Risk Factors Associated with the Occurrence of Bovine Tuberculosis in Cattle in the Southern Highlands of Tanzania

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ABSTRACT

A study was conducted in the Southern Highlands of Tanzania to determine the prevalence of bovine tuberculosis and the risk factors associated with the occurrence of the disease in cattle of different categories and in different climatic zones. The overall prevalence of the disease was 13.2%, and 51% of the herds tested contained reactor cattle. Assessment of risk factors was based on comparisons of the reactivity of the cattle in the single comparative intradermal tuberculin test (SCITT). Older cattle were more affected by the disease than yearlings and calves ($p < 0.0001$). There were significant differences between male and female cattle ($p < 0.05$) and between cattle with exotic blood compared to indigenous Short Horn Zebu (SHZ) cattle ($p < 0.05$). The castrated bulls, often used for draught power, were more frequently ($p < 0.01$) affected than the entire bulls, mainly used for breeding. Reactivity to tuberculin did not appear to be influenced by the reproductive status of the animal. The reactivity to tuberculin of pregnant cattle was not significantly different from that of the rest of the cows ($p > 0.05$). However, significantly more (14.6%) lactating cattle reacted in the SCITT than did non-lactating cows (12.0%) ($p < 0.05$). There was a highly significant difference ($p < 0.001$) between reactivity in the SCITT among cattle grazing in the hot and dry lower lands (14.0%) and that in those grazing in the cool and wet highlands (8.7%).

Keywords: age, bovine tuberculosis, cattle, epidemiology, prevalence, sex, tuberculin test

Abbreviations: PPD, purified protein derivative; SCITT, single comparative intradermal tuberculin test

INTRODUCTION

Bovine tuberculosis has long been recognized as an important disease affecting both humans and cattle. In developed countries, the disease has almost been eradicated by the institution of appropriate control measures (Kleeberg, 1984; Caffrey, 1994). In

developing countries, particularly in Africa, the disease is believed to be present but there are scant up-to-date data regarding its distribution (Kleeberg, 1984).

In Tanzania, bovine tuberculosis was first reported after the First World War among cattle imported from South Africa (Hornby, 1949). Thereafter, a number of cases of cattle with tuberculous lesions being detected at meat inspection have been reported in a number of foci, notably the north-western (Jiwa *et al.*, 1997), eastern (Kambarage *et al.*, 1995) and Southern Highland regions (Kazwala *et al.*, 1993). The reasons for the occurrence of the disease in certain foci has yet to be fully elucidated. Studies by Markham (1952) and Maiseli and colleagues (1989) gave only crude information regarding the presence of the disease in the Southern Highlands of Tanzania.

The single compartive intradermal tuberculin test (Lesslie and Herbert, 1975) has been strongly recommended (Monaghan *et al.*, 1994) for identifying animals infected with *Mycobacterium bovis* in countries such as Tanzania. It provides a specific diagnosis in situations with high levels of environmental mycobacteria. This test was therefore used to evaluate the epidemiology of bovine tuberculosis in the Southern Highlands of Tanzania, where the disease is considered to be endemic. This area encompasses the right arm of the Rift Valley and includes the Ruaha National Park in the north, where susceptible game animals are known to spill over into adjacent agricultural and livestock grazing areas during the dry seasons.

MATERIALS AND METHODS

Study area

The study, conducted from August 1994 to July 1997, covered the Southern Highlands of Tanzania encompassing Mbeya and Iringa regions. Within this area, cattle are grazed in the plains in the middle of the Rift Valley. Cattle are also grazed on the escarpment of the Rift Valley. This latter area, at a higher altitude, is cool and receives rain for more than six months of the year, whereas the former grazing area is semi-arid and dry for a longer duration. The main source of water for cattle is the Ruaha River.

