Analysis of spatial clustering of foot-and-mouth disease outbreaks in Brazil in 2005

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Abstract

In the southern region of the State of Mato Grosso do Sul, Brazil, a FMD (foot-and-mouth disease) epidemic started on September 2005. A total of 33 outbreaks have been detected and 33,741 FMD-susceptible animals have been slaughtered and destroyed. There have been no reports of cases in species other than bovines. Based on the data of this epidemic, we carried out an analysis using the *K*-function and we observed spatial clustering of outbreaks within a range of about 25 km. This observation may be related to the dynamics of spread of foot-and-mouth disease and to the measures undertaken to control disease dissemination. The control measures were effective once the disease did not spread to farms more than 47 km apart from the initial outbreaks.

Introduction

In the southern region of the State of Mato Grosso do Sul, Brazil, a FMD epidemic started on 26 September 2005. A total of 33 outbreaks were detected until November 2005 and 33,741 FMD-susceptible animals (32,549 cattle, 566 pigs, 626 sheep and goats) were slaughtered and destroyed (OIE, 2006). There have been no reports of cases in species other than bovines. Several control measures – quarantine, movement control inside the country, screening, zoning, stamping out and disinfection of infected premises – were undertaken. In this work, we carry out an analysis of spatial clustering of disease based on the data of this FMD epidemic.

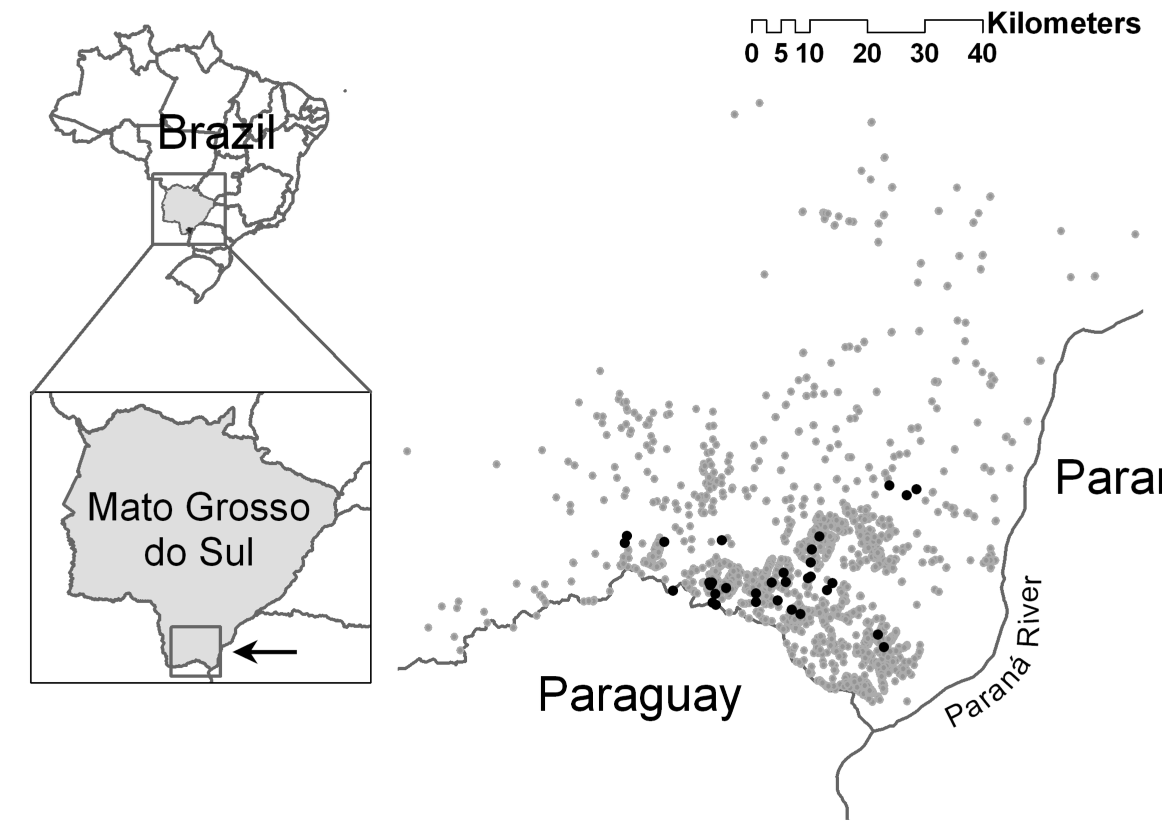

Figure 1 - Map of the Brazilian region where a FMD epidemic was reported in 2005. The outbreaks (cases) and the other premises (controls) within the surveillance area are indicated, respectively, by black and grey dots.

Methods

To test the hypothesis of spatial clustering of disease outbreaks, we performed an analysis using the *K*-function. The *K*-function is defined as the expected number of further points within a distance *s* of an arbitrary point, divided by the overall intensity of the points (Rowlingson and Diggle, 1993).

Surveillance activities were carried out in municipalities of the southern region of the State of Mato Grosso do Sul (Figure 1). For simplicity, the premises within this area in which FMD cases were detected will be called *cases*, whereas the remaining premises will be called *controls*. The total number of controls was 2134.

