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Effect of farmer characteristics on reproductive performance of pigs under natural mating and artificial insemination systems in Manggarai Regency, Indonesia

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Abstract

This study examines the effect of farmer characteristics on reproductive performance of pigs under natural mating (NM) and artificial insemination (AI) systems in Manggarai Regency, Indonesia. Reproductive performance was evaluated using service per conception (S/C), conception rate (CR), and non-return rate (NRR) as key indicators of fertility outcomes. A total of 100 pig farmers who had implemented both mating systems were selected using purposive sampling. Data were collected through structured interviews and field observations from November 2025 to January 2026. Multiple linear regression analysis was applied to determine the effect of farmer characteristics, while independent sample t-tests were used to compare reproductive performance between NM and AI system. The results showed that AI achieved significantly better reproductive performance than NM, as indicated by lower S/C (1.35 vs 1.68), higher CR (92% vs 82.67%), and higher NRR (90% vs 84.6%) ($p < 0.05$). Farmer characteristics, including farming experience, knowledge, attitudes, and skills, significantly influenced reproductive performance in both systems. In the AI system, psychological factors such as motivation and perception also had a significant effect. These findings indicate that AI is more effective in improving reproductive performance; however, its success is strongly dependent on farmer capacity. Therefore, strengthening farmer knowledge, technical skills, and motivation through continuous training and extension services is essential to optimize reproductive outcomes.

Keywords: Pig Reproduction; Reproductive Performance; Artificial Insemination; Farmer Characteristics; Indonesia

1. Introduction

Pig farming plays a vital role in rural agricultural economies, especially in Indonesia. Pigs are characterized by high reproductive efficiency, rapid growth rates, and substantial carcass yield, making them an economically important livestock species [1]. However, the pig population in Indonesia declined from approximately 8.25 million in 2018 to 3.77 million in 2025, mainly due to the African Swine Fever (ASF) outbreak and suboptimal reproductive management practices [2]. In Manggarai Regency, East Nusa Tenggara, pig farming has both cultural and economic importance. The pig population reached 47,829 heads in 2024, indicating gradual recovery following ASF outbreaks.

Reproductive performance in pigs is commonly assessed using service per conception (S/C), conception rate (CR), and non-return rate (NRR). Natural mating (NM) remains widely practiced due to its simplicity. However, it presents limitations such as inbreeding risk and restricted genetic improvement. In contrast, artificial insemination (AI) offers advantages in genetic progress and reproductive efficiency, although its success depends on semen quality, estrus detection, and technical competence of farmers or inseminators [3], [4], [6], [7]. Artificial insemination is an important reproductive biotechnology that has been widely applied to improve genetic quality and reproductive efficiency in livestock [5], [15], [16].

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Farmer characteristics such as age, education, experience, knowledge, attitudes, skills, perception, and motivation play an important role in reproductive outcomes. Previous studies have reported that these factors influence the adoption and success of AI systems. However, limited information is available regarding their specific effects on pig reproductive performance in Manggarai Regency. Therefore, this study aims to analyze the effect of farmer characteristics on reproductive performance under NM and AI systems and to compare the efficiency of both mating methods.

2. Materials and Methods

The study was conducted in Manggarai Regency, East Nusa Tenggara, Indonesia, a region with strong dependence on pig farming. This area provides a suitable setting for comparing natural mating and artificial insemination systems, as both are commonly practiced by farmers. A total of 100 pig farmers were selected using purposive sampling. Inclusion criteria were: (1) at least one year of farming experience, (2) experience in both NM and AI systems, and (3) willingness to participate in the study.

Data were collected from November 2025 to January 2026 using structured interviews and field observations. Secondary data were obtained from the Manggarai District Livestock Service. Independent variables included farmer characteristics (age, formal and non-formal education, farming experience, livestock ownership, household burden, land size, knowledge, attitudes, skills, perception, and motivation). Dependent variables were reproductive performance indicators: S/C, CR, and NRR.

Data were analyzed using multiple linear regression and independent samples t-test with a significance level of $p < 0.05$. Prior to analysis, data were tested for normality, multicollinearity, and heteroscedasticity. Reliability was assessed using Cronbach's alpha and validity using Pearson correlation.

3. Results and Discussion

3.1. Effect of Farmer Characteristics.

Multiple linear regression analysis indicated that farmer characteristics significantly influenced reproductive performance in both natural mating (NM) and artificial insemination (AI) systems, although the magnitude and pattern of effects differed between the two systems (Tabel 1).

In the NM system, reproductive performance was significantly affected by non-formal education, farming experience, knowledge, attitudes, and skills. Among these variables, farming experience emerged as the most influential factor, suggesting that reproductive success in NM largely depends on farmers' practical ability to detect estrus and manage mating effectively. This finding highlights that NM systems rely primarily on experiential knowledge and technical skills acquired through practice.

In contrast, the AI system showed a broader range of significant influencing factors. In addition to non-formal education, farming experience, knowledge, attitudes, and skills, psychological factors such as motivation and perception also had significant effects on reproductive performance. This indicates that AI implementation is not solely dependent on technical competence but also on farmers' cognitive and behavioral readiness to adopt and manage reproductive technologies. These findings are consistent with previous studies emphasizing that the success of AI is strongly influenced by farmer capacity, including knowledge, skills, and motivation [5]–[8], [16].

