Faculty of Agricultural and Nutritional Science

Christian-Albrechts-University Kiel

Institute of Animal Breeding and Husbandry

NETWORK ANALYSIS

Interruption of the chain of infection by removal of the most central premises

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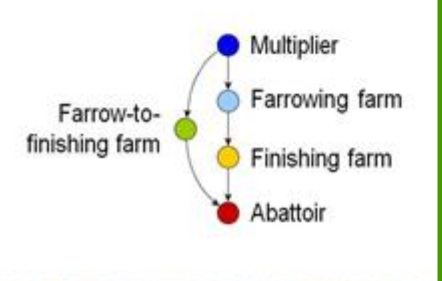
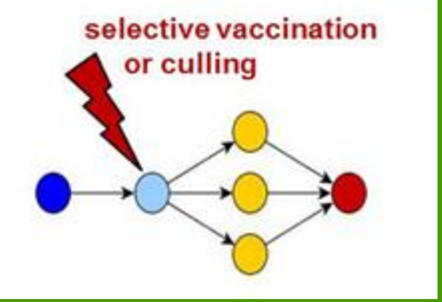
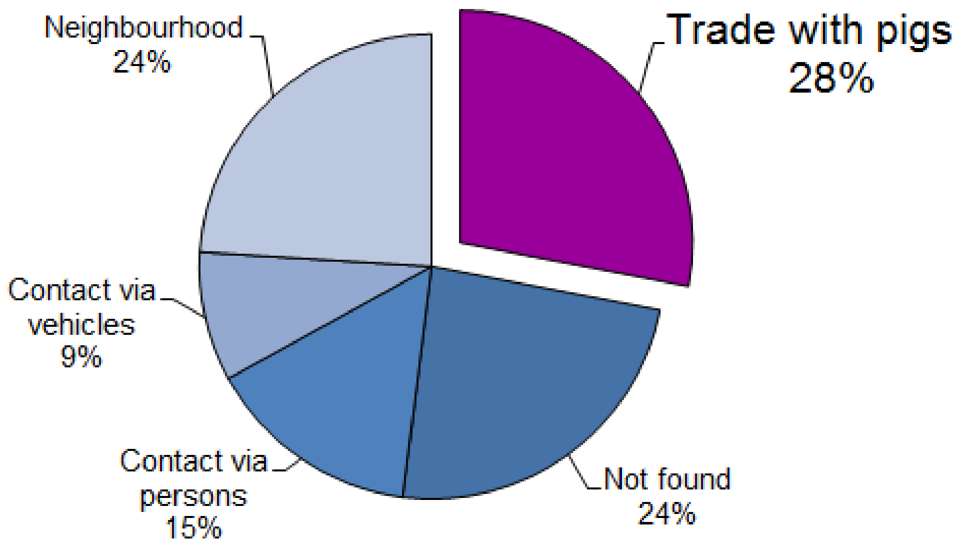




Introduction

- Animal diseases like classical swine fever cause extensive economic losses in the livestock industry
- The transport of live animals is a major risk factor for the spread of infectious diseases
- Source of classical swine fever virus infection in German domestic pig herds from 1993 – 1998



Secondary & follow-up outbreaks

(Fritzemeier et al., 2000)

Introduction

- To interrupt the chain of infection during an epidemic it is important to know the underlying structure of trade networks
- **Network analysis**
  - Characterisation of network topology
  - Detection of central or important farms in the network

