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Literature Review

Evaluation of Embryo Transfer Pregnancy in Beef Cattle

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Abstract

Embryo transfer is one of the reproductive biotechnologies that enables rapid and controlled improvement in genetic quality and livestock populations. This technology allows embryos resulting from fertilisation in superior donor cows to be implanted into recipient cows, thereby producing offspring with high genetic potential without reducing the reproductive capacity of the donor cows. This study aims to evaluate the success of embryo transfer (ET) in beef cattle and the factors influencing the birth rate of calves resulting from ET in Lamongan District. Embryo transfer is a promising assisted reproductive technology for accelerating genetic improvement in beef cattle. The research method used in this study is a literature review employing a quantitative descriptive approach. The study was conducted on community-owned embryo transfer farms in Lamongan District over two months, using eight beef cattle as recipients. Data collection methods involved obtaining data from secondary sources related to embryo transfer outcomes at community-owned embryo transfer farms in Lamongan District. The variable in the study was pregnancy rate. The results showed that the pregnancy rate reached 50%, consistent with the general success range for ET (40–70%). All pregnancies were achieved through embryo placement in the upper third of the uterine horn and natural oestrus synchronisation. However, all pregnancies ended in abortion during the second trimester (4–6 months of age). The main identified causes include unverified embryo quality, genetic incompatibility, environmental stress, micronutrient deficiencies, and inadequate post-transfer management. The evaluation showed farmers had varying education and experience, but lacked sufficient technical training.

Keywords: Beef Cattle, Embryo Transfer, Genetic Improvement, Pregnancy Rate, Reproductive Biotechnology, Post-Transfer Management.

1. Introduction

The demand for beef consumption in Indonesia has been steadily increasing, driven by population growth and growing public awareness of the importance of animal protein intake. Unfortunately, domestic beef production capacity remains insufficient to meet domestic demand, forcing Indonesia to continue relying on beef imports from abroad. To address this issue, various reproductive technologies have been implemented with the aim of increasing the population and productivity of beef cattle, including the application of embryo transfer (ET) technology. Embryo transfer is a reproductive biotechnology that enables the improvement of genetic quality and population size of livestock in an efficient and controllable manner. Through this technology, embryos produced from the fertilisation process of high-quality donor cattle can be transferred to recipient cattle, thereby producing offspring with superior genetic potential without reducing the reproductive capacity of the donor parent.

According to Kadarmideen et al. (2018), the application of embryo transfer technology, especially when integrated with genomic selection, shows great potential in accelerating the

genetic improvement process and increasing cattle production efficiency on a commercial scale. Embryo transfer (ET) is one form of assisted reproductive technology proven to enhance genetic quality and accelerate the production of high-quality livestock. This procedure involves retrieving embryos from donor cows with superior genetic traits through superovulation, followed by transferring the embryos to recipient cows that will carry and give birth to the offspring from those embryos (Hasler, 2014).

The beef cattle industry makes a significant contribution to community economic growth. Beef cattle contribute to economic growth in Indonesia, in addition to being a source of animal protein (Bilyaro et al., 2024). Beef cattle production will continue to increase to meet the demand for animal protein. Genetics is an important factor that can influence cattle productivity (Otoluwa et al., 2016).

Lamongan is one of the districts with high potential for beef cattle development; however, information regarding the effectiveness of embryo transfer (ET) and the performance of calves resulting from ET in the area is still insufficient. Research conducted by Nurkhasanah (2016) at the Cipelang Livestock Embryo Centre in Bogor showed that the success rate of ET in Limousin cattle reached 34.04%, which was better than Simmental cattle with a success rate of 22.50%. These findings indicate that Limousin cattle have promising prospects for ET programmes in Indonesia.

An investigation by Alam (2024) compared the results of the superovulation programme with the subcutaneous method in Simmental and Limousin cattle at the Cipelang Bogor Livestock Embryo Centre. The study results showed that the average percentage of viable embryos for transfer in Limousin cattle was 4.5%, while in Simmental cattle it reached 4.8%. Although the difference was not significant, this data holds important value in determining the optimal superovulation approach.

