Rabies in South Africa between 1993 and 2005 – what has been achieved?

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ABSTRACT

Epidemiological analyses in time and space were carried out on all animal rabies cases reported in South Africa for the period 1993–2005. Validation of state veterinary records was done by comparing these with data from the 2 diagnostic laboratories mandated to test for animal rabies. A discrepancy between state veterinary records and laboratory results was found and is discussed. The total number of positive rabies cases reported to veterinary services between 1993 and 2005 was 4767. During this period the proportion of domestic animal rabies had increased to 79 % (19 % more than for the period 1980–1994), with 59 % of the total cases being domestic dogs. Of the domestic animal cases 74 % were canine and only 21 % were bovine; when compared to the data from 1985–1994 there was an increase of 6 % of rabies in canine and a 3 % decrease in bovine cases. A disturbing trend is the increase in the incidence of rabies over the last 16 years in provinces neighbouring KwaZulu-Natal province, where rabies used to be concentrated, and in Limpopo province.

Keywords: distribution, domestic animals, frequency, production animals, rabies, regions, seasonal, South Africa, wild animals.

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INTRODUCTION

Rabies is caused by a lyssavirus in the family *Rhabdoviridae*. The *Rhabdoviridae* are divided into several genera including; lyssavirus, vesiculovirus, ephemerovirus and fish viruses, and 2 genera of plant viruses. Lyssaviruses are divided into 2 phylogoups and so far there are 7 genotypes specified (see Table 1). In South Africa there are 4 genotypes that are endemic, Genotype 1 being the most common[5,30].

Rabies can infect all mammals including humans. The current host species recognised in South Africa are: domestic canine, black-backed jackal, bat-eared fox and yellow mongoose[2,18,20,24,25]. The distribution of endemic rabies by the host species across South Africa has been illustrated previously by Nel *et al.*[18] (Fig. 1).

The 1st record of canine rabies in South Africa is of a dog that was shipped to the Cape Province from England in 1892. The outbreak that ensued was controlled by August 1894 and no further rabies was reported until 1950 in Limpopo Province from where it spread southwards to KwaZulu-Natal (KZN)[2,23]. Further outbreaks occurred in KZN in 1964 and 1976. Both outbreaks are thought to have originated from Mozambique and the 1964 outbreak had ended by 1968 while the 1976 outbreak continues as at the time of this publication[8]. Rabies has therefore become a disease of increasing public health and veterinary importance and concern in South Africa. In order to assess the success of control strategies and improve on them it is essential to maintain a record of the epidemiological trends of this disease in the country. This paper serves to add to the increasing knowledge of rabies epidemiological trends in South Africa.

MATERIALS AND METHODS

The data concerning all the reported positive cases of animal rabies in South Africa were obtained from the Division of Epidemiology, Directorate of Animal Health (DAH) of the Department of Agriculture in Pretoria, South Africa. Since this is a notifiable disease in South Africa, data are received from state veterinarians in the field who fax through the details of every positive case they diagnose. The DAH data were quality-controlled and validated with data provided by the 2 licensed rabies diagnostic laboratories in South Africa; the OIE rabies reference laboratory of the Agricultural Research Council, situated at the Agricultural Research Council-Onderstepoort Veterinary Institute, and the KwaZulu-Natal Allerton Veterinary Laboratory situated in Pietermaritzburg, KZN. The data were validated by cross-checking the DAH records with those of the 2 laboratories. The diagnostic tests used by these laboratories were the fluorescent antibody technique (FAT) or a biological test in 3-day-old (suckling) mice[10].

The combined data of the 2 laboratories should be more accurate as this is where specimens for diagnosis are sent, but because the data provided by the DAH have data recorded by species, month, year and geographical location, they are more suitable for an epidemiological study.

The animal populations in the data were divided into companion animals, production animals and wildlife. Companion animals were classified as feline and canine; production animals were classified as bovine, ovine, caprine, equine and porcine and wildlife were grouped into Protelidae, Canidae, Hyaenidae, Felidae, Viverridae, Mustelidae, Rodentia, Hyracoidea, Artiodactyla Bovidae and Avian. The Viverridae were further subdivided into Viverrinae and Herpestinae.

Analyses of temporal distributions concentrated on monthly and annual trends for the period 1995–2005 within the different population groups.

