Assessing the value of environmental surveillance for early detection of foot-and-mouth disease

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Introduction

- Due to the fast-spreading nature of foot-and-mouth disease (FMD), early detection is essential to successfully apply control measures during an outbreak in an FMD-free country.
- We have developed a within-herd transmission model where infection can occur via direct contact or through environmental contamination.
- The results of the model can be used to compare methods of detection and determine an effective surveillance regime for use in a future outbreak.
- Environmental sampling methods have been shown to successfully detect FMD virus under field conditions in Nepal, Cameroon and Nigeria, where FMD is endemic. This has the potential to speed up detection of suspected cases.
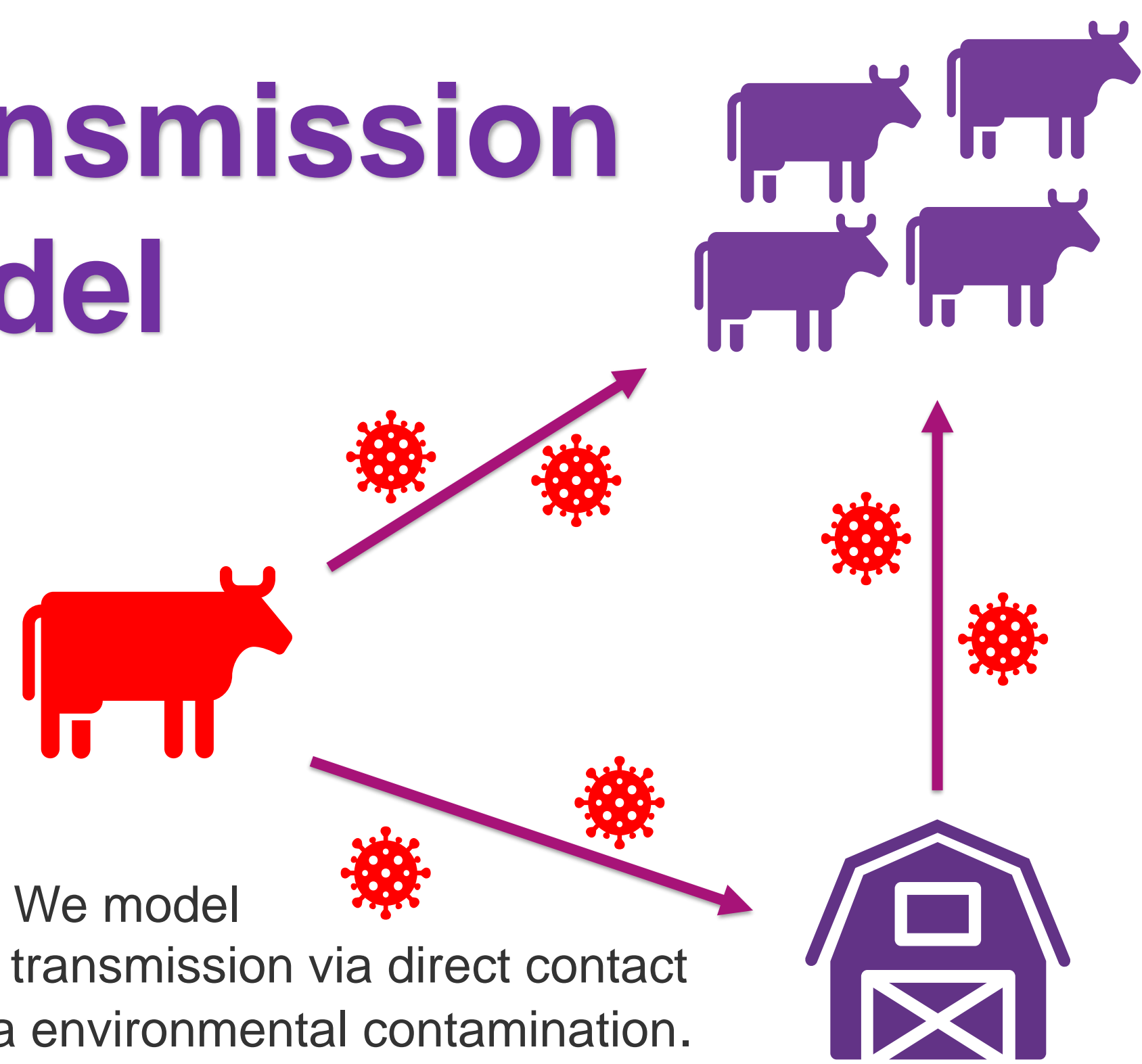
Transmission model

Fig 1. We model FMDV transmission via direct contact and via environmental contamination.

