Epidemiol. Infect. (1999), **123**, 337–346. Printed in the United Kingdom

African horse sickness in Portugal: a successful eradication programme

M. PORTAS[1], F. S. BOINAS[2], J. OLIVEIRA E. SOUSA[3] AND P. RAWLINGS[4]*

[1] *Serviço Nacional Coudélico, Ministério da Agricultura, Av. Duque Ávila 32-2°, 1000 Lisboa, Portugal*
[2] *DETSA, Faculdade de Medicina Veterinária, Universidade Técnica, R. Gomes Freire, 1199 Lisboa codex, Portugal*
[3] *Direcção Geral de Veterinária, Ministério da Agricultura, Lg. Academia Nacional Belas Artes 2, 1200 Lisboa, Portugal*
[4] *Faculty of Computer Studies and Mathematics, University of the West of England, Coldharbour Lane, Bristol BS16 1QY, UK*

(*Accepted 14 May 1999*)

SUMMARY

African horse sickness (AHS) was diagnosed for the first time in southern Portugal in autumn 1989, following outbreaks in Spain. AHS virus presence was confirmed by virus isolation and serotyping. An eradication campaign with four sanitary zones was set up by Central Veterinary Services in close collaboration with private organizations. Vaccination began on 6 October. In February 1990, vaccination was extended to all Portuguese equines (170000 animals). There were 137 outbreaks on 104 farms: 206 of the equidae present died (16%) or were slaughtered (14%); 81·5% were horses, 10·7% were donkeys and 7·8% were mules. Clinical AHS occurred more frequently in horses than donkeys and mules. In the vaccinated population, 82 animals (62·2% horses and 37·8% mules and donkeys), died or were slaughtered due to suspected or confirmed AHS. One year after ending vaccination, December 1991, Portugal was declared free of AHS. Cost of eradication was US$1955513 (US$11·5/Portuguese equine).

INTRODUCTION

African horse sickness (AHS) is endemic to sub-Saharan Africa but occasionally the virus (AHSV) spreads beyond its natural boundaries causing highly damaging epizootics. The most recent of these epizootics occurred when zebras, unknowingly carrying AHSV serotype 4, were exported from Namibia to Spain in the summer of 1987 [1, 2]. After the initial notification of an AHS epizootic in Spain, in September 1987, via l'Office International des Epizooties (OIE), the Portuguese veterinary authorities attended an emergency meeting in Paris to discuss eradication of the disease in the region. From this meeting onward, appropriate measures to deal with the possibility of AHSV crossing the land frontier with Spain were formulated, and then implemented through national legislation by the Central Veterinary Services (DGP). Two years later in Portugal, the full programme of AHSV eradication had to be put into operation when an outbreak of AHS appeared in a border village in the southern province of Algarve. This was the first instance of an AHS epizootic in Portugal.

The eradication campaign was carried out largely according to plan and proved highly effective. Within 13 weeks AHS had been stamped out from Portugal – and has remained so since then – although the disease reappeared the following year in southern Spain. The eradication strategy combined government agencies and private veterinarians. Equine owner participation and widespread public awareness of the dangers of the epizootic were also factors believed to

* Author for correspondence.

be instrumental in the success of the strategy adopted. The eradication strategy is described in this article, together with the details of the outbreaks, to provide a working example of a successful programme for whenever new AHS epizootics might occur.

ERADICATION CAMPAIGN

Pre-eradication phase: preventative measures and initial occurrences

In the autumn of 1987, immediately following the official notification of the presence of an AHS epizootic in Spain, DGP set up an AHS Emergency and Coordination Team (ECT). The functions of the team were distributed amongst the members.

(1) The head of ECT (also head of DGP) was responsible for general coordination of the campaign and contacts with international organizations (OIE and European Union (EU)).

Three directors from departments within DGP were in command of the campaign functions in the country:

(2) The director of the Animal Health Service had responsibility for health legislation with respect to eradication and control measures (slaughter, vaccination, animal movement control and financial compensation).
(3) The director of the Veterinary Customs Service was in charge of international veterinary relationships, particularly potential cross-border animal movements.
(4) The director of the National Stud Service provided the principal hub of information and coordinated action, linking many organizations involved in planning and interventions required by the eradication campaign.

The final two members of the ECT came from the Central Veterinary Laboratory (LNIV):

(5) The head of LNIV was responsible for confirmation of field diagnosis through laboratory testing and necropsy, as well as maintenance of the AHSV vaccine stock.
(6) A senior scientist from LNIV participated in international meetings on behalf of ECT following the disappearance of AHS cases in Spain at the end of 1987. Input from these meetings provided ECT with expert opinion and up to date scientific information on AHS and control measures in neighbouring Spain.

The location of the outbreaks in the rural communities of southern Portugal (provinces of Alentejo and Algarve) required joint action between the national organizations, like DGP and LNIV, the provincial bodies, professional organizations, breeders associations and owners.

The code of practice adopted by ECT in dealing with the AHS epizootic was essentially that set down by OIE [3]. A ban on the importation of all equidae from Spain was implemented by the end of September 1987, including those only in transit. Equines which had recently (less than 3 months) been imported from Spain were identified and tissue samples taken for serological testing to clear them as possible sources of infection. Similar tests were carried out on all susceptible species in Lisbon Zoo, where the consignment of infected Namibian zebras had stayed en route to Spain. By the end of 1987 the AHS epizootic in Spain had been contained within the Alberche Valley, on the edges of Madrid, Avila and Toledo provinces, but before it spread out into the Tagus Valley [4].

