Cattle trade network in Madagascar Highlands and diffusion of Rift Valley Fever virus

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Introduction

In 2008-2009 a RVF outbreak occurred in the Anjozorobe area, a temperate and mountainous area located in Madagascar highlands [1]. In 2009, a serological study conducted in individually identified bovines from this relatively closed area (main channel of communication with the outside by Anjozorobe in west and Alaotra Lake in north-east, through rainforest) showed an IgG seroprevalence rate of 28%. Data analysis suggested a recurrent circulation of RVFV in the area [1]. The objectives of this study were to describe and analyse the cattle trade network in the Anjozorobe area and to assess the potential link between network structure and RVFV circulation.

Data

Trade data:

Questionnaire survey (February to July 2009)

→ breeding practice and data on environment of cattle.

→ trade data (e.g., origin and/or destination of cattle, frequencies of activity, number of cattle treated in each transaction).

Social network analysis method [2] = to describe and analyse trading networks [3].

Serological data:

Disease prevalence (2009) and annual intra-village incidence rate (2009-2010)

→ 2009: blood sampling on cattle in each village of the commune.

→ 2010: blood sampling on cattle negative in 2009

Statistical analysis:

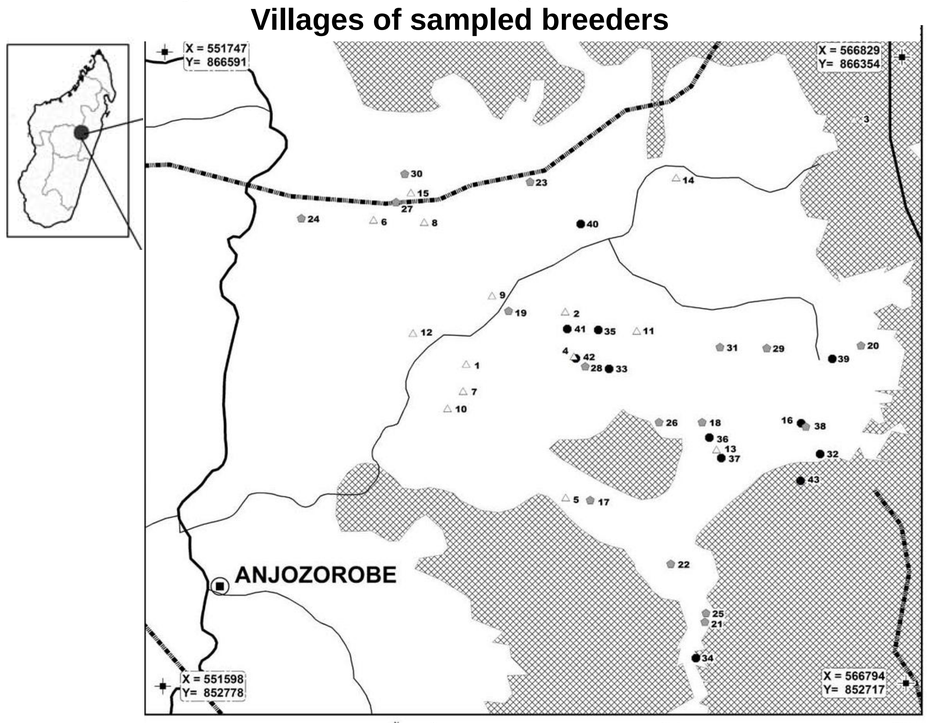
1. Computation of centrality parameters (*i.e.,* degree, indegree, outdegree ...)

2. Multivariate analysis (generalized linear model) : to study the association between the occurrence of seroconversion, centrality parameters, distance of village to the nearest water point [1]) and the seroprevalence level in 2009 (i.e. the level of herd immunity).