Table 1 Multiple linear regression analysis of farmer characteristics on reproductive performance under natural mating and artificial insemination system

Variable	Natural Mating (t, p)	Interpretation	Artificial Insemination (t, p)	Interpretation
Age	1.157; 0.954	Not significant	2.783; 0.038	Significant
Formal Education	1.045; 0.964	Not significant	2.694; 0.044	Significant
Non-Formal Education	2.072; 0.043	Significant	3.168; 0.002	Significant
Farming Experience	3.112; 0.003	Significant	4.913; 0.001	Significant
Livestock Ownership	2.360; 0.020	Significant	1.563; 0.122	Not significant

Household Burden	1.060; 0.952	Not significant	1.432; 0.666	Not significant
Land Size	1.013; 0.990	Not significant	1.187; 0.238	Not significant
Knowledge	2.210; 0.034	Significant	3.881; 0.001	Significant
Attitude	2.848; 0.005	Significant	3.998; 0.001	Significant
Skills	3.173; 0.002	Significant	3.954; 0.001	Significant
Perception	1.214; 0.831	Not significant	2.533; 0.013	Significant
Motivation	1.266; 0.791	Not significant	3.255; 0.002	Significant

Notes: not significant ($p \geq 0.05$); significant ($p < 0.05$); Values presented as t-value; p-value.

Overall, these results demonstrate a fundamental difference between the two systems: NM is predominantly influenced by experiential and technical factors, whereas AI is more complex and influenced by a combination of technical, educational, and psychological factors.

3.2. Comparison of reproductive performances.

The independent samples t-test revealed significant differences in reproductive performance between NM and AI systems (Figure 1). AI achieved lower service per conception (S/C) values (1.35 vs 1.68), higher conception rates (CR) (92% vs 82.67%), and higher non-return rates (NRR) (90% vs 84.6%), indicating superior reproductive efficiency compared to NM.

These findings suggest that AI provides more controlled breeding conditions, including the use of high-quality semen and precise timing of insemination, which contribute to improved fertility outcomes. Similar results have been reported in previous studies demonstrating that AI enhances reproductive efficiency compared to natural mating systems [6], [12], [15], [16].

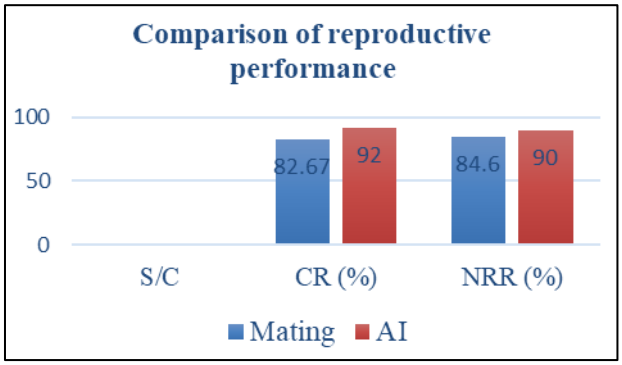

Figure 1 Comparison of reproductive performance (service per conception, conception rate, and non-return rate) between natural mating and artificial insemination systems. Values are expressed as mean percentages

3.3. Implication for farmer training.

The findings highlight the critical role of farmer capacity in determining reproductive performance in both systems. Key factors such as experience, knowledge, skills, and motivation were consistently associated with improved outcomes. Farmer characteristics have been widely recognized as important determinants of livestock productivity and development [9].

In AI systems, the role of human factors becomes even more pronounced. The success of artificial insemination depends not only on biological and technical aspects but also on the competence of farmers and inseminators in implementing proper procedures [10]. Furthermore, farmer motivation has been identified as a key driver of adoption and performance in livestock production systems [11].

Socioeconomic factors, including farmer characteristics, also contribute to variations in productivity and farm income, reinforcing the importance of human capital in livestock systems [13], [14]. Therefore, strengthening farmer capacity

through continuous training, extension services, and technical support is essential to optimize reproductive performance, particularly in AI-based systems.

3.4. Synthesis with Previous Studies.

The results of this study are consistent with previous findings indicating that artificial insemination improves reproductive performance compared to natural mating, while farmer-related factors significantly influence reproductive outcomes. This agreement with prior research strengthens the conclusion that both technological and human factors must be considered simultaneously to achieve optimal reproductive efficiency in livestock production systems.

4. Conclusion

Artificial insemination (AI) demonstrates significantly higher reproductive performance than natural mating, as indicated by improved S/C, CR, and NRR values. However, reproductive performance in both systems is strongly influenced by farmer characteristics, particularly farming experience, knowledge, skills, and motivation. AI is more sensitive to psychological factors such as motivation and perception, which play an important role in determining its success. Therefore, strengthening farmer capacity through continuous training and extension services is essential to optimize reproductive performance and ensure sustainable pig farming systems.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

This study was conducted in accordance with ethical standards. Data collection involving farmers and livestock was approved by relevant institutional authorities.

Statement of informed consent

Informed consent was obtained from all participating farmers prior to data collection. Participants were informed about the objectives of the study, and their participation was entirely voluntary.

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