Introduction

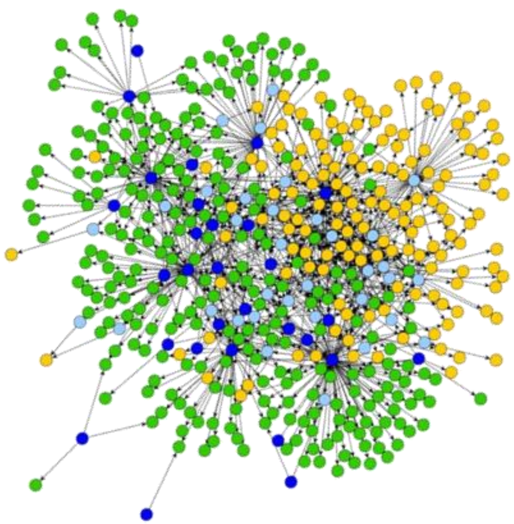
- To interrupt the chain of infection during an epidemic it is important to know the underlying structure of trade networks
- **Network analysis**
  - Characterisation of network topology
  - Detection of central or important farms in the network

- **Aim of the study**
  - To characterize the changes in the network topology by successive removal of the most central farms in the trade network
  - To evaluate which centrality parameter is the most suitable measure for a rapid fragmentation of the trade network

  ➢ **Interruption of the chain of infection**

Materials and methods – Data basis

- Trade network of the pork supply chain from a producer community in Northern Germany
- **Observation period:** June 2006 to May 2009
- **Transported livestock:** Piglets, pigs, sows and boars



483 farms

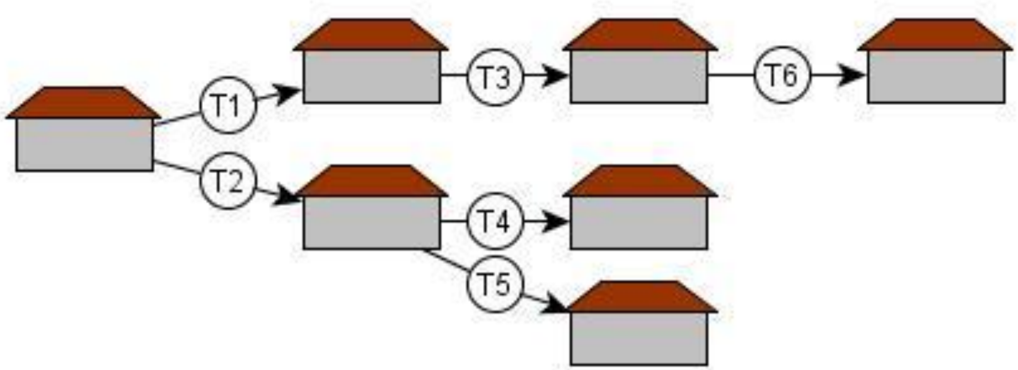
● (dark blue)	29	Multipliers
● (light blue)	34	Farrowing farms
● (yellow)	153	Finishing farms
● (green)	267	Farrow-to-finishing farms

926 trade contacts

- **Network properties:** Directed & static

Materials and methods – Centrality parameters

- **Degree:** Number of **direct** trade contacts
  - Ingoing trade contacts: **In-degree**
  - Outgoing trade contacts: **Out-degree**
- **Infection chain:** Number of **direct and indirect** trade contacts regarding the chronological order of the trade contacts
  - Ingoing trade contacts: **Ingoing infection chain**
  - Outgoing trade contacts: **Outgoing infection chain**