Estimates of the *K*-functions were computed for the cases ($K_{case}(s)$) and the controls ($K_{control}(s)$). The function *D(s)*, defined by

$$D(s) = K_{case}(s) - K_{control}(s),$$

was also estimated. Positive values of *D(s)* represent spatial aggregation of cases above the degree of spatial aggregation of controls attributable to environmental inhomogeneity. Thus, significantly positive values of *D*(*s*) would constitute evidence of spatial clustering of FMD.

The function *D(s)* and the 95% confidence envelope were calculated using the Splancs library (Rowlingson and Diggle, 1993) in R statistical package version 2.3.0 (R Development Core Team).

Results

Figure 2 shows the function $D(s)= K_{case}(s)- K_{control}(s)$. Within a range of about 25 km, the values of *D(s)* are above the upper limit of the 95% confidence envelope, indicating that cases are more spatially clustered than controls. This result may be related to the dynamics of spread of FMD and to the intervention to control the disease dissemination.

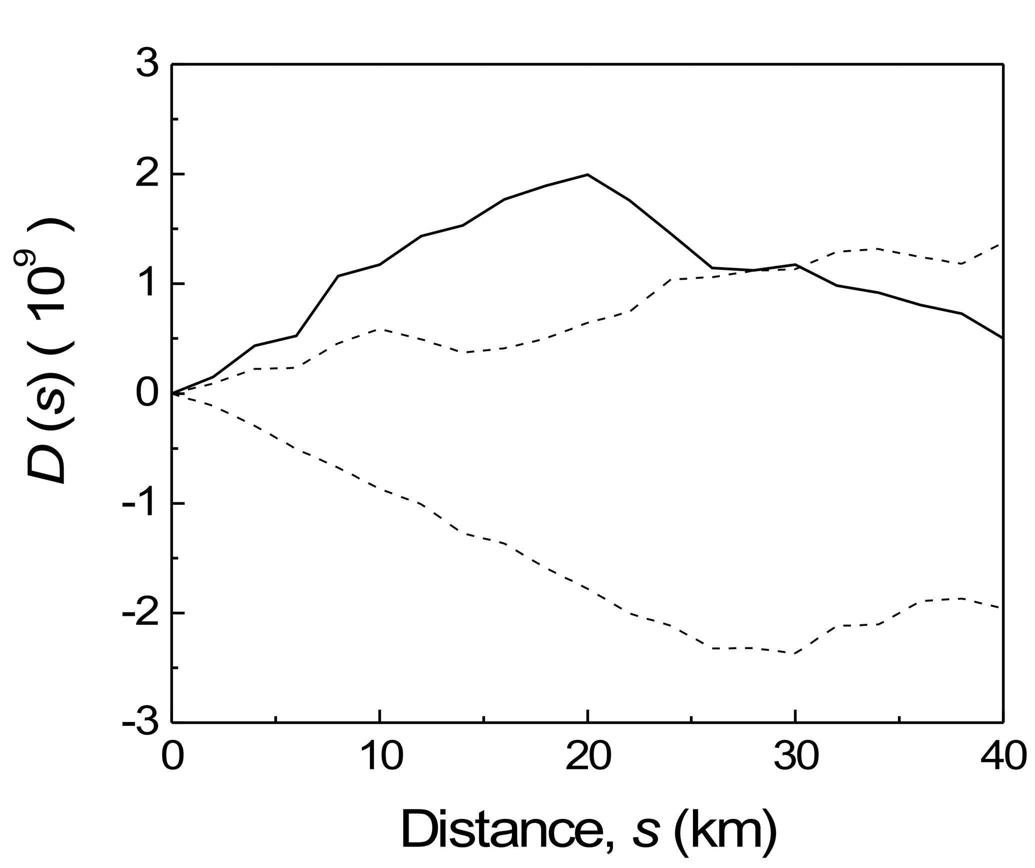

Figure 2 - *K*-function difference, *D(s)*, as a function of the distance *s* (solid line) and 95% confidence envelope (dashed lines) for the FMD cluster analysis.

Discussion

The control measures were effective once the disease did not spread to farms more than 47 km (maximum distance between two outbreaks) apart from the initial outbreaks. The identification of disease clustering in this case shows that a rapid and efficient intervention can avoid the dissemination of FMD.

The spatial clustering observed may also be related to the epidemic nature of the FMD cases in the State of Mato Grosso do Sul. In the case of an endemic disease, a homogeneous spatial pattern would be expected, without clustering of disease.

Although the sources of the outbreaks are unknown according to the follow-up reports (OIE, 2005b and previous reports), factors related to the movement of animals, vehicles and people have probably contributed to the disease dissemination.

Ferreira (2000) estimated, for a FMD epidemic that occurred in 1990 in the State of Santa Catarina, Brazil, a minimum speed of propagation of approximately 1.36 km per day. We found that the first and the twenty-second notified outbreaks − located at the boundary of the infected area, but in opposite sides − were 45 km apart from each other, and were detected with a time-lag of 36 days. Dividing these figures, we obtain a rough estimate of 1.25 km per day for the speed of propagation, similar to the speed estimated by Ferreira (2000).

References

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