

# Use of vaccination against foot and mouth disease in zoo animals, endangered species and exceptionally valuable animals

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## Summary

A historical review of foot and mouth disease (FMD) in non-domestic species is given and the use of FMD vaccines to protect those species is described. Several non-domestic species are susceptible to FMD. Legislation in many countries, based on the definition of FMD-free status as determined by the Office International des Epizooties (OIE: World organisation for animal health), forms an important barrier against the use of vaccines. National authorities may even feel obliged to slaughter animals of threatened species protected by international agreements during an outbreak of FMD to preserve their FMD-free status. The importance of international breeding programmes for endangered species is forcing the international community to reconsider the role that vaccination against FMD should play in animal health prevention programmes of captive populations. Much research is still required in regard to vaccine types and diagnostic procedures. Species-specific differences in susceptibility to FMD make this a challenging research topic for zoological institutions.

## Keywords

Endangered species – Foot and mouth disease – Non-domestic animals – Vaccination – Vaccines – Zoo animals.

## Introduction

Foot and mouth disease (FMD) has played only a minor role in the history of zoos: reports of outbreaks are scarce, and most of these are anecdotal rather than based on scientific data. This is probably not because the disease has not occurred, but rather because it was not considered serious: before the 1930s, FMD was considered an infectious disease just as any other disease for which no specific treatment was available. Certainly, in addition to domestic species, there are a number of non-domestic species that are also susceptible to FMD. It is not surprising that species congeneric with domestic cattle, e.g. gayal (*Bos frontalis*) and zebu (*Bos indicus*) that are often kept in zoos are also highly susceptible to FMD. Natural FMD infections have been described in closely related species such as the Asian water buffalo (*Bubalus bubalis*) (8).

The first reported veterinary intervention in an FMD outbreak in a zoo occurred at the Paris Zoo in 1937 (45). At around the same time, research institutions progressed in the development of vaccines and hyper-immune serum to combat FMD. Some of these facilities worked with zoos to eradicate FMD infections when outbreaks occurred on the premises of the zoo. Zoos in

some European countries carried out regular preventive vaccination programmes for selected susceptible animals in their collections between 1950 and 1990. A country in North Africa demanded preventive FMD vaccination of all susceptible species destined for zoos shipped from Europe in the 1980s. A total of 70 animals in three shipments were vaccinated, including species of deer and antelope, as well as giraffe, maras and capybaras (H. Gass, personal communication, 2001).

However, zoos in European Union member states ceased preventive FMD vaccination programmes in 1991 when member states of the European Union implemented Directive 85/511/EEC that banned preventive vaccination against FMD (6). Some zoos outside the European Union have continued to vaccinate selected susceptible animals sporadically (mostly domestic stock in zoos for children), but little information has been documented (G. Eshkar, personal communication, 2001).

This paper summarises the little data available on the impact of FMD in captive non-domestic species. Scarce reports on FMD vaccinations in zoos are described and the role vaccination plays, or should play, in case of future FMD outbreaks is discussed.

## Historical overview of foot and mouth disease in captive non-domestic species

Table I gives an overview of FMD cases in non-domestic animals; most reports are of captive animals in zoos. The first reported incident of FMD in a zoological collection occurred in the Leipzig Zoo (Germany) in 1931 (25). One reindeer (*Rangifer tarandus*) was affected and died of myocarditis. A crested porcupine (*Hystrix cristata*) was also reported to have died of FMD. Diagnosis was based on the histological finding of myocardial necrosis; no other proof of FMD involvement was given (37). Salzert *et al.* (38) reported that camels are susceptible to FMD: one case at a zoo resulting in death due to myocarditis is described. Several cases of FMD in captive Asian elephants (*Elephas maximus*) and relatively few cases in African elephants (*Loxodonta africana*) have been documented: the duration of disease ranged from several days to three months. Symptoms described are inappetence, salivation, inflamed oral cavity with aphthae and fever. Lameness, including detachment of the sole from the foot, has also been observed. In young animals, the aphthae affected the intestinal mucosa, resulting in diarrhoea and eventually death (18, 19, 25, 35, 36).

