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Eradication of foot and mouth disease in Japan

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Summary
An outbreak of foot and mouth disease (FMD) was recorded in Japan in the spring of 2000, the first for ninety-two years. Between 25 March and 11 May, four farms were infected. However, the disease was eradicated without resorting to vaccination, through a campaign of culling, movement control of cloven-hoofed animals in areas surrounding infected premises, and intensive clinical and serological surveillance. Japan regained FMD-free status by the end of September 2000. The authors describe the nature of the outbreaks, the eradication measures implemented, and the clinical and serological surveillance methods used. The possible sources of infection are also examined. Finally, the direct and indirect economic losses are presented.

Keywords
Clinical surveillance – Eradication – Foot and mouth disease – Japan – Pan Asian topotype – Serological surveillance.

Introduction

Foot and mouth disease (FMD) is a highly contagious disease which had been absent from Japan since 1908. As a result of the policy of non-vaccination against FMD that Japan has adopted, the national population of cloven-hoofed livestock is highly susceptible to the disease. The authors provide information on the outbreak of FMD in Japan which commenced on 25 March 2000. Details are provided of the successful measures taken to eradicate the disease through a slaughter policy (stamping-out) and intensive surveillance, without the use of vaccine.

Livestock industry in Japan

The livestock industry is an important sector in Japan, producing a gross national product of approximately 2.4 billion yen, a quarter of the total agricultural product (in 1998). The population of cloven-hoofed animals is presented in Table I.

Table I
Livestock population and number of livestock farms in Japan
(Figures for dairy cattle, beef cattle and pigs: 1 February 2000; figures for sheep and goats: 31 December 1997)

Animal	Area	Number of farms	Number of animals
Dairy cattle	Japan (total)	33,600	1,765,000
	Hokkaido	9,950	886,900
	Kyushu	3,610	157,876
Beef cattle	Japan (total)	116,500	2,823,000
	Hokkaido	3460	413,500
	Kyushu	50,610	977,200
Pigs	Japan (total)	11,700	9,805,000
	Hokkaido	540	546,000
	Kyushu	3,150	2,675,500
Sheep and goats	Japan (total)	6,290	44,800

Source: Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, Japan

Japan has an area of approximately 370,000 square kilometres and consists of four principal islands, namely: Hokkaido, Honshu, Shikoku and Kyushu. Kyushu and Hokkaido islands, where the outbreaks of FMD were recorded, are the primary livestock-producing areas of the country. In Kyushu, many small-scale cow-calf operations exist, in which Japanese Black cattle are kept; the Japanese Black is one of the principal breeds of beef cattle in Japan, a 'wagyu' breed that produces high quality beef. Kyushu is also a major area for pig production. Many large-scale beef and dairy farms are located in Hokkaido.

Outbreaks of foot and mouth disease

On 25 March 2000, an outbreak of FMD was reported on a beef cattle fattening farm in Miyazaki City, Miyazaki Prefecture. Following this outbreak, farms in the movement control and surveillance areas, farms with epidemiological links to the infected farm and farms that were using imported forage as feed, were subjected to serological surveillance. As a result, two cow-calf operations in Takaoka town, adjacent to Miyazaki City and one farm in Honbetsu town, Hokkaido Prefecture, were confirmed as being affected by FMD. These farms are named A, B, C and D, respectively. Information concerning the location of the four outbreaks, the number of susceptible animals kept on the farms, the clinical signs and the results of laboratory investigations, are presented in Table II. The maps in Figure 1 indicate the location of these outbreaks.

Farm A

Ten Japanese Blacks were being kept on farm A, for fattening purposes. On 8 March, the farmer found cattle showing pyrexia, anorexia and coughing. A private veterinarian visited the farm on 12 March and found anorexia and nasal and mouth erosions which were spreading to other cattle. The veterinarian reported the observations to Miyazaki Livestock Hygiene Service Centre on 21 March. The farm was visited by a prefecture veterinary inspector on the same day. Diagnostic samples were taken and sent to the Department of Exotic Diseases, National Institute of Animal Health (NIAH) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) on 22 March.

On 22 March, a sample of epithelium tissue sent to the NIAH was examined by the antigen capture enzyme-linked immunosorbent assay (ELISA) and the complement fixation test for antigen detection; both gave negative results. On 23 March, a gene segment of FMD virus type O was detected by reverse transcriptase-polymerase chain reaction (RT-PCR). On 24 March, serum samples from nine animals showed high antibody levels in the liquid-phase blocking (LPB) ELISA; on 25 March, all ten animals on the farm were assessed as being affected by FMD, and the animals were destroyed on 26 March.

Chinese wheat straw, used as a feedstuff on Farm A, was suspected as a source of FMD virus. Of the 23 farms found to be using Chinese wheat straw from the same source, none was found to be affected by FMD, following clinical and serological investigations. No evidence was found to suggest that the movement of animals, vehicles or people, or air-borne transmission were sources of infection.

Farm B

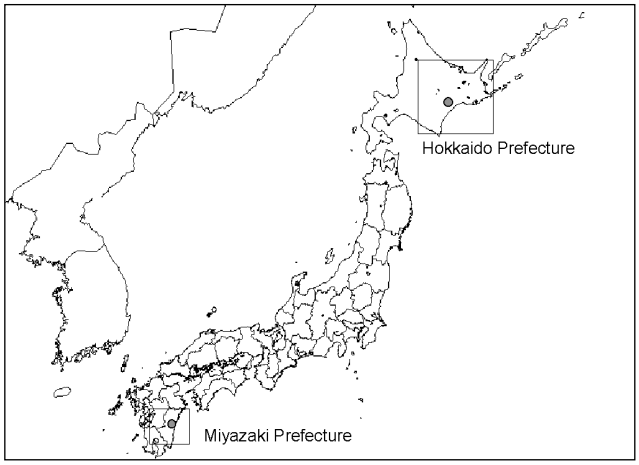
Farm B was a cow-calf operation with nine Japanese Black cattle (six cows and three calves). Serum samples obtained on 29 March revealed that three animals had antibody levels greater than 1:45 in the LPB-ELISA. On 2 April, serum samples were taken from all nine cattle, six of which showed a rise in antibody level. On 3 April, the farm was assessed as being affected by FMD, and all the cattle were destroyed on 4 April.

