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Research article

A participatory epidemiological investigation of causes of cattle abortion in Jimma zone, Ethiopia

Benti Deresa Gelalcha [a], Dereje Tulu Robi [b,*], Feyissa Begna Deressa [a]

[a] School of Veterinary Medicine, College of Agriculture and Veterinary Medicine, Jimma University, P. O. Box 307, Jimma, Ethiopia
[b] Ethiopian Institute of Agricultural Research, Tepi Agricultural Research Center, P. O. Box 34, Tepi, Ethiopia

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ABSTRACT

A participatory epidemiological study was conducted with cattle keepers in Jimma zone, Ethiopia, between October 2018 and October 2019 to identify the causes of abortion in cattle. Data collection involved 20 group discussions (each comprising 8–12 people) in 10 peasant associations. Methods used in group discussions included semi-structured interviews, pairwise ranking, matrix scoring, proportional piling, and seasonal calendar. The result of pairwise ranking identified brucellosis, leptospirosis, listeriosis, trypanosomosis, and Foot and mouth disease (FMD) in decreasing order as the most important causes of abortion in cattle. Mechanical or physical agents were also identified as less important non-infectious causes of cattle abortion in study areas. A very strong agreement ($W = 0.880$; $P < 0.001$) was observed among informant groups in pairwise ranking as to the most important cause of cattle abortion in study areas. Proportional piling showed that brucellosis was responsible for the highest proportion of abortions (39.9%) followed by leptospirosis (22.5%) and listeriosis (16.3%). A lesser proportion of abortion was attributed to trypanosomosis and FMD which comprise 11.6% and 9.7%, respectively. Matrix scoring showed strong agreement ($W = 0.572$ to 0.898; $p < 0.001$) concerning causes of abortion and its clinical signs between informant groups. According to the discussants, brucellosis and FMD tend to occur more frequently in the winter and spring seasons whereas listeriosis and trypanosomosis occurred frequently in the summer and autumn seasons, respectively. Strong agreement was observed among informant groups about the seasonal pattern of occurrence causes of abortion ($W = 0.525$–0.794; $P < 0.001$). Participants used medicinal plants and other traditional practices to manage cattle abortion in their areas. Farmers' knowledge should be incorporated to investigate health problems of unknown causes, designing, and implementing the intervention program in the areas.

1. Introduction

Abortion is an important cause of production losses in the dairy industry and has a significant negative impact on the reproductive efficiency of dairy cows (De Vries, 2006; Dinka, 2013). Like in many other countries, abortion is a major problem for dairy producers in Ethiopia (Regassa and Ashebir, 2016). Abortion is defined as the premature expulsion of the fetus between 42 days (the estimated time of attachment) and approximately 260 days of gestation (the age at which the fetus can survive outside of the uterus) (Peter, 2000).

Cattle abortion is caused by infectious and non-infectious agents (Hovingh, 2009; Tulu et al., 2018). These causes are global in distribution and of great concern to the dairy cattle (Pal, 2006). An infectious cause of abortion is an important reproductive disease of cattle, which may occur in sporadic as well as in epidemic form and is caused by diverse types of agents. Infectious causes of abortion in cattle include several groups of viruses, bacteria, protozoa, and fungus (Parthiban et al., 2015). Some of the infectious causes of cattle abortion such as brucellosis, leptospirosis, listeriosis, and Q fever in cattle have also public health significance (Pal et al., 2016; Tulu et al., 2018). Non-infectious causes of abortion can be classified as genetic and non-genetic factors. The most important non-genetic factors are heat stress, production stress, and seasonal changes (Hansen, 2002; Sani and Amanloo, 2007). Abortion can be also caused by non-infectious agents like chemical poisoning, drugs, hormones, nutritional disorders, and genetics disorder (Regassa and Ashebir, 2016).

In many developing countries investigating causes of abortion is a major challenge due to resource and technical limitations (Allport et al.,

* Corresponding author.
E-mail address: derejetulu5@gmail.com (D.T. Robi).

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2005). In this kind of setting, possible causes of abortion can be investigated using Participatory epidemiology (PE) techniques (Catley, 2005; Thrusfield, 2005). Participatory epidemiology is a proven technique that overcomes many of the limitations of conventional epidemiological methods and has been used to elucidate the causes of abortion without laboratory diagnostics (Catley, 2006; Jost et al., 2007). Participatory epidemiology provides dairy practitioners with a set of tools that maximize the chance of successfully identifying and reporting the underlying cause of dairy herd abortion (Mark, 2002).

It is important to note that the causes of abortion in cattle are numerous and thus, their diagnosis often challenging (Murray, 2006; Ernest, 2009). The laboratory diagnosis of abortion is particularly difficult in Ethiopia due to the presence of most of the infectious and non-infectious causes of abortion and the lack of resources for laboratory investigation on these possible causes. Furthermore, there is an added challenge related to appropriate sample processing and also factors on the diagnostic performance of the available tests to accurately identify the causes. In the Ethiopian setting where there are very limited veterinary diagnostic facilities, the use of PE methods could improve our understanding of potential causes of abortion in cattle. Participatory epidemiologists recognize that local people have very rich and have detailed ethnoveterinary knowledge about the cattle they keep and the characteristic of health problems that affect their cattle (Jost et al., 2007).

