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The epidemiology of *Sarcocystis* spp. in cattle of Western Australia

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SUMMARY

Oesophagus samples from 714 cattle from Western Australia were examined by artificial digestion to detect the presence of *Sarcocystis* spp. The overall prevalence of infection was 52%. The prevalence of infection increased with age and was highest in the entire males (92%). The prevalence was lower in cattle which originated from arid and semiarid regions (9 and 31% respectively) than those from tropical (87%) and temperate (60%) regions. Possible reasons for these differences are discussed and it is concluded that environmental and management factors as well as host age and sex influence the prevalence of infection with *Sarcocystis* spp. in cattle.

INTRODUCTION

Sarcocystis infection is a common parasitosis of livestock and can be an important factor limiting animal productivity [1]. Because chemical treatment or prophylaxis of sarcocystosis is not possible, control must be based on a sound understanding of the life cycle and epidemiology of the parasite.

The *Sarcocystis* life cycle is indirect and necessarily involves two hosts [2]. Herbivorous and omnivorous intermediate hosts (IH) become infected after ingesting sporocysts shed in the faeces of the definitive host (DH) which is a predator or scavenger. The DHs contract the infection by ingesting mature forms of *Sarcocystis* encysted in muscle and nervous tissue of an infected IH, in this case cattle.

A preliminary study revealed that *Sarcocystis cruzi* is the most common species infecting cattle in Western Australia (Savini and colleagues, unpublished). The species was identified as *S. cruzi* on the morphological criteria of Gestrich and co-workers [3] and Mehlhorn and co-workers [4] and on the basis of experimental infection of dogs (Savini and colleagues, unpublished). For this species dogs and other canids act as the DH [5]. From the epidemiological point of view the life cycle can be divided into two phases: first the IH with intramuscular sarcocysts and secondly the DH excreting sporocysts. Sarcocysts and sporocysts are potentially long-lived resting stages in the life cycle of *Sarcocystis*, capable of further development only if ingested by the appropriate DH or IH respectively. Although some information is available on the survival of sarcocysts and sporocysts under experimental conditions [6, 7], survival under field conditions

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has not been thoroughly investigated. In this paper we report the results of an epidemiological survey on the prevalence of *Sarcocystis* in cattle in Western Australia (WA) and analyse the effect of factors such as sex, age and geographic origin of the animals on the prevalence of infection.

MATERIALS AND METHODS

Between May 1989 and December 1990, samples of oesophagus were collected from 714 cattle slaughtered at three abattoirs in WA. After an initial survey on 203 cattle, the oesophagus was chosen as the most suitable organ for detecting *Sarcocystis* infection. This was in line with previous studies on bovine sarcocystosis [8, 9].

The geographic origin of the cattle was determined by their property tail tag. Western Australia has been divided into four zones (Fig. 1) according to different climatic conditions and management practices [10]. The rainfall in the state is very seasonal with a winter regime in the south and a summer regime in the north. The inland areas are characterized by only occasional rainfall.

The farming system of WA reflects these typical climatic conditions. Stocking rates are directly related to rainfall. Winter rain or summer rain is the most important single factor in determining stocking rates in the southern or northern areas respectively.

Area A: Wet-dry temperate zone

Rainfall in this zone is reliable but generally confined to the winter, ranging from about 1500 mm annually in the south-west to slightly less than 300 mm along the northeastern side. Temperatures are relatively mild. The average property size is 400–1000 ha and the stocking rate is 1·5–2 beasts/ha.

Arid and semi-arid region (B and C)

Rainfall is erratic, more prevalent in winter in the south and in summer in the northern part of the region. Yearly median falls are around 100–400 mm. The cattle industries are extensive and the grazing properties are very large with average areas of 84000 ha. The stocking rates are, however, very low approximately 1 beast/150 ha.

We divided the arid and semi-arid region into areas west and east of 117° E longitude (Fig. 1). This divides the region into an arid inland part and a coastal section with a higher relative humidity. These two areas have been designated as Area B, the west arid and semi-arid region; the relative humidity usually is around 60% and Area C, the east arid and semi-arid region; the relative humidity in this area rarely reaches 50% throughout the year.

Area D: the wet-dry tropical zone

In the wet-dry tropics up to 90% of the yearly rainfall occur in the summer months. The yearly median rainfall varies from 750 mm to 1250 mm over the major part of the zone. The stocking rates are 1 beast/32 ha.

Samples (10 g) of oesophagus, fresh or sometimes chilled for several days at 4 °C, were subjected to muscle digestion using the method described by Dubey and colleagues [11].

