Serosurveillance of wild deer and wild boar after the epidemic of foot-and-mouth disease in the Netherlands in 2001

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Veterinary Record 2003 153: 678-681
doi: 10.1136/vr.153.22.678

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Blood samples from 140 wild deer and 208 wild boar shot in the aftermath of the epidemic of foot-and-mouth disease in the Netherlands in 2001 were examined for antibodies to foot-and-mouth disease virus. They were all negative.

THE Netherlands had been free from foot-and-mouth disease (FMD) since 1984, but in February 2001 an outbreak of the disease was detected in a slaughterhouse in the UK; this was the start of an epidemic which led to the disease being introduced into other countries of the EU, including France, Ireland and the Netherlands (Bouma and others 2003). Immediately after the report of the first outbreak in the UK on February 20, 2001, animal movements from the UK into the Netherlands were halted, and livestock markets were prohibited; only one-to-one transport of susceptible animals within the Netherlands was allowed, that is, transport from one farm to another followed by cleaning and disinfection. In addition, FMD virus (FMDV)-susceptible animals imported from the UK and France since January 24, 2001, were traced and inspected clinically, and all sheep and goats imported since February 1, 2001, from those two countries were killed and destroyed. No FMDV was detected. Despite these preventive measures, a suspicion of FMD was reported in the Netherlands on March 15, 2001, and the first outbreak was confirmed on March 20. In total, 26 outbreaks in domestic livestock were detected, the last on April 22, 2001.

In the Dutch media, several reports appeared of observations by farmers of lame deer and deer with abnormal gait in the nature reserve in the centre of the epidemic (Sutmöller 2001). During outbreaks of the disease, farmers commonly believe that wildlife (and especially wild deer) may become infected and may pose a risk of transmitting it to domestic cattle (Stroh 1912, 1938, Bartels and Claassen 1936). During and after the eradication campaign there was a lively discussion, not only in the UK but also in the Netherlands, on the possible role of wildlife, in particular of wild deer, in the epidemiology of FMD and the consequences for the eradication campaign (Boardman and others 2001, Fletcher 2001, Sutmöller 2001, Wilesmith 2001).

Wildlife can play a role in the epidemiology of the disease because it can act as a reservoir for the virus, with the possibility of transmitting it to domestic farm animals (McDiarmid 1962). In the same way, the African buffalo plays a pivotal role in the maintenance of the virus in southern Africa (Thomson 1995).

In North America and Europe, there are large populations of wild deer and wild boar in many rural areas which may come into contact with domestic livestock. They are susceptible to natural and experimental infection with FMDV (Ercegovac and others 1968, Forman and Gibbs 1974), and laboratory experiments have indicated that wild deer can transmit the virus to domestic livestock (Gibbs and others 1975).

As part of the disease emergency programme, a serological survey was conducted in wild deer and wild boar after the Dutch epidemic in 2001, as has been suggested and executed in connection with other epidemics of the disease (Brooksby 1969, Lawman and others 1978, Danish State Veterinary Service 1982). This paper reports the results of this survey and considers the possible role of wild deer and wild boar in the epidemiology of FMD.

MATERIALS AND METHODS

General measures before and during the disease eradication campaign in the Netherlands

Information on the first outbreak in the UK on February 20, 2001, led to control measures being implemented in the Netherlands (Bouma and others 2003). Susceptible livestock on Dutch farms that had imported animals from farms in the protection zone of outbreaks in the UK were culled. Among the affected farms were eight deer farms, which were culled on February 25; blood samples taken from a number of these captive deer were negative for antibodies to FMDV. The State Forestry Service and Dutch Society for the Preservation of Nature closed down certain national parks and estates with wildlife open to the general public. Sheep flocks and free-ranging cattle in the parks and estates were housed in order to prevent contact with the general public (Beleidsonderzoek and Advies 2002). Despite these preventive measures, FMDV was introduced into the Netherlands and the first outbreak of the disease was confirmed on March 20, 2001, in an area close to national forests and estates with wild deer and wild boar (Fig 1). On March 21, national forests and parks were subdivided into compartments and the hunting of wildlife was prohibited (Beleidsonderzock and Advies 2002). The prohibition was lifted on July 1, 2001, and it was decided to collect blood samples from a sample of wild boar and wild deer shot after June 25.

Twenty-four of the 26 outbreaks were in the central part of the Netherlands, the Veluwe area, in which herds of livestock are located close to national forests and parks in which wild deer and wild boar live in open and partly fenced areas. In recent years, owing to the general ecological idea of a more 'open society', to create more contact possibilities between wildlife inside and outside the fenced national parks and forests. Blood samples were collected from wild deer and wild boar in the areas that were close to the premises with infected livestock. Blood samples from wild boar were collected until January 15, 2002, and from wild deer until October 26, 2001. A few wild deer found dead as a result of road accidents in the period before June 25, 2001, but during the epidemic, were also examined.

