

Review of the Occurrence of FMD in Israel and a Clinical Description of the Outbreak of the Disease in 2021

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ABSTRACT

In January 2021, Israel encountered an outbreak of foot and mouth disease in several ruminant herds in the Galilee, in the north of the country. Clinical signs such as eating disorders, fever, oral lesions, drooling, rise in body temperature, lesions around the hoof, limping and mortality of young kids and calves were recognized. Tiger heart was seen mainly in autopsied kids. Samples were collected and sent to the Kimron Veterinary Institute in accordance with guidelines for Foot and Mouth disease (FMD). Twenty herds belonging to fifteen villages were identified as being infected by FMD either by clinical signs and/or laboratory tests. In addition a single wild Fallow Deer and a mountain gazelle were found dead in the area which proved positive for FMD. Epidemiological investigations were carried out and the FMD virus Type O was found to be the cause of this outbreak. Suspicion for O/PanAsia-2 strain was considered. DNA sequencing in the village from Rosenfeld (Zar'it), Eilon Richania and in Had Ness identified sequencing differences in three nucleotides from the O/PanAsia-2 strain. This article differs from others published on outbreaks of FMD in Israel as it concentrates on the findings of the outbreak in the field, describing the development of the disease as it progressed. No other descriptions of this nature have been prepared for previous outbreaks in Israel.

Keywords: Foot and Mouth Disease; FMD; Serotype; Mortality; Outbreak.

INTRODUCTION

FMD is a highly infectious viral disease which spreads very rapidly among cloven hoofed animals (1, 2) causing major economic damage (3). The virus has the ability to spread through aerosol and through direct contact between animals. Furthermore, it may also spread by adhering to objects and contaminating clothes, vehicles, trucks (fomites), by humans working on farms or visiting them. (4).

FMDV belongs to the *Picornaviridae* type *Aphthovirus*. It is a small non-enveloped single-stranded positive-sense RNA virus. More than 80 subtypes have been identified with 7 serotypes (5) (Table 1).

Among serotypes O and A are the most common causative agents of FMDV outbreaks globally. Vaccination

plays a predominant role in the control and prevention of FMDV (6).

One serotype does not protect against another (6). The most prevalent serotype in Israel is Oise (1) (Table 2). It is important to note that the serotype Asia-1 has been diagnosed only twice in the last 25 years. The last time that type A (subtype A22) was diagnosed in Israel was in 2017 (7). In 2009, a strain resembling type A (Iran 05) was diagnosed in Israel (8). This strain was also responsible for an outbreak of FMD in Bahrein, Egypt, Iraq, Iran, Lebanon, Liberia and Turkey (8). The virus was reported again in Bahrein in 2006 (9).

For this study the authors set out to describe the outbreak of FMD in Israel in 2021 concentrates findings concerning the progress of the outbreak in the field, describing the devel-

Table 1: Seven serotypes of FMD

Serotypes	
A	Allemagne
O	Oise
C	Island Riems
SAT1	South African Territories
SAT2	South African Territories
SAT3	South African Territories
Asia-1	Asia

opment of the disease as it progressed. No other descriptions of this nature have been prepared for previous outbreaks in Israel.

MATERIALS AND METHODS

Samples collected from the field, were tested to confirm the FMD suspicion; methods used are in agreement with the "OIE – Terrestrial Manual 2.1.5; Foot and Mouth Disease" (2012), 145-173, (9) which consisted of:

- Reverse Transcription Polymerase Chain Reaction (RT-PCR) for all FMD virus types detection.
- PCR for Type identification
- Antigen (Elisa Ag-Elisa) for Type identification
- Monoclonal Antibodies Elisa (MoAb-Elisa) for FMD virus identification
- Non-Structural Protein (NSP) antibodies detection (differentiate between vaccination or infection antibodies)

THE CLINICAL APPEARANCE OF FMD IN ISRAEL

Israel is endemic for FMD which is encountered frequently almost every year (Figures 1 and 2). FMD generally appears seasonally during the months of January-February, with a climax of infections in April-May (Figure 2, 3 and 4). Most outbreaks occur in the North of the country on the borders with Lebanon and Syria (Figure 6). It is possible that wild pigs play a role in the transmission of the disease into Israel (10).

Vaccination is considered the most effective method for preventing FMD. Therefore, the Israeli Veterinary Services apply a policy of fixed scheduled vaccinations (11). Even during the years when the disease is not present, the Veterinary Services carry out vaccination (Aftopor, Merial), according to

Table 2: The incidence of the different serotypes in Israel from 1957 to 2021.

Serotype	Years
FMDV-O:	1962-1964, 1976, 1981, 1985, 1987-1992, 1994-1996, 1999, 2002, 2004-2009; 2011-2014, 2016-2021
FMDV-A:	1965, 1971, 1979, 1981, 2009
FMDV-C:	1970
FMDV-Asia 1:	1957-1959, 1963-1964, 1984, 1989
FMDV-SAT 1:	1962
FMDV-SAT 2:	Has not been diagnosed in Israel.
FMDV-SAT 3:	Has not been diagnosed in Israel.

a fixed schedule. That is, Divalent O, A vaccination according to protocol:

2 vaccinations in first year - annual booster - outbreak booster.

OUTBREAK REPORT

DESCRIPTION OF FMD OUTBREAK OF 2021 AND LABORATORY RESULTS

On January 1, 2021 the veterinarian attending the dairy herd of Kibbutz Ayalon, which is close to the Lebanese border, reported the first case of FMD to the Veterinary Services, Two dairy cows were showing signs of salivation and then lesions on the nipples were identified during milking. During the first few days, lesions were not seen around the hoofs. On the 1st of January 2021 the veterinarians of the Veterinary Services examined the animals of the herd for clinical signs. They observed vesicles at different stages on the nipples, lameness, reluctance to move and oral lesions, all of which are the typical clinical signs of FMD.

