Case Report

Reproductive Efficiency of Friesian Holstein Cows in a Partnership-Based Dairy Production Model: Evidence from the Greenfields Smallholder Scheme in Indonesia

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Abstract | Reproductive efficiency is vital for sustaining milk productivity and profitability in smallholder dairy systems. However, limited evidence exists on how structured partnership schemes affect reproductive outcomes. This study provides the first evaluation of Friesian Holstein cows raised under the Greenfields Partnership, a distinctive model that differs from conventional smallholder systems by applying standardized feeding, record-keeping, and artificial insemination (AI) services. A total of 136 cows were assessed between August 2023 and July 2024. Reproductive parameters included postpartum mating (PPM), services per conception (S/C), days open (DO), calving interval (CI), and body condition score (BCS). Data were analyzed using descriptive statistics, ANOVA, Spearman's correlation, and regression models. The mean values were 81.20 ± 46.20 days for PPM, 3.36 ± 2.15 for S/C, 176.66 ± 101.45 days for DO, 434.95 ± 99.04 days for CI, and 2.33 ± 0.34 for BCS. PPM was close to the efficient range, but prolonged DO and CI alongside elevated S/C indicated reduced reproductive efficiency. The observed variability reflects inconsistent adoption of standardized practices under the partnership model. This study highlights both challenges and opportunities within partnership-based systems and suggests that improved estrus detection, AI timing, and nutritional management consistency are essential to enhance fertility, profitability, and sustainability of tropical smallholder dairying.

Keywords | Body condition score, Calving interval, Dairy cow, Friesian Holstein, Reproductive performance, Partnership model

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INTRODUCTION

The Indonesian government launched the Free Nutritious Meal Program in 2024, designating milk as one of the mandatory components. This policy is projected to substantially increase national milk consumption and, in turn, intensify the demand for domestic milk supply. At present, local production meets only around 20% of total demand (Directorate General of Livestock and Animal Health, 2023). East Java Province is the largest contributor, providing 51.79% of national milk production, with Malang Regency as the main hub at 31.24% (BPS Statistics Indonesia, 2023). The highland topography of Malang, located approximately 500 meters above sea level, offers favorable conditions for raising Friesian Holstein (FH) dairy cattle. Within this setting, the Greenfields Partnership has emerged as a distinctive production model that integrates smallholder farmers into a structured and sustainable milk supply chain.

Despite this structured organization, reproductive inefficiencies persist, indicating that structure alone may not guarantee biological performance. The Greenfields Partnership distinguishes itself through centralized insemination, feed formulation standards, and regular data auditing elements rarely available in traditional smallholder systems. Nevertheless, previous field studies in the same region have documented management related health challenges such as subclinical mastitis (Rifa'i *et al*., 2024) and poor milking hygiene practices (Surjowardojo *et al*., 2025), highlighting that even within structured frameworks, on farm behavioral consistency remains a key determinant of herd productivity. Evaluating how these partnership mechanisms influence reproductive parameters therefore provides valuable insight into both the strengths and limitations of structured smallholder dairy systems.

Reproductive efficiency remains fundamental to sustaining dairy herd productivity, as milk yield can only be maintained through well-regulated reproductive cycles. However, balancing reproductive performance with high milk output remains a major challenge (Crowe *et al*., 2014). Poor reproductive efficiency prolongs calving intervals, reduces conception rates, and diminishes lifetime productivity (Imbayarwo-Chikosi *et al*., 2016; Nogalski and Barański, 2023). Previous studies have reported that breeding programs with an excessive focus on milk yield often lead to deterioration of reproductive traits (Castañeda-Bustos *et al*., 2017). Consequently, many breeding programs worldwide now incorporate reproductive indicators such as calving interval and days open to counteract the negative effects of selection for milk yield alone (Hu *et al*., 2021; Rasad, 2009).