Wild boar serosurveillance

In the Netherlands, the population of wild boar (*Sus scrofa*) lives in a restricted number of areas: in completely fenced areas, such as the Hoge Veluwe National Park and the Crown dominions in the central-eastern part of the country, and in the so called 'free wildlife belt', consisting of the national park 'De Veluwe' in the centre of the country, and the Roerstreek in the south (Elbers and others 2000). Since 1994 there has

Veterinary Record (2003) **153,** 678-681

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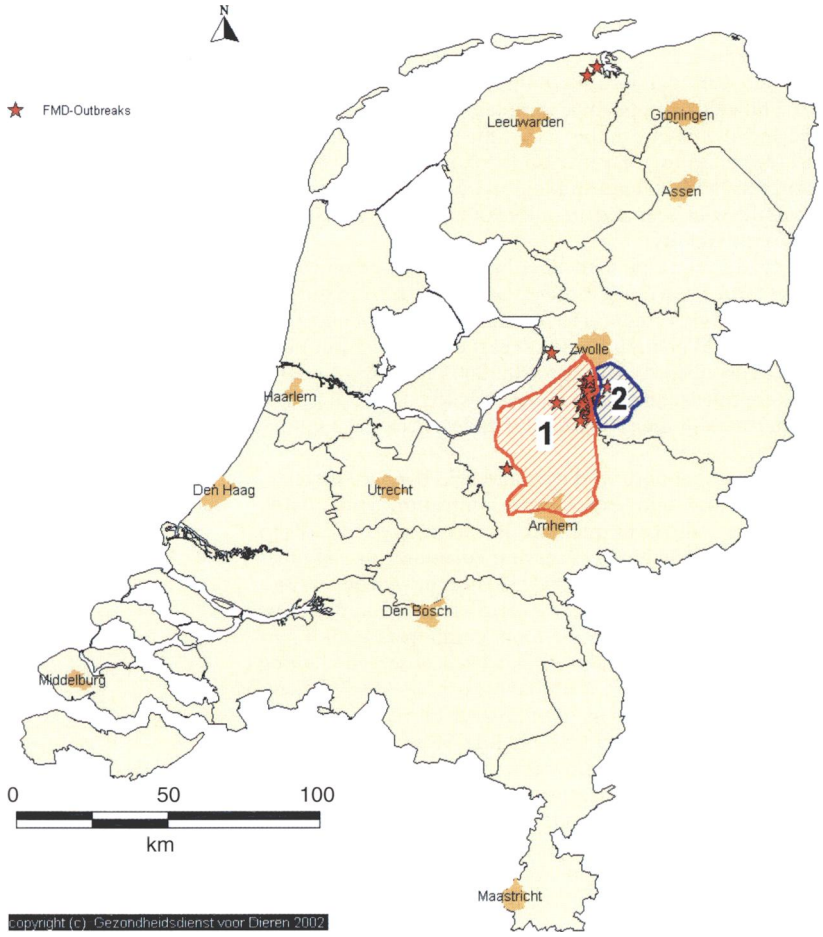

FIG 1: Sites of the outbreaks of foot-and-mouth disease in the Netherlands in 2001, and the areas from which blood samples from wild deer (areas 1 and 2) and wild boar (area 1) were examined for antibodies to foot-and-mouth disease virus

been a serosurveillance system, set up in cooperation with hunting associations and estates that manage the areas in which wild boar live, and blood samples collected from wild boar shot during the hunting season are examined. Immediately after a wild boar has been shot, blood is collected into two sterile plastic tubes, identified by the unique licence number that is given to the hunter, which is linked to the hunting area. The samples are sent by mail or courier service to the laboratory of the Animal Health Service, Deventer, where they are centrifuged at 2500 *g*, and the serum is stored at –20°C until it can be examined. Samples collected by this system from wild boar shot in the region affected by outbreaks of FMD in 2001 (area 1 in Fig 1) were examined for antibodies to FMDV.

Wild deer serosurveillance

The National Inspection Service for Livestock and Meat was responsible for the collection of samples from wild deer; an official of the Service joined the hunting party and was responsible for the collection of the blood. The blood samples from the wild deer, which were all roe deer (*Capreolus capreolus*), were sent directly to the Institute for Animal Science and Health (ID-Lelystad), where they were centrifuged at 2500 *g*, and the sera were stored at –20°C until examined.

