



Reproductive Disorders and Subsequent Fertility in Primiparous and Multiparous Holstein–Friesian Cows

H. A. Syah^{1,2}, T. Susilawati², M. Rifa'i³, A. P. A. Yekti², N. Isnaini², Mashudi⁴, T. E. Susilorini⁵, Suyadi², P. Utami², & A. D. Pramudhita²

¹ Doctoral Student, Department of Animal Reproduction and Breeding, Faculty of Animal Science, Universitas Brawijaya, Malang 65145, East Java, Indonesia

² Department of Animal Reproduction and Breeding, Faculty of Animal Science, Universitas Brawijaya, Malang 65145, East Java, Indonesia

³ Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, Malang 65145, East Java, Indonesia

⁴ Department of Feed and Animal Nutrition, Faculty of Animal Science, Universitas Brawijaya, Malang 65145, East Java, Indonesia

⁵ Department of Animal Production, Faculty of Animal Science, Universitas Brawijaya, Malang 65145, East Java, Indonesia

*Corresponding author: tsusilawati@ub.ac.id

(Received 15-09-2025; Revised 19-12-2025; Accepted 22-12-2025)

ABSTRACT

Reproductive disorders, including abortion, retained placenta, and dystocia, are significant challenges in dairy cows which can negatively affect reproductive efficiency, particularly in tropical smallholder farming systems. Therefore, this study aimed to evaluate the effects of abortion, retained placenta, and dystocia on subsequent reproductive performance in Holstein-Friesian cows and compare the effects between primiparous and multiparous animals raised under smallholder conditions. Data were collected from 415 cows, namely 40 healthy primiparous, 68 healthy multiparous, 18 primiparous and 32 multiparous with abortion, 47 primiparous and 67 multiparous with dystocia, and 71 primiparous and 72 multiparous with retained placenta. Reproductive parameters included first service conception rate (FSCR), pregnancy rate (PR), overall pregnancy rate (OPR), services per conception (S/C), days to first service (DFS), and open days (DO). Two-way binary logistic regression was applied to categorical variables, and analysis of variance (ANOVA) in a General Linear Model (GLM) was used for continuous variables. Kaplan–Meier survival analysis was performed to compare DFS and DO among disorder groups. Cows with reproductive disorders showed numerically lower FSCR, PR, and OPR, as well as higher S/C, compared with healthy counterparts, and these differences were not statistically significant ($p > 0.05$). Kaplan–Meier analysis detected shorter mean DFS and DO among affected cows despite the reduced hazard for pregnancy. Although the effects were not statistically significant, the numerical patterns suggested potential biological relevance. The results showed the importance of effective postpartum management to maintain optimal reproductive performance in smallholder dairy systems.

Keywords: *abortus; dairy cows; dystocia; fertility; retained placenta*

INTRODUCTION

Reproductive health is a key determinant of profitability in dairy production due to directly influencing insemination frequency and veterinary costs. Reduced fertility often demands repeated inseminations, which increase reproductive expenses and the potential of early culling in cows that fail to conceive (Han *et al.*, 2024; Tadesse *et al.*, 2022). Reproductive failure has significant financial consequences, as the loss of pregnancy in dairy cows results in costs between US\$90 and US\$1900, depending on the gestational stage at which the pregnancy is terminated (Cabrera, 2014; De Vries, 2006). This

occurs because problems that happen before mating may harm oocyte fertilization and impair subsequent development to the morula stage (Ribeiro *et al.*, 2016). Nevertheless, cows that have successfully conceived remain vulnerable to reproductive disorders that may compromise post-conception performance. Among reproductive disorders, abortion, retained placenta, and dystocia are particularly important due to their prevalence and economic impact. Abortion is defined as fetal death occurring between 42 and 260 days of gestation (Peter, 2000). This death occurrence frequently exerts negative impacts on post-abortion reproductive efficiency, including prolonged days open (DO) and an increased number of artificial inseminations (AI)

required for conception (Mahnani *et al.*, 2021; Vindas-van der Wielen *et al.*, 2025), as well as a higher tendency of premature culling (Wathes *et al.*, 2020). Furthermore, each abortion in dairy cows is thought to cost between US\$868 and US\$1,866 in lost income. The magnitude of these losses varies according to the gestational stage and the age of the cow at the time of abortion, with the most considerable losses noted in late-term abortions of primiparous heifers experiencing their first pregnancy (Carrillo Parraguez *et al.*, 2025).

Retained placenta is defined as the persistence of all or part of the fetal membranes beyond 12 hours postpartum (Dervishi & Ametaj, 2017; Yazlık *et al.*, 2019). Mahnani *et al.* (2021) reported that retained placenta adversely affected dairy cow production and reproduction, resulting in milk yield losses of 282–295 kg per lactation, extended DO by 8–20, and economic losses ranging from US\$ 350.4 to 481.2 per case. Dystocia is a reproductive disorder that causes difficulty for cows to give birth (Hossein-Zadeh, 2016). Kim *et al.* (2016) found that dystocia in Friesian cows negatively affected performance by lengthening the service period, DO, and calving interval, reducing the conception rate, and raising the number of services per conception. Each case of dystocia is estimated to initiate economic losses ranging between US\$116.26 and US\$465.04, depending on the severity of the calving problem (McGuirk *et al.*, 2007). Furthermore, the incidence of these disorders has been associated with ovarian recovery and diminished reproductive effectiveness in the ensuing breeding season.

A delayed return to ovarian activity following calving is a significant concern for prompt insemination after the voluntary waiting period in dairy cows (Chebel *et al.*, 2025). Decreased ovarian function hinders estrus detection, prolongs the interval to initial insemination, and lowers conception rates (Bruinje *et al.*, 2023). In addition to reproductive disorders that may occur during parturition, health interventions applied at calving have been associated with delayed postpartum ovulation (Carbonari *et al.*, 2024; Pinedo *et al.*, 2020).

Parity influences reproductive performance after calving, and this influence is associated with the occurrence of reproductive disorders. However, most existing reports on parity and reproductive disorders are limited to prevalence-based observations. Previous studies have shown an increased risk of abortion and dystocia among primiparous cows, compared to multiparous cows (De Amicis *et al.*, 2018; Hohnholz *et al.*, 2019; Yaqoob *et al.*, 2016), while retained placenta cases were more prevalent in multiparous cows (Bonneville-Hébert *et al.*, 2011; Kamel *et al.*, 2022). The impact of the disorders on future reproductive performance remains insufficiently explored, particularly with respect to the role of parity. Therefore, this study aimed to assess the effects of abortion, retained placenta, and dystocia on subsequent reproductive performance in Holstein-Friesian cows, and compare the effects between primiparous and multiparous groups. Extra focus was given to examining how parity and reproductive disorders interacted to influence fertility results, with the intention to

strengthen more targeted management practices in dairy production systems.

MATERIALS AND METHODS

Data and Herds

Records from 415 intensively managed Holstein-Friesian cows reared on smallholder farms located in the tropical climates of Malang, East Java, Indonesia, were collected for data analysis. There were 108 healthy cows (n primiparous= 40, n multiparous= 68) as the control group and 307 with reproductive disorders, including abortion (n primiparous= 18, n multiparous= 32), dystocia (n primiparous= 47, n multiparous= 67), and retained placenta (n primiparous= 71, n multiparous= 73). The animals were additionally categorized into two parity classifications, namely primiparous and multiparous.

