

# Analysis of poultry trading network and its implication for surveillance of avian influenza and Newcastle disease, Alaotra Lake Madagascar.

**Role of the trading network in the diffusion of Newcastle disease in the lake Alaotra region, Madagascar: a social network analysis.**

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# Context



## □ Poultry trading

- Renewal, sale, flows between different areas
  - Farmers, middlemen, live-birds markets, consumers (no slaughterhouse)
  - No regulation
- ➔ Considered as main source of disease spread (by farmers)
- ➔ Exploratory study: higher seroprevalences (AI, ND) associated with “many small markets”, “poultry/egg collectors”, ...



# Context

## ➤ Newcastle disease and avian influenza

- Considered as major avian diseases (especially ND)
- Avian influenza: threat since spread of H5N1 from Asia
- Available data (Porphyre, 1999; Maminiana et al, 2007; Rasamoelina-Andriamanivo et al, 2011)
  - ND: 44% of mortality, seroprevalence 60% [ CI<sub>95</sub> 57-63%]
  - Avian influenza (seroprevalence): 15% (*n*=204) of chickens and 3% (*n*=175) of domestic fowls; 9% [CI<sub>95</sub> 7-10%] (➔ 25% in Alaotra Lake) and no H5/H7

➔ Priority diseases (National veterinary services)

➔ Confounded in field because of similarities in clinical signs and epidemiology

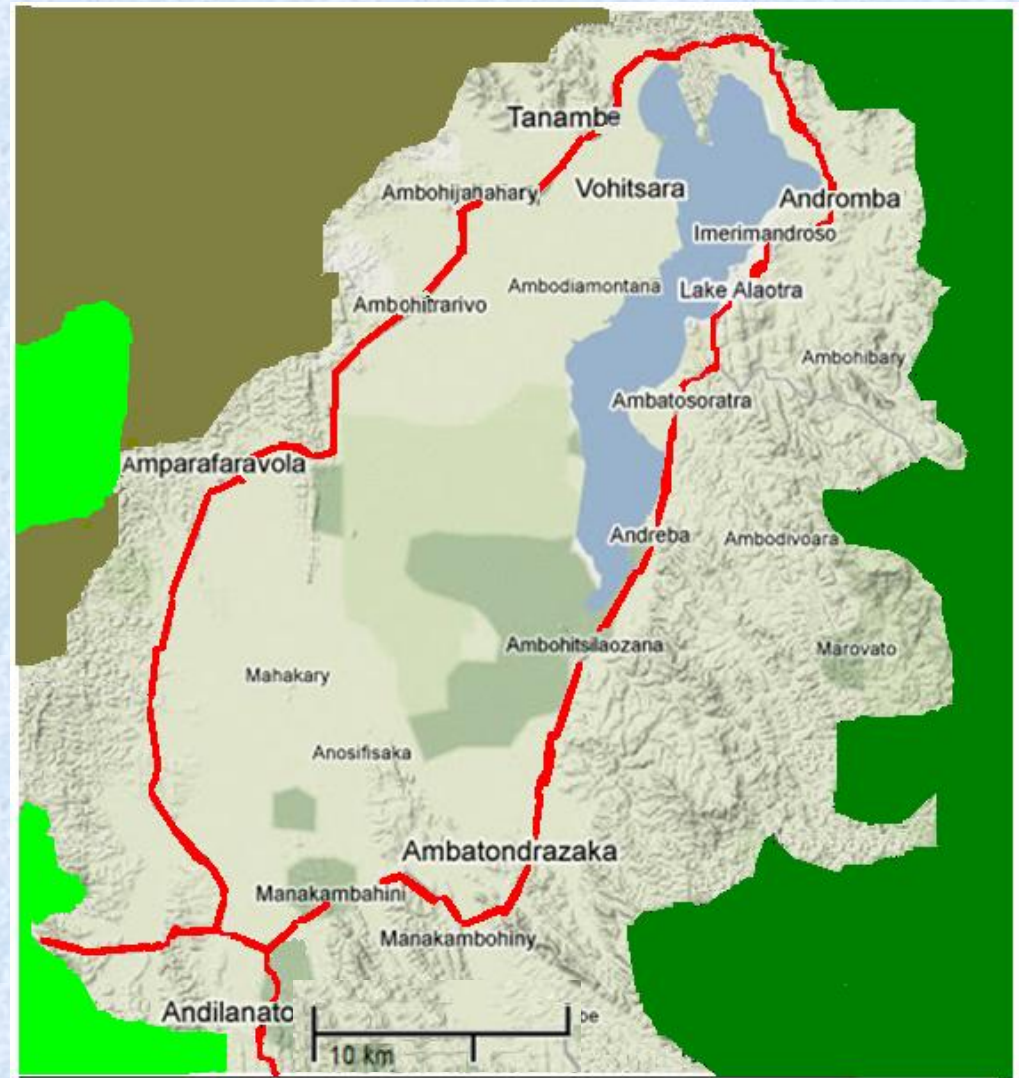
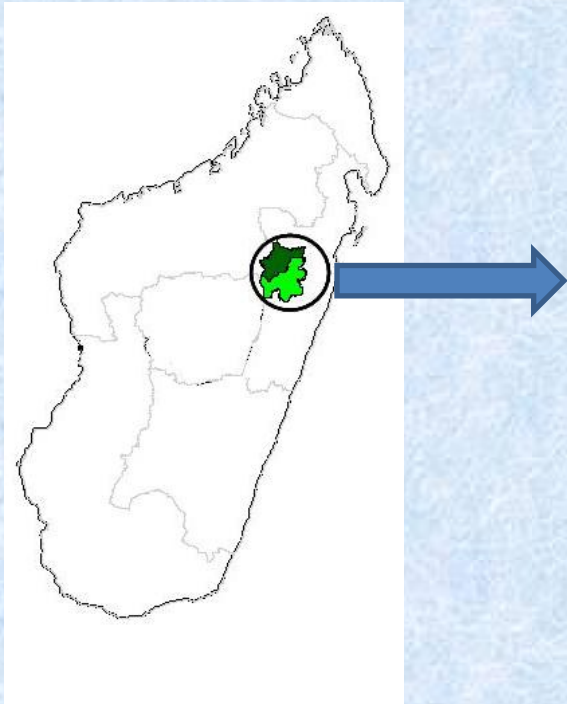
➔ Unknown relative importance (clinical incidence)

