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IMPORTANCE OF RELATIONSHIP BETWEEN FERTILITY AND LACTATION FOR SUSTAINABILITY OF DAIRY FARMING

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Abstract

Data from 192 dairy cows with the mean lactation number of 2.51 (1 to 10) were subjected to descriptive statistics to evaluate lactation and fertility parameters. The mean days in milk (DIM, lactation stage) was 170 for lactating cows (N=172), excluding dry cows (N=20, 10.42%). Cows were housed in early fresh (N = 21, DIM = 20), late fresh (N = 17, DIM = 48), peak (N = 50, DIM = 107), mid lactation (N = 44, DIM = 246), and late lactation (N = 40, DIM = 294) paddocks. Dry cows were housed in far-off (N = 13) and close-up (N = 7) paddocks. The average milk yield was 33.18 L/head/day. The percentage pregnant and inseminated cows were 46.97 and 26.77%. Herd program required to synchronize cows within 70 days postpartum. Avoiding hypocalcemia and ketosis during early postpartum, while strictly providing comfort, cows were expected to achieve pregnancy at peak milk production paddocks. In conclusion, achieving greater than 50% pregnant cows within 180-200 DIM ascertains sustainability of dairy farming.

Key words: *fertility, lactation, sustainability, days in milk, pregnant cow percentage.*

INTRODUCTION

Milk and meat are two of the indispensable foods for mankind. As global warming and drought become major issues, ruminant farming faces limitation challenges. Strategies are setup to perform environmentally friendly practices while maximizing productivity (Wang et al., 2025). The sustainability of dairy farming relies on lactation-fertility synchronization within economically reasonable calving intervals.

With improvements in genomic selection, health, nutrition, and mechanization as well as data management, lactation and fertility considering longevity are prominent parameters. Briefly, calving interval of < 14 months, daily milk yield average of > 40 L, and longevity of > 2.7 are targeted in breeders and age at first calving < 22 months in replacement heifers (Hayirli and Colak, 2011). Peripartum period nutrition pacing with endocrinal adaptation is key point to achieve maximal lactation and efficient fertility, as reflected by rapid increase in milk production and uterine involution. Dry period management and nutrition are often neglected. In opposite, it is an investment period for subsequent lactation and fertility.

Rapid growth of fetus and production of colostrum as well as neurohormonal changes take place, particularly, during the close-up period (Overton & Waldron, 2004). Switching from high roughage-based diets fed during late prepartum to high concentrate-based diet fed during early postpartum is critical for ruminal health, thereby for dramatic increase in milk yield and for accelerated uterine involution.

The objective of this study was to evaluate the relationship between fertility and lactation parameters, which is crucial for sustainability of dairy farms.

MATERIALS AND METHODS

Lactation and fertility data were obtained from 192 (20 dry-10.42% and 172-89.58% lactating) Holstein cows with an average of parity of 2.51 (1 to 10). Cows were housed in 2 row-free stall barns at different paddocks according to DIM

and lactation status for easing reproduction and nutrition management (Table 1). Of 20 dry cows, 13 were far-off dry and 7 were close-up dry. There were 5 paddocks for lactating cows: fresh group, cyclic group, peak lactation group, mid-lactation group, and late-lactation group.

All cows were fed to meet nutrient requirements for dairy cows (NASEM, 2021). On a dry matter basis, ration for lactating cows contained 1.87% straw, 11.65% alfalfa hay, 4.32% barley silage, 29.87% corn silage, 24.16% protein concentrate (RasyoLife, Mugla Türkiye), 23.12% corn flake, 3.12% premix of vitamins, minerals, buffering agents, yeast-sodium bicarbonate-magnesium oxide, toxin binder, salt, limestone, and dicalcium phosphate (RasyoLife) [roughage:concentrate (R:C), 47.68:52.32; crude protein (CP), 16.73%; neutral detergent fiber (NDF), 32.56%; starch, 25.62%, ether extract (EE), 5.23%; and ash, 8.31%].

On a dry matter basis, ration for dry cows contained 21.95% straw, 15.21% alfalfa hay, 30.46% corn silage, 19.52% protein concentrate (RasyoLife, Mugla Türkiye), 11.68% corn flake, 1.19% premix of vitamins, minerals, buffering agents, yeast-sodium bicarbonate-magnesium oxide, toxin binder, salt, limestone, and dicalcium phosphate (RasyoLife) [R:C, 67.61:32.39; CP, 14,10%; NDF, 44.37%; starch, 18.28%, EE, 2.88%; and ash, 7.43%). Close-up cow ration was added with 250 g/h/d anionic salt to avoid hypocalcemia and its consequences.