Table II
Location, number of susceptible animals, clinical signs and results of laboratory investigations of foot and mouth disease outbreaks in Japan in 2000

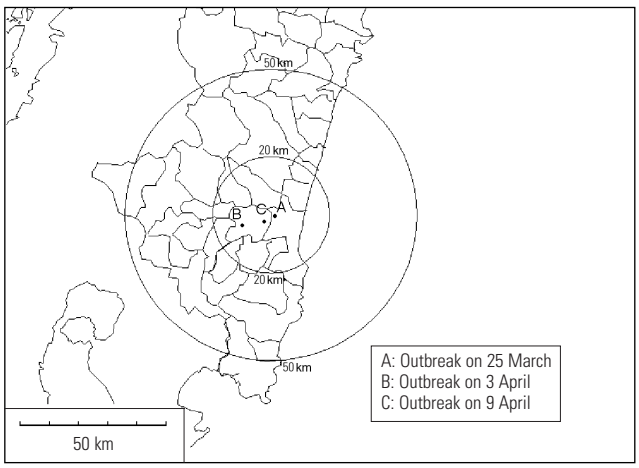
Outbreaks	Location	Susceptible animals	Date of diagnosis	Date of completion of stamping-out	No. of animals destroyed	Movement control area applied	Clinical signs	Laboratory verification
Farm A	Miyazaki City, Miyazaki Prefecture	10 fattening cattle	25 March	26 March	10	25 March-22 April	Nasal and mouth erosions	Type O (RT-PCR, LPB-ELISA)
Farm B	Takaoka town, Miyazaki Prefecture	6 breeding cows and 3 calves	3 April	4 April	9	3 April-25 April	No clinical signs	Type O (LPB-ELISA)
Farm C	Takaoka town, Miyazaki Prefecture	10 breeding cows and 6 calves	9 April	10 April	16	9 April-2 May	Salivation and anorexia	Type O (LPB-ELISA, virus isolation)
Farm D	Honbetsu town, Hokkaido Prefecture	705 fattening cattle	11 May	15 May	705	11 May-9 June	No clinical signs	Type O (LPB-ELISA, RT-PCR)

LPB-ELISA : liquid-phase blocking enzyme-linked immunosorbent assay
RT-PCR : reverse transcription-polymerase chain reaction

a) Japan



b) Miyazaki Prefecture



c) Hokkaido Prefecture

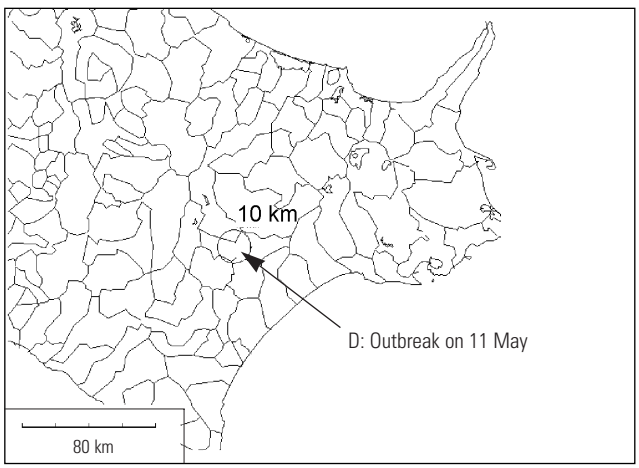


Fig. 1
Location of foot and mouth disease outbreaks in Japan, 2000

Farm B is located 7 km west of Farm A. The private veterinarian who visited Farm A on 21 March was also found to have visited Farm B and two other farms following the visit to Farm A. The veterinarian had also visited 105 other farms around this date. None of these farms was found to be infected with FMD virus following clinical and serological surveillance. No evidence was found to suggest that the movement of animals or vehicles, the feeding of contaminated feedstuffs or air-borne transmission, were the sources of infection.

Farm C

Farm C was a cow-calf operation of sixteen Japanese Black cattle (ten cows and six calves). Serum samples taken from two animals on 29 March were found to be positive in the LPB-ELISA. On 6 April, sera from ten cattle on the farm had high antibody levels. On 9 April, this farm was assessed as being infected with FMD virus, and all cattle were destroyed on 10 April. It was subsequently determined that a private veterinarian had visited the farm on 20 March to treat animals showing salivation and anorexia.

On 14 April, FMD virus type O was isolated from a probang sample taken from one of the fifteen animals destroyed on 10 April. On 26 April, this virus was found to have an identical gene sequence to that of the segment detected on Farm A.

Farm C is located 2 km west of Farm A. The private veterinarian who visited Farm C on 20 March had visited 75 farms between 20 and 23 March. None of these farms was found to be infected with FMD virus following clinical and serological surveillance. No evidence has been found to suggest that the movement of animals, the feeding of contaminated feedstuffs, or air-borne transmission were sources of infection. Similarly, there is no evidence to indicate that people or vehicles were causes of virus transmission.

Farm D

Farm D was a feedlot in which 705 cattle were kept for fattening purposes (Holstein steers, Japanese Black cattle and first generation cross-breeds of Holsteins and Japanese Blacks). The LPB-ELISA performed on serum samples taken on 7 April resulted in the identification of one seropositive animal. Further sampling on 24 April revealed an increase in seropositive animals and the use of LPB-ELISA demonstrated a rise in antibody level in some animals. This farm was subjected to the Herd under Quarantine Programme (as described later in the section entitled 'Serological surveillance') on 29 April; LPB-ELISA followed by probang tests on positive animals were conducted repeatedly. An RT-PCR on probang material collected on 9 May resulted in the identification of two positive animals. Between 11 and 15 May, all 705 animals were destroyed. None of the animals showed clinical signs which suggested the presence of FMD.

Farm D used rice straw from Taipei China and sugar cane tops from Indonesia as feed. No other farms which used rice straw

or sugar cane from the same source were found to be infected with FMD virus. No evidence has been found to suggest that the movement of animals, vehicles or people, or air-borne transmission were sources of infection.

