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Case Study of Impact and Risk Factors of Brucellosis (*Brucella abortus*) in Beef Cattle

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ABSTRACT

Bovine Brucellosis is endemic in Polewali Mandar Regency with a prevalence above 2%. Control programs implemented through active and passive surveillance, public awareness of the impact of the disease, and tests and slaughter have not been able to reduce the prevalence rate. This study aimed to examine the impact and risk factors of brucellosis on the productivity of beef cattle in Polewali Mandar Regency. A total of 100 primary data from cattle farmers related to brucellosis were used in this cross-sectional study. Descriptive analysis was employed to determine the parameters that were important in the occurrence of brucellosis. To establish risk factors, a univariate logistic regression analysis was carried out and revealed that odds of infection were significantly higher in history of abortion (OR = 11.82, 95% CI: 4.08 - 34.19, $p < 0.001$) and in gestational age (OR = 0.0214, 95% CI: 0.0063 - 0.0724, $p < 0.001$) and in dry season than wet season (OR = 14.89, 95% CI: 4.97 - 44.62, $p < 0.001$). The brucellosis control program through mass vaccination must immediately become a recommendation for regional and central governments to reduce brucellosis transmission to prevent economic impacts and losses for farmers, particularly the public health risk.
Keywords: brucellosis, beef cattle, impact, risk factor, productivity

INTRODUCTION

Meyer and Shaw, in 1920, explained the genus *Brucella* which is a pathogenic bacterium that belongs to the class of zoonotic diseases, so it is classified as a disease related to veterinary public health diseases. Three species cause brucellosis in livestock and humans, also found in pets and wildlife. The first attempts to define the *Brucella* genus led to the economic and public health implications of combining zoonotic species of bacteria into the same group. However, in time, its benefits became clear for brucellosis control programs and epidemiological and medical purposes. It is no coincidence that the first three *Brucella* species described are the most zoonotic and virulent organisms affecting livestock, whereas the last species studied are those that infect wild, cold-blooded animals [1].

Brucellos is a neglected zoonotic disease and is a high occupational hazard prevalent in several developing countries. The disease is caused by *Brucella* spp., a Gram-negative intracellular bacterium [2, 3]. Twelve species of *Brucella* have been identified to date, and most of them can infect several species of animals, including humans [4]. In cattle, *Brucella* infection is primarily caused by *B. abortus*, less often by *B. melitensis,* and occasionally by *B. suis* [5, 6]. Transmission to humans can occur through contact with infected animals, inhaling or consuming raw materials from animals. Brucellosis also causes abortion in humans. Infected animals are the main source of human infections. Human brucellosis is undulant fever, Maltese Fever, Goat Fever, or Gibraltar Fever [7]. Human brucellosis is debilitating and can permanently end injury and disability, resulting in attributable financial loss for medical expenses and lost work hours [8].

The study from Garut District, Indonesia, was conducted to determine the seroprevalence of human brucellosis and abortus cases associated with human brucellosis among dairy farm workers in Cilawu-Garut. The result is there was a brucella antibody among the respondents in Cilawu. The seroprevalence was a negative result in abortus cases, so it needs further testing to detect whether the abortion is caused by *Brucella* sp. [9].

Research to determine the risk of transmission of brucellosis to breeders, livestock workers, and animal health officers in Enrekang District, South Sulawesi Province, the results of the study found cases of transmission of brucellosis to breeders and animal health workers in Enrekang District [10]. Related to the data, the other hand found that the prevalence of the Enrekang District was 15.60% [11]. The research conducted by Lucia., et al., 2016 showed positive brucellosis in two cattle farmers samples in Pinrang District, South Sulawesi Province, Indonesia [12]. A surveillance plan for brucellosis in humans in Polewali Mandar Regency is being planned in 2023 to be examined by the local, regional regional health ministry.

Brucellosis is one of the obstacles in the development of livestock in Indonesia and is a concern that has a huge economic impact. Indonesia's economic losses caused by Brucellosis in cattle annually reach 3.6 trillion [13]. Globally, it is the second most frequently reported zoonotic disease by the World Organization for Animal Health (OIE) because it is a transboundary animal disease that causes trade barriers [6]. Brucellosis is spread in developing countries and is a serious problem in 84 countries worldwide. Brucellosis in cattle (bovine brucellosis) is a reproductive

disease caused by the *brucella* bacterium, which causes miscarriage (abortion), stillbirth, calving interval extension, and decreased milk production in beef and dairy cows [14].

