

The Epidemic of Foot-and-Mouth Disease in Saskatchewan, Canada, 1951-1952

R.F. Sellers and S.M. Daggupaty

ABSTRACT

The epidemic of foot-and-mouth disease in Saskatchewan in 1951 and 1952 was studied in order to determine origins of outbreaks and methods of spread. The epidemic was initially considered to be vesicular stomatitis and foot-and-mouth disease was not recognized until February 1952, three months after the initial infection. The reports prepared at that time were reviewed in order to obtain details of the numbers of animals infected and the source and date of infection for the outbreaks. Methods of spread were rated according to their likelihood. The introduction of infection by an immigrant through his clothes as well as by sausage was possible. The sequence of events from the first outbreak to the spread from a feedlot/packing plant and from a dairy farm, which failed to report the disease, were clarified. Methods of spread included movement of animals, animal products and people and the airborne route. Milk delivery and artificial insemination did not result in spread of infection. The quarantine of affected farms reduced spread by animals and deterred visits by people. The original diagnosis of vesicular stomatitis was due to misinterpretation of a lesion in an inoculated horse. Laboratory tests established the presence of foot-and-mouth disease. The limited extent of the epidemic, despite the delay in diagnosis, is attributed to (i) the low density of cattle, (ii) few infected pigs and hence less airborne virus and (iii) absence of

waste food feeding and milk collection in addition to the limited quarantine imposed.

RÉSUMÉ

On s'est penché sur l'épidémie de fièvre aphteuse qui eut lieu en Saskatchewan en 1951 et 1952 pour en connaître l'origine et les moyens de transmission. Initialement, on avait confondu cette épidémie avec la stomatite vésiculaire et ce n'est qu'en février 1952, soit trois mois après le début de l'infection, qu'on s'est rendu compte qu'il s'agissait bien de fièvre aphteuse. Les rapports rédigés à cette époque ont été examinés pour mieux connaître les détails quant au nombre d'animaux infectés, l'origine et la date du début de l'infection. Les modes de transmission de la maladie furent classifiées par ordre de vraisemblance. L'introduction de cette infection par un immigrant soit par ses vêtements ou par un saucisson demeurent possible. La série d'événements, à partir du premier cas jusqu'à la contamination d'un parquet d'engraissement commercial (jumelé à un abattoir) et d'une ferme laitière, qui avaient négligé de rapporter la maladie ont été clarifiés. Les modes de transmission de la maladie ont tenu compte du va et vient des animaux, des produits d'origine animale, des gens et de la possibilité de transmission par voie aérienne. Le mode de transport du lait et l'insemination artificielle n'ont pas contribué à propager l'infection. La mise en quarantaine des

fermes positives a toutefois contribué à diminuer la propagation de la maladie chez les animaux et a réduit les mouvements de visiteurs. Le diagnostic initial de stomatite vésiculaire était dû à une mauvaise interprétation d'un test de dépistage chez un cheval malade. Les tests de laboratoire ont effectivement confirmé la présence de fièvre aphteuse. L'étendue limitée de l'infection, malgré le retard important à poser le diagnostic, serait attribuable 1) à la faible densité animale dans cette région, 2) au fait que peu de porcs aient été infectés et par conséquent que moins de virus aérien ait été retrouvé en circulation et 3) à la non-utilisation d'aliments recyclés et à l'absence de collecte de lait à domicile dans cette région, en plus de la quarantaine qui fut imposée. (Traduit par Dr André Cécyre).

INTRODUCTION

Canada has experienced only one outbreak of foot-and-mouth disease (FMD) in this century. This occurred from November 1951 until April 1952. Forty-two premises were involved, of which 29 were infected and 13 were in contact. The livestock destroyed included 1,313 cattle, 294 swine, 97 sheep, 1 goat, 2,372 fowl and 15,828 eggs. The eradication costs were one million dollars (Canadian), but owing to the ban on exports the value of livestock fell by 651 million dollars and 70 million dollars were spent in support prices. Thus the total loss was 722 million dollars plus one year's loss

Agriculture Canada, Health of Animals Laboratory Branch, Halldon House, 2255 Carling Avenue, Ottawa, Ontario K1A 0Y9 (Sellers) and Environment Canada, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 (Daggupaty). Present address of Dr. R.F. Sellers: 4 Pewley Way, Guildford, Surrey, England GU1 3PY.

Reprint requests to The Library, Animal Diseases Research Institute, P.O. Box 11300, Station H, Nepean, Ontario K2H 8P9.

Submitted January 2, 1990.

TABLE I. Chronology of the FMD epidemic in Saskatchewan

Date	Incident
1951	
26 Nov	Disease noticed in cattle on farm 1
3 Dec	Quarantine imposed on farm 1
8 Dec	Field test in horse interpreted as vesicular stomatitis
12-29 Dec	Disease found on farms 2, 3 and 5 Disease found in feedlot 4
1952	
23 Jan-11 Feb	Disease found on farms 6-16 Foot-and-mouth disease suspected after seeing lesions in pigs on farm 8
14 Feb	Vesicular material sent for laboratory examination
18 Feb	General quarantine imposed
12-19 Feb	Disease found in feedlot 4, farms 17-19 and at Truax
25 Feb	Laboratory confirmation of foot-and-mouth disease
29 Feb	Disease found on farm 24
7 March	Disease found on farm 23
19 April	Disease found at Ormiston
29 April	Disease found at Weyburn
19 August	Canada declared free of foot-and-mouth disease

of livestock and livestock products trade (1-4).

