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Early warning systems for vectorborne diseases

Paolo Calistri

Tunis, 2 December 2015

Objectives of surveillance activities

- Diseases **that are present** in the country/territory
  - For estimating the levels of infection (prevalence/incidence)
  - For describing the spatial and temporal distribution of infection
  - For identifying the main transmission routes and risk factors
- Diseases **that are absent** in the country/territory
  - For demonstrating freedom from disease status
  - For early detecting the incursion of new, (re)-emerging or exotic pathogens

Diseases that are present

- For estimating the prevalence or spatial/temporal distribution:
  - Random surveys
    - Vectorborne diseases **are not homogeneously distributed in the territory** or during time and biotic/abiotic variables must be taken into account.
    - Vectorborne diseases **are not clustered within herds**

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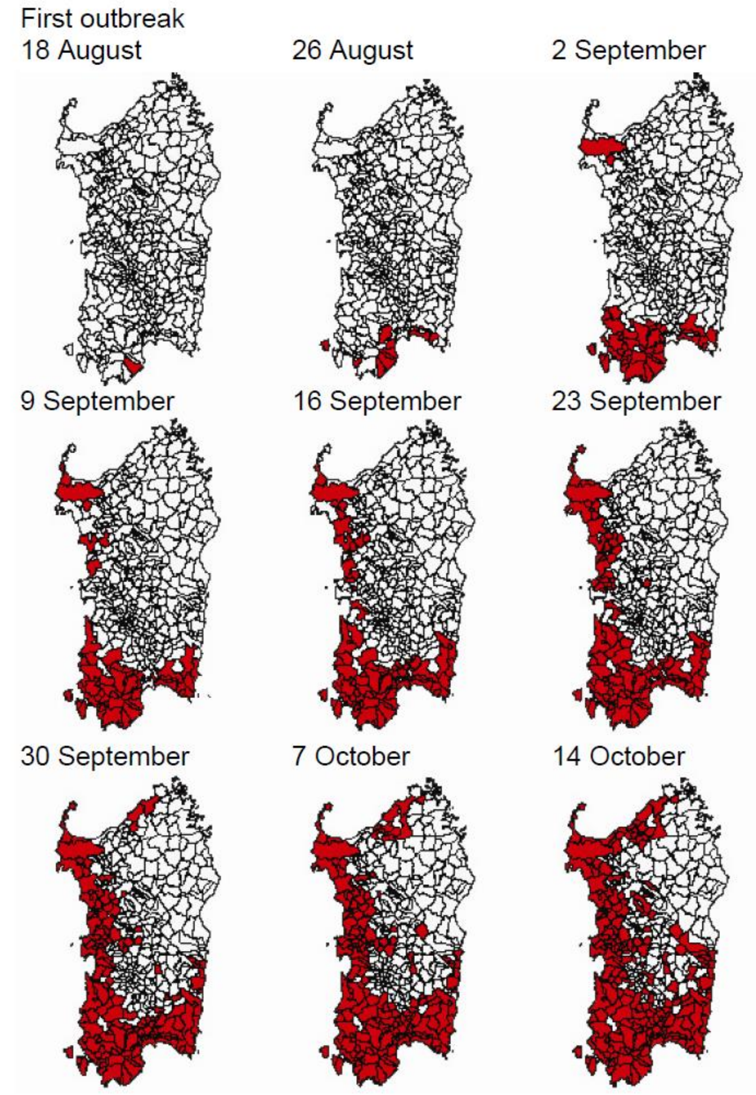
Bluetongue in Italy

EXAMPLE

An extended epidemic occurred during summer 2000 in Sardinia



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A first *ad hoc* survey was carried out in Sardinia

EXAMPLE

- to determine the actual geographic distribution of infection
- to determine the prevalence of infection in sheep and cattle populations for deciding upon vaccination strategies

Targeted surveillance approach was chosen:

- target populations and sampling design varied in relation to
  - observed behavior of the epidemic
  - knowledge already acquired

Sampling strategy

EXAMPLE

- When the *ad hoc* survey should be carried out ?

- Which population ?