Farm was equipped with herringbone milking parlor (HB50 with DelProTM, DeLaval, Sweden). Cows were milked thrice daily. After 45-d voluntary waiting period cows were subjected to reproductive synchronization protocol depending on their ovarian status.

A commercial statistics software was used in data analyses (MedCalc Software Version 9.6.2.0, Mariakerke, Belgium). Data (parity, paddock, days in milk, milk yield, and fertility status) from breeders (N = 192) as well as data (age in month and fertility status from replacement heifers (N = 228) were harvested from dairy management system. After sorting by the paddocks and parity, data were subjected to the descriptive statistics for determination of mean and variation and Q-Q plotting for determining concordance correlation between days in milk and fertility status. The effect of paddock (stage of lactation) and parity on response variables (days in milk, milk yield, and days in pregnancy) were established using one-way ANOVA. Differences among paddocks and parities were attained using the LSD option.

RESULTS AND DISCUSSIONS

The mean for DIM and milk yield was 170 and 33.18 L for lactating cow (N = 172), respectively.

In dairy herd, percentages of lactating and dry cows are 84 and 16%. In this herd lower percentage of dry cows (10.42%) is related to voluntarily skipped insemination in cyclic periods occurring during summer due to heat stress. In early summer, dry cow percentage can be as high as 35%. As can be seen in Table 1, cows reached peak production (37.9 L) by DIM 107 and remained in paddock 3 until DIM 246.

Group 1 constitutes early postpartum cows, Groups 2 and 3 constitute peak period cows. Breeding started by DIM 45 if there was natural estrus, otherwise cows were subjected to synchronization. Establishment of the peak period grouping is mostly based on parity pace with social hierarchy.

Group 4 includes mid lactating cows. Their milk yield was considerably lower than Group 3. One can notice a dilemma that persistency of lactation was sharp (46.81 ml/day).

The number of fresh, pregnant, inseminated, open, and to be culled were 48 (25.00%), 87 (45.31%), 53 (27.60%), 2 (1.04%), and 2 (1.04%), respectively. Overall pregnant cow and inseminated cow percentages were 45.31 and 27.60% (Table 1; Figure 1). Considering 40% of insemination efficiency, pregnant cow percentage reach 56.35% with an insemination efficiency of 2.53. This indicates that this farm is about 7 L milk per cow and 3.65% pregnancy below the target level. However, data obtained at the end of September 2025, after 4 months of extreme summer condition. Likewise milk yield, in general, increases in early winter. The agreement between stage of lactation and fertility status, considering either cows pregnant-inseminated or open-fresh was r = 0.89 (Figure 1).

Table 1. Lactation and fertility characteristics of paddocks[1]

	Lactation Status			Cow Distribution by Fertility Status				
Group	N	DIM	Milk, L	F	P	I	O	C
1	21	20±3^{e}	33.0±1.6^{b}	21	0	0	0	0
2	17	48±9^{d}	28.6±1.8^{c}	15	0	2	0	0
3	50	107±8^{c}	37.9±1.1^{a}	12	4	34	1	0
4	44	246±18^{b}	31.3±0.9^{bc}	0	29	14	1	0
5	40	294±23^{a}	31.4±1.2^{b}	0	34	3	0	2
6	13	355±30^{a}	-	0	13	0	0	0
7	7	303±19^{a}	-	0	7	0	0	0

[1]Data are mean±SEM and N. DIM = days in milk; F = fresh, P = pregnant; I = inseminated; O = open; C = to be culled. Different superscripts within the same columns differ (P<0.05).

