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Risk Factors and Occurrence of Bovine Brucellosis in the Limpopo Province, South Africa

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ABSTRACT

Background: Bovine brucellosis causes substantial loses in livestock production systems through abortions and infertility. The aim of this study was to determine whether the occurrence of bovine brucellosis is influenced by climatic variabilities.

Methods: Data on confirmed cases of bovine brucellosis from the year 2013 to 2018 was retrieved from the Limpopo Department of Agriculture Land Reform and Rural Development. Temperature and rainfall data was retrieved from the South African Weather Services. A semi structured questionnaire was used to gather information on management related risk factors from 60 purposively selected farmers. Data were analysed using microsoft excel, simple linear regression, Pearson's correlation coefficient and Mann-Kendall test.

Result: The average occurrence rate of bovine brucellosis was 3.96%. Simple linear regression coefficient analysis indicated a non-significant ($p>0.05$) effect of temperature and rainfall variabilities on occurrence of bovine brucellosis. Seventy seven per cent of cattle farmers were aware of bovine brucellosis and 83% experienced cases of abortion in their herds.

Key words: Abortion, Brucellosis, Climatic variabilities, Management related, Relationship.

INTRODUCTION

Bovine brucellosis is considered a widespread zoonosis by the World Health Organization and the Office International des Epizooties because it causes veterinary, public health and economic challenges in developing countries across the world (Tesfaye, 2021; Negash and Dubie, 2021; Lukambagire *et al.* 2021). Bovine brucellosis causes substantial losses in dairy and beef cattle farms through reproductive inefficiencies and pregnancy loses. Brucellosis is often linked to cow and heifer infertility, inflammation of the accessory sex glands and orchitis in bulls (Sandengu, 2018; Dhand *et al.* 2021; Tulu, 2022).

There is limited literature on how the occurrence and prevalence of bovine brucellosis is influenced by climatic factors, however, studies on the relationship between climatic factors and human brucellosis, *Brucella melitensis* and *Brucella suis* have been conducted before. Additionally, progressive peaks in cases of human brucellosis were reported to be strongly associated with low temperatures (Li *et al.,* 2013). *Brucella melitensis* and *Brucella Suis* have been reported to thrive in environments with high humidity and low temperatures.

MATERIALS AND METHODS

This study was conducted in the Limpopo Province of South Africa. The province is divided into five district municipalities namely, Capricorn, Mopani, Waterberg, Vhembe and Greater Sekhukhune. Three climatic zones are recognisable within the Limpopo Province namely, subtropical lowveld region, subtropical plateau and escapement region (Limpopo Department of Agriculture, 2008). The state veterinary division in the Limpopo Department of Agriculture, Land Reform and Rural Development provided provincial data on confirmed cases of bovine brucellosis. The data covered the period of 2013 to 2018. Bovine brucellosis data was based on blood samples that were collected and screened for brucella antibodies from suspected cattle herds across four districts of Limpopo Province. The Rose Bengal Plate test was used as a primary screening test while the Complement Fixation test was used for confirmation. This study also used temperature and rainfall data obtained from the South African Weather Services for the same period to determine the variabilities of these climatic factors in Limpopo Province. Furthermore, primary data was collected from sixty purposively selected cattle farmers from the Limpopo Department of Agriculture database for farmers whose cattle tested positive for bovine brucellosis during the study period. The farmers were interviewed with a pre-tested semi-structured questionnaire to identify management related risk factors that have an impact on the occurrence of brucellosis.

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The results of temperature and rainfall variabilities, the occurrence of bovine brucellosis and the questionnaire responses were analysed using IBM Statistical Package for the Social Sciences Statistics 27 and XLSTAT 2022. Mann-Kendall test was used to determine the annual trends of temperature and rainfall (Mosase and Ahiablame, 2018). Mann-Kendall test equation is shown below (Adeola *et al.,* 2019).

$$S=\sum_{i=1}^{n-1}\left[\sum_{j=i+1}^{n} sgn(Xj-Xi)\right]$$

Where;

$$sgn\ (x) = \begin{cases} 1\ \forall x > 0 \\ 0\ \forall x = 0 \\ -1\ \forall x < 0 \end{cases}$$

S= Mann-Kendall statistic.
n= Length of the data set and Xj and Xi are the sequential data points in the data.
S= Normally distributed if the null hypothesis (H0) is true.

Multiple linear regression model was used to determine the relationship between bovine brucellosis occurrence and temperature and rainfall variabilities. The multiple linear regression equation shown below was used;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where;
Y= Modelled as the dependent variable.
X= Modelled as the independent variable.
X_1= First independent variable.
X_2= Second independent variable.
β_0= Intercept (the value of outcome when the independent variable is zero).
β_0= Constant.
β_1= Slope for the first independent variable.
β_2= Slope for the second independent variable.
ε= Random error.