In addition to genetic influences, body condition score (BCS) plays a pivotal role in reproductive performance. Cows with low BCS are prone to fertility problems due to negative energy balance and metabolic disorders (Pryce *et al*., 2001). Evaluating reproductive performance in relation to BCS therefore provides critical insights for both breeding and management practices. From a management standpoint, pre-partum nutritional interventions, such as steaming up, have been shown to improve colostrum production and physiological readiness for lactation (Surjowardojo *et al*., 2023). Such interventions are essential references for designing sustainable herd management strategies (Gutiérrez-Reinoso *et al*., 2023).

Although numerous studies have investigated reproductive performance of Friesian Holstein cattle in Indonesia, no research has specifically examined this issue within the context of a structured partnership model such as the Greenfields scheme. This model differs from conventional smallholder systems in its standardized feeding practices, record-keeping, and AI services, potentially leading to different reproductive dynamics. Therefore, the present study aimed to evaluate the reproductive efficiency of Friesian Holstein cows raised under the Greenfields smallholder partnership in Malang Regency and to analyze the association between body condition score (BCS) and reproductive parameters.

MATERIALS AND METHODS

Time and location

The study was conducted in Malang Regency, East Java, over a twelve-month period from August 2023 to July 2024. The research sites were smallholder dairy farms participating in the Greenfields Dairy Partnership (KSG), located in Wagir and Ngajum Districts on the slopes of Mount Kawi. The highland topography of this region provides suitable conditions for the development of Friesian Holstein (FH) dairy cattle.

Research materials

The research material consisted of 136 FH dairy cows selected using a purposive sampling method. The selection criteria included: (1) cows in their first to third lactation, (2) cows vaccinated against foot-and-mouth disease (FMD) at least twice, and (3) cows with complete and verified reproductive records. Purposive sampling was chosen because it allowed the inclusion of cows that best represented the reproductive characteristics relevant to the study objectives, particularly those within productive age and with reliable records (Rachman *et al*., 2024). This approach ensured that the sample closely reflected the target population under the Greenfields partnership scheme. However, purposive sampling also has inherent limitations, including the potential for selection bias and reduced generalizability beyond the defined population. These limitations are acknowledged in interpreting the results, and findings should be viewed as most applicable to comparable smallholder partnership systems rather than all dairy production contexts.

Research methods

A survey method was employed to collect both primary and secondary data. Primary data were obtained through direct observation of cows' body condition using the Body Condition Score (BCS) assessment. Secondary data were collected from farmers' reproductive records and cross-verified with the official records of the Greenfields Partnership. These data included information on herd size, parity, postpartum mating (PPM), days open (DO), services per conception (S/C), and calving interval (CI).

Under the Greenfields Partnership scheme, farm management practices follow standardized protocols designed to ensure consistency across participating smallholders. Cows were fed a combination of Napier grass and concentrate at a ratio of approximately 60:40 on a dry-matter basis, provided twice daily, with mineral and clean-water supplementation ad libitum. Estrus detection was primarily carried out by farmers through visual observation of behavioral signs (mounting, vulvar swelling, and mucus discharge) and subsequently confirmed by trained Greenfields technicians. Artificial insemination (AI) was performed by certified inseminators employed by the partnership using high-quality frozen semen from approved breeding centers, ensuring uniform AI procedures and record-keeping across farms.

Research procedures

The research was carried out in the following stages:

- Site surveys and interviews with field officers and partner farmers.
- Identification of cows that met the selection criteria, with the recording of individual identification numbers.
- Body Condition Score (BCS) assessment conducted through visual inspection and palpation, using a scale of 1 (emaciated) to 5 (obese), following the guidelines of Ariffien (2021).
- Collection of reproductive data (parity, PPM, DO, S/C, and CI) from farmers' recording cards and verification against the records maintained by insemination officers.

The method of BCS assessment through inspection and palpation is widely used to evaluate the body energy reserves of dairy cows and is closely associated with reproductive status (Berry *et al*., 2003; Kim *et al*., 2023).