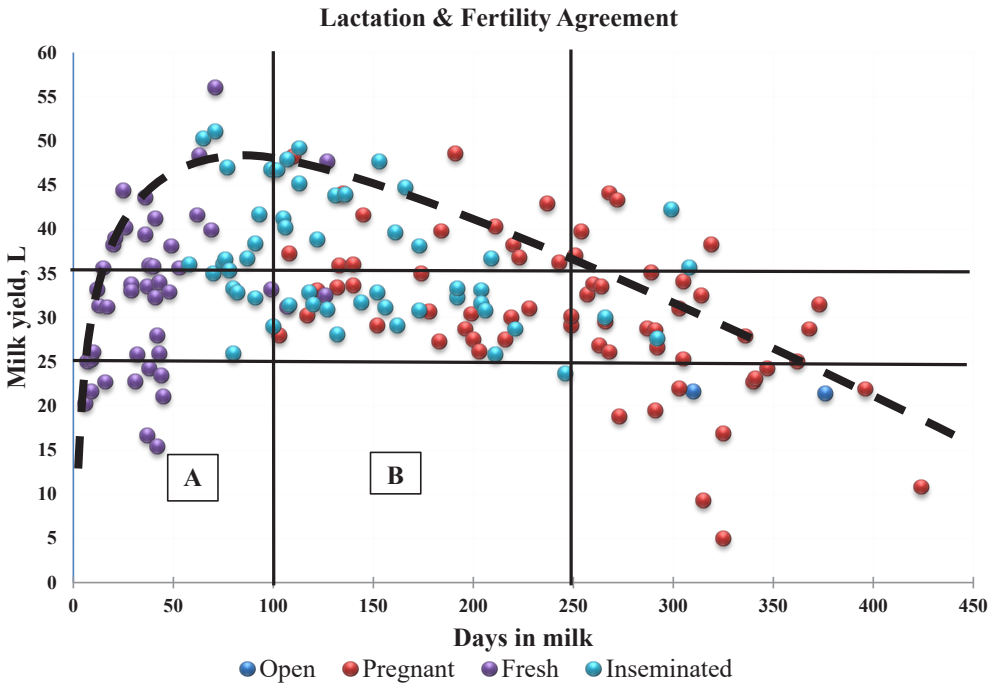

Figure 1. Distribution of cows according to milk yield and fertility status. Concordance correlation value was 0.89

Expectedly milk production continuously increased as the parity advanced up to 5th lactation and then decreased (Table 2).

Parity distribution provides information about longevity and/or culling rate of the breeder cows. 95.84% of the cows were up to 4th lactation (Table 2). This ratio may change depending upon selection for higher productivity accompanied by application of sex-semen. Longevity may be considered an indication of health and productivity. The mean parity was 2.51.

Figure 1 shows all cows based on their lactation performance and fertility status. One can establish upper and lower standard level (horizontal lines on y-axis) in milk yield that is economically feasible. This illustration ease visualization of ill and/or low producing cows considering DIM (Region A and B). One also can establish upper and lower standard level (vertical lines on x- axis) in fertility status that is approximate calving interval, consequently feed cost on milk yield as well as herd size. All cows must be inseminated at least once by DIM 100. Cows are still not pregnant after DIM of 250 have prolonged calving interval.

Table 2. Lactation and fertility characteristics of paddocks[1]

	Lactation Status				Pregnant Cow Distribution		
Parity	N	%	DIM	Milk, L	P, N	P, %	DIP
1	54	28.13	187±19	29.92±0.8[b]	23	26.44	101±11[b]
2	46	23.96	155±24	34.45±1.2[a]	16	18.39	65±11[c]
3	53	27.60	208±18	34.64±1.2[a]	37	42.53	147±11[a]
4	31	16.15	104±24	35.91±1.4[a]	7	8.05	43±11[c]
5	4	2.08	215±60	31.03±4.2[ab]	2	2.30	134±52[a]
7	2	1.04	120±91	29.75±4.0[ab]	0	0	0
8	1	0.52	206±na	31.12±na	1	1.15	177±na
10	1	0.52	341±na	23.10±na	1	1.15	208±na

[1]Data are mean±SEM, N, %. DIM = days in milk; P = pregnant cow as a count and a percentage; DIP = days in pregnancy, a mean number of inseminations for pregnancy was 2.53. Different superscripts within the same columns differ (P<0.05).