Objective of monitoring	Target population	Sampling criteria
Prevalence of infection in cattle population	Cattle	Cluster sampling, stratified by cattle population density and by date of first detection of infection in the municipality
Prevalence of sub-clinical infection in sheep population	Sheep	Serological testing of animals in flocks clinically affected during the epidemic season

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Results of *ad hoc* survey

- Average prevalence of seropositive sheep: 23.27%
- For cattle:

EXAMPLE

Risk categories for municipalities	Tested herds	Tested cattle	No. of positives	% positives	Lower C.L. (95%)	Upper C. L. (95%)
Mun. where disease occurred before 29th of Sep. and cattle density < 8 heads/km^2	27	762	390	51%	48%	55%
Mun. where disease occurred before 29th of Sep. and cattle density > 8 heads/km^2	140	2660	1901	71%	70%	73%
Mun. where disease occurred after 29th of Sep. and cattle density < 8 heads/km^2	7	94	29	31%	22%	41%
Mun. where disease occurred after 29th of Sep. and cattle density > 8 heads/km^2	120	3436	883	26%	24%	27%
Municipalities with no disease	23	447	18	4%	3%	6%
TOTAL	**317**	**7399**	**3221**	**44%**	**42%**	**45%**

Diseases that are present

- For estimating the incidence of infection and detecting the circulation of pathogens
  - Repeated testing / sentinel animals
    - Seasonality must be taken into account and spatial distribution of sentinel animals is crucial
  - Targeted surveillance
    - In areas and period at major risk of transmission on the basis of the knowledge of vectors distribution and biology
  - Target surveillance on selected hosts
    - A throughout knowledge of the epidemiology of infection is needed

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Bluetongue: Surveillance on sentinel animals

EXAMPLE

- In 2015 the Italian territory has been divided in **20 x 20 km squares grid in free territories and 45 x 45 km in zones under restriction**
- In each square, around **58 animals** are selected and used as **sentinel animals**

In free territories the main objective of the serological surveillance system is to **early detect the BTV incursions** to promptly delimit the areas under movement restriction and subjected to vaccination. A higher sensitivity of the surveillance system is applied in free areas to **increase the probability of early detecting the virus** in case of introduction.

Bluetongue:
Surveillance on sentinel animals

In all these years the sentinel system has been a **very effective and sensitive tool**, crucial for detecting BTV circulation in Italy

In 2014 around **33%** of BT outbreaks were revealed by the sentinel animals

EXAMPLE

Use of sentinel animals

Pros

- **The time and location of virus circulation can be determined with a good precision**
- **Sentinels can be tested for multiple pathogens**

