

Outbreak of Foot-and-Mouth Disease in Miyazaki from March to July 2010

- Effect of Yellow Sand and Local Surface Wind -

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Abstract: The transport of foot-and-mouth disease (FMD) virus (FMDV) and the appearance of FMD based on yellow sand transported by global winds high in the atmosphere, and the spread of FMD diffused by local winds of the surface air layer based via particles adhered FMDV were investigated concerning to climatic properties of global wind about yellow sand and of local wind in Miyazaki. FMD appeared and spread in Miyazaki from March to July, and 289,000 domestic animals was slaughtered. It is deeply related between transportation of FMDV by yellow sand, and appearance and spread of FMDV by local winds of monsoon. Japan has to predict the transport of yellow sand adhered with FMDV and bio-aerosol, and to protect against various diseases at any time.

Key Words: Desert, Foot-and-mouth disease, Global and local winds, Miyazaki, Yellow sand

1. Introduction

A report entitled "Clarification on the global circulations of yellow sand or Kosa, and cross-border air pollutants and countermeasure of their effects" was published by the Science Council of Japan on February 25, 2010 (Maki *et al.*, 2010a). The report describes the relationship between yellow sand and foot-and-mouth disease (FMD) virus (FMDV). After the appearance of FMD in China on December 30, 2009 and in Korea on January 2, 2010, interest in FMD increased in Japan.

This paper discusses the transport of FMDV and the appearance of FMD based on yellow sand (**Fig. 1**) transported by global winds high in the atmosphere, and the spread of FMD diffused by local winds of the surface air layer based via particles to which FMDV adhered (Maki, 2010; Maki *et al.*, 2010b).

2. Methods and Results

2.1. Relationship between yellow sand and the appearance of FMD overseas

FMD was spread out almost all across Asia in 2010. East Asia, including China, Mongolia, Korea, Taiwan, and Hong Kong, was struck mainly by FMD of O and A types. In Japan, only O type was found in 43 and 292 cases until on May 7 and July 4, 2010, respectively. The O type was found on March 14 in Gansu and on March 25, 2010 in Shanxi, China. It is presumed that the origin of FMDV spread on March 25 in Shanxi, China and on March 26 in Japan is based on the FMDV found on March 14, 2010, in Gansu, China.

2.2. Cause of the first appearance of FMD and its spread

The first informal FMD infection in livestock was detected in buffalo on March 26, 2010, at Tsuno Town in Miyazaki Prefecture, Kyushu, Japan. But the first formal infection of three cattle; cow and bull was recognized at Tsuno on April 20.

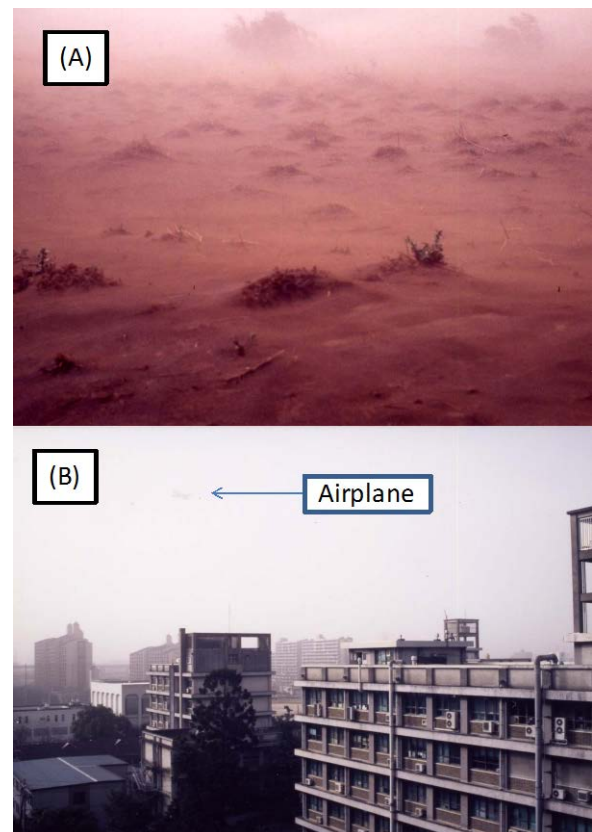


Fig. 1. Yellow sands flying up from China and falling down to Japan.
(A) Outbreak of yellow sand with wind erosion at Turpan, China.
(B) Yellow sand observed at Kyushu University in Fukuoka, Japan.