There is one report of presumed FMD in a grizzly bear (*Ursus arctos horribilis*) in a South American zoo (9). However, no serological confirmation or virus isolation was carried out and because there have been no other reports of FMD in bears, this diagnosis is suspect.

A detailed report of the FMD outbreak in the Paris Zoo in 1937 was made by Urbain *et al.* (Table I) (45). Of the 250 susceptible animals present in the zoo, 32 showed clinical symptoms and 4 died. This is the only report of clinical FMD in tapirs (*Tapirus indicus* and *Tapirus terrestris*). Hyper-immune serum and serum containing virus were recovered from an infected gaur (*Bos gaurus*) and were used on several animals to induce protective immunity (45). It is not clear how this treatment contributed to the spread of the virus amongst the zoo animals.

An outbreak of FMD affected the domestic cattle population around Amsterdam in the Netherlands during the summer of 1937. In September of the same year, the virus infected the wisents (*Bison bonasus*) at the Amsterdam Zoo (10) and the important breeding male 'Schaljapin' died. Other animals that were affected were mouflon sheep (*Ovis musinum*), Tedal sheep (*Ovis sp.*), American bison (*Bison bison*), eland (*Taurotragus oryx*), African buffalo (*Syncerus caffer*) and Asian water buffalo. However, banteng (*Bos javanicus*), zebu and watussi (*Bos taurus*), housed on the same premises, were not affected. All of

**Table I**  
**Historical overview of foot and mouth disease (FMD) cases in non-domestic animals**

Year	Location	Species	FMD	Dead	Comment	Reference
1931	Leipzig Zoo (Germany)	Reindeer ( <i>Rangifer tarandus</i> )	1	1	Myocarditis; vaccination of remaining artiodactyls	25
1932	Leipzig Zoo (Germany)	Blackbuck ( <i>Antilopa cervicapra</i> )	4	4		25, 38
		Porcupine (unknown species)	(?)	(?)		
1937	Amsterdam Zoo (Netherlands)	African buffalo ( <i>Syncerus caffer</i> )			Hyper-immune serum used in wisent	10
		Bison ( <i>Bison bison</i> )				10
		Eland ( <i>Taurotragus oryx</i> )				10
		Mouflon ( <i>Ovis musimon</i> )				10
		Tedal sheep ( <i>Ovis sp.</i> )				10
		Water buffalo ( <i>Bubalus bubalis</i> )				10
		Wisent ( <i>Bison bonasus</i> )				10
1937	Paris Zoo (France)	Babirusa ( <i>Babyrousa babyrussa</i> )	4	0	Artiodactyls and tapirs treated with hyper-immune serum; some immunised with a combination of immune serum and serum containing virus	46
		Bison ( <i>Bison bison</i> )	2	0		
		Eld's deer ( <i>Cervus elsi</i> )	1	0		
		Fallow deer ( <i>Dama dama</i> )	2	1		
		Gaur ( <i>Bos gaurus</i> )	1	0		
		Gayal ( <i>Bos frontalis</i> )	1	1		
		Kouprey ( <i>Bos sauveli</i> )	1	0		
		Kudu ( <i>Tragelaphus strepsicornis</i> )	2	2		
		Reindeer ( <i>Rangifer tarandus</i> )	4	0		
		Tapir ( <i>Tapirus indicus</i> and <i>Tapirus terrestris</i> )	4	0		
		Warthog ( <i>Phacochoerus aethiopicus</i> )	3	0		
		Water buffalo ( <i>Bubalus bubalis</i> )	2	0		
		Wild boar ( <i>Sus scrofa</i> )	4	0		
		Wildebeest ( <i>Connochaetes gnou</i> )	1	0		
1938	Bern Zoo (Switzerland)	Bison ( <i>Bison bison</i> )	11	0		25
		Steinbok ( <i>Rhaphicercus campestris</i> )	12	1		

Table I (contd)