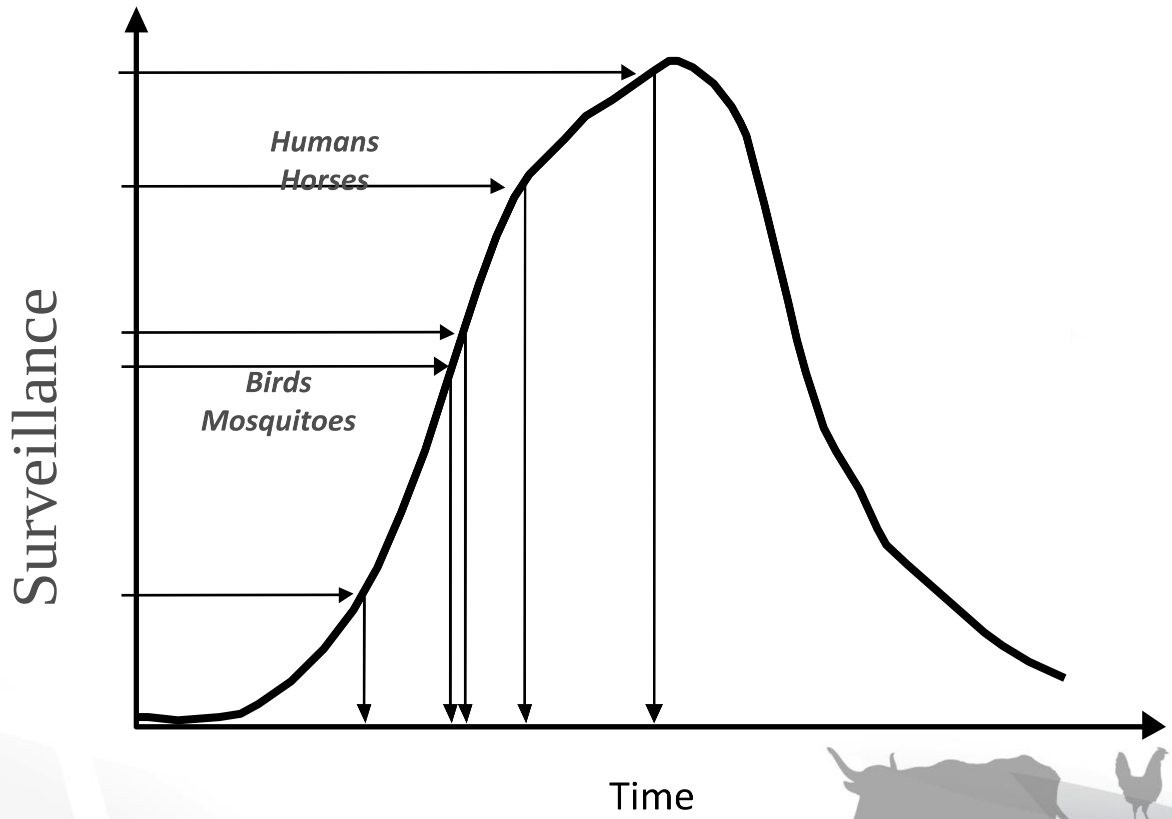
Cons

- **Pre-requisite: good animal identification and registration system**
- **In the lack of entomological data the choice of locations is crucial for the effectiveness of the system**
- **It is expensive and requires significant sampling efforts**