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The suspected infection of six cattle was recognized on April 21 at Tsuno and that of five pigs on April 27 at Kawaminami Town. After that, the number of infected livestock increased very rapidly, and FMD spread out widely in Miyazaki. The durations of FMDV incubation are 6.2 days for cattle and 10.6 days for pig according to Newspaper of Agriculture in 2010, or 2 to 8 days in Ministry of Agriculture, Forestry and Fisheries.

If the first infection occurred on March 26, the cause of FMD is presumed to be yellow sand blown into Japan from the Gobi Desert of northern and central China on March 16 with rain on March 15 and/or 21 with rain March 20, 2010 by WNW to W wind directions, based on certainly FMD appeared in Gansu on March 14, 2010. Yellow sand on March 21 was observed to be arriving in very strong scales and across a wide area, at 63 out of 67 points in Japan, and the arrival of the sand continued for a long time. The yellow sand observed in Japan in 2010 remained at a fairly high level for 30 days and 381 point-days in 67 Observatory until May 31, 2010.

According to the average appearance rate (day) by month, the yellow sand season is from March to May.

According to variation of precipitation; rain and dust storm; dust and yellow sand at Dunhuang in northwest China, climate of summer rainy season is from June to August, and main yellow sand season is from March to May to similar in Japan.

2.3. Spread after the first appearance of FMD

There are two means by which FMD has spread to Japan. One type caused the first appearance, on March 26, and the other type caused later appearances. The authors concluded that the first appearance was based on yellow sand transported a long distance and that the virus was not spread by direct contact with FMDV carried by humans, nor was it conveyed through feed (straw). Rather, the first appearance of FMDV is attributable to the virus adhering to yellow sand particles transported long distances by high-altitude winds.

Although we cannot exclude the possibility of infection and diffusion from Tsuno to other areas in Miyazaki is by human movement, feed, and so on, it is rather certain that the virus was based on soil-sand particles and fine matter transported by local winds, because the same virus, the O type, was found around a certain area at the same time.

2.4. Meteorological reason for yellow sand blown into Miyazaki

It is interesting that FMD appeared only in Miyazaki but not at other places. The reasons are clearly that Miyazaki is located in the leeward wind area of the Kyushu Mountains, an area that has frequent clear and fine days in winter and spring and that a northwesterly wind also blows frequently. In

general, on the leeward side of a mountain there are relatively many fine, dry days as a result of Foehn or Bora winds, similar to a phenomenon in desert areas on the leeward side of a high mountain. In both cases, a downward wind reaches the ground from high altitudes. Thus, more yellow sand falls there than elsewhere.

In May, 2010, as in the middle of the period spread of FMD and in the last month of the yellow sand season, yellow sand was investigated in seven prefectures on Kyushu Island; Nagasaki (N), Saga (S), Fukuoka (F), Oita (O), Kumamoto (Ku), Miyazaki (M), and Kagoshima (Ka). The total number of observation was N 1, S 5, F 3, Ku 8, O 4, M 5 and Ka 4.

Kumamoto of 8 was probably affected by air contamination, and Miyazaki and Saga of same 5 followed. For the reasons explained above, yellow sand is found as pretty high levels in Miyazaki despite the high amount of precipitation in south Kyushu. Differences in the amount of yellow sand between these areas were found even in May 2010, for example.

2.5. Possibility of FMDV transportation by yellow sand

It is said that FMDV is quickly destroyed under the following conditions; ambient temperature exceeding 50°C, relative humidity below 60%, and pH above 10 or below than 6. However, as yellow sand particles have rough surfaces and sometimes crack (**Fig. 2A**), the virus adhering to a particle can survive despite these conditions. If it rains occasionally, the particle surface with the virus would be covered with clay.

The environmental conditions under which the virus survives (below 50°C temperature, above 60% humidity, pH 6-10) can easily persist for a few days. Even if it does not rain, the virus could be alive in rough particles and deep inside particles without a problem, indeed with a fairly high probability. Yellow sand can fly to Japan in 2 to 3 days from Gobi Desert and Taklimakan Desert or, if it originates from the Loess Plateau, in only 1 day. Of course, the total probability of appearance of FMD is low, however the possibility still remains.

