DOI: https://doi.org/10.21323/2414-438X-2026-11-1-87-96
Received 12.09.2025
Accepted in revised 20.03.2026
Accepted for publication 25.03.2026

Available online at https://www.meatjournal.ru/jour
Original scientific article
Open Access

ECONOMIC LOSSES DUE TO REPRODUCTIVE DISORDERS DURING FOOT AND MOUTH DISEASE OUTBREAK IN JEMBER REGENCY, INDONESIA

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Keywords: *FMD, reproductive disorders, abortion, economic losses, cattle, disease*

Abstract

Jember Regency as one of the regencies with the largest beef cattle population in East Java, recorded a high number of FMD cases. In the beef cattle farming business, reproduction is a key factor in the success of beef cattle breeding, therefore this study aims to determine how much impact FMD has on abnormalities in the cattle reproductive system so that it can be known what reproductive disorders occur, the factors that most influence abortion during FMD and the potential economic losses for farmers and business actors engaged in this field in Jember Regency. This study is a quantitative descriptive study aimed at determining the incidence of post-FMD reproductive disorders, identifying the main factors influencing abortion, and estimating the economic losses resulting from abortion and reproductive disorders based on the increase in days open and calving intervals. The results of the study showed that reproductive disorders after FMD were found in 56 % of studied animals with the largest percentage being ovarian hypofunction at 27 %. The incidence of abortion during FMD outbreaks reached 12 % and the most influential factor in the incidence of abortion was FMD virus infection. The economic losses caused by abortions were estimated at IDR 210,840,000 (approximately USD14,000), while the losses due to reproductive disorders calculated on the basis of increased days open and calving intervals were estimated at IDR 1,015,200,000 (approximately USD67,700). Based on the results of this study, it is necessary to further study service per conception, conception rate and calving rate so that the value of the livestock's reproductive efficiency is known more precisely.

For citation: **Nugroho, R., Mustofa, I., Luqman, E.M., Khairullah, A.R., Hidanah, S., Lokapirnasari, W.P.** et al. (2026). Economic losses due to reproductive disorders during foot and mouth disease outbreak in Jember Regency, Indonesia. *Theory and Practice of Meat Processing,* 11(1), 87–96. https://doi.org/10.21323/2414-438X-2026-11-1-87-96

Funding:

This study is supported by Skema Penelitian Dasar Unggulan (PDU) Universitas Airlangga Year 2023, with grant number: 1286/UN3.1.6/PT/2023.

Acknowledgements:

We would like to thank Dr. Andi Prastowo, M.Si. for expertise support, and Dr. Dwi Astalia Y and Dr. Nanik Ariyani for technical support.

Introduction

Foot and mouth disease (FMD) is an acute and highly contagious viral disease affecting cloven-hoofed animals such as cattle, buffalo, sheep, goats, and pigs [1]. The disease is characterized by the formation of vesicles and erosions in the oral cavity, nostrils, teats, and interdigital spaces. These clinical manifestations have been widely reported in previous studies on FMD pathogenesis and clinical

presentation [2]. FMD can cause major economic losses due to decreased production and become an obstacle in the trade of animals and their products [3].

Based on data from the integrated National Animal Health Information System in 2022, the number of FMD incident reports was 192,169 in 38 regencies/cities in East Java, with the number of recoveries being 187,712, the number of deaths being 3,965 and the number of forced slaughter being 2,483. Jember Regency is one of the regencies with the highest number of FMD cases in East Java with a total of 14,292 cases, with the number of recoveries being 14,123, the number of deaths being 154 and the number of forced slaughter being 15 [4].

East Java Province is the center of beef cattle in Indonesia. Data from the Badan Pusat Statistik (BPS), the Statistics Indonesia Agency, indicate that East Java consistently has the largest beef cattle population in Indonesia. In 2021, the population reached approximately 4.94 million head, and subsequent reports in 2022–2023 confirm that East Java remains the primary national center for beef cattle production. According to the data on the population of beef cattle in East Java, Jember Regency is one of the regencies with the largest population of beef cattle with a total of 274,162 heads or equivalent to 5.56 % of the total population in East Java. From Integrated National Animal Health Information System data, it is known that Jember Regency is also a regency that sends quite a lot of livestock outside the province. FMD is the most feared contagious animal disease in the world because it causes enormous economic and social losses [5].