For each cow, we determine:

- **The viral shedding profile**
- **Probability of infection via direct contact**
- **Probability of infection via the environment**
- **The incubation period**
- **The viral accumulation rate**
- **The natural viral decay rate**

The model is parameterized using data from transmission experiments and 2007 outbreak in GB.

Environmental sampling

- The probability of a sample testing positive has been inferred from experimental data. Several samples were taken from four areas of the environment (walls, floor, trough and faeces).

- We model the probability of a positive sample as a function increasing with amount of virus (E):

$$P(E) = 1 - e^{-\xi E}$$

  and fit to experimental data using a **Metropolis-Hastings algorithm** (see Fig. 2).

- We combine these results with the transmission model, and simulate sampling strategies, whereby a chosen number of samples are taken at regular intervals.

- We compare strategies by finding the average **day of detection** post infection and the **proportion of infectiousness** that occurs before detection (assumed to be proportional to total viral shedding, Fig. 3) .
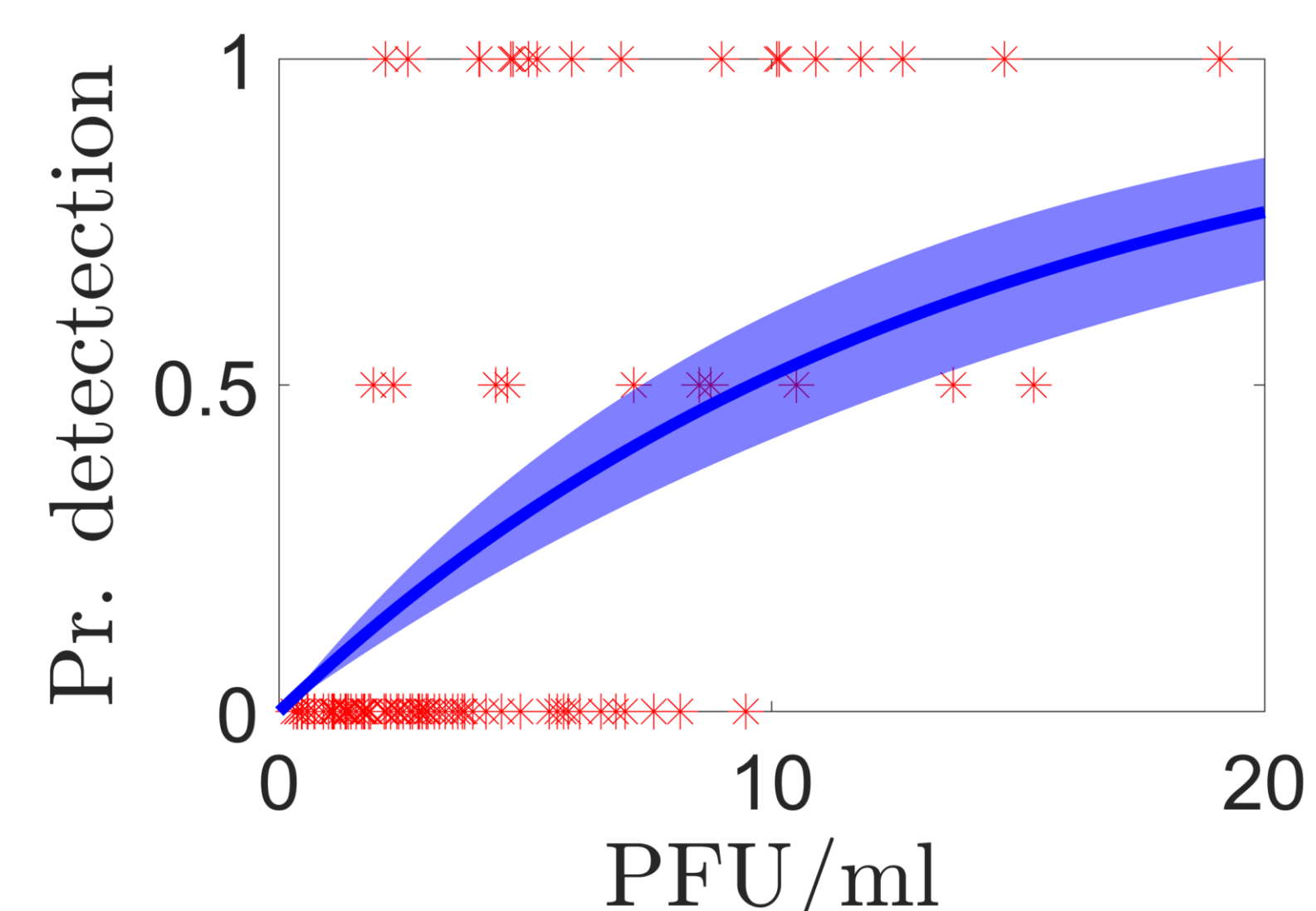