Although embryo transfer technology has been widely adopted, continuous assessment of the procedure's effectiveness and the performance of the resulting calves remains necessary. This is crucial for evaluating the success of embryo transfer programmes and identifying the factors contributing to their success (Adriani et al., 2007).

Pregnancy rates, embryo transfer-related abortions, and evaluation of embryo transfer (ET) recipient farmers are some factors that must be assessed to determine the success of embryo transfer. Meanwhile, birth weight and calf mortality rates are used to evaluate calf performance after embryo transfer (Ihsan & Wahjuningsih, 2011).

In a global context, the FAO training guidelines on embryo transfer in cattle highlight that effective management, including the selection of suitable donors and recipients, the use of high-quality semen, and the application of appropriate transfer techniques which has a significant impact on the success of ET. According to Hasler's research (2014), the success rate of embryo transfer in the United States varies depending on recipient management, embryo quality, and transfer techniques. This underscores the importance of conducting a comprehensive assessment of the ET programme to achieve the best results.

An evaluation of the success of embryo transfer in beef cattle in Indonesia is still needed to obtain a clearer picture of the effectiveness of this programme in improving the productivity and genetic quality of national beef cattle. Therefore, researchers are interested in conducting research to determine the success of embryo transfer in beef cattle.

2. Literature Review

2.1. Embryo Transfer

Embryo transfer (ET) is one of the assisted reproductive technologies that has been applied to cattle in Indonesia for the past few decades. This technique aims to improve genetic quality and the population of superior cattle by transferring embryos from donor cattle with superior genetic quality to recipient cattle. In Indonesia, ET has been applied to both beef and dairy cattle, with a primary focus on improving livestock productivity (Situmorang & Triwulaningsih, 2004).

ET technology enables the production of a large number of high-quality calves. Embryo transfer involves several important processes, including superovulation, oestrus synchronisation, artificial insemination, embryo collection, and embryo transfer. Embryo production can be carried out in vitro or in vivo (Adriani et al., 2007).

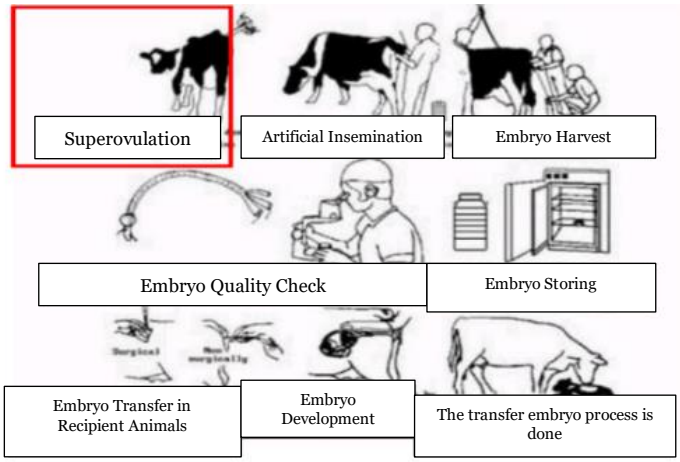

Figure 1. Transfer Flow

2.2. Factors Affecting the Success of Embryo Transfer

The success of ET is influenced by various factors. Rizal (2003) identified several key factors that influence the success of ET in beef cattle in Indonesia, including:

a. Embryo quality

Embryo quality is the most crucial factor in determining the success of embryo transfer. Good quality embryos have normal morphological characteristics, development appropriate to the stage, and high cell viability. Embryo quality assessment is typically based on the stage of development (blastomeres), cytoplasmic fragmentation, cell symmetry, and an intact zona pellucida. Embryos graded A or Grade 1 have a higher implantation success rate compared to those of lower quality.

b. Recipient physiological condition

The physiological condition of the recipient is crucial in determining the uterus's ability to accept and maintain the transferred embryo. Important factors include synchronisation of the oestrus cycle between the donor and recipient, endometrial thickness and condition, reproductive hormone levels (oestrogen and progesterone), reproductive health status, and anatomical condition of the reproductive tract. The recipient must be in optimal condition to support embryo implantation and development.