As Knight-Jones and Rushton et al. [3] stated the impact of FMD in a region can be direct or indirect. The losses caused by Foot and Mouth Disease (FMD) include reduced milk production (up to 25 % annually), decreased growth rates in beef cattle (resulting in 10–20 % longer time to reach market weight), reduced draft power capacity (up to 60–70 % in the first month after infection), decreased fertility (with abortion rates reaching up to 10 %) and delayed conception, increased mortality in young animals (20–40 % in sheep and pigs), culling of chronically affected livestock, disruption of domestic trade and livestock management systems, loss of export opportunities, and the costs associated with disease control and eradication programs. In developed countries, FMD is also one of the most feared diseases because it has an impact on livestock population and productivity as well as significant economic losses. Various eradication measures taken include slaughtering cattle that show clinical symptoms (depopulation), caution in obtaining meat, destroying milk production, carrying out mass disinfection, emptying farms for 6 months, and carrying out quarantine measures with a radius of 15–25 km [6].

Indonesia is actually very suitable for eradication because it consists of islands, but many neighboring countries are not free from FMD. In accordance with the guidelines of the World Organisation for Animal Health (WOAH), formerly known as the Office International des Epizooties (OIE), the government has implemented adjustments to its FMD control strategy. These modifications include strengthening post-outbreak surveillance, conducting reproductive status examinations in cows that have recovered from FMD, and improving the management of reproductive disorders. These measures are intended to accelerate herd recovery, reduce production losses, and support the long-term eradication of FMD by ensuring that recovered animals do not become a source of prolonged productivity decline or potential disease persistence [7].

Attention and assistance are required from the government to help smallholder farmers due to the difficulties experienced during and after the FMD outbreak. Reproductive performance is a critical determinant of success in beef cattle farming [8]. Therefore, the aim of this study was to evaluate the impact of FMD on reproductive disorders in beef cattle in Jember Regency. Specifically, this study aimed to identify the types of reproductive abnormalities occurring during the FMD outbreak, determine the main factors associated with abortion cases, and estimate the resulting economic losses for farmers and stakeholders involved in the beef cattle sector.

Objects and methods

Time and location of research

The sampling location was livestock in the Jember Regency Animal Health Center area that reported FMD cases in the area of several sub-districts, namely Ambulu, Arjasa, Balung, Jelbuk, Jenggawah, Jombang, Kencong, Kalisat, Ledokombo, Mumbulsari, Puger, Silo, Sukowono, Tempurejo and Wuluhan. Jember Regency is a regency in East Java Province which is astronomically located between 6° 27′ 29″ to 7° 14′ 35″ East Longitude and 7°59′ 6″ to 8° 33′ 56″ South Latitude (Figure 1).

Figure 1. The research location is in the districts of Ambulu, Arjasa, Balung, Jelbuk, Jenggawah, Jombang, Kencong, Kalisat, Ledokombo, Mumbulsari, Puger, Silo, Sukowono, Tempurejo and Wuluhan, Jember Regency, East Java, Indonesia (This figure was generated using MapChart.net)

Jember Regency has territorial boundaries, namely Bondowoso Regency and Probolinggo Regency in the north, the Indonesian Sea in the south, Banyuwangi Regency in the east and Lumajang Regency in the west. The implementation of questionnaire data collection with interviews and the following per rectal examinations on the female cows to determine their reproductive status were carried out on May 1 — September 30, 2023.

Research design

The research method used in this study is quantitative descriptive using a survey approach. Beef cattle data were collected from several Animal Health Centers in several sub-districts of Jember Regency that have been recorded as having reported FMD cases. The types of data used in this study are primary and secondary data. Primary data were obtained directly from respondent monitoring through interviews and filling out a previously compiled questionnaire. The respondents in this study were beef cattle breeders in Jember Regency. After obtaining the questionnaire data, the study was then continued with a per rectal examination to determine the reproductive status of the cattle. Secondary data were obtained from various related agencies such as data from the Integrated National Animal Health Information System of the Directorate General of Animal Husbandry and Animal Health, the Central Statistics Agency of Jember Regency, the East Java Provincial Animal Husbandry Service, the Jember Regency Food Security and Animal Husbandry Service and several relevant publications obtained through journals, research results, the internet and reference books.