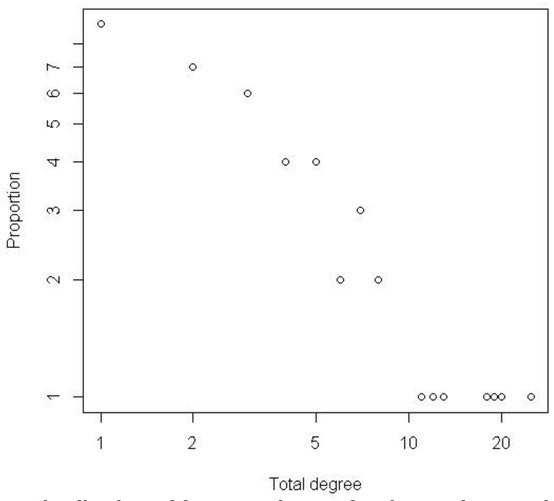
Non-independence of the observations (villages are linked together in a trade network)

→ bootstrap procedure used to assess the effects of the explicative variables.

Study area location: Ambongamarina Commune
Villages of sampled breeders



Results



Distribution of freeman degree for the total network (log-log scale)

Trade data:

Questionnaire survey = 389 breeders from 47 of the 52 villages of the Anjozorobe area.

2 types of cattle movements observed: exchanges and buy/sale → 2 networks built and analyzed.

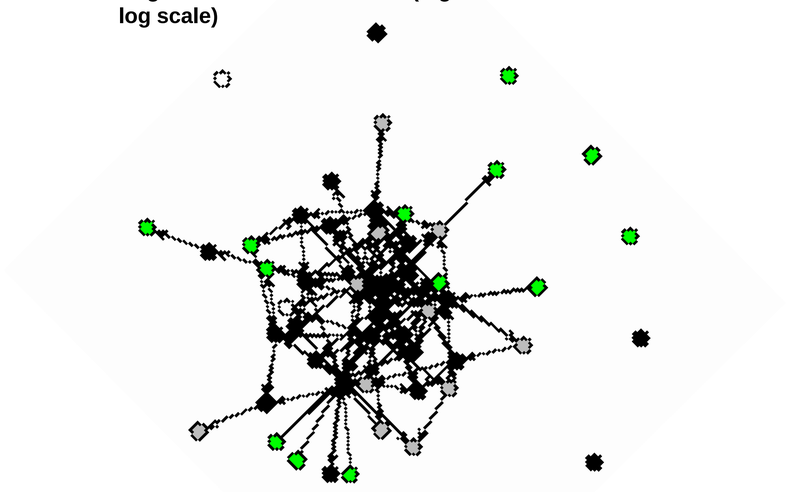
→ Degree distribution = scale-free networks with a high degree of heterogeneity.

→ Significant but low correlation observed between the two networks (0.16, p<0.0001).

Serological data:

- 484 bovines, seronegative in 2009, were sampled again in 2010
- Average annual intra-village incidence rate of 7%, ranging from 0% to 20%

→ I=0 for 1/3 of Villages.



Nodes = Villages; Arcs = Cattle movements
Black: Villages where Incidence > 0 & Infected.1stYear > 0; White: Villages where Incidence = 0 & Infected.1stYear = 0; Red: Villages where Incidence > 0 & Infected.1stYear = 0; Grey: Villages where Incidence = 0 & Infected.1stYear > 0; Green: Villages without data of incidence

Structure of the total trading network of cattle in the Ambongamarina Commune. Madagascar.

Statistical analysis:

Occurrence of seroconversion

- POSITIVE ASSOCIATION
  - freeman degree of Exchanges (p = 0,069*)
- NO ASSOCIATION
  - freeman degree of Buy/Sale (p = 0,477)
- NEGATIVE ASSOCIATION
  - Distance to the nearest water point (p = 0,033*)
  - Village-level seroprevalence in 2009 *(herd immunity)* (p = 0,093*)

Conclusion

The degree distributions suggest that the two studied networks could be formed by a preferential attachment mechanism, due to the better reputation of some breeders or villages. Results show that the exchanges network could be the support for RVFV introduction in villages, the buy/sale network being probably rather implicated in the introduction of RVFV in the area, from other parts of Madagascar. Finally, the negative effect of the distance to the nearest water point suggests that, after the virus has been introduced in a village, vector-based transmission is a support for the local (within-village) circulation of RVFV.

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