Observed variables

The research variables consisted of:

- Postpartum Mating (PPM): The number of days from calving to the first artificial insemination or natural mating.
- Days Open (DO): The number of days from calving until the cow conceived again after insemination.
- Services per Conception (S/C): the number of inseminations required to achieve conception.
- Calving Interval (CI): The time interval between one calving and the subsequent calving.
- Parity: the total number of calves born from an individual cow.
- Body Condition Score (BCS): Body condition evaluated by visual observation and palpation of the ribs, back, pelvis, tail head, and pins, using a scale from 1 (emaciated) to 5 (obese) (WHFF, 2022).

Data analysis

Data were analyzed descriptively to obtain the mean, minimum, maximum, and standard deviation for each reproductive variable. Differences among parities were tested using Analysis of Variance (ANOVA) at a 5% significance level. The relationship between BCS and reproductive variables was assessed using Spearman's rho correlation with SPSS software version 25. The BCS assessment results were compared with the recommendations of the World Holstein Friesian Federation (WHFF, 2022).

RESULTS AND DISCUSSION

Reproductive performance

Postpartum mating (PPM): The average interval from calving to first service (postpartum mating; PPM) in this study was 81.20 ± 46.20 days Table 1. This value falls within the efficient range for dairy cattle reproductive management (< 90 days) as reported by Christi *et al*. (2023). However, the wide variation observed (30–376 days) suggests substantial heterogeneity in reproductive management and physiological recovery among cows within the Greenfields smallholder partnership. Such variation may reflect differences in estrus detection accuracy, nutritional management, and overall farm-level practices.

These results align with previous reports indicating that the timing of the first postpartum service is largely determined by the rate of uterine involution and the resumption of ovarian cyclicity (Pryce *et al*., 2001). International studies have also emphasized that insemination conducted 60–90 days postpartum is optimal, as this period corresponds with complete uterine recovery and the re-establishment of estrous cycles (Crowe *et al*., 2014; Lucy, 2001; Walsh *et al*., 2011).

Within the context of the Greenfields scheme, the average PPM close to the efficient range highlights the potential benefits of structured partnership systems, where reproductive records are routinely monitored. Nevertheless, the presence of cows with prolonged PPM underscores the need for more consistent estrus detection training and nutritional interventions at the smallholder level. Addressing these factors could reduce variation and improve overall herd reproductive efficiency.

Table 1: Postpartum mating (PPM) of Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Parity	N (cows)	Mean ± SD (days)	Min (days)	Max (days)
I	130	85.05 ± 52.97	30	376
II	70	73.71 ± 34.99	31	234
III	18	82.50 ± 25.39	40	125
Total	218	81.20 ± 46.20	30	376

Service per conception (S/C)

The average number of services per conception (S/C) in this study was 3.36 ± 2.15 Table 2, which is substantially higher than the recommended standard of 1.5–2.0 (Opsomer *et* *al*., 2000; Walsh *et al*., 2011). This finding suggests that cows within the Greenfields smallholder partnership face reproductive inefficiencies that may reduce conception success rates.

A high S/C value is typically indicative of underlying reproductive challenges, which may include inaccurate estrus detection, suboptimal artificial insemination practices, poor semen quality, or the presence of reproductive disorders (Arezhi *et al*., 2025; Diskin and Morris, 2008). The wide variation observed in this study also reflects inconsistencies in management practices across participating smallholder farms.

An increasing trend in S/C with advancing parity was noted, consistent with Ananda *et al*. (2020), who reported a positive correlation between cow age and the number of insemination attempts required. More recent international studies have reinforced this association, highlighting that higher S/C values are closely linked to lower conception rates and prolonged days open, ultimately extending the calving interval (Zetouni *et al*., 2018).

In the context of the Greenfields scheme, the elevated S/C underscores the importance of strengthening farmer capacity in estrus detection and ensuring the consistent application of artificial insemination protocols. Partnership-based monitoring could provide a valuable platform for training and supervision, thereby reducing the number of services required per conception and improving overall reproductive efficiency.