Population

The population used in this sample was 274,162 cows and the drawing of areas for samples in this study was in accordance with the recommendations of the Ministry of Agriculture and the Food Security and Livestock Service of Jember Regency. The study was carried out in the area consisted of 15 sub-districts in Jember Regency with the predefined sampling criteria, namely that a farmer has one female cow that has at least one incisor tooth (two years old) and has been infected with FMD, so 251 samples were obtained. Thus, the data taken included 251 female beef cattle infected with FMD that were owned by smallholder farmers as the initial data sample to be analyzed.

Clinical examination

Clinical examinations included assessment of general reproductive health, pregnancy diagnosis, and identification of reproductive disorders. Rectal palpation of the reproductive organs was carried out to assess the structure of the ovaries and the condition of the uterus. Cattle were diagnosed as pregnant if there was uterine development. On the other hand, if the uterine development was not observed but there was a corpus luteum (CL) or dominant follicle (DF) in the ovary that could be palpated, it was stated that these were normal cycle cattle. Ovarian cysts were defined as one or more follicle-like structures with a diameter of >25 mm. Ovarian structures were evaluated by rectal palpation. Ovaries were classified as inactive when no palpable follicles ≥10 mm and no corpus luteum (CL) were detected during the examination [9].

Variables

The variables analyzed in this study included breed type, age, vaccination history, duration of recovery from FMD, return to estrus after FMD, pregnancy status after FMD, and reproductive disorders observed in female cattle following FMD infection.

Parameters

The parameters measured in this study were the type of reproductive disorders, factors that influence the occurrence of abortion, and the economic losses caused by them. The types of reproductive disorders include anestrus, cysts (both follicular cysts and luteal cysts), uterine disorders such as pyometra, and metritis, cervical disorders (cervicitis), urovagina. The percentage of pregnant and non-pregnant cattle, non-pregnant cattle experiencing reproductive disorders, types of reproductive disorders, and inactive ovaries were calculated by dividing the total number of cattle multiplied by 100. Data analysis in this study was presented in the form of numbers and percentages using descriptive statistical methods. The most influential factors in the occurrence of abortion in pregnant cows affected by FMD were analyzed by neural network analysis using the Statistical Product for the Service Solution (SPSS) program. The value of economic losses was determined by calculating the total costs incurred by farmers due to abortion in pregnant cows and reproductive disorders based on indicators in the assessment of reproductive efficiency in reproductive management of female beef cattle, namely days open and calving interval.

Data analysis

Losses due to abortion were calculated by estimating the economic impact of disease events according to De Vries [10]. Meanwhile, losses associated with prolonged days open and extended calving intervals were estimated by calculating the additional costs incurred, as described by Rushton [11].

Results and discussion

Distribution of beef cattle affected by FMD

The distribution of beef cattle affected by FMD in Jember Regency, East Java Province, Indonesia, based on breed, age, vaccination history, recovery duration, interval to return to estrus after FMD, pregnancy rate, reproductive examination results, and abortion incidence, is presented in Tables 1–8.

Table 1. Beef cattle breeds affected by FMD

Breed	Percentage
Limousin	69.72 % (175/251)
Ongole crossbreed	4.78 % (12/251)
Simmental	25.50 % (64/251)

As shown in Table 1, the majority of FMD-affected cattle were Limousin (69.72 %), followed by Simmental (25.50 %) and Ongole crossbreeds (4.78 %).

The predominance of Limousin cattle among affected animals is likely related to the population structure in the study area, where Limousin crossbreeds are widely maintained due to their favorable growth performance and economic value. Therefore, the higher proportion of affected Limousin cattle in this study may reflect their greater representation in the local population rather than increased breed susceptibility.

In Indonesia, Limousin cattle are commonly developed as crossbreeds with local and exotic breeds, contributing to their widespread distribution in smallholder farming systems [12]. Previous studies have shown that reproductive performance, including conception rate, is more strongly influenced by management practices, nutritional status, and reproductive protocols than by breed differences alone. For instance, Yendraliza et al. [13] reported comparable conception rates between Bali and Limousin cattle under similar estrus synchronization protocols.