This retrospective observational study utilized reproductive and health records collected between 2020 and 2021 from smallholder dairy farms under a single cooperative. Data were obtained from farm records of cows diagnosed with reproductive disorders and their equivalent control animals under the same management system. The study area lies at an elevation of approximately 623–797 m above sea level and is characterized by a tropical climate. Average daily temperatures typically range from 22 to 25 °C, although midday values can rise to around 38 °C, while relative humidity varies between 67% and 94%. All farms selected had complete records regarding AI, rectal palpation, and disorder management. Pregnancy diagnosis was performed by veterinary staff using rectal palpation between 60 and 90 days after insemination.

Data were processed and edited using Microsoft Excel software, and this study only included cows that met the following criteria: (1) Experience of reproductive disorders between January 2020 and December 2021, (2) administration of AI after the occurrence of reproductive disorders, and (3) absence of any other reproductive disorders during the observation period. The dataset did not include cows with multiple reproductive disorders during the observation period.

Reproductive Management

AI at the study sites was performed following reports from farmers regarding cows in the estrus stage. Farmers identified and reported estrus symptoms to local field officers when cows showed behavioral and physiological signs of heat. AI was carried out during normal business hours (8:00 a.m. to 4:00 p.m.) with frozen sperm from genetically tested Holstein-Friesian bulls bought from the Singosari Artificial Insemination Center (AIC). All of the inseminators who did the insemination operations were certified and skilled.

Inseminators monitored a digital reporting system that kept track of each insemination service, and the record of each cow also contained a record of the service. On the 60th day after AI, the pregnancies of cows that did not show signs of estrus were checked by inseminators using rectal palpation.

In cases of reproductive disorders, farmers notified local officers, who subsequently visited the farms to conduct clinical examinations, establish diagnoses, and provide appropriate treatments. Abortion is typically characterized as fetal demise happening between 42 and 260 days of gestation (Peter, 2000). In this study, cows were categorized under abortion cases when fetal loss transpired after the confirmation of pregnancy (60 days post-AI). Dystocia in dairy cows, marked by challenging or extended labor, arises from a confluence of direct (maternal and fetal) and indirect variables (Hosseini-Zadeh, 2016). Observed cases of dystocia were ascribed to maternal factors, including insufficient cervical dilatation, fetal macrosomia, or atypical fetal positioning. Cows with abortion or dystocia were given antibiotics to stop uterine infections, as well as multivitamins and painkillers to promote health improvement.

Retained placenta was characterized as the failure to discharge all or a portion of the fetal membranes within 12 hours post-calving (Yazlık *et al.*, 2019). Colibact boluses and antibiotics were administered to cows with retained placenta for three days in a row.

Definition of Variables

First service conception rate (FSCR). FSCR is the percentage of cows that become pregnant at the first insemination after calving (in healthy cows) or following a disorder (Hesse *et al.*, 2017; Syah *et al.*, 2024). The parameter is crucial because it represents early reproductive efficiency and the ability of cows to conceive promptly following the postpartum or disorder phase. An elevated FSCR signifies enhanced reproductive efficiency by diminishing the expenses connected to multiple inseminations.

$$FSCR = \frac{N \text{ of pregnant cows at first insemination}}{N \text{ of inseminated cows}} \times 100\%$$

Pregnancy rate (PR). PR is the percentage that becomes pregnant among all cows given AI during the study period (Melendez *et al.*, 2003; Yekti *et al.*, 2022). This parameter is essential for providing a general overview of the success of the reproductive program at the population level, rather than being limited to the first insemination.

$$PR = \frac{N \text{ of pregnant cows during the study}}{N \text{ of inseminated cows}} \times 100\%$$

Overall pregnancy rate (OPR). OPR is the percentage of inseminations that result in pregnancy out of the total inseminations performed (Kumaresan & Srivastava, 2022). Unlike PR, which is based on the number of individual cows, OPR is calculated based on the number of insemination events. Monitoring OPR is important as it overcomes the limitation of S/C, which only accounts for cows that became pregnant while ignoring inseminations in non-pregnant cows. Since the data in this study were collected over a two-year period, a single cow might have conceived more than once.

$$OPR = \frac{N \text{ of pregnancies during the study}}{N \text{ of artificial insemination}} \times 100\%$$

Days to first service (DFS). In this study, DFS is defined as the number of days from a reproductive disorder occurrence to the first service, with day 0 set as the time of the disorder (Nyabinwa *et al.*, 2020). This parameter is used to assess the recovery rate of cows until the first insemination after experiencing the disorder.

Days open (DO). DO is defined as the number of days from the occurrence of a reproductive disorder (day 0) until conception is achieved (Temesgen *et al.*, 2022).

Service per conception (S/C). S/C is defined as the average number of inseminations required to achieve pregnancy (Ryan *et al.*, 2020). A lower S/C value represents higher reproductive efficiency in cows, as fewer inseminations are needed to establish conception (Akbarinejad *et al.*, 2017). However, this parameter only applies to pregnant cows, which is a limitation as non-pregnant cows are excluded from the calculation.

$$S/C = \frac{N \text{ of artificial inseminations required for conception}}{N \text{ of pregnant cows}}$$

Ethical Approval

This study was based solely on reproductive records collected between 2020 and 2021 and excluded experimental manipulation, invasive methods, or direct physical interaction with the animals, leading to no requirement for formal ethical approval by considering institutional and national guidelines. All participating farms were members of a licensed dairy cooperative operating under veterinary supervision and complied with established standards for animal health and welfare. AI procedures were carried out by trained and certified personnel, with care taken to minimize stress and ensure proper handling of the cows throughout the process.

Statistical Analysis

The effects of reproductive disorders (group) and parity (primiparous vs. multiparous) were assessed on the reproductive performance of dairy cows. The results included binary variables (FSCR, PR, and OPR) and continuous variables (DFS, DO, and SC).

Binary logistic regression model (GLM with a logit link and binomial variance) was used to estimate the probability of successful binary results for variables such as FSCR, PR, and OPR. The model was:

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 G_i + \beta_2 P_j + \beta_3 (G \times P)_{ij},$$

where p is the probability of success (e.g., FSCR = 1, PR = 1, or OPR = 1), β_0 represents the intercept, and β_1 - β_3 are coefficients for *group*, *parity*, and the interaction. Factor significance was assessed through analysis of deviance (likelihood-ratio χ^2 tests). Predicted

probabilities for each *group* × *parity* combination were derived using emmeans with type = “response” and appropriate multiplicity adjustment.

To obtain continuous results for the variables, data were analyzed using two-way ANOVA in GLM to estimate the main effects of *group* and *parity* and the interaction. The model was:

$$Y_{ijk} = \mu + G_i + P_j + (G \times P)_{ij} + \epsilon_{ijk}$$

where Y_{ijk} denotes DFS, DO, or SC for the k -th cow in the i -th group and j -th parity class; μ is the overall mean; G_i and P_j are fixed effects of *group* and *parity*; $(G \times P)_{ij}$ represents the interaction; and $\epsilon_{ijk} \sim N(0, \sigma^2)$ signifies the residual error. Model assumptions (normality and homoscedasticity) were evaluated using residual diagnostics, and data transformations or robust variance procedures were applied as needed. Predicted means and post-hoc comparisons were obtained with emmeans, and Tukey adjustment was conducted where appropriate.

