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REGULAR ARTICLES

Risk factors associated with clinical dermatophilosis in smallholder sector cattle herds of Zimbabwe at the *Amblyomma variegatum* and *Amblyomma hebraeum* interface

Daud Nyosi Ndhlovu · Patrick Julius Masika

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Abstract A cross-sectional study was conducted to investigate factors for clinical dermatophilosis herd-level positivity in smallholder dip tanks from Gokwe (Chemawororo, Gwanyika), Kwekwe (Koronika) and Chegutu (Chivero), Zimbabwe, between September 2013 and April 2014. A total of 185 herds were clinically examined for disease and tick infestation. Data on herd and potential herd level risk factors were collected using a structured questionnaire. A herd was classified as clinically positive if an animal satisfied any of the following criteria: small lesions characterised by hairs clumping like a small paint brush, clear exudative circumscribed lesions with scabs of at least 1 cm in diameter and confluent progressive exudative scab lesions affecting significant parts of the animal's body. *Amblyomma variegatum* and *Amblyomma hebraeum* ticks were identified in situ with further laboratory confirmation. The potential herd-level risk factors for clinical dermatophilosis were tested using multiple logistic regression with herd infection status (positive, negative) being the binomial outcome and risk factors being predictors. Of the herds examined, clinical bovine dermatophilosis was detected in 45 % (84/185, 95 % confidence interval (CI) 38.2, 52.6 %) of the herds. The herd prevalence ranged from 6.9 % (95 % CI 0.00, 16.7) to 56.7 % (95 % CI 43.8, 69.6) with Chivero and Chemawororo dip tanks recording the lowest and highest prevalence, respectively. Herds infested with *A. variegatum* were associated with higher odds (OR=6.8, 95 % CI 1.71, 27.10) of clinical dermatophilosis while the association was not significant ($p>0.05$) in *A. hebraeum*-infested herds. A history of having bought cattle (OR=3.5, 95 % CI 1.09, 11.12) compared to not buying was associated with increased herd clinical positivity status. It was concluded that management practices aimed at movement and tick control would help reduce the prevalence of clinical dermatophilosis in cattle herds.

Keywords Fisher's exact test · Ticks · Exudative · Univariate

Introduction

Amblyomma variegatum, a three-host tick, is one of the most important and widely distributed of the *Amblyomma* ticks (Stachurski et al. 2010). All stages of the tick infest cattle, sheep and goats. The distribution of this tick extends from north-western Zimbabwe, the central highveld and on the eastern border of the country, to central and northern Mozambique (Estrada-Peña et al. 2008) which also reported its absence from drier arid areas. Adults of this tick are present throughout the year on cattle and buffalo although infestations are heavier during the wet warm months (Ahoussou et al. 2010). In Zimbabwe, the most commonly occurring *Amblyomma* species is *Amblyomma hebraeum*, which in the adult stage is parasitic on cattle and other medium- to large-sized ungulates, leopards and ostriches (Walker et al. 2003). The distribution of *A. hebraeum* is from central Zimbabwe southwards into South Africa, eastern Swaziland, southern Mozambique and eastern Botswana (Walker et al. 2003). *A. hebraeum* is the principal vector of heart-water in Zimbabwe; however, it is replaced by *A. variegatum* in the northern parts of the country (Estrada-Peña et al. 2008). Of importance when considering *A. hebraeum* and *A. variegatum* in Zimbabwe is the fact that these two species have an area of overlap (Peter et al. 1998). It was reported that in an area of overlap,

D. N. Ndhlovu
Department of Clinical Veterinary Studies, Faculty of Veterinary Science, University of Zimbabwe, P.O. MP 167, Mt Pleasant, Harare, Zimbabwe

D. N. Ndhlovu · P. J. Masika (✉)
Agricultural and Rural Development Research Institute (ARDRI), University of Fort Hare, Private Bag X1314, Alice 5700, Republic of South Africa
e-mail: Pmasika@ufh.ac.za