These findings suggest that the higher proportion of affected Limousin cattle observed in this study is more likely associated with herd composition and management systems rather than inherent breed-related susceptibility to FMD [14].

Table 2. Age of beef cattle affected by FMD

Age	Percentage
< 3 years	0.80 % (2/251)
> 5 years	23.51 % (59/251)
3–5 years	75.70 % (190/251)

As presented in Table 2, most affected cattle in this study were 3–5 years old (75.70 %), followed by cattle older than 5 years (23.51 %), while animals younger than 3 years accounted for only 0.80 % of cases.

In Jember Regency, the majority of cattle are within the 3–5 years age group, which also accounted for the highest percentage of FMD-affected animals in this study. This finding is likely related to the population structure, as cattle aged 3–5 years represent the most active reproductive and productive segment of the herd and constitute the largest proportion of animals exposed during the outbreak [15]. Therefore, the higher number of cases in this group may reflect population structure and management practices rather than age-specific susceptibility. Similar patterns have been reported in previous studies, where the predominance of FMD cases reflects the demographic composition and management systems of the cattle population [16].

Age is an important factor influencing reproductive performance in cattle. Increasing age is associated with physiological and hormonal changes that may affect estrus expression, ovulation, conception rate, and pregnancy maintenance, potentially leading to reduced reproductive efficiency [17].

In addition, age and parity have been reported to influence reproductive efficiency indicators such as services per conception (S/C). Higher age and parity are often associated with increased S/C values, indicating decreased reproductive efficiency [18]. Therefore, age-related physiological changes should be considered as a contributing factor when evaluating reproductive disorders in cattle affected by FMD.

Table 3. History of FMD vaccination of beef cattle with FMD

Frequency	Percentage
0	21.91 % (55/251)
1	37.05 % (93/251)
2	25.90 % (65/251)
3	15.14 % (38/251)

The results in Table 3 show that most cattle received only one dose of FMD vaccination (37.05 %), while 21.91 % had never been vaccinated. Only a small proportion (15.14 %) received three doses. These findings indicate that vaccination coverage in the study area was not yet optimal, particularly regarding booster administration.

FMD has significant economic impacts on livestock production, including reduced productivity and decreased market value of animals and their products [6]. Vaccination is therefore an essential strategy to control the spread of FMDV by inducing protective immunity and reducing virus transmission.

Various types of FMD vaccines have been developed and are used globally, including inactivated vaccines formulated against different viral serotypes [19]. The type of vaccine used, dosage, and vaccination schedule may vary depending on national control programs, manufacturer recommendations, and outbreak conditions.

In general, FMD vaccines are administered to clinically healthy animals as a preventive measure, since vaccination is intended to stimulate immunity in susceptible populations rather than to treat infected animals [20]. In the study area, vaccination was implemented as part of a national emergency response program, which typically includes primary vaccination followed by booster doses. The interval between doses may vary; however, previous studies have suggested that the second dose is commonly administered several weeks after the first, followed by subsequent boosters at longer intervals depending on control strategies and epidemiological conditions [21,22].

Table 4. Recovery time from FMD in beef cattle

Recovery	Percentage
> 6 month	7.17 % (18/251)
1–3 month	68.92 % (173/251)
4–6 month	23.90 (60/251)

As shown in Table 4, most cattle (68.92 %) recovered within 1–3 months after FMD infection, while a smaller proportion required 4–6 months (23.90 %) or more than six months (7.17 %). These findings indicate variability in

recovery duration, which may be influenced by factors such as management practices, nutritional status, severity of infection, and supportive treatment.

Clinical recovery in cattle is generally characterized by the return of normal appetite and behavior, as well as the healing of lesions in the mouth, feet, and other affected tissues. However, the course of the disease and recovery outcomes may vary depending on the age and physiological condition of the animals [23].

High mortality has been reported in young calves, and in some cases this has been associated with acute myocarditis caused by FMD virus infection. Previous studies have indicated that sudden death in calves may occur due to myocardial damage, even in the absence of severe clinical signs [24].