During the development of the disease, an increase in body temperature was not detected, but vesicles were present. These vesicles gave way to lesions on the tongue, gums, lips and hooves. The general condition of the cows deteriorated and they showed a decrease in milk production and appetite. There were no deaths among the suckling calves, and therefore no pathological examinations were carried out to identify the classical pathology of the myocardium which generally appear as lighter lesions on the surface of the heart and termed "tiger heart" (12).

At this stage the veterinarian of the regional district vaccinated the herd. Samples were collected for laboratory investigation from cows showing clinical signs: Blood

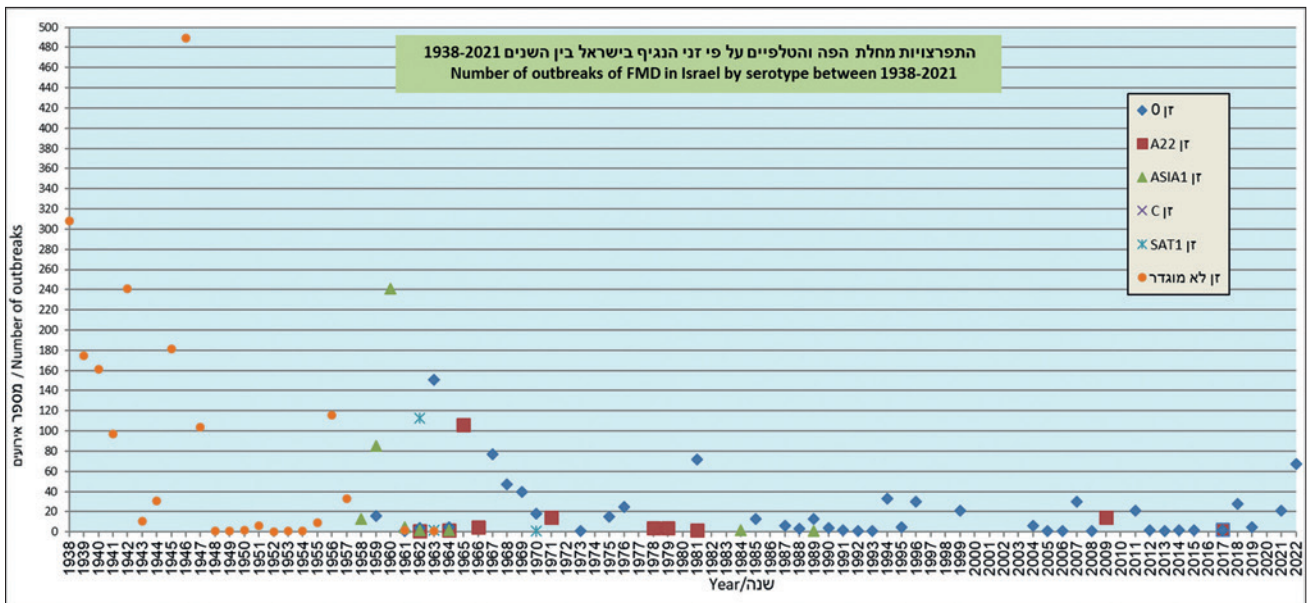


Figure 1: Number of FMD outbreaks in Israel from 1938 to 2021 by serotype

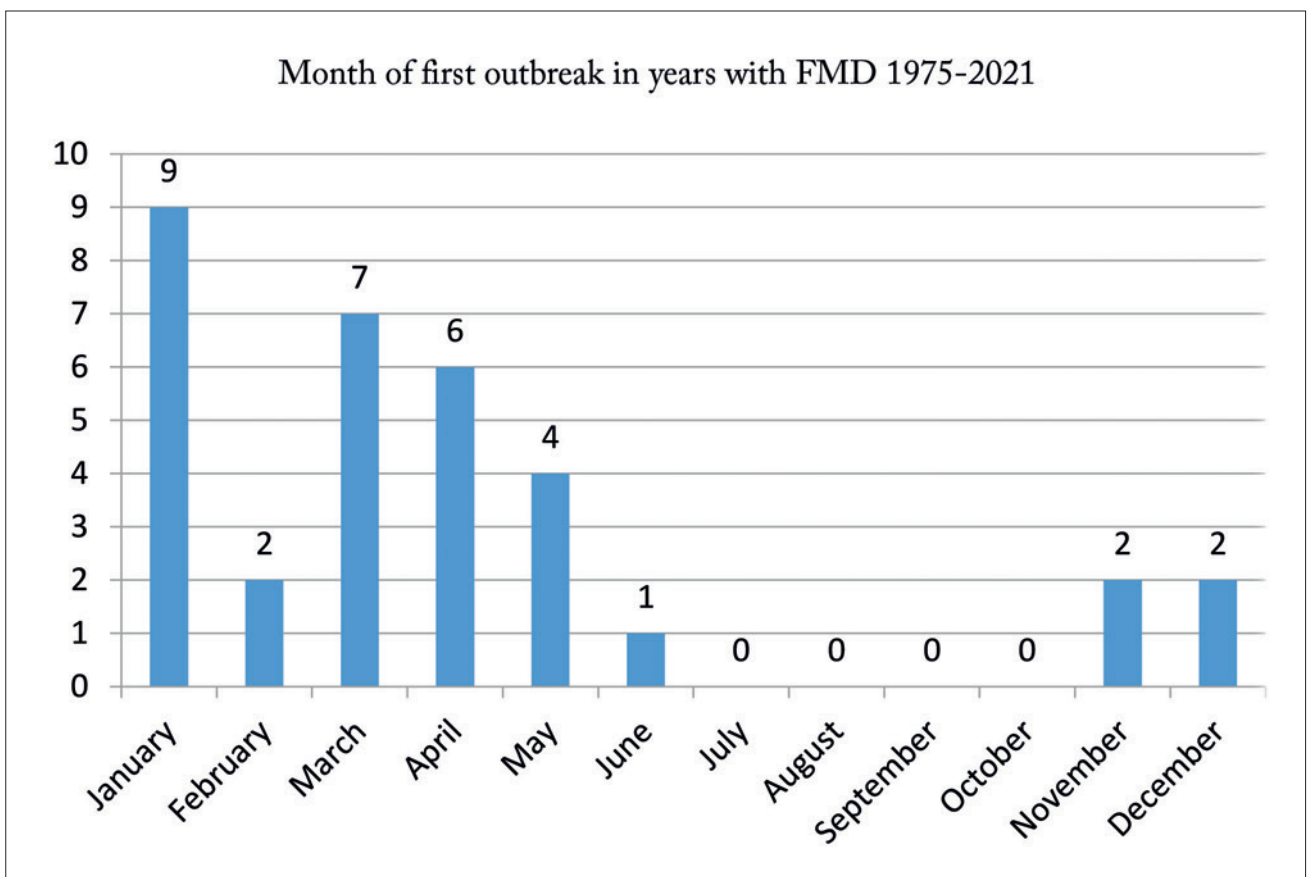


Figure 2: Incidence by month of first detection of FMD outbreak over the years 1975 to 2021 by month (total of 33 years with outbreaks during 47 years).

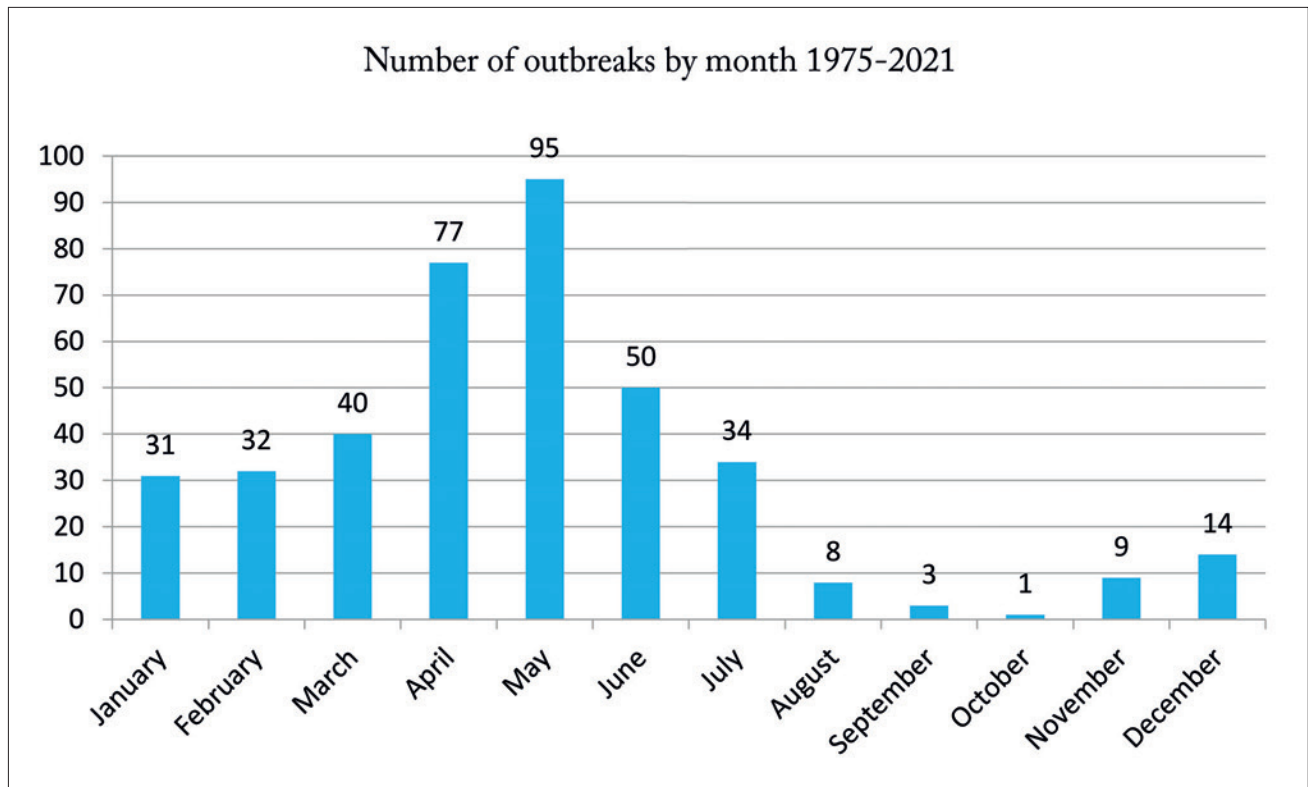


Figure 3: Number of FMD outbreaks over years from 1975 to 2021 by Month (total of 394 outbreaks)