The prevalence of infection was correlated with sex, age and geographic origin

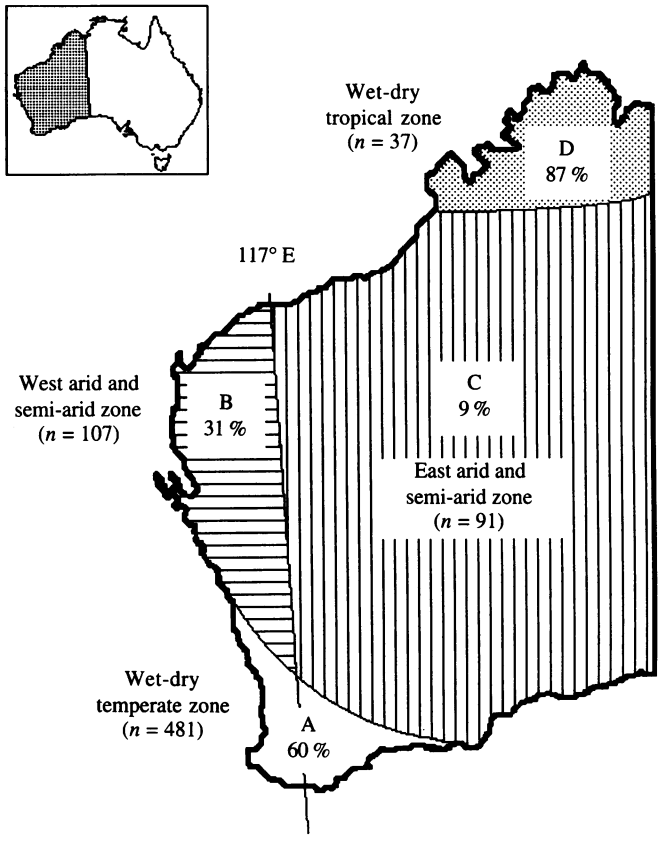

Fig. 1. Prevalence of *Sarcocystis* spp. infection in cattle in climatic zones of Western Australia.

of the animals and the statistical significance of their association or independence were tested by χ^2 or Student t tests. Linear regression analysis was also used to study the relationship between the age and the prevalence of infection.

In addition to estimating the percentage of infected cattle, it was also possible to estimate the percentage of infected properties. Because not many properties were involved, the two arid zones (B and C) were combined to give a total of 28 to compare with the 79 properties in zone A (zone D was ignored in this analysis because of inadequate property numbers). The proportion of infected animals within infected herds was also calculated (this figure was only calculated for herds from which at least five animals were examined).

Age and sex analyses were limited to zone A because it was relatively uniform in climate and management and because most animals came from that zone. The small number of bulls examined and the similar prevalence of infection found in cows and castrated males induced us to use (for age analysis) only the animals of these two latter categories for which an estimated age was available.

RESULTS

Of the 714 WA cattle examined by muscle digestion, 52% were infected with *Sarcocystis*.

Table 1. *The prevalence of infection with* Sarcocystis cruzi *within and between herds*

Zone	Herds infected (%)	Individuals infected in infected herds (%)
A	91* ($n = 79$)	67** ($n = 25$)
B and C	32* ($n = 28$)	56** ($n = 12$)

* There is a significant difference ($P < 0{\cdot}001$) between the two zones.
** There is no significant difference between the two zones.

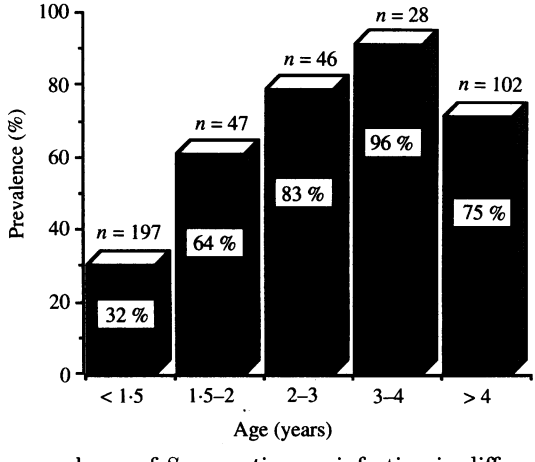

Fig. 2. The prevalence of *Sarcocystis* spp. infection in different age groups.

The results of the geographic analysis are summarized in Fig. 1. The prevalence of infection in areas B and C, the arid and semi-arid zones (31 % and 9 %) were significantly lower ($P < 0{\cdot}0001$) than those in areas A and D, the wet-dry zones (60 and 87 %). In addition, the prevalence of *Sarcocystis* spp. infection in the coastal side of the arid regions (B) was 31 % which was significantly higher ($P < 0{\cdot}01$) than the 9 % found in the arid inland (C) (Fig. 1). A significantly higher ($P < 0{\cdot}001$) proportion of positive herds was found in the wet-dry temperate zone (A) (91 %) compared to the arid zones (B and C) (32 %) (Table 1). However the average percentage of positive animals in infected herds with more than five animals tested was similar between region A and the combined regions B and C (66·6 and 56·1 % respectively) (Table 1). In other words, although a lower percentage of herds in the arid zones were infected with *Sarcocystis*, those herds which were infected showed a similar prevalence of infection as did those in the higher rainfall regions.