# Objectives

- Describe the poultry trade network
- Assess the potential role of its components and its structure in the diffusion of NDV and AIV
- Measure the relative importance of NDV and AIV in regular outbreaks in village poultry
- Assess the possibility to ameliorate surveillance

# Material and methods

## ➤ Study area: Lake Alaotra region



- Agricultural basin (rice paddy)
- Poultry farming and trading
- Goose production

# Material and methods

## ➤ Network data collection

- From December 2009 to December 2010
- 2 types of actors in the commercial network
  - villagers (farmers) → **Participatory-epidemiology surveys**
  - Middlemen and stallholders → **Cross-sectional survey**

## ➤ Disease occurrence

- Disease surveillance network (passive surveillance)
  - Field actors (CAHW, villages leaders): phone report
  - Mobile team: sampling ( sera, tracheal and cloacal swabs)
  - Lab analysis: Quantitative PCR
- Participatory surveillance
  - Report of all NCD suspicions (Dec 2009 to Dec 2010)
  - Validation if the description corresponded with outbreak definition

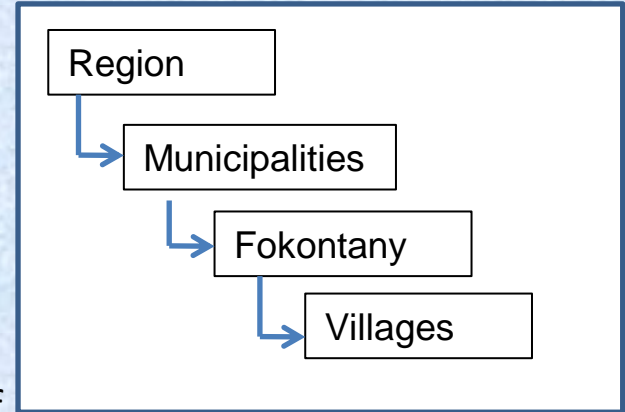
# Material and methods

## ➤ Data analysis

### ➔ Social network analysis

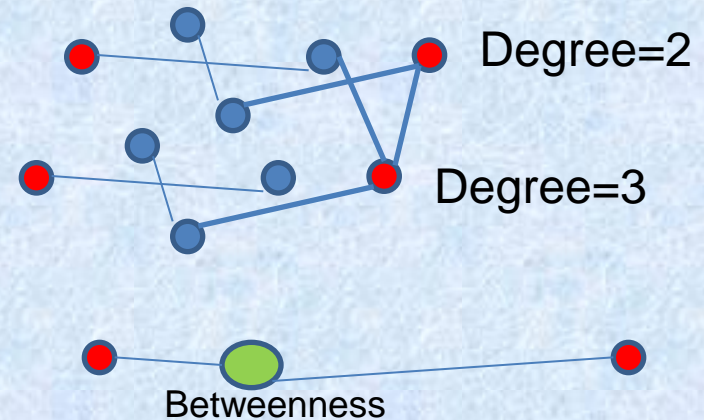
#### – Definition of network elements

- Nodes: Fokontany
- Ties: all birds trade which connected 2 nodes
- Attributes: presence of markets, occurrence of outbreak



#### – Description of network (network parameters and topology)

- Number of nodes and ties
- Distribution of degree
- Density
- Centrality measures (Degree, Random walk-betweenness)



# Material and methods

## ➤ Data analysis

### – Network and disease occurrence

- Yearly disease occurrence per Fokontany → Attribute of nodes
- Generalized linear model (Logistic Bernoulli model):
  - Disease occurrence =  $f(\text{Centrality measure})$
- Positional analysis (position within network)
  - Measure of structural equivalence with Euclidean distance
  - Partitioning: Hierarchical clustering → Classes of nodes
  - Comparison of number of nodes having outbreak among classes by a chi-squared test
  - Class description