In addition to its direct health effects, FMD can have long-term impacts on reproductive performance. Prolonged recovery periods may delay the return to estrus, thereby extending the interval between calving and conception [25]. Under normal conditions, the ideal calving interval in beef cattle is approximately 12 months [26,27]. However, cows experiencing extended recovery periods following FMD infection may exhibit longer calving intervals, which can reduce reproductive efficiency and negatively affect herd productivity.

Table 5. Return to estrus in beef cattle affected by FMD

Re-estrus	Percentage
1–3 month	25.10 % (63/251)
4–6 month	52.19 % (131/251)
> 6 months	22.71 % (57/251)

As shown in Table 5, most cows (52.19 %) returned to estrus within 4–6 months after FMD infection, while 22.71 % required more than six months to resume estrus. Only 25.10 % returned within 1–3 months. These findings suggest that FMD infection may contribute to delayed resumption of ovarian activity in a substantial proportion of animals.

The estrous cycle plays a crucial role in regulating ovulation and the establishment of pregnancy in cattle [28,29]. Under normal conditions, the estrous cycle ranges from approximately 18 to 24 days, with an average of 21 days [30]. Disruptions in estrous cyclicity may negatively affect ovulation, conception, and overall reproductive performance.

Delayed return to estrus following FMD infection may be associated with physiological stress, systemic illness, and alterations in hormonal balance. In addition, factors such as age, nutritional status, and body condition may further influence the recovery of reproductive function. Therefore, impaired estrus expression and delayed ovarian activity can contribute to reduced fertility and lower efficiency of reproductive management, including artificial insemination.

Table 6. Pregnancy rates in beef cattle affected by FMD

Pregnancy	Percentage
Pregnant	7.97 % (20/251)
Not pregnant	92.03 (231/251)

As shown in Table 6, the pregnancy rate of cows after FMD infection was very low (7.97 %), while the majority of animals (92.03 %) were not pregnant. This finding indicates a substantial decline in reproductive performance following FMD outbreaks.

The low pregnancy rate may be associated with a prolonged anestrous period in cows affected by FMD [26], which delays the resumption of ovarian activity and reduces the opportunity for successful conception. In addition, silent estrus has been reported in FMD-affected cattle [31], further complicating estrus detection and reducing the effectiveness of breeding programs. Consequently, farmers may fail to identify the optimal timing for insemination.

Overall, prolonged recovery, disruption of normal reproductive cycles, and impaired ovarian function following FMD infection may collectively contribute to reduced conception rates and decreased reproductive efficiency in affected cattle.

Table 7. Reproductive diagnosis results in beef cattle with FMD

Reproduction diagnosis	Percentage
Pregnant	7.97 % (20/251)
Clinically normal reproductive status	36.25 % (91/251)
Persistent corpus luteum (PCL)	1.20 % (3/251)
Delayed puberty	1.99 % (5/251)
Endometritis	16.33 % (41/251)
Ovarian hypofunction	27.49 % (69/251)
Ovarian hipoplasia	1.59 % (4/251)
Placental retention	3.19 % (8/251)
Follicular cyst	3.98 % (10/251)

The results presented in Table 7 indicate that ovarian hypofunction was the most frequently observed reproductive disorder in beef cattle affected by FMD in Jember Regency, accounting for 27.49 % (69/251) of the diagnosed cases.

Ovarian hypofunction is commonly associated with inadequate nutritional intake, which can impair hormonal regulation of the reproductive cycle [32,33]. In FMD-affected cattle, decreased appetite due to oral and foot lesions may lead to insufficient nutrient intake, thereby affecting energy balance and reproductive hormone activity [34]. Poor nutritional status has been identified as a major contributing factor to ovarian hypofunction in cattle [35]. In addition, body condition plays an important role in reproductive performance, as cows with low body condition scores are more likely to experience impaired ovarian activity [36].

Previous studies have also reported ovarian hypofunction as one of the most common reproductive disorders in cattle populations. For example, Utomo et al. [37] reported that ovarian hypofunction accounted for 14.55 % (136/935) of reproductive disorder cases. Clinically, cows with ovarian hypofunction typically show inactive ovaries with no palpable follicles or corpus luteum.