In early 1988 ECT reviewed its eradication procedures in the light of the previous year's experiences of the Madrid and Castilla la Mancha regional veterinary authorities, which appeared to have removed AHSV entirely. It was decided to disseminate information on the potential damage which could occur if there was a resurgence of AHS on the Iberian peninsula in 1988. Public information bulletins were broadcast and meetings arranged between informed veterinary officers and owners and breeders associations. Information given out to the public and horse professional bodies indicated how AHSV was transmitted and the consequences of the disease.

In the autumn of 1988 AHSV resurfaced in Spain but this time in the southern region of Andalucia. Outbreaks were confined, however, to three municipalities between Gibraltar and Malaga [4]. ECT readopted and maintained the measures put in place during the autumn of 1987 but with a sense of greater confidence in the value of the measures and accuracy of the information available. Preventive measures during 1988 included: intense vigilance near the border; prohibition of all importation of equidae from Spain, including those only in transit; insecticide application in and around trucks arriving from Spain.

The sense of readiness was strongly felt. Importations of equines had been halted for more than 12 months and serological evidence had not shown any signs of AHSV antibodies or antigen in tested animals in Portugal (277 negative results during 1988 and 1989 before the first outbreak).

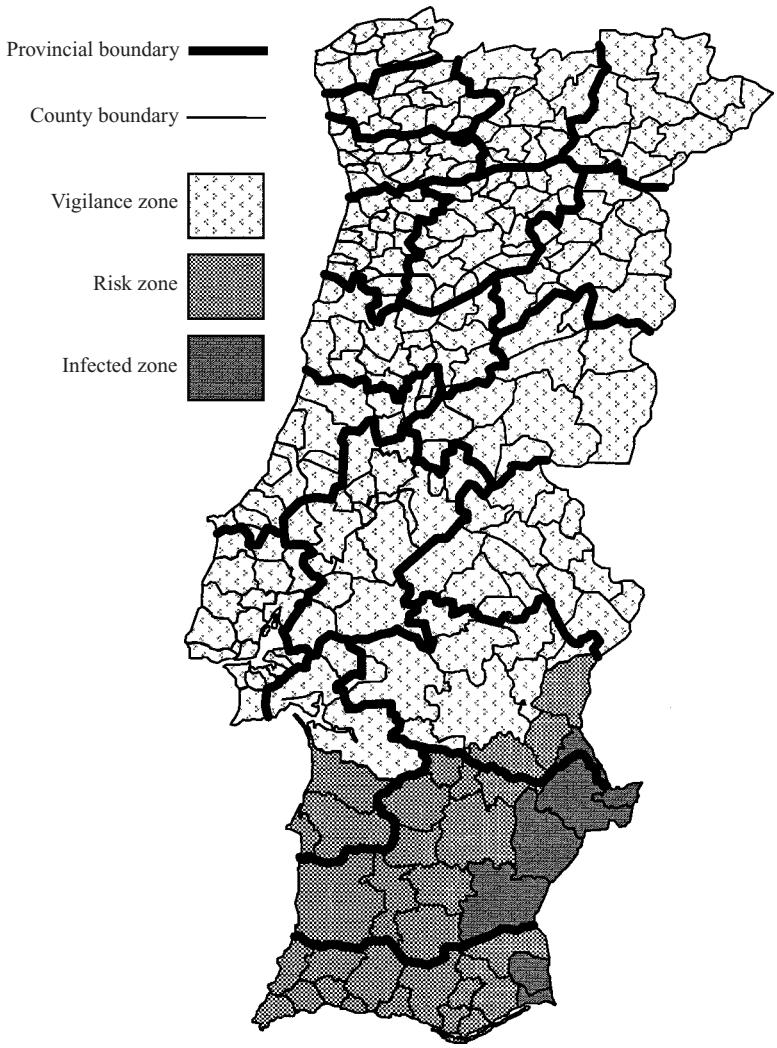

Fig. 1. Sanitary zones as set up under First Edict for Control and Eradication Measures Against AHS on 25 September 1989 and operated during weeks 1–3 (25 Sept.–15 Oct. 1989).

In August 1989 there was a rapid resurgence of AHSV in Andalucia, beginning at San Roque and Sotogrande, Cadiz province, where there had been outbreaks the previous autumn. In the same month farms became infected in Sevilla and Huelva provinces, the latter sharing the lower Guadiana River as a frontier with Algarve province in Portugal [4].

Following the Spanish outbreaks in Sotogrande compulsory preventive measures were issued by 6 September to all the border councils in Portugal. A ban was placed on all movements of equines in these council areas close to the Spanish frontier. The participation of equidae in markets and fairs was restricted to horses in special sporting events authorized by ECT.

These strict vigilance measures were further strengthened following the Spanish outbreak in Sanlucar de Guadiana on 9 September, only a few kilometres from Portugal. Movement of all equidae to and from the Algarve in four council areas (V.R.S. António, Castro Marim, Tavira and Alcoutim), all of which adjoin or are close to the frontier, was prohibited from 21 September. However, on 23 September a horse within one of those councils (Castro Marim), was reported by a provincial veterinary officer as presenting AHS symptoms. Blood samples from the sick horse were dispatched to LNIV and the AHS World Reference Centre in Onderstepoort, South Africa, for confirmation of the field diagnosis.

