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ORIGINAL PAPER

A cross-sectional study of bovine tuberculosis in the transhumant and agro-pastoral cattle herds in the border areas of Katakwi and Moroto districts, Uganda

F. O. Inangolet · B. Demelash · J. Oloya · J. Opuda-Asibo · E. Skjerve

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Abstract A study to determine the prevalence of bovine tuberculosis in the transhumant and agro-pastoral cattle herds in the border areas of Katakwi and Moroto districts in Uganda was carried out from July 2006 to January 2007 using comparative intradermal tuberculin test containing bovine and avian PPDs. A total of 1470 animals, 612 (41.6%) males and 858 (58.4%) females, 883 (60%) young, 555 (37.8%) adult and 32 (2.2%) old animals were included. The study involved a cross-sectional multistage sampling technique with random selection of individual animals from a herd. The results revealed a 1.3% overall prevalence of bovine tuberculosis in cattle herds in the study area, with a marked variation between sub-counties. The highest recorded prevalence was 6.0% in Kapujan, while no cases were recorded in Ongogonja, Magoro and Katakwi sub-counties. Distinctly different patterns in the avian-bovine reactions were also found in different sub-counties. A multivariate logistic regression showed more positive reactions (OR=6.3; 95%CI (1.4–26.34) in females than males. BTB prevalence did not differ significantly between cattle maintained in pastoral and agro pastoral production systems. The study demonstrated a relatively low prevalence of bovine tuberculosis in local zebu cattle reared under traditional husbandry systems in Uganda, suggesting low infectiousness of the disease under such mode of production. The risk associated with the consumption of raw milk among the pastoral communities and that, the pooling of milk together from different animals is a common practice, warrants more investigation into the zoonotic transmission of tuberculosis within these communities.

Keywords PPD tuberculin reactors · Bovine tuberculosis · Cattle · Katakwi · Moroto · Uganda

F. O. Inangolet · B. Demelash · E. Skjerve (✉)
Centre for Epidemiology and Biostatistics,
Norwegian School of Veterinary Science,
P.O. Box 8146, Dep., 0033 Oslo, Norway
e-mail: eystein.skjerve@veths.no

J. Oloya · J. Opuda-Asibo
Department of Veterinary Public Health and Preventive Medicine, Makerere University,
Kampala, Uganda

Introduction

Tuberculosis, one of the most widespread infectious diseases, has been the leading cause of death as a single infectious agent among adult humans in the world (Acha and Szyfres 1987). Tuberculosis in mammals is typically caused by bacteria of the *Mycobacterium tuberculosis* complex (MTC), with *Mycobacterium tuberculosis* the most common cause of tuberculosis in humans (Acha and Szyfres 1987) and *Mycobacterium bovis* causing most lesions in cattle and other mammals. Bovine tuberculosis (BTB) is zoonotic, transmitted to humans by an aerogenous route, consumption of infected milk and other cattle products (Ameni et al. 2003).

In developing countries, BTB is widely distributed and control measures are not applied or applied sporadically and pasteurization of milk is rarely practiced (Collins and Grange 1983). The direct correlation between *Mycobacterium bovis* infection in cattle and disease in humans has been well documented in industrialised countries. This is not true for developing countries, but risk factors for *Mycobacterium bovis* in both animals and humans are widely present (Cosivi et al. 1995).

Tuberculosis is a major opportunistic infection in HIV infected persons. The vast majority of people carrying dual infections live in developing countries, though dual HIV and *Mycobacterium bovis* infections are also reported in industrialized countries (Houde and Dery 1988). The epidemic of HIV in developing countries, particularly countries in which *Mycobacterium bovis* is present in animals could make zoonotic tuberculosis a serious public health threat to persons already at risk (Grange and Yates., 1994).

In Uganda, the largest population of cattle in this agro-pastoral interface districts are the short-horn zebus. Available diagnostic and prevalence data on BTB in these areas is often based on routine abattoir reports and on pathological lesions which have serious limitations (Acen 1991). Reports from transhumance cattle in Karamoja region which forms part of this interface, have shown a low individual but high herd prevalence of PPD tuberculin reactors of 40% in Moroto and Nakapiripirit and 80% in Kotido (Oloya et al. 2006). Movement of animals from these transhumant areas into the agro-pastoral areas during dry season could lead to introduction of the infectious agent. Though *Mycobacterium bovis* has been isolated from human specimens from the transhumant areas, environmental Mycobacteria were also reported to have an increasing role in human tuberculosis in the area (Oloya et al. 2006).