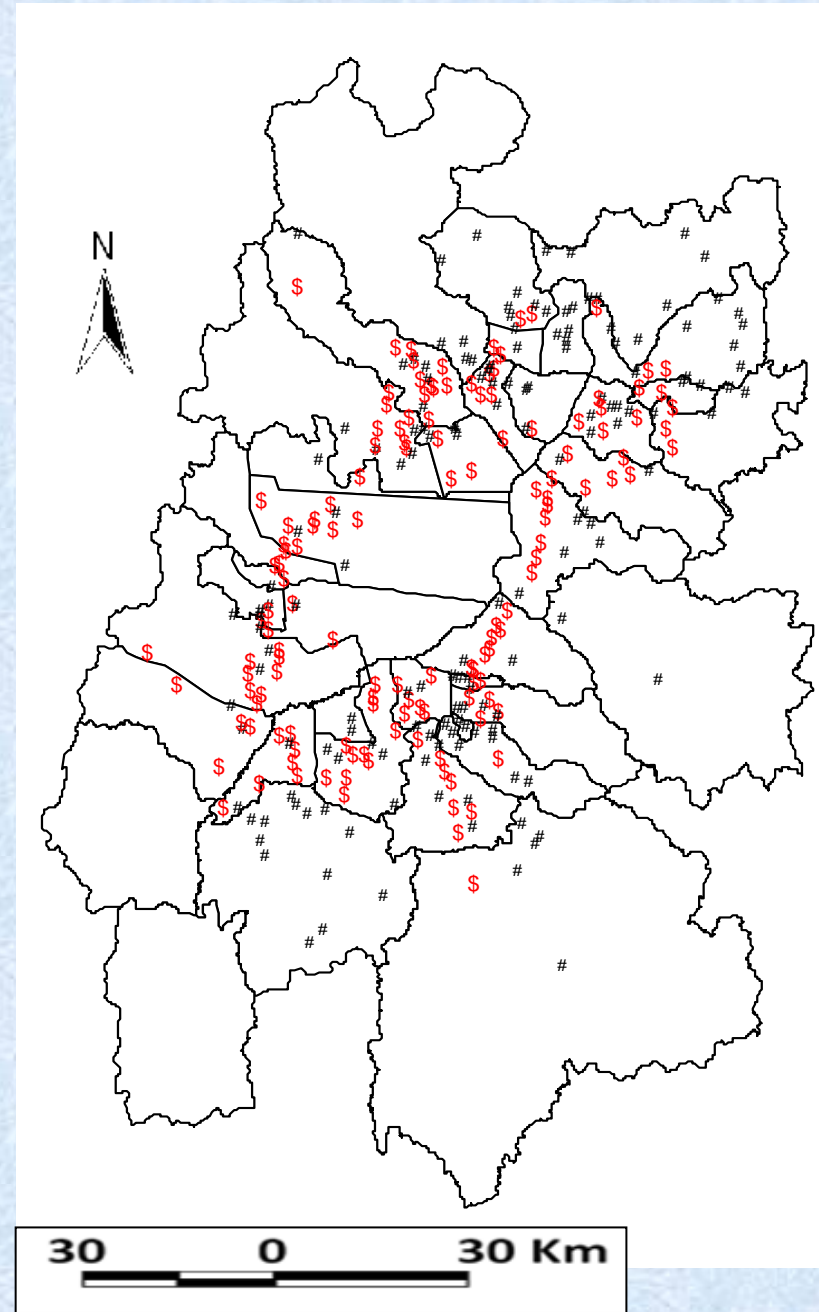
# Material and methods

- Toward targeted surveillance
  - ➔ highest probability of viruses circulation
    - Class(es) selection
      - Density matrix & Image matrix
    - Selection of nodes within the selected class(es)
      - Centrality parameter (Random walk betweenness)