Year	Location	Species	FMD	Dead	Comment	Reference
1939	Zurich Zoo (Switzerland)	Bison ( <i>Bison bison</i> )	?	0		1
		Watussi ( <i>Bos taurus</i> )	?	0		
		Yak ( <i>Bos grunniens</i> )	?	0		
		Zebu ( <i>Bos indicus</i> )	?	0		
1951	Rotterdam Zoo (Netherlands)	Yak ( <i>Bos grunniens</i> )	?	0	All susceptible artiodactyls vaccinated	G. van der Graaf (personal communication, 2001)
1951	Wuppertal Zoo (Germany)	Bison ( <i>Bison bison</i> )	?	0	Domestic pigs infected first	25
1953- 1954	Niepolomice, Lopuszna and Pszcyna reserve (Poland)	Wisent ( <i>Bison bonasus</i> )	?	42	Type A5 (1954)	13
1957	Berlin Zoo (Germany)	Water buffalo ( <i>Bubalus bubalis</i> )	?	1		25
		Watussi ( <i>Bos taurus</i> )	?	0		
		Wisent ( <i>Bison bonasus</i> )	?	0		
1958	Circus (Germany)	Asian elephant ( <i>Elephas maximus</i> )	1	1	Type C	25
1961	Hannover Zoo (Germany)	Yak ( <i>Bos grunniens</i> )	?	0		25
		Watussi ( <i>Bos taurus</i> )	?	0		
1962	Cologne Zoo (Germany)	Watussi ( <i>Bos taurus</i> )	2	0	Vaccination of remaining artiodactyls	25
		Pudu ( <i>Pudu pudu</i> )	8	5		
1962	Berlin Zoo (Germany)	Bison ( <i>Bison bison</i> ) Wild boar ( <i>Sus scrofa</i> )	? ?	0 1	Vaccination of remaining artiodactyls	25
1962	Leipzig Zoo (Germany)	Reindeer ( <i>Rangifer tarandus</i> )	1	0	Type C; hyper-immune serum used; vaccination of remaining artiodactyls	25
1962	Halle Zoo (Germany)	Bison ( <i>Bison bison</i> )	2	1	78 artiodactyls vaccinated with type C (including one elephant)	20
		Caucasian tur ( <i>Capra aegagrus</i> )	5	0		
1962	Waszana Zoo (Poland)	Mouflon ( <i>Ovis musimon</i> )	2	0	60 artiodactyls vaccinated with type C	34
		Wisent ( <i>Bison bonasus</i> )	3	1		
		Zebu ( <i>Bos indicus</i> )	3	0		
1963	Waszana Zoo (Poland)	Wisent ( <i>Bison bonasus</i> )	2	2	36 artiodactyls vaccinated with types A and O	34
1963	Łódź Zoo (Poland)	Bison ( <i>Bison bison</i> )	3	0	Artiodactyls vaccinated with types A, C and O	34
		Wisent ( <i>Bison bonasus</i> )	3	1		
1963	Poznán Zoo (Poland)	Bison ( <i>Bison bison</i> )	6	0	Artiodactyls vaccinated with types A and O	34
		Wisent ( <i>Bison bonasus</i> )	1	0		
1970	Circus (Italy)	African elephant ( <i>Loxodonta africana</i> )	1	0	Type A7; 1 out of 15 animals; source: cattle	33
1975	Kathmandu Zoo (Nepal)	Asian elephant ( <i>Elephas maximus</i> )	16	0	Type O, 60% of the herd affected; suspected source: water buffalo	35
1981	Assam State Zoo (India)	Gayal ( <i>Bos frontalis</i> )	2	0	Type O	39
		Sambar deer ( <i>Cervus unicolor</i> )	34	1	Type O	
1985	Ramot Yissakhar Nature Reserve (Israel)	Mountain gazelle ( <i>Gazella gazella</i> )	>300	1,500	Type O	40
1987	India	Asian elephant ( <i>Elephas maximus</i> )	1	0	Type Asia 1; source: cattle and water buffalo	36
1990	Calcutta Zoo (India)	Gayal ( <i>Bos frontalis</i> )	5	2	Type O; myocardial necrosis; source: domestic animals	5

the above animals were attended by a keeper living on a farm where an FMD outbreak in cattle had recently occurred. The wisent calf 'Arsène' (studbook number 288), born during the outbreak, was inoculated immediately after birth with hyper-immune serum provided by the Central Veterinary Institute in Rotterdam. Inoculation was repeated several times in the days that followed and the animal never showed any signs of clinical FMD (10).