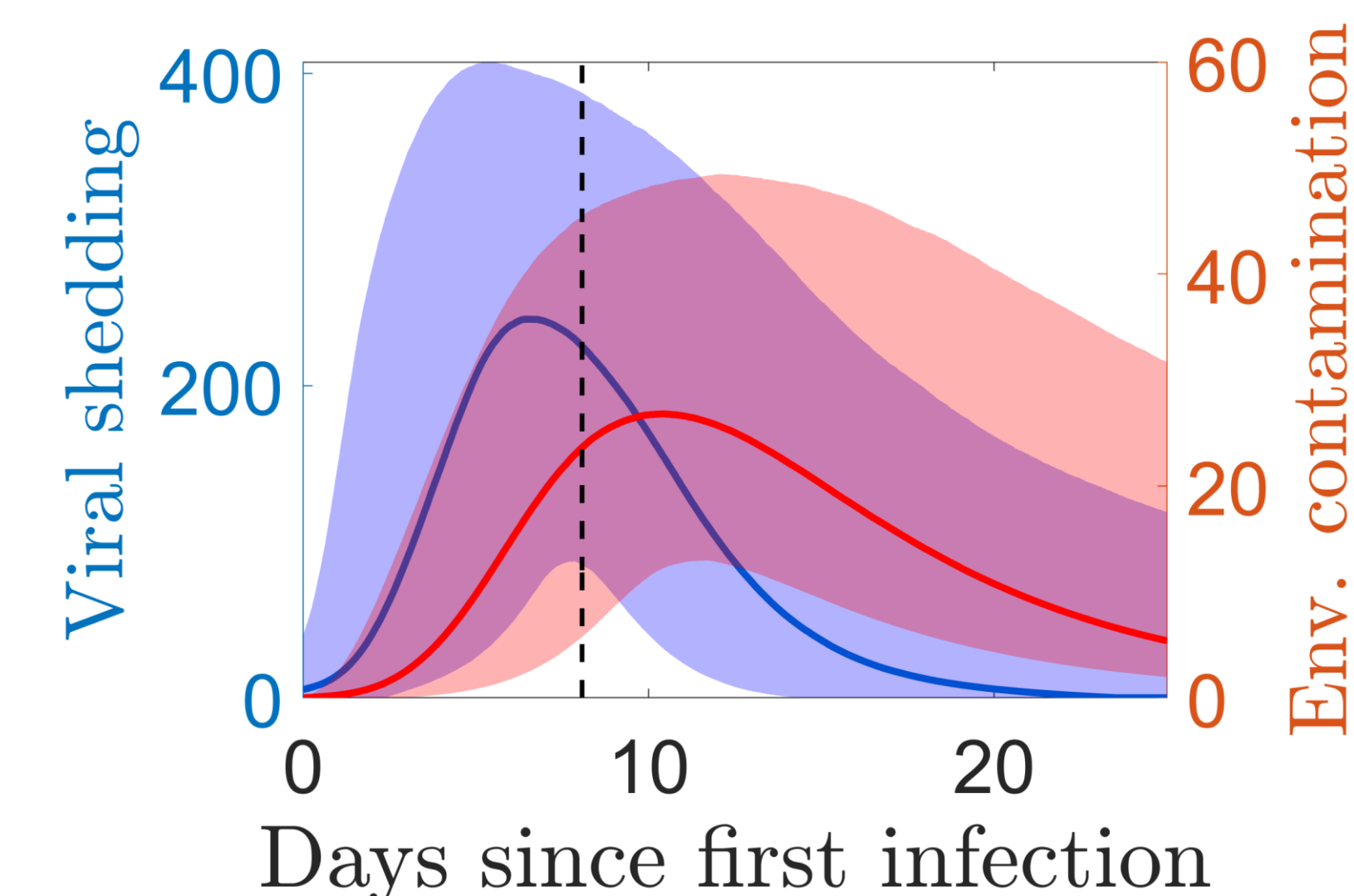**Fig 2.** The probability of detecting FMDV in environmental swabs from feed troughs.

Fig 3. Total viral shedding (blue) and environmental contamination (red) since first infection. Dotted line shows 8 days.

Fig 4. The median day of detection (top) and proportion of infection that occurs before detection (bottom) for different strategies. Red dotted line shows 8 days.

Key results and conclusions

- The day of detection and proportion of infectiousness before detection are shown in Fig. 4 for different sampling intervals and numbers of samples taken.