The impact of economic losses on beef cattle in Polewali Mandar district is currently under a different study by researchers. The brucellosis surveillance program is a local government program through surveillance and investigation of infectious animal diseases. A prevalence study of brucellosis spread at the Disease Investigation Centre Maros showed a prevalence of 8.4% which illustrates the condition of the heavily infected area [15]. The surveillance results for 2021 obtained 859 cow serums from 42 villages in 15 sub-districts, and the results of the analysis showed that the prevalence of Brucellosis in Polewali Mandar Regency was 8.4% so it was categorized as a heavily infected area. The *Brucella abortus* vaccination program needs to be implemented as a control effort to reduce the prevalence to below 2% and the need for continuous sero surveys to determine the success of the Brucellosis control program in Polewali Mandar Regency, West Sulawesi Province.

This brucellosis disease has a significant impact on the development of cattle production in Indonesia, as well as an economic impact on farmers in Polewali Mandar Regency, the largest provider of cattle in West Sulawesi. Therefore, it is very important to study the impact of brucellosis on the productivity of beef cattle.

MATERIALS AND METHODS

Study Area

Polewali Mandar has 16 sub-districts with 167 villages/wards with a high potential for spreading brucellosis, Binuang, Anreapi, Polewali, Matakali, Wonomulyo, Tapango, Mapilli, Bulo, Tutar, Luyo, Campalagian, Balanipa, Tinambung, Alu, Limboro, Matangnga. The sub-district is divided into coastal areas, plains, and mountains (Figure 1). The coastal areas are in 27 villages (16.16 percent), while the plains are in 83 villages (49.70 percent). The village's potential has made the development of beef cattle quite successful in this region, but the rearing system is also a risk factor for the spread of brucellosis cases.

Study Design

A descriptive cross-sectional study was conducted from August to November 2022 in 14 sub-districts with a history of positive case reports for brucellosis in 2022. Cattle owners are voluntary, and all farmers are willing to be research participants by filling out an informed consent. An electronic questionnaire compiled by researchers concerning some literature and expert opinion so that it can be used in the field as a research data collection tool. To anticipate villages that are difficult to reach with an internet network, manual questionnaires are prepared by keeping records. The questionnaire was available both in English and Indonesian.

Questionnaire Interview Method

A structured questionnaire consisting of open and closed questions is then given in face-to-face interviews with respondents to get information about potential risk factors associated with Brucella exposure well transmitted to cattle. The questionnaire has been tested in a group of farmers not included in the final data set and subsequently adjusted to ensure a good flow of questions and responses. Questionnaire data consists of the farmer's name, farmer age, farmer sex, farmer's education, number of cattle owned by each age, breed of cattle, type of breeding system, rearing pattern, source of drinking water, seasons, history of abortion and other possible questions point to other risk factors.

Questionnaires were given to respondents by enumerators for 35 minutes. During the interview process, the respondent focused on gathering information regarding the impact brucellosis might have and the factors that might correlate with the emergence of brucellosis on livestock production. The geographical coordinates of each location were recorded using the app store Android Time Stamp application and were then used to generate a map of the study area using QGIS.

Data Analysis

The raw data collected from the paper questionnaire was manually entered into the MS Excel spreadsheet. Data analysis adopted the use of descriptive statistics were used to characterize different frequencies. Pearson chi-square was used to establish the proportionality between the parameters. Logistic regression was then used to establish the relationship between the risk factors. All P-Value ≤ 0.005 at a 95 % Confidence Interval was considered statistically significant.