Before confirmatory results were received by the Algarve veterinary authorities on the blood from the first suspected Portuguese case of AHS, another horse in the municipality died (25 September) and was given a post mortem. The first blood-tested horse died 2

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

days later. Necropsy of both horses clearly showed pathognomonic signs of AHSV infection in the lung area and peritoneal linings [5]. The laboratory results on the blood, serum and spleen samples, which arrived on 28 September, confirmed the presence of AHSV type 4.

At the same time as confirmation of AHS cases was made in Algarve a horse with AHS-type symptoms was found in Alentejo, 300 km to the north. This horse was slaughtered on 6 October without AHSV infection being corroborated but positive laboratory tests and post-mortems of confirmed cases appeared in the same area from 30 September onwards. In Spain, outbreaks continued to spread northwards through Huelva into Badajoz province during September, where confirmed cases of AHS were eventually reported in October.

Eradication: development of the epizootic and establishment of sanitary zones

Mass vaccination, stamping-out at infected farms and strict control of animal movement were the main methods employed in combatting the spread of AHSV and then achieving eradication in Portugal. The campaign was based almost entirely in the rural areas of southern Portugal. Less than a quarter of the equines of Portugal were distributed across the two affected provinces (Algarve 12000 animals, 7% national herd; Alentejo 26500, 16%), and there were considerably fewer equines in the infected border counties.

ECT set up one vigilance and three control zones. All counties containing confirmed cases were assigned to the Infected Zone and those counties surrounding the Infected Zone to the Risk Zone. Surrounding the Risk Zone was the Safety Zone, and finally the Vigilance Zone over the rest of the country [6, 7] (Fig. 1).

The First Edict for Compulsory Preventive Measures Against AHS (issued on 6 September as cases advanced through Spain towards the Portuguese frontier) set precautionary control measures for all areas adjacent to the frontier (all counties along the eastern and northern border with Spain) and was replaced by the First Edict for Control and Eradication Measures Against AHS on 28 September 1989 (the day of the laboratory confirmation of the presence of AHSV). A wide net of active control measures was thrown across the south-eastern quarter of Portugal.

The movement of AHS cases across the country was a continuous feature of the epizootic: during the first 3 weeks (23 September–15 October but campaign weeks defined as beginning on 25 September when the First Edict for Control and Eradication Measures Against AHS was issued) (Fig. 1) seven counties were affected and thus were included in the Infected Zone (total of 52 cases in 44 outbreaks). Despite the control measures, cases continued to appear in these seven counties during weeks 4–6.

During weeks 4–6 (16 October–5 November) (Fig. 2) cases advanced to the north and to the west. AHSV spread to one county in the Risk Zone in Alentejo and four counties in the Risk Zone in Algarve. The epizootic reached its peak in number of outbreaks (67) and cases (124) in these weeks. The Risk Zone included a total of 15 counties in Alentejo and all remaining 10 (to date, uninfected) counties in Algarve. During this period the Vigilance Zone was partitioned to include the Safety Zone (Fig. 2).

During weeks 7–9 (6–26 November) (Fig. 3) cases in the northern-most counties of Alentejo were extinguished at the beginning of week 7 but these counties remained within the defined Infected Zone. In the Algarve outbreaks arose in another county further west. During these weeks the total number of outbreaks was 19 with 22 cases and the Safety Zone remained unchanged from weeks 4–6.

After week 10 (starting 27 November) (Fig. 4) there were no more cases in Alentejo but a few, new AHS cases appeared in three previously uninfected counties in Algarve as well as continuing in another two counties (from week 10 onwards only 7 outbreaks with 7 cases). During week 13 (week beginning 18 December) the last, accepted case of AHS in the epizootic appeared in Aljezur, a county on the north-west Atlantic seaboard of Algarve.

In total, 206 AHS cases (but 137 notified outbreaks because of reinfection of some farms) had appeared, in 16 counties, on 104 separate farms, 52 of which had multiple outbreaks on the same farm. On 75 farms all the equine animals died or were slaughtered. The AHSV-affected counties formed an almost continuous L-shaped band from the north of Alentejo (Reguengos de Monsaraz) down the Portuguese/Spanish frontier to the south then west along the coast, moving inland to reach the main Atlantic coast of Algarve at Aljezur. Unaccountably, no cases appeared in Alcoutim – the county immediately to the north of Castro Marim, where the first identified case of AHS in Portugal was discovered. No cases had appeared outside the original Risk Zone set up during week 1 (Fig. 1). The