Pregnant cattle are the most important and promising part of the herd structure both for milk production and for calving. Thus, farmers closely follow pregnant cows and sometimes separate them from the herd and keep them around the homestead for proper care. Thus, if abortion happens farmers usually have a full history of what happened before and after the abortion making this topic ideal for a PE study. Furthermore, animal health workers in the zone always appreciate and value the livestock owners' knowledge on animal health as they always help them figure out animal diseases (including outbreaks) and their drivers in the areas (field veterinarians, personal communication). Therefore, the authors believe that a cattle producer's involvement in the initial investigation of the causes of abortion could help narrow down the most probable causes of abortion and paves way for laboratory-based diagnostic work.

Several studies indicated that abortion is one of the most frequent cattle reproductive health problems in different parts of Ethiopia (Tesfaye and Shamble, 2013; Benti and Zewdie, 2014; Regassa and Ashebir, 2016). There is widespread cattle abortion in the Jimma zone that compromises health and production. Abortion commonly occurs in dairy cattle of Jimma zone: 1041 cases in 2013, 1534 cases in 2014, and 5456 cases in 2015 were reported from various districts (Tulu, 2018). These figures only include official case reports from some peasant associations which have access to animal health workers. This implies the actual figure is expected to be very high. The local veterinary authorities were alarmed by an increasing trend of abortion episodes in cows in the past three consecutive years and approached Jimma university to help identify the possible causes of abortion.

This study was done to generate evidence on the importance and causes of abortion in the cows in the areas. The evidence can inform policy and interventions aimed at reducing the impacts of abortion. Therefore, the present study was designed to assess how farmers associate different disease syndromes with abortion, describe the seasonality of these syndromes, and describe the relative incidence of these syndromes using participatory epidemiology techniques in Limu Seka and Chora Boter districts of Jimma zone.

2. Materials and methods

2.1. Ethics statement

The research protocol was approved by the Jimma University School of Veterinary medicine, college of Agriculture, and Veterinary medicine ethic committee with the AgVmVM/16/1 reference number. All activities involving human participants have followed the ethical standards of protecting the right and welfare of participants. Participants were provided with verbal information on the aim of the study. Informed consent of participants was verbally obtained before commencement of each section of participatory exercise in every community and none declined participation.

2.2. Study areas

Limu Seka district is located at an altitude of 1400–2200 m above sea level, 09°29′ North latitude, and 37°26′ East longitudes. Its agro-ecology is characterized by 13% highland and 55% mid-highland and 32% lowland. The average temperature varies from a minimum of 15 °C to a maximum of 31 °C. There are two distinct seasons in Limu Seka: the rainy season (from late March to October), and the dry season (November to early March). The rainfall is often more than 1,800 mm per annum. Limu Seka district has 295,627 cattle, 104,892 sheep, 89,079 goats and 134,370 human populations (CSA, 2017). Local cattle breeds (Horro and Guraghe breeds) are the most dominant ones followed by some crosses of Holstein-Friesian. The management systems of the study area are extensive and semi-intensive (in urban areas).

Chora Boter district is located at 9°–10°24′ North latitude and 37°56′-40° 35′ East longitude with an altitude range of 1100–2200 m above sea level. The agroecology is characterized by 25% highland, 73.5% mid-highland, and 2.3% lowland. The annual average temperature ranges from 18.3 °C to 26.7 °C. Similar to the Limu Seka district, the district has two seasons. The rainfall is often more than 1,800–2,200 mm per annum. Chora Boter district has 228,846 cattle, 47,854 sheep, 68,037 goats and 215,348 human populations (CSA, 2017). The management system of the area is extensive (crop-livestock production) and semi-intensive (urban production) systems. Local cattle breeds (Horro and Guraghe breeds) are the most dominant ones followed by some crosses of Holstein-Friesian.There is no substantial difference in cattle production between the two districts and also between the highland and the mid-highland areas (Figure 1).

2.3. Study population

Target populations were female cattle in Limu Seka and Chora Boter districts of Jimma zone whereas the study population was breeding cows and households who keep cattle in selected peasant associations of the study districts.

2.4. Participatory epidemiology methods

Participatory epidemiological methods were applied to identify (based on cattle owner's knowledge) and prioritize the potential causes of abortion. The participatory epidemiological methods used include a semi-structured group interview, pair-wise ranking, proportional piling, matrix scoring, and seasonal calendar (Catley et al., 2001; Catley, 2005).