Abattoir reports has revealed that 1.8% slaughter cattle originating from the eastern region of Uganda, such as Teso, Karamoja and Bugisu, showed generalized tuberculosis (Ministry of Agriculture Animal Industry and Fisheries 1990). No more recent update on this figure exists. Teso shares a common border with Karamoja and cattle traders from Teso are the main buyers of livestock from Karamoja. These animals are mainly used for restocking purposes in Teso (Lutheran World Federation 1994). While agro-pastoralism is a predominant production system in Teso, transhumance remains an important practice in Karamoja. Transhumance is often characterised by well-organised seasonal mobility in search of better grazing and watering areas (Karamoja Data Centre 2004). This allows the cross-border movement of animals from Karamoja deep into Teso (Katakwi District Local Government 1999) and subsequent transmission of infectious disease like BTB. Records from the Department of Veterinary services and animal industry in Moroto District suggested a prevalence of 7% bovine tuberculosis suspected cases in Bokora, one of the counties in Karamoja. In spite of the prevailing risk factors of disease transmission, to date there has been no study carried out to determine status of BTB in cattle in the area, thus information on prevalence of the disease remains largely unknown.

Among the several factors attributing to failure in establishing systematic investigation of BTB are lack of awareness of the local authorities about the economic and public health importance. The high cost of sustainable testing procedures as well as logistic inputs and financial constraints are also other added factors for low attention accorded to BTB. Social unrest due to ethnic wars in the area has led to massive displacement of human and animal populations, also having an effect on disease control program. Various BTB related risk factors documented elsewhere such as large herd size, extensive herd interactions, muddy or stagnant water sources etc. (Oloya et al. 2006) are reportedly common in these interface areas. Without proper documentation about the occurrence of BTB in various geographical areas of Uganda, it is not possible to establish a risk-based control program in animals to minimize its production effects as well as zoonotic transmission.

Therefore, the main aim of this study was to establish the prevalence of bovine tuberculosis in transhumance-agro pastoral interface areas of Katakwi and Moroto districts, and secondly, to describe the pattern of reactions to bovine and avian PPD tuberculin. Furthermore, we wanted to identify risk factors associated with the occurrence of bovine tuberculosis in the study areas.

Materials and methods

Study areas

This study was carried out in Katakwi and the neighbouring Iriiri sub-county in Moroto district, Uganda. Katakwi district is located in the North-

Eastern region of Uganda, lying between longitudes 33° 48′-34 14′ E and latitudes 1° 38′N-2° 20′ N. It shares its borders with Moroto, with Iriiri Sub County in the North, Nakapiripirit in the East, Amuria in the West and North-West, Soroti in the South West and Kumi in the South (Katakwi District Local Government 2006). Katakwi is found in the Acholi-Kyoga climatic zone in North-Eastern Uganda. This climatic zone has a rainfall average of 1250 mm occuring in 140 to 170 days of the year. The wet season extends from April to October, with peaks in April, May and August. The drier periods occurs in June and July (Kamanyire 2000). The area is characterized by the Teso farming system, where there is bi-modal rain falling on sandy-loam medium to low fertility soils. The Teso farming system region encompasses the districts of Kumi, Soroti, Katakwi and Kaberemaido. The area is predominantly agro-pastoral and livestock are important contributors to food security as they are more resilient to the climatic fluctuations as compared to crops (Oluka 2004). There is short grassland, ideal for grazing.

Moroto district is bordered by Katakwi in the South West. Iriiri sub-county shares a border with Katakwi District. The main agricultural activity in Iriiri Sub County is pastoral livestock production. However, a few crops like sorghum and maize are cultivated, as a supplement to the meat and milk production. The main domestic animals reared here include: cattle, goats, sheep, camels, donkeys and few chicken (Moroto District Local Government 2006).