Kaplan–Meier survival analysis was used to analyze and visualize the interval from calving or the onset of the reproductive disorders to first insemination (DFS) and the first confirmed conception (DO). In this analysis, comparisons were made across reproductive-disorder groups without differentiating parity status.

All analyses were conducted in R version 4.4.1 (R Core Team, Vienna, Austria), which was used to apply

linear models through `lm()` and logistic models through `glm(family = binomial)`. The `lme4`, `lmerTest`, and `emmeans` packages were used for modeling and inference, while statistical significance was declared at $\alpha = 0.05$.

RESULTS

First Service Conception Rate, Pregnancy Rate, and Overall Perganancy Rate

Logistic regression models showed no significant effects of group, parity, or the interaction on FSCR ($\chi^2(3) = 3.59, p = 0.310; \chi^2(1) = 0.540, p = 0.540; \chi^2(3) = 3.04, p = 0.385$), PR ($\chi^2(3) = 5.75, p = 0.125; \chi^2(1) = 0.74, p = 0.391; \chi^2(3) = 1.69, p = 0.640$), and OPR ($\chi^2(3) = 2.75, p = 0.431; \chi^2(1) = 0.57, p = 0.449; \chi^2(3) = 0.59, p = 0.899$). Model-based estimates (emmeans with 95% CIs) for each group × parity combination are provided in Table 1 and visualized as bar plots with 95% CIs in Figures 1A–C. The extensive overlap of the CIs corroborates the absence of statistically meaningful differences across groups or parities. Descriptively, FSCR was highest in healthy–multiparous cows (0.28; CI 95% = 0.19–0.40) and lowest in retained placenta–multiparous cows (0.13; CI 95% = 0.07–0.22). PR tended to be highest in healthy cows (0.68; CI 95% = 0.52–0.80) and lower in the disorder groups, with OPR following a similar pattern (0.21; CI 95% = 0.15–0.29 in healthy cows).

Table 1. Post-disorder pregnancy metrics (first service conception rate, pregnancy rate, and overall pregnancy rate) by group and parity in Holstein–Friesian cows (model-based proportions, 95% CI)

Trait	Parity	Post-disorder pregnancy metrics		
		FSCR	PR	OPR
Healthy	primipara	0.15 (0.07–0.30)	0.68 (0.52–0.80)	0.21 (0.15–0.29)
	multipara	0.28 (0.19–0.40)	0.65 (0.53–0.75)	0.21 (0.16–0.28)
Abortion	primipara	0.11 (0.03–0.35)	0.44 (0.24–0.67)	0.13 (0.07–0.24)
	multipara	0.19 (0.09–0.36)	0.59 (0.42–0.75)	0.19 (0.12–0.28)
Distocya	primipara	0.19 (0.10–0.33)	0.49 (0.35–0.63)	0.17 (0.12–0.24)
	multipara	0.16 (0.09–0.27)	0.60 (0.48–0.71)	0.19 (0.14–0.25)
Retained placenta	primipara	0.15 (0.09–0.26)	0.51 (0.39–0.62)	0.16 (0.12–0.22)
	multipara	0.13 (0.07–0.22)	0.51 (0.40–0.63)	0.18 (0.13–0.23)
P (group)		0.31	0.31	0.31
P (parity)		0.54	0.54	0.54
P (group × parity)		0.38	0.64	0.89

Note: FSCR, first service conception rate; PR, pregnancy rate; OPR, overall pregnancy rate. Healthy–P (n=40), healthy–M (n=68), abortion–P (n=18), abortion–M (n=32), distocya–P (n=47), distocya–M (n=67), retained placenta–P (n=71), retained placenta–M (n=72)

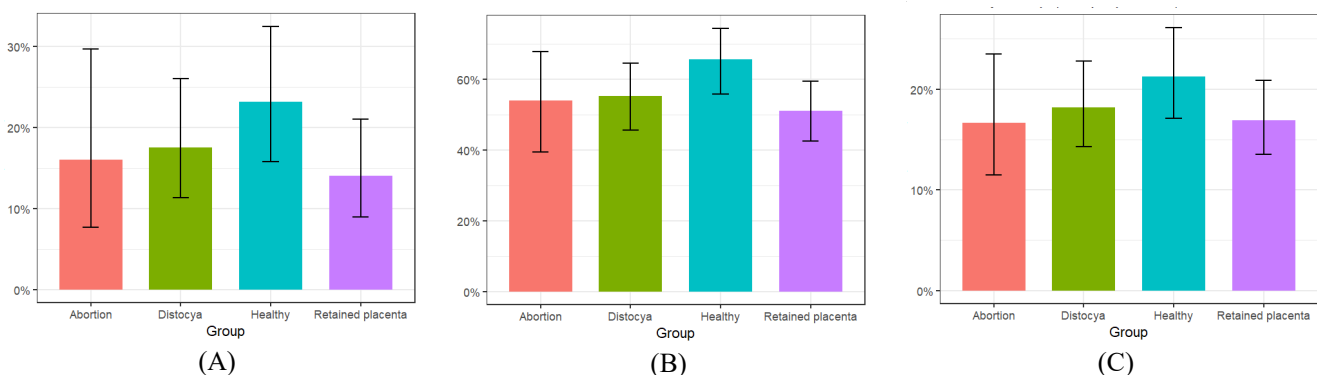


Figure 1. Pregnancy results by group in Holstein–Friesian cows (model-based proportions, 95% CI): (A) first-service conception rate, (B) pregnancy rate, and (C) overall pregnancy rate.

Days to First Service, Days Open, and Service per Conception

Kaplan–Meier analysis showed that reproductive performance in healthy cows was not consistently superior to the observations in counterparts experiencing reproductive disorders. As shown in Figure 2, cows in the abortion group received first insemination earlier than those in other groups, while healthy cows had a longer mean interval to first service. The retained placenta and dystocia groups had relatively similar survival curves, both showing a slower decline compared with the abortion group.

Kaplan–Meier analysis up to 500 days postpartum (Figure 3) found that cows in the Abortion (HR = 0.79; 95% CI, 0.51–1.23; p = 0.29), Retained placenta (HR = 0.71; 95% CI, 0.51–0.98; p = 0.04), and Dystocia (HR = 0.80; 95% CI, 0.57–1.13; p = 0.21) groups had HR below 1, signifying a lower instantaneous probability of achieving first pregnancy compared with healthy cows (reference group). However, the mean DO were shorter in cows with abortion (16.2 days earlier), retained placenta (12.5 days earlier), and dystocia (18.8 days earlier) than in healthy cows.

Two-way ANOVA showed significant main effects of group on DFS ($F(3, 407) = 7.37, p < 0.01$), while parity and the group \times parity interaction were not significant ($p > 0.05$). In multiparous cows, DFS was longer in healthy than abortion (+32.12 days, 95% CI 14.01 - 50.23) and dystocia subjects (+18.36 days, 95% CI 3.82 - 32.91). Retained placenta subjects experienced longer DFS than those with abortion (+24.64 days, 95% CI = 6.69 - 42.59), and all primiparous comparisons were not significant. This pattern is consistent with the DFS plot in Figure 4, while model-based means and 95% CI are presented in Table 2.