In the present study, endometritis was the second most common reproductive disorder, accounting for 16.33 % (41/251) of cases. Endometritis is an inflammatory condition

of the uterus, commonly associated with bacterial infection, particularly by *Escherichia coli* and *Trueperella pyogenes* [38]. Affected cows may exhibit abnormal vaginal discharge, often characterized by foul-smelling mucus. This condition can impair uterine function and reduce fertility if not properly managed [39].

Overall, reproductive disorders in beef cattle are multifactorial and may be influenced by nutritional status, disease conditions, and management practices, including postpartum care [40].

Table 8. The incidence of abortion in beef cattle affected by FMD

Abortion	Percentage
No	87.65 % (220/251)
Yes	12.35 % (31/251)

The results presented in Table 8 show that the incidence of abortion among female beef cattle affected by FMD in Jember Regency was 12.35 % (31/251).

Foot-and-mouth disease (FMD) outbreaks are known to cause significant production losses, including impaired reproductive performance. Although the primary manifestations of FMD involve epithelial tissues, systemic effects such as fever, stress, and metabolic disturbances during infection may indirectly contribute to reproductive failure, including abortion [41].

In addition, transplacental transmission of FMD virus has been reported, which may lead to fetal infection and abortion. Ranjan et al. [42] demonstrated the presence of FMD virus in multiple fetal tissues, indicating vertical transmission and its role in fetal mortality. Severe pathological findings, including myocarditis and hemorrhagic lesions, have also been observed in aborted fetuses, supporting the role of viral infection in reproductive failure.

Furthermore, elevated body temperature during infection may disrupt normal cellular processes, including protein synthesis, and impair placental function, thereby increasing the risk of abortion [43]. Physiological stress associated with disease conditions may further compromise reproductive performance and pregnancy maintenance [44].

Economic losses due to abortion during FMD

Losses due to abortions and an increase in days open and calving intervals can be calculated using estimates of economic losses due to disease events according to De Vries [10].

From the research results, the following data was obtained:

- Number of FMD cases 251.
- Total livestock population 251 heads.
- Proportion of animals affected by FMD

$$(\mathrm{Ip}) = \frac{\text{Number of FMD cases}}{\text{Livestock population}} = \frac{251}{251} = 1.$$

- Miscarriage rate (Ag) = 12 % or 0.12
- Average calf price (Ha) based on survey in animal market = IDR 7.000.000

Economic losses due to abortion in the research population sample can be calculated using the following formula [10]:

$$\begin{aligned}\text{Abortion Loss} &= \mathrm{Ag} \times (\mathrm{Ip} \times \mathrm{P}) \times \mathrm{Ha} \\ &= 0.12 \times (1 \times 251) \times 7.000.000 \\ &= 0.12 \times 251 \times 7.000.000 \\ &= 210.840.000\end{aligned}$$

If the formula is simulated in the beef cattle population in Jember district, the following results are obtained:

- Data on the Number of FMD Case Reports in Jember Regency: 14.292 with the number of infected productive females reaching 10.004.
- Beef Cattle Population Data in Jember Regency: 274.162 heads
- Proportion of animals affected by FMD $(\mathrm{Ip}) =$

$$= \frac{\text{Number of FMD cases reports}}{\text{Livestock population}} = \frac{10.004}{274.162} = 0{,}0365$$

- Miscarriage rate (Ag) = 12 % or 0.12
- Average calf price (Ha) based on price survey at animal market in Jember = IDR 7.000.000

$$\begin{aligned}\text{Abortion Loss} &= \mathrm{Ag} \times (\mathrm{Ip} \times \mathrm{P}) \times \mathrm{Ha} \\ &= 0.12 \times (0.0365 \times 274.162) \times 7.000.000 \\ &= 0.12 \times 10.004 \times 7.000.000 \\ &= 8.403.360.000\end{aligned}$$

The analysis of economic losses caused by abortion during the FMD outbreak in beef cattle in Jember Regency demonstrated a substantial economic impact, reaching IDR 210,840,000. This finding reflects the proportion of abortion cases observed in the present study (12 % of total FMD cases).