This area lies within the Karamoja Region climatic zone characterized by an intense hot and dry season lasting from November to March. There is a single rainy season beginning in April and ending around August, with a marked minimum in June and peaks in May and July. December and January are the driest months. Average annual rainfall is in the range of 100 mm to 625 mm (Kamanyire 2000).

Study design

We wanted to sample all 8 sub-counties in Katakwi and the sub-county Iriiri. Due to security reasons we had to use a convenient sampling strategy to identify one study site within each sub-county. For each sub-county we had a list of kraals, presented by the veterinary assistant working for the Government at the sub-county level. In some areas a bit of problems were encountered due to the nomadic lifestyle of the transhumant communities. Threats of impending cattle raids particularly in Katakwi district also affected the progress of the research work. Thus, some kraals were not available for the study. At each study site we chose a various number of available kraals (4–6) to represent the population in the sub-county. To be considered for sampling, a kraal had to contain above 10 cattle. From the available kraals with >10 cattle, 50% were sampled, with selection of kraals based upon geographical distribution within each study site. In each kraal selected, 50% of the individual animals were randomly selected for sampling, resulting in an approximately 25% sampling of individuals in target kraals. The final study population included 1470 animals from 45 kraals.

Study implementation

The purpose of the study was introduced to the farmers by the local veterinary assistant, helped by the area local opinion leaders to establish contacts with the herd owners. For each animal tested, information about age and sex were recorded, while management system (pastoral or agro-pastoral) was linked to study site.

Skin test procedure and interpretation

The equipment and the tuberculin used in this research work were provided by the Lelystad, Instituut voor Dierhouderij er Diergezondheid BV, together with the Divisions of Animal Production, Infectious Diseases and the Department of Animal Sciences of Wageningen University, the Netherlands. A comparative intradermal tuberculin test was used based on description given by Oloya et al (2006). Briefly two injection sites 12–15 cm apart in the middle third of the right and one on the left neck were clipped and cleaned. A fold of skin within each clipped area was measured with callipers and recorded. On the left of each animal 0.1 ml of 50,000 IU/ml of bovine tuberculin was injected intradermally. On the right side a 0.1 ml dose of 50,000 IU/ml bovine PPD (Lelystad tuberculin) was injected into the upper site and a 0.1 ml dose of 25,000 IU/ml of avian PPD into the lower site using a short needle. A correct intradermal injection was confirmed by palpating a small pea- like swelling at each site of the injection. The same person measured the skin before the injection and when the test is read.

The test interpretation was based on the observation and the recorded increases in the skin fold thickness. A reaction was considered positive, if the bovine was test skin reaction measured more than 4 mm, doubtful if the bovine reaction was from 2–3.9 mm and greater than the avian reaction, and negative if the bovine reaction was <2 mm. Overall results were interpreted together with the observations at the inoculation sites such as diffuse or extensive oedema, exudation, necrosis, pain or inflammation of the lymphatic ducts in that region or of the lymph nodes (Kazwala et al. 2001b).

The readings were interpreted alone and correlated with reactions at the bovine and avian sites. Readings from both sides in individual animals were considered separately.

Statistical analysis

Results from individual animal testing were entered in an Excel spreadsheet together with epidemiological data and information about management systems and the data was validated by determining the number of valid observation and missing values. All statistical analysis were carried out in Stata (Stata SE/ 9.0, College Station, TX). Descriptive analyses were done using tabular and graphical analyses. Prevalence, the proportion of cattle with skin test measurement >4 mm, was established using the *ci* command in Stata with the binomial exact confidence interval. The degree of association and predictive value of individual animal risk factors (sex and age) for the presence of BTB reactivity was determined by constructing a multivariate logistic regression model, with study site as a cluster random variable. Fitness of the model was assessed by computing the Hosmer-Lemeshow goodness-of-fit using a default approach of putting data in 10 groups. using post estimation procedure of Stata.

Results

Of the total 1470 animals tested for the presence of tuberculosis by the comparative intradermal tuberculin test, 19 (1.3%) showed a positive reaction. The associations between sex, age and location of the study sites with prevalence of bovine tuberculosis is presented in Table 1. The prevalence showed a clear variation between study sites with the highest record of 6.0% (95% CI=2.2, 12.6) in Kapuja and no record of tuberculosis cases in Ongogonja, Magoro and Katakwi sub counties. Likewise, there was trend towards a higher preponderance of the disease among older animals than adult and young stocks. On the other hand, tuberculosis prevalence did not differ significantly between cattle maintained in pastoral and agro pastoral production systems,though cattle maintained in pastoral production system tend to show a slightly higher inconclusive results to tuberculin test reaction (16/207) than those in agro pastoral system (54/1163) (data not shown).

