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FROM TIMELY ESTRUS TO FOOD SECURITY: AN SDG-BASED APPROACH TO LIVESTOCK REPRODUCTIVE MANAGEMENT AND FARMER WELFARE IN GRATI, PASURUAN, INDONESIA

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ABSTRACT

Livestock reproductive efficiency is an important determinant of sustainable livestock production, food security, and farmer welfare. This community-based program aimed to strengthen farmers' knowledge and practical skills in livestock reproductive management through an SDG-based assistance program in Grati District, Pasuruan Regency, East Java, Indonesia. The program was implemented in collaboration with the BRMP for Large Ruminants in Grati and involved livestock farmers as the primary participants. The activities consisted of preliminary assessment, reproductive management education, practical training on estrus detection and breeding management, field assistance, and activity evaluation using a structured questionnaire. A total of 24 respondents participated in the evaluation, comprising predominantly male participants (95.8%), with 79.2% having more than 10 years of livestock-farming experience and 79.2% working primarily as livestock farmers. The participant profile indicated substantial practical farming experience but generally limited formal educational backgrounds, emphasizing the importance of practical and farmer-oriented reproductive management training. The program provided an opportunity to integrate farmers' experiential knowledge with evidence-based reproductive management practices, particularly in estrus detection and appropriate breeding management. The intervention represents a community-based approach that may contribute to improved livestock reproductive management and, indirectly, to sustainable livestock production, food security, and farmer welfare. Further evaluation using pre-test and post-test scores and reproductive performance indicators is required to quantify the effectiveness of the intervention.

Keywords: Cattle; Estrus detection; Reproductive management; Farmer empowerment; Food security; Sustainable Development Goals.

1 INTRODUCTION

Livestock production plays an important role in food systems, rural livelihoods, and sustainable agricultural development. Beyond its contribution to the supply of animal-source foods, livestock provides income, productive assets, and livelihood support for rural households. The Food and Agriculture Organization of the United Nations (FAO) recognizes livestock as an important contributor to food security, nutrition, poverty reduction, and economic development, particularly within smallholder farming systems (FAO, 2016; FAO, 2026).

Reproductive efficiency is a fundamental component of sustainable livestock production because reproductive performance directly influences herd productivity and the continuity of animal production. In cattle, accurate estrus detection and appropriate timing of breeding or artificial insemination are critical determinants of reproductive success. Inaccurate or missed estrus detection can reduce breeding efficiency and contribute to prolonged calving intervals and economic losses. Previous studies have identified estrus detection and the determination of appropriate insemination timing as major challenges in achieving optimal reproductive performance in cattle (Senger, 1994; Roelofs et al., 2010).

The challenge of estrus detection may be particularly relevant under tropical production conditions. Environmental, behavioral, and management factors can influence the expression and observation of estrus, making accurate identification more difficult for farmers. Therefore, improving farmers' knowledge and practical skills in recognizing estrus signs and determining appropriate breeding times is an important component of reproductive management, particularly in smallholder cattle production systems (Orihuela, 2000; Roelofs et al., 2010).

Improving livestock reproductive management also has broader implications for food security and sustainable development. The FAO emphasizes that sustainable livestock development can contribute to multiple Sustainable Development Goals (SDGs), including SDG 1 (No Poverty) and SDG 2 (Zero Hunger), through improved productivity, income generation, nutrition, and rural livelihoods (FAO, 2026). Sustainable livestock development therefore requires not only improvements in animal production but also capacity building and the adoption of evidence-based management practices by farmers.

In this context, farmer-oriented assistance and knowledge transfer can serve as important mechanisms for improving the adoption of appropriate livestock management practices. Community-based interventions that integrate technical knowledge, practical training, and collaboration among farmers, academic institutions, and government-supported livestock institutions may strengthen farmers' capacity to manage livestock reproduction more effectively. Such approaches are consistent with the FAO's emphasis on capacity building, evidence-based livestock development, and multi-stakeholder collaboration to promote sustainable and inclusive livestock systems.

Grati District, Pasuruan Regency, East Java, represents an important local context for community-based livestock development. In this setting, strengthening reproductive management through farmer assistance is expected to improve the practical capacity of livestock farmers to identify estrus and implement appropriate breeding management. Collaboration with the BRMP for Large Ruminants in Grati provides an institutional basis for transferring reproductive management knowledge and supporting the application of appropriate livestock production practices at the farmer level.