Pearson's correlation coefficient was used to investigate the significance of the relationship between the variability of temperature and rainfall and the occurrence of bovine brucellosis. The statistical equation of Pearson's correlation coefficient shown below was used.

$$Pearson\ (P, Q)= \frac{\sum_{i=1}^{n}(pi-\bar{p})\ (qi-\bar{q})}{\sqrt{\sum_{i=1}^{n}(pi-\bar{p})^2 \sum_{i=1}^{n}(qi-\bar{q})^2}}$$

Where;
P and Q= Variables.
p and q= Means of the variables P and Q and.
n= Total number of cases.

RESULTS AND DISCUSSION

There were no records on the occurrence of bovine brucellosis in the Vhembe district during the study period while Mopani district had no records during the year 2013 (Table 1). There were significant differences ($p<0.05$) in the occurrence of bovine brucellosis cases across the districts during the year 2013, while the differences between the districts from 2014 to 2018 were non-significant ($p>0.05$). The results also revealed positive non-significant temperature trends in Capricorn and Mopani districts ($p>0.05$) (Table 2). However, there were no observable temperature trends in Sekhukhune and Waterberg districts (p= 1.000). There were no observable rainfall trends in Capricorn district (p= 1.000) while the other districts experienced positive non-significant rainfall trends during the study period ($p>0.05$).

Multiple linear regression analysis indicated non-significant effects of temperature variability on bovine brucellosis cases with R2= 0.09, 0.93, 0.34 and 0.13 in Capricorn, Sekhukhune and Waterberg districts, respectively ($p>0.05$) (Table 3). The analysis indicated a non-significant effect ($p>0.05$) of rainfall on bovine brucellosis cases with R2= 0.85, 0.91, 0.26 and 0.47 in Capricorn, Mopani, Sekhukhune and Waterberg districts, respectively (Table 7). The results of Pearson's correlation analysis for the relationship between the occurrence of bovine brucellosis and temperature variabilities revealed that there were non-significant correlations ($p>0.05$) in Mopani and Sekhukhune districts (Tables 5 and 6). In Capricorn district, the results depicted a no correlation (p =0.000) between bovine brucellosis cases and temperature (Table 4). The Pearson's correlation analysis for the relationship between the occurrence of bovine brucellosis and rainfall variabilities revealed that Sekhukhune district was the only district which had a non-significant correlation ($p>0.05$) (Table 6). The results revealed that Waterberg district had a significant correlation ($p<0.05$), while both Capricorn and Mopani districts had significant positive correlations ($p<0.05$) (Tables 4 and 5). The study investigated the potential contribution of management related

Table 1: Occurrence of bovine brucellosis in four districts of Limpopo Province from the year 2013 to the year 2018.

Year	Occurrence according to district (%)					P-Value
	Capricorn	Mopani	Sekhukhune	Waterberg	Overall occurrence (%)	
2013	6.73	-	3.55	8.31	4.65	0.00
2014	7.75	1.92	1.52	4.46	4.00	0.27
2015	3.18	7.76	2.77	6.68	5.10	0.46
2016	4.58	1.82	1.97	5.87	3.56	0.09
2017	4.83	1.59	0.76	5.42	3.15	0.50
2018	3.25	0.12	6.20	3.59	3.29	0.63

risk factors to the occurrence of bovine brucellosis in the study area (Table 8). Majority of the farmers had knowledge of bovine brucellosis while 83% of the farmers indicated that they had experienced cases of abortions in their herds. Majority of the farmers were not disinfecting the abortion sites or screening new or arriving animals.

The results of this study indicated that the overall occurrence of bovine brucellosis was 3.96%. This finding suggests that bovine brucellosis was not prevalent in most cattle herds in the study area during the study period.

Table 2: Trends and p-values of temperature and rainfall in the districts of Limpopo Province during the period 2013 to 2018.

District	Temperature		Rainfall	
	p-value	Trend	p-value	Trend
Capricorn	0.462	0.400	1.000	0.000
Mopani	0.734	0.333	0.734	0.333
Sekhukhune	1.000	0.000	0.221	0.600
Waterberg	1.000	0.000	0.806	0.200

Table 3: Multiple linear regression coefficients between temperature and rainfall variabilities and the occurrence of bovine brucellosis in Limpopo Province during the period 2013 to 2018.

District	Bovine brucellosis and temperature variability		Bovine brucellosis and rainfall variability	
	R^2	P	R^2	P
Capricorn	0.09	0.88	0.85	0.07
Mopani	0.93	0.07	0.91	0.09
Sekhukhune	0.34	0.58	0.26	0.67
Waterberg	0.13	0.83	0.47	0.42

Table 4: Pearson's correlation coefficients between bovine brucellosis cases and temperature (°C) and rainfall (mm) variabilities in Capricorn district of Limpopo Province during the period 2013 to 2018.

	Temperature	Rainfall	Bovine brucellosis
Temperature	1		
Rainfall	0.422**	1	
Bovine brucellosis	0.000^{ns}	0.036^{ns}	1

**. Correlation is significant at the 0.01 level (2-tailed), ^{ns} correlation is non-significant.

Table 5: Pearson's correlation coefficients between bovine brucellosis cases and temperature (°C) and rainfall (mm) variabilities in Mopani district of Limpopo Province during the period 2013 to 2018.