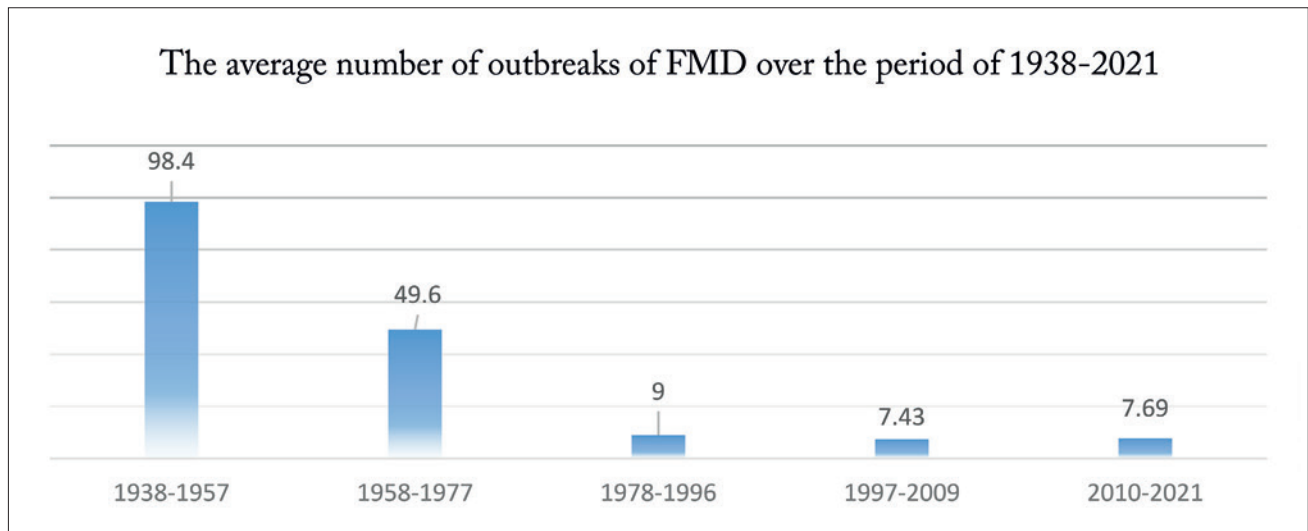


Figure 4: The average number of outbreaks of FMD over the period of 1938 to 2021

samples (without anticoagulants) and epithelial samples. All the samples were sent immediately to the FMD laboratory of the Kimron Veterinary Institute, Beit Dagan.

The differential diagnoses were of diseases which have similar or identical clinical symptoms as does FMD, includ-

ing swine vesicular disease (SVD), vesicular stomatitis (VS), rinderpest (RP) and peste des petits ruminants (PPR) (13).

Vaccination was carried out periodically in this herd and the adult cows in the herd had received their annual vaccination in January 2020 and the calves had been vac-

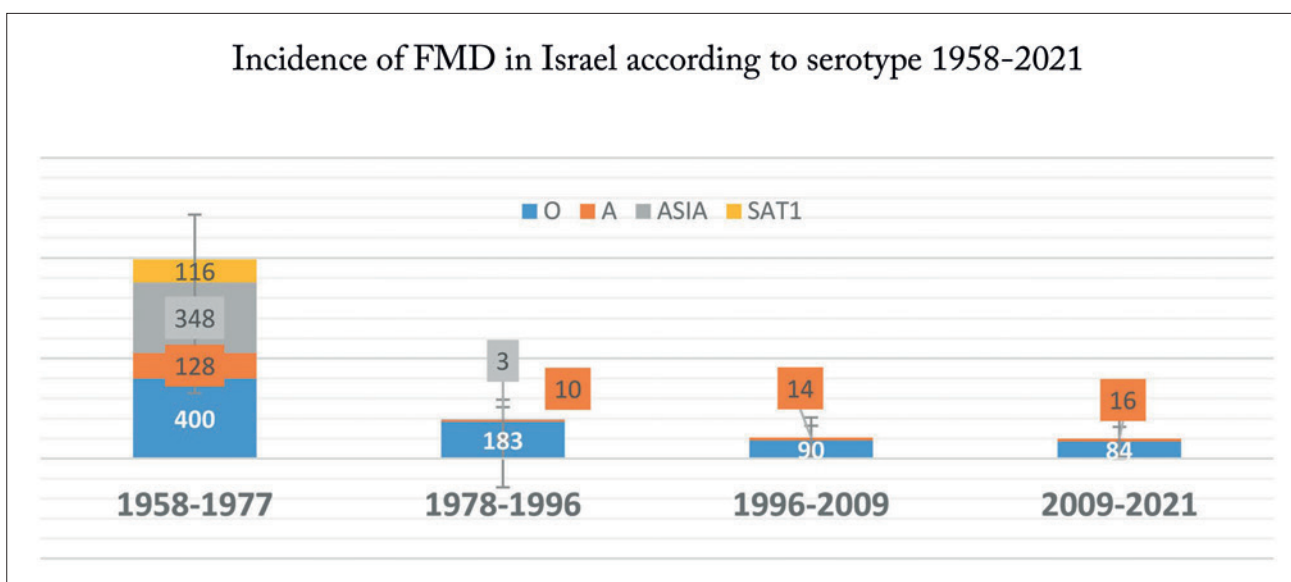


Figure 5: Incidence of FMD in Israel from 1958 to 2021. The strains involved over this period of time are indicated by different colors.