Positive cases of the disease were captured spatially in decimal degrees east and decimal degrees south. These cases were then grouped according to the provincial boundaries of the Eastern Cape, Free State, Gauteng, KZN, Mpumalanga, North West Province, Northern Cape, Limpopo Province, Northern Province and Western Cape, with the exception of rabies outbreaks in the Kruger National park, which were recorded as a separate spatial unit (Central Government).

Data on vaccination numbers were obtained from the DAH records.

All data were received in Excel spreadsheets (Microsoft Office 2003©) from the DAH and imported into EpiInfo© (database and statistics software for public

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Table 1: **Classification of lyssaviruses.**

Phylogroup	Genotype	Species	Abbreviation (ICTV)[a]	Geographical origin	Potential vector(s)
Isolates characterised					
I	1	Rabies virus	RABV	Worldwide (except several islands)	Carnivores (worldwide); bats (Americas)
I	4	Duvenhage virus	DUVV	Southern Africa	Insectivorous bats
I	5	European bat lyssavirus type 1	EBLV-1	Europe	Insectivorous bats (*Eptesicus serotinus*)
I	6	European bat lyssavirus type 2	EBLV-2	Europe	Insectivorous bats (*Myotis* sp.)
I	7	Australian bat lyssavirus	ABLV	Australia	Frugivorous/insectivorous bats (Megachiroptera/ Microchiroptera)
II	2	Lagos bat virus	LBV	Sub-Saharan Africa	Frugivorous bats (Megachiroptera)
II	3	Mokola virus	MOKV	Sub-Saharan Africa	Unknown
Isolates to be characterised as new genotypes					
–	–	Aravan virus	ARAV	Central Asia	Insectivorous bats (isolated from *Myotis blythi*)
–	–	Khujand virus	KHUV	Central Asia	Insectivorous bats (isolated from *Myotis mystacinus)*
–	–	Irkut virus	IRKV	East Siberia	Insectivorous bats (isolated from *Murina leucogaster*)
–	–	West Caucasian bat virus	WCBV	Caucasian region	Insectivorous bats (isolated from *Miniopterus schreibersi*)

[a]ICTV = International Committee on Taxonomy of Viruses. Overview of genotypes and phylogroups[30].

health professionals, Centers for Disease Control and Prevention (CDC), USA) for the purposes of data analysis. The primary focus of the data analysis was to compare the different geographical areas and time series to ascertain whether any epidemiological trends could be observed.

RESULTS

Rabies trends 1993–2005

The total number of positive rabies cases reported to the DAH between 1993 and 2005 was 4767; the annual number of cases is presented as the dotted line in Fig. 2. There was a decrease in total rabies cases between 1995 and 1999 followed by an increase until 2003; the highest peaks occurred in 1993 and 1995. From 2003 the total numbers began decreasing once again. The combined total number of confirmed cases from the 2 diagnostic