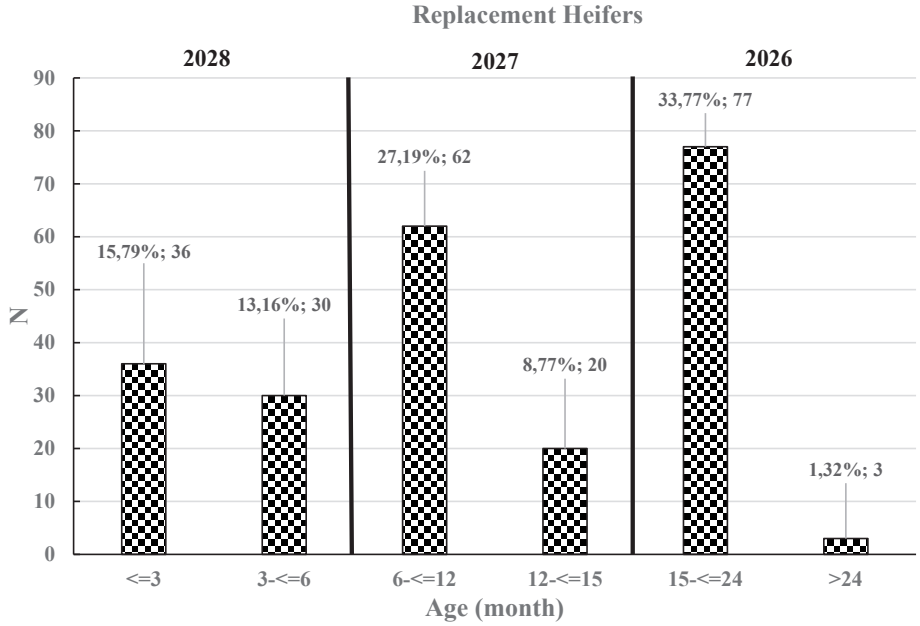

Figure 2. Age distribution of replacement heifers

Under normal conditions, herd complete capacity through replacement heifers (Figure 2). Thus, survival, growth and development of heifer calves are critical in addition to the breeder longevity. Based on culling rate of breeders, one either can expand herd size or sell heifers. Therefore, reproduction in heifers is as important as breeders (Table 3). If conventional sperm is used for insemination, while reaching first calving at age of 24 months, mother would have two lactations. Namely, one lactation yield is about to afford the cost of replacement heifer to make a cow. Therefore, parity average of equal to or greater than three is highly profitable and sustainable. Replacement heifers older than 15 months and 6 months and those aged up to 6 months are potential replacement of current year and following two years.

Achieving fertility parameters (Table 3) along with high lactation yield is directly related to nutrition management (Table 4). As compared to suggestions of National Research Council (NRC, 2001) of nutrient requirements for dairy cows, NASEM (2021) suggest single ration type of recommendation as reflected by elimination of time "t" variable from dry matter intake (DMI) equation. Cows are still grouped based on stage of lactation, lactation yield, or reproductive status in practice.

Table 3. Targets in reproductive parameters (adopted from Hayirli et al., 2011)

Parameter		Value
Age at the first estrus (month)		< 12
Age at the first insemination (month)		13-14
Age at the first calving (month)		24
Weight at the first insemination and after first calving (kg)		380-540
Onset of the first cyclist postpartum (day)		<40
Estrus detection rate (%)		85
Voluntary waiting period (day)		45-75
Conception rate at the first service (%)		35-50
Insemination per pregnancy		< 2.7
Estrus rate within two months postpartum (%)		> 90
Percentage of cows to be pregnant upon > 2 insemination (%)		< 20
Days open		85-110
Percentage of cows with days open >120 (%)		< 15
Calving interval (month)		13-14
Culled cows due to infertility (%)		< 10
Aborts (%)		< 4
Retained placenta (%)		< 8
Uterine infections and cystic ovary (%)		< 10

The grouping of cows is important to keep up with process that should be enforced and affirmed (Table 5). As can be seen in both Figure 1 and Table 5, primary focus should be on maintaining normocalcemia and normoketonemia. These are two major factors endogenously affecting feed intake. Normocalcemic cows are also less likely to have retained placenta and displaced abomasum. Cows consuming dry matter more than 3% of body weight are less likely to experience ketosis while having increased milk production. Metabolic profiling test is essential to maintain health and/or effective treatment for metabolic disorders and reproductive disorders (Emmam et al., 2024; Hayirli et al., 2016). Obese cows and undernourished cows are prone to ketosis and abomasum displacement and have suppressed immunity (Hayirli et al., 2012). Thus, they cannot reach lactation peak and experience silent estrus and frequent embryonic loss.

The periparturient period management, health, and nutrition have been focus of numerous research and review articles. A comprehensive analysis of factors affecting sustainability of dairy farms is well documented in serial studies by Kerwin et al (2021a; 2021b; 2023). Strong management of peripartum period management and nutrition (Bruinje and LeBlanc, 2025; Mezzetti et al., 2021) is the key factor for maximizing milk production and fertility success (Cook et al., 2024; Leroy and Kruif, 2006; Lucy, 2003; Opsomer, 2006). In addition to provision welfare, eliminating incidence of hypocalcemia (Goff, 2006) and ketosis (Kerwin et al., 2021a) allow cows to reflect their genetic capacity.