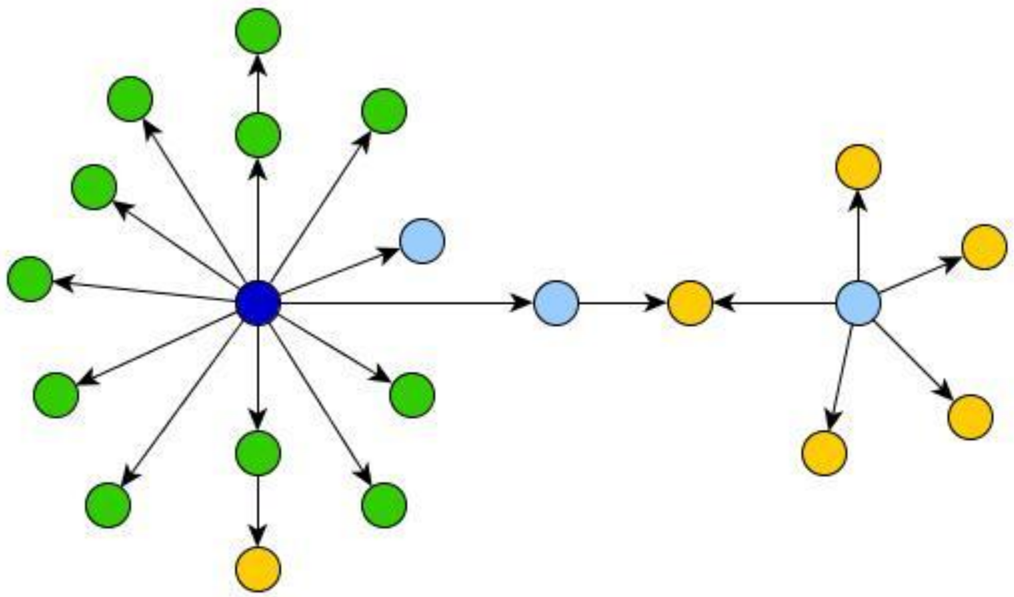


Materials and methods – Evaluation criteria

- **Components:** Two farms are part of the same component if they are connected by at least one path through the network
  - Number of components
  - Size of components

- **Fragmentation:** Number of components in relation to the number of farms in the network
  - Fragmentation = 0 (totally connected network)
  - Fragmentation = 1 (every farm is isolated)

Materials and methods – Example

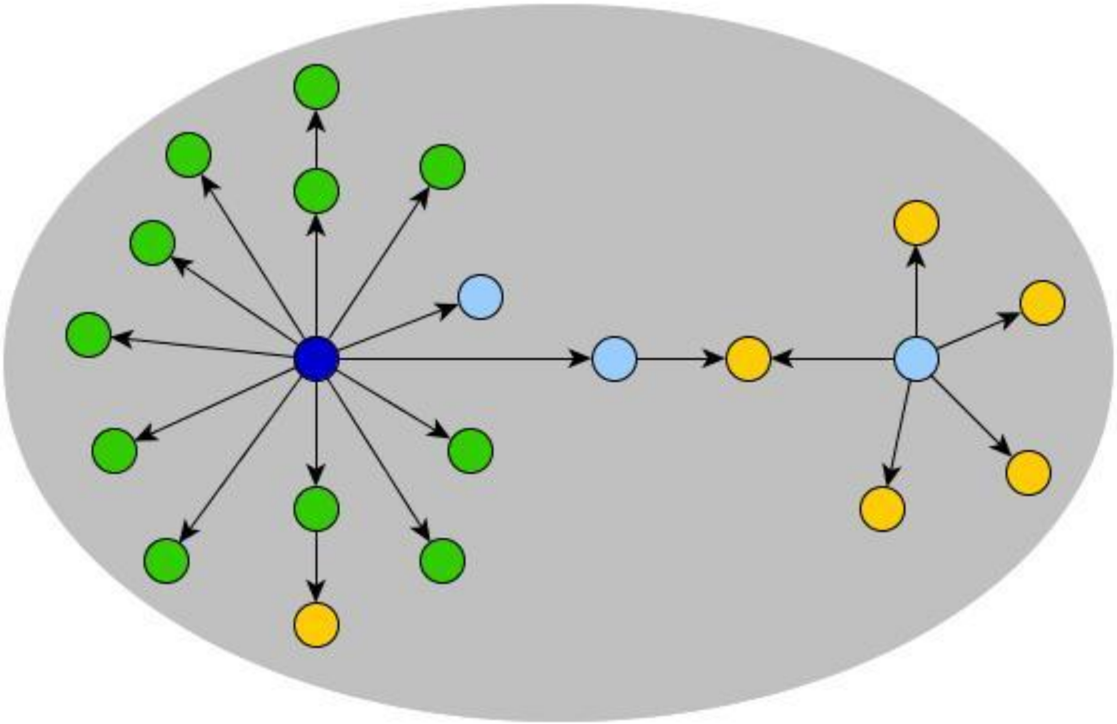


Number of components:

Size of largest component:

Fragmentation:

Materials and methods – Example

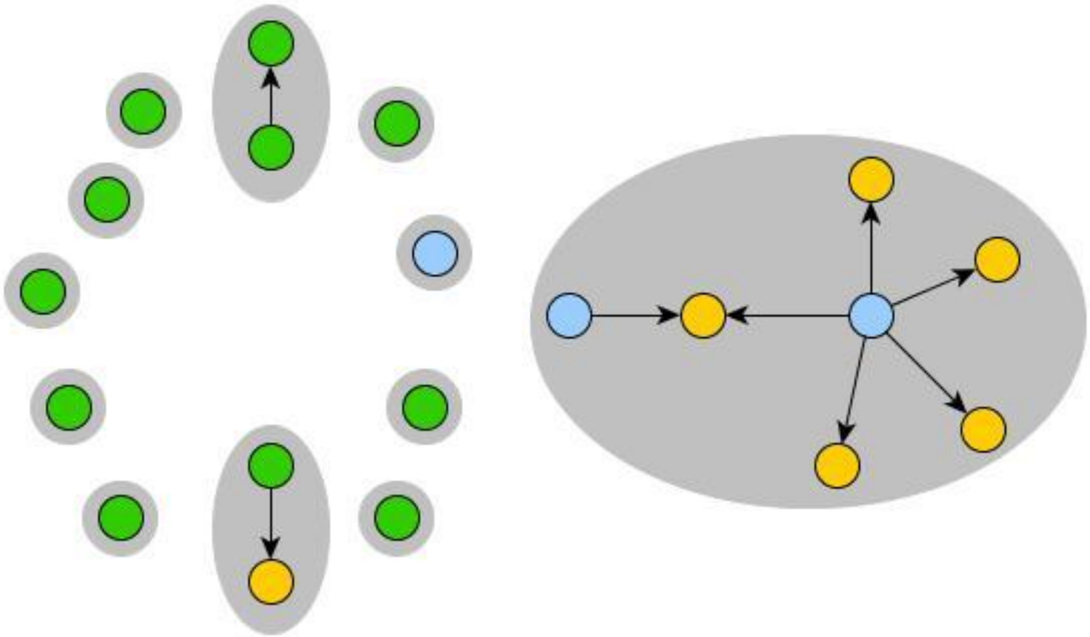


Number of components: 1

Size of largest component: 21 (100 %)