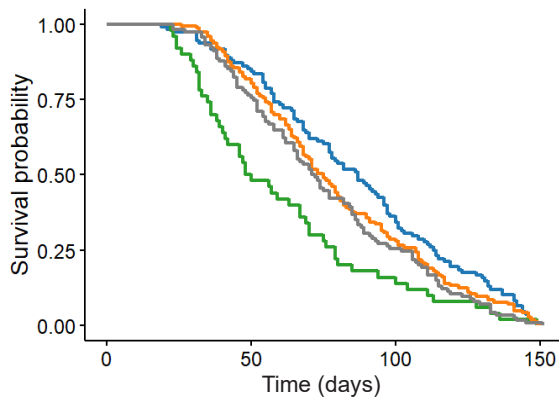


Figure 2. Kaplan–Meier survival curves were constructed to evaluate the time to first service (either following parturition or reproductive disorder) up to 150 days postpartum in 415 Holstein–Friesian cows. The cows were classified as healthy (n = 108), cows that experienced abortion (n = 50), cows with dystocia (n = 114), and cows with retained placenta (n = 143). The mean DFS was 86.8 days (range: 19–149) for healthy cows, 61 days (22–149) for cows with abortion, 80.4 days (26–150) for cows with retained placenta, and 76.5 days (23–150) for cows with dystocia. Note: ■ = healthy; ■ = retained placenta; ■ = abortion; ■ = dystocia.

Significant associations were not found between healthy and reproductive disorder cows ($p > 0.05$) for group, parity, or the interaction in relation to DO (p -value of group = 0.76; p parity = 0.37; p group \times parity = 0.94). However, cows with reproductive disorders tended to have shorter DO values (152.70–177.65 days) compared to healthy counterparts (172.74–183.59 days). There were no significant differences in S/C among groups, parity, or the interaction (p group = 0.31; p parity = 0.94; p group \times parity = 0.91). Descriptively, healthy cows had the lowest S/C values (2.35–2.53) compared to those with reproductive disorders (2.77–3.05).

DISCUSSION

This study investigated the effects of reproductive disorders on subsequent fertility in dairy cows, with parity considered as a contributing factor. Previous studies reported that abortion (Keshavarzi *et al.*, 2020; Vindas-van der Wielen *et al.*, 2025), dystocia (Hossein-Zadeh, 2016; Kim *et al.*, 2016), and retained placenta (Nyabinwa *et al.*, 2020) were associated with poorer reproductive performance compared with healthy cows. However, in this study, not all reproductive performance parameters showed a decline. The differences in reproductive performance indicators (FSCR, PR, OPR, and S/C) between healthy and affected cows were not statistically significant ($p > 0.05$). A numerical trend toward lower performance was observed in cows with reproductive disorders.

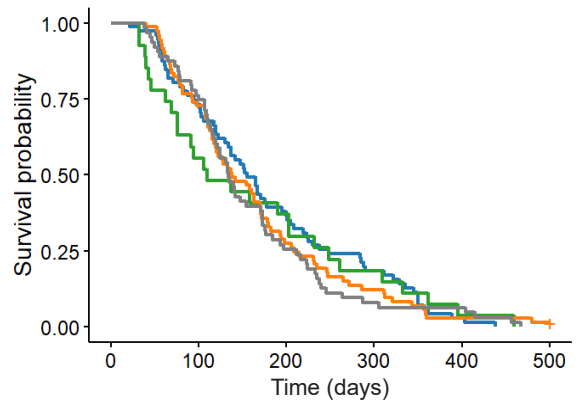


Figure 3. Kaplan–Meier survival curves were generated to evaluate the time from calving or reproductive disorders to the first pregnancy up to 500 days postpartum in 234 Holstein–Friesian cows. Values shown as n/N show the number of cows that conceived during follow-up (events) over the total enrolled per group. The mean days to pregnancy were: healthy (n=71/108) = 179.5 days, abortion (n=27/50) = 163.3 days, dystocia (n=73/114) = 160.7 days, and retained placenta (n=63/143) = 167 days. Using the healthy group as the reference category, the hazard ratio (HR) for cows with abortion was 0.79 (95% CI: 0.51–1.23, p = 0.29), for cows with retained placenta was 0.71 (95% CI: 0.51–0.98, p = 0.04), and for cows with dystocia was 0.80 (95% CI: 0.57–1.13, p = 0.21). Note: ■ = healthy; ■ = retained placenta; ■ = abortion; ■ = dystocia.

Table 2. Reproductive performance of Friesian Holstein (model-based mean, 95% CI) for days to first service, days open, and services per conception by group and parity

Trait	Parity	Post-disorder reproductive metrics		
		DFS (days)	DO (days)	S/C
Healthy	primipara	78.65 (68.47–88.83)	172.74 (132.62–212.86)	2.35 (1.65–3.06)
	multipara	91.62 (83.81–99.43)	183.59 (152.16–215.02)	2.53 (1.98–3.09)
Abortion	primipara	63.67 (48.49–78.84)	170.13 (96.41–243.84)	2.94 (1.64–4.23)
	multipara	59.50 (48.12–70.88)	160.38 (112.54–208.20)	3.05 (2.21–3.89)
Distocya	primipara	81.13 (71.74–90.52)	152.70 (109.22–196.17)	3.00 (2.24–3.76)
	multipara	73.25 (65.39–81.12)	165.33 (132.36–198.29)	3.00 (2.42–3.58)
Retained placenta	primipara	76.58 (68.94–84.22)	156.08 (121.34–190.83)	3.03 (2.42–3.64)
	multipara	84.14 (76.55–91.73)	177.65 (143.37–211.92)	2.77 (2.17–3.37)
P (group)		<0.01	0.76	0.31
P (parity)		0.31	0.37	0.94
P (group × parity)		0.08	0.94	0.91

Note: DFS, days to first service; DO, open days; S/C, services per conception. Healthy-P (n=40), healthy-M (n=68), abortion-P (n=18), abortion-M (n=32), distocya-P (n=47), distocya-M (n=67), retained placenta-P (n=71), retained placenta-M (n=72)

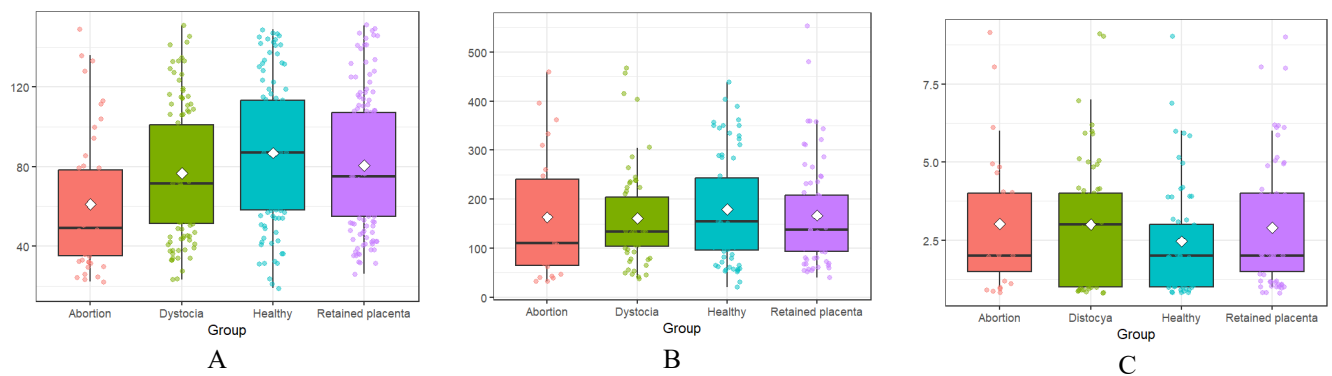


Figure 4. Boxplots of continuous reproductive results by group in Holstein–Friesian cows. (A) Days to first service, (B) open days, (C) services per conception. Bold line = median, box = IQR, whiskers = 1.5×IQR, diamonds = mean; dots are individual cows.