A semi-structured group interview was carried out by modifying the method described by Bellet et al. (2012). A prepared checklist (open--ended questions) that captures major aspects of the study objectives were used to guide the discussion. The participants (n = 234) were asked to list the most frequent cause of abortion in cattle encountered in the last year. They mentioned the local names of the diseases and described the clinical signs associated with each cause of abortion. The questions were open-ended to allow participants the opportunity to introduce topics and issues. Probing questions were used throughout the PE techniques to get detailed information on the topic of discussions and to check the consistency of information provided by other discussants. Each group interview or focus discussion (n = 20) session was run for approximately 2 h during which four activities were completed. We have ensured all participants in the discussion group had an opportunity to express their opinions, and that the discussion was open and not dominated by one or a

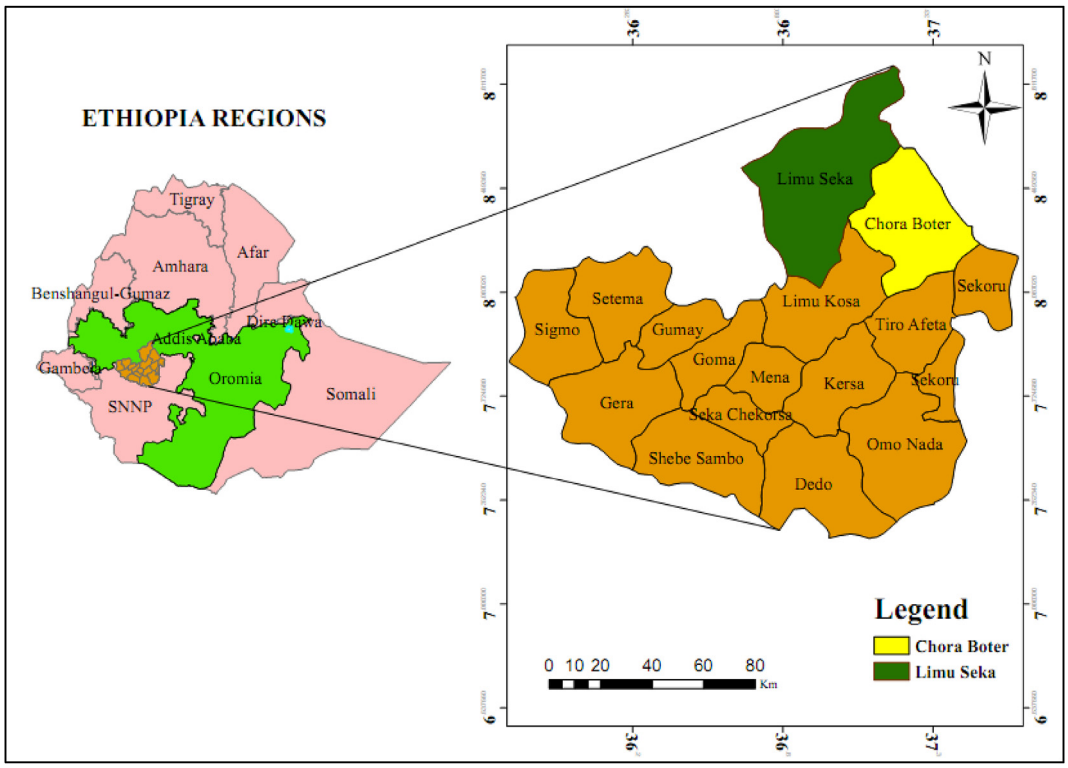

Figure 1. Map showing the study areas (Limu Seka and Chora Boter districts).

few individuals. Participants were given enough time to discuss and reach a consensus. The facilitators followed the topic guide while being sensitive to participants' wishes to express concerns and comments outside this frame, and ensured that the discussion was not dominated by one or a few individuals. Notes were taken on all group meetings.

2.4.1. *Pairwise ranking*

This method was used to identify the most important or frequent causes of abortion in cattle as perceived by the farmers. The diseases or causes of abortion mentioned by participants were introduced into a discussion with their local names. The local names of the disease were translated to their English equivalent with the help of the local veterinary service provider, veterinary clinical records, and the description given by the farmers of each disease. Major animal disease in the areas has an established local name given to it based on the clinical signs, its causes, or risk factors. Farmers have described how one disease differs from the other based on the clinical signs which all causes of abortion were line up with a veterinary textbook. For instance, when the local farmers mentioned that their cows are suffering from 'Dhukkuba Hantuuta' (literally translated as 'disease of rats') the veterinary service providers suspect that the pathogen associated was *Leptospira* species. Besides, the causes of abortion were also represented by pictures. The pictures were drawn by participants using color pens showing signs of the different causes of abortion. The pair-wise ranking was done by first listing the potential causes of abortion on cardboard vertically (y-axis) and horizontally (x-axis), and comparing two of them at a time until all the causes of abortion had been compared against each other (Catley et al., 2002). The final rank was recorded by counting the number of times a given

Figure 2. Pairwise ranking by informant group in study areas.

cause of abortion was selected first over the other and ranked based on the number of times a given cause of abortion is prioritized over the others (Figure 2). The method was repeated in twenty different groups.

2.4.2. Matrix scoring

The matrix scoring was adapted from the methods described by Catley (2005). This method was used to assess whether the participants can identify the different diseases implicated as causes of abortion based on a list of clinical signs. A matrix was drawn on a sheet of cardboard and causes of abortion were represented by pictures and placed along the top X-axis of the matrix. Each cause of abortion in the matrix scored against a list of clinical signs was illustrated along the Y-axis of the matrix. Five stones per cause of abortion were used to identify the differences easily (to count the stone easily) (Byaruhanga et al., 2015). Participants were asked to score each cause of abortion by dividing 25 piles of stone against the clinical signs. The matrix was discussed, agreed upon and the scores were recorded. The method was repeated in twenty different groups and scores were summarized using the median, minimum, and maximum scores (Figure 3).

