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Implications of the cattle trade network in Cameroon for regional disease prevention and control

Background: The patterns of contacts in populations are a central driver of disease dynamics, therefore, understanding the architecture of livestock movements is key for more cost-effective infectious diseases surveillance and control. Trading points represent a strategic contact node in livestock movements. Here we present a study of the current cattle trading network in Cameroon identifying key livestock markets and connections and quantifying their impact in manipulating the network structure.

Approach:

•Targeted and a snowball sampling identified 63 livestock markets across 6 Regions of Cameroon;

•Official records and a questionnaire based survey for the period between Sept 2013➔Aug 2014 allowed to identify 127 connected markets from 6 different countries (Fig.1);

•Social network analysis, including "key-actors analysis"[1], were applied to a static yearly network;

•Network resilience and fragility were assessed through a percolation approach.

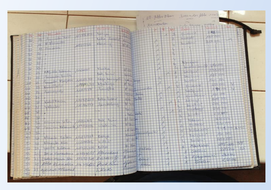


Fig. 1. Markets records, official reports at a livestock market in Cameroon

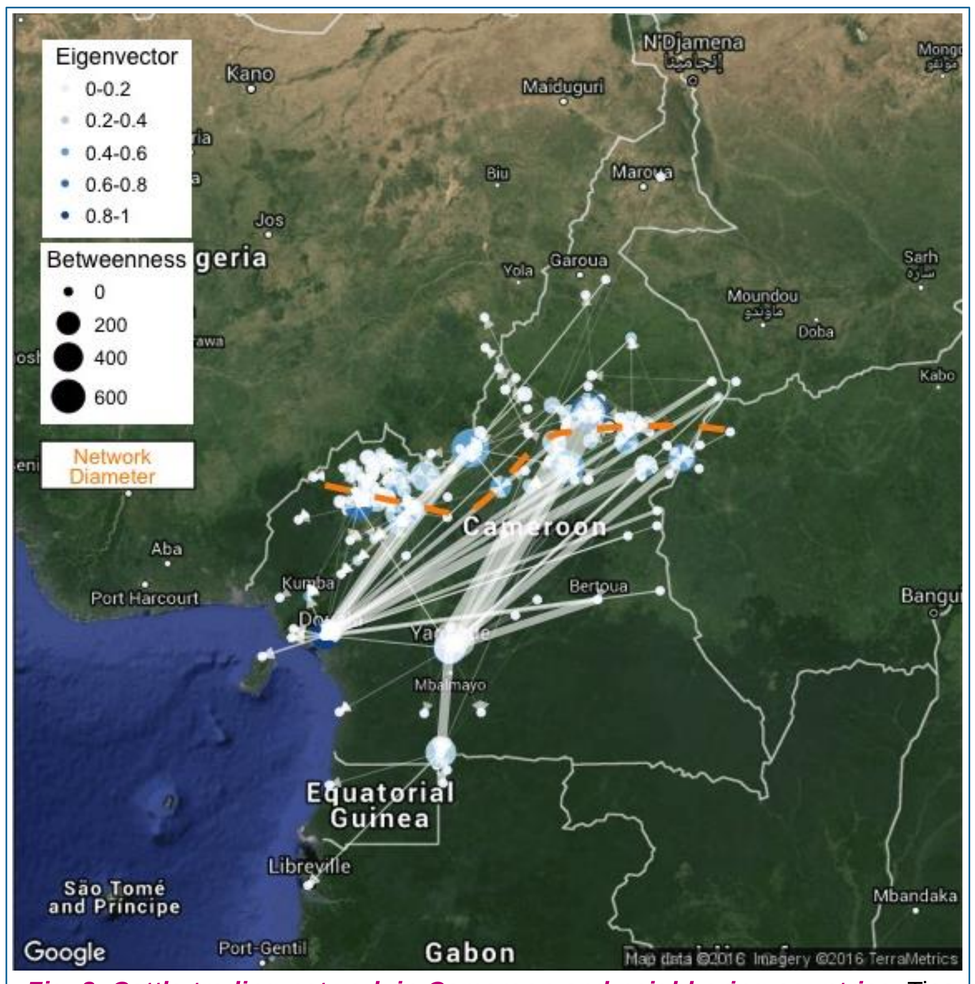


Fig. 2. Cattle trading network in Cameroon and neighboring countries. Ties show the direction of the cattle movement and the volume of traded animals. The orange dotted line shows the path of the network diameter crossing the trading network from East to West.

Key Findings:

- Low reciprocity (15.5%) and the negative degree of assortativity (-0.06) revealed a sequential flow of cattle through the trading system;
- The network diameter (= 8) showed a direct cross border path for the rapid spread of infectious agents (Fig.2);
- Key actors analysis revealed different functional roles of the central markets within the network (Fig.3);
- Targeted removal of markets regarding their centrality measures (particularly betweenness, in-degree, eigenvector) and key actor analysis regressions values (bet~eig) showed to be more effective than a random approach in fragmenting both the weak and strong largest components (Fig.4);
- Interruptions on markets connections was a valuable alternative to market removal only in the early stages of disruption of the largest strong component (Fig.4).