Table 1 Prevalence of bovine tuberculosis skin test reactors as influenced by study location, sex and age

Variable	No. Animals (Positive)	Prevalence, % [95% CI]
All animals	1470(19)	1.3[0.8–2.1]
Ongogonja	110 (0)	0.0 [0.0, 3.3]
Usuk	280 (2)	0.7 [0.08, 2.6]
Ngariam	299 (1)	0.3 [0.009, 2.6]
Magoro	173 (0)	0.0 [0.0, 2.1]
Katakwi	100 (0)	0.0 [0.6, 3.6]
Omodoi	100 (4)	4.0 [1.1, 9.9]
Toroma	101 (3)	3.0 [0.61, 8.4]
Kapujan	100 (6)	6.0 [2.2, 12.6]
Iriiri	207 (3)	1.5 [0.3, 4.2]
Male	612 (2)	0.3 [0.04, 1.2]
Female	858 (17)	2.0 [1.1, 3.1]
Age<5	883 (8)	0.9 [0.39, 1.8]
Age 5≤X< 10	555 (10)	1.8 [0.87, 3.30]
Age ≥10	32 (1)	3.1 [0.08, 16.2]

The number of inconclusive reactions was higher in Kapujan (9/100), Omodoi (8/101) and Iriiri (16/207) sub-counties. Like for PPD positive results, old stocks had higher number of inconclusive test reaction (3/32) as compared to the younger animals. These test results across area, sex and age are presented in Table 2.

With inclusion of sex and age as the main explanatory/predictive variable for TB test outcome, the logistic regression model fit the data well (Hosmer-Lemeshow goodness-of-fit=1.65, P=0.65). It was shown that sex and age of an animal are reasonably good indicators of TB positivity in any pastoral herd in Uganda constituting indigenous zebu cattle, with a higher Odds Ratio among older animals than young and females vs. males (Table 3).

Table 2 Frequency distribution of responses to tuberculin reaction (positive, doubtful and negative) with respect to study sites, sex and age

Variable	Label	Skin test reaction		
		Positive (%)	Doubtful (%)	Negative (%)
Study site	Ongogonja	-	6(5.5)	104(94.6)
	Usuk	2 (0.7)	9 (3.2)	269 (96.1)
	Ngariam	1(0.33)	8 (2.7)	290 (96.9)
	Magoro	-	7 (4.0)	166 (95.9)
	Katakwi	-	4 (4.0)	96 (96.0)
	Omodoi	4 (4.0)	8 (8.0)	88(93.0)
	Toroma	3(2.9)	8 (7.9)	90 (89.1)
	Kapujan	6 (6.0)	9(9.0)	85 (85.0)
	Iriiri	3(1.5)	16(7.7)	188(90.8)
Sex	Male	2(0.33)	27(4.4)	583(95.3)
	Female	17(1.9)	43(5.0)	798(93.0)
Age	Age<5	8(0.9)	38(4.3)	837(94.8)
	Age 5≤X< 10	10(1.8)	29(5.2)	516(92.9)
	Age ≥10	1(3.1)	3(9.4)	28(87.5)

The association between simultaneous response to test with bovine and avian tuberculin with respect to the study sites is shown in Fig. 1. As can be seen, there was a positive but weak correlation between bovine and avian tuberculin test reactions for most of the study sites, with the most expressed pattern in Kapujan and Omodoi.

Discussion

The low (1.3%) prevalence of BTB observed in the present study agrees with findings of earlier works carried out elsewhere in Uganda as well as in Africa under similar management and climatic conditions (Kazwala et al. 2001a; Laval and Ameni, 2004 and Oloya et al. 2006). This could indicate that the infectiousness of BTB under traditional mode of cattle production and unfavorable climatic condition is low, which may be due to inefficient close contact between diseased and health animals, and possibly decreased virulence and transmission capacity of the causal strains due to adverse weather (Oloya et al. 2006).