The results of investigations into the origin and spread and methods of control of the disease were published at the time or shortly afterwards (1-3). From 1953 onwards considerable research carried out in various parts of the world has led to a fuller understanding of the epidemiology of foot-and-mouth disease. It was therefore decided to re-examine the origin and spread of the epidemic in Saskatchewan in the light of the new epidemiological findings.

HISTORY OF THE EPIDEMIC

In late November and early December 1951 vesicular stomatitis (VS) was diagnosed in Saskatchewan at a farm 55 km ENE of Regina (Fig. 1a). The diagnosis was based on clinical observation of the animals and administration to horses of vesicular material. During December a further four infected premises were found including a feedlot at a meat packing centre in Regina. No further outbreaks were reported until 23 January 1952; between then and 11 February, 11 outbreaks of stomatitis were diagnosed on clinical examination, all

in Regina or nearby. Disease was reported as mild on the first three farms affected in December and the cattle recovered quickly. However on 11 February 1952 pigs on an affected farm were observed to have separation of the hoof and the possibility of the disease being foot-and-mouth disease was suspected. On 14 February 1952 vesicular material was collected and forwarded to the Animal Diseases Research Institute, Hull, Quebec for laboratory examination on Grosse Ile. On 18 February 1952 a general quarantine of the area was imposed which superseded the quarantines of infected premises already in force, when vesicular stomatitis was diagnosed. On 25 February the presence of type A FMD virus in the vesicular material was reported by the laboratory. Steps were immediately taken to slaughter all animals on infected premises and premises in-contact. Between 12 and 19 February disease reappeared on the feedlot and was reported on three farms near Regina and two at Truax (65 km SWS of Regina). After 25 February a further two premises with affected animals were found near Regina and a third farm was found to have had the disease during December and January. In April 1952 FMD was confirmed at Ormiston (85 km SW of Regina) and at Weyburn (100 km SE of Regina). No further outbreaks of disease were found and by 19 August Canada was declared free of foot-and-mouth disease. The chronology of the epidemic is given in Table I.

MATERIALS AND METHODS

RECORDS

The following were consulted for information on the outbreaks:

1. Minutes of Proceedings and Evidence Respecting Foot and Mouth Disease, Nos. 1-8 April-June 1952. House of Commons Standing Committee on Agriculture and Colonization (5).
2. Unpublished report of the investigation of 2/Constable W. Sherman, R.C.M.P., Regina under the Animal Contagious Diseases Act dated 20 March 1952 (6).
3. Publications of Childs (1,2) and Wells (3,4).

TABLE II. Numbers of animals on farms and numbers affected with foot-and-mouth disease

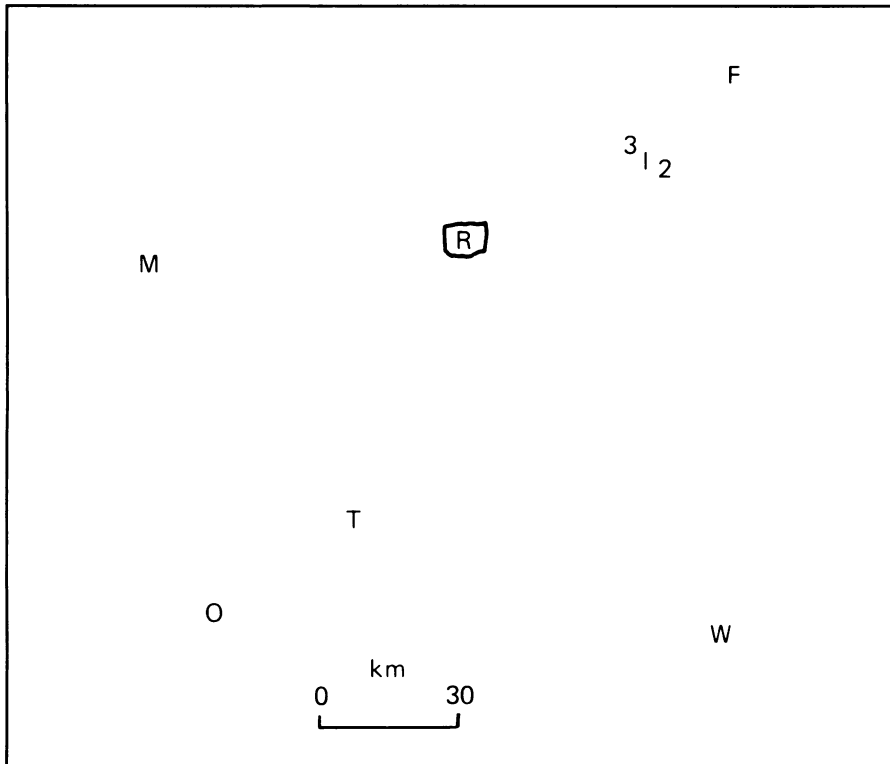
Farm	Numbers on farm			Numbers affected
	Cattle	Sheep	Pigs	
1	38	0	3	3 P ^a 31 C ^a
2	52	0	4	Several C 3 P
3	32	0	1	6 calves
4a ^b	207	145	56	> 100 C
4b ^b	74	68	0	> 3 C
5	3	0	0	2 C 1 calf
6	10	0	0	10 C
7	40	0	0	40 C
8	19	0	2	> 14 C 1 P
9	36	0	0	36 C
10	12	0	1	> 10 C 1 P
11	60	0	0	> 45 C
12	6	0	0	5 C 1 calf
13	40	0	0	> 35 C
14	23	0	0	8C
15	4	0	0	1C
16	34	0	10	> 12 C
17	8	0	19	8 C 4 P
18	5	0	0	> 2 C
19	36	0	0	> 30 C
20	180	0	0	> 100 C
21	76	0	3	> 10 C
22	65	0	2	> 19 C
23	84	0	0	> 4 C
24	9	1G ^c	0	2 calves
25	6	0	5	None