A. variegatum completely replaces *A. hebraeum* over a period of 3 years (Norval et al. 1994).

Bovine dermatophilosis is an important disease of cattle in Africa, and it was first reported in Belgian Congo in 1915 (Oppong 1996). It has been reported in most countries in the continent of Africa (Hamid and Musa 2009). Bovine dermatophilosis is a tick-associated disease caused by an actinomycete bacterium, *Dermatophilus congolensis* (Molia et al. 2008; Gebreyahannes and Gebresselassie 2013), characterised by an exudative acute or chronic dermatitis which could be localised or generalised (Admassu and Alemu 2011). The lesions vary in severity: from small lesions which make hair stand like a small paint brush, to clear circumscribed scabs over 1 cm in diameter and finally to more confluent progressive lesions (Hadrill and Walker 1994). Stewart (1972) describes a carrier state in cattle; in such a state, the lesions are not easily observed and it was concluded that carrier animals were the chief means of survival for *D. congolensis*. According to Estrada-Peña et al. (2007), the saliva of *A. variegatum* contributes to the pathogenesis of bovine dermatophilosis. The disease can occur in tick-free animals, but it is more severe in those that are infested by the *A. variegatum* ticks (Stachurski et al. 2010). Walker (1996) stated that *A. variegatum*'s role in the development of dermatophilosis was through immunosuppression. The tick was postulated to secrete an immunosuppressing agent in its saliva or waste metabolites that were toxic to the host. Economically, bovine dermatophilosis is important due to morbidity and mortality, damage to hides and its effect on draught animal power (Ahoussou et al. 2010; Bayisa et al. 2012). In other parts of Africa, it has frustrated the introduction of exotic breeds to improve meat and milk production (Koney 1996).

The treatment of bovine dermatophilosis is mainly through the use of penicillin, streptomycin and dihydrostreptomycin given intramuscularly (Hamid and Musa 2009). Awad et al. (2008) indicated that a double dose of long-acting tetracyclines given a day apart gave better results than a single dose. Penicillin could be used in combination with streptomycin to produce a cure while gentamycin was reportedly the most effective antibiotic (Hamid and Musa 2009). Acaricides have been reported to be the best option for the control of bovine dermatophilosis (Hadrill and Walker 1994). Amitraz-based acaricides applied on the predilection sites of *A. variegatum* ticks on cattle reduced the prevalence of dermatophilosis (Morrow et al. 1993, 1996) as did deltamethrin. The method of tick control is important in the control of bovine dermatophilosis. Chatikobo et al. (2001) reported that plunge dipping could in fact increase the spread of the disease while hand spraying reduced the risk of spread.

In Zimbabwe, research on bovine dermatophilosis has been conducted focusing on its control, prevalence and distribution (Chatikobo et al. 2001, 2004, 2009). The aim of the current study was to identify potential herd-level risk factors related to bovine dermatophilosis and its association with *A. variegatum* and *A. hebraeum* ticks at selected dip tanks where the two ticks have been reported to interface. Knowledge of these risk factors will assist animal health decision-makers in the control and management of bovine dermatophilosis.

Materials and methods

Study sites

The study sites were at four dip tanks where co-existence/interface of the two species of *A. hebraeum* and *A. variegatum* was reported by Peter et al. (1998) (Table 1).

Study design and selection of individual herds

A cross-sectional study was conducted between September 2013 and April 2014. The study animals (herds) were purposively selected (Dohoo et al. 2003). A sample of 30 to 60 stockowners was systematically selected per dip tank. This figure was arrived at considering financial and material resources. Stockowners served as proxies for the herds. That is, herds belonging to selected stockowners became the primary sampling units. One hundred and eighty five (185) herds with a total of 1788 cattle were sampled. On the day of sampling, stockowners were interviewed by the principal investigator and by two district veterinarians using a pretested structured questionnaire written in English. The interviews were conducted in the local Shona and siNdebele languages. The questions sought information on herd-level factors such as herd size, keeping of cattle confined in kraals at night, materials that were used to construct the kraals, source of drinking water, how long farmers had been keeping cattle, history of purchase of cattle in the past 3 years, personal methods of tick control, if farmers treated their cattle for diseases, knowledge of and on the treatment of bovine dermatophilosis, how the stockowners rated dipping service delivery, and dipping sessions attended in the past 12 months (verified from stock cards).