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

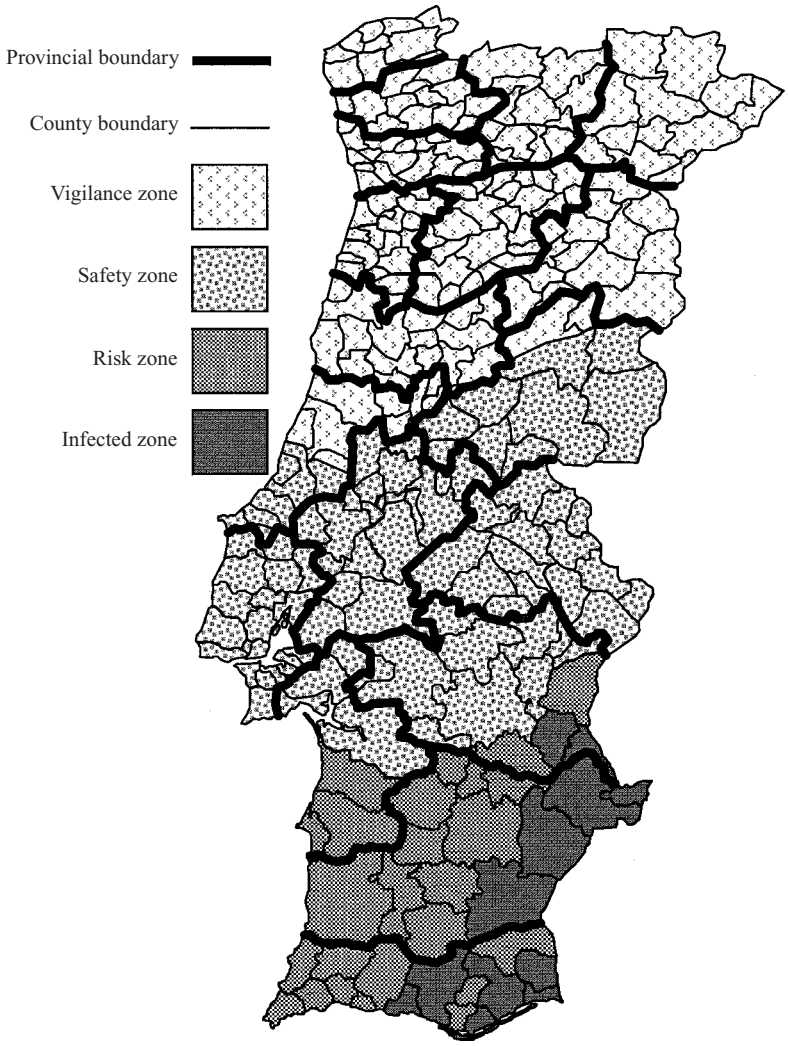

Fig. 2. Sanitary zones as operated during weeks 4–6 (16 Oct.–5 Nov. 1989).

Safety Zone, first designated on 25 October 1989, also remained free of AHS (Fig. 2).

Eradication: methods of control

Information about the AHS epizootics in Spain and, historically, elsewhere enabled ECT to successfully implement the mass vaccination campaign. Owners and veterinarians had been made aware of the consequences of allowing AHSV to spread uncontrollably and the vital need to vaccinate as comprehensively as possible and as widely as necessary in the area at risk. However, no precautionary, preventive vaccination had been implemented in the 2 years (1987 and 1988) previous to the first occurrence because vaccination against AHS was an admission of the presence of circulating wild virus and OIE guidelines would have prevented all owners in Portugal from exporting horses. The arrival of confirmed cases in the border regions was the trigger to mount the planned vaccination campaign, quickly and over a large area, using all the resources of both the private veterinarians and the provincial and national veterinary authorities.

Implementation of a widespread vaccination campaign in the midst of an epizootic naturally resulted in the vaccination of infected equines. Amongst the 206 confirmed or suspected AHS cases there were 82 animals which had been vaccinated but died within 3 weeks of receiving the vaccine. The large majority of deaths (died or were slaughtered with suspected AHS symptoms) were horses (168), with only 22 donkeys and 16 mule deaths.

The need for a rapid implementation of mass vaccination and absence of secure vaccine testing facilities for large animals like horses meant that there was no testing in Portugal before the eradication campaign began using the initial 30000 doses of

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

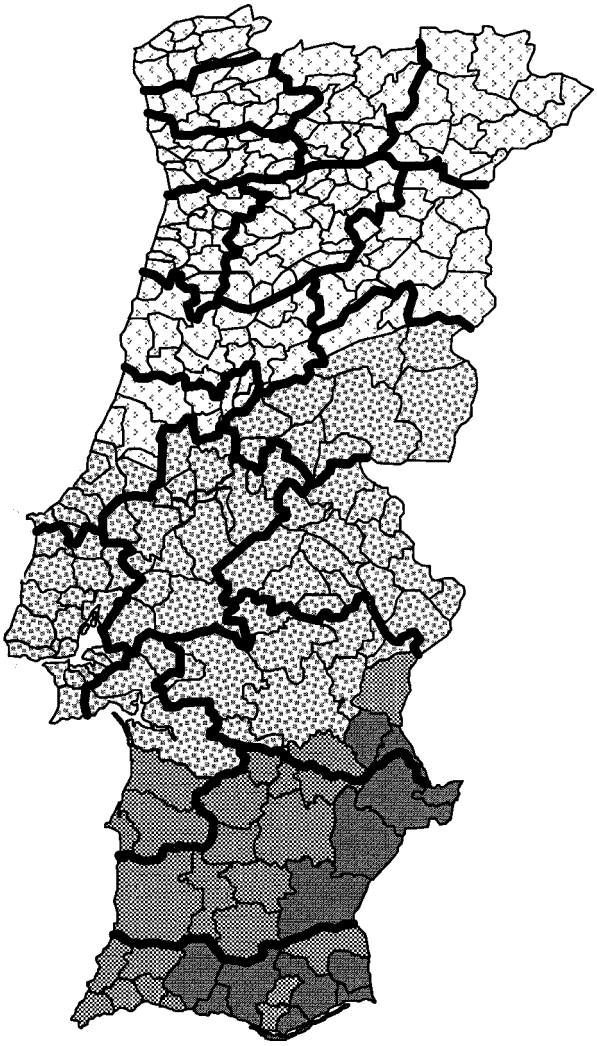

Fig. 3. Sanitary zones as operated during weeks 7–9 (6–26 Nov. 1989) (legend as for Fig. 2).