RESULTS AND DISCUSSIONS

Response Rate

The target sample of this study was smallholder cattle farmers who had positive and negative case reports of brucellosis from the database of the Agriculture and Food Office of Polewali Mandar Regency. This study involved beef cattle breeders with an elementary school education level of 66%, junior high school of 16 %, Senior High School of 11 %, and Diploma or Bachelor 4 %, the age of cattle breeders < 25 years was 1 % (n = 1), ages 25 - 44 years was 35 % (n = 35) and breeders with ages over 45 years were 64 % (n = 64). The gender of the cattle breeders was male 94 % (n = 94) and female 6 % (n = 6). The type of breeding system was natural, 74 % (n = 74), and artificial insemination, 26% (n = 26). The main source of drinking water for cattle was pond 22 %, river 22 %, and wellspring 56 % (Table 1). Access to water sources needs to be considered because *Brucella* spp bacteria easily contaminate the surrounding environment.

Table 1. Demographic Characteristics of the Study Population

Characteristic (n=100)	Frequency	Percentage (%)
Level Education of the Farmers		
Elementary school	69	69%
Junior High School	16	16%
Senior High School	11	11%
Diploma/Bachelor	4	4%
Age of the farmers (in years)		
< 25	1	1%
25-44	35	35%
> 45	64	64%
Gender of the farmers		
Male	94	94%
Female	6	6%
Type of Breeds		
Bali	100	100%
Exotic	0	0%
Type of breeding system		
Natural	74	74%
Artificial Insemination	26	26%
Main source of drinking water of cattle		
Pond	22	22%
River	22	22%
Wellspring	56	56%
Presented are N (%) for all categories		

A total of 100 community cattle farmers were involved as respondents spread across 16 sub-districts in Polewali Mandar Regency, as shown in Figure 1 (created by using QGIS).

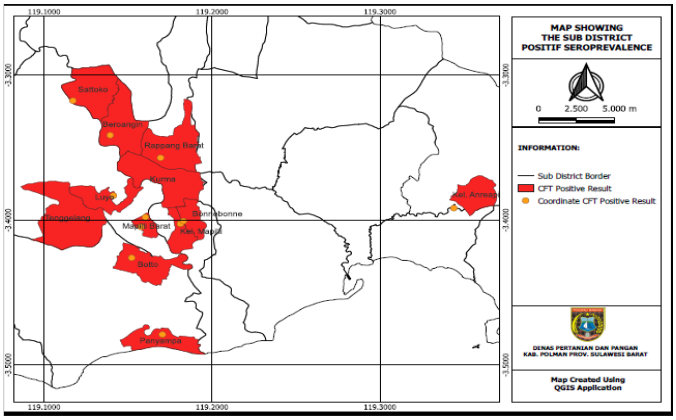

Figure 1. Map of the study area of brucellosis in Polewali Mandar Regency.

Brucellosis in Polewali Mandar District

According to the Livestock Statistics Report for Polewali Mandar Regency (2022), there are 35,683 cattle populations. The district was chosen for the study because it has areas that are at high risk of contracting the disease, as well as the movement of livestock, especially cattle from outside the area and out of the area, which is quite high. Epidemiologically, brucellosis is influenced by several factors, namely demography, reservoir, transmission, and host susceptibility factors. Epidemiologically dominant factors include transmission (source of infection and level of exposure, route of exposure, interherd transmission, and intraherd transmission) and host susceptibility factors (age, sex, breed, pregnancy, parity number, and others [16]. Infectious miscarriage in beef cattle is characterized by abortion at the age of 6-8 months of gestation (Figure 2). Another clinical sign that can be observed is swelling of the knee joints, which is not only found in cows but also in heifers and bulls.

Figure 2. Abortion of gestation and swollen joint (Hygroma) Bali cattle (*Bos Javanicus*) in Polewali Mandar Regency.

Reports of brucellosis cases that attack cattle in Polewali Mandar Regency yearly show a fairly high incidence. This can be seen by the increasing number of reports from farmers and responses by Animal Health Center officers through the integrated- National Animal Health Information System (i-SIKHNAS) and testing by the laboratory in Figure 3.