^aP = pigs, C = cattle
^ba = during December and January,
^b = during February
^cG = goat
 The numbers on farms are those on the farm at slaughter
 For 4a and 5 the numbers are those at the end of December

4. (a) City plans of Regina prepared in the 1940s and 1950s.
- (b) Fire Insurance Plan, 1957, showing the location of the feedlot and packing plants in Regina.
- (c) Rural Municipality Maps of South Qu'Appelle, Sherwood and Lumsden showing concessions.
- (d) Maps of the National Topographic System, Surveys and Mapping Branch, Department of Energy, Mines and Resources.
5. Day/hour matrix of hourly weather data from 4016560 Regina A (Regina Airport) 1 November 1951-31 March 1952.
6. Verbal recollections and guided tour of the farms in Regina and Wascana Creek from Mr. H. Beatty, owner of one of the infected farms.

BACKGROUND DATA

The incubation period or disease interval between farms was taken to be from 3 to 16 days.



The likelihood of suggested sources of infection for the different farms was rated as probable, possible or improbable based on criteria developed in the analysis of the Hampshire, U.K. epidemic of FMD (7). Movement of animals from an infected farm, feeding of infected meat or milk, handling of animals by persons previously in contact with infected animals were regarded as probable. Visits by persons not previously coming into contact with infected animals, insufficient information on the visit or a long disease interval were possible; too short or an excessively long disease interval were improbable. The possibility of airborne spread is assessed in the accompanying paper (8).

RESULTS

COMPILATION OF DATA FOR EACH FARM

In Table II the numbers of each species and the animals affected are listed for each farm and numbered 1-25 according to the order in which disease was reported. The data were derived from records in reference 6 and the text in reference 5. The outbreaks at Ormiston and Weyburn were not included owing to insufficient data. The location of the outbreaks is shown in Fig. 1a and 1b.

Table III gives the date on which disease was first reported to veterinarians, the dates of quarantine and the date of slaughter. For farms 6-20 and 23-25 quarantine remained in force until the control measures were complete. The date of appearance of disease and the last date of disease were determined from the description of the lesions on each farm. There was insufficient information for farms 21 and 22.

Table IV lists the suggested sources of virus for each farm and the date of infection as given in references 1-6. The difference between the date of infection and the date of appearance of disease as shown in Table III represents the disease interval or incubation period. The likelihood of the suggested source of infection is according to the criteria given previously.