Fragmentation: 0

Materials and methods – Example

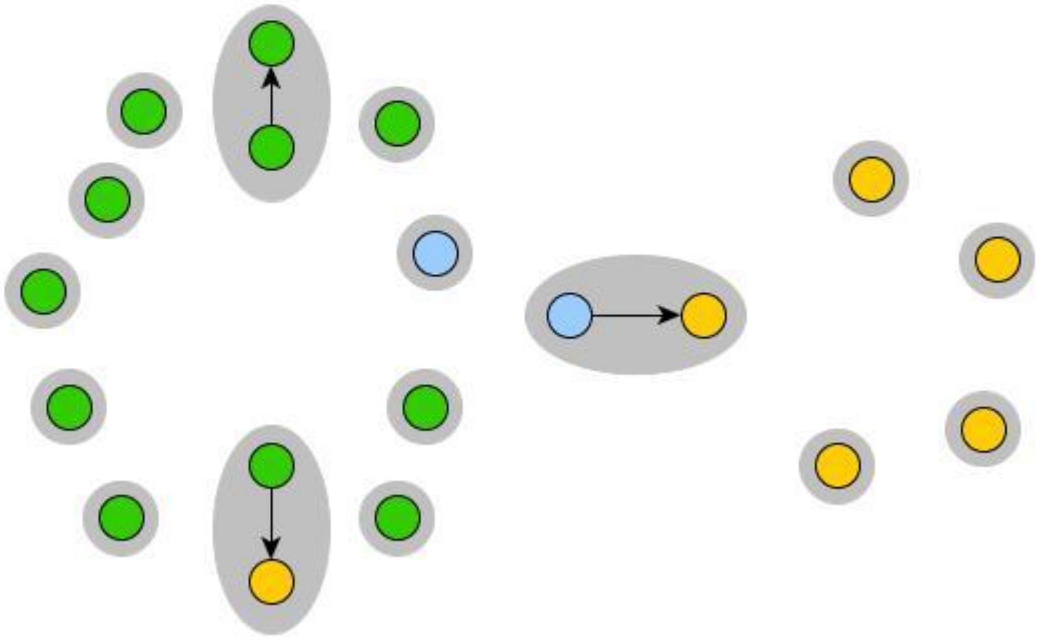


Number of components: 12

Size of largest component: 7 (33.3 %)

Fragmentation: 0.89

Materials and methods – Example



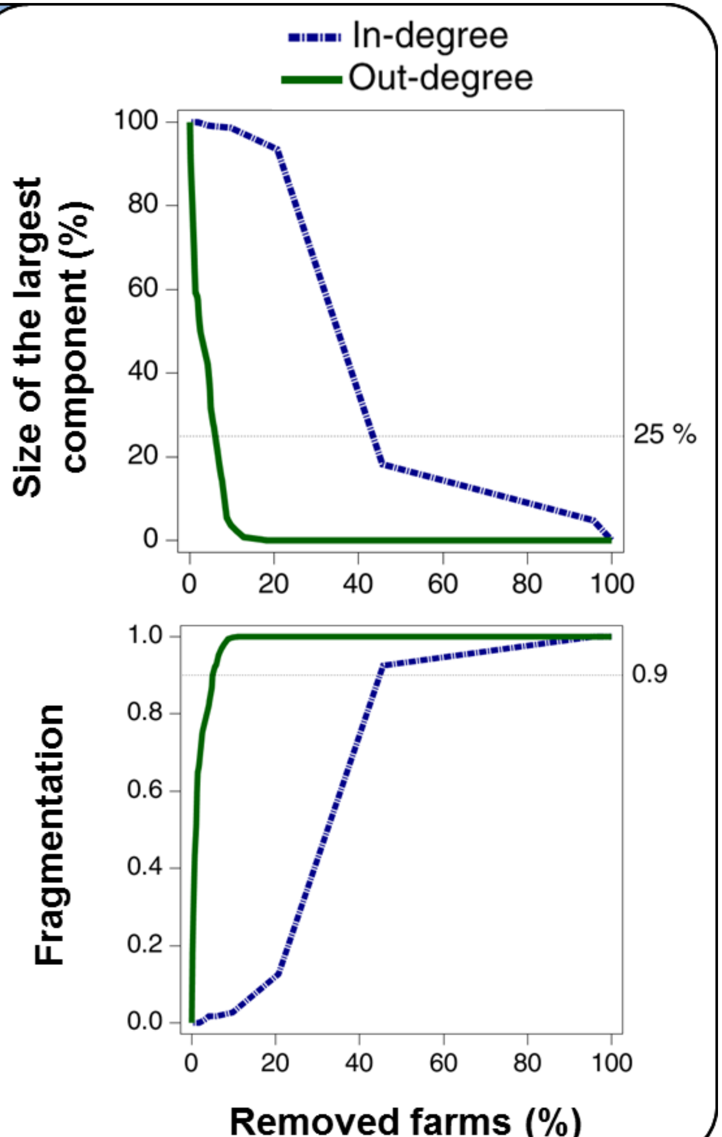
Number of components: 16

Size of largest component: 2 (9.5 %)

