Aspects of rabies epidemiology in Tsumkwe District, Namibia

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ABSTRACT

LAURENSON, K., ESTERHUYSEN, J., STANDER, P. & VAN HEERDEN, J. 1997. Aspects of rabies epidemiology in Tsumkwe District, Namibia. *Onderstepoort Journal of Veterinary Research*, 64:39–45

Aspects of rabies epidemiology were investigated in the Tsumkwe District, Namibia, during December 1993 and January 1994. A cross-sectional seroepidemiological survey for rabies antibodies was carried out in domestic (n = 70) and wild dogs [*Lycaon pictus* (n = 6)]. An overall seroprevalence rate of 30 % was found in domestic dogs, but it must be borne in mind that seroconversion can result from infections from either rabies or rabies-related viruses. Older dogs were more likely to be seropositive and there was spatial and temporal clustering of seropositivity. No wild dogs were found seropositive. A demographic survey of the domestic-dog population in the area showed that the total dog-population size was 132, or 0,027 dogs per km^2. The dog population consisted mainly of young dogs with a median age of 1,5 years, and had a female bias of 0,63 males per female. Questionnaire surveys suggested that spotted hyaenas (*Crocuta crocuta*) and black-backed jackals (*Canis mesomelas*) were the most common larger carnivores found in and around villages, and that dogs were kept mainly for guarding.

Keywords: Dogs, epidemiology, Namibia, rabies, seropositive, seroprevalence, Tsumkwe

INTRODUCTION

Rabies is a public health risk throughout the world, and the domestic dog is responsible for most human exposures and for up to 98% of human fatalities to rabies (WHO 1992). Although effective rabies vaccines are available for domestic dogs, control programmes have often failed. In part, this has been due to economic or logistical problems, but probably also to a lack of a thorough understanding of the epidemiology of the disease, as well as of knowledge of the ecology and behaviour of the host population (Perry 1993). Accordingly, a number of domestic-dog population studies have been carried out to collect demographic and behavioural information, particularly data on population size, distribution and structure. The majority of these studies have been carried out in urban areas (but see Ogunkoya, Beran, Umoh, Gomwlak & Abdulkadir 1990; Kital, McDermott, Kyule & Gathuma 1993, Cleaveland 1996).

Free-ranging wild species may be involved in the epidemiology of rabies, either as reservoirs of infection, or as "spillover" hosts (Wandeler 1993). Recently, the implications of rabies infections in endangered populations have been highlighted by outbreaks in the endangered wild dog (Gascoyne, Laurenson, Lelo & Borner 1993; Alexander, Smith, Macharia & King 1993), the Ethiopian wolf (*Canis simensis*) (Sillero-Zubiri, King & Macdonald 1996) and in a small population of Blandfords' fox (*Vulpes cana*) in Israel (Macdonald 1993). In these cases, high mortality rates occurred in the population as a whole or in individual groups or packs associated with confirmed cases of rabies.

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Accepted for publication 20 November 1996—Editor

In Namibia, rabies has been reported periodically in domestic and wild animals since 1887 (Schneider 1985; Depner 1992), with domestic-dog and human cases being most common in the north, where the human population density is highest. Rabies cases in black-backed jackals (*Canis mesomelas*), kudu (*Tragelaphus strepsiceros*) and cattle predominate in the central ranching areas, while wild felids and viverrids account for most recorded cases in the southern sheep-rearing areas (Depner 1992). In Etosha National Park, rabies cases have been most commonly recorded in kudu, then in black-backed jackals, eland, bat-eared fox (*Otocyon megalotis*), lion (*Panthera leo*) and spotted hyaena (Etosha Ecological Institute, unpublished data 1995).

The communal lands of Tsumkwe District, which abut the Kaudom Game Reserve in north-eastern Namibia (Fig. 1) are the hunting grounds of the Ju/'hoan San. Lately, since the drilling of boreholes, these people have settled and taken up some agricultural practices, although they still rely on hunting and gathering for most of their nutritional requirements. This area contains the last potentially viable population of wild dogs in Namibia at a density of 0,019–0,031 dogs per km^2 (Hines 1990). However, the growing awareness that sympatric domestic dogs can act as reservoirs of disease for wild canids (Cleaveland & Dye 1995), and the considerable population of domestic dogs in Ju/'hoan villages scattered throughout the region, mean that this wild-dog population may be at risk from disease. This paper examines aspects of the epidemiology of rabies in Tsumkwe District by presenting preliminary results from a dog-ecology and seroepidemiological survey.

