2013), who found that parity had a major impact on milk yield. In contrast, parity did not significantly affect lactation milk yield, according to Gadmade (1999). According to this study, there was a slight decrease in the overall lactation milk yield from the first to the seventh lactation number, but the trend was not statistically significant (Figure 1). The findings of Mohamed (2004), who showed that milk yield increased with advancing lactation up to 4th parity, are disagree with this result. Additionally, Ray et al. (1992) reported a significant increase in milk production with lactation number up to the third or fourth parity. The total milk yield of first lactation cows was significantly higher than that of cows in parity 7, 9, and 10. Similarly, compared to the second and third lactations, Madani et al. (2008) reported significantly more milk produced during the first lactation. Due to cow maturity and active mammary epithelial cells, lactation total milk yield did not differ (p>0.05) amongst dams of the second through eighth parities in the current study. This is in line with the findings of Afzal et al. (2007), who found no differences in milk production between the first, fifth, sixth, and seventh lactations. Conversely, Johnson et al. (2002) observed that older cows produced more milk than younger ones due to the physiological development of the udder in higher parity cows compared to lower parity cows. Furthermore, McNamara et al. (2008) observed that the number of lactations increased milk production, and they concluded that this was because of increased cell activity, decreased apoptosis in mammary epithelial cells (MEC), increased MEC numbers, and frequent removal of the feedback inhibitor of lactation from mammary glands. This disproved the findings of numerous researchers (Ray et al., 1992; Cilek, 2009; Muller and De Waal, 2016) who reported that the higher milk yield levels of older cows were not maintained beyond the 6th lactation in the conventional milking method. However, in this study, cows of the first lactation significantly produced higher milk per lactation than those in the later lactation (p<0.05) and this is associated with longer days in milk production or longer lactation length. It agrees with Shindarska et al. (2016), who found that the milk yield from the first lactation was highest. This consecutive decrease in milk yield implied that cows may not regain all lost body energy in the first lactation which recovered in the second. This carryover effect is consistent with the findings of Coffey et al. (2002).

The lactation milk yield result in Figure 1 demonstrated a sharp decline beginning at the end of lactation number 8, with cows in lactation numbers 9 and 10 significantly produced the lowest overall lactation milk yield. This was due to the shortest lactation length for cows in parity 9 and 10. According to the findings of this study, crossbred Holstein Friesian cows could be productive until the 8th lactation number without a significant decrease in the lactation milk yield.

Effect of lactation number on milk yield and number of services per conception.

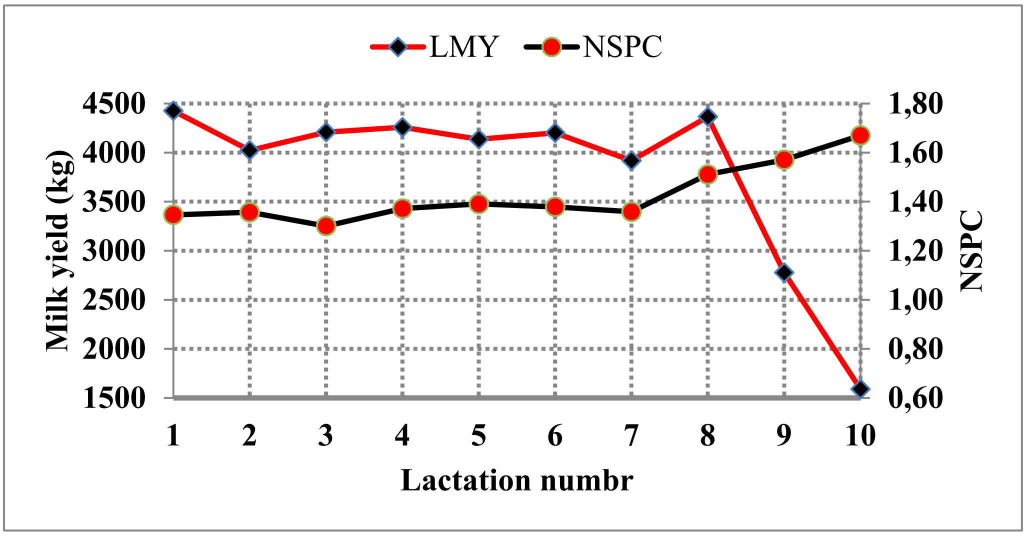

Figure 1 – Effect of lactation number on milk yield and number of services per conception