2.4.3. Proportional piling

Proportional piling was employed to estimate the relative frequency of abortion related to five top infectious causes of abortion that occurred in cattle during the past two years as previously identified in the pair-wise ranking. Circles were drawn on cardboard representing every cause of abortion. The most important potential causes of abortion in cattle were selected by the participants. They were provided with 100 stone counters to allocate into the circles according to the relative frequency of occurrence of abortion related to each disease (Catley et al., 2014). When placing the stones against the cause of abortion was completed, the groups were requested to thoroughly check the scores and if they want, rearrange the scores until all of them agree on the score (Figure 4). Similar exercises were conducted with twenty different focus groups and score recorded based on their final scores. At the end of each activity, stones were counted and recorded, and pictures were taken.

2.4.4. Seasonal calendar

Seasonal calendars were used to describe the seasonal occurrences of causes of abortion identified in the matrix scoring as described by Catley et al. (2002). The methodology for constructing a seasonal calendar was similar to matrix scoring. The season's local name (Afan Oromo) 'Birraa' (autumn), 'Bona' (winter), 'Arfaasaa' (spring), and 'Ganna' (summer) were listed horizontally (x-axis) on a piece of cardboard and causes of abortion were listed vertically (y-axis). Also, the season's local name and causes of abortion were represented by pictures. Five stones were used per season. For each cause of abortion, discussants were asked to score each cause of abortion by dividing 20 piles of stone against season to show the seasonal pattern of the abortion (Figure 5). This method was repeated in twenty different groups and scores were summarized using the median, minimum, and maximum scores.

2.5. Sampling procedure and approaches

The study districts were selected purposively based on a history of abortion reported to the district veterinary departments. A simple random sampling technique was used to select the peasant associations (PA). PA also known as Kebele is the smallest administrative unit in Ethiopia. Limu Seka has 19 PAs whereas Chora Boter has 16 PAs. Six and four PAs were purposively sampled from Limu Seka and Chora Boter districts, respectively based on the history of abortion cases. A participatory epidemiological study involving a combination of group discussions, pair-wise ranking, proportional piling, matrix scoring, and the seasonal calendar was carried out in selected PAs. Two group discussions were held in each peasant associations with different people in each discussion. A total of 234 discussants was selected purposively from households who have cattle and volunteer to participate in the study. A total of 20 focus groups with 8–12 persons in each group were used in the discussion. Stones were used as counters for scoring purposes. Animal health assistants, one veterinarian, and one traditional healer (veterinary healer) were selected from each PA of the study districts as the key informants. Key informant interviews regarding the selection of group discussants and also describing local names for the common causes of abortion were held at each PA before the actual days of group discussion. Triangulation was done by probing and examining consistency in response and characteristics of the causes of abortion using all the methods used in the study. The local names of the diseases and the clinical signs mentioned by the informants were cross-checked with the district veterinarians, who are familiar with the local disease status, naming, and description of the diseases. In addition, the description provided by the informants on each cause of abortion was collated with and compared with previous clinical findings and laboratory diagnoses made in the areas and then with the available statistical records and relevant literature.

2.6. Data management and analysis

Data obtained from participatory epidemiological techniques results were recorded and stored in Microsoft® Excel for Windows 2010 and transferred to Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM SPSS, 2011). The level of agreement between informant groups was assessed using Kendal's coefficient of concordance (W). Evidence of agreement between informant groups was categorized as weak ($W < 0.26$; $P > 0.05$), moderate ($W = 0.26$–0.38, $P < 0.05$), and strong ($W > 0.38$, $P < 0.01$ to 0.001) according to published guidelines on the interpretation of W (Siegel and castellan, 1998) and the P-values assigned to W.

Figure 3. Matrix scoring by informant group in study areas.

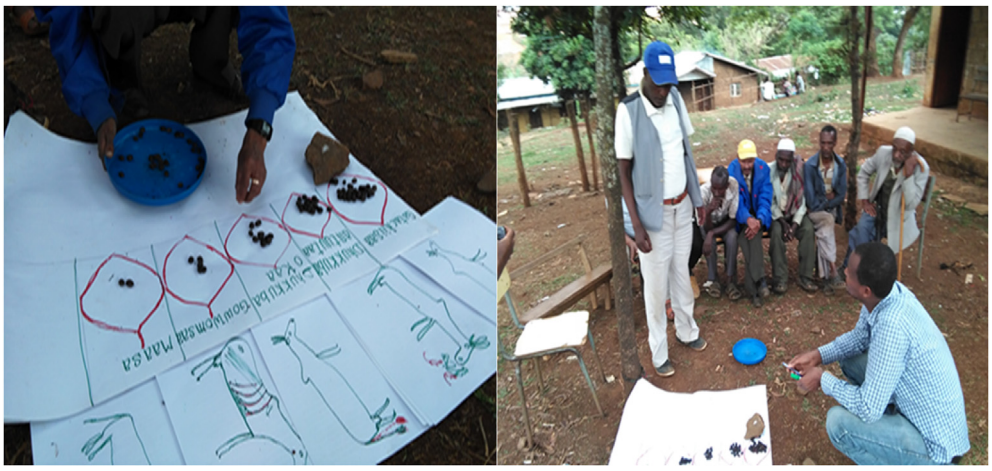

Figure 4. Proportional piling by the informant group in study areas.