There is some conflict of information from references 5 and 6. Accord-

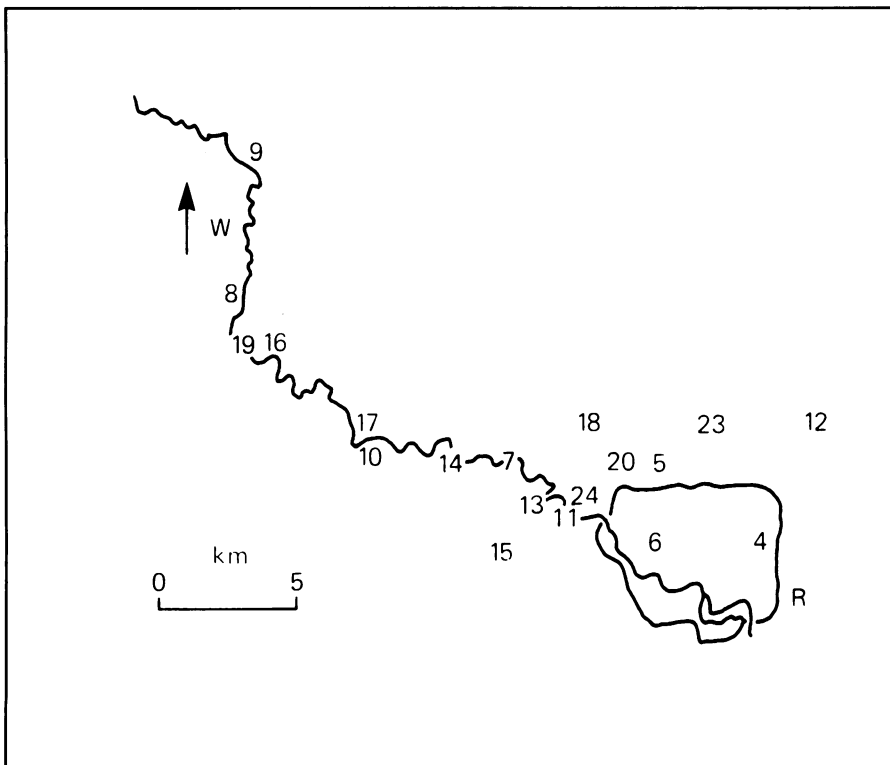


Fig. 1. Location maps of FMD outbreaks in Saskatchewan, 1951-1952.
 (a) General map of the area showing the location of farms outside Regina and surroundings. 1, 2, 3 = farms 1, 2 and 3; T = Truax, farms 21 and 22; O = farms in Ormiston; W = farms in Weyburn. R = Regina, M = Moose Jaw, F = Fort Qu'Appelle.
 (b) Map showing the location of farms in Regina and surroundings. 4-24 = farms 4-24; R = Regina showing city boundary; W = Wascana Creek; → = direction of flow of water in creek.

TABLE III. Dates of disease for each farm

Farm	Disease reported	Quarantine	Slaughter	Duration of lesions
1	29 Nov	3-8 Dec	14 March	P ^a 19-25 Nov C ^a 26 Nov-8 Dec
2	12 Dec	12-22 Dec	6 March	C 10-22 Dec P 16-22 Dec
3	13 Dec	14-22 Dec	6 March	10-22 Dec
4 ^a _b	19 Dec	28 Dec-17 Jan	—	14 Dec-17 Jan
4 ^b _b	12 Feb	18 Feb	29 Feb	12-29 Feb
5	28 Dec	29 Dec-21 Jan	29 Feb	26 Dec-10 Jan
6	15 Jan	31 Jan	3 March	10-31 Jan
7	23 Jan	23 Jan	2 March	18 Jan-3 Feb
8	24 Jan	25 Jan	2 March	C 21 Jan-1 Feb P 29 Jan-11 Feb
9	28 Jan	28 Jan	2 March	28 Jan-10 Feb
10	28 Jan	29 Jan	4 March	C 24 Jan-10 Feb P 29 Jan-10 Feb
11	30 Jan	31 Jan	29 Feb	27 Jan-10 Feb
12	31 Jan	31 Jan	29 Feb	29 Jan-4 Feb
13	1 Feb	1 Feb	29 Feb	29 Jan-10 Feb
14	1 Feb	2 Feb	3 March	30 Jan-7 Feb
15	4 Feb	4 Feb	2 March	4-9 Feb
16	11 Feb	11 Feb	2 March	22 Jan-12 Feb
17	14 Feb	14 Feb	3 March	10-25 Feb
18	14 Feb	14 Feb	3 March	12-18 Feb
19	18 Feb	18 Feb	2 March	29 Jan-20 Feb
20	—	19 Feb	3 March	15 Dec-15 Feb
23	7 March	7 March	11 March	2-11 March
24	29 Feb	29 Feb	2 March	14-29 Feb

^aP = pigs, C = cattle

^ba = during December and January, b = during February

ing to reference 5 farm 25 had infected animals, but no infection occurred in the bulls at site 6. The reports in reference 6 stated that infection occurred in the bulls at site 6, but no disease was present on farm 25.

STATISTICS

The statistics involving the farms and cattle population in the three municipalities, South Qu'Appelle, Sherwood and Lumsden, are given in Table V.

SOURCE AND SPREAD OF DISEASE

Information on the evidence in the reports and the sequence of events of those farms considered important in the spread of disease are given in Tables VI-IX. Comments on the information are made in the text.

Source for farm 1

The origin of the outbreak on farm 1 was attributed to introduction of virus by an immigrant from an infected farm in West Germany. Foot-and-mouth disease, type A, was at that time present in West Germany and in many countries in Europe. Type A was also present in Mexico and in South America, but no record was found of

visitors to Regina and district from these areas (6).

TABLE IV. Sources of infection for each farm as suggested in 1952

Farm	Suggested source	Date of infection	Date of disease	Interval (days)	Likelihood
1	Worker — W. Germany	3-4 Nov	19 Nov	15-16	Poss ^a
2	Owner visit to farm 1	30 Nov	10 Dec	10	Prob ^a
3	Owner visit to farm 1	30 Nov	10 Dec	10	Prob
4 ^a _b	Owner farm 1 + 5 calves	22 Nov	14 Dec	22	Poss
4 ^b _b	Cattle from farm 19	4 Feb	12 Feb	8	Prob
5	Calf from farm 20, owner visit to farm 20	23 Dec	26 Dec	3	Prob
6	Visitors	?	10 Jan		Poss
7	Unknown				
8	Unknown				
9	Unknown				
10	Unknown				
11	Person	?	27 Jan		Poss
12	Vet from farm 7	22-23 Jan	29 Jan	6-7	Prob
13	Person	?	29 Jan		Poss
14	Unknown		30 Jan		
15	Cow at barn 6	30 Jan	4 Feb	5	Prob
16	Visit by vet	22 Jan	22 Jan	0	Impr ^a
17	Cow at barn 6	28 Jan	10 Feb	13	Poss
18	Person	end of Jan	12 Feb	> 12	Poss
19	Owner visits farm 16	13 or 20 Jan	29 Jan	9 or 16	Poss
20	Worker from farm 1	29 Nov	15 Dec	16	Prob
21	Calves from farm 20	8 Feb	16 Feb	8	Prob
22	Owner handling inf. animals	?	2 March		Poss
24	Calves fed milk from farm 13	1 Feb	14 Feb	13	Prob
25	Calves from feedlot 4	22 Jan	3 March	41	Impr