MATERIALS AND METHODS

Twenty-eight villages in Tsumkwe District (4 868 km^2) were visited between 10 December 1993 and 20 January 1994 (Fig. 1). A total of 425 adults lived in these villages (Stander 1993). The town of Tsumkwe was unfortunately not included in the serological survey, owing to difficulty in catching stray dogs and problems in identifying owners and obtaining their permission. The dogs in each village were identified and their ages assessed by examination of tooth wear and by questioning the owners. One dog owner in each village was asked a series of questions about the dogs, why they were kept, which wild animals came to the village and what the dogs had been doing when this occurred. Accuracy and reliability of answers were not determined. In addition, owners were asked about the causes of dog mortality. Where possible, up to 20 mℓ of blood was taken from the cephalic or tarsal vein of all adult dogs (> 5 months of age). Two-and-a-half milliliters of blood was immediately placed in anticoagulant (EDTA, Teklab, UK) while the remaining blood was allowed to clot. After separation, serum was extracted, frozen and kept at –10 °C until shipped to the laboratory on dry ice.

A small number of wild dogs were sampled during the course of a radio-collaring programme that involved the collaring of 1–2 members of each pack. Wild dogs were darted with disposable 1-mℓ darts (Pneu Dart Inc.) containing a mixture of 70 mg of zoletil (Zoletil, Virbac) and 30 mg of xylazine hydrochloride (Rompun, Bayer) from an air-powered rifle or by the indigenous bow and arrow (Stander, Ghau, //,Tsisaba & Txoma 1996). Two wild dogs were still alive 2,5 and 3 years after they had been darted, one wild dog survived for 17 months before it was found dead in a snare, two were translocated and not radio-collared, and the destiny of one is unknown, as the collar failed.

A liquid-phase blocking ELISA was used to test sera for rabies antibodies (Esterhuysen, Thomson & Prehaud 1995). Titres were calculated as the dilution at which 50% of the maximal optical density was inhibited, and presented as $\log_{10}$ reciprocal titres, with titres > 1,40 being considered positive.

RESULTS

Domestic-dog demography

The dog population in the 28 villages in Tsumkwe District totalled 102 animals, a mean of 3,64 (SE = 0,4) dogs per village, or 0,24 dogs per adult. The dog population in Tsumkwe was estimated at approximately 30, therefore the density of dogs was calculated as 0,027/km^2 in Tsumkwe District, although the population was not homogeneous. The age distribution was biased towards young dogs (Fig. 2) with 46 % (n = 94) dogs aged 1 year or less (median age = 1,5 years). The population was biased towards females, with a ratio of 0,63 males per female (n = 85; Chi square test, χ^2 = 2,03, df = 1, P = 0,02).

The majority of owners kept dogs for herding (67%, n = 27 owners) although guarding (37%), companionship (26%) and hunting (11 %) were also cited as reasons. Hunting was probably under-reported as a reason for keeping dogs, owing to its illegality. Spotted hyaenas were reported to visit 96,5% villages (n = 27), with brown hyaenas (*Hyaena brunnea*) and black-backed jackals reported in 70% villages. Wild dogs were said to occur in the vicinity of 44,4% villages, with fox-like canids (bat-eared fox and Cape fox, *Vulpes chama*, 25,9%), lions (33,3%) and leopards *Panthera pardus* (14,8%) less commonly reported. All but one of 19 owners said that their dogs barked when these wild species entered villages, and that 32% dogs also chased the intruders. No owners reported that their dogs had engaged in fights with wildlife. Dogs frequently went to other villages or out in the veld (34,6%, n = 26 owners questioned).