# Results

## ➤ Data collected

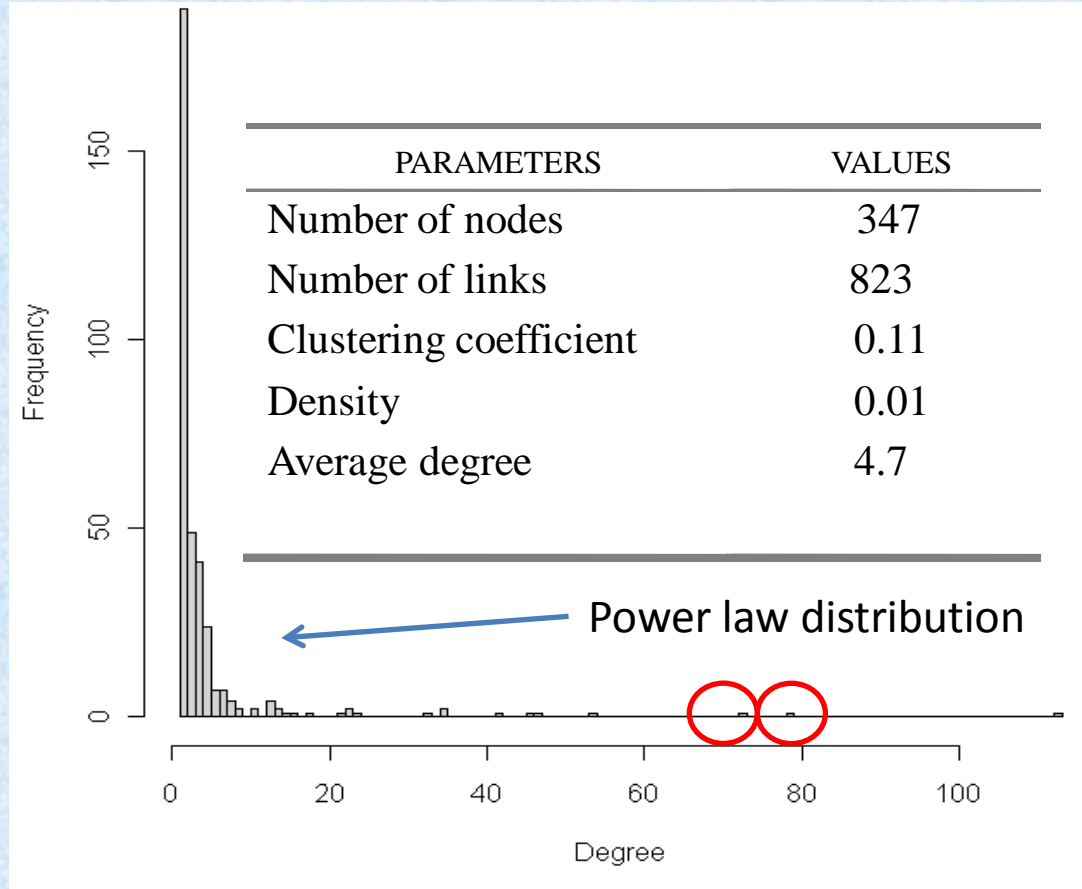
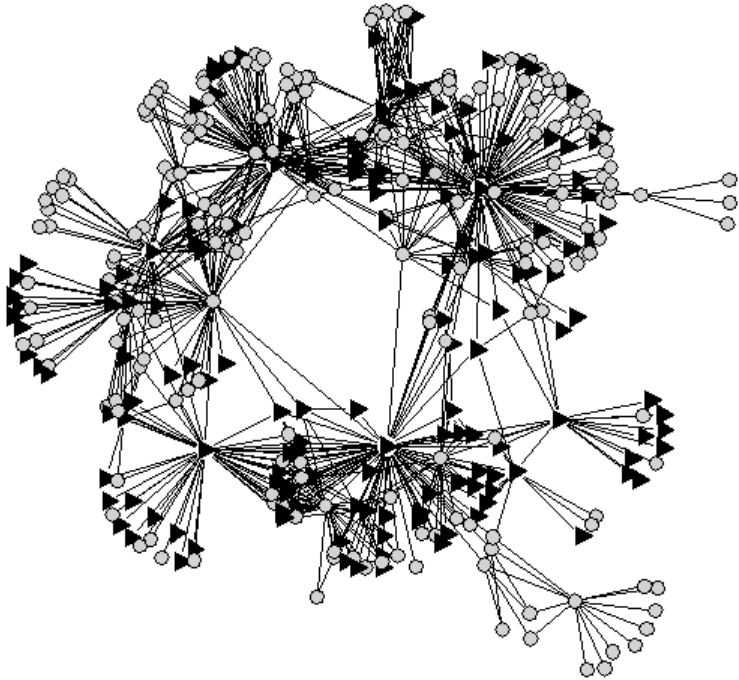
- Network actors
  - 40 CAHW and all Fokontany leaders in 35 municipalities
  - 231 professional traders from 21 markets and 20 collection points
- Diseases occurrence
  - Surveillance network:
    - 35 outbreaks detected
    - 84% due to NDV with 44% of mortality rate
    - No AI outbreak
  - Participatory surveillance:
    - 151 Fokontany with outbreaks (43% of nodes)



# Results

- Network parameters and topology

- Connected non-directed network
- Heterogeneous



➔ SCALE-FREE NETWORK

➔ Favourable for disease spread (Shirley, and Rushton 2005; Barthélemy et al 2004 & 2005)