^aProb = probable, Poss = possible, Impr = improbable

^ba = during December and January, b = during February

Table VI records summaries of reports involving farm 1 and farm 20. Changes from the early reports include recall by the owner of farm 1 of sickness being present in the pigs (C), statements of sausage being fed to the pigs on farm 1 (E, F) and reduction in the disease intervals on farms 1 and 20 (C,D,E). The interval between the time the immigrant left the farm in West Germany (15 October 1951) and contact with animals on farm 1 (3 November 1951) was 19 days. The interval between the last opportunity for contact with animals by the immigrant (4 November 1951) and the first observed signs of disease in cattle (26 November 1951) was 22 days — a long incubation period. The recollection by the owner that he noticed pigs were off their feed would reduce the incubation period to 15 days (C) or 10-14 days (D, E).

Spread from farm 1

The sequence of events on farm 1 is given in Table VII. The owners of farms 2 and 3 helped the owner of farm 1 to treat his sick animals and probably carried infection back to their farms. On farm 2 the animals

TABLE V. Cattle population in three districts affected with foot-and-mouth disease

	South Qu'Appelle	Sherwood	Lumsden
Area (km ²)	880	800	880
No. of farms ^a	498	371	352
Cattle population ^b	5169	2489	3990
Cattle km ⁻²	5.87	3.11	4.53
Cattle/farm	10.4	6.7	11.3
Farms with FMD	3	18	1
No. of cattle on affected farms	123	902	36
Estimated no. of cattle with FMD on affected farms	> 50	> 480	36

^a1946 census

^bTB test records

South Qu'Appelle lies to the southwest of Fort Qu'Appelle, Sherwood lies on all sides of the city of Regina but mainly to the west, Lumsden lies to the northwest of Regina and to the north of Sherwood (see Fig. 1 for location of Regina and Fort Qu'Appelle and the outbreaks)

TABLE VI. Reports of the events on farms 1 and 20

Report	Farm 1	Farm 20
A. RCMP (6) 20 March 1952	W. German immigrant worked with cattle 3-4 Nov	Worker from farm 1 wore same clothes to work with cattle 29 Nov; cattle ill 15 Dec
B. Evidence (James) (5) 5 May 1952	Pigs did not develop disease although with cattle	
C. Childs (1) 1952	Immigrant left West Germany 15 Oct. In contact with cattle wearing same clothing. Owner recollected pigs sick seven days before cattle (i.e. 19 Nov)	Disease in cattle ten days after 26 Nov (i.e. 6 Dec)
D. Wells (3) 1953	Immigrant wore clothes previously worn on infected farm in West Germany. First signs in pigs 10-14 days after arrival (i.e. 12-16 Nov)	
E. Childs (2) 1953	Immigrant left infected farm in W. Germany 17 Oct. Pigs sick ten days after immigrant left farm (i.e. 15 Nov). Probable that immigrant had sausage in baggage	Cattle showed inappetence in early Dec
F. Wells (4) 1970	Immigrant had dry sausage in overall pockets. Threw sausage into pig trough	

TABLE VII. Sequence of events on farm 1

Date	Event
15 Oct	Immigrant left infected farm in West Germany
2 Nov	Immigrant arrived at farm 1
3-4 Nov	Immigrant worked with cattle
5 Nov	Immigrant left
22 Nov	Owner took five calves to packing plant at feedlot 4
26 Nov	Cattle sick. Dairy helper left for farm 20
29 Nov	Owner phoned local veterinarian; owners of farms 2 and 3 helped to treat cattle
1 Dec	Visit of veterinarian
2 Dec	Visit of federal veterinarians
3 Dec	Farm placed in quarantine. Two horses given vesicular material on tongue
8 Dec	One horse with small vesicles on tongue and gums. Quarantine lifted
19 Feb	Quarantine reimposed
9 March	38 cattle challenged with FMD virus of type A isolate. 31 protected
14 March	Animals slaughtered

affected were milking cows and on farm 3 calves, with both of which the owners would have come into contact.

The owner of farm 1 delivered calves to the packing plant next to the feedlot (site 4) on 22 November 1951. The owner was a frequent visitor to the packing plant and feedlot. The interval between slaughter of the calves at the packing plant and the date of disease on the feedlot was 22 days. Although the interval is long, disease may have been undetected in the feedlot for several days before 18 December.

A worker left farm 1 on 26 November 1951 on the same day that disease was noticed. He started work on farm 20 on 29 November 1951 and wore the same clothes that he had worn on farm 1. The interval before the disease was seen on farm 20 was 16 days but in a later report the interval was seven days (Table VI C).