Clinical examination of animals and sample collection

All cattle belonging to participating stockowners were placed in a race and clinically examined. The herd was initially visually inspected for any signs of bovine dermatophilosis. Clinically ill cattle were restrained in a race and a thorough physical examination was conducted. There was a predefined case definition for bovine dermatophilosis. This definition was based on the literature (Samui and Hugh-Jones 1990; Hadrill and Walker 1994) and also on the experiences of the investigating veterinarians. Cattle were classified as follows: positive, if their clinical presentation complied with the case definition for bovine dermatophilosis, or negative, if clinical

Table 1 Locations where *A. hebraeum* and *A. variegatum* co-exist (Peter et al. 1998)

Province	District	Location	Agro-ecological zone	Latitude	Longitude
Midlands	Gokwe south	Gwenyika	3	−18° 24′ S	29° 12′ E
Midlands	Gokwe south	Chemawororo (Nyaje)	3	−18° 19′ S	28° 47′ E
Midlands	Kwekwe	Koronika	3	−18° 07′ S	29° 26′ E
Mashonaland West	Chegutu	Chivero	2	−18° 21′ S	30° 36′ E

presentation did not conform to the case definition. The case definition embraced an animal whose clinical presentation satisfied any of the following three criteria: small lesions characterised by hairs clumping like a small paint brush, clear exudative circumscribed lesions with scabs of at least 1 cm in diameter and confluent progressive exudative scab lesions affecting significant parts of the animal's body. Presence or absence of *A. variegatum* and *A. hebraeum* was also recorded, and the ticks were identified in situ using their characteristic ornate markings (Walker et al. 2003). Tick inspections were conducted on at least five animals and tick samples collected and stored in 70 % ethanol for further verification at the University of Zimbabwe Parasitology laboratory. A herd was considered to be dermatophilosis positive if one animal in the herd presented with clinical signs that conformed to the case definition. With regards to tick infestation, a herd was considered to be *A. variegatum* or *A. hebraeum* positive if one animal in the herd was infested with either of the ticks.

Statistical analysis

The potential risk factors, stockowner and animal biodata were captured using the Epi Info software make view questionnaire utility (Epi Info TM version 3.5.3 database and statistics software for public health professionals 2012). Statistical analysis was performed using Stata/SE 11.2 for Windows (StataCorp, College Station, Texas, USA). Fisher's exact test was used in univariate analysis to evaluate the association between the outcome, bovine dermatophilosis (yes or no) and categorical risk factors. Variables with a p value <0.25 in univariate analysis were recruited into the binary logistic regression. In the multivariable logistic regression, the model was built as follows: the outcome was the binomial herd-level clinical dermatophilosis positivity status (negative herd=0, positive herd=1) and the explanatory variables with p values <0.25, identified in the univariate analysis, were fit into the model. The model was manually constructed using forward selection applying the maximum likelihood estimation procedure and statistical significance contribution of individual predictors (or group of predictors). The logistic regression model was assessed for goodness of fit using the Hosmer-Lemeshow test while its predictive ability was determined using the receiver operating characteristic (ROC) curve (Dohoo et al. 2003).

Results

Herd clinical bovine dermatophilosis prevalence

Bovine dermatophilosis clinical positivity was detected in 45 % (84/185, 95 % confidence interval (CI) 38.2, 52.6 %) of the herds that were investigated. The herd prevalence ranged from 6.9 % (95 % CI 0.00, 16.7) to 56.7 % (95 % CI 43.8, 69.6) with Chivero and Chemawororo dip tanks recording the lowest and highest prevalence, respectively (Table 2). The proportion of positive herds was significantly lower ($p<0.05$) at Chivero than at other dip tanks. Prevalence at the other three dip tanks did not differ significantly ($p>0.05$). Using the Fisher's exact test in univariate analysis (Table 3), *A. variegatum* was significantly ($p<0.05$) associated with the occurrence of clinical dermatophilosis while association of the latter with *A. hebraeum* was not significant ($p>0.05$). *A. variegatum* ticks infested 69. 7 % (129/185, 95 % CI 63.0, 76.4) of the herds while 28.1 % (52/185, 95 % CI 21.6, 34.6) were infested by *A. hebraeum*.