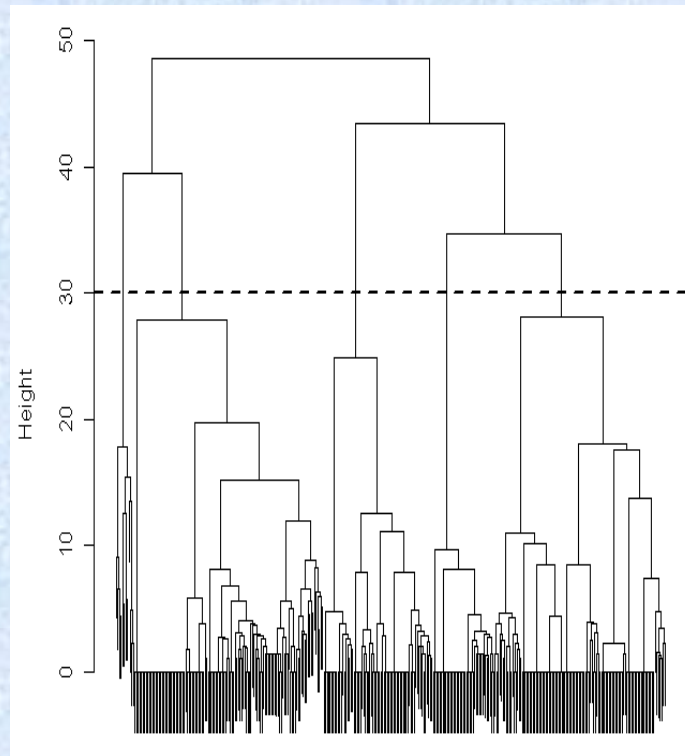
# Results

## □ Centrality measures and disease occurrence (GLM)

- Occurrence of outbreak associated with degree ( $p < 10^{-2}$ ) and Random walk betweenness ( $p = 0.01$ )

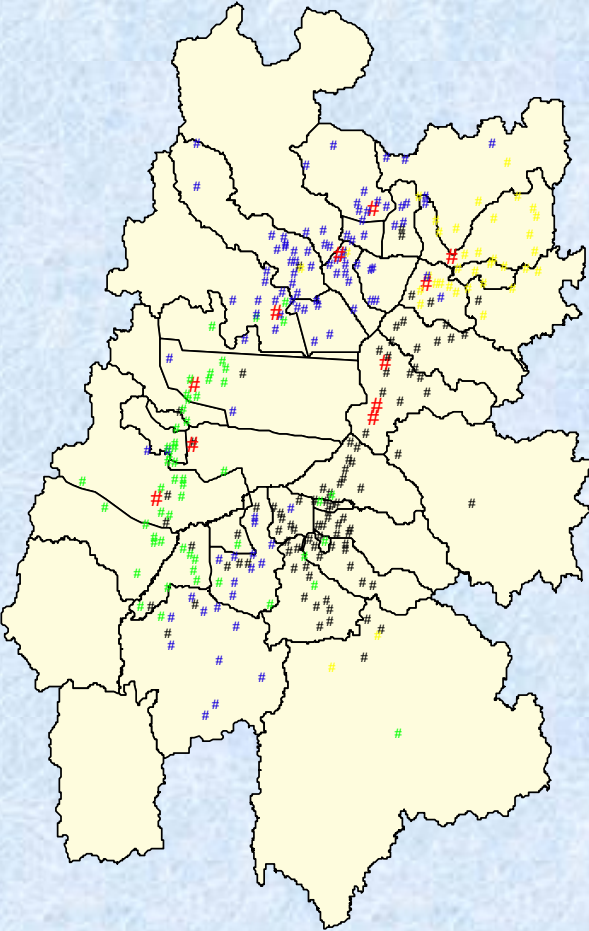
## □ Positional analysis and disease occurrence