Economic losses due to abortion have a significant impact on cattle farmers, as the loss of pregnancy directly reduces the number of calves produced and delays herd replacement and expansion [45]. In addition, abortion may increase the risk of subsequent reproductive disorders, such as retained placenta and endometritis, which can lead to additional treatment costs and prolonged recovery periods [43].

Furthermore, reduced reproductive performance and increased reproductive disorders may contribute to slower herd population growth, posing a challenge to the sustainability and productivity of beef cattle farming systems [46].

Economic losses due to reproductive disorders

Losses due to post-FMD reproductive disorders can be seen through the following data:

- Length of recovery from FMD (LS) with an average value = two months
- The duration of estrus return after recovery from FMD (LE) with an average value = five months
- Length of time for a cow to be ready for insemination (SI) = LS + LE = two + five = seven months
- The cost of livestock maintenance per head per month is calculated by adding the components: feed costs (greens + concentrate) + other operational costs (Table 9).

Labor costs are calculated based on the daily hourly wage in Jember Regency, which is IDR 10.000

- Additional costs (EC) incurred due to delays in the time when the cow is ready for insemination can be calculated using the following formula:

$$EC = SI \times BP$$
$$= 7 \times 1.000.000$$
$$= 7.000.000$$

- Cost of reproductive disorder treatment per head per treatment = IDR 100,000,0 with treatment carried out twice so that the average cost of reproductive disorder (OB) treatment = IDR 200.000.

Economic losses due to reproductive disorders that occur in the research population sample can be calculated using the following formula:

$$\text{Infertility losses} = (EC + OB) \times (\text{sample population of cattle affected by FMD} \times \% \text{ number of cases of reproductive disorders})$$
$$= (7.000.000 + 200.000) \times (251 \times 56\,\%)$$
$$= 7.200.000 \times 141$$
$$= 1.015.200.000$$

If the formula is simulated in the beef cattle population in Jember district, the following results are obtained:

$$\text{Infertility losses} = (EC + OB) \times (\text{population of cattle affected by FMD} \times \% \text{ number of reproductive disorder cases})$$
$$= (7.000.000 + 200.000) \times (10.004 \times 56\,\%)$$
$$= 7.200.000 \times 5.602$$
$$= 40.334.400.000$$

Table 9. Cost components of maintaining beef cattle experiencing FMD

Component	Cost/tail (IDR)	Cost per month (IDR)
Labor	10.000	300.000
Green fodder	15.000	450.000
Concentrated feed (1.5 kg/head/day)	5.000	150.000
Other operations		100.000
Total		1.000.000

Economic losses due to post-FMD reproductive disorders in the study population were estimated at IDR 1.015.200.000. This substantial loss is associated with the high proportion of cattle experiencing reproductive disorders after FMD infection, which reached 56 % of the observed population.

Post-FMD reproductive disorders are generally multifactorial and not limited to a single condition [26]. These disorders may lead to delayed resumption of estrus, which subsequently affects the timing of conception, prolongs days open, and extends the calving interval. In the present study, the combined duration of recovery and return to estrus indicates a considerable delay in reproductive activity.

Prolonged reproductive recovery increases production costs, particularly due to extended feeding and maintenance requirements during non-productive periods [47]. In addition, reduced fertility following FMD infection further contributes to economic losses by lowering reproductive efficiency and overall herd productivity.

Conclusion

Post-FMD reproductive disorders in beef cattle in the study population in Jember Regency reached 56 %, with ovarian hypofunction being the most frequently observed disorder (27 %), followed by endometritis (16 %).

Abortion was also identified as one of the reproductive consequences observed during the FMD outbreak, contributing to additional production losses. The economic losses associated with abortion in the study population were estimated at IDR 210.840.000 (approximately USD 14.000).

Furthermore, economic losses due to post-FMD reproductive disorders in productive female beef cattle were estimated to reach IDR 1.015.200.000. IDR (approximately USD 67.700) These losses are primarily associated with delayed resumption of estrus, which leads to postponed conception, prolonged days open, and extended calving intervals. Consequently, farmers incur increased feed and operational costs due to longer non-productive periods.

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The authors declare no conflict of interest.