Another source of FMD infection for the Amsterdam Zoo could have been the FMD vaccine production unit of the Central

Veterinary Laboratory, located near the zoo (S.J. Barteling, personal communication, 2001). Efficacy of the vaccine was tested in cattle at a slaughterhouse only 200 meters away from the zoo. Personnel working with the cattle regularly ate lunch at the zoo. A variety of artiodactyls at the zoo showed clinical signs of FMD on different occasions during the 22-year period (1950 to 1972) when vaccinated and non-vaccinated cattle were challenged experimentally with FMD virus at the slaughterhouse. Susceptible animals at the zoo were usually vaccinated with the help of the Central Veterinary Laboratory employees as soon as signs of FMD were observed, and the

disease was contained. Several animals in the children's section of the Amsterdam Zoo that included cattle, goats, sheep and pigs contracted FMD in 1956 (41). No other animals were affected during that episode, but subsequently, from 1956 to 1965, the animals in the children's section of the zoo were vaccinated three to four times per year with a trivalent vaccine, containing serotypes A, O and C (A. Erken, personal communication, 2001). Vaccination frequency was reduced to twice a year in 1965, a programme that was continued until 1972, when obligatory annual vaccination of the cattle population in the Netherlands resulted in a dramatic decline in FMD outbreaks in domestic livestock. Given that this measure greatly reduced the risk of FMD spreading to zoo animals, the preventive vaccination programme was discontinued, except for the mandatory vaccination of cattle.

Data on an outbreak of FMD at the Rotterdam Zoo in 1951 have been retrieved from old zoo records and interviews with retired staff members (Fig. 1) (G. van der Graaf, personal communication, 2001). The head keeper of the yaks (*Bos grunniens*), the only animals having shown clinical signs during this outbreak, reported that he had visited a farmer with cattle suffering from FMD. He had been shown oral lesions in diseased cows and had even assisted in opening the mouth of affected animals to examine the tongue and gums (G. van der Graaf, personal communication, 2001). As soon as FMD was confirmed in the yaks, the Dutch Central Veterinary Institute assisted Rotterdam Zoo in a large-scale campaign: within a two-week period, all susceptible artiodactyls, except those yaks that were already infected and the giraffes which were difficult to capture, were vaccinated. Species vaccinated included greater kudu (*Tragelaphus strepsiceros*), eland, nilgai (*Boselaphus trachocamelus*), Arabian oryx (*Oryx leucoryx*), gemsbok (*Oryx gazella*), blackbuck (*Antilopa cervicapra*), Asian water buffalo, banteng, addax (*Addax nasomaculatus*), anoa (*Bubalus*



**Fig. 1**  
**Indoor enclosure for yaks suffering from foot and mouth disease, Rotterdam Zoo, February 1951**

Translation of the sign: foot and mouth disease, no admittance  
Courtesy of G. van der Graaf

*depressicornis*), wildebeest (*Connochaetus taurinus*), bison, wapiti (*Cervus canadensis*), pudu (*Pudu pudu*), fallow deer (*Cervus dama*) and babirusa (*Babirusa babyrussa*). Since no remote injection system was available at the time, animals up to the size of a female kudu were manually restrained to inject them. Other animals were caught using a lasso (Fig. 2).



**Fig. 2**  
**Manual restraint of a clinically normal adult yak bull using a lasso for a subcutaneous injection of 40 ml foot and mouth disease vaccine, Rotterdam Zoo, 1957**

Courtesy of Rotterdam Zoo

## Foot and mouth disease in wildlife

Several species of deer may act as temporary reservoirs of FMD and a source of infection for domestic animals. Descriptions of FMD in mule deer (*Odocoileus hemionus*) were made during the outbreaks which occurred in California from 1924 to 1926 (23). The virus spread from domestic cattle to the deer population in the Stanislaus National Forest. Approximately 22,000 deer were killed and examined, of which 10% showed typical lesions of FMD (23). A group of investigators at the Animal Virus Research Institute in the United Kingdom

studied FMD in cervids in 1974. Signs observed varied from aphthae to death, with roe deer showing the most severe signs among the species studied. It was concluded that of the five deer species indigenous to the United Kingdom, only roe deer (*Capreolus capreolus*) would be likely to be involved in an epizootic by infecting both cattle and sheep (11, 12, 15). Signs in these animals, which varied from aphthae to death, were also found in a laboratory study of FMD infection in white-tailed deer (*Odocoileus virginianus*) at the Plum Island Animal Disease Laboratory, United States of America (27).