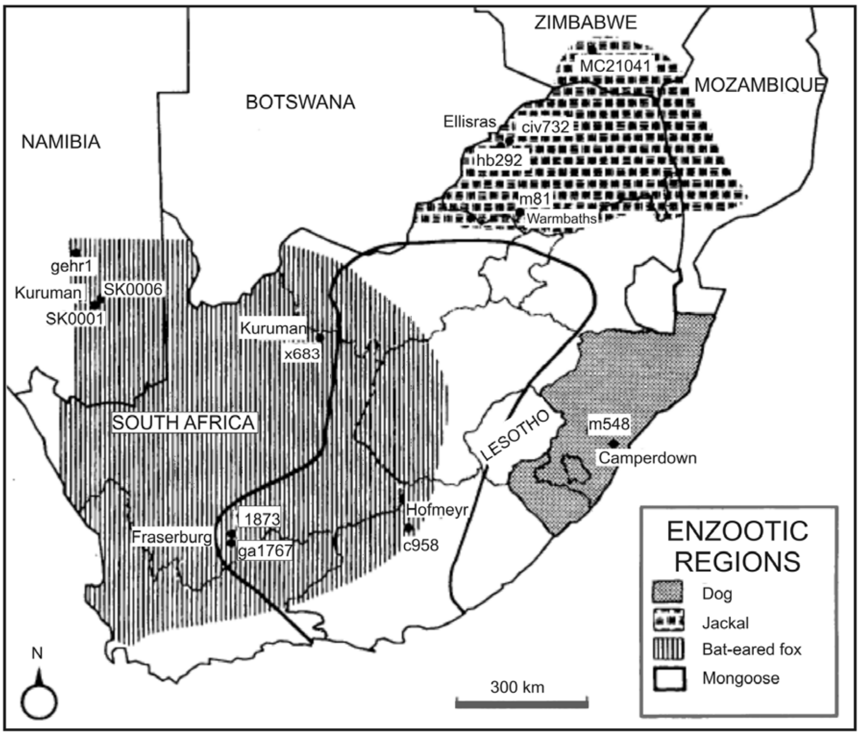

Fig. 1: **Map of South Africa showing host-specific rabies enzootic areas** (simplified for clarity) **and the locations of the different isolates included during the course of Nel *et al.*'s study**[18].

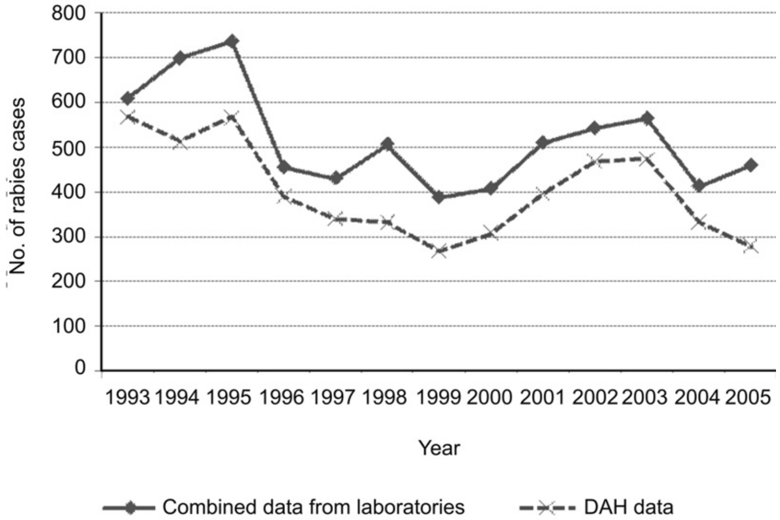

Fig. 2: **Combined number of animal rabies-positive cases diagnosed by the OIE rabies reference laboratory and the Allerton provincial laboratory compared to the total number of cases reported to the Directorate of Animal Health in South Africa for the period 1993–2005.**

laboratories is presented as a solid line in Fig. 2. The trend is similar to that of the DAH's data, but there is a higher number of rabies cases in the combined data from the 2 laboratories. The reason for this is uncertain but may be due to specimens submitted to the laboratories that do not go through state veterinary channels.

Trends during the 1980s showed that there was an increase in rabies prevalence in domestic animals that accounted for the increase in the total number of cases[11]. From 1980–1984 approximately 60 % of the total cases were domestic and from 1985–1994 that had increased to 71 %[11,16]. Since 1995, the proportion of domestic animal rabies increased further to 79 %, with 59 % of the total cases being domestic dogs.

Figure 3 shows that the animal trend of total rabies cases (Fig. 2) largely follows that of companion animal rabies. Production animals show a similar trend to companion animal rabies except for the period 1996–2000, when there was a rise in companion animal rabies but a decline in production animal rabies. Wildlife rabies has stayed at much the same level, but it must be borne in mind that the true number of wild rabid animals cannot be established because most rabid wild animals probably go undetected.

Population trends

The data from the DAH show that the majority (79 %) of rabies cases occur in domestic animals (companion animals plus production animals) and of these, the majority (74 %) are canine and 21 % are bovine. When compared with the data from 1985–1994 there is an increase of 6 % of rabies in canine and a 3 % decrease in bovine cases[11,16]. Caprine, ovine, equine and porcine account for the remaining 4 % of domestic cases.

The majority of the confirmed rabies cases in wildlife occurred in the yellow mongoose. The Viverridae together make up 60.9 % of all wildlife cases. Most of these cases will be the viverrid (mongoose) biotype of rabies, with occasional spill-overs into domestic animals.

Black-backed jackal and bat-eared foxes account for 10 % and 19 % of all the wildlife cases respectively. From 1980 to 1984 the total percentage of cases in the black-backed jackal and the bat-eared fox was only 17 %. This increased to 21 % between 1985 and 1995 and now stands at 29 % of all wildlife cases[11,16].