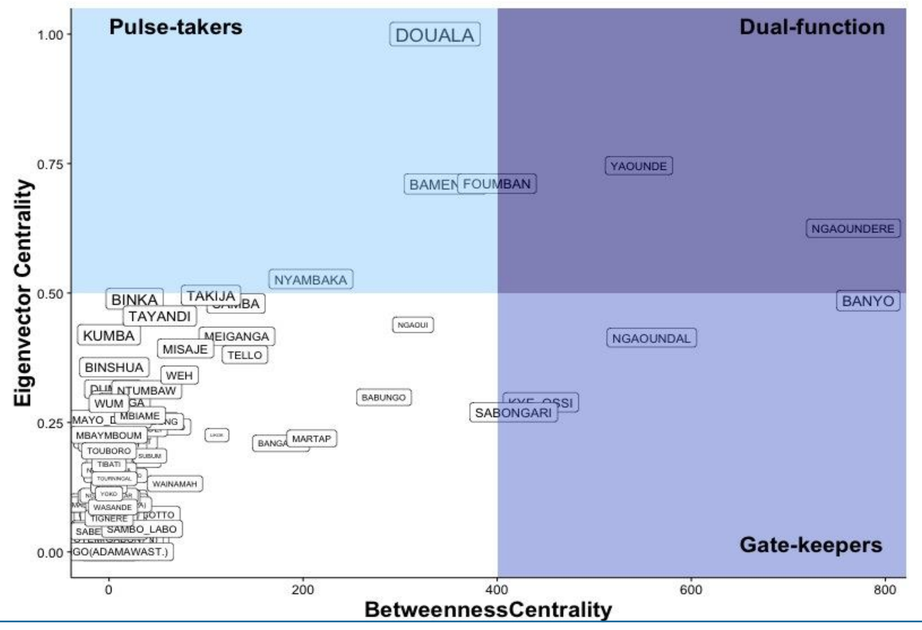


Fig. 3. Key-actors analysis.

Correlation and regression analysis between betweenness centrality and eigenvector centrality is identifying markets with different roles in the trading network:

- bottom-right quadrant: central markets for their ability to make connections to isolated areas of the network;
- top-left quadrant: the markets having the shortest paths to other central markets;
- top-right quadrant: nodes displaying both abilities.

The size of the labels is given by their residuals obtained through linear regression of betweenness centrality over eigenvector centrality, indicating the extent of their deviation from a linear relation.

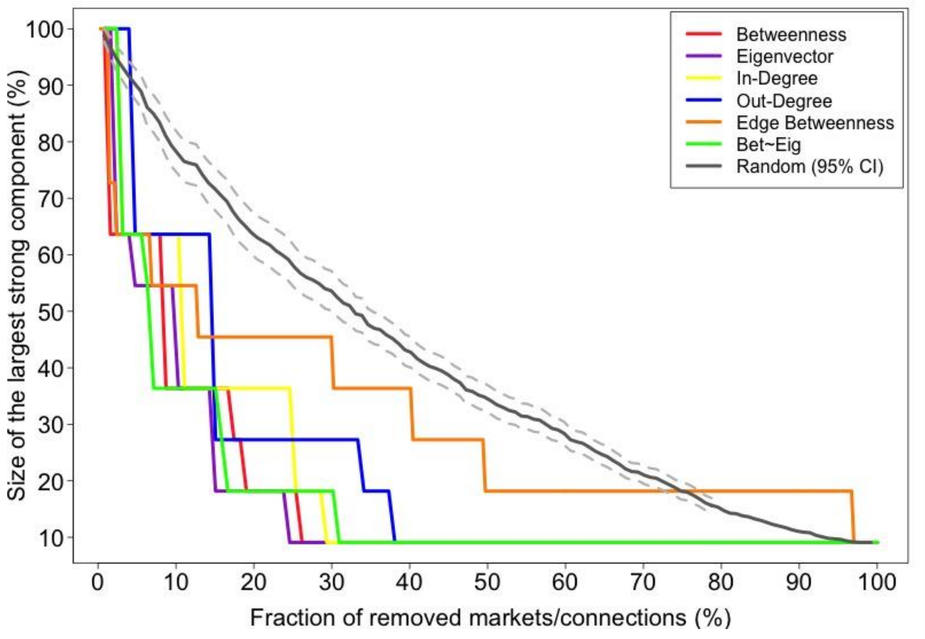
Fig.4 Effectiveness of targeted removal of markets and connections.

Size of the largest strong component over the fraction of removed:

a)Markets regarding their scores of centrality parameters (betweenness centrality, eigenvector centrality, in- and out-degree) and the residual from the "key actor" analysis;

b)Connections regarding their scores of edge betweenness;

c)Random removal of markets over 1000 simulations is showed with the mean value (dark grey line) and its 95% CI (grey dotted lines).



Conclusions: This first attempt to understand the influence of cattle trade on infectious diseases' spread in the Cameroon shows that:

•Large geographical distances and national borders do not present a barrier to the dissemination of infectious agents

•Targeting key markets and trading connections would enable more cost-effective control, surveillance and communication strategies

1. Conway, D. (2009) 'Social Network Analysis in R' URL http://blog.revolutionanalytics.com/2009/08/social-network-analysis-in-r.html [accessed March 2016]

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