Targeting on species early infected in the transmission cycle

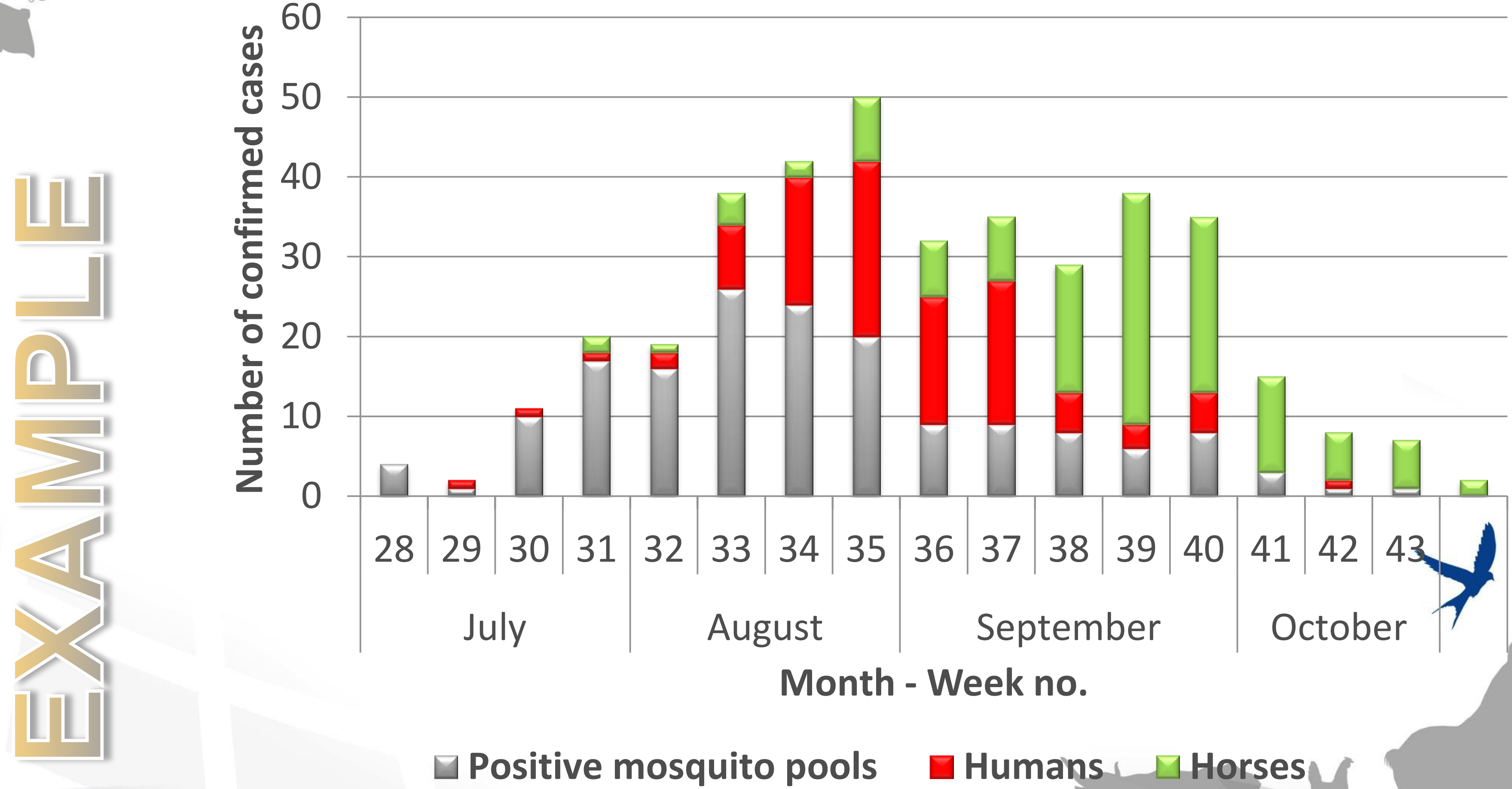
- West Nile disease

EXAMPLE



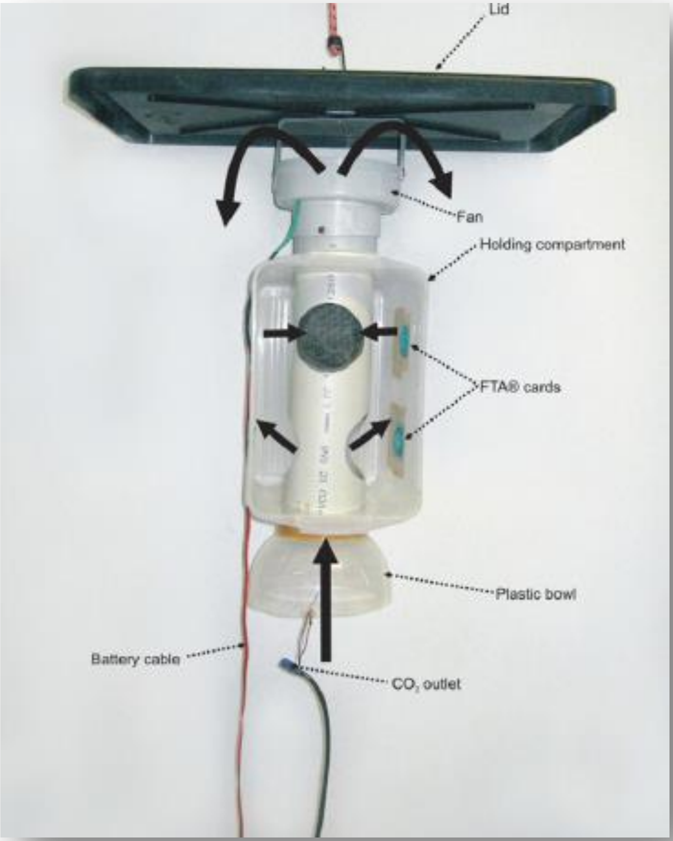
West Nile Disease 2008-2014

Seasonal distribution of humans and horse cases and comparison with entomological results



Use of mosquito traps with FTA® cards for virus detection

- Flinders Technology Associates filter paper (FTA®) cards
- Honey-soaked FTA® cards for sugar feeding insects
- to detect arboviruses in the mosquitoes saliva during sugar feeding



Exploiting mosquito sugar feeding to detect mosquito-borne pathogens

Sonja Hall-Mendelin[a], Scott A. Ritchie[b,c], Cheryl A. Johansen[d], Paul Zborowski[a], Giles Cortis[e], Scott Dandridge[f], Roy A. Hall[a], and Andrew F. van den Hurk[g,a,1]

PNAS | June 22, 2010 | vol. 107 | no. 25 | 11255–11259

Targeting on host species early infected

Pros

- Useful for zoonoses to detect the infection before human cases will occur
- Reduction of costs due to the targeting approach

Cons

- Comprehensive knowledge of the epidemiology of the disease is needed
- In case of targeting on non domestic species: difficulties for performing sampling on wild animals
- In case of targeting on vectors: difficulties in the estimation of the Se of the system, feasibility of sampling

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Diseases that are absent

- For demonstrating freedom from disease
  - Random survey may be difficult to perform and sometimes not efficient
  - Sentinel systems need an assessment of surveillance performances (sensitivity), which can be difficult to be done
  - Risk-based approaches based on the probability of introduction and spread of the infection
- Early warning systems
  - Performances of the surveillance system (Sensitivity and Specificity) MUST be assessed
  - Estimation of expected delay in infection detection
  - Random approaches are not useful
  - Passive surveillance is always needed for clinically detectable diseases
  - Risk-based approaches are the best options