c. Technician skills

The technician's expertise and experience in performing the embryo transfer procedure significantly influence the success rate. Technicians must have the ability to handle embryos properly, use minimally invasive transfer techniques, place embryos in the optimal location

within the uterus, and recognise the recipient's anatomical conditions. Skills in maintaining sterility and minimising stress on the embryo and recipient are also very important.

d. Post-transfer maintenance management

Post-transfer management includes administering supportive hormones (such as progesterone), monitoring the recipient's condition, providing adequate nutrition, maintaining an optimal environment (temperature, humidity, cleanliness), and early detection of signs of pregnancy or complications. Proper maintenance increases the likelihood of successful implantation and continued embryo development until birth.

Embryo quality is a key factor in the success of ET, and evaluation of the production and quality of embryos from superovulated cows is essential. They reported that the average number of embryos available for transfer ranges from 3 to 5 embryos per donor, with a transfer success rate of approximately 50–60%.

3. Research Method

This study was conducted over a period of two (2) months, starting from 15 November 2024 to 15 January 2025. The research was conducted at a community-owned embryo transfer farm in Lamongan District, East Java Province. The study used eight (8) beef cattle that were scheduled to receive embryo transfers in Lamongan District in 2024. The selection of these eight cattle was based on the latest data indicating that only eight cattle in Lamongan District were scheduled to receive embryo transfers in 2024. Data was obtained from literature reviews and research reports related to the evaluation of embryo transfer success in beef cattle. Secondary data was collected from embryo transfer personnel and supporting data from local stakeholders.

3.1. Research Variables

The research variables used in this study are as follows:

1. TE acceptor parent pregnancy rate

The percentage of recipient cows that successfully become pregnant after embryo transfer is known as the TE recipient cow pregnancy rate. This is a very important metric for assessing the effectiveness of embryo transfer programmes (Spell et al., 2001). The TE recipient cow pregnancy rate is obtained using the following formula (Hasler, 2001).

$$\text{Pregnancy Rate (\%)} = \frac{\text{Number of pregnant females}}{\text{Number of dams receiving TE}} X100\%$$

2. Factors Affecting the Success Rate of Embryo Transfer

Factors influencing the success of embryo transfer include the condition of the corpus luteum (CL), the progesterone levels of the recipient cow, and the quality of the embryo based on the synchronisation time of the donor and recipient oestrus, which are the main considerations. In addition, the physiological condition and environmental management at the farm location, the expertise of the operator, and the embryo transfer procedure also have a significant impact (Baruselli et al., 2009).

4. Results and Discussion

Table 1. Embryo Transfer Acceptor Pregnancy Rate

Name of Livestock Owner	Respien Selection									Embryo Transfer			Pregnant		Failure of Pregnancy	Miscarriage		Calf
	No	Group	NKT	Date of Estrus	Degree	Synchronisation Method	Reproductive Examination Results	L/T	TE Date	Embryo Code	Embryo Cluster	Position	Yes	No		Yes	No	
Suwignyo	19449	Brangus	3	12/7/2024	+++	Natural	Left CL	L	19/7/2024	BET 6111016-7-1 2000SM30335121002	Simental	1/3 right horn	✓		6 (Abortus)	✓		–
Jai	58256	Limousin	3	12/7202 4	+++	Natural	Right CL	L	19/7/2024	BET 417291 16-5-1 200BR0800200623	Brahma	1/3 right horn		✓	–	–	–	–
Usman	22412	Limousin	3	12/7/2024	+++	Natural	Holus (HPO)	L	19/7/2024	BET 1411831T200BN008020 40422	Brangsu	1/3 right horn	✓		4 (Abortus)	✓		–
Sukarno	25649	Simental	3	12/7/2024	+++	Natural	Right CL	L	19/7/2024	BET 815167 5-6-1 200LM60306040723	Limousin	1/3 left horn		✓	–	–	–	–
Giman	21465	Limousin	3	12/7/2024	+++	Natural	Ovoka CL	L	19/7/2024	BET 141831T 1-6-1 0200BN00802111022	Brangus	1/3 right horn		✓	–	–	–	–
Tari	15539	Limousin	3	12/7/2024	+++	Natural	Right CL	L	19/7/2024	BET 6161671-6-1 61697 050423	Simental	1/3 left horn	✓		4 (Abortus)	✓		–
Mustari	23466	Simental	3	12/7/2024	+++	Natural	Left CL	L	19/7/2024	BET 618184 T 7-5-1 618123270623	Simental	1/3 left horn		✓	–	–	–	–
Kulsam	23532	Limousin	3	12/7/2014	+++	Natural	Left CL	L	19/7/2024	BET 611101 11-7-1 200SM30335121022 11-7-1 200SM30335121022	Simental	1/3 left horn	✓		5 (Abortus)	✓		–