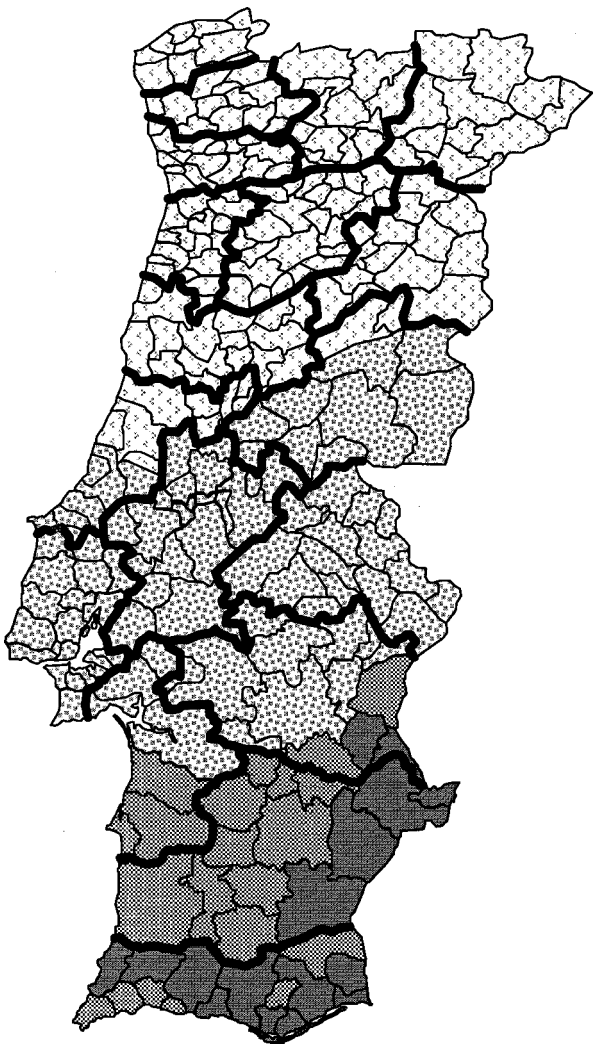

Fig. 4. Sanitary zones as operated from week 10 onwards (27 Nov.–1 Feb. 1990) (legend as for Fig. 2).

serotype 4 vaccine, bought and imported from the AHS World Reference Laboratory at Onderstepoort, South Africa. Equines were vaccinated subcutaneously with a single dose of 1 ml/animal at either of two skin sites on the breast or neck; animals were only vaccinated on a single occasion.

At the onset of the vaccination programme all horses, donkeys and mules over 2 weeks of age were vaccinated; foals born to immune (vaccinated) mares were vaccinated at 3 months of age. There was no boosting of any sort. At the time of vaccination a permanent brand mark was applied on either the upper left side of the neck (near the mane) or left buttock (under the tail). The mark, consisting of code letters from each province whose authorities were implementing the vaccination programme, served as a method for permanent identification of vaccinated horses, mules and donkeys [8]. These marks were added to the descriptive and outline identification diagrams of passports used in equine movement. All owners were advised not to work vaccinated animals hard for at least 21 days afterwards.

Vaccination started on 6 October 1989 in the affected counties of the Infected Zone, moving outwards to the Risk Zone (inset, Fig. 5). Simultaneously, other veterinary teams started vaccinating all equines in the Risk Zone, moving from the middle of these counties towards the farms with known outbreaks as well as outwards towards the Vigilance Zone. In the Safety Zone, after 25 October, mass vaccination was implemented without any specific direction.

As the epizootic shifted its course provincial and private veterinarians were incorporated in the campaign as appropriate and necessary. The coordination of this programme devolved to Director of the