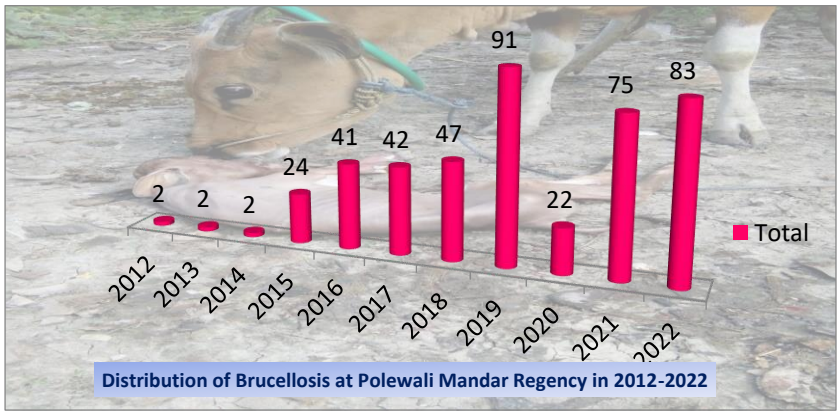

Figure 3. Graph of brucellosis disease in Polewali Mandar Regency.

The Parameters Related to Brucellosis

The increase in cases of beef cattle brucellosis in Polewali Mandar Regency, West Sulawesi Province, from year to year can be caused by many factors. The parameters observed in this study were the education level of the farmers who had cattle infected by brucellosis, the age of the cattle infected by brucellosis, gestational age, history of abortion, variant of seasons, and rearing patterns that may cause brucellosis. The data were obtained from the Agriculture and Food Department Polewali Mandar Regency using the result of brucellosis testing and complement Fixation Test history in 2022. The data was collected by filling out the questionnaire by interviewing cattle farmer respondents to validate and gather data related to the impact and risk factors associated with the emergence of brucellosis disease in the cattle.

The level of education on the data questionnaire is the last description of the formal education explained by the farmer as a respondent. The level of education in this study was divided into 4 categories, which are Elementary School, Middle School/equivalent, High School/equivalent, Diploma, and Bachelor Degree. The secondary data was found that the education level of farmers who had beef cattle with positive CFT test results, smallholder cattle with primary school education level of 57%, Junior high school education level of 10%, upper middle class as much as 7% and tertiary education level as much as 2%, respectively.

Figure 4 shows that the positive incidence of brucellosis with a proportion of over three years of age is higher, equal to 72%, compared to those aged less than 1 year with a percentage of 3%. The data obtained showed that the percentage of female cattle detected to be seropositive for brucellosis in the second trimester of pregnancy was 35%, and in the last trimester of pregnancy was 25%, higher than cattle with seropositivity in the first trimester of gestation, which was only 6%. The history of abortion in the questionnaire data obtained, there were as many as 65% of farmers who had cattle with a history of abortion with positive seroprevalence results, while cattle without a history of abortion had a proportion of 11%. Cattle rearing systems with extensive, intensive, and semi-intensive rearing patterns, respectively, contained 20%, 4%, and 52% of cattle with positive CFT results and 5%, 1%, and 18% of cattle, with negative CFT results. From the graph of variations in height where cattle are kept with the results of the CFT test, it is obtained that 5% of cattle with positive CFT results, and 13% with negative CFT results for highland locations. Meanwhile, for livestock reared in the lowlands, data obtained as much as 71% of cattle with positive CFT results and 11% with negative results.

Figure 4. The parameters observed in smallholder cattle farmers in Polewali Mandar Regency.

The Risk Fact Associated with Brucellosis

There was various risk factor that cause brucellosis in cattle. The potential risk factors were determined in this study with a questionnaire and analyzed for their association with

seropositivity history by using the secondary data from the Animal Health Department authorized in Polewali Mandar Regency are shown in Table. 2 and illustrated in Figure 4.