Fragmentation: 0.99

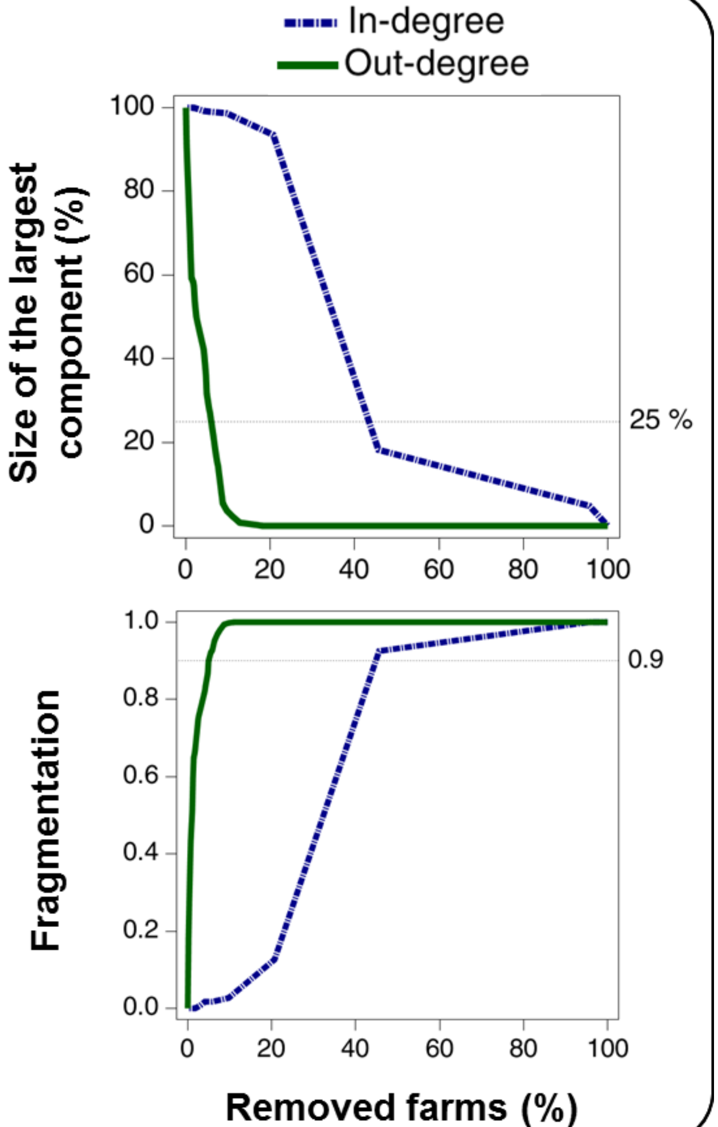
Removal by degree & infection chain

Degree



Removal by degree & infection chain

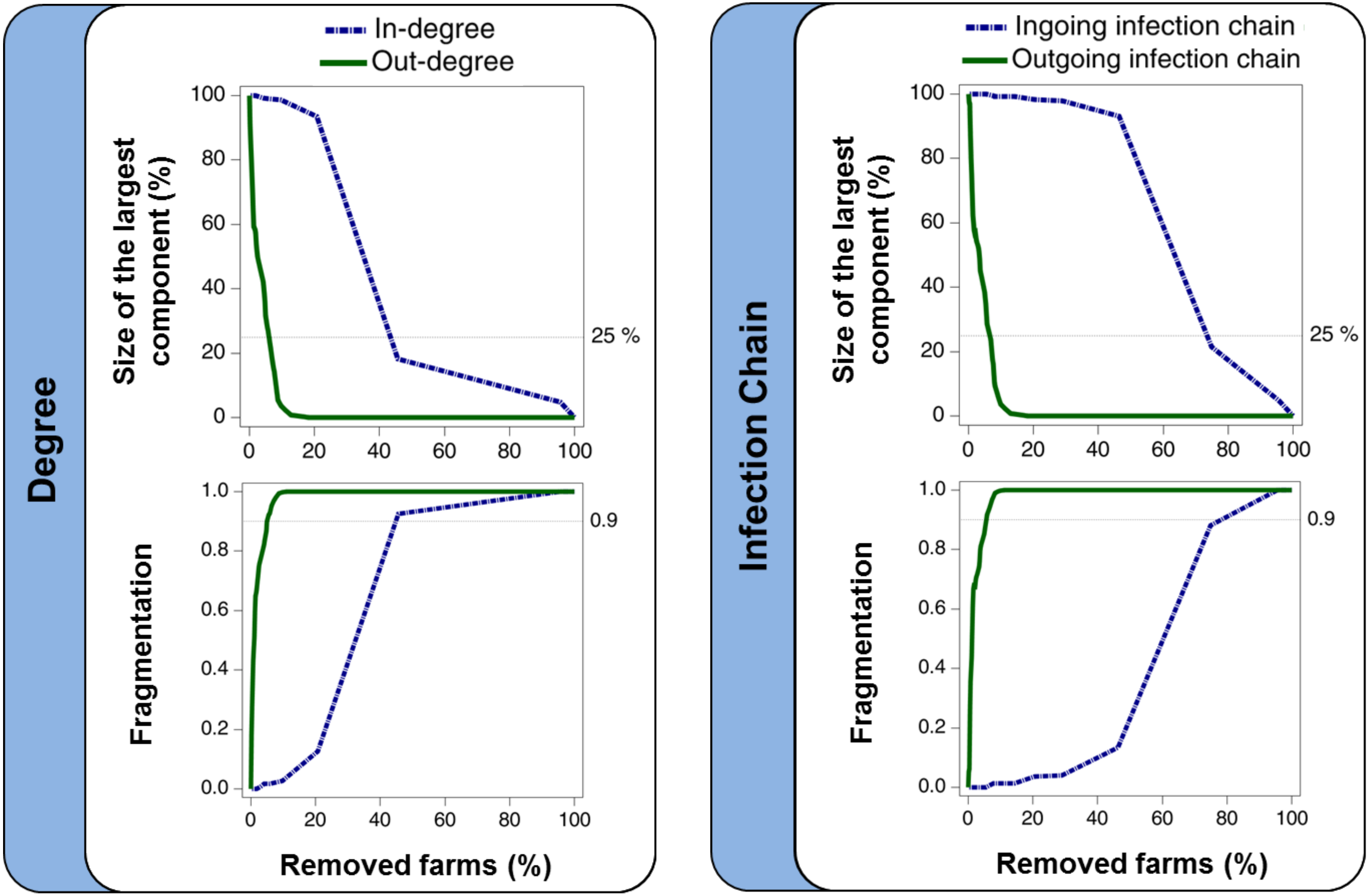
Degree



Reduction of the size of the largest component of more than 75%

Farm type	n	Number (Proportion) of removed farms	
		In-degree	Out-degree
Multiplier	29	5 (17.2%)	16 (55.2%)
Farrowing farm	34	24 (70.6%)	11 (32.4%)
Finishing farm	153	77 (50.3%)	-
Farrow-to-finishing farm	267	114 (42.7%)	4 (1.5%)
Total	**483**	**220 (45.5%)**	**31 (6.4%)**