Table 2: Services per conception (S/C) of Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Parity	N (cows)	Mean ± SD (days)	Min (days)	Max (days)
I	59	3.08 ± 1.69	1	9
II	128	3.34 ± 2.19	1	12
III	60	3.65 ± 2.45	1	11
Total	247	3.36 ± 2.15	1	12

Days open (DO)

The average days open (DO) in the study population was 176.66 ± 101.45 days Table 3, which is considerably higher than the recommended range of 85–120 days (Kartikasari, 2015). This prolonged DO indicates reduced reproductive efficiency within the Greenfields smallholder partnership scheme.

When compared with previous studies, the present value was lower than that reported by Wicaksono (2019) in Jabung District (226 days) but higher than the findings of Setyaningrum (2019) in Kediri (126–144 days). The broad range in this study (45–516 days) highlights heterogeneity in reproductive management among farmers, likely reflecting differences in estrus detection accuracy, insemination timing, and nutritional support across herds.

Prolonged DO not only delays conception but also extends the calving interval, thereby reducing herd productivity and increasing economic losses (Zainudin *et al*., 2013; Walsh *et al*., 2011). Recent studies have further confirmed that extended DO is a key indicator of inefficiency in tropical dairy production systems, where environmental and management pressures exacerbate reproductive challenges (Nogalski and Barański, 2023).

In the Greenfields partnership context, the observed DO underscores both the potential and the limitations of smallholder integration. While partnership-based record-keeping provides opportunities for better monitoring, variability across farms suggests a need for targeted interventions such as farmer training on estrus detection, improved synchronization programs, and consistent nutritional management during the postpartum period. Strengthening these components would help reduce DO and improve overall reproductive performance under the partnership model.

Table 3: Days open (DO) of Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Parity	N (cows)	Mean ± SD (days)	Min (days)	Max (days)
I	117	183.44 ± 101.90	45	487
II	64	166.55 ± 105.09	51	516
III	10	162.10 ± 67.70	61	273
Total	191	176.66 ± 101.45	45	516

Calving interval (CI)

The average calving interval (CI) in this study was 434.95 ± 99.04 days Table 4, which exceeds the recommended range of 365–420 days (Pryce *et al*., 2004). This extended CI reflects delayed reconception after parturition and highlights ongoing reproductive inefficiencies in the Greenfields smallholder partnership scheme. When compared with earlier studies, the present finding was better than that of Wicaksono (2019) in Jabung District (493 days) but higher than the results of Setyaningrum (2019) in Kediri (414 days). The variation observed across cows further suggests inconsistencies in management, particularly in estrus detection, insemination timing, and postpartum nutritional support.

Prolonged CI has serious implications: it increases maintenance costs, raises the likelihood of premature culling, and ultimately reduces overall productivity of dairy herds (Budiyanto *et al*., 2016; Roxström *et al*., 2001). Moreover, CI has been increasingly incorporated into breeding objectives worldwide, as it provides a robust indicator of both reproductive sustainability and herd longevity (Hu *et al*., 2021).

In the Greenfields context, the elevated CI underscores the need for more uniform reproductive management practices across participating farmers. Strengthening capacity in estrus detection, optimizing insemination protocols, and ensuring adequate postpartum nutrition are critical strategies to shorten CI. The structured nature of the partnership system could be leveraged to implement standardized reproductive monitoring, thereby reducing CI and improving long-term herd productivity and sustainability.

Table 4: Calving interval (CI) of Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Parity	N (cows)	Mean ± SD (days)	Min (days)	Max (days)
I	75	448.67 ± 105.95	299	736
II	24	394.67 ± 60.22	326	561
III	1	373.00 ± 00.00	373	373
Total	100	434.95 ± 99.04	299	736

Body condition score (BCS)

The average body condition score (BCS) of cows in this study was 2.33 ± 0.34 Table 5, which falls within the moderate category. Values remained relatively consistent across parities, although some cows exhibited low BCS (1.75), indicating inadequate energy reserves. A moderate BCS generally reflects balanced nutritional management; however, individuals with low scores remain at risk of impaired fertility.