Eradication measures

Eradication measures were taken in accordance with the Domestic Animal Infectious Diseases Control Law (Law No. 166, 1951) (2), and Malignant Exotic Animal Diseases Control Guidelines (MAFF Livestock Industry Bureau Director General Administrative Notification No. 50-Chiku-A-3843, 1975 amended by No. 51-Chiku-A-2760, 1976) (1), and based on the following principles:

– immediate depopulation of infected farms

– movement control of cloven-hoofed animals in the areas around the infected farms

– intensive surveillance of farms in the movement control and surveillance areas and farms epidemiologically related to the infected farms in the rest of the country

– nation-wide clinical surveillance and diagnosis of any animals showing clinical signs suspicious of FMD.

Based on these principles, specific measures were developed by the central FMD emergency management unit, which was formed within the MAFF immediately after the first outbreak. This was composed of members of the Animal Health Division of MAFF and headed by the Director of the same Division.

Organisation of eradication

Eradication measures against FMD were implemented by prefecture veterinary inspectors with the support of voluntary defence organisations and private veterinarians, under the guidance and instructions of the MAFF.

Prefecture veterinary inspectors are veterinarians appointed by prefecture governors to implement measures prescribed by the Domestic Animal Infectious Diseases Control Law.

Emergency management units were established in the Prefectures of Miyazaki, Kagoshima, Kumamoto and Hokkaido, as well as in Miyazaki and Tokachi Livestock Hygiene Service Centres. A Livestock Hygiene Service Centre is a body which is responsible for the diagnosis of animal diseases within a given prefecture. Kagoshima and Kumamoto Prefectures are adjacent to the Miyazaki Prefecture and some of the cities and towns in the former Prefectures were located in the surveillance area. These FMD emergency management units were responsible for the co-ordination of eradication activities taken at all levels.

During the eradication campaign, the voluntary defence associations provided farmers with disinfectants, helped increase the awareness of farmers in regard to clinical signs of FMD, and promoted the early notification of animals which were suspected of being affected by FMD.

Figure 2 illustrates the organisational relationship between MAFF, the prefecture governments and voluntary defence associations.

Depopulation of infected farms

Immediately after diagnosis of FMD, all animals kept on the four infected farms were destroyed. Feed, bedding materials, manure and compost were buried. Housing facilities and equipment used for handling the animals were disinfected.

Stamping-out on Farms A, B and C was completed in a single day, while four days were required to complete stamping-out on Farm D.

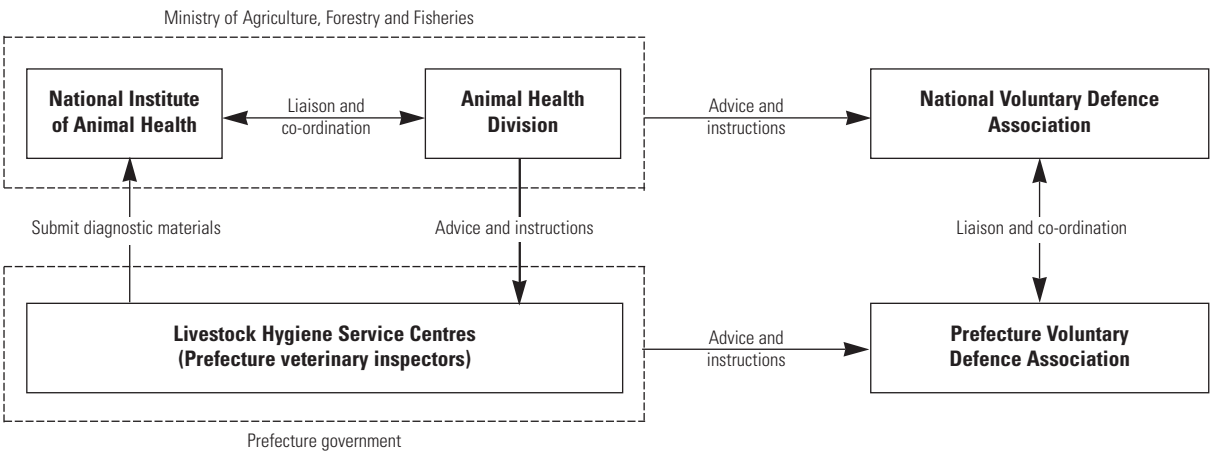


Fig. 2
National and prefecture organisation for control of animal diseases in Japan
Foot and mouth disease emergency management units were established in the Animal Health Division of the Ministry of Agriculture, Forestry and Fisheries, prefecture governments and Livestock Hygiene Service Centres for development of specific eradication measures and co-ordination of eradication actions

A *cordon sanitaire*, with a radius of approximately 50 m around the infected farm, was established immediately after diagnosis of FMD until the depopulation of the infected farm was completed.

Movement control

On 25 March, when the first outbreak was suspected on Farm A, a movement control area of 20 km in radius was established, which included twelve cities, towns and villages. A surveillance area of between 20 and 50 km in radius around Farm A, including thirty-two cities, towns or villages was established on the same day.

In the movement control area, the movement of cloven-hoofed animals, farm equipment and other goods that had the potential to become a mechanical vector of infection, was prohibited. Livestock markets and slaughterhouses were closed and reproduction and artificial insemination practices were prohibited in this area.

On 23 April, the surveillance area was lifted and the movement control area was reduced to a 10-km radius around Farm B and around Farm C. The epidemiological findings at that date provided no evidence of air-borne transmission. On 26 April, the movement control area was further reduced to an area of 10-km radius around Farm C; this was lifted on 2 May.

On 11 May, when the outbreak on Farm D was confirmed, a movement control area of 10 km in radius was established and the movement of cloven-hoofed animals and other goods that had the potential to become a mechanical vector of infection, pasturing of animals, reproduction and artificial insemination were prohibited in this area. There was no slaughterhouse in this area. The movement control was lifted on 9 June.

Road blocks and disinfection points were established on main roads bordering the movement control and surveillance areas. Vehicles transporting feedstuffs and milk were disinfected at these points.