The African buffalo is the natural reservoir of the three South African Territories (SAT) types of FMD virus in southern Africa, probably extending into other parts of Africa as well. Although most infections pass asymptotically, buffalo calves are suspected to excrete virus when they are two to three months old, based on indirect evidence: impalas (*Aepyceros melampus*), which are highly susceptible to FMD, become infected when in close contact with buffalo calves of this age group (3, 14, 24, 44). Several antelope species have been found to be susceptible to FMD but do not act as long-term carriers (17, 44).

An outbreak of FMD in free-ranging mountain gazelles (*Gazella gazella*) in Israel resulted in a high morbidity and mortality rate: at least 1,500 animals (50% of the population) of all age groups died (40).

The European hedgehog (*Erinaceus* sp.) has been found to be highly susceptible to natural FMD infection (22, 26). Respiratory virus excretion is important in the epidemiology of FMD in this species, and can play a role in cross-species transmission as FMD was induced in calves housed near infected hedgehogs. The virus could still be isolated from hedgehogs directly after hibernation (22). Capybaras (*Hydrochaeris hydrochaeris*) are reported to be susceptible to FMD (16); however, it is not known whether capybaras play a role in the epidemiology of FMD in domestic cattle in South America. Nutrias (*Myocastor coypus*) have been experimentally infected with FMD (4). Findings showed that nutrias are susceptible to serotype C by contact with infected cattle, while serotype A could only be transmitted by parenteral inoculation.

## Species-specific susceptibility

Susceptibility to FMD is species-specific. In one trial, several species were experimentally challenged with FMD by keeping the animals in close contact with infected cattle. In this trial, impala, roan antelope (*Hippotragus equinus*), waterbuck (*Kobus ellipsiprymnus*) and kudu appeared to be more susceptible than wildebeest and common eland (17). African buffalos are mostly non-symptomatic carriers (46). Roe deer are more severely affected than larger cervid species (11). The smallest true deer, the South American pudu, is reported to be highly susceptible: five out of eight animals died during an outbreak in Cologne Zoo, while other deer species in the same zoo were not affected

(25). The African elephant is reported to be far less susceptible to FMD than the Asian elephant (18, 21). Although hippopotamus (*Hippopotamus amphibius*) are also artiodactyls, no reports of FMD diagnosis in hippopotamus are known. Furthermore, serological testing of 877 hippopotamus in South Africa failed to reveal any evidence of infection (44).

## Vaccines against foot and mouth disease

Vaccines against viruses can be either live (attenuated) or killed (inactivated). Most vaccines against viral diseases are developed for domestic animals and live vaccines may retain pathogenic potency for the host when used for non-domestic species, resulting in disease or death of the vaccinated animal. This phenomenon has been clearly demonstrated in many carnivore species vaccinated against canine distemper (7). The rule in zoo animal medicine is that live vaccines are unsuitable for use in non-domestic species because of their unpredictable effects and exceptions can only be made after controlled experimental research. In principle, only killed vaccines should be used against FMD.

Vaccines currently used for FMD are chemically inactivated cell-culture-derived preparations of the virus that have been blended with a suitable adjuvant. Two categories of killed vaccine are available, namely: water-based and oil-based vaccines. There are two oil-based vaccines: single oil emulsions and double oil emulsions (DOE-vaccine) (2). Water-based vaccines are usually registered for use in cattle, sheep and goats. The more recently developed oil-emulsion vaccines induce better immunity than water-based vaccines in most species, including domestic cattle, sheep, goats, pigs and water buffalo, and immunity lasts longer (2). A monovalent vaccine containing the appropriate serotype can be used for emergency vaccination during an FMD outbreak. Since there is no cross-immunity between the seven different serotypes, preventive vaccination should target the serotype most likely to be encountered.