4.1. Pregnancy Rate

Based on the data shown in Table 1, out of a total of eight beef cattle dams used as recipients in the embryo transfer programme in Lamongan District, four dams successfully became pregnant, resulting in a pregnancy success rate of 50%. This value was calculated by comparing the number of pregnant dams with the total number of dams that received embryo transfers, then multiplying by 100%.

$$\text{Pregnancy Rate } (\%) = \frac{4}{8} X100\%$$

This figure represents a significant success for the embryo transfer programme, considering that the entire procedure was carried out using a natural approach without the use of artificial hormonal synchronisation. According to the researchers, these results reflect that the recipient selection process, oestrus timing, and transfer technique implementation were carried out appropriately and in accordance with technical field standards. Additionally, the uniform physiological condition of all recipients, with a Body Condition Score (BCS) of 3, further supported this success. This BCS indicates a healthy body condition with sufficient energy reserves to support the implantation and early embryonic development during the initial stages of pregnancy.

In a broader sense, this 50% pregnancy rate is still within the range acceptable by scientific standards. The pregnancy success rate in cattle embryo transfer programmes worldwide varies from 40% to 70%, according to Hansen (2020) and Bó et al. (2019). This success rate depends on various factors, including the physiological readiness of the recipient, transfer technique, embryo quality, and post-transfer environmental management. This is supported by the success of this study, which shows that the technical strategies used have yielded successful results.

Further, the four cows that successfully became pregnant were the result of crossbreeding between recipient cows and different embryos. Hapari (2022), in his research, also showed that crossbred cows have a higher pregnancy success rate than purebred cows, indicating that crossbred cows exhibit better physiological responses to embryo transfer. This may be because crossbred cows are genetically more adaptable and have more stable hormonal responses when receiving and storing embryos from different types.

Based on the findings, all embryo transfer procedures performed on eight recipient cows in Lamongan District showed consistency in terms of embryo placement at the one-third position of the uterine horn (1/3 cornu), both on the left and right sides of the uterus. This position was strategically chosen because the area is known to have good vascularisation, optimal endometrial thickness, and an ideal distance from the cervix and ovaries, which collectively support successful implantation and embryo development. These results indicate that field staff have followed technical guidelines in selecting the embryo placement location. Embryo placement in this area is also considered to reduce the risk of excessive uterine contractions, which can cause embryo expulsion after transfer.

Researchers assess that consistency in this embryo placement technique is one of the factors contributing to the achievement of a 50% pregnancy rate, which falls within the global standard range for TE programme success. However, the success of this technique remains highly dependent on the precision and depth of placement performed by the operator. This is in line with the statement by Maillo et al. (2016), who stated that placing the embryo accurately and deeply is very important to ensure that the embryo is in a supportive uterine environment, especially during the pre-implantation stage. Careful transfer procedures that follow technical guidelines are essential to optimise the embryo's chances of survival, implantation, and development through the later stages of pregnancy.

The results of the study also showed that all recipients in this embryo transfer programme were prepared using natural oestrus synchronisation methods. This strategy reflects a more physiologically friendly approach to livestock management, as it does not involve the use of synthetic hormones, which can cause side effects if not properly controlled. Some of the methods used include the group effect (Whitten Effect), the male effect (Ram/Buck Effect), photoperiod manipulation, and nutritional flushing to improve body condition and fertility. Placing female cattle in a single pen, the presence of males, lighting control, and providing a high-energy and protein diet for 2–3 weeks before mating are strategies that have theoretically proven effective in synchronising oestrus cycles.