Figure 5. Seasonal calendar by informant group in study areas.

3. Results

3.1. Demographics of participants

The age of the participants ranged between 23 and 75 years with an average mean age (mean ± SD) of 48.43 ± 16.17 years. The majority of the participants (81.2%) were males. The majority of participants (37.2%) in study areas had attended elementary school (Table 1).

3.2. Focus group discussion and semi-structured interviews

The common causes of abortion in cattle were given literal meanings in local language which correspond to specific disease entities. Brucellosis was recognized by cattle keepers as 'Gatachiisa' (contagious abortion). The participants mentioned that brucellosis is typically characterized by retained fetal membrane and infertility. Leptospirosis, identified as another cause of abortion was known by cattle keepers as 'Dhukkuba Hantuuta' (rat disease), and they associated the disease with

Table 1. Demographic characteristic of participants in study areas.

Variables	Limu Seka (n = 139)	Chora Boter (n = 95)	Overall (n = 234)
Age (mean ± SD)	49.87 ± 17.20	47.48 ± 15.83	48.43 ± 16.17
Sex			
Male	115 (82.7%)	75 (78.955%)	190 (81.2%)
Female	19 (20.0%)	25 (26.32%)	44 (18.8%)
Educational level			
Illiterate	36 (25.9%)	31 (32.6%)	67 (28.6%)
Read and write	23 (16.6%)	12 (12.6%)	35 (15.0%)
Elementary (1–8)	51 (36.7%)	36 (37.9%)	87 (37.2%)
Secondary school	20 (14.4%)	9 (9.5%)	29 (12.4%)
College graduated	6 (4.3%)	5 (5.3%)	11 (4.7%)
University graduated	3 (2.2%)	2 (2.1%)	5 (2.1%)

the presence of rats in stored feed. The participants characterize the disease through coffee/dark colored urine and yellowish discoloration of eyes. Listeriosis which the farmers locally called 'Dhukkuba Hokaa' (hay disease) was mentioned as another cause of abortion in the areas. The participants mentioned that the disease causes the animals to move in circles. Trypanosomosis was known locally as 'Gowwoomsaa' (deceiver) which was incriminated as one of the causes of abortion by the participants was associated with the bite of flies and characterized by loss in body weight and loss of tail hair. Foot and mouth disease (FMD) is called locally as 'Maasa' to mean sowing disease which is characterized by salivation, lameness, and vesicles on feet and mouth. Blackleg was locally called 'Gubaa' (burn disease)/'Abbaa Gorbaa' which was characterized by lameness and swelling of the hind leg. Diarrhea ('Garaa-Kaasa'), mechanical or physical ('Rukuttaa'), seasonal change, and genetic disorder ('Michii'/'Umaaman') also reported as causes of abortion in cattle (Table 2).

3.3. Management of causes of abortion in cattle

All participants indicated that they were treating the cause of abortion in cattle. Oxytetracycline was the drug most frequently used and it was used for different infectious causes of abortion. All participants in two districts showed that they used a 20% concentration of oxytetracycline and some of them (n = 62) also used 10% concentration. From our observation, oxytetracycline was more accessible and low-cost than other drugs and used by the cattle keepers to have a broad spectrum of activity against the various cause of cattle abortion. Some participants (n = 53) were used penicillin-streptomycin formulation for treating infectious causes of abortion in cattle. The participants (n = 68) also indicated that diminazene aceturate was used to treat trypanosomosis in their areas. The majority of participants have also used oxytetracycline and diminazene aceturate as prophylactic drugs. The participants differentiated the drugs by the color of the bottle and the price of the drugs. Identify of the drugs was obtained through probing, combined with the veterinarian and key informants. The cattle keepers did not necessarily take into account the weight of the cattle and the dose regimen was not properly followed. Medicinal plants were also reported as a treatment of the cause of abortion in cattle. These included *Salvadora persica* for brucellosis, *Vernonia amygdaline* for foot and mouth disease, *Ricinus communis* and *Allium sativum* for blackleg, and *Ocimum lamiifolium* for trypanosomosis. The medicinal plants were also used for prevention of abortion in cattle. Moreover, the burning of the swelling part of the cattle with a hot iron was also another method used by some participants (n = 31) to treat the blackleg.

3.4. Participatory epidemiology methods

3.4.1. Pair-wise ranking

Pair-wise ranking indicated that brucellosis is the most important cause of abortion and leptospirosis and listeriosis is the second and third most important cause of abortion in study areas, respectively (Table 3).