Therefore, this study aimed to implement an SDG-based livestock reproductive management assistance program in Grati District, Pasuruan Regency, Indonesia. The program focused on strengthening farmers' knowledge and practical skills in estrus detection and reproductive management. More broadly, the study aimed to demonstrate the potential contribution of improved livestock reproductive management to livestock productivity, food security, and farmer welfare within a sustainable, community-based livestock production system.

2 MATERIAL AND METHODS

2.1 Study Design and Study Area

This study employed a community-based participatory approach to strengthen livestock farmers' knowledge and practical skills in reproductive management. The program was implemented in Grati District, Pasuruan Regency, East Java, Indonesia, in collaboration with the BRMP for Large Ruminants in Grati. The intervention was designed as a structured farmer-assistance program consisting of baseline assessment, reproductive management education, practical training, field assistance, and post-intervention evaluation.

The study area was selected based on the relevance of livestock farming to local livelihoods and the need to strengthen farmers' capacity in livestock reproductive management. Collaboration with the BRMP for Large Ruminants provided technical support and facilitated the transfer of reproductive management knowledge and practices to participating farmers.

2.2 Participants

The participants were livestock farmers involved in cattle production in Grati District, Pasuruan Regency. Participants were recruited in collaboration with local farmer groups and the partner institution. Eligibility was based on active involvement in livestock husbandry and willingness to participate in the educational, practical, and evaluation components of the program.

The number of participating farmers and livestock included in the program was recorded at the beginning of the activity. Participant characteristics, including age, farming experience, herd ownership, and previous experience with reproductive management and artificial insemination, were documented using a structured questionnaire.

2.3 Program Implementation

The intervention consisted of five sequential stages: (1) preliminary assessment and coordination, (2) reproductive management education, (3) practical training and demonstration, (4) field-based assistance, and (5) monitoring and evaluation. A similar combination of counseling, practical training, demonstration, and evaluation has been applied in previous livestock reproductive-management programs and has been associated with improvements in farmers' knowledge and technical capacity.

2.4 Preliminary Assessment and Coordination

The preliminary stage involved coordination with the BRMP for Large Ruminants, local stakeholders, and participating farmer groups. The assessment was conducted to identify farmers' existing knowledge, reproductive-management practices, and major problems related to estrus detection and breeding management. Information collected during this stage included farmers' routine methods of estrus detection, timing of mating or artificial insemination, reproductive records, and difficulties encountered in managing reproductive events. The findings were used to determine the training materials and practical activities required during the intervention.

2.5 Reproductive Management Education

The educational component was delivered through interactive presentations, discussions, and question-and-answer sessions. The training materials covered basic reproductive physiology, the estrous cycle, signs of estrus, methods for improving estrus detection, appropriate breeding or artificial insemination timing, reproductive record keeping, and factors affecting reproductive performance. Particular emphasis was placed on practical recognition of behavioral and physical signs of estrus because accurate estrus detection is an important component of successful breeding management. Farmer training programs that combine theoretical instruction with practical learning have been used to improve knowledge and confidence in cattle reproductive management.

2.6 Practical Training and Demonstration

Following the educational session, participants received practical training in estrus detection and reproductive-management procedures. Demonstrations were conducted using appropriate teaching materials and, where available, livestock under field conditions. Farmers were trained to identify relevant behavioral and physical indicators of estrus and to determine the appropriate time for reporting animals for breeding or artificial insemination. Participants were encouraged to perform the identification procedures themselves under the supervision of the facilitators. The practical component was intended to transform theoretical knowledge into applicable skills that could be implemented independently at the farm level.

2.7 Field Assistance and Monitoring

Field assistance was conducted following the training to support farmers in applying the reproductive-management practices introduced during the program. Farmers were encouraged to monitor reproductive events and maintain basic reproductive records, including estrus occurrence, breeding or artificial insemination dates, and subsequent reproductive outcomes. The facilitators and technical personnel provided feedback during field visits and assisted farmers in resolving difficulties encountered during implementation. Continued assistance was considered important because previous community-based reproductive programs have shown that farmers may require follow-up guidance before they can consistently apply reproductive technologies independently.

2.8 Evaluation of Farmer Knowledge and Skills

The effectiveness of the educational intervention was evaluated using a pre-test and post-test design. The same or equivalent structured questionnaire was administered before and after the intervention to assess changes in farmers' knowledge of livestock reproductive management.