The results showed variation in pregnancy results between healthy and reproductive disorder cows over the observation period (Table 1). Healthy cows had numerically superior reproductive performance, with multiparous FSCR of 0.28 (95% CI 0.19–0.40), primiparous PR of 0.68 (95% CI 0.52–0.80) and multiparous PR of 0.65 (95% CI 0.53–0.75), and primiparous OPR of 0.21 (95% CI 0.15–0.29) and multiparous OPR 0.21 (95% CI 0.16–0.28). Furthermore, the corresponding S/C were 2.35 in primiparous and 2.53 in multiparous healthy cows (Table 2). The reproductive performance of healthy Holstein-Friesian cows at the study site was lower than previous reports, which showed higher fertility levels in the subjects raised in higher locations of Indonesia. The reports showed a CR of 47.3% (Syah *et al.*, 2023), a PR of 68.7% (Susilawati *et al.*, 2023), and S/C value of 1.47 (Setyorini *et al.*, 2022). The OPR in this study was relatively low, remaining below 65% (Kumaresan & Srivastava, 2022). The poor reproductive performance reported by the healthy group was probably due to the high temperature and humidity in the environment, which could cause heat stress (Asmarasari *et al.*, 2023). Holstein-Friesian cows perform best when the temperature is between 13 and 25 °C and the relative humidity is 50 to 60% (Lim *et al.*, 2021). The average daily temperature at the study site was between

22 and 25 °C, but the temperature throughout the midday might reach 38 °C, and the relative humidity tended to range from 67% to 94%. These conditions are known to lower the fertility of dairy cows by making sperm less viable, leading to difficulties with egg fertilization, slower embryo growth, and less intense estrus (Llamas-Luceño *et al.*, 2020; Rahman *et al.*, 2018; Reith & Hoy, 2018). Despite some level of acclimatization, these cows cannot be considered fully adapted to the high heat and humidity typical of the study area.

Reproductive performance is further compromised in cows with reproductive disorders by bacterial contamination and uterine infections that lead to endometritis and reduced embryo viability (Husnain *et al.*, 2023). Bacterial toxins, particularly lipopolysaccharides (LPS), suppress pituitary LH secretion, inhibit dominant follicle growth, and impair ovulation (Opsomer *et al.*, 2000; Sheldon *et al.*, 2002). Additionally, LPS directly disrupts steroidogenesis in ovarian follicular cells and reduces oocyte developmental competence, lowering embryo quality (Magata, 2020). The combination of uterine damage, hormonal disruption, and reduced oocyte quality contributes to lower conception rates and higher pregnancy failure risks in cows with a history of reproductive disorders compared with healthy subjects (LeBlanc *et al.*, 2002).

Cows affected by reproductive disorders showed lower FSCR, PR, and OPR and higher S/C than healthy cows (all $p > 0.05$), but DFS and DO were attained more rapidly. Abortion victims were inseminated 25.8 days before healthy cows, while those with dystocia and retained placenta were inseminated 10.3 and 6.4 days earlier, respectively (Figure 2). Consistent with the Kaplan–Meier plot, Table 2 shows the shortest mean DFS of 63.67 d (95% CI 48.49–78.84) in the abortion group of primiparous cows and 59.50 d (95% CI 48.12–70.88) in multiparous types. Meanwhile, the healthy multiparous group had the longest mean DFS of 91.62 d (95% CI 83.81–99.43), and the tendency persisted for DO, adhering to the same pattern. Hazard-ratio (HR) analysis found diminished probabilities of conception in comparison to healthy cows for abortion (HR = 0.79; 95% CI 0.51–1.23; $p = 0.29$), retained placenta (HR = 0.80; 95% CI 0.57–1.13; $p = 0.21$), and dystocia (HR = 0.71; 95% CI 0.51–0.98; $p = 0.04$) (Figure 3). The healthy multiparous group had the longest average number of DO, which was 183.59 days (95% CI 152.16–215.02), compared to the disorder groups (Table 2). These results show that HR and mean DO do not necessarily have to be the same. HR presents the chance of conception at any given time, and mean DO signifies the time required for half of the cows to conceive.

The phenomenon explained above can be attributed to the more rigorous post-disorder treatments administered to cows with reproductive problems, including antibiotics, multivitamins, and supportive care, which may have expedited reproductive recovery. Healthy cows in smallholder systems generally did not receive specialist postpartum treatment, initiating more vulnerability to negative energy balance (NEB) originating from increased energy requirements during peak lactation. Walsh *et al.* (2011) asserted that the described condition prevented ovarian recovery in healthy cows. Cows with the experience of abortion (Vindas-van der Wielen *et al.*, 2025), dystocia (Roche *et al.*, 2023), or retained placenta (Mahnani *et al.*, 2021) typically had less milk production, leading to a less severe NEB, which promoted earlier estrus and ovulation (Butler, 2003). This phenomenon clarifies why cows with reproductive abnormalities have earlier DFS and DO, despite possessing lower total conception rates. Intra-group variation might have played a role because a few cows conceived rapidly, reducing the mean DO, and others did not conceive during the 500-day observation period, leading to diminished herd reproductive values. Effective postpartum treatment is essential for expediting reproductive recovery in dairy cows. Numerous studies show that using targeted antibiotics for reproductive disorders significantly enhances conception rates and reduces the calving-to-conception interval (Denis-Robichaud & Dubuc, 2015; Menta *et al.*, 2024). Vitamin supplementation during the transition phase has shown efficacy in enhancing uterine function, facilitating a more rapid return to estrus cyclicity (Moghimi-Kandelousi *et al.*, 2020; Morrison *et al.*, 2018). The combination of targeted antibiotic treatment, multivitamin supplementation, and adequate

postpartum nutritional support can be considered the most effective strategy for enhancing reproductive recovery following parturition.

Parity showed no observable effects across all results in the collected dataset. In logistic GLMs for the binary endpoints (FSCR, PR, OPR), the primiparous–multiparous comparison produced $p > 0.05$ for all parameters (Table 1). Similarly, in two-way ANOVA (GLM) for the continuous endpoints (DFS, DO, S/C), the main effects of parity were non-significant (all $p > 0.05$; Table 2). These results were consistent with previous reports, such as Tadesse *et al.* (2022), who observed no parity effects on conception odds in multivariable logistic models. Similarly, (Nan *et al.*, 2023) detected no meaningful differences in continuous reproductive measures across parity groups. The evidence shows that parity, as assessed in this study, is not a major determinant of fertility performance. Primiparous and multiparous cows have broadly identical probabilities of conceiving following reproductive disorders.