A significantly higher ($P < 0{\cdot}0001$) prevalence of *Sarcocystis* infection was found in entire males (92 %) ($n = 51$) than in either castrated males (60 %) ($n = 261$) or females (51 %) ($n = 170$). The latter two groups were not significantly different.

Age analysis demonstrated a positive correlation ($r = 0{\cdot}98$, $P < 0{\cdot}05$) between the prevalence of infection and the host age up to 4 years. The prevalence of infection significantly ($P < 0{\cdot}01$) dropped in the oldest group (Fig. 2).

DISCUSSION

This survey found a prevalence of *Sarcocystis* spp. infection of 52% which is lower than that reported from other countries. Using similar techniques, Hinaidy and co-workers [12] reported a prevalence of 87% in Austria, Vercruysse and colleagues [9] found 97% of cattle infected in Belgium, Boch and Erber [13] reported a prevalence of 99% in the Federal Republic of Germany and Bottner and co-workers [8] reported a prevalence of 97% in New Zealand. The factors thought most likely to be responsible for the low prevalence in WA include the low densities of both the definitive and the intermediate host and the relative aridity of much of the region. The heteroxenous life cycle of *Sarcocystis cruzi*, the species which is most common in WA, requires that cattle encounter canine faeces and that dogs or other canids ingest bovine tissue. The frequencies of these encounters may decline with increasing property size, although there are always stockyards to which animals are brought at least annually and where encounters between species may occur. The type of grazing in WA is characterized by very large properties (7620 ha in average) and low stocking rates (1 cattle beast/12·5 ha) [10]. The stocking rates decrease and the property size increases with increasing aridity. Both factors, aridity and frequency of interspecific encounter, are likely to affect the prevalence of *Sarcocystis*. High temperature and low humidity may have detrimental effects on sporocysts passed by the DH and reduce their survival time. This is in line with studies on other coccidia such as toxoplasma and *Eimeria* spp. [14].

In this survey it was clear that the regions of WA with the lowest overall prevalence of bovine sarcocystis infection were the arid and semiarid regions B and C. The prevalence was higher in the less arid coastal belt (B) than in the interior (C). Because property size and management practices are believed to be similar in the coastal and inland parts we regard this as epidemiological evidence that aridity significantly affects the prevalence of *Sarcocystis* in WA cattle. In each of the higher rainfall regions A and D there is a period of low or zero rainfall each year. However in both there is a much higher prevalence of *Sarcocystis* than in B and C and this is additional evidence that the parasite is affected by the permanent aridity of the environment.

The reduced prevalence of infected cattle in the arid regions appeared to have been due to a reduced proportion of herds being infected. The prevalence of infected animals within an infected herd was similar to that found in the higher rainfall regions. It is possible that in these zones of low stocking density there may be places where cattle come in contact with *Sarcocystis* contamination. The likely areas are the cattle yards to which all animals are mustered at least annually or the water sources where definitive and intermediate hosts may congregate.

Infection of cattle in the yards may also explain why there is a higher prevalence of *Sarcocystis* spp. in entire males as compared to females and castrated males. Bulls are more frequently pastured in closer proximity to the farm yards and buildings. However the possibility of hormonal effects cannot be discounted [15].

In this survey the prevalence of infection and the host age varied together in positive manner up to the age of 4 years. The prevalence of *Sarcocystis* spp.

significantly dropped in the oldest group. It is still unclear whether immunity acquired with increasing host age removes the sarcocysts from the muscle tissue. The host-response to *Sarcocystis* infection may account for the fall in the prevalence of *Sarcocystis* spp. in the oldest age group. Broken and degenerating sarcocysts surrounded by host inflammatory reaction in muscle tissue of infected goats, sheep and pigs have been reported [16–18]. The rupture of the sarcocysts, which may occur spontaneously or be caused by a host-immune reaction, is more likely to occur in old cysts found in older animals and may cause progressive reduction in cyst number over time [16, 18]. Alternatively, the fall in the prevalence in older animals may be a reflection of natural or managerial selection where the healthier animals are kept for longer periods. The increase in prevalence with age, at least up to 4 years, is possibly due to the greater opportunity for older hosts to come in contact with sporocysts. Few cattle were infected below 1 year of age although the prepatent period is much less than this. Fully formed cysts containing bradyzoites develop in cattle approximately 70–80 days after ingestion [19]. This may be explained by the fact that in this region the calf suckling period lasts approximately 9 months and young calves, therefore, have few chances to come in contact with sporocysts. In conclusion the results from this survey show that climatic factors as well as management practices are associated with variation in the prevalence of *Sarcocystis* infection. There is also a significant association between age and sex of cattle with the prevalence of naturally occurring bovine sarcocystosis.

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