Seasonal trends

This study confirms earlier statements that there is a yearly peak in the incidence of rabies in the winter months in companion animals, production-animals and in wildlife[11].

Geographical distribution of rabies in South Africa

The spatial distribution of rabies in South Africa is illustrated in Fig. 4. Forty-six per cent of all reported rabies cases occurred in KZN and 89 % of these cases were canine. Eastern Cape and Mpumalanga each accounted for 15 % of the cases and 48 % and 44 % respectively of these cases were canine. The bovine cases were the highest (54 %) of the 9 % of the total reported cases in Limpopo, but also reached high levels in Eastern Cape and Free State.

The geographical distribution of rabies has not changed over time and KZN still accounts for almost half of the rabies cases. The percentages are almost exactly the same as described from 1985–1994[16].

The geographical distribution of cases by host species is illustrated in Fig. 5. Forty-two per cent of wildlife cases in the Free State were confirmed yellow mongoose cases, while the main species in the Northern Cape and Western Cape was the bat-eared fox. In Limpopo Province the black-blacked jackal predominates.

While the distribution of the rabies cases in different species in the provinces has not changed[3,6,15,17,19], the current data (Fig. 5) show a disturbing trend when compared with previous maps (Fig. 1), in that there is an increase in canine rabies cases in provinces neighbouring KZN and in Limpopo Province.

Vaccinations

The annual number of reported vaccinations increased between 1996 and 2004 in KZN, Eastern Cape, Limpopo Province

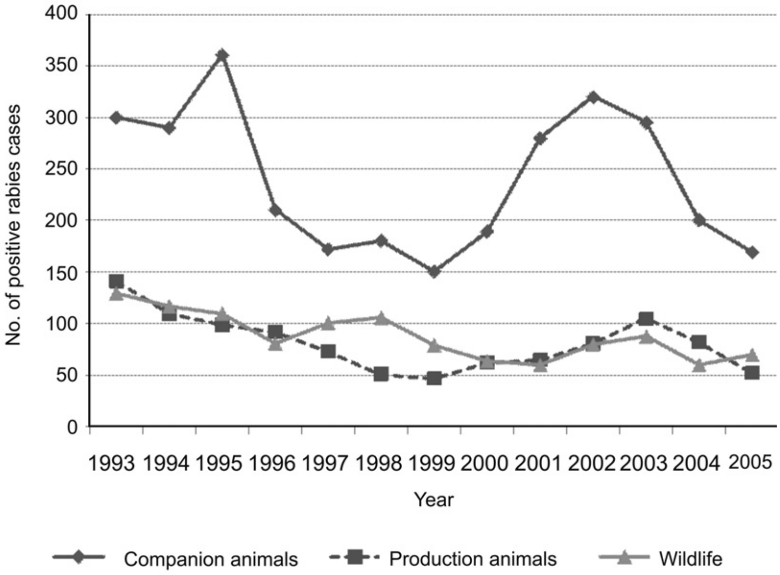

Fig. 3: **Annual confirmed rabies cases in companion animals, production animals and wildlife reported in South Africa from 1995–2005.**

and the Western Cape (DAH internal records, Pretoria), but in all these provinces the level of reported vaccinations dropped again in 2005.

The majority of all reported vaccinations between 1993 and 2005 were in the Eastern Cape (37 %), with KZN (23 %) and Limpopo Province (18 %) having proportionally less of the total. Mpumalanga made up 10 % of all vaccinations and the other provinces were below 7 %. The actual figures are, however, thought to be higher due to underreporting by state veterinarians and private vaccination of animals, which is not included in these figures. These figures should therefore be seen as conservative estimates rather than precise prevalence but provide an indication of trends within the provinces.

In 2004 Veterinary Services reported estimated dog populations and vaccination rates per district (Table 2). The 2 districts with the highest number of cases (one each in KZN and Eastern Cape) both have vaccination percentages below 10 %.