Animals

Indigenous cattle kept by pastoralists and grade or exotic cattle kept by a few farmers and government institutions were sampled. Using a multi-stage random sampling procedure (Martin *et al.*, 1988), a total of 5692 indigenous cattle, that is 1% of all the cattle in the zone, were included in the study. These cattle belonged to 239 herds in seven villages. The decision to sample 1% of the population was based on the amount of tuberculin available for the study and the financial implications of the study. For exotic breeds of cattle, all 244 kept in selected villages were tested for tuberculosis. Most of these exotic cattle were Friesian, Ayrshire, Guernsey or Jersey. These cattle were kept by several government institutions and progressive farmers for milk production or as breeding units for producing crosses with the indigenous Short Horn

Zebu breed. Prior to tuberculin testing, all the cattle were ear-tagged and clinically examined, and data pertaining to the individual animals were collected.

These data included the following information: identification number; village of origin; herd identity; breed; sex; age based on number of permanent incisor pairs; for males, whether entire or castrate; for females, whether pregnant or lactating.

Tuberculin test

Cattle were subjected to the single comparative intradermal test (SCITT) as described by Monaghan and colleagues (1994). Briefly, 2000 IU each of avian and bovine purified protein derivatives (PPDs) supplied by two European laboratories (Central Veterinary Laboratory, Weybridge, UK, and Central Veterinary Laboratory, Lelystad, The Netherlands) were injected into the neck at least 12 cm apart. Readings of skin thickness were made prior to and 72 h after injection of the PPDs. Since preliminary studies (Kazwala, 1996) had established the presence of *M. bovis* infection in cattle in the area, animals were considered to be reactors when there was a bias towards the bovine reaction of 3 mm or more (Lesslie and Herbert, 1975).

RESULTS

Overall, 781 of the 5936 (13.2%) animals tested were classified as reactors. Positive animals originated from 122 of the 239 (51.0%) herds included in the study. Analysis of risk factors associated with the occurrence of the disease in this area (Table I) revealed the following important observations.

The reactor rate among the age group differed very significantly ($p < 0.001$), with more older cattle affected than younger cattle and calves. The proportion of indigenous cattle reacting positively was significantly higher ($p < 0.05$) than that of the exotic breeds.

More male cattle were affected than female cattle and castrates were significantly more affected by tuberculosis than bulls. There was no significant association between pregnancy and reactivity to SCITT, but significantly more lactating cows than non-lactating cows were positive. Significantly more of the cattle that grazed on the plains situated in the middle of the Rift valley were affected by tuberculosis than those resident in the highlands.

DISCUSSION

The observations that 51% of the herds contained reactor animals showed that tuberculosis is widespread in pastoral cattle in the Southern Highlands of Tanzania. The prevalence of 13.1% in individual cattle concurs with that reported by Markham (1952) but is much more than that reported by Maiseli and colleagues (1989). This disparity could be attributable to the difference in sample sizes.

TABLE I

Comparison of the risk factors affecting the reactivity of cattle to the tuberculin test in Southern Highlands of Tanzania

Variable	Number of reactors (%)	Level of significance (chi-square statistics)
Age		$p < 0.001$
Calves <18 months ($n = 1211$)	110 (9.1)	
Cattle $1\frac{1}{2}$–3 years ($n = 855$)	83 (9.7)	
Cattle >3 years ($n = 3723$)	570 (15.2)	
Sex		$p < 0.05$
Female ($n = 4039$)	509 (12.6)	
Male ($n = 1814$)	268 (14.8)	
Breed		$p < 0.05$
Exotic breeds ($n = 244$)	20 (8.2)	
Short Horn Zebu ($n = 5692$)	761 (13.4)	
Male cattle		$p < 0.01$
Entire bulls ($n = 922$)	114 (12.4)	
Castrated (oxen) ($n = 892$)	154 (17.3)	
Pregnancy		$p > 0.05$
Pregnant ($n = 493$)	59 (12.0)	
Non-pregnant ($n = 3600$)	450 (12.5)	
Lactation		$p < 0.05$
Lactating ($n = 1627$)	237 (14.6)	
Non-lactating ($n = 2079$)	248 (12.0	
Climate		$p < 0.001$
Highlands ($n = 1117$)	97 (8.6)	
Rift Valley ($n = 4614$)	646 (14.0)	