3.4.2. Proportional piling

A hundred stone counters were given to each informant group to prioritize the important causes of cattle abortion. Accordingly, brucellosis (39.9%) and leptospirosis (22.5%) were mentioned as the most frequent causes of abortion in study areas (Table 4). There was a strong agreement between the 20 informant groups ($W = 0.942$; $P < 0.001$).

3.4.3. Matrix scoring

The result of the matrix scoring indicates that there was strong agreement ($W = 0.572$ to 0.898; $P < 0.001$) among the informant groups for all the causes of abortion and their clinical signs. Brucellosis received the highest score for retained fetal membrane and infertility signs whereas leptospirosis received the highest score for coffee/dark colored urine and yellowish discoloration of eyes. Listeriosis received the highest score for circling sign. FMD got the highest score for salivation, lameness, and vesicles on feet and mouth (Table 5).

3.4.4. Seasonal calendar

The informant groups divided a year into autumn (Birraa), winter (Bona), spring (Arfaasaa), and summer (Ganna) seasons. Strong agreement was seen among 20 informant groups about the seasonal occurrence of brucellosis, leptospirosis, listeriosis, trypanosomosis, and FMD ($W = 0.525$–0.794; $P < 0.001$) diseases (Table 6).

4. Discussion

Abortion is the most frequent cattle reproduction problem in Ethiopia. For instance, it has been reported as widespread in the Jimma zone, compromising cattle health and production (Regassa and Ashebir, 2016; Deresa et al., 2020). However, the investigation of the causes of abortion has always been challenging in developing countries like Ethiopia mainly due to resource limitations for laboratory diagnostic. The present study used a participatory epidemiological tool to identify and prioritize the causes of cattle abortion in the Jimma zone. Thus, the use of participatory epidemiology helps narrow-down to the most likely causes involved in abortion in cattle in the study areas.

In the present study, the five major diseases incriminated as causes of abortion by participants were brucellosis, leptospirosis, listeriosis, trypanosomosis, and FMD. Strong agreement was observed among focus groups for all causes of abortion and clinical signs ($W = 0.572$ to 0.898; $P < 0.001$). This indicates that discussants were knowledgeable and able to describe the diseases commonly resulting in abortion based on their clinical characterization in study areas. The clinical signs listed for each cause of abortion were consistent with the standard veterinary literature (Radostits et al., 2007).

Brucellosis was indicated as the most important cause of abortion in cattle in two districts by pair-wise ranking. The participants mentioned retained fetal membrane and infertility as a typical clinical feature for the disease which concurs with veterinary textbooks (Radostits et al., 2007). This finding is in line with some previous studies that have reported brucellosis as an endemic and widespread cause of abortion in Ethiopia

Table 2. Local, English, and conventional names of infectious causes of cattle abortion with its clinical signs in study areas.

Local name (Afan Oromo)	English name	Conventional medical name	Clinical signs	Number of respondent (%)
Gatachiisa	Contagious abortion	Brucellosis	Retained fetal membrane, infertility	113 (48.29)
Dhukkuba Hantuuta	Rat disease	Leptospirosis	Dark/coffee color urine, yellowish discoloration of the eye	40 (17.09)
Dhukkuba Hokaa	Hay disease	Listeriosis	Moving in circle	31 (13.25)
Gowwoomsaa	Deceiver	Trypanosomosis	Loss of body weight, loss of tail hair	20 (8.55)
Maasa	Sowing disease	Foot and mouth disease	Salivation, lameness, vesicle on feet and mouth	11 (4.70)
Gubaa/Abbaa Gorbaa	Burn disease	Blackleg	Lameness, swelling of the hind leg	9 (3.85)
Garaa-Kaasa	Diarrhea		Diarrhea, fever	4 (1.71)
Rukuttaa	Mechanical/physical	Mechanical/physical	Wound on abdomen	4 (1.71)
Michii/Umaaman	Seasonal change/genetic	Seasonal change/genetic	Aborted without any signs	2 (0.85)

Table 3. Pairwise ranking causes of abortion in cattle in study areas.

Cause of abortion					
Scientific name	Local name	Number of groups	Total score	Average score	Overall rank
Brucellosis	Gatachiisa	20	106	5.3	1
Leptospirosis	Dhukkuba Hantuuta	20	77	3.9	2
Listeriosis	Dhukkuba Hokaa	20	73	3.7	3
Trypanosomosis	Gowwoomsaa	20	50	2.5	4
FMD	Maasa	20	28	1.4	5
Blackleg	Gubaa	10	12	1.2	6

Kendall's coefficient of concordance (W) for informant groups for causes of abortion indicated strong agreement in districts ($W = 0.880$, $P < 0.001$, $n = 20$).

Table 4. Median scores of incidence of cattle abortion estimates for five top causes of abortion in study areas.

Cause of abortion		Median scores for abortion		
Scientific name	Local name	Limu Seka	Chora Boter	Overall incidence (%)
Brucellosis	Gatachiisa	40.5 (34, 47)	39.3 (30, 45)	39.9
Leptospirosis	Dhukkuba Hantuuta	22.5 (16, 29)	22.5 (19, 26)	22.5
Listeriosis	Dhukkuba Hokaa	15 (11, 19)	17.5 (16, 19)	16.3
Trypanosomosis	Gowwoomsaa	11.9 (5, 15)	11.1 (5,14)	11.6
FMD	Maasa	8.5 (2, 13)	11.5 (7, 16)	9.7

Results obtained by incidence scoring technique (number of informant groups = 20), the number outside the bracket represents medians, and minimum and maximum values are in the bracket.