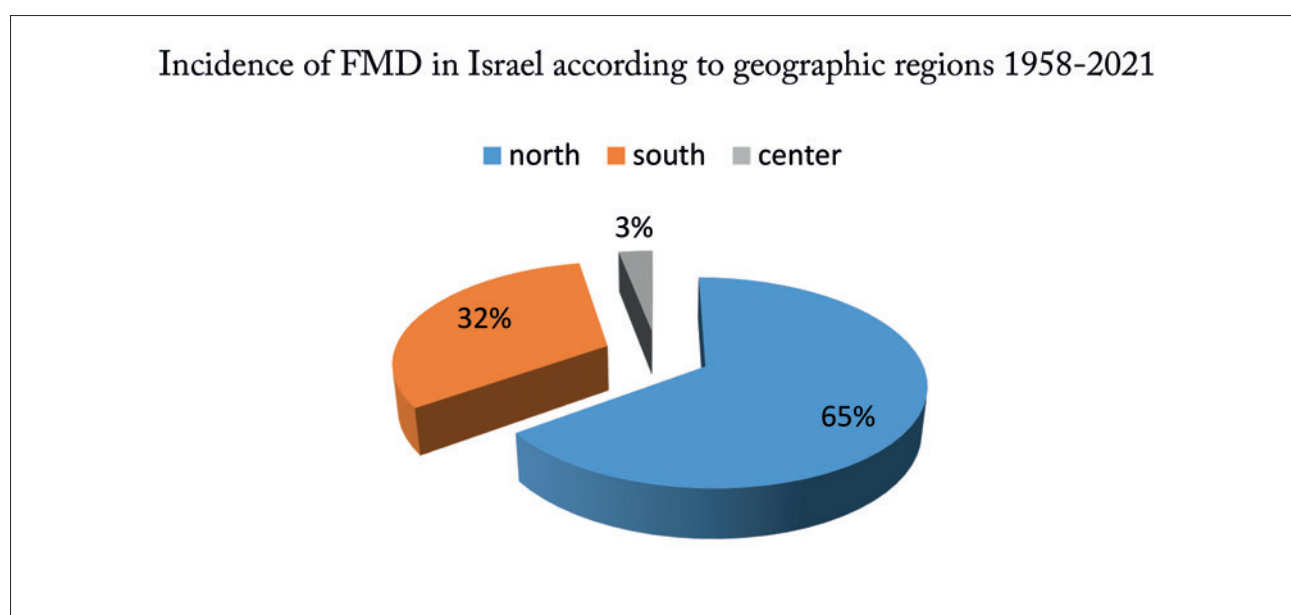


Figure 6: The outbreaks of FMD according to geographic regions (1958-2021)

cinated according to the protocol of the manufacturer of the vaccine.

As the this kibbutz was situated close to the border with Lebanon, near a nature reserve in which wild boars and deer could be often observed close to the border fence, this wildlife possibility of the source of FMD introduction was considered (10). At the beginning of the outbreak, animals were treated with supportive therapy. The area of 3 km radius around the

infected area was put under quarantine, furthermore an area of 10 kilometer radius was declared infected. In cooperation with Governmental districts, landfills were prepared for the burial of animals dying from the disease.

Herd vaccination was carried out on the 3rd of January. A bivalent vaccine against A and O strains was used in a lipid emulsion. Each head received 2 milliliters. Slaughter or transfer was prohibited during the time of quarantine.

Table 3: Chronological events in infected farms with FMD confirmation and number of animals affected

Timeline	Location	Species affected	No. of animals showing clinical signs
01/01/2021	Kibbutz Ayalon	Dairy Cattle	650
02/01/2021	Moshav Zar'it	Milking Goats	1190
05/01/2021	Havat Hanaclaim	Fattening calves	30
05/01/2021	Havat Hanaclaim	Growing Heifer	100
06/01/2021	Fasuta	Beef	80
06/02/2021	Aramshe	Beef	23
07/01/2021	Rechania	Fattening calves	85
09/01/2021	Tel Kadesh	Cows before parturition	40
02/01/2021	Had Ness	Beef	10
10/01/2021	Netua	Beef	170
11/01/2021	Havat Yanay	Beef	240
11/01/2021	Moshav Goren	Goats	1000
11/01/2021	Aramshe	Sheep	30
13/01/2021	Aramshe	Goats	300
16/01/2021	Muler	Fattening	115
16/01/2021	Moshav Goren	Deer	30
20/01/2021	Kibbutz Malkia	Fattening calves	228
16/02/2021	Giv'at HaEm	Dairy Cattle	117
25/02/2021	Kibbutz Shamir	Beef	370
25/02/2021	Kibbutz Shamir	Fattening calves	350
09/03/2021	Tuba Zangaria	Beef	90
14/03/2021	Jehudia	Beef	220
17/03/2021	Lehavot Habashan	Beef	60

DESCRIPTION OF THE COURSE OF THE FMD IN THE FARMS FROM WHERE THE 1ST SYMPTOMS OF FMD WERE NOTED

- Kibbutz Ayalon:** The farm was divided into zones: Milking zone; cows distributed according to age and according to other maintenance criteria. The dominant symptoms were salivation, vesicular lesions and lameness. In the farm there were 650 cows, 500 heifers and 80 calves of up to 4 months of age. The clinical signs of the disease began on the 1st of January 2021 and ended on the 7th of February.
- Fasuta:** Infection among the beef cattle which occurred mostly in the grazing animals. Bovines were presented with vesicular nipple lesions from farms from the village of Fasuta. Other signs were mainly salivation and

lameness which were seen between the 8th of January 2021 and the 2nd of February 2021. The herd had been vaccinated on 18 August 2020. It is important to note that until 26 January, 30% of animals showed clinical signs out of a population of 80 cows and 2 animals died. Also, during the visit and examination to the goat herd of the same owner, no morbidity was present among the animals which had been vaccinated at the same time as the cows.