Spread from feedlot 4 and farm 20

The feedlot 4 and the dairy farm 20 were the greatest sources of virus in December 1951 and January 1952 (Table III). In the feedlot quarantine was not imposed until 28 December 1951 and the outbreak on farm 20 was not reported at the time of its occurrence. Thus spread through movement of animals, animal products, vehicles and fomites was possible from feedlot 4 until 28 December 1951 and from 18 January until 18 February 1952 and from farm 20 until 18 February. Other methods of spread (people, wild animals and birds, airborne) were possible for the whole period. The sequence of events on feedlot 4 and farm 20 is given in Tables VIII and IX.

Farm 5 became infected through its owner visiting farm 20 and purchasing a calf which died two days later.

Spread of disease from January onwards can be described according to the area in which it occurred: (i) Wascana Creek to the NW of Regina, (ii) the northern outskirts of Regina and (iii) Truax, Ormiston and Weyburn (Fig. 1a and 1b).

(i) *Wascana Creek*. Premises 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 19 and 24 lay on or near Wascana Creek. The sequence in order of appearance of disease on these premises was 6, 7, 8, 16, 10, 9, 11, 13, 19, 14, 15, 17, 24.

TABLE VIII. Sequence of events at feedlot 4

Date	Event
22 Nov	Owner of farm 1 delivered five calves to packing plant and visited feedlot
23 Nov	Calves slaughtered
18 Dec	Cattle noticed to be sick
19 Dec	Veterinarian examined sick cattle
28 Dec	Quarantine imposed. 30 cattle affected
29 Dec	60 cattle affected
30 Dec	100 cattle affected. No signs in sheep and pigs
10 Jan	34 cattle affected
13 Jan	No signs in cattle
17 Jan	Quarantine lifted
26 Jan-12 Feb	Scars seen at slaughter on tongues and mouths of currently purchased cattle
4 Feb	Three cattle from farm 19
12 Feb	Vesicular disease noted in cattle
14 Feb	Vesicular material collected and sent to Hull
18 Feb	General quarantine
29 Feb	Animals slaughtered

Visits by people were possible sources of infection for premises 6, 11, 13 and 19; for 7, 8, 16, 10 and 9 no adequate reason was put forward. Movement of an infected animal and feeding of infected milk were probable causes of infection of 15 and 24. Movement of an animal from site 6 was a possible cause of infection for farm 17 (Table IV). The infection by the airborne route of all these premises except 15 and 24 was investigated and the findings given in the accompanying paper show that such a route of infection could have occurred (8). The pigs at the feedlot 4 could have been a source for airborne infection of premises 6, 7, 8, 16 and 10 and then premises 7, 8, 16 and 10 could be the source for premises 9, 11, 13, 19, 14 and 17 (8).

The possibility was put forward that spread of disease had occurred through contaminated water running downstream (towards the northwest) in Wascana Creek. Although the surface of the water was frozen at that time of year, farmers cut through the ice so that the cattle could drink the water or the farmer could draw water to give to the cattle. The treated effluent from the Regina Sewage Works, which in 1951-1952 were located west of the city upstream of farm 7, was released into the creek. The effluent from the packing plant and feedlot at 4 was mixed with the effluent from the city before release from the sewage works. Any virus present would have been considerably diluted. On farm 8, which lies about 34 km as the water flows downstream on the creek from farm 7, disease

appeared only three days after farm 7. Dilution of virus would have occurred over the 34 km and the amount possibly available would have most likely fallen short of the minimum amount required to infect by ingestion ($> 10^6 ID_{50}$) (9).

(ii) *Northern outskirts of Regina.* Farms 12, 18 and 23 were situated on the northern outskirts of Regina. The cattle on farm 12 were infected by a veterinarian who had previously treated infected cattle on farm 7. Spread to farm 18 was attributed to the driver of a van delivering brewers' mash; however farm 18 was contiguous to farm 20 and infection could have occurred by the airborne route (8). Farm 23 could have been infected through visits of people. There was doubt whether farm 25 became infected; the only contact, through the owner buying a calf from feedlot 4 in January would have given a 41 day incubation period (Tables III and IV).

(iii) *Truax, Ormiston and Weyburn.* Two heifer calves bought from farm 20 were probably responsible for spreading disease to Truax giving rise to two

outbreaks (Tables I, IV and IX). The outbreaks around Ormiston involved two farms and those around Weyburn eight farms (Table I). The outbreaks were attributed to animals coming into contact with discarded meat, which had originally come from the packing plant at site 4.

LESIONS IN AFFECTED ANIMALS

On farms 1, 2 and 3 the lesions were reported as mild and the animals recovered rapidly. The owner of farm 20 stated that the dairy cattle were off their feed, showed signs of disease and recovered in a short time. At the time when cattle on farm 20 were inspected (19 February), no signs of disease were seen and milk production was normal. On feedlot 4 over 100 cattle were affected but the animals were said to have recovered quickly. However on those farms, which reported disease after 23 January, lesions appeared to be more severe and separation of the hoof developed in affected pigs. Classical signs of acute foot-and-mouth disease were described in the outbreak at Weyburn (5). During the epidemic eight newborn and sucking calves were found dead; some of them died just before disease was reported indicating that FMD virus was probably being excreted in the milk. Another three calves (up to one year old) were reported sick and developed lesions.