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

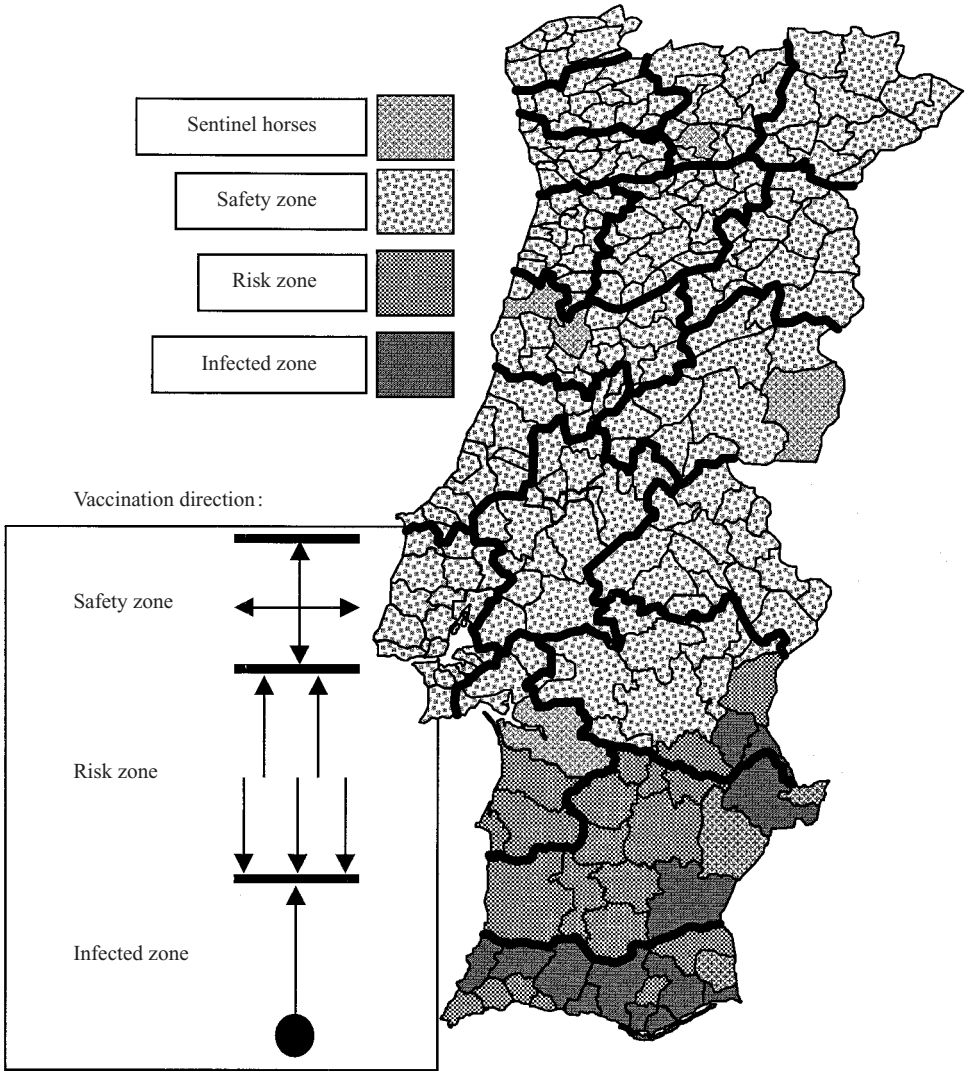

Fig. 5. Sanitary zones as operated 2 Feb.–2 Dec. 1990 and location of sentinel horses.

National Stud Service, the ECT coordinator with responsibility for linking community action with the national eradication plan. Widespread public awareness of the presence of AHS in Spain, reinforced by local news bulletins that the epizootic had crossed into Portugal, ensured that nearly all organizations and individuals concerned, those that owned or kept horses or donkeys, were cooperative when contacted. Veterinary interventions concerned diagnosis and decisions about slaughter. In the Infected and Risk Zones any equine exhibiting characteristic symptoms (particularly swelling in the supraorbital fossae, general edema, dyspnea, anorexy and sweaty skin) was immediately slaughtered. This policy was extended to any equine in these zones which had raised body temperatures (more than 40 °C) but no symptoms characteristic of AHSV infection.

Slaughter decisions on the farm were taken only on a clinical diagnosis basis, without waiting for laboratory-test confirmation. Serology on samples taken from slaughtered and dying animals was used to reinforce the on-the-spot veterinary diagnosis and for retrospective epidemiological value. ECT had established a clear policy of compensatory payments to equine owners to remove potential conflicts between the need for veterinarians to make on-farm decisions which were needed to prevent the rapid spread of AHSV, and the interests of equine owners and stable hands. The death of 82 animals after vaccination was a cause for concern for veterinarians and owners alike but at the time was complicated by the circulation of wild-type virus. The 1990 vaccination programme, as well as investigation of these 'vaccination deaths' themselves, helped resolve some of these problems.

Vaccination went hand in hand with movement restrictions of equines in each of the sanitary zones.

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

There was no movement of equines out of the infected or immediately adjoining counties, a policy enforced with the help of the National Guard Corporation. In the Risk Zone movement off farm was prohibited, except in cases of delivery to a slaughterhouse located in the zone for intended human consumption. Movement to the slaughterhouse required complete identification documents to accompany each animal. In the Infected and Risk Zones all equines were required to be kept stabled in strict isolation, particularly between dusk and dawn (18.00 to 07.00 h). All markets, fairs, exhibition and sporting events involving equines were banned. Within the Safety Zone equine movements were restricted by short term (96 h) licence to the point of delivery, but under strict necessity to provide complete animal identity papers.

Insecticidal measures were obligatory on infected farms. Spraying with insecticide (permethrin, a synthetic pyrethroid) was carried out by the official veterinary services around farm buildings and likely midge breeding sites close to manure dumps and dense vegetation. Owners and stable hands were also advised to use insect repellents on stabled horses and around the stable doors. Entomological investigations to identify the presence and distribution of the vectors of AHSV (biting midges of the genus *Culicoides* Latreille: Diptera: Ceratopogonidae) were not carried out whilst the epizootics continued but began early in 1990.

Post-eradication: preventive measures during 1990

It was suspected that the ending of AHS cases at Aljezur in mid-December 1989 might follow the Spanish experiences of 1987 and 1988: active eradication measures and onset of cold weather in early winter would halt the current epizootic but not necessarily eradicate the virus from the area. It was considered essential to prepare for the possibility of a resurgence of disease anytime the following summer or autumn. Accordingly, demarkation of 'at risk' areas, where the principal vector of AHSV, *Culicoides imicola* Kieffer, was to be found in Portugal, became a higher priority from January 1990 onwards. These entomological investigations continued for 3 years [9, 10] and were further reinforced by EU projects covering all the Iberian peninsula [4] and Morocco [11].

AHSV vaccination and the presence of circulating wild-type virus during 1989 automatically prohibited any export of equines from Portugal for 12 months after the last round of vaccination [12]. Re-designation of the Safety Zone to include the whole of Portugal from 2 February 1990 (Fig. 5), brought all Portuguese equines under the same regulations [13, 14]. Mass vaccination, using the same vaccine and regime of 1989, was extended to all 170000 equines in the country under strict animal movement controls until 2 December 1990. These controls, though, allowed owners to move equines to any part of the country, if supported by proper animal identification, including notice of AHSV vaccination.