Table 5. Matrix score of abortion-causing diseases and clinical signs in 20 different focus groups.

Clinical signs	W	Median score (range)				
		Brucellosis	Leptospirosis	Listerosis	Trypanosomosis	FMD
Bodyweight loss	0.895***	3 (0–7)	2 (0–5)	2 (1–4)	17.5 (14–21)	5 (3–7)
Loss of tail hair	0.898***	4 (0–7)	3 (0–5)	4 (1–5)	17 (14–18)	2 (3–6)
Vesicle on foot and mouth	0.627***	2 (1–3)	7 (5–9)	6 (1–7)	1 (0–6)	10 (7–11)
Salivation	0.789***	0 (0–0)	0 (0–0)	0 (0–1)	0 (0–2)	25 (22–25)
Lameness	0.576***	0 (0–2)	0 (0–3)	0 (0–3)	0 (0–2)	25 (19–25)
Circling	0.727***	0 (0–0)	0 (0–2)	25 (20–25)	0 (0–3)	0 (0–3)
Coffee colored urine	0.821***	0 (3–8)	16 (14–17)	2 (0–3)	2 (0–5)	1 (0–3)
Retained Placenta	0.572***	19 (15–22)	2 (1–4)	1 (0–3)	3 (1–5)	0 (0–2)
Infertility	0.576***	16 (13–21)	3 (1–4)	2 (0–4)	2 (1–6)	2 (0–4)
Yellowish color of eyes	0.637***	0.5 (0–3)	19 (16–23)	1 (0–3)	3 (1–5)	1 (0–2)

W Kendall's coefficient of concordance for median ($W < 0.26$ = weak, $0.26 < W < 0.38$ = moderate, $W > 0.38$ = strong) *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, the number outside the bracket represents medians, and minimum and maximum values are in the bracket (Tables 5 and 6).

Table 6. Seasonal occurrence of different causes of abortion in cattle in study areas (Spring and Summer are wet seasons whereas Autumn and Winter are dry seasons in Ethiopia).

Seasons		W	Median score (range)				
English names	Local names		Brucellosis	Leptospirosis	Listerosis	Trypanosomosis	FMD
Autumn	Birraa	0.525***	3 (1–8)	2.5 (0–5)	2 (0–9)	7 (5–9)	4 (0–14)
Winter	Bona	0.794***	9 (5–12)	8 (6–13)	4 (1–6)	5.5 (4–9)	7.5 (0–12)
Spring	Arfaasaa	0.683***	6.5 (2–9)	6 (4–7)	5 (2–8)	4 (3–6)	5.5 (0–18)
Summer	Ganna	0.752***	2 (0–3)	3 (0–4)	9 (3–16)	3 (1–3)	2 (0–6)

(Pal et al., 2016) and Nigeria (Elelu et al., 2016). However, previous studies conducted on the seroprevalence of brucellosis in the Jimma zone reported a low prevalence (Tolosa et al., 2008; Ibrahim et al., 2010; Bashahun et al., 2015).

The participants ranked leptospirosis as the second most important cause of abortion in the study areas. They characterized the disease with coffee/dark-colored urine (hemoglobinuria) and yellowish discoloration of the eyes which is consistent with clinical signs reported in the textbook (Radostits et al., 2007). Similarly, leptospirosis was stated as the second important cause of abortion in cattle in Algeria (Derdour et al., 2017). Leptospirosis has been reported in Ethiopian cows (Moch et al., 1975) as cited in Yadeta et al. (2016) and is also one of the five priority zoonotic diseases identified in the country (Pieracci et al., 2016). Elelu et al. (2016) from Nigeria also reported leptospirosis as one of the common

causes of abortion in cattle using participatory tools. The third important disease mentioned as a cause of abortion was listeriosis. According to the participants, the main clinical sign of the disease is circling which is consistent with veterinary literature (Radostits et al., 2007) as the bacteria that cause listeriosis damages the central nervous system.

Participants ranked trypanosomosis as the fourth important cause of abortion in study districts. The common clinical signs mentioned by participants (bodyweight loss and loss of tail hair) are consistent with the disease (Radostits et al., 2007). The seasonal flare-up of trypanosomosis maybe leads to abortion in pregnant cows due to fever induced by the parasite. This concurs with a previous study carried out by Jittapalapong et al. (2009) that reported protozoan pathogens such as trypanosomosis could cause abortion in cows. In addition, our results also agree with previous studies conducted in Ethiopia (Shimelis et al., 2005; Tesfaye et al., 2011; Seyoum et al., 2013), Kenya (Catley and Irungu, 2000; Machila et al., 2003), Tanzania (Catley et al., 2004) and Nigeria (Elelu et al., 2016).