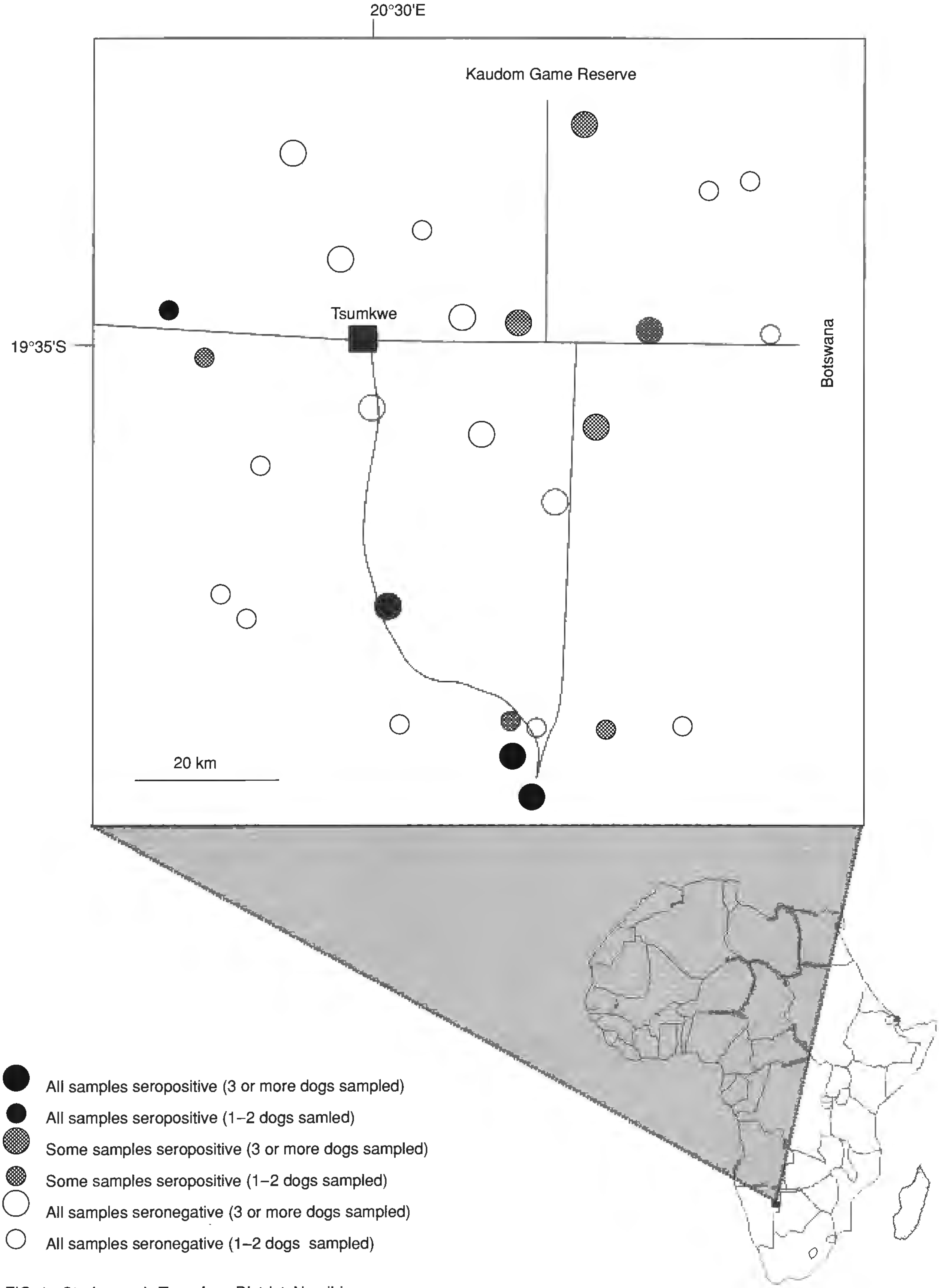

FIG. 1 Study area in **Tsumkwe** District, Namibia

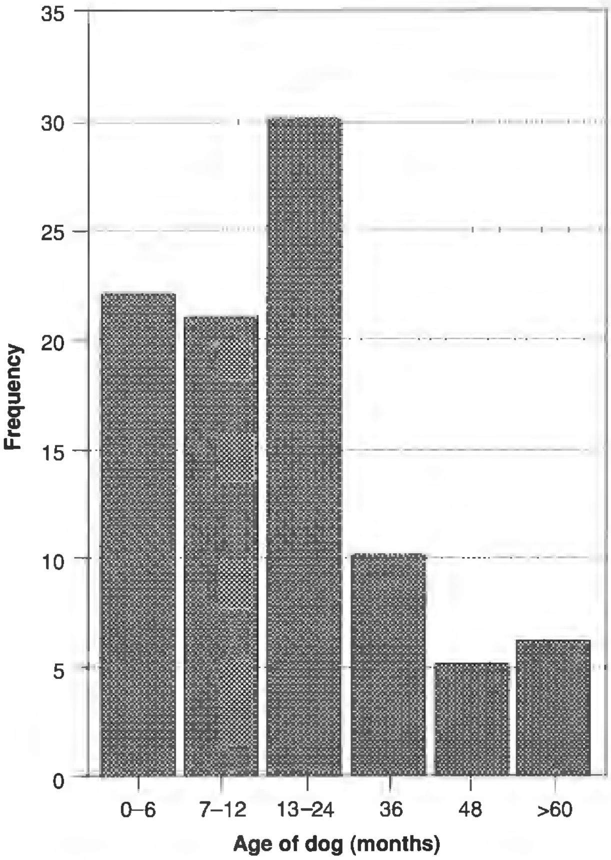

FIG. 2 Frequency distribution of age of domestic dogs in **Tsumkwe** District, Namibia

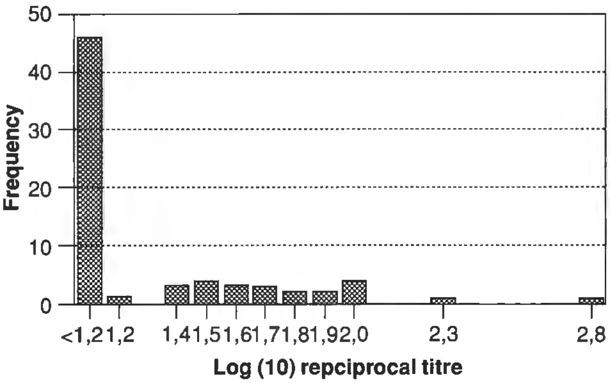

FIG. 3 Frequency distribution of rabies antibody titres of domestic dogs in **Tsumkwe** District, Namibia

All owners reported sickness as a cause of dog deaths, while snakes (four owners), fights and poisonous plants (one owner) were also mentioned.

Rabies serology

Thirty percent domestic dogs tested (n = 70) had antibody titres consistent with exposure to rabies virus. There was no sex difference in seroprevalence