Table 2 shows a wide CI for cows with a history of abortion, which may reflect the limited sample size in this subgroup (n primiparous = 18, and n multiparous = 32). A limited sample size increases uncertainty in the estimates, reflected in wider CI, less stable OD, and reduced Statistical power to detect moderate effects (Button *et al.*, 2013; Zeng *et al.*, 2022). As a result, results related to the abortion subgroup should be interpreted cautiously (Rafati *et al.*, 2010). Greater precision would likely be achieved through studies with larger samples or by combining data across herds.

Reproductive disorders, including abortion, dystocia, and retained placenta, were generally not connected to a significant reduction in reproductive performance in Holstein-Friesian cows. DFS and DO sometimes showed faster postpartum recovery in reproductively challenged cows than in healthy animals, potentially associated with differences in milk yield or management practices. The lack of a clear parity-related effect confirms the primacy of preventive measures, timely clinical intervention, and control of environmental stressors for sustaining reproductive performance across the herd.

CONCLUSION

Although post-disorder pregnancy metrics (FSCR, PR, OPR) showed no statistically significant connection to reproductive problems, affected animals numerically underperformed their healthy counterparts. The control group maintained a better mean S/C than cows suffering from reproductive issues. Despite the diminished conception-related metrics, cows with reproductive abnormalities had reduced DFS and DO, potentially due to the postpartum interventions implemented following the onset of the disorders. There was a lack of statistical significance in the observed effects, and the numerical patterns still suggested possible biological relevance, showing the necessity of efficient postpartum management to enhance reproductive success in smallholder dairy production systems.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this study.

ACKNOWLEDGEMENT

The authors are grateful to the Directorate General of Research and Development, Ministry of Higher Education, Science and Technology, for supporting this study through Program Magister Menuju Doktor untuk Sarjana Unggul (PMDSU) with contract number 697/UN10.A0501/B/PT.01.03.2/2025.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this study, the author(s) used ChatGPT (OpenAI) to improve language clarity and grammar and Scopus AI to assist in literature searching. After using these tools, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

REFERENCES

- Akbarinejad, V., Gharagozlou, F., & Vojgani, M. (2017). Temporal effect of maternal heat stress during gestation on the fertility and anti-Müllerian hormone concentration of offspring in bovine. *Theriogenology*, 99, 69–78. <https://doi.org/10.1016/j.theriogenology.2017.05.018>
- Asmarasari, S. A., Azizah, N., Sutikno, S., Puastuti, W., Amir, A., Praharani, L., Rusdiana, S., Hidayat, C., Hafid, A., Kusumaningrum, D. A., Saputra, F., Talib, C., Herliatika, A., Shiddieqy, M. I., & Hayanti, S. Y. (2023). A review of dairy cattle heat stress mitigation in Indonesia. *Veterinary World*, 16(5), 1098–1108. <https://doi.org/10.14202/vetworld.2023.1098-1108>
- Bonneville-Hébert, A., Bouchard, E., Tremblay, D. D., & Lefebvre, R. (2011). Effect of reproductive disorders and parity on repeat breeder status and culling of dairy cows in Quebec. *Canadian Journal of Veterinary Research*, 75(2), 147–151. <https://doi.org/10.21423/aabppro20104178>
- Bruinjé, T. C., Morrison, E. I., Ribeiro, E. S., Renaud, D. L., Serrenho, R. C., & LeBlanc, S. J. (2023). Postpartum health is associated with detection of estrus by activity monitors and reproductive performance in dairy cows. *Journal of Dairy Science*, 106(12), 9451–9473. <https://doi.org/10.3168/jds.2023-23268>
- Butler, W. R. (2003). Energy balance relationships with follicular development, ovulation and fertility in postpartum dairy cows. *Livestock Production Science*, 83(2–3), 211–218. [https://doi.org/10.1016/S0301-6226\(03\)00112-X](https://doi.org/10.1016/S0301-6226(03)00112-X)
- Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature reviews neuroscience*, 14(5), 365–376. <https://doi.org/10.1038/nrn3475>
- Cabrera, V. E. (2014). Economics of fertility in high-yielding dairy cows on confined TMR systems. *Animal*, 8(1), 211–221. <https://doi.org/10.1017/S1751731114000512>
- Carbonari, A., Burgio, M., Frattina, L., Ceci, E., Sciannamblo, M., Ricci, P., Cicirelli V., & Rizzo, A. (2024). Oxytocin, prostaglandin F2 α , and scopolamine for uterine involution of dairy cows. *Frontiers in Veterinary Science*, 11, 1405746. <https://doi.org/10.3389/fvets.2024.1405746>
- Carrillo Parraguez, M., Ponssa, E., Caffarena, D., Artagaveytia, J., Sotelo, F., Fariña, S., Mendoza, A., & Giannitti, F. (2025). Estimation of direct economic and productive losses due to abortions caused by *Neospora caninum* in the primary dairy sector of Uruguay. *Frontiers in Veterinary Science*, 12, 1502742. <https://doi.org/10.3389/fvets.2025.1502742>
- Chebel, R. C., Mirzaei, A., Yu, H., Lopes Jr, G., & Bisinotto, R. S. (2025). Early postpartum estrous characteristics: Unveiling their predictive potential for fertility in dairy cows. *Journal of Dairy Science*, 108:12734–12758. <https://doi.org/10.3168/jds.2025-27175>
- De Amicis, I., Veronesi, M. C., Robbe, D., Gloria, A., & Carluccio, A. (2018). Prevalence, causes, resolution and consequences of bovine dystocia in Italy. *Theriogenology*, 107, 104–108. <https://doi.org/10.1016/j.theriogenology.2017.11.001>
- De Vries, A. (2006). Economic value of pregnancy in dairy cattle. *Journal of dairy science*, 89(10), 3876–3885. [https://doi.org/10.3168/jds.S0022-0302\(06\)72430-4](https://doi.org/10.3168/jds.S0022-0302(06)72430-4)
- Denis-Robichaud, J., & Dubuc, J. (2015). Randomized clinical trial of intrauterine cephalosporin infusion in dairy cows for the treatment of purulent vaginal discharge and cytological endometritis. *Journal of Dairy Science*, 98(10), 6856–6864. <https://doi.org/10.3168/jds.2014-9129>
- Dervishi, E., & Ametaj, B. N. (2017). Retained placenta: A systems veterinary approach. In B. N. Ametaj (Ed.), *Periparturient diseases of dairy cows: A systems biology approach* (pp. 121–137). Springer International Publishing. https://doi.org/10.1007/978-3-319-43033-1_7
- Hohnholz, T., Volkmann, N., Gillandt, K., Waßmuth, R., & Kemper, N. (2019). Risk factors for dystocia and perinatal mortality in extensively kept Angus suckler cows in Germany. *Agriculture*, 9(4), 85. <https://doi.org/10.3390/agriculture9040085>
- Han, R., Kok, A., Mourits, M., & Hogeveen, H. (2024). Effects of extending dairy cow longevity by adjusted reproduction management decisions on partial net return and greenhouse gas emissions: A dynamic stochastic herd simulation study. *Journal of Dairy Science*, 107(9), 6902–6912. <https://doi.org/10.3168/jds.2023-24089>
- Hesse, A., Bertulat, S., & Heuwieser, W. (2017). Survey of work processes on German dairy farms. *Journal of Dairy Science*, 100(8), 6583–6591. <https://doi.org/10.3168/jds.2016-12029>
- Hossein-Zadeh, N. G. (2016). Effect of dystocia on subsequent reproductive performance and functional longevity in Holstein cows. *Journal of Animal Physiology and Animal Nutrition*, 100(5), 860–867. <https://doi.org/10.1111/jpn.12460>
- Husnain, A., Arshad, U., Zimpel, R., Schmitt, E. J., Dickson, M. J., Perdomo, M. C., Marinho, M. N., Ashrafi, N., Graham, S. F., Bishop, J. V., Hansen, T. R., Jeong, K. C., Gonella-Diaza, A. M., Chebel, R. C., Sheldon, I. M., Bromfield, J. J., & Santos, J. E. P. (2023). Induced endometrial inflammation compromises conceptus development in dairy cattle. *Biology of Reproduction*, 109(4), 415–431. <https://doi.org/10.1093/biolre/ioad088>
- Kamel, E. R., Ahmed, H. A., & Hassan, F. M. (2022). The effect of retained placenta on the reproductive performance and its economic losses in a Holstein dairy herd. *Iraqi Journal of Veterinary Sciences*, 36 (2), 359–365. <https://doi.org/10.33899/ijvs.2021.130287.1791>
- Keshavarzi, H., Sadeghi-Sefidmazgi, A., Ghorbani, G. R., Kowsar, R., Razmkabir, M., & Amer, P. (2020). Effect of abortion on milk production, health, and reproductive performance of Holstein dairy cattle. *Animal Reproduction Science*, 217, 106458. <https://doi.org/10.1016/j.anireprosci.2020.106458>
- Kim, D. U., Lee, S. C., Jeong, J. K., Choi, I. S., Moon, S. H., Kang, H. G., & Kim, I. H. (2016). Effects of dystocia on the postpartum complications, milk production and reproductive performance in dairy cows. *Journal of*