Following the decision to vaccinate the whole of the national herd of equines, a surveillance and research programme was established. This involved the serological monitoring of sentinel horses as well as the entomological investigations mentioned above. The sentinel horses came from the Azores Islands (AHSV free) and were not vaccinated. Altogether, 21 horses were placed strategically around the country, including areas not affected by the AHS epizootic (Fig. 5). The main target areas for this surveillance operation were the counties most affected by the epizootic – Barrancos, Serpa and Castro Marim where three sentinels were kept in each county – and areas with high concentrations of equines. In Alcácer do Sal, Idanha-a-Nova and Vila Real there were three sentinel horses in each, two near Coimbra and finally one further north west in the county of Cantanhede. Twice daily, each sentinel was observed for AHS symptoms and tested for raised temperature. None of these sentinel animals showed any indications of AHSV infection.

A research programme to test the efficiency of the vaccine used in the eradication campaign was also initiated. Serological tests were taken from about 5% of the vaccinated horses as well as all suspected cases in the Infected and Risk Zones. Results from these 7847 samples will be reported elsewhere.

In December 1991, 1 year after ending vaccination and movement control, and 2 years after the last reported and confirmed case of AHS with subsequent slaughter of animals, Portugal was declared free of AHS [15, 16].

DISCUSSION

AHS appears to have crossed into Portugal from Spain at two distinct places, at least. The timing of probable infection of the equines in the counties along the frontier points to numerous invasions of AHSV from Spain rather than infection just spreading from

Barrancos and Castro Marim. The absence of cases from Alcoutim county also supports the conclusion that the Portuguese epizootic did not arise from a single focus which fanned out across the infected area but rather invaded Portugal at a number of places and spread opportunistically from each of these initial sites.

Investigations on the farms where the earliest cases of AHS in Portugal appeared showed that there had been no contact with infected animals in Spain. The First Edict with Preventive Measures, issued on 6 September 1989, had prohibited movement of equines in the frontier counties so infection from itinerant horses was also ruled out. Cross-border infection thus seems to have occurred by means of infected vectors, most probably *C. imicola*. Analysis of the bluetongue epizootics in Portugal and Spain in 1956 suggested that the origin of infection had been the wind-borne spread of infected female biting midge vectors arriving in Portugal across the Atlantic from Morocco [17]. AHSV was similarly considered to have arrived in Spain from Morocco in 1966 and into Cyprus from Turkey in 1960 [18]. The much shorter crossing of the River Guadiana by infected *C. imicola* at the height of the Spanish epizootic seems to be the most likely source of AHSV infection in Portugal.

Relentless movement of AHSV to uninfected farms and areas appears to be typical of the progress of this disease. This may be simply because of the demography of equine ownership or the process of notification of infection but could be a necessary survival strategy for this virus. Unlike bluetonni0gue virus AHSV does not have large concentrations of potential hosts to cycle through. Equines are rarely kept in large herds or widely grazed so the arrival of AHSV results in rapid removal of hosts through death or immunity, either that acquired naturally or through vaccination. For an epizootic to persist AHSV must strike out to uninfected farms. In Spain in 1987 and at the beginning of the 1989 outbreaks, the AHS epizootic also shifted swiftly from municipality to municipality.

The swift movement AHSV infection to new areas created a need to frequently modify the eradication plan to incorporate veterinarians and veterinary authorities further afield. The size of the Safety Zone also needed to be extensive to contain any possible outbreaks within its boundaries. Each of these factors increased the requirement for strict management control of the operation and a high level of co-operation with practitioners in the affected areas. Consequently, in the short term the costs of the operation were increased but in the long term these may well have been reduced. In Morocco, the Government eventually had to extend vaccination to all equines in the country, despite trying to confine the outbreaks to the northern part of the country during the first 2 years [19].

Compensation payments to owners for slaughter or death attributable to AHSV, which were made entirely from Portuguese national funds, totalled about US$334219 the vast majority being payments for horses (US$272567) with the remainder for donkeys and mules (US$61652). The costs of extending the vaccination campaign to the whole country were shared by the Government and the EU. The eradication campaign and subsequent preventive measures required 230000 vaccine capsules (about US$248641), 170474 inoculations (US$1289457, costing about US$7·5 for each veterinary inoculation), supply of identification documents for all equines (US$26466) and the implementation of control measures (US$56730) – US$1955513 in total (including compensation payments). Relative to the number of deaths the costs directly attributable to the epizootic were enormous – US$9493/mortality – but over the whole of the Portuguese equine population (170000 animals) the costs appeared small – US$11·5 per animal.

Compensation included payments to owners of 82 animals which died even though they had been vaccinated during the epizootic in 1989. These 'vaccine' deaths also occurred in counties of the Risk Zone where there was no AHSV wild-type penetration. During 1990 there were no compensation payments for equine deaths post-vaccination even though the same vaccine and regimen was used. The high adverse reaction rate amongst the vaccinated animals during the progress of the epizootic occurred up to 3 weeks after vaccination.