The *Manual of Standards for Diagnostic Tests and Vaccines* of the Office International des Epizooties (OIE: World organisation for animal health) gives guidelines for the use of vaccines in domestic animals: 'In order to establish a satisfactory level of immunity it is usual to give a primary course of two inoculations, 2-4 weeks apart, followed by revaccination every 4-12 months. The frequency of revaccination will depend on the epidemiological situation and the type and quality of vaccine used. Where access to the animals is difficult, it is preferable to use oil adjuvanted vaccine at 4 months and 1 year of age, followed by annual revaccination. For calves born of vaccinated dams, the first vaccination should be delayed as long as possible to allow decline of maternal antibody, but not beyond 4 months, as at that time a high proportion can be expected to respond effectively to vaccination. For calves born

of non-vaccinated dams, the first vaccination may be at 1 week of age' (29). How appropriate these guidelines are for non-domestic species is not known.

### Injection methods

Before projectile inoculation devices were available, vaccination had to be performed by hand in manually-restrained animals. This very labour-intensive method posed certain risks for both the animals and personnel involved (32; G. van der Graaf, personal communication, 2001).

The first (water-based) vaccines had to be administered at a high volume dose of 40 ml for an adult, cattle-sized animal. This excluded delivery by using short-distance injection pistols and long-distance injection rifles that became available in 1960, as these could only inject 10 ml in a single shot. The Dutch Central Veterinary Institute therefore developed a special vaccine formula for zoo animals in 1961 (41, 42, 43). A 10 ml volume of the new formula appeared to be as effective as a 40 ml dose of the formerly used vaccine. The entire population of susceptible animals at a large zoo could now be vaccinated in a single day (Fig. 3). Remote vaccination was intramuscular, while the vaccine used previously was administered subcutaneously. According to the veterinarian of the Amsterdam Zoo, no side effects, e.g. abscess formation or tissue necrosis, were observed after intramuscular administration of the higher-concentration formulation (42).



**Fig. 3**  
The use of remote injection systems largely facilitated the implementation of a preventive foot and mouth disease vaccination programme at the Rotterdam Zoo, 1961  
Courtesy of Rotterdam Zoo

### Efficacy of foot and mouth disease vaccines

After the introduction of the higher-concentration water-based FMD vaccine in 1961, the Dutch Central Veterinary Institute conducted experiments in cattle to establish the minimal protective dose and the effectiveness of intramuscular vaccination compared to subcutaneous delivery (43). Nineteen cattle were injected intramuscularly and 25 injected

subcutaneously with 5 ml of the higher-concentration vaccine for serotype C. These animals and a control group were challenged with 10,000 infectious doses of homologous virus derived from cattle. The same experiment was repeated with serotype O. While all control animals developed generalised FMD, only one case of generalised FMD was observed in the vaccinated animals. Appearance of FMD was restricted to local lesions in the mouth or on the hoofs in some of the vaccinated animals with no significant difference between the intramuscularly and subcutaneously injected groups. Neutralising antibodies were measured and compared with the antibodies found in one zebu, one gayal and two yaks that had been vaccinated with a 10 ml dose. Serum antibody titres two weeks post injection were considered satisfactory. The conclusion of this trial was that intramuscular injection of 5 ml of the higher-concentration of FMD vaccine provided satisfactory protection against challenge with the virus (42).

Very few data concerning the efficacy of FMD vaccines in non-domestic species are available in the literature. One study was conducted in African buffalo, impala and eland. An oil-based FMD vaccine (containing SAT strains) was used at the cattle dose of 3 ml, administered subcutaneously (19). A second injection was given 21 days later and a final booster, six months later. Serum neutralising antibody titres were compared with those in domestic cattle. Generally, titres were lower than in domestic cattle. Although further studies were recommended, it was suggested that the initial vaccination be given as a double dose with an interval of approximately 21 days between inoculations. To maintain acceptable levels of immunity, booster vaccinations were recommended after four to six months and thereafter, at six-monthly intervals (19).

At present, an FMD vaccine produced in the Netherlands is claimed to be effective in Asian water buffalo.

### Tests for distinguishing between vaccinated and infected animals

An FMD marker enzyme-linked immunosorbent assay (ELISA) has been recently developed in Switzerland. This test distinguishes antibodies induced by natural infection from vaccine-induced antibodies, based on the absence of non-structural proteins in the vaccine. The test is generally accepted – including by the OIE – as useful as a herd test, but has not been accredited for use in individual animals to date. The use of such a discriminatory test in any future vaccination research in non-domestic species is highly recommended. If such a test could be used for zoo animals, it could play an important role in case of emergency vaccination of these animals during an outbreak of FMD in farm animals near that zoo.