The questionnaire covered key topics including reproductive physiology, estrus characteristics, estrus detection, appropriate breeding timing, and basic reproductive management. Each correct response was assigned a score, and the total score was converted into a percentage using the following equation:

Knowledge score (%) = (Number of correct responses / Total number of questions) × 100

Practical skills were assessed through direct observation during the practical training and field-assistance sessions. The assessment focused on farmers' ability to recognize major estrus signs, identify animals requiring breeding services, and apply the recommended reproductive-management procedures. The use of pre-test and post-test assessments combined with practical observation has been applied in previous farmer reproductive-management programs.

2.9 Reproductive Performance Indicators

Where reproductive records were available, selected reproductive indicators were documented to complement the assessment of farmer knowledge and skills. These indicators included the number of animals identified in estrus, number of animals presented for breeding or artificial insemination, and subsequent reproductive outcomes. Where applicable, pregnancy status was determined through the routine diagnostic procedure performed by qualified veterinary or animal-health personnel. Reproductive records were used descriptively to assess the practical application of the intervention and were not interpreted as evidence of a causal treatment effect unless an appropriate experimental or quasi-experimental design was implemented.

2.10 Data Analysis

Descriptive statistics were used to summarize participant characteristics, livestock characteristics, training participation, and reproductive-management indicators. Changes in farmers' knowledge were evaluated by comparing pre-test and post-test scores. For paired observations, the statistical significance of changes in knowledge scores should be assessed using a paired-samples statistical test. A paired *t*-test may be used when the difference scores meet the assumptions of approximate normality; otherwise, the Wilcoxon signed-rank test should be applied. Statistical significance was considered at $p < 0.05$. Qualitative observations obtained during discussions, practical sessions, and field assistance were summarized descriptively to identify changes in farmers' understanding, practical difficulties, and adoption of recommended reproductive-management practices.

2.11 Ethical and Institutional Considerations

The activity was conducted in collaboration with the relevant institutional and local stakeholders. Participation in the educational and evaluation activities was voluntary, and information obtained from participating farmers was used for program evaluation and scientific reporting. Personal identifying information was not included in the analysis or reported in the manuscript.

3 RESULTS AND DISCUSSION

3.1 Participant Characteristics

A total of 24 participants were recorded as respondents in the community-based livestock reproductive management assistance program conducted in Grati District, Pasuruan Regency, East Java, Indonesia. The participants were predominantly male, with 23 men (95.8%) and one woman (4.2%). This distribution indicates that livestock-related activities in the participating community were largely represented by male farmers. Although sex was not an experimental variable in this program, participant characteristics are relevant when interpreting the reach and inclusiveness of community-based agricultural interventions.

The educational background of the participants was predominantly elementary school level. Sixteen participants (66.7%) had completed elementary school or an equivalent level, while two participants (8.3%) reported no formal education. One participant (4.2%) had completed junior high school, two (8.3%) had completed senior high school/vocational high school, one (4.2%) had a diploma qualification, and two (8.3%) had an undergraduate degree. No participant reported a master's degree. This educational profile emphasizes the importance of using practical, visual, and context-specific approaches when delivering technical information concerning livestock reproductive

management. Farmer-oriented extension and knowledge-transfer approaches are particularly important when technical recommendations need to be translated into routine management decisions at the farm level.

In terms of occupation, 19 participants (79.2%) were livestock farmers, whereas five participants (20.8%) were classified as having other occupations. No participants were recorded as extension officers, BRMP personnel, or students. The high proportion of livestock farmers indicates that the program reached its primary target group, namely community members directly involved in livestock production. Direct engagement with farmers is important because reproductive management decisions, including estrus observation and the timing of breeding or artificial insemination, are frequently made at the farm level.

The participants also had considerable livestock-farming experience. Nineteen participants (79.2%) had been raising livestock for more than 10 years, four participants (16.7%) had 5–10 years of experience, and only one participant (4.2%) had less than five years of experience. The predominance of experienced farmers suggests that the intervention was implemented among participants who already possessed substantial experiential knowledge of livestock husbandry. Nevertheless, farming experience should not be considered equivalent to mastery of reproductive management. Reproductive efficiency depends on specific competencies, including recognition of estrus, appropriate timing of breeding, reproductive record keeping, and monitoring of reproductive outcomes (Senger, 1994; Roelofs et al., 2010; Walsh et al., 2011).