- Hierarchical Clustering → 5 classes



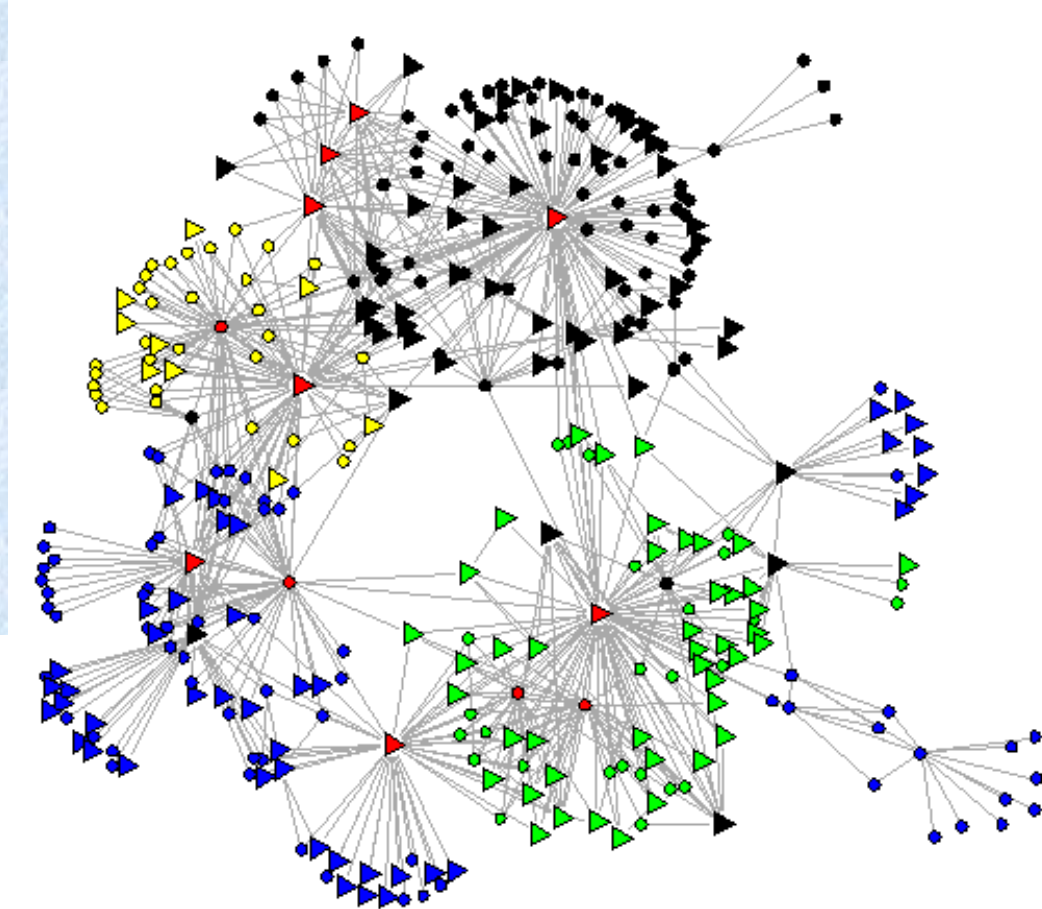
# Results

## Classes of nodes



- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

- ▵ Node with outbreak
- Node without outbreak



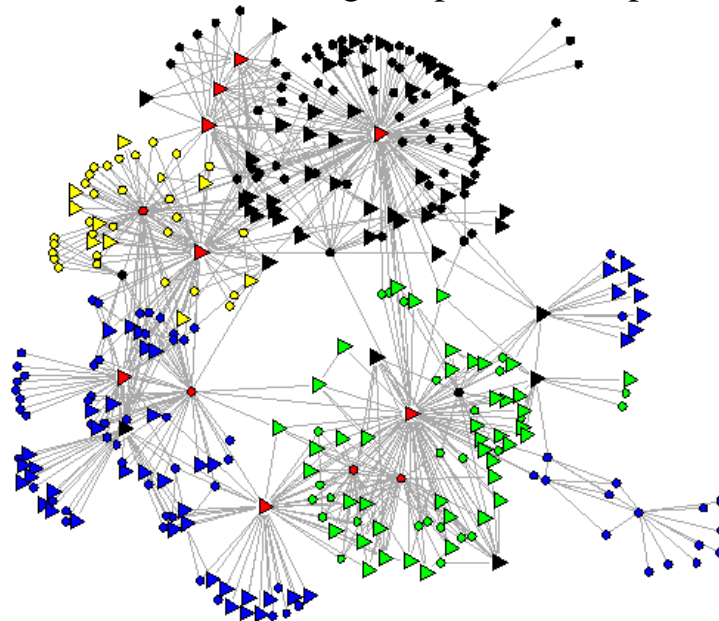
# Results

## Classes description

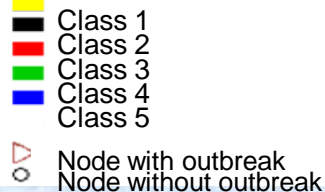
| Class | Nodes number | Intra-class density    | Market 1 <sup>(1)</sup> frequency (%) | Market 2 <sup>(2)</sup> frequency (%) | Eligible outbreaks (%) |
|-------|--------------|------------------------|---------------------------------------|---------------------------------------|------------------------|
| 1     | 39           | $0.675 \cdot 10^{-2}$  | 3                                     | 8                                     | 23                     |
| 2     | 119          | $1.211 \cdot 10^{-2}$  | 8                                     | 10                                    | 40                     |
| 3     | 12           | $39.394 \cdot 10^{-2}$ | 100                                   | 0                                     | 67                     |
| 4     | 108          | $0.675 \cdot 10^{-2}$  | 1                                     | 9                                     | 40                     |
| 5     | 69           | $0.725 \cdot 10^{-2}$  | 0                                     | 3                                     | 62                     |

<sup>(1)</sup> Market 1: Large markets with regular presence of poultry trading.