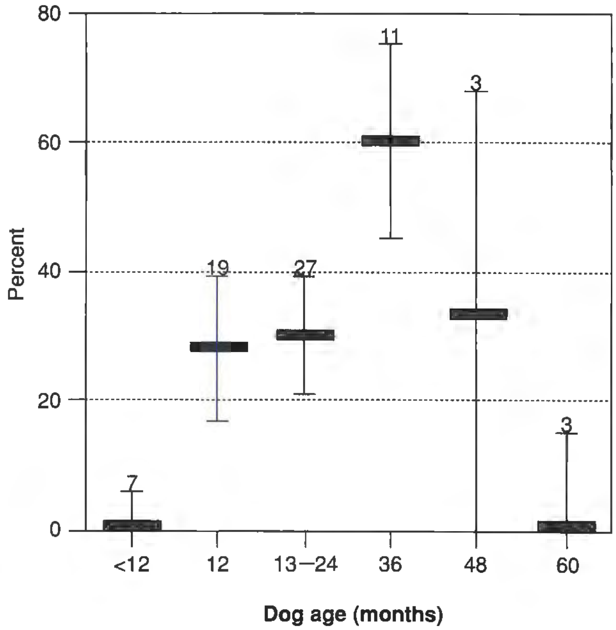

FIG. 4 Age seroprevalence rabies antibodies in domestic dogs in **Tsumkwe** District, Namibia. Bars represent standard errors and numbers above bars indicate sample size

(males, females, respectively, 25,0%, 34,9% seropositive, n = 28, 43; χ^2 = 0,78, df = 1, NS). The frequency distribution of titres (Fig. 3) was overdispersed and three individuals had titres of over 2,0. An age-prevalence curve (Fig. 4) showed that 3-year-old dogs had a higher rate of seroprevalence and higher titres than younger dogs did (χ^2 = 6,49, df = 1, P = 0,01), and that dogs under a year old were all seronegative. All six wild dogs tested were seronegative.