### Vaccination of endangered species in future outbreaks of foot and mouth disease

There is no doubt that many species in zoological institutions may be affected by FMD. Modern zoos play an active role in the

conservation of endangered species through international captive breeding programmes. Genetic material of endangered species is distributed in recognised zoos all over the world to minimise the risk of loss of a large proportion of the captive population through external factors (diseases, natural disasters, political instability, etc.). The type and amount of veterinary support that can be given to these breeding programmes are largely dependent on veterinary regulations in the different countries where the animals are kept. With regard to diseases such as FMD, regulations are dictated by the national status with regard to these diseases, as determined by the OIE. The international community recognises the importance of the breeding programmes for endangered species and rare breeds, and the need to establish internationally recognised rules to provide optimal protection for animals in such programmes. The following statement was made in Recommendation No. 2 of the OIE/Food and Agriculture Organization (FAO) International Scientific Conference on Foot and Mouth Disease, held in Paris from 17 to 18 April 2001: 'OIE Member Countries have an obligation to conserve endangered species and in particular those covered by The Convention on International Trade in Endangered Species' and 'When the veterinary authorities consider that the risk of FMD infection appears imminent, vaccination is one measure that might be considered for the protection of such animals' (30).

To free the way for preventive vaccination, the Conference recommended that:

'3. Chapter 2.1.1., Article 2.1.1.6. of the *Code* be modified, where appropriate, to allow for emergency vaccination of certain rare or valuable animals to be permitted without prejudice to the FMD free without vaccination status of the country/zone, provided that such vaccinated animals are individually identified and are maintained in a location that has physical barriers and where zoosanitary procedures are applied that are adequate to prevent contact with any susceptible animals that may be situated beyond the confines of the location, and that measures are in place that would prevent the spread of infection by fomites. This location could be considered as an "FMD-free zone where vaccination is practised", where all attendant *Code* restrictions will apply to the vaccinated animals, their progeny, embryos, ova and semen and other products derived from these animals' (30). This recommendation has since been discussed and adopted by the International Committee of the OIE (31).

Now formally approved by the OIE, this decision will enable zoos to provide better veterinary care for their animals in case of a nearby outbreak of FMD.

Theoretically, the present *International Animal Health Code* does not impede such an approach (28). However, no Member Country has ever applied for an 'FMD-free zone status where vaccination is practised in zoos'. In the 2001 outbreak in the Netherlands, the Dutch Federation of Zoos asked for such a

provision, but the European Union did not consider this as a realistic option.

A point of contention in the FMD vaccination issue is that vaccinated animals may still become infected and that a proportion of such animals may become carriers. The discussion at the OIE/FAO Conference about whether vaccinated animals might be a potential source of infection only focused on domestic species, not because this problem would only apply to domestic animals, but because the participants apparently recognised the fact that the international community, which has expressed concern about the decline of so many endangered species by the ratification of several international agreements, should free the way to protect animals belonging to these species in breeding programmes in any possible form, including vaccination. National veterinary authorities and the international scientific community therefore have the obligation to support the development of an appropriate prevention programme that would enable zoos to safeguard their conservation efforts. When a zoo is situated in a zone close to an FMD outbreak, vaccination might be advisable to protect susceptible animals against disease for animal welfare reasons. If zoo animals (vaccinated or not) become infected by FMD virus, this may create a tremendous problem for the official veterinary authorities when threatened species are involved. Modern zoos are increasing their efforts to participate in breeding programmes for the conservation of endangered species. For example, in the 2001 outbreak of FMD in the Netherlands, the Rotterdam Zoo kept six Philippine spotted deer (*Cervus alfredi*). This is a substantial sample of the total world population of this species that is estimated at less than 70 animals. These figures illustrate the dilemma that is created by national legislation and international regulations that are principally developed for commercially kept animals. Politicians will not have a direct answer when veterinary authorities see themselves forced to impose the same rigorous measures that are applied to cattle and pigs on animals belonging to highly threatened species kept in zoos.