Before flying yellow sand from the surface at the blowing sand area, it sometimes rains. If there are rainclouds, the air is saturated with vapor or water and the sand particles are caught in rain drops. Thus FMDV lands in Japan via sand particles and the rain. Yellow rain is found and sedimentation of yellow sand is also recognized. Livestock drink fallen rainwater and are suffered by FMDV. Although the probability is low, FMDV infection through this route is possible. As yellow sand in the presence of a passing cold front has a high chance of encountering vapor because that it sometimes rains, *i.e.*, 2 cases before yellow sand and the living virus can land in Japan.

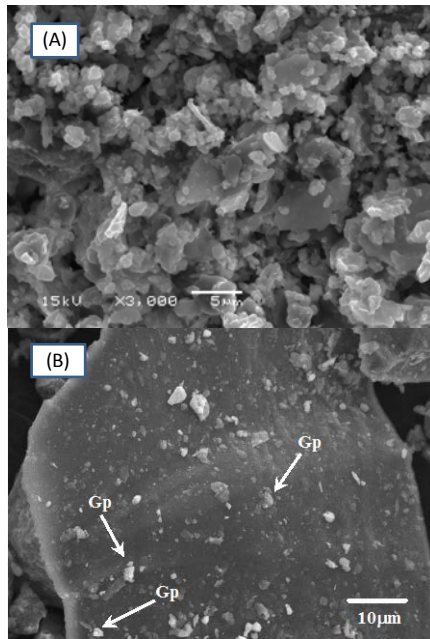


Fig. 2. Yellow sands surveyed by electron microscope (Hatta *et al.*, 2009). (A) Surface structure of yellow sand. (B) Fine matter (Gp; gypsum) adhered on quartz surface.

The flight of yellow sand from China depends on the type of wind blowing, high or low pressure, cold or warm front, topography, and so on. That is, these factors can determine not only from what region and what place the sand lifts off from the surface, but also the route the sand flies and where it lands. The frequency with which contaminated sand has fallen in Miyazaki is interesting, but final result remains unclear.

Yellow sand fallen in Japan sometimes consists of gypsum and ammonium sulphate adhered on yellow sand (Fig. 2B). The chemical reaction does not occur on the ground surface, but happens rather high in the sky under the conditions of high humidity and near-neutral pH (Hatta *et al.*, 2009). The alkalinity of yellow sand and acid rain by air contamination can be near neutral. In this environment, the virus remains alive.

In conclusion, if the first appearance of FMDV is brought about by yellow sand at Tsuno, and then the further spread of the virus is generally affected by local winds, based on the very high possibility of surface winds.

2.6. FMD in Miyazaki and Hokkaido spread in 2000

Yellow sand blows from China to Korea and Japan, passes over the Pacific Ocean to the USA and Canada, crosses the Atlantic Ocean to Europe with the portion of the sand falling on the earth surface, and returns to China, and begins the cycle again as a global transportation. It circles the earth in 12 to 13 days (Uno, 2009).

In 2000, yellow sand from China and Mongolia is also

supposed the source of FMDV in spring at Miyazaki City in Kyushu and at Honbetsu Town in Hokkaido in Japan, as well as in Korea and far-eastern Russia. The reason is considered that FMD is based on the general circulation of yellow sand transportation from China and Mongolia because that it was found in same yellow sand season of spring. FMD appeared on March 12 at Miyazaki is presumably attributed to yellow sand observed at Miyazaki Observatory on March 7, and FMD appeared on May 11 at Honbetsu in Hokkaido is to yellow sand observed on April 8 at Asahikawa Observatory.

Although spread of FDM was finished just in Miyazaki on this time, dust and yellow sand come overseas by long distance transportation. As FMDV falls continuously to earth from overseas, it is necessary to protect in anytime.

3. Discussions

3.1. Spread of FMD in Miyazaki

Here we discuss the appearance and spread of FMD. FMD was actually recognized at Tsuno, Miyazaki, on April 20, but it was presumed by precise inspection that the first animal infected with FMDV was found on March 26. The outbreak spread from Tsuno to Kawaminami. It was said that the causes of this spread were unclear finally. However, the authors predict that they probably did not include the transportation of livestock, feed, human activity, cars, and so on. For meteorological researchers, the exclusions of an atmospheric cause by virus specialists on the appearance of infection in the first and on the spread of infection after appearance are difficult to comprehend.