3.2. Number of Service per Conception (NSPC)

The lactation number had no effect on the number of services per conception (Table 2). This is in line with the findings of Ray et al. (1992), who found that lactation number had non-significant impact on NSPC. Conversely, past research has shown that lactation number has a significant effect on the NSPC (Motlagh et al., 2013; Khan et al., 2015). Despite the study's non-significant findings, the NSPC increased, with cows calving for the 10th number showing the highest NSPC (figure 1). In line with this, Motlagh et al. (2013) observed that NSPC increased as age increased. Besides, Ozcelik and Arpacık (2000) stated that NSPC increases as lactation number increases. The findings of Khan et al. (2015), who reported a decline in the quality of eggs ovulated with subsequent fertilization, which resulted in embryonic or fetal loss or uterine failure due to hormonal imbalance or deficiency that occur in advanced age, may be linked to this increase in NSPC or decline in fertility with advancing age or lactation number. According to Ata (2013), the NSPC of cows in lactation numbers one through nine was below the optimal NSPC of 1.65. This may suggest that crossbred Holstein Friesian cows are highly fertile up until their ninth lactation.

3.3. Effects of lactation number on lactation length

The length of lactation was significantly impacted by lactation number (Table 2). Likewise, Licitra et al. (1990) observed that lactation length was significantly influenced by the number or parity of lactations. On the other hand, a number of researchers found that parity had insignificant on the duration of lactation (Koc, 2011; Hoka et al., 2019). The milking duration of cows at parity 1 (LN1) was slightly longer than that of cows at later parities. Similarly, compared to advanced parities in Sahiwal cattle, primiparous cows had the longest lactation period, according to Bajwa et al. (2004). The length of lactation did not differ amongst cows in the second through eighth parities (P>0.05). The cows of first parity were significantly higher by their lactation length than the cows that calved for second or more parity. This might be because the cows are younger when they calve, which means they continue to grow more after calving. This necessitates additional open days for the cows to get back into heat, allowing the first-calving cows to continue milking for longer periods. Additionally, it might be linked to the anticipated advantages of prolonged lactations, such as fewer days dry during the cow's lifetime, lower costs per cow for mating and calving, improved animal health through decreased metabolic stress, exposure to fewer times of high risk, and longer lifespans (Borman et al., 2004). According to this discovery, lactation length decreased as the number of lactations increased (figure 2). Accordingly, Hossein-Zadeh (2012) observed that Holstein cows' lactation duration decreased from the first to the third parity. Conversely, Kefena et al. (2011) found that in Ethiopian dairy cows, lactation length grew from the first parity to the fourth parity. The shortest periods of lactation was noted in cows that calved for the 9th and 10th parity . This could be due to the older age of the cows. Therefore, this study revealed that crossbred cows calved more than eight times significantly lasted short days in milking which is lower than the recommended lactation length (305 days) for Holstein cows.

Effect of lactation number on lactation length, calving interval, and calf birth weight.