Table 1: Demographic and farming characteristics of participants

Characteristic	Category	n	%
Sex	Male	23	95.8
	Female	1	4.2
Education	No formal education	2	8.3
	Elementary school/equivalent	16	66.7
	Junior high school/equivalent	1	4.2
	Senior high school/vocational school	2	8.3
	Diploma (D1–D4)	1	4.2
	Bachelor's degree (S1)	2	8.3
	Master's degree (S2)	0	0.0
Occupation	Livestock farmer	19	79.2
	Extension officer	0	0.0
	BRMP personnel	0	0.0
	Student	0	0.0
	Other	5	20.8
Livestock-farming experience	<5 years	1	4.2
	5–10 years	4	16.7
	>10 years	19	79.2

3.2 Relevance of Participant Characteristics to Reproductive Management

The high proportion of experienced farmers is an important finding because reproductive-management interventions should build upon farmers' existing experiential knowledge rather than assuming that participants have no prior knowledge. Practical livestock experience may provide farmers with familiarity with animal behavior and routine husbandry, but accurate estrus detection requires recognition of specific behavioral and physical indicators and appropriate interpretation of these signs (Orihuela, 2000; Roelofs et al., 2010).

Estrus detection is widely recognized as one of the critical components of cattle reproductive management. Inadequate detection can result in missed estrus, inappropriate timing of artificial insemination, extended calving intervals, and increased reproductive costs (Senger, 1994; Roelofs et al., 2010; Walsh et al., 2011). Roelofs et al. (2010) emphasized that successful estrus detection depends not only on the expression of estrus by the animal but also on the farmer's

ability to recognize and interpret the associated behavioral changes. The timing and frequency of observation also influence detection efficiency. Similarly, Senger (1994) identified inefficient estrus detection as a major limitation in reproductive management and highlighted the need for improved approaches to recognizing estrous animals.

The issue is particularly relevant under tropical production conditions. Orihuela (2000) reported that environmental and social factors can influence the expression and observation of estrus in cattle maintained under tropical conditions. Behavioral manifestations may be less conspicuous under certain management and environmental circumstances, increasing the possibility of missed estrus. More recent reviews likewise emphasize that estrus expression is affected by cow-related, environmental, housing, and management factors (Valenza et al., 2012; Roelofs et al., 2017).

Therefore, the finding that most participants had more than 10 years of farming experience should not be interpreted as evidence that additional reproductive training is unnecessary. Instead, the result indicates an opportunity to integrate farmers' long-term practical experience with evidence-based reproductive management. Such integration is particularly important because reproductive performance is influenced by multiple interacting factors, including estrus expression, observation frequency, health, nutrition, postpartum status, environmental conditions, and breeding management (Walsh et al., 2011; Crowe et al., 2014).

3.3 Importance of Accurate Estrus Detection

The emphasis on estrus detection in the present program is supported by extensive reproductive research. Estrus detection is a prerequisite for successful implementation of conventional artificial insemination because insemination must be appropriately synchronized with the reproductive events associated with ovulation (Senger, 1994; Roelofs et al., 2010). Inaccurate detection may lead to insemination of animals that are not actually in estrus, whereas failure to detect estrus can result in missed breeding opportunities and prolonged days open.

Roelofs et al. (2010) reported that the expression of standing estrus alone does not capture all estrous events, and several secondary behavioral signs can contribute to improved detection. These include mounting activity, increased locomotion, chin resting, licking, sniffing, and changes in social behavior. Consequently, farmer training should emphasize recognition of multiple indicators rather than reliance on a single behavioral sign.

This consideration is further supported by research on estrus behavior under different production environments. A review by Valenza et al. (2012) demonstrated that estrus expression and detection can be affected by environmental and management conditions, while a later review by Roelofs et al. (2017) emphasized the importance of understanding the range of behavioral signs associated with estrus.

The limitations of visual estrus detection have also stimulated the development of technological approaches. Nebel et al. (2000) and Firk et al. (2002) reviewed the use of activity monitoring and other automated approaches for detecting estrus. Such technologies can improve detection efficiency, although their applicability and cost may be limiting factors in smallholder production systems. For community-based livestock systems such as those represented in Grati, strengthening farmers' ability to perform systematic visual observation remains a practical and relatively accessible strategy.

3.4 Implications for Farmer Capacity Building

The demographic profile indicates that the intervention had to accommodate participants with heterogeneous educational backgrounds and substantial differences in farming experience. This supports the use of participatory and practice-oriented extension methods. Rather than presenting reproductive physiology exclusively through theoretical explanations, the program emphasized the recognition of observable estrus signs and their application to breeding decisions.