Although these natural methods offer advantages such as cost efficiency and minimal hormonal risks, researchers note that the effectiveness of natural synchronisation heavily relies on careful visual observation of oestrus signs, which are subjective and require specialised skills. A pregnancy rate of 50% may indicate that natural oestrus synchronisation was sufficiently successful in aligning ovulation timing and uterine readiness, at least in supporting early embryo implantation. However, the subsequent 100% miscarriage rate may indicate that the synchronisation was not fully aligned with the embryo's developmental phase, particularly in terms of mid-to-late hormonal support.

Vasconcelos et al. (2018) emphasise that timely oestrus synchronisation between donor and recipient is a crucial factor for embryo transfer success. Suboptimal synchronisation can lead to mismatches between uterine phase and embryo development stage, ultimately resulting in miscarriage despite successful initial implantation. Therefore, researchers recommend that future ET programmes consider the use of controlled hormonal synchronisation in recipient cows that are difficult to visually detect oestrus signs, to improve the precision and final outcome of pregnancy success and calf birth.

4.2. Abortion Rate

Although the pregnancy rate showed quite encouraging results, none of the pregnancies were successfully maintained until the end of the gestation period, with 100% of pregnancies ending in miscarriage between the 4th and 6th months of gestation. This phenomenon indicates a serious problem in the mid-term maintenance phase of pregnancy, especially after the initial implantation process was declared successful. From the researchers' perspective, the failure to maintain pregnancy until the end of the gestation period is likely due to a combination of various factors related to genetic, physiological, and environmental aspects. Genetic incompatibility between the embryo and the recipient may trigger a maternal immune response, causing the recipient's body to reject foetal tissue, even though the early stages of pregnancy have been successfully completed. Additionally, the specific quality of the embryos, which was not known in this study, is also suspected to be a contributing factor, as embryos with morphological abnormalities or chromosomal abnormalities tend to experience miscarriage in the middle phase of pregnancy.

Lonergan and Fair (2016) emphasise that embryo quality is the dominant factor determining the success of embryo transfer, both in terms of achieving pregnancy and live birth. Embryos produced in vitro (IVP) have been reported to have a higher miscarriage rate compared to in vivo embryos due to the potential for abnormal epigenetic modifications during the laboratory culture phase. Thus, researchers can conclude that suboptimal embryo quality, particularly in the context of long-term foetal development, may be one of the causes of abortion and requires further evaluation in future ET programmes.

Another factor to consider is the adequacy of micronutrients, such as zinc and selenium, which are essential for maintaining reproductive hormone balance and supporting placental development. Deficiencies in these nutrients are often unrecognised but can significantly impact embryo retention and foetal development. Additionally, environmental stress, particularly heat stress due to high temperatures or inadequate cage ventilation, also plays a significant role. Roth (2018) explains that heat stress can increase levels of the embryo-toxic hormone cortisol, thereby increasing the likelihood of abortion even after pregnancy has entered the second trimester. This is supported by Wiltbank et al. (2016), who state that miscarriages in the second trimester of pregnancy are often caused by deficiencies in micronutrients and hormonal disturbances resulting from uncontrolled environmental stress.

Another aspect of concern in this study is the possibility of subclinical infections in recipients, such as Bovine Viral Diarrhoea (BVD), Infectious Bovine Rhinotracheitis (IBR), or leptospirosis. Gebremedhn et al. (2016) noted that such infections often do not show clear clinical symptoms but severely damage the uterine environment and cause miscarriage during the mid-pregnancy phase. Although all transferred embryos were viable, and embryo placement was optimally performed in the upper third of the uterine horn, without continued health monitoring and adequate post-transfer management, pregnancy success is difficult to maintain until birth.