Geographical analysis revealed an uneven distribution of seropositive dogs, with clusters in the south-east, north-east and west of Tsumkwe District (Fig. 1). In the 13 villages from which three or more dogs were sampled, either all dogs were negative (n = 6) or positive (n = 3), whereas in the remaining four villages, older dogs (two years or older) were more likely to be seropositive (n = 6 young, 12 old; seropositivity 16,7% young, 66,7% old; χ^2 = 4,00, P < 0,05). These results suggest that seropositivity was a real phenomenon in response to a wave of infection which might have reached a particular village. Further analysis of these results suggest that, of the 13 positive dogs in the south of the area, five were young dogs 1–2 years old, whereas of the seven seropositive dogs in the six north-eastern villages, only one dog was younger than two years of age.

DISCUSSION

Domestic-dog demography

The high turnover rate of 46%/year (the proportion of dogs under 1 year of age) in the domestic-dog population of Tsumkwe District, Namibia, is typical of that found in developing countries. Such rapid turnover of the population is important in consideration of the feasibility and implementation of control programmes. With nearly half of this dog population changing each year and a targeted vaccine coverage of 80% (WHO 1987), a vaccination campaign must be conducted at intervals of less than a year. The relatively low number of rabies-seropositive dogs under one year old, suggests that under this regime, few dogs would be exposed to rabies before vaccination, although this might reflect the timing of the past epidemic. Although the vaccination of dogs is compulsory and free of charge in Namibia (Depner 1992), the Ju/'hoan San have no access to veterinary care within the region investigated, and Animal Health Inspectors did not vaccinate dogs in the region sampled before 1994. However, a dog-rabies vaccination campaign was initiated by the Animal Health Inspectors in late 1994 and repeated in September 1995 (Directorate Veterinary Services, Grootfontein, unpublished data 1995).

The female-biased sex ratio found in this dog population, however, is more unusual, as selective killing of females is often conducted by dog owners in developing countries in order to control population size. The causes of differential mortality rates, whether due to natural causes or human selection, cannot be elucidated without further study of this population. This result has epidemiological significance, as a lower proportion of male dogs, which are more likely to range away from home, could slow down pathogen spread between villages.

Significance of seropositivity

The results from this study are consistent with epidemiological surveys of dogs in rural communities (e.g. Ogunkoya *et al.* 1990; Mebatsion, Sillero-Zibiri, Gotelli & Cox 1992; Alexander *et al.* 1993; Cleaveland & Dye 1995), where a significant number of dogs have been found to exhibit rabies antibodies. Previous work has suggested that the rabies seropositivity detected by the blocking ELISA used in this study can reflect genuine and recent natural exposure to rabies virus as antibodies were not detected in negative control sera from Mauritius, a correlation was detected between rabies cases and seropositivity, amnestic responses occurred after rabies vaccination and seroconversion occurred in a number of dogs that had been bitten by rabid dogs (Cleaveland & Dye 1995). The origin of this specific rabies antibody is, however, also contentious; traditionally, rabies antibodies in unvaccinated dogs were thought to be detectable only when clinical signs were apparent in infected individuals and shortly before death. Recent laboratory and field findings, however, suggest that specific rabies antibodies can arise from sublethal infections either with or without the onset of clinical signs (Fekadu 1988; Cleaveland 1996). However, rabies antibodies could also be generated by infections by rabies-related viruses or be produced during prolonged incubation periods. Neither of these explanations can be ruled out, but they are unlikely. Preliminary experiments with hyperimmune sera suggest that cross-reactions to this blocking ELISA, from rabies-related viruses, are very mild or do not occur (Cleaveland, personal communication 1996) and would not be considered seropositive in terms of the cut-off point in this study. However, as there is no surveillance in the area and virus cannot be isolated, it is impossible to rule out the presence of rabies-related viruses, and some, but not all, researchers might consider this to be the most likely explanation (Ogunkoya 1990; Meredith, personal communication 1996).