- Veterinary Clinics, 33(2), 87–92. <https://doi.org/10.17555/jvc.2016.04.33.2.87>
- Kumaresan, A., & Srivastava, A. K. (2022). Current concepts in bovine reproduction. Springer Nature. <https://doi.org/10.1007/978-981-19-0116-4>
- LeBlanc, S. J., Duffield, T. F., Leslie, K. E., Bateman, K. G., Keefe, G. P., Walton, J. S., & Johnson, W. H. (2002). Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. *Journal of Dairy Science*, 85, 2223–2236. [https://doi.org/10.3168/jds.S0022-0302\(02\)74302-6](https://doi.org/10.3168/jds.S0022-0302(02)74302-6)
- Lim, D. H., Kim, T. I. L., Park, S. M., Ki, K. S., & Kim, Y. (2021). Evaluation of heat stress responses in Holstein and Jersey cows by analyzing physiological characteristics and milk production in Korea. *Journal of Animal Science and Technology*, 63(4), 872–883. <https://doi.org/10.5187/jast.2021.e83>
- Llamas-Luceño, N., Hostens, M., Mullaart, E., Broekhuijs, M., Loneragan, P., & Van Soom, A. (2020). High temperature-humidity index compromises sperm quality and fertility of Holstein bulls in temperate climates. *Journal of Dairy Science*, 103(10), 9502–9514. <https://doi.org/10.3168/jds.2019-18089>
- Magata, F. (2020). Lipopolysaccharide-induced mechanisms of ovarian dysfunction in cows with uterine inflammatory diseases. *Journal of Reproduction and Development*, 66(4), 311–317. <https://doi.org/10.1262/jrd.2020-021>
- Mahnani, A., Sadeghi-Sefidmazgi, A., Ansari-Mahyari, S., & Ghorbani, G. R. (2021). Assessing the consequences and economic impact of retained placenta in Holstein dairy cattle. *Theriogenology*, 175, 61–68. <https://doi.org/10.1016/j.theriogenology.2021.08.036>
- McGuirk, B. J., Forsyth, R., & Dobson, H. (2007). Economic cost of difficult calvings in the United Kingdom dairy herd. *Veterinary Record*, 161(20), 685–687. <https://doi.org/10.1136/vr.161.20.685>
- Melendez, P., Donovan, G. A., Risco, C. A., Littell, R., & Goff, J. P. (2003). Effect of calcium-energy supplements on calving-related disorders, fertility and milk yield during the transition period in cows fed anionic diets. *Theriogenology*, 60(5), 843–854. [https://doi.org/10.1016/S0093-691X\(03\)00103-1](https://doi.org/10.1016/S0093-691X(03)00103-1)
- Menta, P. R., Fernandes, L. G., Prim, J., De Oliveira, E. B., Lima, F. S., Galvão, K. N., Bicalho, R. C., Chebel, R. C., & Machado, V. S. (2024). A randomized controlled trial evaluating the efficacy of systemic ceftiofur administration for metritis therapy in dairy cows and the effect of metritis cure on economically important outcomes. *Journal of Dairy Science*, 107(9), 7092–7105. <https://doi.org/10.3168/jds.2023-24406>
- Moghimi-Kandelousi, M., Alamouti, A. A., Imani, M., & Zebeli, Q. (2020). A meta-analysis and meta-regression of the effects of vitamin E supplementation on serum enrichment, udder health, milk yield, and reproductive performance of transition cows. *Journal of Dairy Science*, 103(7), 6157–6166. <https://doi.org/10.3168/jds.2019-17556>
- Morrison, E. I., Reinhardt, H., Leclerc, H., DeVries, T. J., & LeBlanc, S. J. (2018). Effect of rumen-protected B vitamins and choline supplementation on health, production, and reproduction in transition dairy cows. *Journal of Dairy Science*, 101(10), 9016–9027. <https://doi.org/10.3168/jds.2018-14663>
- Nan, L., Du, C., Fan, Y., Liu, W., Luo, X., Wang, H., Ding, L., Zhang, Y., Chu, C., Li, C., Ren, X., Yu, H., Lu, S., & Zhang, S. (2023). Association between days open and parity, calving season or milk spectral data. *Animals*, 13(3), 509. <https://doi.org/10.3390/ani13030509>
- Nyabinwa, P., Kashongwe, O. B., Hirwa, C. D. A., & Bebe, B. O. (2020). Effects of endometritis on reproductive performance of zero-grazed dairy cows on smallholder farms in Rwanda. *Animal Reproduction Science*, 221, 106584. <https://doi.org/10.1016/j.anireprosci.2020.106584>
- Opsomer, G., Grohn, Y. T., Hertl, J., Coryn, M., Deluyker, H., & de Kruijff, A. (2000). Risk factors for postpartum ovarian dysfunction in high producing dairy cows in Belgium: A field study. *Theriogenology*, 53, 841–857. [https://doi.org/10.1016/S0093-691X\(00\)00234-X](https://doi.org/10.1016/S0093-691X(00)00234-X)
- Peter, A. T. (2000). Abortions in dairy cows: New insights and economic impact. In *Proceedings of the Western Canadian Dairy Seminar: Advanced Dairy Technology* (pp. 233–244). Red Deer, Alberta, Canada.
- Pinedo, P., Santos, J. E. P., Chebel, R. C., Galvão, K. N., Schuenemann, G. M., Bicalho, R. C., Gilbert, R. O., Rodriguez Zas, S., Seabury, C. M., Rosa, G., & Thatcher, W. W. (2020). Early-lactation diseases and fertility in 2 seasons of calving across US dairy herds. *Journal of dairy science*, 103(11), 10560–10576. <https://doi.org/10.3168/jds.2019-17951>
- Rafati, N., Mehrabani-Yeganeh, H., & Hanson, T. E. (2010). Risk factors for abortion in dairy cows from commercial Holstein dairy herds in the Tehran region. *Preventive Veterinary Medicine*, 96(3-4), 170–178. <https://doi.org/10.1016/j.prevetmed.2010.05.008>
- Rahman, M. B., Schellander, K., Llamas Luceno, N., & Van Soom, A. (2018). Heat stress responses in spermatozoa: Mechanisms and consequences for cattle fertility. *Theriogenology*, 113, 102–112. <https://doi.org/10.1016/j.theriogenology.2018.02.012>
- Reith, S., & Hoy, S. (2018). Review: Behavioral signs of estrus and the potential of fully automated systems for detection of estrus in dairy cattle. *Animal*, 12(2), 398–407. <https://doi.org/10.1017/S1751731117001975>
- Roche, S. M., Ross, J. A., Schatz, C., Beaugrand, K., Zuidhof, S., Ralston, B., Allan, N., & Olson, M. (2023). Impact of dystocia on milk production, somatic cell count, reproduction and culling in Holstein dairy cows. *Animals*, 13(3), 346. <https://doi.org/10.3390/ani13030346>
- Ribeiro, E. S., Gomes, G., Greco, L. F., Cerri, R. L. A., Vieira-Neto, A., Monteiro, P. L. J., Lima, F. S., Bisinotto, R. S., Thatcher, W. W., & Santos, J. E. P. (2016). Carryover effect of postpartum inflammatory diseases on developmental biology and fertility in lactating dairy cows. *Journal of Dairy Science*, 99(3), 2201–2220. <https://doi.org/10.3168/jds.2015-10337>
- Ryan, N. J., Meade, K. G., Williams, E. J., O'Farrelly, C., Grant, J., Evans, A. C., & Beltman, M. E. (2020). Purulent vaginal discharge diagnosed in pasture-based Holstein-Friesian cows at 21 days postpartum is influenced by previous lactation milk yield and results in diminished fertility. *Journal of Dairy Science*, 103(1), 666–675. <https://doi.org/10.3168/jds.2019-17116>
- Setyorini, Y. W., Kurnianto, E., Sutopo, S., & Sutyono, S. (2022). Effect of age at first calving on milk production and reproductive performance of Indonesian Holstein dairy cattle. *Buletin Peternakan*, 46(4), 243–247. <https://doi.org/10.21059/buletinpeternak.v46i4.77097>
- Sheldon, I. M., Noakes, D. E., Rycroft, A. N., Pfeiffer, D. U., & Dobson, H. (2002). Influence of uterine bacterial contamination after parturition on ovarian dominant follicle selection and follicle growth and function in cattle. *Reproduction*, 123, 837–845. <https://doi.org/10.1530/rep.0.1230837>
- Susilawati, T., Yekti, A. P. A., Firdaus, A., Damayanti, D. A., Prafitri, R., Febrianto, N., Kuswati, K., Rachmawati, A., Wahjuningsih, S., & Isnaini, N. (2023). The study of artificial insemination with double doses at different times in Friesian Holstein crossbred. *Advances in Animal and Veterinary Sciences*, 11(7), 1159–1164. <https://doi.org/10.17582/journal.aavs/2023/11.7.1159.1164>