4.3. Evaluation of TE Acceptor Farmers

Based on the research data, the characteristics of the eight farmers who participated in the embryo transfer programme showed considerable diversity in several important aspects, such as educational level, farming experience, and managerial capacity in managing recipient cows. All farmers in this study had farming experience ranging from 13 to 25 years, which is quite long and reflects a high level of direct involvement in farming activities. In addition, the educational levels of the farmers varied from high school graduates to university graduates. This variation is a relevant factor in evaluating the quality of embryo transfer programme

implementation at the field level, as the personal and professional characteristics of farmers play an important role in the success of this assisted reproduction programme.

According to the researchers, the diversity of farmer characteristics has direct implications for the success rate of pregnancy and calving from embryo transfer. Although farming experience is relatively high, the 100% miscarriage rate indicates that experience alone is insufficient to guarantee programme success if not complemented by adequate understanding of post-transfer management and technical knowledge of cattle reproduction. This highlights the importance of enhancing farmers' capacity through more structured and sustainable education and training.

The results of this study align with Mikkola (2017) findings, which emphasise that a deep understanding of farmer characteristics, such as experience, management capacity, and infrastructure quality, is closely related to the success of assisted reproductive technology. In this context, Siqueira et al. (2017) revealed that farmers with more than five years of experience and basic knowledge of the reproductive cycle showed a 25% higher success rate in ART compared to novice farmers. This serves as a reference that the duration of experience must be accompanied by improved knowledge quality and adherence to technical protocols to have a significant impact on programme success.

Further, Velazquez (2008) states that educational level is also correlated with the ability to adapt to technology, as well as compliance with post-transfer technical procedures, which are crucial in maintaining pregnancy. This means that farmers with higher educational levels are more open to innovation and have better information literacy skills in managing recipient cows. In terms of capacity building, Lonergan et al. (2016) emphasise that good reproductive management training can increase TE success rates by up to 30%, especially if the training covers aspects such as accurate oestrus detection, specific nutritional management, and environmental stress control.

Researchers also highlight that the lack of post-transfer monitoring and record-keeping by most farmers is one of the key challenges to long-term success. This is supported by a study by Diskin and Morris (2008), which, through a longitudinal analysis of 210 recipient farmers, found that those who consistently followed post-transfer protocols and had good recording systems achieved a success rate of 62%, far above the national average of 45%. Therefore, in the context of this study, the researchers assessed that improving farmers' capacity in terms of post-transfer monitoring and management, especially during the critical pregnancy phase between the 4th and 6th months, should be a top priority. This step is important considering that all pregnancy cases in this study ended in abortion during that time frame, which may reflect weaknesses in mid-term pregnancy management.

5. Conclusions

This study shed light that the embryo transfer (ET) programme in beef cattle in Lamongan District successfully achieved a pregnancy rate of 50%, reflecting the proper application of technical procedures, from recipient selection, natural oestrus synchronisation, to the strategic placement of embryos in the uterine horn. All recipients exhibited optimal body condition, and the embryos used were viable at the time of transfer. However, this initial success did not extend to birth, as all pregnancies ended in abortion during the second trimester. This finding highlight that the primary challenge lies not in the implantation phase but in the maintenance of mid-term pregnancy. Factors such as embryo quality, genetic incompatibility, environmental stress, micronutrient deficiencies, and limitations in post-transfer management were found to play a crucial role in the final success of the programme.

An evaluation of the recipient farmers also revealed that high farming experience does not necessarily correlate with programme success if it is not complemented by adequate technical and managerial education.

To improve the success of embryo transfer programmes in the future, a more holistic and integrated approach is needed. The use of in vivo embryos, which have been scientifically proven to have a higher success rate than in vitro embryos, should be prioritised, especially to minimise the risk of miscarriage in the second trimester. Estrus synchronisation using a controlled hormonal approach can also be a solution for recipients whose oestrus is difficult to detect visually, ensuring more accurate uterine readiness. Additionally, nutritional management must be improved, particularly ensuring adequate intake of essential micronutrients such as selenium and zinc, as well as controlling environmental stress through improved housing conditions and ventilation. Equally important is the need for ongoing technical training for acceptor farmers, covering post-transfer management, early detection of reproductive issues, and systematic pregnancy recording. Through the synergy of technical, managerial, and educational approaches, the embryo transfer programme at the community level can be more effective in supporting the growth of the national beef cattle population and genetic quality.

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