Voluntary Defence Associations, agricultural co-operatives and mutual assistance co-operatives conducted disinfection of farms and milk collection facilities in the movement control and surveillance areas.

Vaccines and vaccination

No vaccination was used for the eradication of FMD. For emergency use, MAFF imported 3.8 million doses of type O vaccines between 3 and 27 April. This was in addition to the 300,000 doses imported annually. All vaccines are stored at the Animal Quarantine Services and other national institutions under the supervision of MAFF.

Information activities

The MAFF issued a total of sixty-one press releases between 25 March 2000 and 27 September 2000; these were available on the MAFF homepage (http://www.maff.go.jp/eindex.html).

On 27 March, the National Voluntary Defence Association circulated 266,000 copies of leaflets with colour photographs of FMD lesions, to stimulate vigilance and awareness of farmers and urging the early notification of animals with clinical signs suggestive of FMD.

Reports were sent to the Office International des Epizooties (OIE) in accordance with the requirements of the OIE *International Animal Health Code* (8). Japan notified the OIE by facsimile on the evening of 25 March (local time in Japan). This report described the nature of diagnosis, the date of initial detection of an animal health incident, the outbreak location, the number of outbreaks, a description of the affected population, the total number of animals in the outbreak, the laboratory in which diagnosis was performed, the diagnostic tests used, the causal agent, the source of agent/origin of infection and the control measures taken during the reporting period. Following this emergency report, Japan sent seven follow-up reports to the OIE between 25 March 2000 and 26 September 2000; these were sent by Dr Matsubara, the Delegate from Japan to the OIE at that time.

Other measures

To protect Japan from further introduction of FMD, imports of straw and forages from Taipei China were subjected to SK-disinfection on arrival in Japan from 27 March 2000. This involved using fumigation with pressured formalin gas (6). The straw and forages imported from other FMD-affected countries/areas were subjected to this disinfection procedure from 30 March 2000. Farmers were also instructed not to use imported straw and forage for feed or bedding.

Importation of meat and meat products of cloven-hoofed animals from the Republic of Korea was suspended on 27 March, soon after FMD was suspected to have been reported in that country, and was prohibited on 10 April, after the completion of legal formalities. On 31 May 2000, the Domestic Animal Infectious Diseases Control Law Enforcement Regulations were amended to prohibit importation of cloven-hoofed animals and their products (excluding heat-processed meat treated at the plants designated by the Minister of Agriculture, Forestry and Fisheries) from the People's Republic of China (3).

Surveillance

Two forms of surveillance were conducted, as described below.

The LPB-ELISA was used to screen the sample animals for antibodies against FMD, following the procedures described in the OIE *Manual of Standards for Diagnostic Tests and Vaccines* (OIE *Manual*) (7) using kits provided by the World Reference Laboratory for FMD in Pirbright, United Kingdom. The virus neutralisation test (VNT) was also used for definitive diagnosis, following the procedures described in the OIE *Manual* (7).

For virus diagnosis, the sandwich ELISA (S-ELISA) and virus isolation were used to detect antigen or infectious virus, in accordance with the procedures described in the OIE *Manual* (7). The RT-PCR procedure was also used for detecting evidence of FMD virus genome in samples using the method described by Forsyth *et al.* (4).

Clinical surveillance

Clinical diagnosis was performed after an examination of animals for vesicles, erosions and ulcers in the mouth, or on the hoofs or udders, and for excessive salivation, difficulty in mastication, acute lameness and poor general condition. Prefecture veterinary inspectors were later instructed to examine the animals very carefully, bearing in mind that the overt clinical signs associated with infection with the type O strain in Japan may not be easy to detect. Private veterinarians and farmers were warned to inform the Livestock Hygiene Service Centres immediately if any animal presenting such clinical signs was found.

Between 25 March and 9 June, a total of 93,225 visits were made by prefecture veterinary inspectors for clinical surveillance purposes (Table III). In the same period, 143,306 farm visits were made by private veterinarians. All the farms in the movement control and surveillance areas and some other farms in other parts of the country were incorporated in this clinical surveillance programme. As a result, thirty-one cases were reported to the MAFF. Diagnostic samples were submitted to the NIAH. No case was diagnosed as FMD following LPB-ELISA, S-ELISA and RT-PCR, or after attempting to isolate virus in tissue culture from lesion swabs and probang samples.

Serological surveillance

After the first outbreak in Miyazaki Prefecture, 47,177 serum samples from 27,890 farms were collected by prefecture veterinary inspectors in accordance with the sampling regime described in Table IV. The number of farms and animals subjected to the serological surveillance is detailed in Table V. The farms involved were as follows:

– all cattle farms in the movement control and surveillance areas

– farms that had introduced animals from farms in the movement control and surveillance areas in the preceding three months

– farms on which imported forages were fed to animals.

Figure 3 outlines the measures taken. Sera were sent to the NIAH and were screened for antibody using the LPB-ELISA, with a cut-off value of 1:90. All sera with antibody levels exceeding 1:90 were titrated in the LPB-ELISA.

At least one animal with an antibody level in excess of 1:45 was found on 405 farms. These farms were re-tested using at least ten sera collected from each of the farms. Farms were considered to be free from infection if all the sampled animals reacted negatively or if only one animal reacted positively with

Table IV
Sampling regime used for epidemiological surveillance in Miyazaki and other Prefectures

Areas	Farms sampled	Animals sampled No. in herd	Animals sampled No. sampled
1-km radius area around the infected farm	All farms	10 animals from each herd	
20-km movement control area and 50-km surveillance area	All farms	1-10	1
		11-30	2
		31-100	3
		Over 100	5

Table V
Number of farms and animals subjected to serological surveillance after the first outbreak in Miyazaki

Area/farm	Number of farms	Number of animals
Movement control area	3,619	8,258
Surveillance area	12,184	17,873
Areas not in movement control and surveillance areas in Miyazaki, Kagoshima and Kumamoto Prefectures	8,054	8,712
Farms that introduced cattle from movement control and surveillance areas	1,535	4,325
Farms feeding imported forages	1,169	4,235
Others	1,329	3,774
Total	**27,870**	**47,207**

Table III
Number of farm visits made by prefecture veterinary inspectors and private veterinarians (26 March-9 June 2000)

Visits	Dairy farms	Beef cattle farms	Pig farms	Sheep and goat farms	Other farms	Total
Prefecture veterinary inspectors	21,707	64,575	5,823	816	304	93,225
Private veterinarians	69,443	68,337	4,535	859	132	143,306
Total	**91,150**	**132,912**	**10,358**	**1,675**	**436**	**236,531**

a high antibody level (but not in excess of 1:181). Farms on which one animal had an antibody level higher than 1:181 after the ELISA, but had an antibody level lower than 1:45 using VNT were considered to be free from infection.