## Further research

The OIE/FAO Conference also recommended that: '4. In respect of zoological collections, stakeholders should consider the funding of research into the efficacy of vaccines in non-domesticated ruminants and other species and the application of diagnostic tests in such species' (30). This recommendation is in accordance with the mission statement of many modern zoos, for which research is an important activity. When vaccination was discussed during the FMD outbreak in the Netherlands in 2001, arrangements were made to perform serological studies in several species following vaccination. However, vaccination of zoo animals was never permitted by the national government because of the current European Union regulations. Now that the recommendations of the OIE/FAO Conference have been accepted by the International Committee of the OIE, the zoo community should propose an

international research programme to study the efficacy of vaccines and the application of diagnostic tests in non-domestic species kept in zoos. However, the recommendation of the OIE/FAO Conference only refers to emergency vaccination. A special permit from the member states involved is required for such a research programme in non-domestic species. The countries involved in this study should apply to the OIE for recognition of the participating zoos as zones free of FMD where vaccination is applied. That zone would then be subject

to the provisions for that status. As long as no live virus is used, such research does not jeopardise the FMD-free status of the countries involved.

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# La vaccination contre la fièvre aphteuse des animaux des parcs zoologiques, des espèces menacées et des animaux de valeur exceptionnelle

W. Schaftenaar

## Résumé

L'auteur retrace l'histoire de la fièvre aphteuse chez les espèces animales autres que domestiques et de l'utilisation de la vaccination pour assurer leur protection. Plusieurs de ces espèces sont sensibles à la fièvre aphteuse. La législation de nombreux pays, qui repose sur la définition du statut indemne de fièvre aphteuse de l'OIE, constitue un obstacle important à la vaccination. Il arrive parfois, lors de l'apparition d'un foyer de fièvre aphteuse, que les autorités nationales s'estiment contraintes d'abattre des animaux appartenant à une espèce menacée, pourtant protégée par les conventions internationales, dans l'unique but de préserver le statut indemne de fièvre aphteuse du pays. De par leur importance, les programmes internationaux de sélection génétique des espèces menacées vont forcer la communauté internationale à redéfinir le rôle que devrait jouer la vaccination contre la fièvre aphteuse dans le cadre des programmes de protection sanitaire des populations d'animaux vivant en captivité. La recherche concernant les types de vaccins et les procédures de diagnostic requiert de nombreux développements complémentaires. Compte tenu des différences de sensibilité de chaque espèce animale à la fièvre aphteuse, ce type de recherche constitue une véritable gageure pour les parcs zoologiques.

## Mots-clés

Animaux autres que domestiques – Animaux de parcs zoologiques – Espèces menacées – Fièvre aphteuse – Vaccination – Vaccins.



# Uso de vacunas contra la fiebre aftosa en animales de zoológico, especies amenazadas y animales de excepcional valía

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## Resumen

El autor repasa la historia de la fiebre aftosa en los animales no domésticos, y describe el uso de vacunas contra la enfermedad para proteger a esas especies, varias de las cuales son sensibles al virus. En muchos países la legislación en la materia, basada en la definición de país libre de fiebre aftosa establecida por la

OIE, constituye un importante obstáculo a la utilización de vacunas. Durante un brote de fiebre aftosa puede ocurrir incluso que las autoridades sanitarias nacionales se sientan obligadas a sacrificar ejemplares de una especie amenazada y protegida por convenios internacionales a fin de mantener la condición de país libre de la enfermedad. El auge de los programas internacionales de reproducción de especies amenazadas está obligando a la comunidad internacional a replantearse la función de las vacunaciones contra la fiebre aftosa en los programas zoonosarios de prevención aplicados a poblaciones cautivas. Es preciso investigar muy a fondo los tipos de vacunas y los procedimientos de diagnóstico. En este terreno las instituciones zoológicas tienen ante sí una ardua labor de investigación, habida cuenta de las diferencias de susceptibilidad a la fiebre aftosa que se derivan de las características propias de cada especie.

#### Palabras clave

Animales de zoológico – Animales no domésticos – Especies amenazadas – Fiebre aftosa – Vacunación – Vacunas.



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