Approaches for early warning systems

EXAMPLE

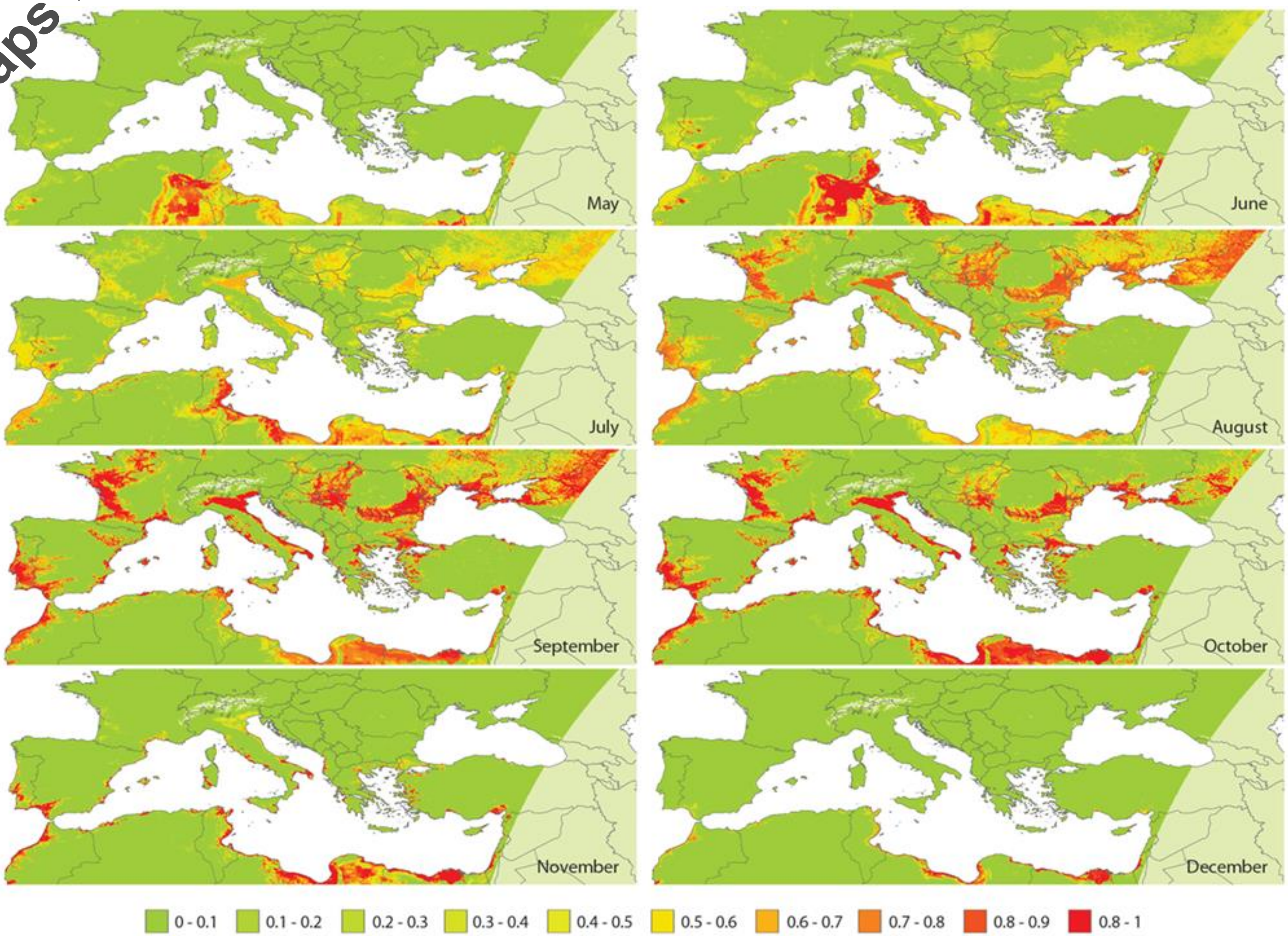
Risk map for *Hyalomma marginatum*

Estrada-Peña A. and VENZAL J.M. Climate Niches of Tick Species in the Mediterranean Region: Modeling of Occurrence Data, Distributional Constraints, and Impact of Climate Change. J. Med. Entomol. 44(6): 1130Ð1138 (2007)