It is also impossible to rule out the fact that the antibodies were detected in dogs incubating rabies in this cross-sectional serological study, but again, it would seem unlikely for several reasons. It is highly improbable that such a high proportion of dogs (30%) would be incubating rabies virus at the time of sampling. The temporal and geographical clustering of apparently seropositive dogs, suggests that these dogs seroconverted in response to waves of rabies-virus or rabies-related virus infections. Although it may seem unlikely that waves of rabies infection would be undetected in this community, as we did not receive descriptions of clinical signs associated with the "mad" form of rabies, and rabies cases were not confirmed, it is quite possible that they did occur. Standards of health care and education are low in the region and information may have been lost in interpretation, leading to poor reporting. Also, veterinary care and surveillance are virtually non-existent, therefore it is quite possible that rabies cases could go undetected. Relatively few cases of dog rabies are associated with mad rabies and it is possible that many of the clinical signs of illness in dogs described by owners could be associated with "dumb" rabies.

Rabies epidemiology

Rabies antibodies produced in domestic dogs, either by natural infections or by vaccination under field conditions, have a relatively short half life and are rarely detectable after 1–2 years unless reinfection occurs (Cleaveland & Dye 1995). Therefore positive titres represent exposure to infection over the previous 1–2 years. Age-prevalence data from the area as a whole showed that older dogs were more likely to be seropositive. This could represent higher exposure rates or higher survival rates after infection in older dogs. In this study and others (e.g. Cleaveland 1996), there are few data to support or reject either of these two hypotheses. However, if older dogs had previously been exposed to rabies virus, superinfection yielded higher antibody titres which took longer to decline. Therefore a higher proportion of previously infected dogs than of previously seronegative dogs would appear to have been infected shortly before the time of sampling. If this hypothesis holds, then there is evidence for differential timing of infection within Tsumkwe District. Although data are limited, a geographical analysis of the data shows that more or less equal proportions of dogs of all ages were seropositive in the south and west of the area, indicating relatively recent infection, whereas only older dogs in the north-east were seropositive, suggesting a wave of infection more than a year brfore, and an epidemic more than two or three years before.

None of the wild dogs sampled was seropositive, although the sample size was limited. There is clear evidence, however,that rabies virus is present in the area and could potentially cross over into the wild-dog population, as has occurred in east Africa (Gascoyne *et al.* 1993; Alexander *et al.* 1993). The potential for cross-infection of pathogens in this area illustrated by the significant correlation between seroprevalence rates of seven different pathogens in wild and domestic dogs (Laurenson, K., Van Heerden, J., Stander, P. & Van Vuuren, M.J. Disease threats for endangered populations: seroepidemiological survey of domestic and wild dogs (Lycaon pictus) in Tsumkwe District, north-eastern Namibia.

Preliminary analysis of the rural domestic-dog population in Tsumkwe District suggests that the density is very low at 0,027 dogs per km^2 overall, although population distribution is not homogeneous. This density may be comparable to populations elsewhere in Namibia (Depner 1992) and also rural Serengeti (Cleaveland 1996). With such low densities in a relatively small area, it would seem unlikely that rabies could be maintained in this domestic-dog population alone. Furthermore, the suggestion of two waves of infection in the area suggests that rabies is continually being introduced from an external source. This could be from neighbouring domestic-dog populations or from persistence in a wild-animal reservoir. Dogs in Tsumkwe District could have acquired infection from other dogs in or outside the region, as dogs travelled with their owners to other villages. Infection from wildlife is also feasible; in Namibia, the majority of rabies-virus infections in wildlife have been confirmed in black-backed jackals, bat-eared foxes and kudu (Depner 1992), and these species occur in Tsumkwe District. Elsewhere in southern Africa, the yellow mongoose (*Cynictis penicillata*), also present in this district, is a wildlife reservoir for rabies virus (Swanepoel, Barnard, Meredith, Bishop, Bruckner, Foggin & Hubschle 1993). Dogs frequently went to other villages or out in the veld, and wild species also came to the villages. Unfortunately, veterinary surveillance in the area is extremely limited and human health care basic, therefore the incidence of rabies cases in humans, domestic animals and wildlife, is unknown. Further research must be done to ascertain the role of wildlife species in the epidemiology of rabies in this area and to examine the role of metapopulations of domestic dogs in rabies-virus persistence.

ACKNOWLEDGEMENTS

Samples were collected with the help of Tsisaba Debe, //au, /Kgali and Simon Thirgood. We would like to thank Annatjie Bonthuys of the Namibian Nature Foundation for her logistical support. This project was funded by the British Ecological Society, with indirect help from Grand Canyon Spur, Windhoek, the Ministry of Environment and Tourism, and WWF (US). Sarah Cleaveland made helpful comments on the manuscript.

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