About FMD infection via the air, infected livestock can easily spread the virus through their exhalations, which contain small floating particles of solids and liquids in the aerosol blown out from a trachea or windpipe of throat (Ono, 2010). According to the US Department of Agriculture shown in **Figure 3**, 22% of cases of FMD infection are spread by wind and flying birds. The spread by FMDV floating in the wind is understandable in the case of Miyazaki. It is possible that FMDV was transported in the wind on dust, soil-sand particles, shed fur, and skin from livestock, air pollutants, and SPM; suspended particulate matter.

FMD was transferred from north to south as an order from Tsuno to Kawaminami, Takanabe, Shintomi, and Miyazaki from March to May by northwest wind. The direction is from north to south and not to east because the border of east side is sea. Ebino is not included in this order because infected cattle were transported there from other areas. The infection was clearly transferred by the northwesterly wind in spring, and after that, from May to July, it was mainly based on the change to monsoon season by the southeast wind, which

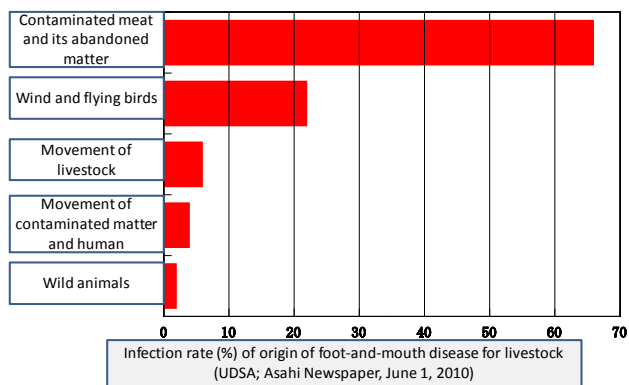


Fig. 3. Infection rate (%) of origin of foot-and-mouth disease for livestock (UDSA; Asahi Newspaper, June 1, 2010).

spread the virus to Kijyo, Kunitomi, Saito, Miyakonojyo, and Hyuga, enlarging the area of infection. The directions and transfer of infection from March to July is thus clarified by the usual wind speed and wind directions.

3.2. Investigation of yellow sand adhered with FMD

The authors investigated three places (Okinawa, Fukuoka, and Tsukuba) where yellow sand samples were obtained by a high-volume air sampler. It is presumed that the evidences of FMDV were detected in all in three places (Shi *et al.*, 2009). The method used was a DNA evaluation technique, thus it is unclear whether the detected virus was alive or dead because of traces of FMDV.

The analysis points to a high possibility that FMDV was blown from China and Mongolia, by virtue of the fact that it was detected in yellow sand at all three observation points covering a wide area of Japan. In fact, active FMDV was found in 2010, and FMD was spread to Miyazaki. How do you think about the relation between the active FMD in Miyazaki, and the situation from appearance to spread of FMD?

We have to predict the transport of FMDV-adhering yellow sand or bio-aerosol, and to protect against FMD and various other diseases at all times.

4. Conclusions

The results of our study of the appearance and spread of foot-and-mouth disease are as follows: 1) It is deeply related between transportation of active virus by yellow sand, and appearance and spread of foot-and-mouth disease virus by local winds in Miyazaki. 2) As the first infected livestock by foot-and-mouth disease virus were detected on March 26, 2010, in Miyazaki, the cause is presumed to be yellow sand blown from Gansu, China on March 14 and landing in Miyazaki, Japan on March 16 and/or 21, 2010. 3) After the first appearance of foot-and-mouth disease, it is certain that local

winds further spread the virus on soil-sand particles and fine matter, because the same O type of virus was found in a wide area at the same time. 4) The virus was clearly spread by northwesterly winds, because the infections spread from north to south from March to May. The direction of infection was clarified by the wind direction, which changed to a southeast direction from May to July. 5) As Miyazaki is located in the leeward wind area of the Kyushu Mountains, it has frequent clear or fine days in spring, and a northwesterly wind blows down from high altitudes, similar to the leeward phenomenon in deserts. The amount of yellow sand is rather greater in this area despite the high amount of rain this area receives in spring. 6) It is presumed that, in 2000, the infection detected on March 12 in Miyazaki is attributable to the yellow sand observed on March 7 in Miyazaki, and that the infection detected on May 11 at Honbetsu, Hokkaido is to the yellow sand observed on April 8 at Asahikawa, Hokkaido. 7) We have to predict the transport of yellow sand adhered with foot-and-mouth disease virus and bio-aerosol, and be prepared to protect against various diseases at any time.

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