- Syah, H. A., Isnaini, N., Yekti, A. P. A., Rifai'i, M., & Susilawati, T. (2023). Successful artificial insemination of sexed semen using albumin sedimentation on Friesian Holstein cows. In *BIO Web of Conferences*, 81, 00015. EDP Sciences. <https://doi.org/10.1051/bioconf/20238100015>
- Syah, H. A., Yekti, A. P. A., Utami, P., Isnaini, N., & Susilawati, T. (2024). Effect of artificial insemination timing on conception rate in lactating Holstein-Friesian cows. *World's Veterinary Journal*, 14(4), 529–535. <https://doi.org/10.54203/scil.2024.wvj60>
- Tadesse, B., Reda, A. A., Kassaw, N. T., & Tadege, W. (2022). Success rate of artificial insemination, reproductive performance and economic impact of failure of first service insemination: A retrospective study. *BMC Veterinary Research*, 18(1), 226. <https://doi.org/10.1186/s12917-022-03325-1>
- Temesgen, M. Y., Assen, A. A., Gizaw, T. T., Minalu, B. A., & Mersha, A. Y. (2022). Factors affecting calving to conception interval (days open) in dairy cows located at Dessie and Kombolcha towns, Ethiopia. *PLOS ONE*, 17(2), e0264029. <https://doi.org/10.1371/journal.pone.0264029>
- Vindas-van der Wielen, E., Romero-Zúñiga, J. J., & Monti, G. (2025). Productive and reproductive losses associated with abortion in specialized dairy cattle from Costa Rica. *Journal of Dairy Science*, 108(2), 445–453. <https://doi.org/10.3168/jds.2024-25283>
- Walsh, S. W., Williams, E. J., & Evans, A. C. O. (2011). A review of the causes of poor fertility in high milk producing dairy cows. *Animal Reproduction Science*, 123(3–4), 127–138. <https://doi.org/10.1016/j.anireprosci.2010.12.001>
- Wathes, D. C., Oguejiofor, C. F., Thomas, C., & Cheng, Z. (2020). Importance of viral disease in dairy cow fertility. *Engineering*, 6(1), 26–33. <https://doi.org/10.1016/j.eng.2019.07.020>
- Yaqoob, B., Mridula, S., & Anoop, S. (2016). Effect of parity of animal, season and sex of fetus on the rate of abortion in dairy cattle. *Advances in Animal and Veterinary Sciences*, 4(11), 571–574. <https://doi.org/10.14737/journal.aavs/2016/4.11.571.574>
- Yazlık, M. O., Çolakoğlu, H. E., Pekcan, M., Kaya, U., Kaçar, C., Vural, M. R., Kurt, S., Baş, A., & Küplülü, Ş. (2019). The evaluation of superoxide dismutase activity, neutrophil function, and metabolic profile in cows with retained placenta. *Theriogenology*, 128, 40–46. <https://doi.org/10.1016/j.theriogenology.2019.01.020>
- Yekti, A. P. A., Riyanto, J., Hanim, C., Prafitri, R., Ciptadi, G., Rahayu, S., & Susilawati, T. (2025). Successful Artificial Insemination using Sexed and Non Sexed Semen on Limousin Crossbred Cow. *Indian Journal of Animal Research*, 59(10), 1631–1634. <https://doi.org/10.18805/IJAR.BF-1436>
- Zeng, L., Brignardello-Petersen, R., Hultcrantz, M., Mustafa, R. A., Murad, M. H., Iorio, A., Traversy, G., Akl, E. A., Mayer, M., Schünemann, H. J., & Guyatt, G. H. (2022). GRADE Guidance 34: update on rating imprecision using a minimally contextualized approach. *Journal of clinical epidemiology*, 150, 216–224. <https://doi.org/10.1016/j.jclinepi.2022.07.014>