To our knowledge there is no recorded information on status of BTB in Katakwi district, and hence it may be difficult to make a comparative argument. However, our finding is similar with 1.1% record of prevalence of BTB from Iriiri Sub-County of Moroto district (Oloya et al. (2006). It is therefore possible to suggest that the infectiousness of bovine tuberculosis under traditional cattle husbandry system in African is low.

The finding that the prevalence of BTB didn't differ much between pastoral and agro pastoral systems contradicts the earlier work by Faye et al. (2004) from Mbarara district, where the prevalence was recorded to be higher in agro-pastoral than in pastoral production system. This is probably explained by the influence of cattle husbandry system where animals from Moroto district, predominantly a transhumant area, are forced to move as far deep into Katakwi giving rise to mixing of animals from different localities. The movement is more intensive particularly during dry season, when this study was carried out, characterized by well organized mobile herding groups under the guidance of kraal leaders. It is during these moments that there is a lot of interaction between the agro-pastoral and the pastoral cattle possibly resulting in similarity of infection prevalence. Similar studies carried out in Tanzania showed that bovine tuberculosis occurs in both intensive and pastoral farming systems with no distinct differences in prevalence (Kazwala et al. 2001b).

The variation in TB prevalence with location is attributed mainly to environmental and climatic factors. Usually TB prevalence is higher in humid and intensified conditions than in extensive, dryer areas (Kazwala et al. 2001a). Accordingly, Kapujan and Omodoi, sub-counties with relatively higher record of TB prevalence (6% and 4%, respectively), are known for humid climate and largely surrounded by vast swampy areas, in addition to high cattle population managed under an intensive mode of production. Furthermore, the frequent occurrence of floodings in those areas might help build up of mycobacteria in the

Table 3 Logistic regression model with study site as a random effect showing effects of individual animal predictive variables (sex, age) on the response variable (tuberculosis status)

Variable	Odds Ratio	95 % CI
Females vs. males	5.6	1.9–16.8
Age <5 years	1.0	-
Age 5–10	1.7	0.74–3.7
Age >10	2.7	0.29–25.0

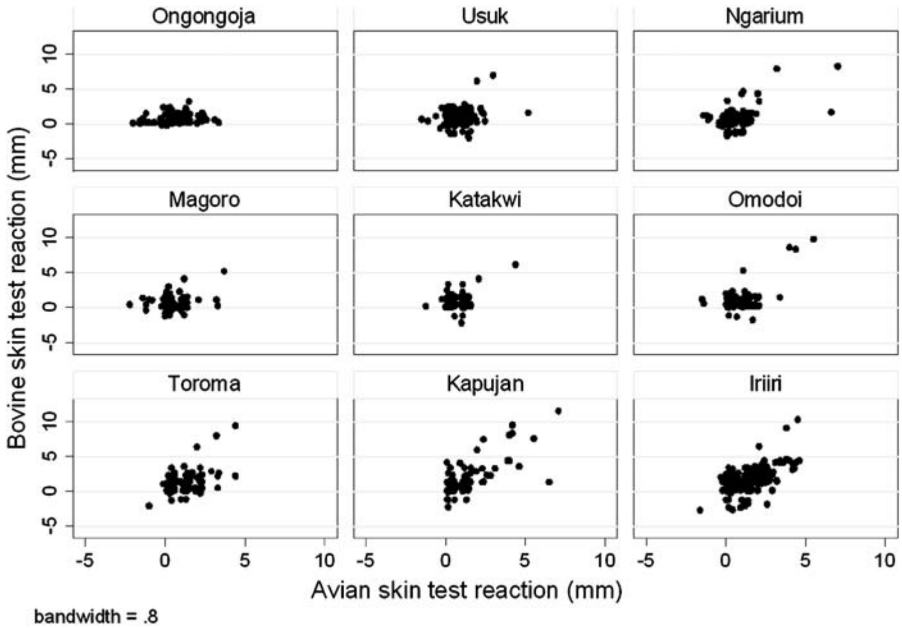

Fig. 1 Scatter graphs showing association between bovine (B) and avian (A) tuberculin test reactions at different sites

environment, thus giving rise to higher prevalence of tuberculous infection.

