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The field effectiveness of routine and emergency vaccination with an inactivated vaccine against foot and mouth disease

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ABSTRACT

High potency, inactivated foot and mouth disease (FMD) vaccines may be used in non endemic countries for emergency vaccination during outbreaks in order to prevent virus spread. In endemic countries either standard or high potency vaccines are used for routine vaccination. Despite their wide use there is a shortage of data on the field effectiveness of inactivated FMD vaccines. Epidemics of FMD caused by viruses of serotype O occur frequently in Israel, where a high potency ($\geq$6PD$_{50}$) vaccine is used for both routine and emergency vaccination. We investigated an outbreak of FMD caused by a virus of serotype O, which took place during 2011 in a feedlot and an adjacent dairy herd. Post outbreak testing of antibodies against non-structural protein demonstrated that infection occurred in 96% of the calves that received two doses of vaccine at least three months prior to the outbreak and more than 50% showed clinical signs consistent with FMD. Replacement heifers that had been vaccinated 3–5 times with the last vaccination administered 7 months prior to the outbreak were all infected and 18% showed clinical signs. Testing of cattle sera of the same vaccination status as the affected cattle demonstrated low neutralizing antibody (NA) titers against the field virus strain and an r_1 value of 0.37 compared to the vaccine strain. In contrast, cattle vaccinated only once but up to two weeks before the outbreak, were almost all protected from clinical disease and to a lesser extent, protected from FMD virus infection, despite low NA titers. We conclude that emergency vaccination was highly effective due to a mechanism not associated with NA, whereas routine vaccination with the same vaccine formulation provided only limited protection due to poor longevity of the elicited immunity and low matching with the field strain (despite an r_1 higher than 0.3).

1. Introduction

Routine vaccination of cloven hoofed farm animals with inactivated foot and mouth disease virus (FMDV) vaccines is recommended in endemic countries as a measure of prevention of foot and mouth disease (FMD)[1]. In FMD free countries in which vaccination is not performed routinely, one of the strategies for outbreak control is to use emergency vaccination along with culling of infected animals [2,3]. According to the OIE FMD vaccines may be classified as either 'standard' or 'higher' potency vaccines. Standard potency vaccines are formulated to contain sufficient antigen and appropriate adjuvant to ensure that they meet the minimum potency level required (recommended as 3 PD50 [50% protective dose]). This kind of vaccine is usually suitable for use in routine vaccination campaigns. For vaccination in naïve populations to control FMD outbreaks, higher potency vaccines (>6 PD$_{50}$) are recommended for their wider spectrum of immunity as well as their rapid onset of protection [2]. Such vaccines were shown to protect cattle from clinical infection even as short as 2 days and up to at least 21 days post immunization [4] with an average efficacy of 87% [5]. However, the field effectiveness of such vaccines during an outbreak was hardly assessed. In addition, contradicting results were published with regards to the longevity of immune protection after one or several vaccinations. While some studies demonstrated long term immunity after one or more vaccinations [6–10], a model based on a field study found the half life of vaccine induced protection to be only 98 days [11].

Outbreaks of FMDV, mostly of serotype O occur almost every other year in Israel [12], in which vaccination of cloven hoofed farm animals is obligatory [13]. Cattle are vaccinated by a commercial high potency ($\geq$6PD$_{50}$) vaccine. We present here the analysis of an outbreak, caused by a serotype O, Pan-Asia-2 FMDV, which

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occurred in a feedlot and a dairy farm in the north of Israel. The information on the variability of vaccination statuses of the cattle in both farms enabled us to correlate incidence of disease with number of vaccinations and time elapsed from the last vaccination. In addition, emergency vaccination of only a portion of the animals enabled an assessment of its effectiveness for the prevention of clinical disease and viral infection.