- Moshav Zar'it (Kfar Rozenfelt):** A dairy goat farm including 1,000 nannies 200 of which were pregnant for the first time, 40 bucks and 250 kids. The infection started with the death of 10 kids without any clinical signs. Following this, a further 13 kids died on the 4th of January, 2021. Until the end of the FMD disease outbreak, on the 7th of February 2021, 80 kids succumbed.

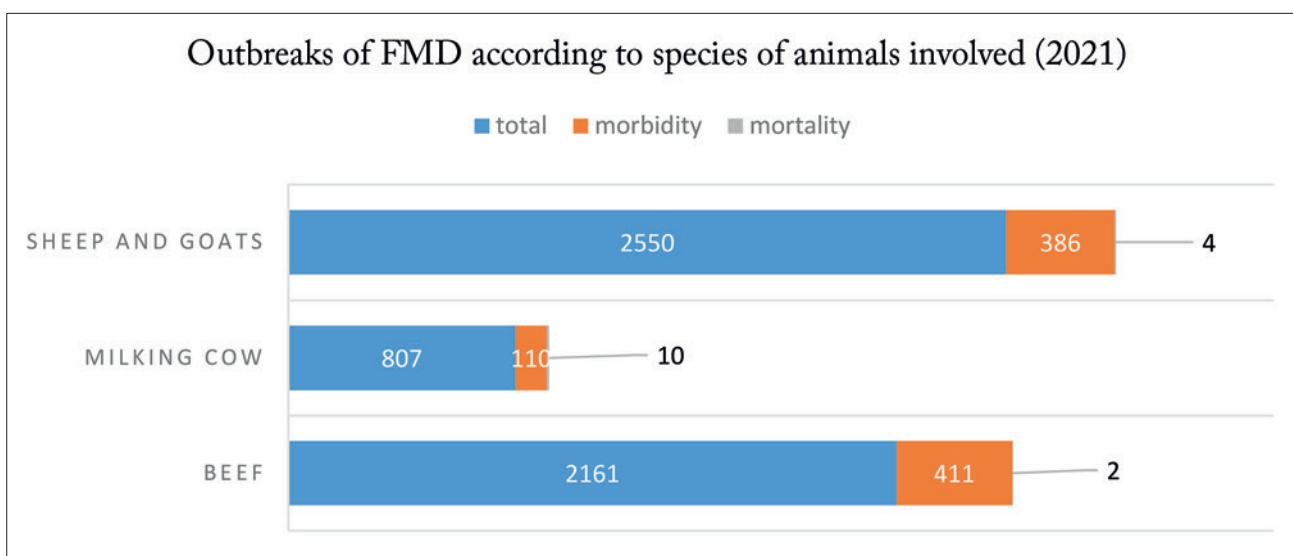


Figure 7: The last outbreaks of FMD in 2021 according to species of animals involved

During the course of the outbreak about 10% of the goats showed clinical signs of lameness without any other lesions. The herd had been vaccinated in March 2020, and then with the current outbreak they were vaccinated once again.

4. **Had Ness:** Signs of infection started on the 3rd January 2021 and ended on the 24th January 2021. First lesions were observed on the nipples of grazing cows and in a calf which arrived to the slaughterhouse showing typical clinical symptoms. Furthermore, in an adjacent flock of dairy sheep, no clinical symptoms of FMD were seen. Until the 26th January 2022, among 114 animals for fattening, 17 calves showed signs of FMD, and 12.5% of grazing animals (10 out of 80). The only group that showed specific signs of FMD were those calves that were not vaccinated and sent to slaughter, and also the group that had received only one vaccination. The herd was vaccinated in December 2020 immediately with the onset of the outbreak.
5. **Malkiah:** Infection was first observed in grazing beef cattle herd on pasture from the 9th January 2021 and ending on the 4th of February 2021. Until the 26th January 2021, mild clinical signs were present among 31 of the 450 cattle. In the vicinity of the farm, 15 fattening calves out of 218 also showed clinical signs. The beef herd of Moshav Malkiah had been last vaccinated on the 29 October 2020 and again on the 13 February 2021.

6. **Rihaniah:** Of the fattening heifers which included 85 head, 50 of the cattle showed clinical signs. Infection was first observed on the 6th of January and ended on the 21 January, 2021. The cattle exhibited mild signs of salivation and limping. Vaccination was carried out where these cattle originated from in July 2020, and thereafter no vaccination was administered.
7. **Goren:** On the 11th of January 2021, in a goat dairy farm which included 1000 head, 20% of them showed clinical signs which included decline in milk production, lameness and mastitis. In view of the clinical appearance which were indicative of FMD no laboratory tests were carried out.
8. On the 19 April 2021 all quarantine was annulled for farms which had experienced FMD outbreaks.

In several farms located near the settlement of Goren, clinical signs of eating disorders and mortality among young mammals were recognized. Samples were collected and sent to the Kimron Veterinary Institute in accordance to guidelines for Foot and Mouth Disease (FMD). Suspicion for O/PanAsia-2 strain was made. DNA sequencing in the village from Rosenfeld (Zarit), Eilon Richania and in Had Ness identified sequencing differences in three nucleotides from the O/PanAsia-2 strain.