Such an approach is consistent with the broader development of practical reproductive management, in which successful reproduction depends on coordinated management activities, accurate observation, appropriate breeding decisions, and systematic reproductive records (Lucy, 2001; Walsh et al., 2011; Wiltbank et al., 2016). Modern reproductive management increasingly integrates animal observation, reproductive records, diagnostic technologies, and decision-support systems to improve reproductive efficiency (Fricke et al., 2014; Senger, 1994).

For smallholder farmers, however, the most appropriate intervention is not necessarily the adoption of sophisticated technologies. Instead, interventions should be adapted to local resources, farmer capacity, and production conditions. Training farmers to observe estrus systematically, recognize multiple behavioral indicators, report animals promptly, and maintain basic reproductive records may represent an important first step toward improved reproductive efficiency.

3.5 Reproductive Management, Food Security, and Farmer Welfare

The relevance of reproductive management extends beyond individual animal fertility because reproductive efficiency influences the continuity and productivity of livestock production. Improved reproductive performance can increase the efficiency of herd replacement, maintain productive animal numbers, and support the availability of livestock-derived food products. Livestock therefore has an important role in food systems and rural livelihoods, particularly in smallholder agricultural systems.

At the global level, sustainable livestock development has been recognized as contributing to food security, nutrition, poverty reduction, and rural livelihoods. The Food and Agriculture Organization emphasizes that sustainable livestock development can support food security and nutrition while contributing to the achievement of the Sustainable Development Goals. In this context, interventions that strengthen farmer capacity in reproductive management may contribute indirectly to SDG 2 (Zero Hunger) and SDG 1 (No Poverty), provided that improved management translates into measurable improvements in livestock productivity and household economic outcomes.

However, the present demographic results alone cannot demonstrate an improvement in food security or farmer welfare. These outcomes require additional evidence, such as changes in reproductive performance, livestock productivity, household income, or farmer-level perceptions of economic benefits. Therefore, claims concerning the contribution of the program to food security and welfare should be supported by the subsequent evaluation results rather than inferred solely from participant characteristics.

3.6 Age Distribution

The age data supplied for the evaluation require verification before being included in the final statistical analysis. The reported frequencies were 23 participants aged <25 years, 2 participants aged 25–35 years, 1 participant aged 36–45 years, 3 participants aged 46–55 years, and 18 participants aged >55 years. These values sum to 47 participants and are therefore inconsistent with the total of 24 participants identified in the other demographic categories. Consequently, the age distribution should be checked against the original questionnaire dataset before publication. Correcting this discrepancy is important because participant age may influence interpretation of farming experience, adoption of new practices, and participation in extension activities. The corrected age distribution should subsequently be presented together with the other demographic characteristics.

3.7 Overall Interpretation

Overall, the participant profile demonstrates that the program primarily reached livestock farmers with extensive practical experience but generally limited formal educational backgrounds. This combination provides a strong rationale for reproductive-management assistance based on practical demonstrations, participatory learning, and direct farmer–technical expert interaction. The scientific literature consistently demonstrates that effective reproductive management requires accurate estrus detection, appropriate breeding timing, systematic observation, and adequate reproductive records (Senger, 1994; Roelofs et al., 2010; Walsh et al., 2011). Estrus detection remains challenging because its expression varies among animals and is affected by environmental and management conditions (Orihuela, 2000; Roelofs et al., 2017).

Thus, the demographic findings support the relevance of implementing farmer-centered reproductive management assistance in Grati. Nevertheless, the effectiveness of the intervention itself should be established using the program's pre-test and post-test results, practical skill assessments, participant satisfaction, and available reproductive performance indicators. These outcome measures will provide stronger evidence regarding whether the intervention achieved its intended objectives of improving reproductive-management capacity and contributing to sustainable livestock production.

4 CONCLUSION

The SDG-based livestock reproductive management assistance program in Grati District successfully engaged local livestock farmers and provided a practical approach to strengthening reproductive-management capacity. The findings highlight the importance of farmer-centered education and practical training in supporting accurate estrus detection and improved reproductive management. This approach has the potential to contribute to sustainable livestock production, food security, and farmer welfare.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no financial or non-financial conflicts of interest related to this study or its publication.

Statement of ethical approval

This community-based program involved farmer education, training, and evaluation and did not involve experimental procedures on animals or human clinical research. Participation in the program and evaluation activities was voluntary.

Statement of informed consent

The participants were informed about the purpose of the activity, and the information collected was used for program evaluation and scientific reporting. Personal identifying information was kept confidential and was not disclosed in the manuscript.

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