2. Materials and methods

2.1. Study population

Ramat Magshimim farm is located on the southern part of the Golan Heights, Israel (32°50′46″N, 35°48′29″E). The feedlot and dairy farm were located within a common site, with only 30 meters separating between the two facilities (Fig. 1A). The site was surrounded by a fence. At the time of the outbreak onset there were two main types of calf groups in the feedlot: The first type comprised groups 1–18, which included 424 Israeli Holstein and mixed breed fattening calves aged 8–15 months (Table 1). These calves originated from Ramat Magshimim local beef herd and from three other dairy herds. All calves were vaccinated twice, with the last vaccine administered between 3 and 10 months prior to the outbreak onset (Table 1, Fig. 1A). The second type comprised group 19, which included 306 mixed breed fattening calves aged 2.5–8.5 months. These calves orginated from several beef herds located in the north of Israel. They arrived the feedlot in five batches, starting from 9 days before the outbreak onset. All were vaccinated only once, on the day of their arrival (Table 1, Fig. 1A).

The dairy farm accommodated 931 Israeli Holstein individuals, divided into 18 groups which were located in 5 sheds (groups A–R, Fig. 1A). There was no introduction of cattle from other localities into the dairy farm. Groups A–H, J, K (Fig. 1A, Table 2) included 611 cows and replacement heifers. These groups (excluding ten of the heifers in group J that were moved from group Q on June 13th) were vaccinated at least 3 times, with the last vaccine administered seven months before outbreak onset (Fig. 1A, Table 2). Groups I, L–Q (Fig. 1A, Table 2) included 261 replacement heifers and calves aged 3–22 months and group R included 59 suckling calves. These groups (excluding calves born after May 2nd) were vaccinated at least once, 14 days prior to outbreak onset in the dairy farm (Fig. 1A, Table 2).

2.2. Data collection

The information was collected as a part of an investigation of the FMD outbreak in 2011 at northern Israel. The herdsmen and the veterinarian were interviewed on arrival to the farms on June 16th, using preformed questionnaires. Follow up visits and phone interviews were conducted until November, 2011 (4 months after outbreak resolution). The collected data included location of the different groups within the farms, number of animals within each group, breed, age, origin and date of arrival to the farm, number and date of administration of vaccines prior to the outbreak, the time of clinical signs onset in each group and the extent of morbidity as was estimated by the herdsmen. Vaccination data were collected from the herd management software.

2.3. Clinical case definition

Morbidity in the feedlot was detected by the herdsman and defined as animal showing lameness with or without excessive salivation, and tongue lesions. In the dairy farm morbidity was detected by both the veterinarian and the herdsman and was defined as an animal showing typical tongue lesions with or without excessive

Table 1
Group data, vaccination status and morbidity data in Ramat Magshimim feedlot during the FMD outbreak on 2011.

Group data				Vaccination			Morbidity		
Group	Breed	Age range (months)	Number of animals	Number of vaccinations[c]	Age at first vaccination (months)	Time since last vaccination[c] (months)	Date of first clinical signs	Incidence rate (%)	NSP positive percentage (# positive/# samples)
1	Mix[a]	14	33	2	5	7.7	05-June-11	>50	NS[d]
2	Mix + IH[b]	8–15	10	2	3–6	3–8	17-June-11	>50	NS
3	IH	8	20	2	4	3.1	19-June-11	>50	96 (70/73)
4	IH	7.7	21	2	4	2.9	12-June-11	>50	
5	IH	7	32	2	3	3.1	19-June-11	>50	
6	Mix	15	26	2	6	7.7	05-June-11	>50	NS
7–8	Mix	14	42	2	5	7.5	01-June-11	>50	NS
9	IH	14.5	20	2	4	10.0	10-June-11	>50	NS
10	IH	13	25	2	3	7.8	10-June-11	>50	NS
11	IH	12.5	23	2	4	6.8	15-June-11	>50	NS
12	IH	9	35	2	4	4.4	19-June-11	>50	NS
13	IH	9	20	2	5	3.1	19-June-11	>50	NS
14	IH	12	22	2	4	6.7	11-June-11	>50	NS
15	IH	11	25	2	3	6.7	12-June-11	>50	NS
16	IH	11	22	2	3	6.7	12-June-11	>50	NS
17	IH	11	24	2	4	5.3	12-June-11	>50	NS
18	IH	10	24	2	3	5.5	19-June-11	>50	NS
19	Mix	2.5–8.5	306	1	2.5–8.5	0–0.3	11-June-11	<1	55 (31/56)

[a] IH – Israeli Holstein.
[b] Mix – mix breed beef cattle.
[c] Administered until the outbreak onset within the feedlot.
[d] Not sampled.