<sup>(2)</sup> Market 2: Small markets with irregular presence of poultry trading



$$\chi^2 = 20.3, df = 4, p < 10^{-3}$$

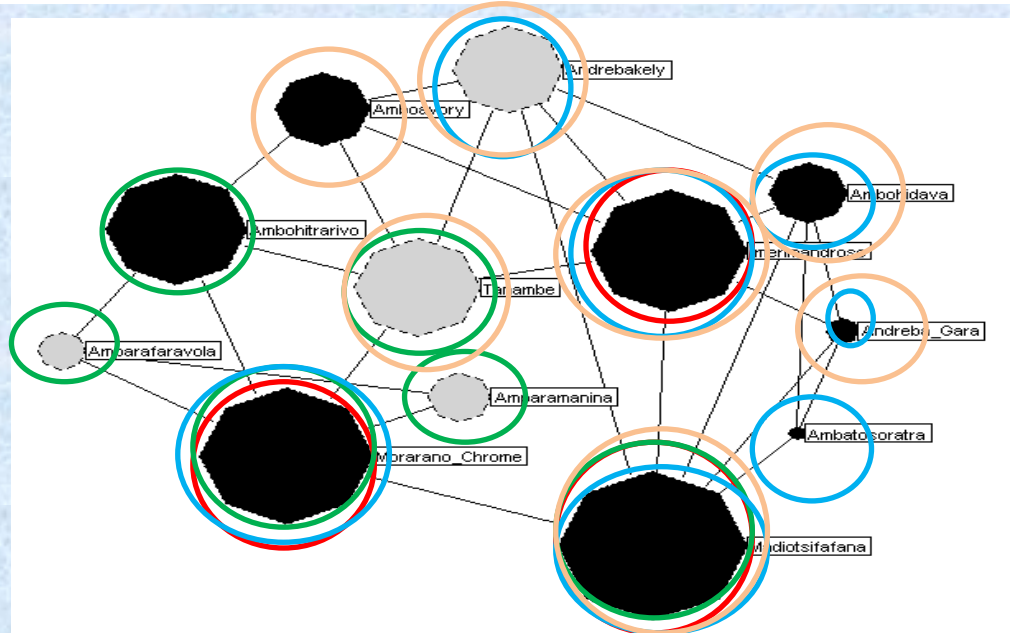


# Results

- Toward targeted surveillance
  - Image matrix (class selection)

|         | Class.1 | Class.2 | Class.3 | Class.4 | Class.5 |
|---------|---------|---------|---------|---------|---------|
| Class 1 |         |         |         |         |         |
| Class 2 |         |         |         |         |         |
| Class 3 |         |         |         |         |         |
| Class 4 |         |         |         |         |         |
| Class 5 |         |         |         |         |         |

- Nodes selection  
(within class 3)  
→ 3 selected nodes :  
Madiotsiafafana  
Imerimandroso  
Morarano Chrome  
(3 first biggest markets)



# Discussion

## 1. Originality

- An almost complete network together with surveillance data
- Importance of participatory approach to deal with lack of data

## 2. ND vs AI

- ND is the major disease
- No AI outbreak → No HPAI

## 3. Surveillance

- Participatory surveillance
  - higher sensitivity, unknown specificity, not an early warning system
  - allow a monitoring of disease evolution over a year
- Passive surveillance
  - **Necessary** (specificity, lab analysis, outbreak description ) but problem of sensitivity (35 /151)
- Targeted surveillance and use of sna:
  - less expensive,
  - possibility to trace infection and contact(Keeling and Eames, 2005) → Prevention measures
  - Possible occurrence of outbreak before detection by this surveillance → Combination with a passive surveillance

**FURTHER STUDIES NEEDED : ....**



# Acknowledgement

- Farmers
- Community workers, Fokontany headmen, Veterinarians, AVSF, field and laboratory staff.
- CIRAD, FOFIFA

**THANK YOU**