Approaches for early warning systems

Risk maps for WND

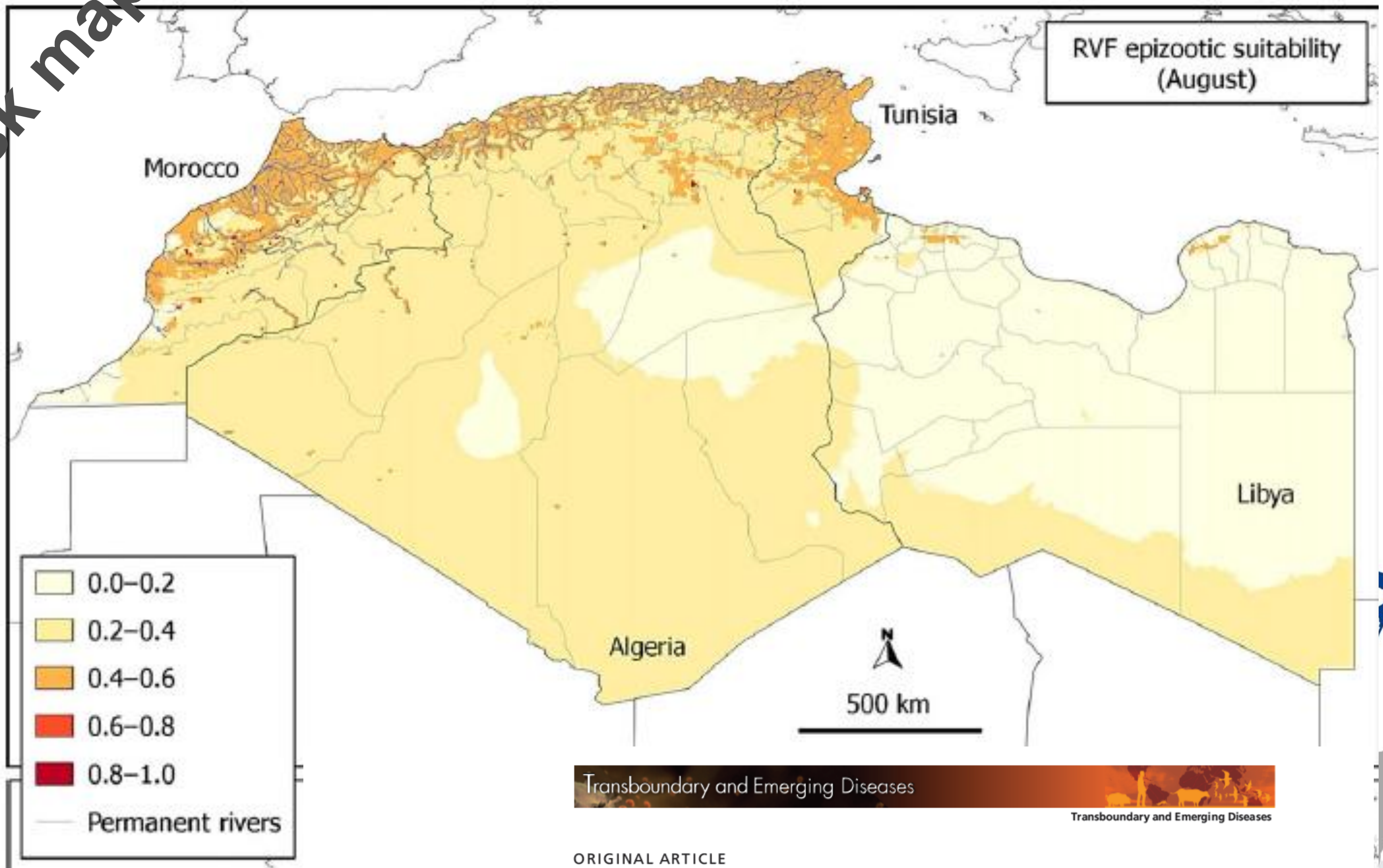
EXAMPLE



Approaches for early warning systems

EXAMPLE

Risk map for RVF



Transboundary and Emerging Diseases

Transboundary and Emerging Diseases

ORIGINAL ARTICLE

Identifying Areas Suitable for the Occurrence of Rift Valley Fever in North Africa: Implications for Surveillance