There could be a variety of causes of these 'vaccine-related' deaths. Three main factors were different in 1989 from 1990. The first was that there was wild-type AHSV circulating during the 1989 vaccination programme. Vaccine-related deaths could be attributable to existing infection with wild-type virus ie vaccination for these animals took place too late. In 1989 it was not possible to differentiate an animal which had been naturally infected and those which had been vaccinated, although that is now possible [20]. More than two-thirds of the 'vaccine-related' deaths were horses but this only amounts to 30·4% of all horse deaths during the epizootic. Horses are known to be far more

https://doi.org/10.1017/S0950268899002897 Published online by Cambridge University Press

susceptible to AHSV than mules and donkeys [21], so some mortality in a vaccination campaign when wild-type virus was circulating was expected. However, 81·6% (31/38) of mule and donkey deaths appear to have been 'vaccine-related', which is surprising as these equines are supposedly much less susceptible to AHSV than horses.

Other causes of 'vaccine-related' deaths may relate to the second difference between 1989 and 1990: compensation payments were readily available to farmers during the epizootic, even in the absence of serological confirmation of AHSV infection of the animal, but confirmation was required after the epizootic. The third factor was that by 1990 there was already considerable experience available among owners, administrators and the veterinary profession concerning AHSV control and serological surveillance. Possible losses, followed by a requirement for confirmation by laboratory tests, due to overworking recently vaccinated animals were avoided under these stricter measures.

Confining the AHS epizootic in Portugal to 13 weeks of a single season was a major success of planning and implementation for ECT and all the field and laboratory personnel involved. Enlarging the Safety Zone to include the whole of the country in 1990, even those areas far above the 40th parallel, and thus probably outside the epizootic zone [22], increased the cost of the eradication campaign but ensured that the whole of the equine population was immune. The comprehensive coverage of the vaccination campaign was sufficient to counteract the apparently high mobility of AHSV and its vectors.

The coordinated cooperative campaign, involving Government agencies, provincial officers and private practitioners serves as a valuable template for future operations which require a far reaching and rapid response to a potentially highly damaging epizootic. Active decision making in the field was supported by laboratory testing and confirmation, then followed up by valuable applied research. This knowledge has advanced the potential to control such outbreaks in future, but without a similarly sound campaign management strategy these more sophisticated tools for eradication will not be effectively deployed. Sensitization of the relevant parties and their active participation in a cooperative campaign were essential to success in Portugal in combatting the first incursion of AHSV to the country.

REFERENCES

1. Lubroth J. African horsesickness and the epizootic in Spain 1987. EquiPrac 1988; **10**: 26–33.
2. Rodriguez M, Castaño M, Escolar E, et al. Peste equina africana: descripcion del brote en España, 1987. Med Vet 1987; **4**: 537–57.
3. International Zoosanitary Code OIE, 5th ed. 1986.
4. Rawlings P, Pro MJ, Pena I, Ortega MD, Capela R. Spatial and seasonal distribution of *Culicoides imicola* in Iberia in relation to the transmission of African horse sickness virus. Med Vet Ento 1997; **11**: 49–57.
5. Lage M, Baptista R, Madeira A, Gomes MJ. A Peste Equina Africana em Portugal. L.N.I.V. (Repositório de Trabalhos), 1989; **21**: 3–9.
6. Edict DGP 28 September 1989.
7. International Zoosanitary Code OIE, 1992.
8. EU Commission Decision 90/553, 9 November 1990.
9. Capela R, Kremer M, Messadeq N, Lemblé C, Waller J. Les *Culicoides* (Diptera, Ceratopogonidae) du Portugal continental et de Porto Santo. Bull Soc Path Exot 1993; **83**: 561–5.
10. Capela R, Sousa C, Pena I, Caeiro V. Preliminary note on the distribution and ecology of *Culicoides imicola* in Portugal. Med Vet Ento 1993; **7**: 23–6.
11. Baylis M, El Hasnaoui H, Bouayoune H, Touti J, Mellor PS. The spatial and seasonal distribution of African horse sickness and its potential *Culicoides* vectors in Morocco. Med Vet Ento 1997; **11**: 203–12.
12. EU Council Directive 90/426, 26 June 1990.
13. Edict DGP 2 February 1990.
14. EU Commission Decision 90/552, 9 November 1990.
15. EU Commission Decision 92/531, 9 November 1992.
16. Anon. Portugal free from AHS. Anim Pharm 1993; **269**: 7.
17. Sellers RF, Pedgley DE, Tucker MR. Possible windborne spread of bluetongue to Portugal, June–July 1956. J Hyg 1978; **81**: 189–96.
18. Sellers RF. Weather, host and vector – their interplay in the spread of insect-borne animal virus diseases. J Hyg 1980; **85**: 65–102.
19. Anon. La peste equine au Maroc. Epizooties de 1989, 1990 et 1991. Données epidémiologique et stratégie de lutte. Ministère de l'Agriculture et de la Reforme Agraire, Royaume de Maroc, Rabat, 1992.
20. Laviada MD, Casal I, Vela C, Sanchez-Vizcaino JM. Use of non-structural protein NS3 of African horse sickness virus for differentiation of vaccinated animals and infected horses. Rev Sci Tec OIE 1994; **13**: 3–4.
21. Erasmus BJ. The pathogenesis of African horsesickness. In: Proceedings of the 3rd International Conference on Equine Infectious Diseases, Paris, 1972. Karger, Basel, 1973: 1–11.
22. Sellers RF, Mellor PS. Temperature and the persistence of viruses in *Culicoides* spp. during adverse conditions. Rev Sci Tec OIE 1993; **12**: 733–55.