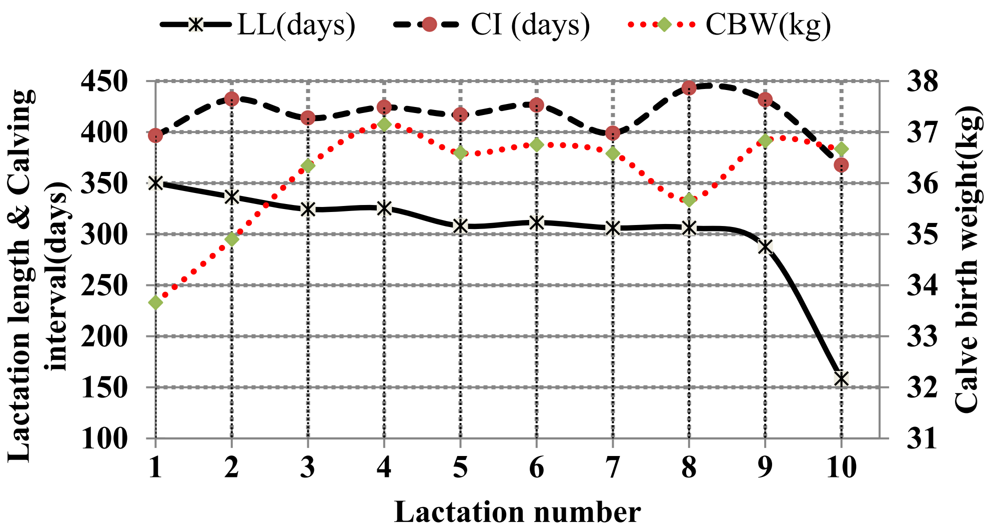

Figure 2 – Effect of lactation number on lactation length, calving interval, and calf birth weight.

3.4. Effects of lactation number on calving interval

According to Table 2, the lactation number had a significant impact on the calving interval. This is consistent with the findings of Goshu et al. (2007), who reported that the calving interval was impacted by the parity number. The shortest days of calving interval noted in the 9th and 10th lactation number is associated with shorter days of lactation length (Table 2). This result deviates from that of Ray et al. (1992), who found that cows in lactations 2 through 5 had a shorter calving interval (CI) than cows in lactations one. On the contrary, Goshu et al. (2007) reported longer CI for the first parity cows than the cows in the later parity due to the practice of selective culling against slow breeders in later parities and the additional nutritional requirements of cows in early lactation life for growth. Furthermore, to achieve maximum production, Meadows et al. (2005) recommended a calving interval of 12 months for multiparous cows and 13 months for primiparous cows. Moreover, Akinokun (1982) noted a progressive decrease in the length of the calving interval as the number of calves produced increased. The calving interval was more persistent from the 2nd through the 7th lactation number (figure 2). This could be related to the vigorous productive age of the cows which indicates that physiological maturity was attained after the 1st lactation and aged after the 7th. A cow in lactation 10 had the shortest days of calving interval and this could be due to their lowest milk production the cows lasted in lactation for the shortest days (DIM). Generally, this study found 367.67 to 443.06 days or 12.26 to 14.77 months of CI (Table 2) which is almost close to the general consensus that the CI should not be less than 420 days or 14 months (Abdel Rahman and Alemam, 2008).

3.5. Effects of lactation number on calf birth weight

The lactation number had a significant impact on the calf's birth weight (Table 2). Similarly, Yakubu et al. (2014) observed that calf parity number or lactation number had a significant impact on calf birth weight. But according to Hoka et al. (2019), the number of lactation had non-significant effect on the birth weight of the calf. Cows in the first parity had the lowest recorded calf birth weight, whereas cows in the fourth lactation had the highest recorded calf birth weight (figure 2). This is consistent with the findings of Adeneye et al. (2009), who noted significantly heavier calves of Friesian dams with three or more parties at birth than calves of younger dams.

The birth weight of the calf increased, reached a peak at the fourth lactation number, and then decreased (figure 2). This revealed that cows reach full physiological maturity at the fourth lactation number. Similarly, Hoka et al. (2019) observed that higher parity or lactation number was associated with higher calf birth weights, with the highest calf weight being delivered to cows at the fourth parity. Yakubu et al. (2014) also reported that the first lactation number had the lowest calf birth weight, while the fourth lactation number had the highest calf birth weight. In addition, older cows were noted to give birth to calves with higher birth weights than younger cows (Hickson et al., 2015). This discrepancy most likely results from younger cows having a lower live weight than older cows.