Laboratory testss

The sera were screened in a monoclonal antibody-based ELISA for the detection of antibodies to FMDV type O, as described by Chenard and others (2002). The ELISA-positive samples were tested in virus neutralisation tests against FMDV type O_1Manisa by the procedure described by Dekker and Terpstra (1996).

RESULTS

In total, sera from 72 wild deer and 208 wild boar shot in area 1, and 68 wild deer shot in area 2 (Fig 1), were examined. All the samples tested negative.

DISCUSSION

FMD has been reported as a natural infection in various species of deer. Large outbreaks of the disease were reported in semi-wild reindeer populations in 1855, 1896 and 1955 in the Russian tundra zone (Gribanov 1958, Ogryzkov 1963). The disease was severe and caused many of the animals to lose their hooves. In some herds all the calves died within a period of 10 to 12 days. The control of FMD in the USSR was later complicated by the presence of the disease in wildlife (in particular the wild Saiga antelope) in Central Asia (Boiko 1959, Boiko and others 1974, Kruglikov and others 1985). The pastures on which these animals lived were used continuously for domestic cattle.

The control of an extensive epidemic of FMD in cattle in California between 1924 and 1926 was severely hampered by the extension of the infection into the deer population of the Stanislaus National Forest in Tuolumne County. Cattle from several herds were ranged during the summer in this reserve, an area of approximately 1000 square miles, and became infected, probably by one or more infected stray animals (Mohler 1925). The first herd of domestic animals was observed to be infected in April 1924 and the last herd was slaughtered in October 1924. The large number of infected cattle on open range in rugged terrain, which made it impossible to round them all up, and the possibilities for contact with a large number of free-ranging deer, which were fed in the winter, provided unique conditions for the rapid spread of FMDV from the cattle to the deer population. The disease was first diagnosed in the deer in July 1924, and by September 1925 approximately 22,000 deer had been shot, 10 per cent of which showed lesions typical of the disease (Keane 1926). The last deer with active lesions was slaughtered on June 10, 1925, and the last deer with old lesions was slaughtered on September 12, 1925. June 10, 1926, the date when the last quarantine was removed, marked the end of the 1924/26 epidemic of FMD in California.

Reports of natural cases of FMD in other species of deer on the European continent have generally recorded solitary cases of clinical disease, such as in elk (Magnusson 1939), red deer (Stroh 1912, Cohrs and Weber 1939), roe deer (Stroh 1912, 1938, 1939, Rosenhaupt 1938, Christiansen 1939, Cohrs and Weber 1939, Sallinger 1939), fallow deer (Bartels and Claassen 1936), moufflon (Mouquet 1920, Roemmele 1938), and chamois (Stroh 1912, 1939, Hess 1967). Wild deer are often blamed by farmers for the transmission of FMDV to domestic livestock, but extensive investigations have always led to the conclusion that wildlife could not be incriminated and that domestic livestock are most likely to have been infected by other cattle and personal contacts (Stroh 1912, Bartels and Claassen 1936, Cohrs and Weber 1939).

Outbreaks of FMD in wild deer and chamois kept in zoos have been reported from zoos in Buenos Aires, Argentina, in 1942, 1948 and 1955 (Grosso 1957), Leipzig and Hannover in Germany (Bartels and Claassen 1936), Bois de Vincennes in France, in 1938 (Urbain and others 1938), Cologne in

Germany, in 1971 (Thalmann and Nöckler 2001) and the Assam State Zoo in India, in 1981 (Sarma and others 1983).

In eastern Europe, in the 1960s, several studies were made on the course of the disease in experimentally infected roe deer, red deer, fallow deer, elk, saigas and Siberian deer (Boukhtiarov and Kindyakov 1965, Dzhupina and Sviridov 1965, Boukhtiarov and others 1968, Ercegovac and others 1968). After the large epidemic in the UK in 1967/68, the Northumberland Committee on FMD (1969) prompted renewed interest in the UK and in the USA of the possible role of wild deer in the epidemiology of the disease. The susceptibility of roe, fallow, red and white-tailed deer to FMDV was studied (Forman and Gibbs 1974, Forman and others 1974, McVicar and others 1974). In the red and fallow deer the disease was mild or subclinical, whereas in roe deer it was severe, with clear lesions and a rapid loss of body condition. It was also shown that cattle, sheep and deer transmitted the virus not only within species but also to the other species (McVicar and others 1974, Gibbs and others 1975).