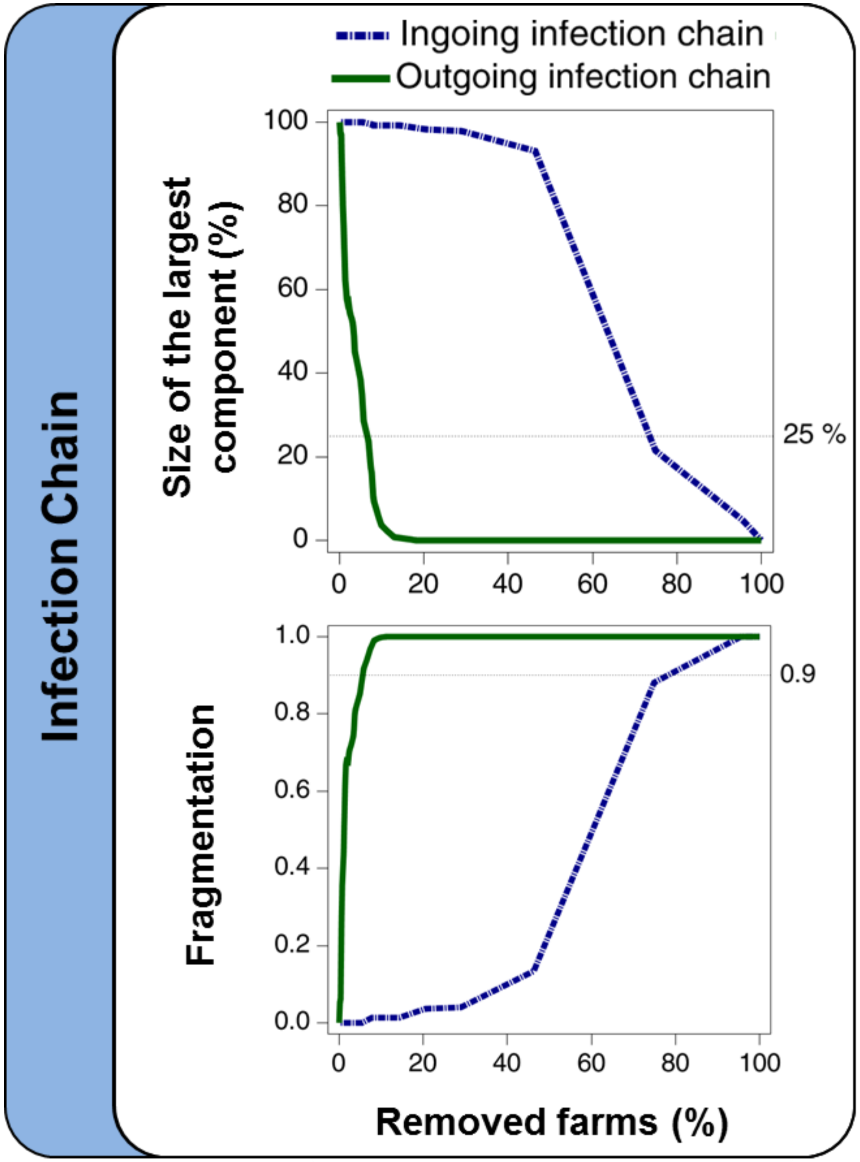
Removal by degree & infection chain



Removal by degree & infection chain

Reduction of the size of the largest component of more than 75%

Farm type	n	Number (Proportion) of removed farms	
		Ingoing infection chain	Outgoing infection chain
Multiplier	29	5 (17.2%)	18 (62.1%)
Farrowing farm	34	29 (85.3%)	9 (26.5%)
Finishing farm	153	129 (84.3%)	-
Farrow-to-finishing farm	267	199 (74.5%)	5 (1.9%)
Total	**483**	**362 (74.9%)**	**32 (6.6%)**



Conclusion

- The parameters regarding the ingoing contacts are not suitable for a rapid fragmentation of the trade network

- The successive removal of the most central premises regarding the parameters
  - **out-degree**
  - **outgoing infection chain**

  is an appropriate method to interrupt the chain of infection during an epidemic

- Only 6% of the farms have to be removed
  - to get a reduction of the largest component of more than 75%
  - to get a fragmentation of more than 0.9

DFG Deutsche Forschungsgemeinschaft

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