On the other hand, the extensive cattle production system accompanied by the relatively dryer conditions in Iriiri sub-county explains the low prevalence of TB in the area. The high number of avian reactors in Kapujan and Omodoi sub-counties could be accounted for by the existence of large poultry population in these areas. The latter sub-counties have several women groups involved in chicken production as a source of income. The poultry production system here is free range type which predisposes the pastures and watering sources to fecal contamination by these birds thus, increases the chances of infection of cattle by *Mycobacterium avium*. These domestic birds are seen often in cattle kraals searching for insects in the dung of cattle, which could also constitute a source of transmission of *Mycobacterium avium* to the cattle population. The fairly high number of avian reactors in Iriiri sub-county can possibly be explained by the high goat and sheep population density in the area and most of the time are seen grazing together with cattle. This scenario of inter-species herd mixing is a common phenomenon in pastoral livestock production systems. Sharing of pastures and watering points amongst these animals could also be a source of infection of the cattle population by *Mycobacterium avium*. It has already been argued that small ruminants (goats and sheep) are good reservoirs of the *Mycobacterium avium* complex and could be responsible for environmental contamination of pastures and water sources (Franck et al. 2004).

Anergy is a long recognized phenomenon in the tuberculin test, which results in false negative reactions. The reasons for this are poorly understood but recently infected cattle, cattle under stress due to malnutrition, gastrointestinal parasitoses and concurrent infections, and cattle with generalized tuberculosis are anergic (Ameni and Medhin 2000) and fail to react to tuberculin test. Stress due to starvation (end of dry season) and concurrent infections like trypanosomosis, tick-borne disease and higher burden of gastro-intestinal parasites are common in study herds. In addition, about 30% of cattle in the peri-parturient period can give false results returning later to a positive state (Blood et al. 1994). In Ongongoja sub-county, most animals were seen stressed, heavily laden with ticks and many herds here presented with symptoms of gastrointestinal infections. This probably explains the extremely low numbers of avian reactors in this sub county with a possibility of some infected animals testing negative. Studies done under similar circumstances in Guinea indicate significantly low number of positive reactions to tuberculin test of *Mycobacterium avium* (Unger et al. 2003).

Our study indicated that age was an important risk factor for prevalence of TB which is in agreement with the previous studies carried out by Kazwala et al.

(2001a) and Oloya et al. (2006). The older animals seemed to be more susceptible to infection as compared to the younger animals and this corroborates with the finding by Oloya (2006) who reported a higher prevalence of tuberculin reactors in animals older than 10 years (3.5%) and a rather lower prevalence (1.6%) in animals aged 4–6 years. The high responses to tuberculin reaction in older animals could be due to non-specific immune responses to environmental mycobacteria in the natural water sources (Grange 1987; Phillips et al. 2003) from which these herds were drinking water. Another possible explanation could be that, due to the physiologically related old-age immune depression, the animals tend to easily succumb to mycobacterial infections hence show a positive test. By contrast, the delayed onset of tuberculin positivity at <5 years of age could be attributed to the long incubation period of mycobacteria infection (Perez et al. 2002).

Our study also found more BTB reactors in females than males, an observation in consent with the finding by Kazwala et al. (2001a, b). Markham (1952) as cited by Unger et al. (2003) argued that due to the occupation of the male cattle with in a herd, male animals had a higher chance of being positive than female animals. Oloya et al. (2006) did not find sex as an important risk factor.

In conclusion, our study demonstrated a low prevalence of bovine tuberculosis in local zebu cattle herds of transhumant and agro-pastoral production systems of Katakwi and Moroto districts in Uganda, despite the dense cattle population and wider possibilities in cattle-to-cattle transmission. This agrees with the findings of studies carried out elsewhere in Africa under similar climate, management and diagnostic approach. It seems that the infectiousness of bovine tuberculosis with in and between cattle herds under pastoral mode of production is low, perhaps due to low and inefficient close contact between infected and health animals, less virulence of the causal strains under unfavorable macroclimatic and microclimatic conditions, and possibly genetic resistance of local zebu cattle.

However, the risk associated with the consumption of raw milk among the pastoral communities and that, the pooling of milk together from different animals is a common practice, warrants more investigation into the risk of zoonotic transmission of tuberculosis in these communities.

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