E. Arsevska[1,†], J. Hellal[2,†], S. Mejri[2], S. Hammami[3], P. Marianneau[4], D. Calavas[1] and V. Hénaux[1]

Risk maps

Pros

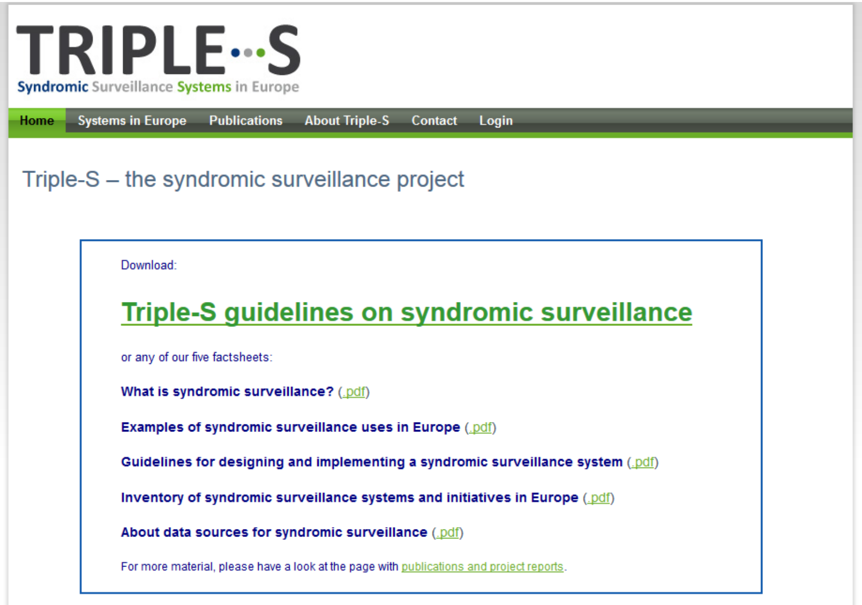
- To better target early warning systems
- To better program the production and store of vaccines and diagnostic material
- To better focus the repartition and dislocation of resources

Cons

- Usually affected by a large degree of uncertainty
- Based on assumptions not always true
- Largely influenced by the quality of data

Syndromic surveillance

- Syndromic surveillance is not based on laboratory diagnosis, but on non-specific clinical signs, symptoms and proxy measures for health (for example animal production reduction, increase use of antimicrobial, etc.).

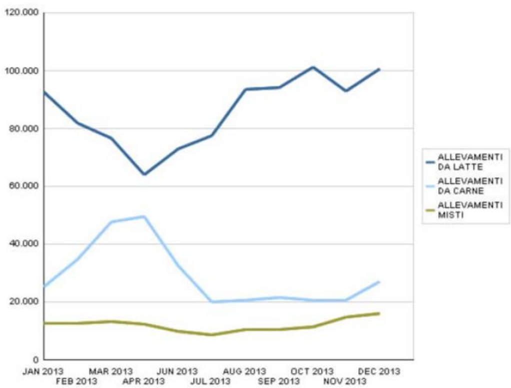


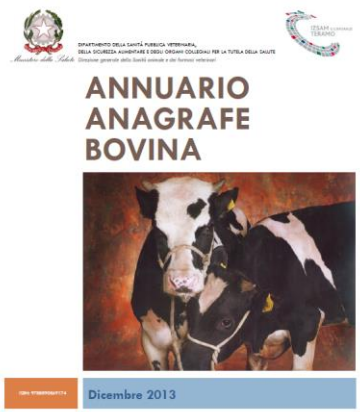
http://www.syndromicsurveillance.eu/

Syndromic surveillance: Mortality / Fertility monitoring

- Analysis of mortality / fertility data produced by the animal I&R systems to detect any significance deviation from the normality

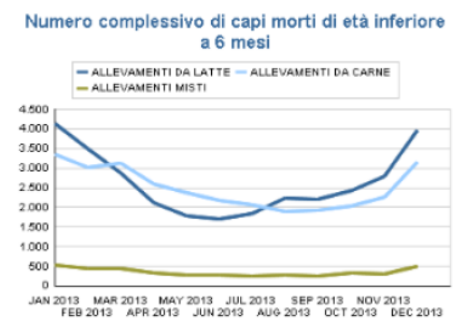
7.1 Nascite per mese nel corso dell'ultimo anno

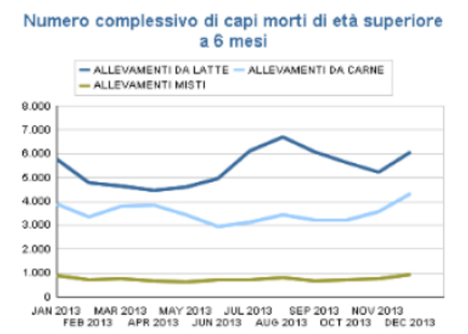




Exploring the Surveillance Potential of Mortality Data: Nine Years of Bovine Fallen Stock Data Collected in Catalonia (Spain)

Anna Alba[1]*, Fernanda C. Dórea[2], Lucas Arinero[3], Javier Sanchez[4], Ruben Cordón[1], Pere Puig[5], Crawford W. Revie[4]