As serological surveillance progressed, it was found that 1% to 2% of the animals sampled always reacted positively (an antibody level of 1:45 or higher), irrespective of the areas, and these criteria were developed to distinguish between false and true positives.

In this way, two farms were considered infected (Farms B and C) and sixty farms were suspected of harbouring infection (Fig. 3). These sixty farms were subjected to the Herd under Quarantine Programme detailed in Figure 4. As a result of this programme, all sixty farms subsequently proved to be free from FMD, with the exception of Farm D.

As part of the Herd under Quarantine Programme, probang material was collected by prefecture veterinary inspectors from seropositive animals using a probang (sputum) cup. By mid-

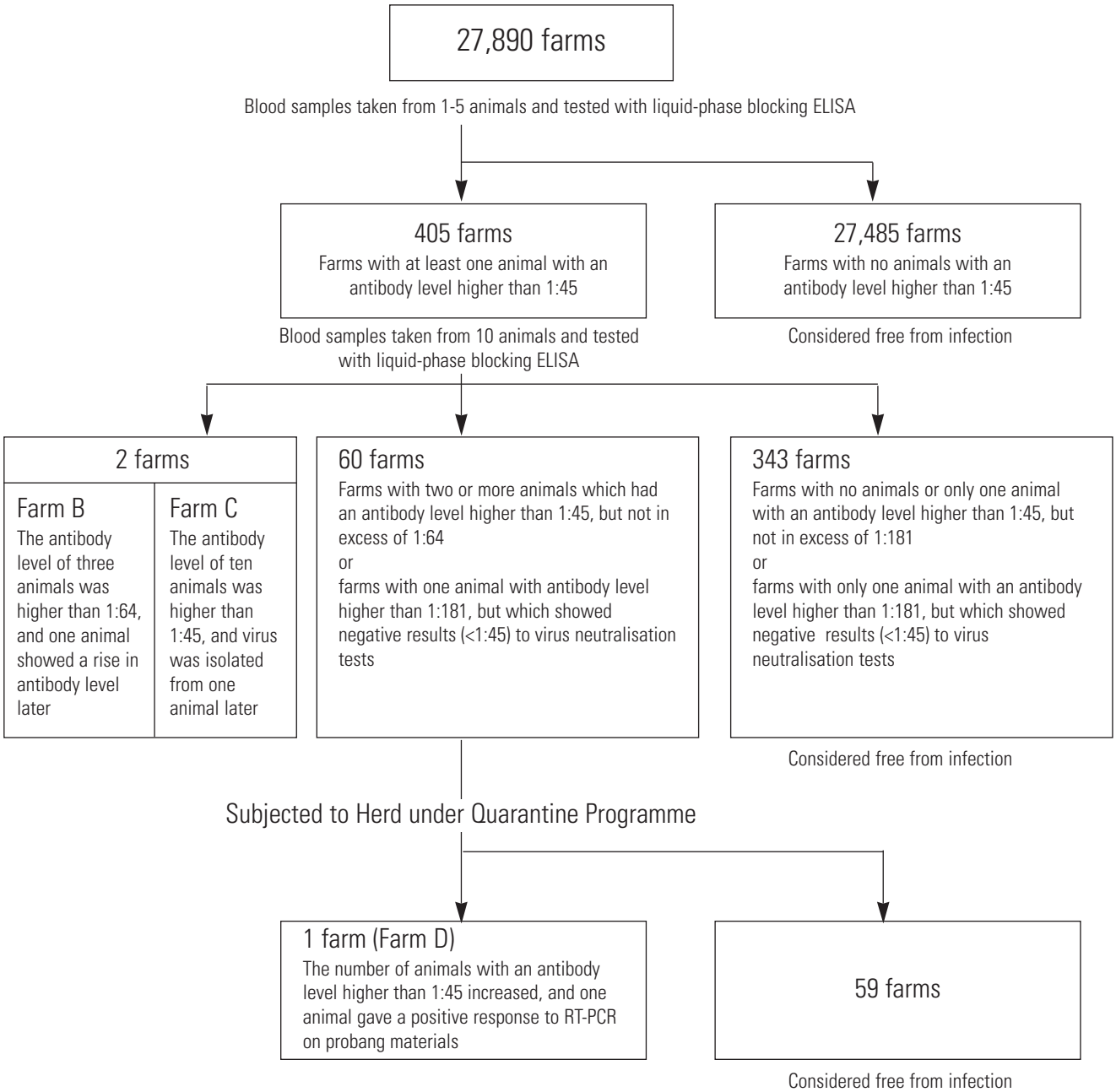


Fig. 3
Chart outlining the measures taken for the serological surveillance conducted after the outbreak in Miyazaki
In assessing the herds, epidemiological information was also considered
ELISA : enzyme-linked immunosorbent assay
RT-PCR : reverse transcriptase-polymerase chain reaction