Tabel 2. The risk fact associated with brucellosis in Polewali Mandar Regency

Risk Fact (n=100)	CFT Result		Number of Sample	Percent (%)	X^2	95 % CI	OR	P-value
	Positive	Negative						
Level education of small holder farmers								
Elementary School	57	12	69	69	0.416	0.4476 - 25.2783	3.3636	0.5118
Junior High School	10	6	16	16				
Senior High School	7	4	11	11				
Diploma/Bachelor	2	2	4	4				
Age of cattle								
Calf Female 6-12 months	0	0	0	0	0.0702	0.0754-3.0467	0.4792	0.7911
Young Female > 1 year	3	2	5	5				
Adult Female > 3 years	72	23	95	95				
Gestational Age								
1st Trimester	6	2	8	8	50.4581	0.0063 - 0.0724	0.0214	<0.0001
2nd Trimester	35	1	36	36				
3rd Trimester	25	5	30	30				
Abort History								
Yes	65	8	73	73	25.21	4.08 - 34.19	11.82	<0.001
No	11	16	27	27				
Type of production system								
Intensive	4	1	5	5	0.3759	0.1359 - 12.0149	1.2778	0.8286
Semi intensive	52	18	70	70				
Extensive	20	5	25	25				
Varian of Seasons								
Dry Season	67	8	75	75	27.24	4.97 - 44.62	14.89	<0.001
Wet Season	9	16	25	25				
*Pearson Chi Square significant at P ≤ 0,05								

There was a significant correlation between the history of abortion during the gestational age (OR = 0.0214; $p < 0.001$) with the occurrence of brucellosis in this study area. The abortion history of pregnant female cattle was more likely to be associated with brucellosis (OR = 11.82; $p < 0.001$). The variant of seasons was observed to be significantly associated with brucellosis; it was evident that the pregnant female cattle that aborted in the dry season were 14.89 times more likely to be infected with brucellosis as compared to the cattle abort in the wet season but not by level education of the smallholder farmer (OR = 3.36; $p = 0.51$), age of cattle (OR = 0.48; $p = 0.8$) and type of production system (OR = 1.27; $p = 0.83$).

Polewali Mandar Regency, West Sulawesi Province, Indonesia, is an endemic for bovine brucellosis, with a seroprevalence in 2022 was 24.4% [17], which was higher than the prevalence in 2021 (8,4%) [16]. This study was conducted to determine the impact and the risk factors that may cause the spread of the diseases.

The current study showed that the education level of the respondents influences the incidence of brucellosis in the cattle they own. In Table 2 of farmers with the lowest level of education, cattle with a positive history of brucellosis were 57%, far higher than breeders with

upper secondary and tertiary education, which were 16%, 11%, and 4%, respectively. Even though the result of Pearson Chi-Square is not significant (OR=3.36, *p* = 0.51). The behavior knowledge influences this and the concern of breeders in handling livestock related to brucellosis. The findings of other researchers reveal that the farmers are uneducated and less educated, significantly associated with higher seropositivity than those whose owners had reached the secondary level and/or higher education [18]. Less educated farmers tend to be uninformed or slow to adopt innovations, and this may be offset by poor management practices such as livestock hygiene and their environment and weaker implementation of recommended control measures such as animal restrictions, movement, and vaccination. This finding is consistent with the findings that reported lower Brucella infection exposure in the herds of educated livestock farmers [19]. Other studies found that several predisposing factors have been associated with brucellosis seropositivity, such as older age of the animal, history of abortion, large herd size, access to surface water, location, and contact with other animals [20, 21, 22, 23, 24].

Other research found that rearing factors such as farmers' education, the origin of seeds, the presence of pens, the location of shepherds, shepherding methods, and water sources had no association with the presence of reactors. Cattle originating from outside or within the village do not play a role as brucellosis reactors, nor do they have pens, grazing outside or around village land, collective or separate grazing methods, and water from protected sources or not. This also applies to the high and low levels of education of breeders. The strength of the association between two variables can be measured if the chi-square test is statistically significant ($p < 0.05$). That is, if the X^2 coefficient is not significant, the OR value is also irrelevant, although some variables show strong associations (OR > 1) [25]. Small-scale farming systems are associated with people who generally have low levels of education, lack of biosecurity knowledge and practices, and high prevalence of practices that pose a risk of zoonotic disease transmission [26]. All of these factors suggest that there is a greater chance of disease spreading to both animals and humans if the disease is present in systems on small farms [26]. Farmer's knowledge and awareness about brucellosis significantly reduces the seropositivity of *Brucella* infection in animals [27, 28, 29].