During the course of the disease, a rise in body temperature (to about 40°C) was observed, which disappeared after 2 to 3 days. Thereafter, vesicles appeared and subsequently ruptured with the formation of ulcerative lesion on the

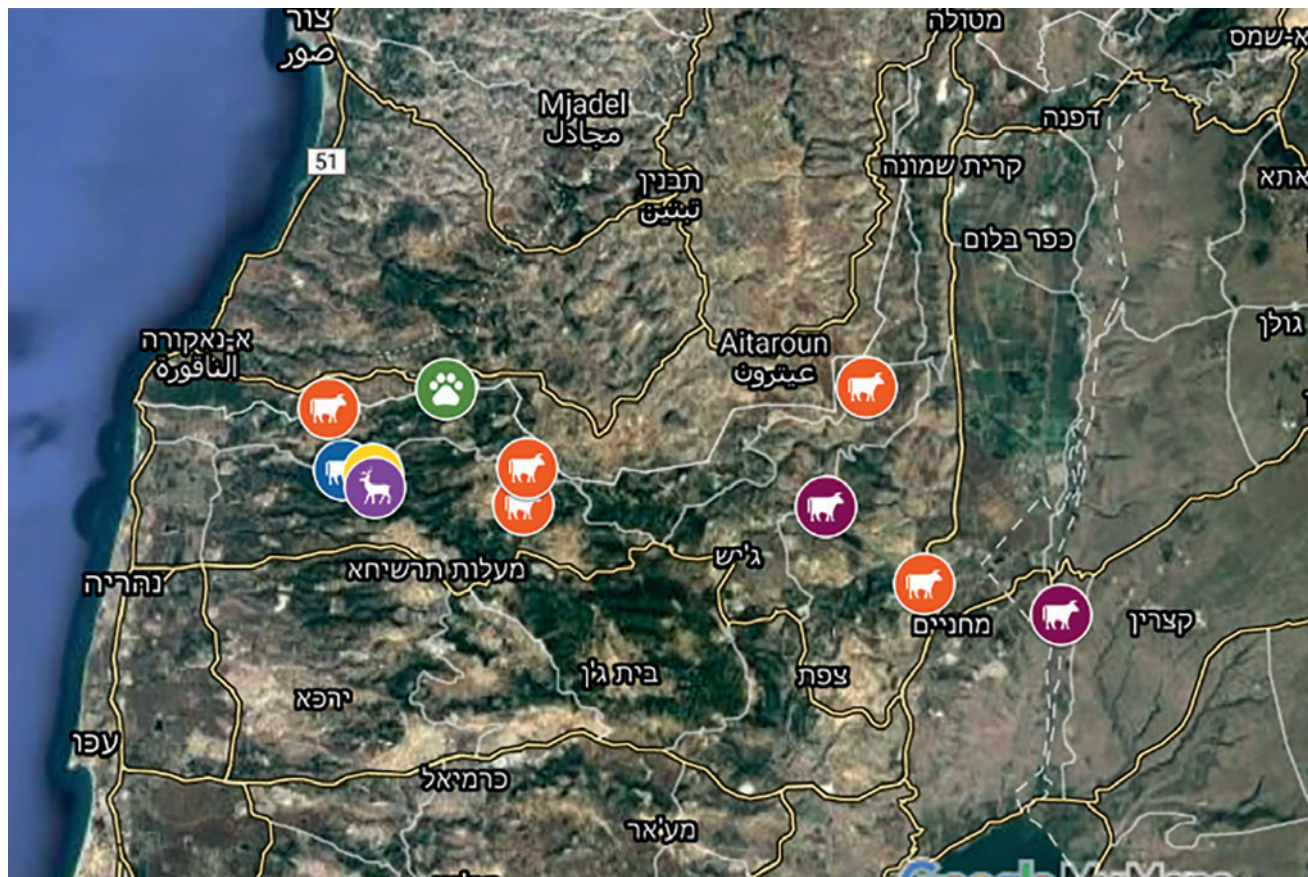


Figure 8: Incidence of FMD in Israel (2021) according to geographic regions on map.

tongue, gingiva, cheeks, lips, muzzle and nipples with a few animals presenting with lesions also around the hoofs. The condition of the animals deteriorated which was accompanied by anorexia.

Among the sheep, and especially the lambs which were autopsied, tiger heart was identified (12). Ten farms in the outbreak area were identified as being infected by FMD either by clinical signs and/or laboratory investigations. In addition a single Fallow Deer and a mountain gazelle were found to be positive for FMD.

On the 14 February 2021, signs of resolution/healing of the lesions or even complete recovery from the presence of vesicular lesions in infected animals, and in the infected herds there were no longer present.

Furthermore, wild animals were tested for FMD in cooperation with the Israel Nature and Parks Authority.

Epidemiological investigations were carried out. It is important to point out that in order to prevent the spread of the disease immediately, an absolute lockdown of all af-

fected farms was imposed by the Veterinary Services and a limitation of animal transport within a radius around the affected farms. Furthermore, additional measures were taken regarding the production of meat products and concerning this matter, the transportation of ruminants to slaughter was limited only to slaughterhouses within the radius of closure by the Veterinary Services.

Vaccinations (priming and booster) were implemented in the infected area and in the adjacent protective area (10 km radius), bordering with Palestinian Authority territories. All the above was monitored by a Supervisory body for food products.

The importance of “herd immunity” is that it can be used to successfully control an outbreak when a certain, pre-calculated percentage of animals in the population is immune to the disease (14). According to the data collected, it emerged that in total there were a number of 5488 susceptible animals, a total of 17% (907) showed clinical signs and 12% of them (113) died.