SOME FACTORS AFFECTING SPREAD

Movement of milk

Only one outbreak could be attributed to infected milk namely the feeding of calves at farm 24 with milk from farm 13. The dairy farms, 1,2,7,10,11,12,13,20 and 23, delivered milk to the dairies, creameries or their own customers.

TABLE IX. Sequence of events on farm 20

Date	Event
29 Nov	Worker from farm 1 started work
15 Dec	Cattle off feed
18 Dec	Cattle sick with stomatitis. Disease not reported
22 Dec	Disease in other parts of farm
23 Dec	Sold calf to farm 5 — disease 26 Dec on farm 5
29 Dec	Sold calves — no disease resulted
11 Jan	Sold calves — no disease resulted
18 Jan	Sold calves to farm 5 — no disease
8 Feb	Sold heifers to farm 22 at Truax. Disease 19 Feb at farms 21 and 22
19 Feb	Cattle examined — all 180 healthy
3 March	Cattle slaughtered

TABLE X. Suggested source and method of infection for each farm

Farm	Source	Method
1	West Germany	Person
2	1	Person
3	1	Person
4a	1	Person, animals
4b	19	Animals
5	20	Animal, person
6	4	Persons, airborne
7	4	Airborne
8	4	Airborne
9	8	Airborne
10	4	Airborne
11	20	Person
	7	Airborne
12	7	Person
13	20	Person
	7	Airborne
14	7	Airborne
15	6	Animal
16	4	Airborne
17	6	Animal
	10	Airborne
18	20	Airborne, person
19	8,16	Airborne
	16	Person
20	1	Person
21, 22	20	Animal
23	?	Person
24	13	Milk
Ormiston	4	Meat
Weyburn	4	Meat

Artificial insemination and natural breeding

Semen collected from the bulls held at the Dominion Livestock Division barn (farm 6) was used to inseminate cattle in the district. Between 1 November 1951 and 24 January 1952 36 herds of cattle received semen. Of these herds 35 were subsequently inspected and found to be healthy. A cow from a herd in the Regina area was also artificially inseminated. This herd was later slaughtered because of other contacts (5). Breeding by natural means at farm 6 probably resulted in disease at farm 15 and possibly at farm 17. This supports the report in reference 6 that the bulls at farm 6 were infected.

Failure of movement of people or animals to result in disease

There were a number of movements of livestock from infected farms which did not result in disease through the animals, people or transport. These were the movement of calves from farm 20 on 2 and 29 December 1951 and 11 and 18 January 1952, the movement of calves from feedlot 4 on

21 January and 2 February 1952 and the dispatch of a cow to farm 10 for breeding on 30 January.

EFFECT OF QUARANTINE

Quarantine was imposed for the first time during the outbreak on farm 1 on 3 December 1951. By that time infection had been spread to farms 2 and 3, feedlot 4 and dairy farm 20. Quarantine was imposed on the feedlot 4 from 28 December 1951 until 17 January 1952. Once quarantine was imposed, there was no evidence of spread of disease from these farms through animal movement. Spread through infected animals occurred from farms which were not quarantined (farm 20) or from farms before quarantine was imposed (farms 6 and 19). After the imposition of general quarantine on 18 February 1952 there was only one outbreak of FMD around Regina (farm 23) together with the outbreaks at Ormiston and Weyburn in April.

SUMMARY OF SPREAD DURING THE EPIDEMIC

Table X shows the conclusions on the source of infection and the means by which the infection reached each farm. Visits by people previously in contact with infected animals could have accounted for infection of six farms and may have been a possible route for seven other farms; the airborne route could have been responsible for infection of six farms and a possible route for another six; movement of infected animals was responsible for three outbreaks and possibly for another three and feeding of infected meat or milk led to three outbreaks.

DISCUSSION

The initial diagnosis of the disease was vesicular stomatitis. This was based on inoculation of the tongues of two horses on farm 1 by rubbing the tongue with epithelial material from affected cattle. One of the horses showed a reaction after five days. In vesicular stomatitis vesicles develop on the tongue one to two days after inoculation and the delayed reaction in this horse could have been nonspecific. The other horse on farm 1 and

three horses on farms 2 and 13 given material failed to react. The measures subsequently taken to quarantine the farms were logical in view of the initial (although mistaken) diagnosis of vesicular stomatitis.

Foot-and-mouth disease virus was isolated in susceptible animals from epithelial material sent from the second incident of disease at feedlot 4 and was shown by complement fixation tests to be FMD virus type A. Subsequently the 38 cattle on farm 1 were challenged with this isolate. Thirty-one of the cattle were protected; six others which had been on the farm before the outbreak and a calf born since the outbreak reacted with typical signs of FMD. In addition six pools of serum from blood collected from the herd before challenge showed neutralizing antibodies in neutralization tests on cattle tongues (5). Thus it is apparent that FMD virus type A had been present on farm 1 in November 1951.

No evidence was found of any connection between Mexico or South America and Saskatchewan. Thus Europe was the most likely origin. It is also feasible that virus could have survived on the clothes of an immigrant and set up infection in animals with which he came into contact (10) as well as being present in sausage.