The observation that older cattle were found to be significantly more affected by bovine tuberculosis than younger cattle is in agreement with other studies (Stamp and Wilson, 1946; Shehu, 1988). It has been argued that more older cattle are positive to the tuberculin test mainly owing to increased chances of exposure rather than the slow progression of the disease (Stamp and Wilson, 1946; Stamp, 1948). The preponderance of the disease among the older stock has an impact on the public health implication of the disease, because it is the older cattle that are normally disposed of for slaughter.

Radostits and colleagues (1994) indicated that *Bos taurus* cattle are more prone to tuberculosis than are *Bos indicus* cattle. This conclusion conflicts with the results of the

present study, where the exotic cattle appeared to be less susceptible to the disease than indigenous cattle. However, this difference may have been caused by the different management systems rather than by breed variation. Shehu (1988) found that indigenous cattle kept under a nomadic management system were more affected than those kept under an intensive management system and attributed the difference to the mixing of cattle from different herds and different geographical areas in the course of communal grazing.

The observation that male animals had a higher chance of being positive than female animals was also made by Markham (1952) but not by Shehu (1988) and may be related to the occupation of the male cattle. Male cattle, and in particular castrates, are mostly used as oxen, who are kept in the herd for longer and therefore have more chance of being exposed to infection compared to female cattle. Similarly, female cattle have less frequent contact with cattle from other herds, except at watering points during the dry season.

Although the current study did not classify lactating reactors according to stage of lactation, a significantly higher ($p < 0.05$) reactor rate was found among lactating than among non-lactating animals. This observation is somewhat at variance with the findings of other studies (O'Reilly, 1987).

The higher reactor rate at the center of the Rift valley, as opposed to that in cattle at the higher altitude, is similar to other reports (Markham, 1952). The difference in the rates of infection may be attributed to the congregation of animals along the valley of Ruaha River, especially during the dry period when grazing becomes scarce. Such congregation increases the chance of disease transmission through inhalation and contamination of pastures. It is also possible that another source of the disease is the wildlife in the Ruaha National Park, in the north of the plains. It has been observed elsewhere that wild animals can be responsible for transmission of the disease to cattle and vice versa (O'Reilly and Daborn, 1995). The park harbours a wide range of wild ruminants, which are equally susceptible and able to transmit the disease to both livestock and the human population and are known to enter adjacent cattle keeping areas during the dry season, sharing water and pastures with domestic animals (Jiwa *et al.*, 1997).

Overall, the results of this study have generated valuable data for strategic planning of further monitoring of the disease and also control of the disease in this zone of Tanzania, where the disease has remained endemic for decades (Markham, 1952; Maiseli *et al.*, 1989; Kazwala, 1996). The presence of the disease in cattle, many of which are destined for slaughter, poses a great public health danger. In Tanzania, most of the pastoral communities normally consume undercooked meat and also favour consumption of unpasteurized milk. A concurrent study (Kazwala *et al.*, 1998) isolated several species of *Mycobacterium*, including *M. bovis*, from the milk of cattle found in the same geographical area. This emphasizes the danger to the human population in this area, especially at the present time, when the proportion of the human population succumbing to HIV/AIDS is increasing. Therefore, this study, as well as revealing the epidemiological importance of the disease in cattle in this area, shows the need for concerted veterinary and medical efforts to control the disease in both animals and humans in Tanzania.