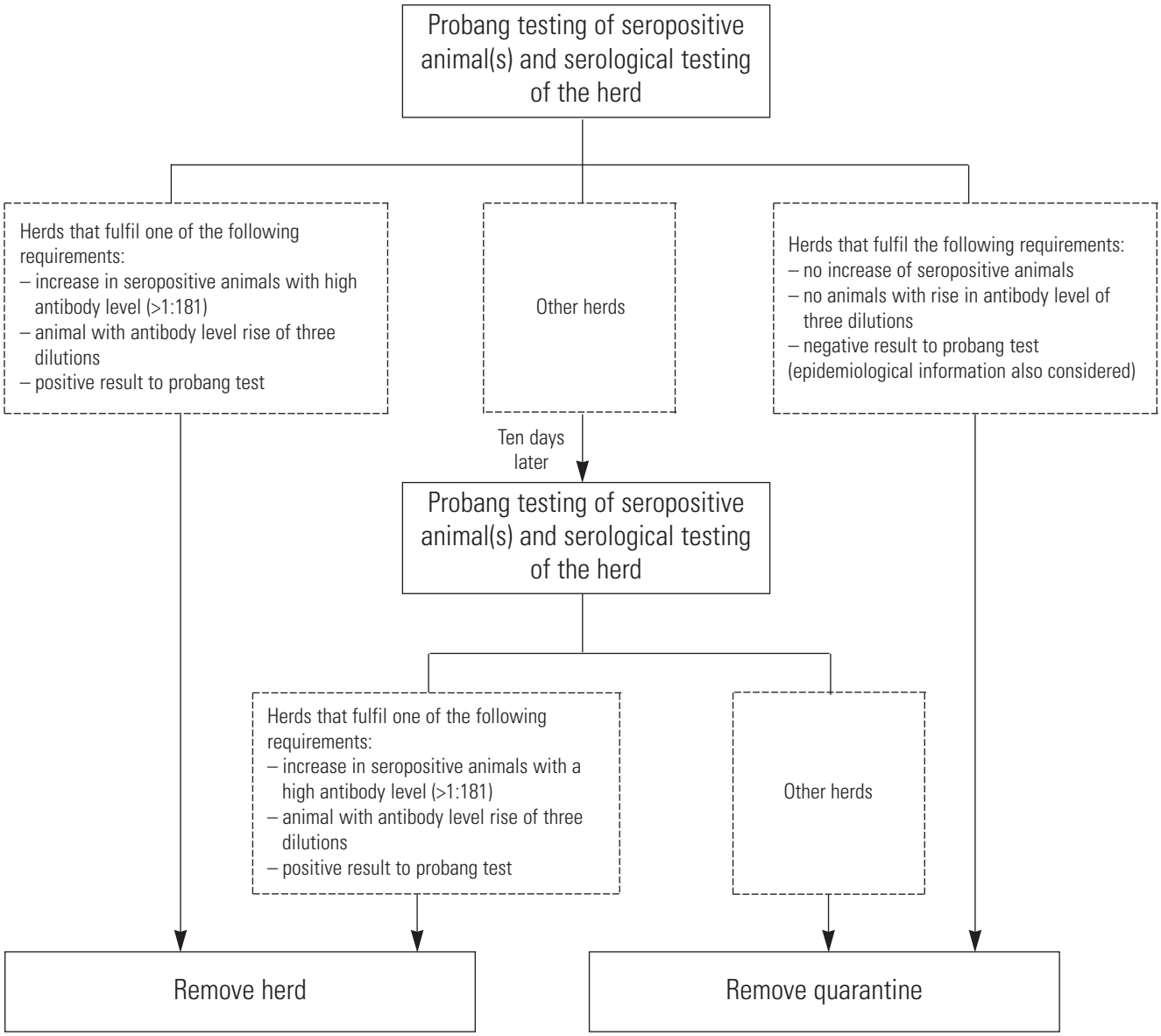


Fig. 4
Chart outlining the measures taken in the Herd under Quarantine Programme
Farms were subjected to this programme if serological surveillance revealed that two or more animals had an antibody level higher than 1:45 but not in excess of 1:64, or if one animal had an antibody level higher than 1:181

April, two weeks after the initial outbreak, MAFF arranged for 500 probang cups to be supplied to Livestock Hygiene Service Centres. The MAFF also supplied video tapes showing the use of probang cups. Probang materials were collected in accordance with the procedures described in the OIE *Manual* (7) and sent to the NIAH for virus isolation, antigen detection ELISA and RT-PCR.

Between the date of the outbreak on Farm D in Hokkaido Prefecture and 20 May, all 139 farms in the movement control area, and 85 farms that shipped animals to Farm D, were subjected to serological testing in accordance with the sampling regime described in Table VI. All of these 224 farms proved to be free of FMD (Table VII).

Sources of infection

Virus strain involved in the outbreaks

The sequence data of the VP1 gene of the FMD virus detected from an animal on Farm A were sent to the World Reference Laboratory in Pirbright, and on 4 April confirmation was received indicating that the virus was a close match to those from type O viruses isolated in countries in Asia. This represented less than a 3% nucleotide difference (nucleotides 469-639 of VP1) between the virus isolated in Japan

Table VI
Sampling regime used for epidemiological surveillance for Hokkaido Prefecture

Areas	Farms sampled	Animals sampled No. in herd	No. sampled
3-km radius area around the infected farm	All pig and cattle farms	**Pig herds**	
		14 or less	All
		over 14	14
10-km movement control area	All cattle farms	**Cattle herds**	
		15 or less	All
		16-20	15
		21-40	20
		41-100	25
		over 100	30

The number of animals sampled was set to provide 95% probability of detecting evidence of foot and mouth disease if present at a prevalence of 10% in cattle herds and 20% in pig herds

Table VII
Number of farms and animals subjected to the serological surveillance after the outbreak in Hokkaido

Farm	Number of farms	Number of animals
Farms in the movement control area	139	3,506
Farms that shipped animals to Farm D	85	2,211
Total	**224**	**5,717**

(O/JPN/2000) and the viruses isolated in the Middle East and other countries in Asia between 1998 and 2000 (Fig. 5) which were found to be of the Pan Asian topotype.

The virus isolated from the outbreak on Farm C was found to have the same gene sequence as that of the virus segment isolated from the outbreak on Farm A. In Figure 5, the PCR product identified from Farm A is shown as O/JPN/A/2000 and the virus identified from Farm C is shown as O/JPN/B/2000, as two different sequences. It was subsequently found that there was a misreading of the Taq polymerase and that O/JPN/B/2000 was the correct sequence. On 13 May, the VP1 gene sequence data of the segment detected by RT-PCR from probang material from Farm D were found to be identical to those of the virus isolated from Farm A. These facts suggested that the FMD virus in Japan originated in East Asia.