Low BCS has been associated with delayed postpartum estrus, slower follicular development, and prolonged calving intervals (Berry *et al*., 2003). Caixeta *et al*. (2013) further noted that the lowest BCS typically occurs at 60–80 days in milk, which coincides with the critical period for conception. Genetic correlations between BCS, health, and reproductive traits have also been reported to be relatively high, underscoring the importance of maintaining stable body condition for overall herd performance (Pryce *et al*., 2001; Berry *et al*., 2003).

Within the Greenfields partnership scheme, the generally moderate average BCS suggests that cows receive adequate nutrition under structured management support. Nevertheless, the presence of cows with critically low BCS points to variability in feed quality and availability among smallholder farms. This highlights the need for more consistent nutritional interventions, particularly during the transition and early lactation periods, when cows are most vulnerable to energy deficits. Partnership-based monitoring and advisory services could be leveraged to standardize feeding practices across farms, thereby stabilizing BCS and enhancing reproductive efficiency.

Table 5: Body condition score (BCS) of Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Parity	N (cows)	Mean ± SD (score)	Min (score)	Max (score)	Category
I	60	2.32 ± 0.38	1.75	3.25	Moderate
II	58	2.36 ± 0.30	2.00	3.25	Moderate
III	18	2.25 ± 0.29	2.00	3.00	Moderate
Total	136	2.33 ± 0.34	1.75	3.25	Moderate

Correlation of reproductive performance

The analysis revealed that postpartum mating (PPM) was moderately correlated with days open (DO) ($r = 0.316$; $p < 0.05$) and calving interval (CI) ($r = 0.290$; $p < 0.05$). This suggests that delays in the first service after parturition are associated with prolonged open days and, consequently, extended calving intervals. A very strong correlation was also observed between DO and CI ($r = 0.807$; $p < 0.01$), confirming that longer DO directly contributes to longer CI.

These findings are consistent with previous reports indicating that extended DO not only lengthens CI but also increases the risk of premature culling and reduces lifetime productivity of dairy cows (Walsh *et al*., 2011; Hu *et al*., 2021). Such outcomes have direct economic implications for farmers, particularly in smallholder systems where herd size is limited and each cow's reproductive contribution is critical.

In the context of the Greenfields partnership, these correlations highlight the interconnected nature of reproductive parameters and the importance of timely conception for sustaining herd productivity. Partnership-based monitoring provides opportunities to track reproductive records systematically; however, the strong association between DO and CI indicates that improved estrus detection and insemination management remain urgent priorities. Addressing these factors at the farm level would not only shorten CI but also enhance the profitability and sustainability of smallholder dairy enterprises integrated into structured partnership schemes.

Correlation of BCS with reproductive performance

The analysis showed that body condition score (BCS) was negatively correlated with postpartum mating (PPM), days open (DO), and calving interval (CI), although these correlations were not statistically significant ($p > 0.05$). This trend suggests that cows with higher BCS tended to be inseminated earlier, experienced shorter open days, and had reduced calving intervals, underscoring the biological importance of body reserves for reproductive success.

Table 6: Correlations of reproductive performance in Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

No	Variable	Correlated variable	Parity	Correlation coefficient (r)	Significance (p)
1	Post partus mating	Services per conception	1	0.066	0.660
			2	-0.104	0.404
			3	0.552	0.022
			Total	-0.037	0.683
		Days open	1	0.265**	0.005
			2	0.444**	0.001
			3	0.408	0.242
			Total	0.316**	0.000
		Calving interval	1	0.300*	0.011
			2	0.390	0.081
			Total	0.290*	0.006
2	Servis per conception	Days open	1	0.224	0.160
			2	0.012	0.926
			3	0.190	0.599
			Total	0.106	0.264
		Calving interval	1	0.445*	0.023
			2	0.071	0.743
			Total	0.142	0.331
3	Days open	Calving interval	1	0.949**	0.000
			2	0.779**	0.000
			Total	0.807**	0.000