- The earliest median day of detection is three days after the first infection. This requires more than **12 samples** to be taken **daily** or 28 every two days.

- In the 2001 UK outbreak, the intervals between first infection and detection has been estimated to have a mean of **8 days**. Our results indicate that a reasonable sampling strategy (e.g., 5 samples every 4 days) would detect infected farms more quickly.

- Even if inspections are frequent, multiple samples must be taken to have a good chance of early detection.

- The proportion of infectiousness that occurs before detection can be as low as 0.1 or as high as 0.7. This reveals the potential for **between-farm transmission** and how it can be reduced.

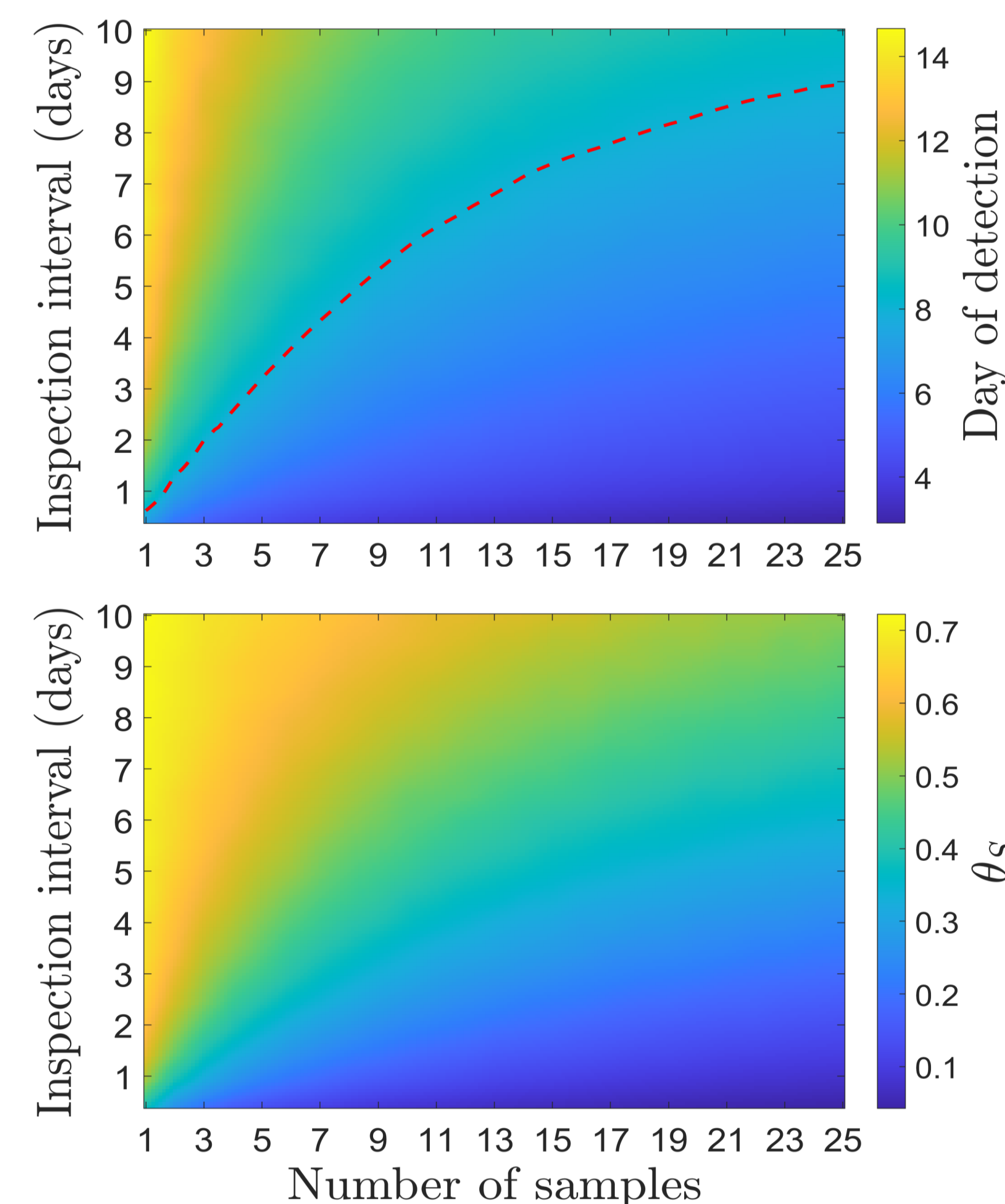- **Environmental sampling can be an effective strategy for detection of FMDV during an outbreak.**