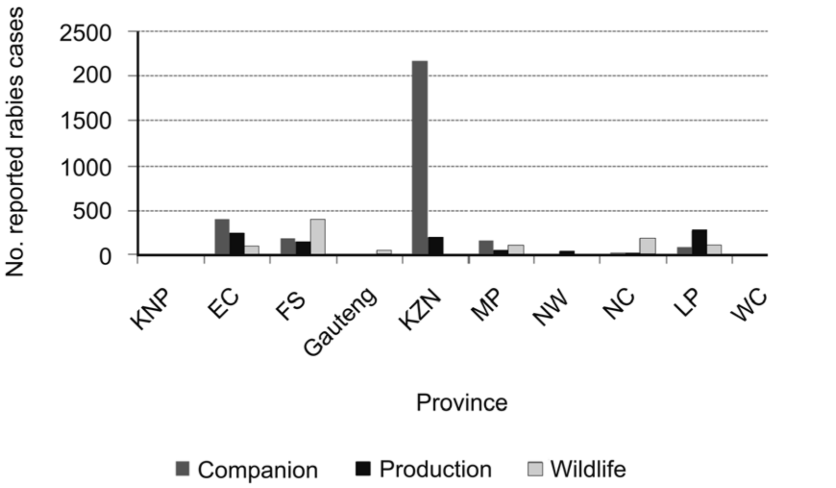

Fig. 4: **Number of reported cases in the different South Africa provinces subdivided into companion animals, production animals and wildlife from 1995–2005.**

Table 2: **The estimated dog population with the percentage of dogs vaccinated and the reported canine cases in South Africa in 2004.**

Province	Estimated dog population	Percentage of dogs vaccinated	Reported canine rabies cases
Mpumalanga	145 237	53.36	15
Gauteng	2 701 009*	**	1
Limpopo Province	122 449	79.62	0
North West	285 840	6.86	3
Free State	255 468	4.76	7
KwaZulu-Natal	278 212	3.80	121
Eastern Cape	435 116	7.55	36
Western Cape	148 425	23.86	2
Northern Cape	217 761	1.78	3
Total 2004	4 588 404		188
Total 2004 – Gauteng	1 887 395	15.34	187

*Cats are included.
**No data available.

DISCUSSION

The fact that the domestic dog population represents the largest group of rabies cases is an early warning to public health workers that the dog is the most likely carrier of rabies to humans. Cats currently account for only 3.8 % of companion animal cases and therefore do not constitute a major problem in South Africa at present. KZN is the province with the most canine cases. However, the significance of the trends identified is emphasised by the more recent increase in dog rabies in Limpopo Province[9]. This indicates that if rabies in domestic canines can be controlled there might be a significant impact on rabies in general in South Africa, and eradicating the canid biotype will have the greatest effect on human rabies. Vaccination programmes in Europe and North America have shown that effective vaccination can eradicate the canid biotype, but Africa differs from these continents in having 4 genotypes of lyssaviruses and several maintenance hosts[21]. Despite this, vaccination and movement control have been successful in eliminating early outbreaks of rabies like the rabies outbreak in KZN in 1964[8]. In the light of this it is hard to understand why rabies is currently so difficult to control in South Africa in comparison with earlier years.

Dog rabies is often called ‘urban rabies’, but the data show that in South Africa rabies is actually more of a rural/informal settlement problem. Families can own up to 10 dogs, with a probable average of around 7 per family (K. Le Roux, KZN Veterinary Services, pers. comm. 2006). These large numbers of dogs are well tolerated and they live in a pack with the owner as the ‘alpha male’. They help in herding cattle and protect the houses, and although it is illegal they are often used in hunting. The actual number of rural dogs is not known and the number of cases is probably under-reported. It is generally accepted that in order to bring the transmission rate (R_0) below 1, at least 70% of the population should be vaccinated[1,28]. Since there is no accurate estimate of dog population numbers, the number of dogs that need to be vaccinated in order to have an impact on R_0 is unknown. However, the fact that the 2 districts where the highest number of rabies cases were reported showed vaccination percentages of less than 10 % of the estimated dog population in a survey by DAH in 2004 is a matter for serious concern because considerable efforts were made to vaccinate the dogs in those areas. Many dogs normally do not get vaccinated against rabies, partly because they are found in remote areas and partly because of sociological issues such as the misconception that dogs vaccinated against rabies are useless as hunting dogs[29]. Factors preventing vaccination are probably largely sociological and contribute to under-vaccination of the dog population, preventing eradication of the virus. A further sociological issue that is playing a role is the impact of the HIV/AIDS epidemic. This will probably result in more free-roaming feral dogs due to the loss of complete families as a result of AIDS and associated diseases. These feral packs are difficult to eliminate or vaccinate and thus potentially serve as a constant reservoir of the virus. This could also explain why education campaigns have not been entirely successful in increasing the population of vaccinated dogs.