The disease intervals (a) between the arrival of the immigrant on farm 1 and disease on farm 1, (b) between farm 1 and the feedlot 4 and (c) between farm 1 and farm 20 were long. It may be that the initial dose of virus was small and that multiplication of virus occurred without development of lesions (11) and that disease only became apparent during a subsequent cycle of infection in in-contact animals. There is also the possibility that disease did not start on farm 1. Instead infection could have already been present in the packing plant 4 and have been brought by the owner of farm 1 to his farm as a result of his frequent visits to the packing plant. If the packing plant had been infected it must have received infection from elsewhere; there were many other immigrants from West Germany that started working on farms in the area at that time. However in the absence of evidence for another farm having previously been infected, farm 1 remains the most likely index case.

The methods of spread did not differ from those found in other outbreaks of FMD in the Northern Hemisphere (9, 10). Movement of animals, animal products and people and the airborne route were important. The airborne route was likely to have been responsible for the two-stage spread of disease along Wascana Creek (8).

The question arises why there were not more outbreaks given that the disease was not recognized as FMD until the middle of February 1952. The cattle density in the area was low — an average of 4.5 km⁻² compared to 71 km⁻² in the parts of Hampshire, England, where an epidemic occurred in 1966-1967 (7). Wintry conditions inhibited the movement of livestock and most animal movements were for slaughter. Feeding of livestock with waste food was not a practice in the district. At that time milk tankers did not come to each farm to collect milk; instead farmers took their milk to the dairy or creamery or sold it off their premises. The quarantines imposed before the middle of February on the farms that were found infected stopped the movement of animals and deterred visits by people. The average size of farms was small; few pigs were kept and so apart from feedlot 4 there was not the possibility of large amounts of airborne virus being excreted. Once the general quarantine on the area was imposed on 18 February 1952 and the slaughter and disinfection procedures put into effect, there were, after 14 days (one incubation period), no further outbreaks which could be attributed to controllable means, i.e. movement of

animals or vehicles. The virus responsible for the later outbreaks was already present on the farms in the form of an earlier infection (farm 23) or frozen meat (Ormiston and Weyburn). The in-contact slaughter policy and follow-up procedures were efficient and effective and Canada was able to be declared free of FMD in August (3, 4).

In conclusion FMD virus type A could have reached Canada in the clothing of an immigrant from West Germany. Spread from the first farm occurred through movement of infected animals and people and led to infection of a dairy farm and feedlot as well as two neighboring farms. The feedlot and dairy farm were the centers for spread and during the next two months the remaining affected farms received infection either directly from them or from intermediate outbreaks, whose source was the two centers. The routes of infection included movement of infected animals and people, the airborne route and feeding of infected meat or milk.

ACKNOWLEDGMENTS

The authors are grateful to the following for information, advice and comments:

Agriculture Canada, Regina — R. Clarke, A. Chofer, F. Bartolf.
 Agriculture Canada, Ottawa — P. Ide, A. Afshar, G. Dulac, W. Sterritt.
 Regina — H. Beatty.
 Manotick, Ontario — J.F. Frank.
 University of Regina, Saskatchewan Archives Board — Margaret M. Hutchison. University of Saskatche-

wan, Western College of Veterinary Medicine — G. Wobeser.
 Pirbright, England — A.I. Donaldson, H.H. Skinner.

REFERENCES

1. **CHILDS T.** Foot-and-mouth disease in Saskatchewan. Proc US Livestock Sanit Assoc 1952; 56: 153-165.
2. **CHILDS T.** Procedures leading to eradication of the first outbreak of foot-and-mouth disease in Canada. Proc XVth Int Vet Congress 1953; 1(1): 217-223.
3. **WELLS KF.** La fièvre aphteuse au Canada. Bull Off Int Epizoot 1953; 39: 180-184.
4. **WELLS KF.** Foot-and-mouth disease: eradication and preventive measures in Canada. PAHO 2nd Inter-Am Meet FMD Zoon Control 1970: 76-81.
5. **STANDING COMMITTEE ON AGRICULTURE AND COLONIZATION.** Minutes of Proceedings and Evidence respecting Foot-and-Mouth Disease. Nos. 1-8. House of Commons Ottawa: Queens Printer, 1952.
6. **REPORT.** Investigation of 2/Cst W. Sherman, RCMP, Regina, under the Animal Contagious Diseases Act, 20 March 1952.
7. **SELLERS RF, FORMAN AJ.** The Hampshire epidemic of foot-and-mouth disease, 1967. J Hyg Camb 1973; 71: 15-34.
8. **DAGGUPATY SM, SELLERS RF.** Airborne spread of foot-and-mouth disease in Saskatchewan, Canada, 1951-1952. Can J Vet Res 1990; 54: 465-468.
9. **SELLERS RF.** Quantitative aspects of the spread of foot-and-mouth disease. Vet Bull 1971; 41: 431-439.
10. **SELLERS RF, HERNIMAN KAJ, GUMM I.** The airborne dispersal of foot-and-mouth disease virus from vaccinated and recovered pigs, cattle and sheep after exposure to infection. Res Vet Sci 1977; 23: 70-75.
11. **DONALDSON AI, GIBSON CF, OLIVER R, HAMBLIN C, KITCHING RP.** Infection of cattle by airborne foot-and-mouth disease virus: minimal doses with O1 and SAT2 strains. Res Vet Sci 1987; 43: 339-346.