CONCLUSIONS

Milking cows with higher longevity produces about 40 L/d milk and calves before 14 months are economically profitable. Thus, pregnant cow ratio should be above 60%.

As lactation yield increases reproduction regresses is not correct phenomenon. If high producing cows fail in reproduction metabolic profile testing is necessary and nutrition should be reevaluated.

Undernourished cows would fail in lactation yield. It may result in excess culling rate (>30%).

Sustainability of dairy herds rely on reproductive efficiency while receiving maximal milk yield. This is the result of successful peripartum period management and nutrition protocols.

Table 4. Suggested nutritive values of rations offered by stages of lactation (adopted from Hayirli et al., 2011)

Parameter[1]	Far-off Dry	Close-up Dry*	Fresh**	Peak	Mid Lact.	Late Lact.
BW, kg	650	680	600	580	610	640
DMI, % BW	2.1	1.8	3.00	3.90	3.80	3.70
F:C***	80:20	70:30	50:50	45:55	55:45	60:40
NE_L, Mcal/kg	1.39	1.52	1.72	1.80	1.75	1.65
CP, %	12	13	18	17	16	15
RDP, %CP	70	60	55	60	55	55
EE, %	2	3	4	5.5	5	4
ADF, %	30	24	21	19	23	25
NDF, %	40	35	30	28	32	35
NSC, %	30	34	35	38	36	34
Ca, %	0.60	0.70	1.00	0.90	0.85	0.80
P, %	0.26	0.30	045	0.40	0.38	0.36
Mg, %	0.16	0.30	0.33	0.30	0.28	0.26
K, %	0.65	0.65	1.00	1.00	0.90	0.90
Na, %	0.10	0.05	0.33	0.30	0.28	0.26
Cl, %	0.15	0.70	0.30	0.25	0.24	0.23
S, %	0.16	0.40	0.25	0.25	0.25	0.25
Fe, mg/kg	150	150	150	150	150	150
Co, mg/kg	0.10	0.10	0.10	0.10	0.10	0.10
Mn, mg/kg	60	60	60	60	60	30
Cu, mg/kg	15	15	15	15	15	15
Zn, mg/kg	60	60	60	60	60	30
I, mg/kg	0.60	0.60	0.60	0.60	0.60	0.60
Se, mg/kg	0.30	0.35	0.35	0.35	0.30	0.30
Vitamin A, IU/d	100.000	125.000	125.000	125.000	100.000	100.000
Vitamin D, IU/d	25.000	30.000	30.000	30.000	25.000	25.000
Vitamin E, IU/d	1.000	2.000	2.000	2.000	1.000	800

[1]BW =body weight; DMI = dry matter intake; F:C = forage:concentrate; NEL = net energy for lactation; CP = crude protein; RDP = ruminally degradable protein; EE = ether extract; ADF = acid detergent fiber; NDF = neutral detergent fiber; NSC = non-structural carbohydrate.
*Anionic salt feeding. Antioxidant and vitamin-mineral premixes.
**Lipogenic agents and glucogenic precursors as well as ruminally protected amino acids. Antioxidant and vitamin-mineral premixes.
***Values vary by roughage quality and fecal consistency (+/-5-10%).

Table 5. Summary of expectations in cows during the lactation period

Stage	Days in Lactation	Expectation
Parturition	1-7	Placental membranes are removed, no vaginal bleeding and udder edema, normocalcemic with good appetite
First 3 weeks	8-21	No mastitis, normal locomotion and vaginal discharge, DMI >3% of BW, ketone z < 1.2 mmol, calcium >9.0 mg/dL, sharp increase in milk with good appetite
Early postpartum	22-60	Completed uterine involution, spontaneous estrus, synchronized for cyclicity, body condition score (BCS) loss < 0.5, DMI >3.5% of BW with reaching peak yield
Peak Period	61-200	DMI >3.8% of BW, reached peak yield, cows are either inseminated or >50% pregnant, maintaining BCS >2.75
Mid Lactation	201-300	DMI >3.8%, gradual decline in milk yield, pregnant cows >70%, gaining condition
Late Lactation	301- till dry (~360)	DMI >3.8%, gradual decline milk yield (40% of peak yield), pregnant cows >90%, gaining condition
Far-off Dry	First 40 d	Reached ideal BCS (~3.25), DMI about 2.2% of BW, nonmastitic, normal locomotion, all pregnant
Close-up Dry	Last 21 d	BCS (~3.50), DMI >1.5%, nonmastitic, normal condition, onset of mammogenesis, all pregnant

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