Other reasons for the persistence of rabies have been put forward by various authors[4,8,13,20,22,24]. These include an increase in urbanisation since the late 1980s

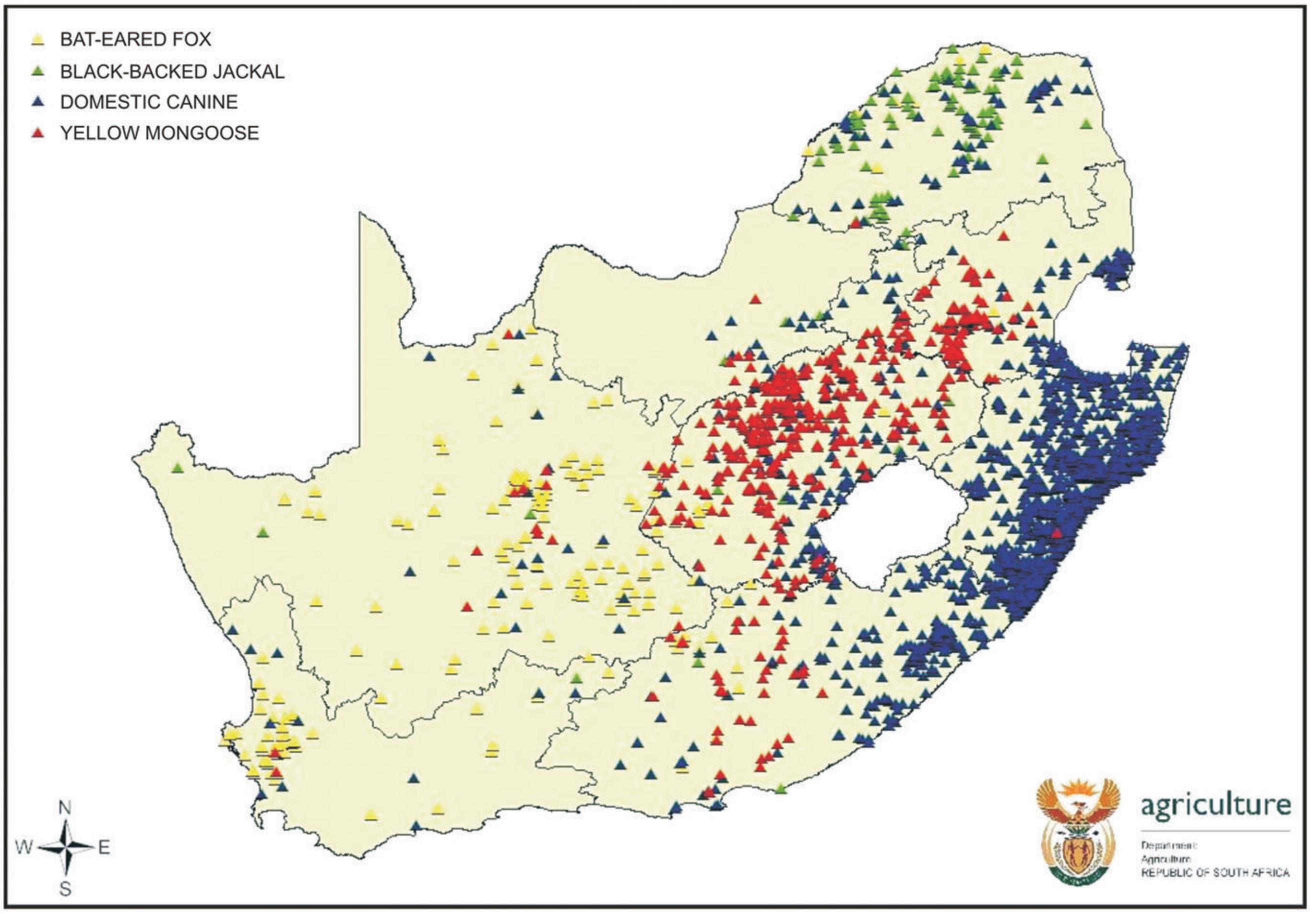

Fig. 5: **Reported rabies outbreaks in South Africa (1993–2005); species: bat-eared fox, black-backed jackal, domestic canine and yellow mongoose.**