Epidemiological studies

The disease began on three farms located in a limited area extending over 9 km in two adjacent municipalities along the Oyodo River (including tributaries) and on one farm in Hokkaido. On the basis of the estimated exposure date, use of forage from countries in East Asia and gene sequence similarity, Farm A is considered to be the primary outbreak, from which location the disease spread locally to Farms B and C.

The following facts support the hypothesis that wheat straw which originated from the People's Republic of China, used on Farm A, carried the FMD virus to Japan:

– Farm A used wheat straw imported from the People's Republic of China as a feedstuff

– the wheat straw from the People's Republic of China was imported in winter, when FMD virus reportedly survives for longer periods

– some of the wheat straw from the People's Republic of China was found to be stained with faecal-like substances (this was confirmed later in the autumn of 2000 [5])

– importation of wheat straw from the People's Republic of China has increased significantly since 1997

– the Prefectures of Miyazaki and Hokkaido store and consume much greater amounts of imported wheat straw than other prefectures (Tables VIII and IX).

Other possible sources were considered, but no evidence was found to suggest any other means of introduction of FMD into Japan.

The VP1 gene sequence of the virus segment isolated from the outbreak in Hokkaido was identical to the gene sequences isolated from Farms A and C. This could mean that the virus in Hokkaido was transmitted from Miyazaki or that the viruses had the same origin in East Asia. However, no epidemiological factors have enabled a link to be established between Farm D and Farms A, B or C. Other possible explanations will have to be considered.

Economic losses

Direct economic losses

The owners of the four farms A, B, C and D were compensated for the animals which were destroyed and for part of the costs of destruction and burial (Table X).

Indirect economic losses

In addition to the compensation paid to the farmers, budgets were allocated for FMD eradication and related measures as detailed in Table XI. Substantial expenditure was required by the prefecture governments for FMD eradication and other related measures, which is not included in Table XI. Most of these budgets can be considered to be indirect economic losses.

Japan exports beef and other livestock products, principally to countries in South-East Asia. These exports were suspended when the first outbreak was reported on 25 March 2000. On 31 March 2001, Australia, Brazil, the People's Republic of China, Hong Kong, the Republic of Korea, the Philippines, Singapore and Thailand lifted the import ban, while the markets of the United States of America and Taipei China remain closed to the import of cloven-hoofed animals and the products of these animals from Japan. The economic losses caused by this export suspension are currently being calculated.

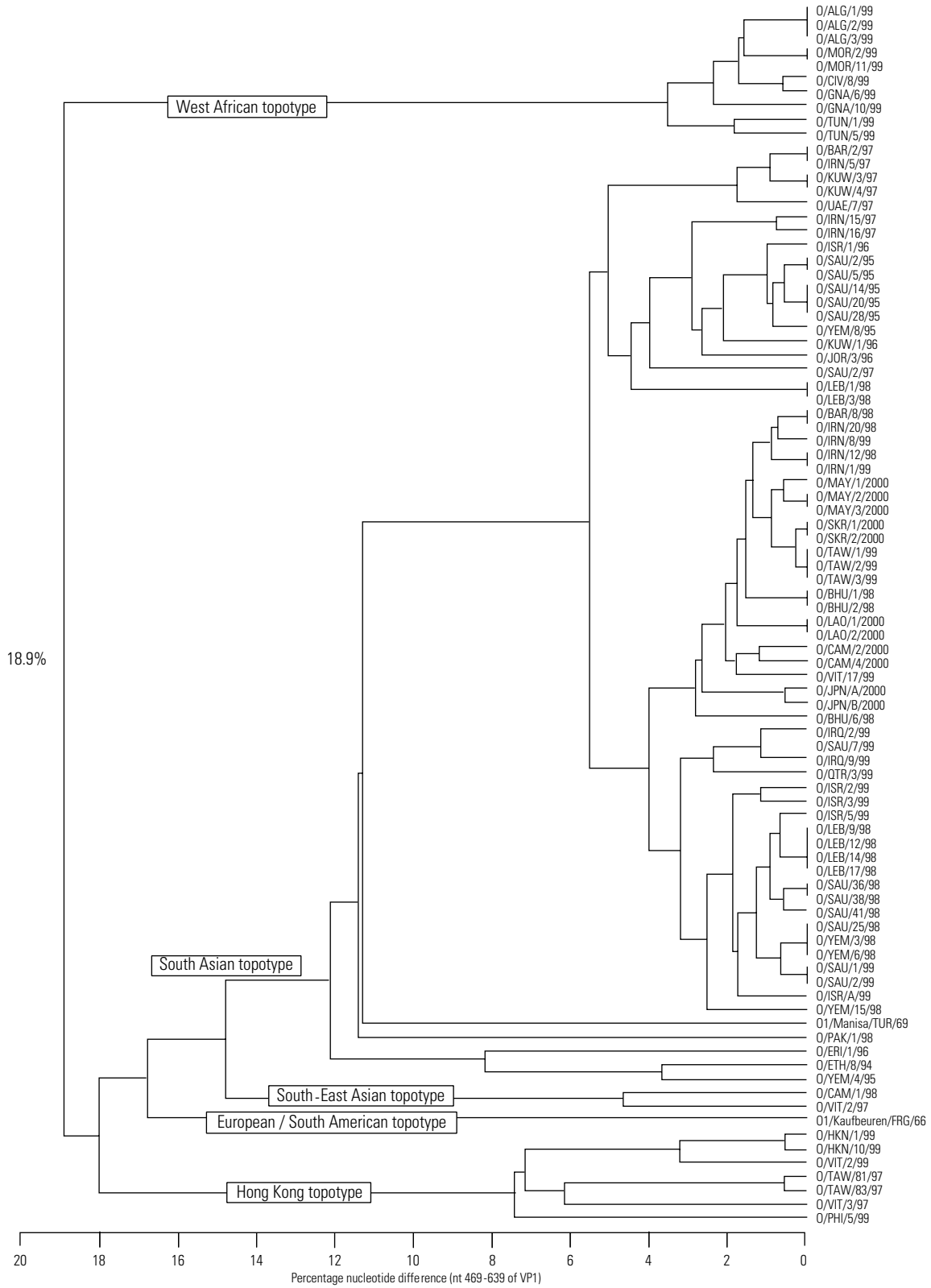


Fig. 5

Comparison of the partial VP1 sequence of viruses from Japan with other foot and mouth disease type O viruses

Although O/JPN/A/2000 and O/JPN/B/2000 were thought to be different strains when this dendrogram was created, it was subsequently discovered that there was a misreading of Taq polymerase and that the viruses are identical.