FMD was the least frequent disease associated with abortion in the study areas. Salivation, lameness, and vesicle on foot and mouth were the clinical presentation of the diseases reported by participants which are consistent with veterinary literature (Radostits et al., 2007).

A strong agreement was seen among participants groups about the seasonal occurrence of abortion ($W = 0.525–0.794$; $P < 0.001$). According to the discussants, brucellosis was reported to occur during the winter and spring seasons. This could be due to the free movement of animals in search of feed and water that potentially increases the chance of contact between infected and susceptible animals. This in turn creates a favorable condition for the transmission of *Brucella* organism among animals. A similar observation on the seasonal pattern of brucellosis occurrence was reported in Sudan by Catley et al. (2002) and in Nigeria by Elelu et al. (2016).

According to the participants, leptospirosis tends to occur in all seasons with slightly less frequency in autumn and more frequency in the rainy season. This could be due to the availability of stored feed (hay) in all seasons, which may allow rodents reservoirs of leptospirosis to breed and contaminate cattle (Tilahun et al., 2013; Tulu, 2020). This result is in line with the finding of Elelu et al. (2016), who reported leptospirosis occurred year-round and high during the rainy season in Nigeria.

In this study, most of the participants agreed that listeriosis was more common in the summer season. The participants' observation concurs with Radostits et al. (2007), who stated the seasonal pattern occurrence of listeriosis is related to stored forage and silage feeding to cattle. The farmers in the study area also mentioned that during the rainy season (summer) they feed stored grass to their animals. Thus, listeriosis frequently occurs in this season as the farmers may provide inadequately fermented feed (pH above 5.0 to 5.5) to their cattle that allows the multiplication of the pathogen (Husu et al., 1990).

The participants stated that abortion caused by trypanosomosis was more frequent during the autumn season. This could be due to the increase in tsetse fly density and the parasite challenge during the late rainy season in the study areas. Several authors in Ethiopia (Chernet et al., 2004; Shimelis et al., 2005; Tesfaye et al., 2011; Rundassa et al., 2013; Seyoum et al., 2013) and Kenya (Catley and Irungu, 2000) also reported the increase in tsetse fly density and trypanosomes challenges in the late rainy season.

Abortion caused by FMD was reported to occur more commonly during the winter and spring seasons. This result is consistent with the finding of Rafael et al. (2008) and Molla et al. (2013), who reported that the incidence of FMD was high during the dry season in Borana and South Omo, respectively. This could be related to the high movement of animals during those seasons that facilitate the chance of close-contact between infected and susceptible animals.

The highest proportion of abortion (39.9%) was caused by brucellosis and followed by leptospirosis (22.5%) using proportional piling. This is in line with the finding of Ndengu et al. (2017) who reported that the proportion of abortion caused by brucellosis was higher (21.6%) than that caused by leptospirosis (3.7%) in Zimbabwe. In the present study, the proportion of abortions caused by listeriosis was 16.3%. According to the participants, trypanosomosis was responsible for 11.6% of the proportion of abortion in study areas. This finding is consistent with the finding of Seyoum et al. (2013), who reported 12.1% of abortions to be caused by trypanosomosis in Southwestern Ethiopia. FMD was accountable for the 9.7% proportion of abortion in our study areas. This was in line with the finding of Rafael et al. (2008) in Borana, Southern Ethiopia.

The participants mentioned mechanical or physical agents as causes of cattle abortion which lines up with a standard veterinary textbook and literature (Peter, 2000; Hovingth, 2009; Givens, 2006; Radostits et al., 2007) that reported the occurrence of abortion in cattle could be due to nutritional deficiencies, trauma, and toxicities. Non-infectious causes of cattle abortion such as seasonal change and genetic disorder have also been reported by some participants which concur with previous findings (Hansen, 2002; Regassa and Ashebir, 2016). This might be due to seasonal change that may reflect changing exposure to disease agents, a changing pattern of endocrine function, the presence of a seasonal vector, or various seasonal feeding regimes (Hafez and Hafez, 2000; Ghorboni and Asadi-Alamoti, 2004). Moreover, cattle abortion also occurs due to genetic disorders such as chromosomal and single gene disorder (Thurmond et al., 2005).

5. Conclusion

Brucellosis and leptospirosis were the most important causes of abortion in cattle mentioned by the farmers. The strong agreement between different focus group discussants and the consistencies of clinical signs mentioned for the five top causes of abortion with veterinary literature shows that farmers were knowledgeable and able to diagnose and characterize different diseases causing abortion. The seasonality of causes of abortion occurrence was important for proper planning for intervention. In this study, mechanical or physical agents were also stated as non-infectious causes of cattle abortion. Participants mentioned using medicinal plants and traditional practices to prevent and treat cattle abortion in their areas. Thus, farmers' knowledge should be incorporated to investigate health problems of unknown causes, designing, and implementing the intervention program in the areas. This finding also suggests the need for further laboratory-based study to identify the precise causes of abortion and devise a control method in the study areas.

Declarations

Author contribution statement

Benti Deresa Gelalcha: Conceived and designed the experiments.

Dereje Tulu Robi: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Feyissa Begna Deressa: Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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