in an environment of social and political changes and the development of numerous informal settlements around towns and cities where the disease can be maintained in large dog populations. These factors too are primarily sociological issues that have emerged in the recent past and could explain why previous outbreaks could be eliminated, while now this is not possible. Continuing logistical, financial and managerial difficulties in the control of dog movement and in the implementation and maintenance of successful vaccination strategies have also come about partially due to a changing political environment[20,22]. It seems therefore that understanding the sociological and political issues is one of the key factors needed to bring about the eradication of the virus.

The reason for the increase in canine rabies cases in provinces neighbouring KZN and in Limpopo Province is uncertain but may be due to a combination of spread from neighbouring countries and from KZN. Molecular genetic analysis has shown that the outbreak strains of canine rabies in 2005 and 2006 in Limpopo Province were closely related to canine strains from southern Zimbabwe[9]. Another study has shown that viruses from KZN and the Eastern Cape belonged to a unique lineage, circulating as 2 independent and expanding epidemiological cycles[8]. The first presented as closely related dog cycles along the eastern coastal regions of the two provinces, while the second, in northern KZN, has entered into at least 1 wildlife reservoir, the black-backed jackal, which could then spread it further north. This could potentially have serious public health implications.

The role of wildlife in the maintenance and distribution of rabies virus is another interesting dynamic that is being uncovered by molecular epidemiology[8,9]. The viverrid biotype virus in yellow mongoose is not modified in any specific way that will restrict spill-over from wildlife into canines. However, species behavioural factors and population densities appear to limit this cross-infection[6,12,18,23,26]. The black-backed jackal and the bat-eared fox are the only species other than domestic canines that are capable of maintaining the canid rabies biotype[2,12,18,23,24,27]. The increase in the percentage of cases registered in these species reported in this study further enhances the significance of the canid biotype in the epidemiology of rabies in South Africa. Black-backed jackals are capable of maintaining continuous infection cycles without the involvement of domestic dogs, under specific ecological conditions[31]. Aggressive interactions during territorial defence create an ideal opportunity for intra-species transmission of the virus. Furthermore, the wide ranges covered by these animals together with the sharing of resources such as water and large carcasses facilitate close contact between remote individuals in the population[31]. In theory, rabies in black-backed jackal and bat-eared foxes could be controlled with oral bait vaccination, as has been done in Europe with the fox population. However, the environmental dynamics, including terrain, sociological issues and the presence of other wild animal species that might consume the bait all make these strategies difficult in an African environment.

Other factors that were examined in this study were the geographical distribution of rabies in South Africa (Fig. 5) and its seasonal occurrence. The fact that more bovine rabies is reported from Limpopo, Eastern Cape and Free State Provinces, which have large cattle-farming industries, is probably due to cattle population density and does not necessarily reflect an increase in absolute risk. The higher number of rabies reports in winter is probably due to increased contact rates related to colder weather and more competition for available food and water.

CONCLUSION

The results of this study show that during the period 1993–2005, eradication and control campaigns were largely unsuccessful and canine rabies was spreading into the centre and the north of South Africa. The year 2006 was a major rabies year, with more cases than in previous years and some of the outbreaks have now been studied in more depth[9]. It does not, however, appear from this study that rabies is re-emerging but rather continuing a trend that began in the 1970s. Major factors that have contributed to this spread and lack of successful eradication appear to be sociological and political, and future strategies should probably look more closely at these dynamics when planning rabies eradication in South Africa.

Sufficient vaccination coverage is proposed as the key to successfully eradicating rabies or preventing more cases and a starting point to achieving this is an accurate estimate of the target population, i.e. how many dogs live in South Africa and how many of these are feral. A key weakness identified in this study is the lack of accurate population census data to enable the calculation of prevalence or incidence rates. Until this is obtained, absolute and relative risks cannot be calculated and we remain reliant on descriptive trends to assess the impact of rabies and its control. Finally, there has to be a safe and effective vaccine delivery system within rural communities and a means to ensure their active participation in such campaigns, which needs to be coupled to eliminating the feral dog population[7,14].

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