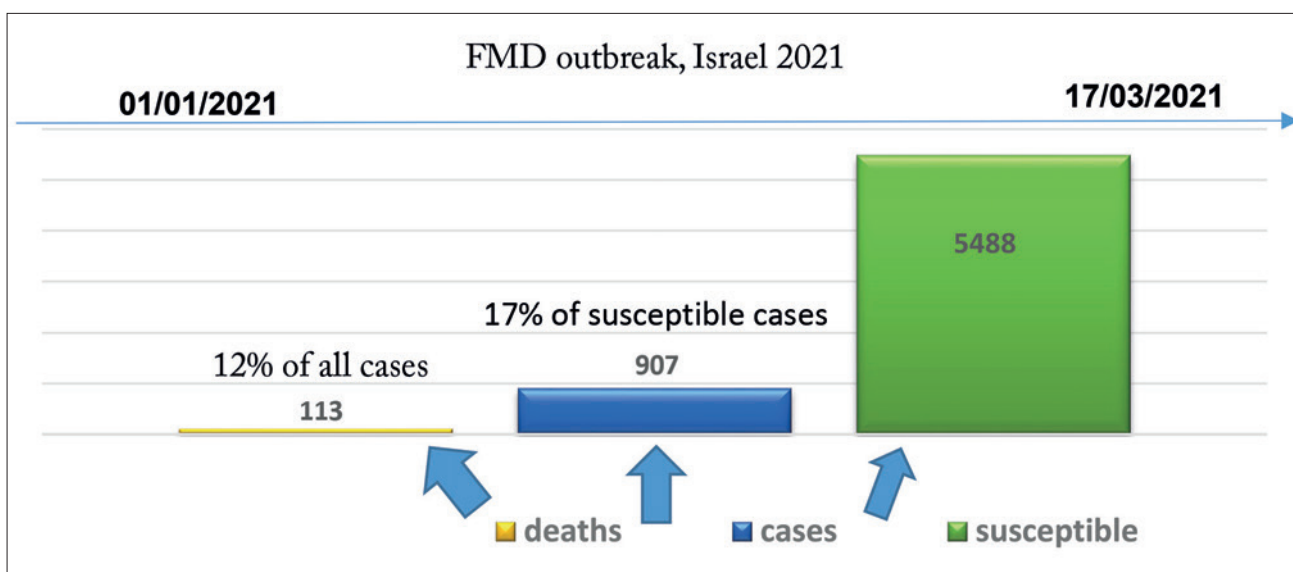


Figure 9: FMD 2021 outbreak according to morbidity and mortality cases

DISCUSSION AND SUMMARY

- Data such as this, from the field should be documented annually for each outbreak. It is hoped that information such as this will help in preventing and will aid in hindering the further spread of the disease when a FMD outbreak occurs.
- Isolated Type O strain found in this study phylogenetically belonged to group O/ME-SA/PanAsia, The strain is located between O/VIT/124/2010 and Urdzhaz/12/2011. The current strain occurring in Israel in 2021 was named **FMD-Fasuta-1**.
- Geographically the appearance of the disease occurred in a randomized fashion, in comparison to previous outbreaks. The first infection was diagnosed in the north of Israel close to the Lebanese/Syrian border. Other farms where the infection was found were not neighboring farms as it did in previous outbreaks but further distant from the original source. The difference from previous outbreaks may possibly been due to contact with wild animals such as wild boars or deer, while the farm animals were on pasture.
- The rainy season and the green pastures may have played a role in the survival of the virus and the persistence of the virus in a chain of contagion. The winter months probably further played a role in the spread of the disease.
- The age of the animals infected were observed especially among the young cattle which were in contact with the older animals. In sheep and goats the young were particularly affected.
- It is important to note that the disease was not observed in farms which had been vaccinated twice in the annual vaccination plan. The lesson that needs to be taken for the future is that the vaccination must be carried out despite the cost.
- Harmonization between countries surveillance strategies, vaccine programs, vaccine monitoring, animals and animal products movement control: Despite the tensions which exist between Israel and its neighbors attempts should be made to limit FMD outbreaks. This could be carried out in a number of ways:
 - Providing neighboring Lebanese and Syrians farms boarding Israel with FMD vaccines, free of charge. This would limit the spread of the disease from these countries into Israel and would be an economic incentive to the local boarder farmers to prevent disease outbreaks on their farms.
 - Furthermore, vaccination of farms in Israel should be made mandatory in all susceptible species and be monitored continuously. This is justified by very high economic cost of outbreaks of FMD to the State of Israel. The program for vaccination must be monitored for all ungulates.
 - The establishment of a "buffer zone" free of FMD with vaccinated ungulates with acceptable levels of

antibody within Israel adjacent to the borders with Lebanon and Syria would be an effective preventive measure for the spread of FMD into Israel.

- d. Mandatory monitoring of FMD vaccinations should also be carried out together with mandatory monitoring of antibody titers for FMD for all ungulates in the barrier region.
- e. Furthermore, a continued surveillance of FMD in susceptible wildlife in Israel including the north of Israel is recommended. Although here are not definite findings that wildlife play a role in the spread to the disease to farm animals, it has been found that many wildlife species are susceptible. However their actual role in FMD dynamics was estimated to be of limited significance (10).
- f. An important conclusion was that there was an apparent lack of “Biosecurity” in many farms which would explain the ease with which the virus spread from the northern border of Israel further south. It is proposed that this spread was mainly in the form of uncontrolled mechanical transfer from the initial infected areas southwards.
- g. It is hoped that the data provided in this article will be an incentive for the responsible authorities to draw up strategies and approaches for the following years in order to cope with the almost annual outbreak, the results of which are detrimental to the farmers and the State of Israel.

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