Table VIII
Amount of stored wheat straw of Chinese origin by prefecture at 1 June 2000

Prefectures	Amount (tons)	Proportion (%)
Hokkaido	156	19.8
Miyazaki	324	41.2
Kagoshima	297	37.7
44 other prefectures	110	1.3
Total	**787**	**100.0**

Source: Animal Health Division, Livestock Industry Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan

Table IX
Amount of wheat straw originating from the People's Republic of China, consumed in each prefecture in 1999

Prefectures	Amount (tons)
Hokkaido	3,391.4
Miyazaki	7,043.6
Kagoshima	6,456.6
44 other prefectures	217.4
Total	**17,109.0**

Source: Plant Protection Service, Ministry of Agriculture, Forestry and Fisheries, Japan

Table X
Compensation paid to the farmers for destruction and burial of animals during the foot and mouth disease eradication campaign in Japan, in 2000

Farm	Compensation	Amount (yen)
A (Miyazaki)	Destroyed animals	3,010,000
	Destruction and burial	305,000
B (Miyazaki)	Destroyed animals	3,614,000
	Destruction and burial	301,000
C (Miyazaki)	Destroyed animals	6,345,000
	Destruction and burial	342,000
D (Hokkaido)	Destroyed animals	292,416,000
	Destruction and burial	26,119,000
Total		**332,452,000**

Table XI
Budgets allocated for foot and mouth disease control measures other than compensation paid to the farmers during the eradication campaign in 2000

Purpose	Use of budgets	Amount allocated (million yen)
Laboratory tests and emergency preparedness	Laboratory supplies and investigations	71
	Voluntary control measures by farmers (Miyazaki)	479
	Importation of vaccine for emergency use	499
Promotion of consumption of animal products	Promotion of safety of animal products (Miyazaki)	315
	Promotion of safety of animal products (Hokkaido)	685
Alleviation of damages on farm management	Interest subsidy for operating capital of farmers (Miyazaki)	211
	Interest subsidy for operating capital of farmers (Hokkaido)	84
	Financial support for animal welfare slaughter	899
	Financial support for farm facilities (Hokkaido)	84
	Financial support for heifers which calved during movement control (Hokkaido)	2
	Price stabilisation of beef calves and heifers	3,771
Promotion of domestic straw production	Domestic straw production increase project	1,800

Discussion and conclusions

The outbreak of FMD in Japan in the spring of 2000 was the first reoccurrence of the disease for ninety-two years. The outbreak was successfully eradicated in a relatively short period of time. Control measures consisted of depopulation of the infected herds, movement control of animals and animal products within the area surrounding the infected premises and intensive clinical and serological surveillance in the movement control and other areas. Over 60,000 animals from 27,000 farms were subjected to serological surveillance for a period of two months. To the knowledge of the authors, this is the first time that serological surveillance on such a scale has been performed in such a short time. The authors acknowledge that some of the sampling regimes used in the serological surveillance did not have a statistical basis, but this was complemented by clinical surveillance, including 237,000 farm visits by prefecture veterinary inspectors or private veterinarians. Serological surveillance demonstrated the absence of infection in the respective areas. Sampling of all the farms in the movement control and surveillance areas also had the effect of providing every farmer in these areas some assurance of negative test results. Wheat straw from the People's Republic of China which was used as feed in the primary outbreak was the most probable source of infection for the outbreaks in the Miyazaki Prefecture. In regard to the source of infection for the outbreak in Hokkaido, no evidence has been found to explain the means of entry of the virus into this Prefecture, either from Miyazaki or from another country in Asia.

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Éradication de la fièvre aphteuse au Japon

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Résumé
Une épidémie de fièvre aphteuse a été signalée au Japon, pour la première fois depuis 92 ans, au printemps 2000. Entre le 25 mars et le 11 mai, quatre élevages ont été infectés. Cependant, la maladie a été éradiquée sans qu'il ait été nécessaire de recourir à la vaccination, grâce à une campagne d'abattage, au contrôle des déplacements des artiodactyles dans les zones entourant les exploitations infectées, et à une surveillance clinique et sérologique intensive. À la fin du mois de septembre 2000, le Japon avait recouvré son statut de pays indemne de fièvre aphteuse. Les auteurs décrivent la nature des foyers, les mesures d'éradication mises en œuvre, ainsi que les méthodes de surveillance clinique et sérologique utilisées. Ils examinent également les sources d'infection possibles et dressent le bilan des pertes économiques, directes et indirectes.

Mots-clés
Éradication – Fièvre aphteuse – Japon – Surveillance clinique – Surveillance sérologique – Topotype panasiatique.

Erradicación de la fiebre aftosa en Japón

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Resumen
En primavera de 2000 se declaró en Japón el primer brote de fiebre aftosa después de noventa y dos años. Entre el 25 de marzo y el 11 de mayo, cuatro explotaciones resultaron infectadas. No obstante, gracias a una campaña de sacrificios sanitarios, control de los movimientos de animales biongulados en las cercanías de las instalaciones infectadas e intensa vigilancia clínica y serológica, pudo erradicarse la enfermedad sin necesidad de recurrir a la vacunación. A finales de septiembre de 2000 Japón recobró el estatus de país libre de fiebre aftosa. Los autores describen la naturaleza de los brotes, las medidas de erradicación aplicadas y los métodos de vigilancia clínica y serológica que se utilizaron. También examinan posibles fuentes de infección, y presentan por último las pérdidas económicas, directas o indirectas, que acarreó la enfermedad.

Palabras clave
Erradicación – Fiebre aftosa – Japón – Topotipo panasiático – Vigilancia clínica – Vigilancia serológica.

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