Table 3 shows the results of univariate analysis and descriptive statistics of 12 variables from the structured interviewer-administered questionnaires. Eight variables that had a $p<0.25$ in univariate analysis, that is, bought cattle (yes vs no), herd size (small, medium, large), knowledge of dermatophilosis, age category of affected cattle, treating cattle for diseases, *A. variegatum* (present vs absent), dip attendance, purchase of own acaricide and dip tank, were fitted into the multivariable logistic regression model.

Multivariable logistic regression model for herd-level bovine dermatophilosis infection

The multivariable logistic regression model revealed study site, bought cattle, *A. variegatum* (yes vs no) and treatment of cattle for diseases as independently associated with herd dermatophilosis positivity (Table 4). The Hosmer-Lemeshow goodness-of-fit test showed that the model fit the data (χ^2=

4.06, *d.f.* 8, p=0.85). The model had a good predictive ability (area under curve=0.96).

Discussion

A limitation of this study was the reliance on clinical signs as a proxy for infection with bovine dermatophilosis and the use of purposive sampling. Regardless, the results from the study do provide a picture of risk factors for bovine dermatophilosis in the smallholder sector of Zimbabwe; purposive sampling is a recognised epidemiological sampling method (Dohoo et al. 2003). Further, the investigators had long years of experience encountering bovine dermatophilosis cases in the field which in this case was a positive factor. Other studies have been conducted by Nyman et al. (2007), Waage and Vatn (2008), and Dippel et al. (2009) where only clinical signs were used as the outcome in efforts to determine potential herd- or individual-level risk factors for the animal health conditions. These studies were carried out to determine potential herd/individual animal-level risk factors for clinical mastitis and lameness in sheep and cattle.

The observed variation in prevalence of dermatophilosis between some dip tanks can be attributed to management factors and agro-ecological factors. Chivero dip tank which had the lowest prevalence (6.9 %) is in agro-ecological zone 2 while the other three study sites with prevalence ranging from 48.1 to 56.7 % were in zone 3; for these latter three sites, the differences in prevalence were not statistically significant. Agro-ecological zone 2 is characterised by intensive farming and moderate rainfall while zone 3 is characterised by semi-intensive farming and moderate to erratic rainfall (Hove et al. 2008). The presence of higher temperatures in zone 3 together with moderate rain could provide an ideal environment for the germination and propagation of *D. congolensis* zoospores as compared to the colder zone 2. The other reason for the difference could be the fact that the proportion of tick-infested cattle differed per study site particularly between Chemawororo and Chivero. Chivero had more cattle infested with *A. hebraeum* than those with *A. variegatum* and vice versa for Chemawororo dip tank. Chatikobo et al. (2004, 2009) have reported on the potential association between *A. variegatum* and bovine dermatophilosis as such that the difference in herd infestations by these two ticks could explain the differences in dermatophilosis herd prevalence. These findings were also in agreement with those of Admassu and Alemu (2011) who reported that dermatophilosis was more prevalent in *A. variegatum*-infested cattle. The prevalence values in the current study differed from those of other works. Dalis et al. (2009) in Nigeria reported a clinical prevalence of dermatophilosis-like cases, of 17 %, which dropped down to 8.7 % after laboratory examination. In Ethiopia, Admassu and Alemu (2011) reported 1.04 % laboratory dermatophilosis positivity. The differences in the prevalence observed between the current study and the other studies could be attributed to cattle management differences and agro-ecological factors. The other reason for the differences could be that in the other studies, dermatophilosis positivity was confirmed through laboratory tests, which was not the case in the current study. Nath et al. (2010) reported that the isolation of *D. congolensis* was in most cases difficult; this can lead to low prevalence detected at the laboratory. In the current study, the case definition was strictly adhered to so as to exclude cases of lumpy skin disease, sweating sickness, parafilariasis, ringworm and scab.