Age, one of the risk factors of brucellosis in cattle, was confirmed by the study showed that age is not a significant predictor of brucellosis seropositivity, even the adult female cattle (> 3 years) and the young female cattle (>1 year) being more affected (OR = 0.48; *p* = 0.8) than the calf female (6-12 months) with no positive result of CFT. The finding was similar to the other studies as there was no statistically significant difference among age groups for *Brucella* seropositivity [30, 31, 32]. This study was contrary to other studies in which the prevalence of brucellosis in cattle was significantly associated with animal age with higher odds of infection in young compared to adult cattle [33]. Age has been referred to as one of the intrinsic factors associated with brucellosis [34]. The decrease of *Brucella* seropositivity with the age of animals contrasted with other studies, which reported a higher risk of infection with increasing age [33, 34]. However, it concurred with the findings from another study by Omer [35].

Several factors may account for the difference observed in this study. It is likely that in endemic areas, the risk of *Brucella* infection (and thus seroconversion) is greater in younger animals as compared to older animals, some of which could be seronegative, possibly due to latency, which is not uncommon in mature animals [34, 36]. Higher seropositivity in young animals can also be attributed to maternal antibodies, which could still be circulated when samples were taken. In addition, the arbitrary range of the age categories used in this study may have contributed to the observed results. Different results could have been observed with more age categories. This is similar to the research in which the age and body condition score were found to have no association with disease presence at the animal level. However, animal age has previously been reported as a risk factor [37].

Bovine brucellosis has been associated with several animal-level risk factors, including age, breed, body condition score, and gender. Similarly, herd-level risk factors for the disease include abortion history, herd size, insemination method, and farm management practices (including lack of disinfection of environment after abortion, sharing calving space, new animal purchases, and common grazing with animals from different herds) [38, 39, 40]. All these factors and practices either contaminate the environment or act as a source for pathogen transmission. The ability of Brucella to survive in humid and cold environments for long periods is also an important factor for defining the risk of Brucella transmission to both animals and humans [41], with climatic variables playing a significant role in the epidemiology of the disease in different geographical zones.

The other researcher found that the age of the cattle was a significant predictor of brucellosis seropositivity, with the medium adult age category (3 to 4 years) and the old cattle (5 years) being more affected (OR = 5, p = 0.005) than young animals [18]. Animals that are kept for a longer period in the herds have more chances of exposure and acquiring brucellosis, and this translates into increased brucellosis seropositivity with increasing age. It has also been reported that *Brucella* spp. has a tropism for reproductive organs of mature female animals, and the sex hormones and erythritol produced are responsible for the survival and multiplication of Brucella species [18]; this contributes to the overall higher seropositivity in sexually mature females. A study conducted on dairy cattle in Zimbabwe showed that cattle aged 2-4 years had a higher risk of being seropositive compared to those aged >7 years, and cattle with a history of abortion tended to be seropositive compared to control samples [18].

Many researchers found significant associations between species, sex, breed, and age of animals with seropositivity [42, 38, 43, 44]. Reports suggest that younger cows are less likely to be seropositive than older cows [40]. Lower seroprevalence of brucellosis in young animals could be attributed to the resistance of sexually immature cattle to infection or to less time of risk of exposure. Increased susceptibility to clinical disease with age could be more associated with sexual maturity due to the effects of sex hormones and placenta erythritol on the pathogenesis of brucellosis [45]. However, one study reported higher seroprevalence of *Brucella* infection in younger calves (10%) than in older animals (9%), and the study suggested that age does not have a positive correlation with seropositivity [46].

At the gestational age, the second Semester (4-6 months of gestation) had a higher occurrence of the abort related to brucellosis (n=35) compared to the 3rd semester (n=25) and the 1st semester (n=6). One study of brucellosis in dairy cattle in West Bandung Regency found one of the risk factors that could contribute to an increase in cases of brucellosis, the history of pregnancy abortion at the age of 7-8 years, a history of abortion at the age of 4-6 months, and cattle age> 2 years [21]. This finding agrees with the reports that pregnant cows are more likely to be seropositive than non-pregnant [47].

This was in agreement with previous reports by Acha et al., 2001 [30]. This could be explained by the presence of higher seropositivity in cows in the last trimester, which may be due to the preferential localization of Brucella in the uterus, in which allantoic fluid factor and erythritol stimulate the growth of Brucella in the uterus and increase in the placenta and fetal fluid from about the 5th month of gestation [48].