	Temperature	Rainfall	Bovine brucellosis
Temperature	1		
Rainfall	0.247^{ns}	1	
Bovine brucellosis	0.18^{ns}	0.027^{ns}	1

^{ns} correlation is non-significant.

Awah-Ndukum *et al*. (2018) reported an occurrence of 5.4% and attained this result through the use of Rose Bengal Plate Test (RBPT) and indirect Enzyme-Linked Immunosorbent Assay (i-ELISA) serological tests. The differences between the findings of the two studies might have been brought about by the different diagnostic tests used. i-ELISA is usually considered to have a higher sensitivity and specificity in determining brucella specific antibodies than other serological tests (Varshochi *et al*., 2011). Ayoola *et al*. (2017) and Mfune *et al*. (2021) reported higher occurrences of 7.8% and 7.5% for studies that were carried out in Nigeria and Zambia, respectively. These authors attributed high occurrences of bovine brucellosis to factors such as limited restrictions on the trans-border movement of cattle which may result in infected cattle being sold in markets (Ogundipe, 2002). The findings of this study may be attributed to the fact that majority of the farmers who contributed data owned smallholder farming systems with reduced inter-herd interactions and that can partly explain a lower occurrence rate reported in this study.

There was an overall increase in annual temperature trends throughout the study period in four districts of Limpopo Province. Chikosi *et al*. (2019) and Shikwambana *et al*. (2021) reported that temperatures were gradually increasing while rainfall was decreasing in the Limpopo Province in line with changes in the climatic factors reported across the sub-Saharan African region. The province experienced an overall decrease in rainfall trends during the study period although some of the districts experienced increased rainfall in line with the observations by Adeola *et al*. (2019) who reported that some areas of Limpopo Province experienced increased rainfall during the period 1999 to 2017.

Multiple linear regression analysis revealed non-significant correlations between bovine brucellosis cases and the variabilities of temperature and rainfall in Limpopo Province during the study period. Pearson's correlation analysis also showed that there were no significant correlations between the occurrence of bovine brucellosis and the variabilities of temperature and rainfall in Limpopo Province during the study period. The findings of this study are in alignment with the hypothesis and the findings of Arif *et al*. (2019) who reported that bovine brucellosis is more prevalent in cooler areas than areas with high temperatures.

The results of the field survey showed that majority of the respondents had knowledge of bovine brucellosis and experienced clinical signs related to bovine brucellosis such as abortions in their herds, however, most of the respondents were not disinfecting abortion sites. The results also showed that 50% of the respondents regularly vaccinated their animals against bovine brucellosis and other diseases. These findings align with those of Segwagwe *et al*. (2018) who reported that majority of cattle farmers do not remove sick animals from the herd, fail to screen new animals or disinfect abortion sites. Frean *et al*. (2018) reported that South African farms are at high risk of experiencing bovine brucellosis in their cattle herds because of poor surveillance and vaccination campaigns.

Table 6: Pearson's correlation coefficients between bovine brucellosis cases and temperature (°C) and rainfall (mm) variabilities in Sekhukhune district of Limpopo Province during the period 2013 to 2018.

		Temperature	Rainfall	Bovine brucellosis
Temperature	Pearson correlation	1		
Rainfall	Pearson correlation	0.428**	1	
Bovine brucellosis	Pearson correlation	0.067^{ns}	-0.097^{ns}	1

**.Correlation is significant at the 0.01 level (2-tailed), ^{ns} correlation is non-significant.

Table 7: Pearson's correlation coefficients between bovine brucellosis cases and temperature (°C) and rainfall (mm) variabilities in Waterberg district of Limpopo Province during the period 2013 to 2018.

	Temperature	Rainfall	Bovine brucellosis
Temperature	1		
Rainfall	0.421**	1	
Bovine brucellosis	0.052^{ns}	-0.021^{ns}	1

**. Correlation is significant at the 0.01 level (2-tailed), ^{ns} correlation is non-significant.

Table 8: Responses of respondents (n = 60) to questions addressing management related risk factors.

Risk factors	Positive responses		Negative responses	
	Number	% (Proportion)	Number	% (Proportion)
Knowledge of bovine brucellosis	46	76.7	14	23.3
Screening of new animals	12	20	48	80
Isolation of sick animals	10	16	50	83.3
Brucellosis vaccination	30	50	30	50
Abortion in herd	50	83.3	10	16
Disinfected abortion site	10	16	50	83.3

CONCLUSION

This study concludes that confirmed cases of bovine brucellosis were not associated with the variations in temperature and rainfall in the Limpopo Province during the study period. Based on the findings of management related risk factors, the disease was more prevalent in herds where mandatory farm practices such as vaccination, screening new animals and disinfecting abortion sites were not practiced. Therefore, future studies to evaluate the influence of management related risk factors on the occurrence of bovine brucellosis are recommended.

Conflict of interest: None.

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