The history of introducing new cattle into herds through purchases placed those herds at higher odds of clinical dermatophilosis. This introduction increased the odds of clinical dermatophilosis by 3.49 (CI 1.09, 11.12). The current findings agreed with others (Matope et al. (2010); and Bamaiyi et al. (2014)) who reported that the purchase of animals increased the odds of disease in the new herd. In the

Table 2 Herd sizes, bovine dermatophilosis clinical cases and *Amblyomma* tick infestation at smallholder dip tanks of Gokwe, Kwekwe and Chegutu, Zimbabwe

Dip tank	Herds sampled	Herd size		Clinical cases		*Amblyomma* tick infestation			
						A. variegatum		*A. hebraeum*	
		Median	Range	Proportion (%)	95 % CI	Proportion	95 % CI	Proportion	95 % CI
Chemawororo	60	7	1, 26	56.7a	43.8, 69.6	73.3c	61.8, 84.9	16.7e	6.96, 26.4
Gwanyika	52	8	2, 50	48.1a	34.0, 62.1	82.7c	72.1, 93.3	17.3e	6.77, 27.9
Koronika	44	8	2, 41	52.3a	36.9, 67.6	65.9c	51.3, 80.5	52.3f	36.9, 67.6
Chivero	29	7	1, 19	6.90b	0.0, 16.7	44.8d	25.6, 64.1	34.5e	16.1, 52.9
Grand total	185	8	1, 50	45.4a	38.2, 52.6	69.7c	63.0, 76.4	28.1e	21.6, 34.6

Proportions with different letters were significantly different at $p<0.05$. Stockowners served as proxies for the herds

CI confidence interval

Table 3 Distribution of bovine dermatophilosis-positive and dermatophilosis-negative cattle herds (n=185) according to the different risk factors and results of univariate analysis using Fisher's exact test

Variable	Category	Number	Dermatophilosis		OR	*p*
			+ve	−ve		
Bought cattle[a]	Yes	92	63	29	7.4	0.00
	No	93	21	72		
Herd size[a]	Small	128	52	76	1.92	0.004
	Medium	40	18	22		
	Large	17	14	3		
Knowledge of dermatophilosis[a]	Yes	95	55	29	1.93	0.001
	No	90	40	61		
Age category[a]	≤4 years	23	23	0	0.37	0.00
	Greater than 4 years	95	36	59		
Treat cattle for diseases[a]	Yes	63	61	2	0.072	0.00
	No	22	14	8		
Dipping quality	Poor	84	41	44	0.99	0.336
	Adequate	74	29	45		
	Good	26	14	12		
Dip attendance[a]	Very poor	10	3	7	1.80	0.05
	Poor	39	12	27		
	Good	136	69	67		
Purchase own acaricide[a]	Yes	145	70	14	1.73	0.134
	No	40	75	26		
Amblyomma variegatum[a]	Yes	129	76	53	8.6	0.00
	No	56	8	48		
Amblyomma hebraeum	Yes	52	25	27	1.16	0.743
	No	133	59	74		
Period keeping cattle	5 years and less	23	2	21	1.16	0.423
	6–10 years	24	7	17		
	11–15 years	15	3	12		
	16–20 years	27	7	20		
	More than 20 years	96	25	71		
Dip tank[a]	Chivero	29	2	27	1.6	0.00
	Koronika	44	23	21		
	Gwanyika	52	25	27		
	Chemawororo	60	34	26		
Source of water	Home borehole	10	4	6	1.0	0.970
	Common borehole	64	30	34		
	Dam	10	4	6		
	River	101	46	55		

OR odds ratio, *+ve* positive, *−ve* negative

[a] These variables had Fisher's exact $p<0.25$ and were presented to the multivariable logistic regression models

other studies, the diseases of interest were bovine and ovine brucellosis. Chatikobo et al. (2009) reported that cattle brought from outside were responsible for the occurrence of dermatophilosis in some cattle herds in Kadoma in Zimbabwe. New introductions to herds could introduce into the herds dermatophilosis infection or the tick *A. variegatum* with which it is associated.

Treatment of cattle for various other diseases was associated with an increased odds (OR=22.9) of dermatophilosis compared to herds where no treatment was provided. This association was most likely due to the fact that farmers were prompted to treat their cattle if they were showing signs of ill health; with such treatment not being effective, this was not a causal association. The findings were similar to those of Nyman et al. (2007) who reported preponderance by farmers to provide treatment as soon as their animals showed signs of clinical mastitis; odds ratio (OR) associated with treatment in that study was 12.5. Treatment would be expected to be associated with odds of less than 1, as treatment is protective (Dohoo et al. 2003).