3.6. Effects of lactation number on gestation length (GL)

Table 2 indicates that the effect of lactation number (LN) on gestation was statistically insignificant (P>0.05). This result agrees with the findings of Messine et al. (2007). In contrast to this discovery, the significant effect of parity or LN on GL was reported by earlier studies (Milun et al., 2010; Hoka *et al.*, 2019). While there was no discernible difference in the length of gestation based on lactation number or parity, cows in the third and ninth parities had the longest and shortest GLs. Parity or lactation number had no significant effect on gestation length. However, the longest and shortest GL was recorded for cows in the third and ninth parity, respectively. Norman et al. (2009) reported that GL was shorter in first parity or younger ages and longer in older cows.

The GL fluctuated from parity to parity between 276.50 and 286.76 days (figure 3). This result was lower than the GL distribution range (285-294 days) reported for Bosindicus breeds by Obese et al. (1999) and somewhat higher than the range of optimal gestation length (275-277) reported by Nogalski et al. (2012). Genetic and non-genetic factors, including the breed and genetic makeup of individual cows, parity, age, calf sex, season of calving, temperature, and the cow's diet during pregnancy, may contribute to variation in gestation length. Milun et al. (2010) observed that breed, calf sex, birth type, age, and diet of the pregnant cow can all affect the length of gestation. However, a shorter gestation period was noted by Wright et al. (2014) as a result of rising temperatures. Furthermore, Tomasek et al. (2017) pointed out that a more significant factor influencing gestation length is the season of calving.

Effect of lactation number on gestation length and calf sex ratio.

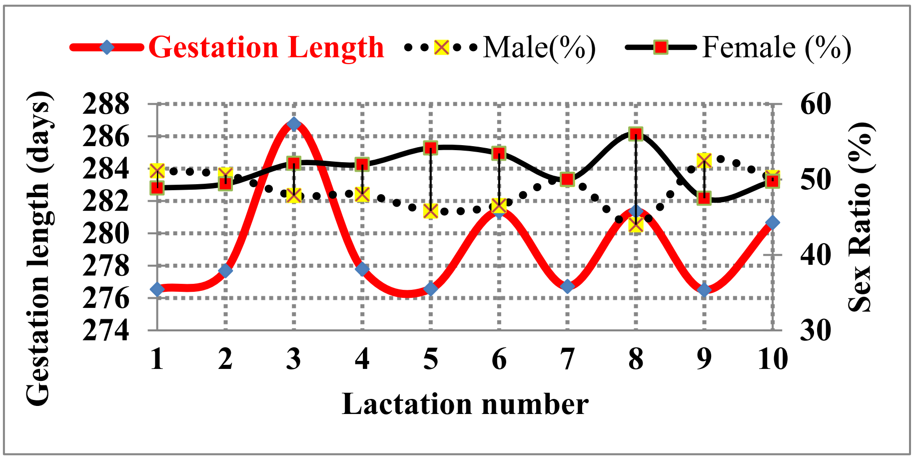

Figure 3 – Effect of lactation number on gestation length and calf sex ratio.

4. Conclusion

The number of services per conception and gestation length were unaffected by the cow parity, but it had a significant impact on the lactation milk yield, length, calving interval, and calf birth weight. From parity to parity, the gestation length varied between 276.50 and 286.76 days. The calf's birth weight increased, peaked at the fourth lactation, and then began to decline.

According to the findings of this study, crossbred Holstein Friesian cows could continue to produce milk until their eighth lactation without experiencing a significant decline in fertility or lactation milk yield. As a result, cow parity ought to be considered a crucial trait in dairy cattle performance. To assess the impact of cow parity on other lactation trait, such as milk composition, further research needs to be done.

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