This study revealed that the total number (n=73) of female cattle observed with the abort history was significantly associated with brucellosis. The history of abortion was found to be a brucellosis risk factor with odds of 11.82 times as compared to those without abortion history.

The finding was similar to the other study that brucellosis causes abortion in pregnant cows, which had histories of abortion during the past 12 months and has been associated with brucellosis [49]. These findings were in agreement with the findings of other studies on dairy cattle [21, 22, 50, 51, 52]. Farmers should be encouraged to report abortions in dairy cattle to livestock officials for closer monitoring of the disease and implementation of control measures.

A significant association between *Brucella* infection and risk markers, such as abortion, retention of placenta, and repeat breeding, is reported by some researchers. [53] found a significant association between brucellosis and abortion and retention of placenta, but not between brucellosis and repeat breeding.

The other researcher found that a history of abortion was significantly associated with brucellosis seropositivity and that dairy cattle kept in a herd with a history of abortion were more likely to be brucellosis seropositive as compared with those in herds with no history of abortion (OR 4.91, 95% CI 1.43–16.9) [49]. These findings agreed with the findings of other studies on dairy cattle [21, 51, 52]. Farmers should be encouraged to report abortions in dairy cattle to livestock officials for closer monitoring of the disease and implementation of control measures.

Different authors also reported that the history of abortions was a significant predictor for herd-level seroprevalence [18], and this is in agreement with previous reports from Uganda [54, 55, 56]. Furthermore, this study also revealed that 98.6% of respondents did not dispose of abortuses properly, and birth sites were not disinfected, which is consistent with a previous report in Nyagatare district [57]. Therefore, it is likely that there will be a continuous circulation of Brucella pathogens within and between herds. Various reproductive disorders that are associated with brucellosis have been reported in the cattle industry in Rwanda, including higher incidences of abortions, retained placenta, infertility of unknown origin, and longer calving intervals [53]. Such abortions can cause tremendous financial losses, and wherever they occur in

the herd, massive screening of the herd against brucellosis is essential, and positive animals should be immediately slaughtered to stop the spread.

This study reported that the higher abortion history that occurred in the dry season was more likely to be associated with brucellosis, in which the number of pregnant female cattle was aborted in the dry season (n=69) than in the wet season (n=9). It can be supposed that the habit of cattle keepers in the Regency of Polewali Mandar exposing their cattle to the common pasture, given the lack of availability of grass feed so that the chances of getting contamination from cattle infected with brucellosis were greater.

In contrast to the study, research conducted in Tanzania reported that the proportions of seropositive animals differed significantly between the wet and dry seasons [58]. The wet season was found to be a brucellosis risk factor, with the odds of seropositivity 3.4 times higher during the wet season than during the dry season. In the dry season, the feeding system of animals that is practiced by many intensive farming systems can serve as a potential risk factor, but this is likely to play a role when fodder is collected from areas used by indigenous traditional cattle which encroach the periurban and urban settings [33]. The breeding cycle (parturition or abortions) in pastoral areas is often naturally synchronized with a wet season and feed availability, which accelerates contamination and maintenance of the pathogens in the environment. In contrast, a lower likelihood of brucellosis during the dry season could probably be due to the lower survival rate of *Brucella* species in aborted materials in dry seasons. It can also be explained by stall feeding, which minimizes contact between herds and animals. The seasons influence animal husbandry and nutrition, principally in pastoral areas [59]. Rain affects animal feed growth and nutritive status [60].

One of the limitations of this study that can be acknowledged is that farmers do not remember much about the gestational age of their cattle having miscarriages and when it occurred. However, researchers identify by asking for a description of the physical form of the aborted fetus. Thus, the age of miscarriage in the female parent can be estimated.

CONCLUSIONS

Brucellosis can occur with clinical signs: the child is born weak, dies, and there is interference with the reproductive organs, which results in permanent infertility. Gestational age, varian of seasons, and history of abortion were found to be risk factors and could make a real contribution to the spread and increase in cases of brucellosis in beef cattle. The brucellosis control program through mass vaccination must immediately become a recommendation for regional and central governments to reduce brucellosis transmission to prevent economic impacts and losses for farmers, particularly the public health risk.

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