In the UK, wild deer have never been incriminated in natural outbreaks of FMD (McDiarmid 1975a, b, Lawman and others 1978, Wilesmith 2001). During outbreaks of the disease in continental Europe in the last six decades, spill-over from infected livestock to free-ranging deer, or vice versa, has never been observed (Hess 1967, Kubin 1972, Danish State Veterinary Service 1982). The fact that, in spite of the cattle population in Europe having been extensively vaccinated from the 1950s until the early 1990s, no circulation of FMDV has been observed in wild deer and wild boar, indicates that the contact structure in wildlife is such that the probability of large outbreaks is small. Roe deer do not live in large groups together, and sick or lame animals tend to leave the group and hide themselves (Cohrs and Weber 1939). Several authors have expressed the belief that wild deer are very unlikely to be an important factor in the maintenance and transmission of FMDV during an epidemic in domestic livestock in western Europe (Stroh 1912, 1938, Bartels and Claassen 1936, Waldmann and Hirschfelder 1938, Cohrs and Weber 1939, Meyer 1939, Gibbs and others 1975, Wilesmith 2001).

During the 2001 epidemic of FMD in the UK, there were six reports from members of the public or officials about wild deer which were thought to be showing signs of the disease. In several cases the deer were found to have suffered trauma and had probably been injured by a car. The few which were shot and examined all tested negative. In total, 484 samples were collected from suspect wild deer and from farmed deer thought to be either at risk or possibly exposed to FMDV; all the samples tested negative. Extensive serosurveillance was carried out in the aftermath of the epidemic, but it focused mainly on sheep and no wild deer were tested (F. Landeg, personal communication).

In New Zealand and Australia there has been much debate on the role of wild boar or feral pigs as potential vectors of FMDV (Martin 1972, Murray and Snowdon 1976, Hone and Pech 1990), especially after the large 2001 epidemic in Europe (Gee 2002). Wild boar are susceptible to the disease, as was shown by their infection in the zoo of Bois de Vincennes in France in 1938 (Urbain and others 1938). There have been sporadic reports of natural infections in wild boar and wild pigs (Geoffroy Saint-Hilaire 1919, Hutyra and Marek 1922, Kleine 1939). Stroh (1912) mentioned a report of FMD in wild boar on Sardinia in 1907. Sludskii (1956) reported outbreaks of the disease in wild boar in the Caucasus in 1902, 1908, 1911, 1917, 1919 and 1925. Ercegovac and others (1968) examined the susceptibility of wild boar to natural and experimental infection with FMDV; they showed distinct clinical signs of the disease after infection. Between 1986 and 1994, wild boar in Israel were monitored for FMDV antibodies and FMDV in oropharyngeal tissue (Yadin and Chai 1994). Because the control of FMD in the Middle East depends predominantly on vaccination, unvaccinated wild animals are excellent sentinels for circulating virus. Of a total of 153 blood samples from wild boar, 29 (19 per cent) had FMDV antibodies and six of 45 (13 per cent) oropharyngeal tissue samples yielded FMDV; however, seropositive samples were collected only in 1992 and 1993. Only in the case of the wild boar sampled in 1992 (36 per cent seropositive, and virus isolated from six animals), was there an epidemiological link between the infection in the wild boar and an outbreak of FMD in a beef cattle herd in the vicinity.

In western Europe there have been no reports of a spill-over of FMDV from domestic livestock to wild boar in the past 80 years. In the UK, there are a few small colonies of feral pigs, including wild boar, in the south east of England, but none was in a surveillance zone during the 2001 epidemic. No samples were collected from feral pigs or wild boar during or in the aftermath of the epidemic (F. Landeg, personal communication).

It is clear that both wild deer and wild boar are susceptible to natural and experimental infection with FMDV. However, it is also clear that spill-over from infected cattle to wild deer and wild boar is a very rare phenomenon and that the infection of cattle by infected wild deer or wild boar is very unlikely. In western Europe, the virus spread from domestic livestock to deer only in the first four decades of the 20th century, since when no spill-over has been observed. Among other factors this change is probably associated with the way cattle are kept nowadays in Europe, which decreases their likelihood of having contact with wildlife. However, lame deer observed during an epidemic of FMD should be taken seriously, although abnormalities of gait are common in wild deer at any time. Because FMDV may be reintroduced from wildlife it is recommended that after an epidemic of FMD there should be a serological survey of wild deer and wild boar to ensure that a wildlife reservoir of FMDV does not become established.

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Notices and divisional events

DIVISIONS of the BVA are entitled to a free notice in *The Veterinary Record* for each meeting that they organise. Notices should contain the date, time, venue and town of the meeting, details of the subject, any speakers and sponsors and the address and telephone number of the person from whom details can be obtained. They should be addressed to: Kathryn Clark, *The Veterinary Record*, 7 Mansfield Street, London W1G 9NQ, fax 020 7637 0620.