These findings are consistent with earlier reports. Carvalho *et al*. (2014) observed that dairy cows maintaining a stable BCS during early lactation had higher conception rates compared with those experiencing body condition loss. Similarly, Berry *et al*. (2003) demonstrated significant genetic associations between BCS and fertility, with lower BCS linked to increased susceptibility to reproductive disorders. Such evidence highlights the necessity of maintaining adequate body condition to ensure reproductive efficiency.

Within the Greenfields partnership scheme, the generally moderate average BCS indicates that structured management support contributes to nutritional adequacy. However, the negative correlations observed though not significant suggest that variability in feeding practices across smallholder farms still influences reproductive outcomes. Strengthening nutritional management, particularly during the transition and early lactation periods, would help stabilize BCS and enhance fertility. Partnership-based advisory services could play a pivotal role in standardizing feeding practices and ensuring that smallholders maintain cows at optimal body condition, thereby improving reproductive efficiency and long-term herd sustainability.

Table 7: Correlation of body condition score (BCS) with reproductive performance variables in Friesian Holstein cows under the Greenfields Partnership, Malang, Indonesia.

Variable	Correlated Variable	Correlation coefficient (r)	Significance (p)
BCS	PPM	-0.142	0.105
	S/C	0.074	0.400
	DO	-0.044	0.630
	CI	-0.041	0.718

CONCLUSION

The Greenfields Partnership demonstrates that structured organization improves record uniformity but does not guarantee reproductive efficiency. Despite standardized AI and feeding programs, wide variability across parameters indicates inconsistent implementation at farm level. Key actions should focus on: (1) enhanced estrus-detection accuracy, (2) AI timing precision, and (3) BCS stabilization through consistent feeding. Partnership specific recommendations include digital reproductive-record auditing, technician and farmer performance feedback, and parity-based reproductive benchmarking. Strengthening these feedback mechanisms within the Greenfields framework can transform structural organization into measurable fertility gains.

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NOVELTY STATEMENT

This study introduces an empirical insight that structured partnerships improve data consistency but not necessarily reproductive outcomes unless behavioral and managerial compliance is maintained. It refines the understanding of partnership models in tropical dairying by showing that biological efficiency depends on implementation quality rather than organizational structure alone.

AUTHOR'S CONTRIBUTION

DWI (Donny Wahyu Indriatmoko – First Author): Led the study design, coordinated fieldwork, collected reproductive and management data, performed statistical analysis, and drafted the initial manuscript.
SS (Suyadi): Provided methodological guidance, supported data interpretation, and contributed to manuscript revision.
PS (Puguh Surjowardojo): Assisted in field coordination, validated reproductive records and management information, and provided technical input during manuscript development.
KK (Kuswati Kuswati): Contributed to conceptual refinement, reviewed the reproductive performance discussion, and assisted in academic and editorial corrections.
TES (Tri Eko Susilorini – Corresponding Author): Supervised the overall research process, validated analytical results, critically reviewed and refined the manuscript, and approved the final version for submission.
All authors read and approved the final manuscript.

Practical implications

Improving reproductive efficiency in smallholder partnerships requires aligning managerial behavior with structural standards. The integration of real-time reproductive data auditing, technician evaluation, and nutrition monitoring can enhance accountability and fertility outcomes within partnership schemes.

Generative AI and AI-assisted technology statement

The authors acknowledge that generative AI and AI-assisted tools (such as Grammarly and ChatGPT) were used solely for language editing, refining grammar, and improving readability. No AI tools were used to generate, analyze, or interpret data, nor to draw scientific conclusions.
The authors take full responsibility for the content and integrity of the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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