The other herd-level factors such as source of cattle drinking water which is associated with the communal use of drinking points at rivers and dams were not associated with increased odds of herd dermatophilosis positivity in multivariable logistic regression. This was in agreement with the findings of Matope et al. (2010). This finding appeared to be at variance with the epidemiology of diseases, which would be expected to increase when animals congregate. Knowledge of bovine dermatophilosis was associated with increased odds (1.93) of herd positivity. Matope et al. (2010) reported that knowledge of brucellosis was associated with reduced odds of disease. In the current study, the increased odds could be the result of increased awareness by farmers of the disease as an important animal health condition. This awareness is possible through colleagues and veterinary extension staff. Herds with a good dipping attendance record had an increased odds (OR=1.8) in univariate analysis, but this was not significant in multivariable logistic regression, of being clinically positive to dermatophilosis than herds with a poor attendance. Chatikobo et al. (2001) reported that plunge dipping increased the risk of cattle contracting bovine dermatophilosis, and this appears to be in agreement with the current study since in this case, cattle were plunge-dipped. During plunge dipping, cattle congregated and mixed with infected cattle; such herds were likely to pick up infection via scabs that contaminate the dip. The quality of dipping service delivery had no association (OR 0.99) with herd-level dermatophilosis positivity. These findings were in contrast to those of Chatikobo et al. (2009) who postulated that poor dipping services were responsible for the spread of dermatophilosis in Zimbabwe. Farmers who purchased their own acaricide had increased odds (OR=1.73) in univariate analysis, that their herds would be clinically positive than herds belonging to farmers who did not buy acaricides. Farmers usually purchased acaricides that were applied by spraying or pour-on. According to Chatikobo et al. (2001), applying acaricides through these methods reduced the incidence of dermatophilosis; this seems to contradict findings in the current study in that purchase of acaricide was associated with increased odds of disease. The increased odds associated with purchasing acaricide could be due to the response of farmers to poor dipping, the latter which is reportedly (Chatikobo et al. 2009) associated with dermatophilosis. A larger herd size had increased odds (OR=1.92) of having dermatophilosis although this was not significant in multivariable logistic regression. Matope et al. (2011) have reported similar findings with this association being significant in the multiple regression models. Large herds increase chances of picking up the disease and these herds are more likely to include brought in or purchased animals. Period of keeping cattle had no association with dermatophilosis as was *A. hebraeum* tick infestation.

In conclusion, the current study showed that clinical dermatophilosis was present in herds at all the four study sites. Area, purchase of cattle, treatment of cattle for diseases and infestation with *A. variegatum* were independently associated with herd-level clinical dermatophilosis while *A. hebraeum*

Table 4 Final multivariable logistic regression of herd-level factors for bovine dermatophilosis positivity in communal area cattle herds of Zimbabwe (2013–2014)

Variable	Level	Multivariable logistic regression[a,b]				
		B	S.E. (*B*)	*p*	OR	95 % CI
Constant		−3.88	1.68	0.021	–	–
Study site	Chivero	–	–	–	–	–
	Koronika	3.07	1.47	0.037	21.46	1.21, 380.96
	Gwanyika	1.53	1.46	0.295	4.62	0.26, 80.8
	Chemawororo	2.11	1.48	0.153	8.33	0.46, 152.20
Bought cattle	No	–	–	–	–	–
No	Yes	1.25	0.59	0.035	3.49	1.09, 11.12
Amblyomma variegatum presence	No	–	–	–	–	–
No	Yes	1.91	0.71	0.007	6.80	1.71, 27.10
Treatment of cattle for diseases	No	–	–	–	–	–
	Yes	3.13	0.98	0.002	22.90	3.31, 158.38

Results are given with beta (*B*), standard errors (S.E.) and odds ratio (OR) with 95 % confidence intervals (CI)

[a] Overall data of the model: log likelihood—42.58, LR chi^2 (7 *d.f.*)=169.73, *p*=0.00, number of observations=185

[b] Dependent variable: herd at least one animal clinically positive (yes/no)

was not. The implementation of strict movement control and tick control could reduce the level of clinical dermatophilosis. As such, spraying instead of plunge dipping should be encouraged in high-risk areas.

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Conflict of interest The authors declare that they have no conflict of interest.

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