REFERENCES

Caffrey, J.P., 1994. Status of bovine tuberculosis eradication programmes in Europe. *Veterinary Microbiology*, **40**, 1–4

Hornby, H.E., 1949. Bovine tuberculosis in tropical Africa. *East African Medical Journal*, **11**, 9–15

Jiwa, S.F.H., Kazwala, R.R., Aboud, A.A.O. and Kalaye, W.J., 1997. Bovine tuberculosis in the Lake Victoria zone of Tanzania and its possible consequence for human health in the HIV/AIDS era. *Veterinary Research Communications*, **22**, 249–255

Kambarage, D.M., Kimera, S.I., Kazwala, R.R. and Mafwere, B.M., 1995. Disease conditions responsible for condemnation of carcasses and organs in short-horn Zebu cattle slaughtered in Tanzania. *Preventive Veterinary Medicine*, **22**, 249–255

Kazwala, R.R., 1996. *Molecular epidemiology of bovine tuberculosis in Tanzania*, (PhD thesis, University of Edinburgh)

Kazwala, R.R., Catley, A.P., Daborn, C.J. and Kambarage, D.M., 1993. The zoonotic implications of bovine tuberculosis in Tanzania. In: *Proceedings of the 10th Tanzania Veterinary Association Scientific Conference*, December 1992, Arusha, Tanzania, **10**, 67–81

Kazwala, R.R., Daborn, C.J., Kusiluka, L.J.M., Jiwa, S.F.H., Sharp, J.M. and Kambarage, D.M., 1998. The isolation of *Mycobacterium* species from raw milk of pastoral cattle of the Southern Highlands of Tanzania. *Tropical Animal Health and Production*, **30**, 233–239

Kleeberg, H.H., 1984. Human tuberculosis of bovine origin in relation to public health. *Revue Scientifique et Technique de l'Office International des Epizooties*, **3**, 11–32

Lesslie, I.W. and Herbert, C.N., 1975. Comparison of the specificity of human and bovine tuberculin PPD for testing cattle. 3. National trial in Great Britain. *The Veterinary Record*, **96**, 338–341

Maiseli, N.G., Lema, F.E., Mchomba, O.K., Mwangoka, H. and Ndunguru, B., 1989. Prevalence of bovine tuberculosis in the Southern Highlands of Tanzania. In: *Proceedings of the 7th Tanzania Veterinary Association Scientific Conference, Arusha, Tanzania*

Markham, A.E.G., 1952. *Bovine tuberculosis in the Southern Highlands Province of Tanganyika*, (PhD thesis, University of London)

Martin, S.W., Meek, A.H. and Willeberg, P., 1988. Multistage sampling. In: *Veterinary Epidemiology – Principles and Methods*, (Iowa State University Press, Ames, IA), 30–31

Monaghan, M.L., Doherty, M.L., Collins, J.D., Kazda, J.F. and Quinn, P.J., 1994. The tuberculin test. *Veterinary Microbiology*, **40**, 111–124

O'Reilly, L.M., 1987. Laboratory studies on tuberculous cows to determine the influence of parturition and puerperium on the intradermal tuberculin response. In: *Proceedings of the Scientific Meeting of Tuberculosis in Animals of the International Union Against Tuberculosis and Lung Diseases*, Paris.

O'Reilly, L.M. and Daborn, C.J., 1995. The epidemiology of *Mycobacterium bovis* infections in animals and man: a review. *Tubercle and Lung Diseases*, **76** (supplement 1), 1–46

Radostits, O.M., Blood, D.C. and Gay, C.C., 1994. *Veterinary Medicine. A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses*, 8th edn. (Baillière Tindall, London)

Shehu, L.M., 1988. *Survey of tuberculosis and tubercle bacilli in Fulani herds, "nono" and some herdsmen in Zaria area, Nigeria*, (MSc thesis, Ahmadu Bello University, Zaria, Nigeria)

Stamp, J.T., 1948. Bovine pulmonary tuberculosis. *Journal of Comparative Pathology*, **58**, 9–23

Stamp, J.T. and Wilson, A., 1946. Some aspects of the pathogenesis of bovine tuberculosis, based on abattoir returns. *The Veterinary Record*, **58**, 11–15