Syndromic surveillance

Pros

- Reduced costs
- Effective for detecting inapparent or subclinical infections

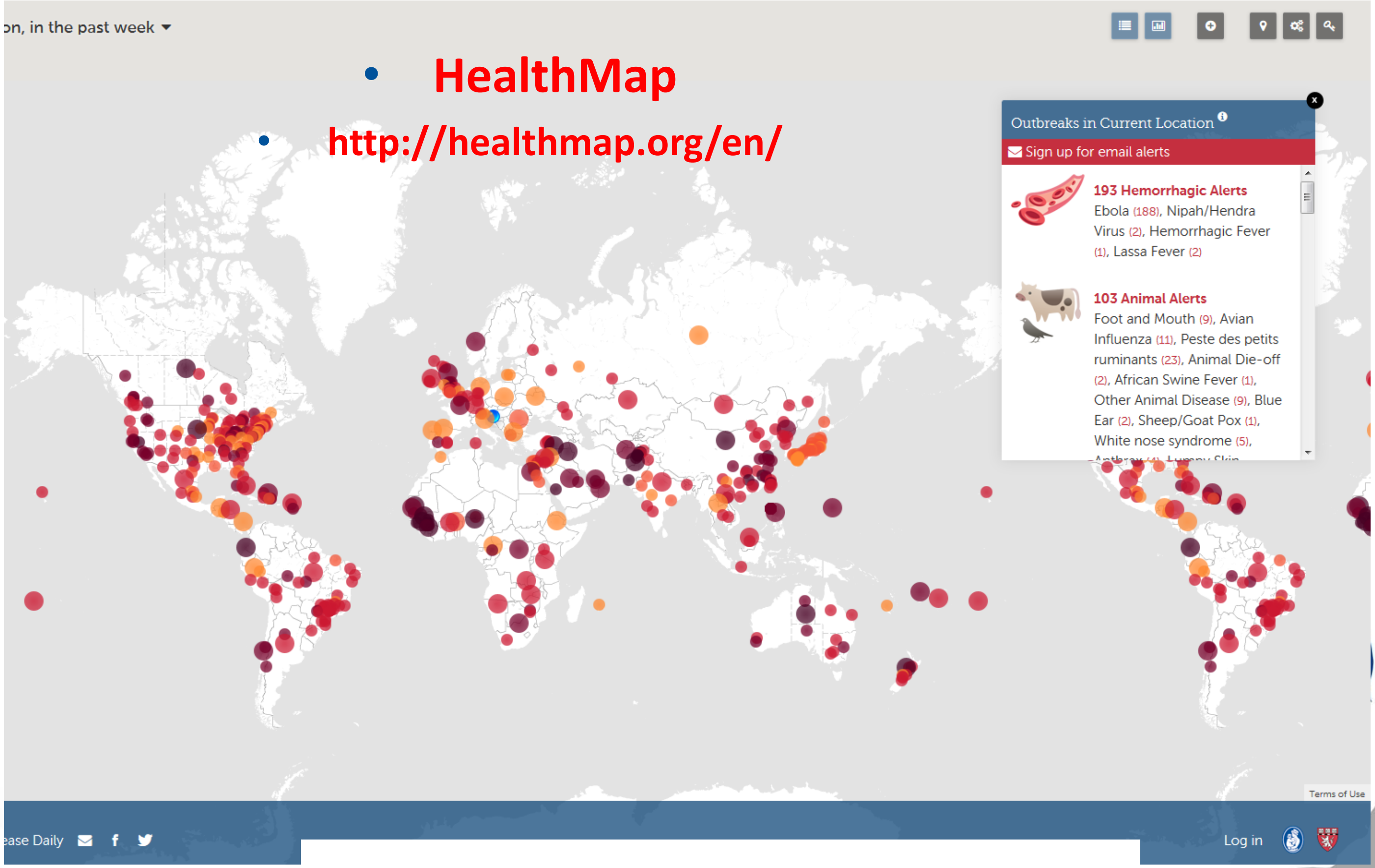
Cons

- Need very detailed and exhaustive data
- Confounding factors may interfere with the results

Approaches for early warning systems

EXAMPLE

- **HealthMap**
- **http://healthmap.org/en/**



Infodemiology and Infoveillance

Tracking Online Health Information and Cyberbehavior for Public Health

Gunther Eysenbach, MD, MPH

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Digital disease detection and internet scanning

Pros

- Not need to produce new data, but use of existing ones
- Theoretically applicable to all health problems
- Scalable scanning system (queries with inclusion and exclusion criteria)

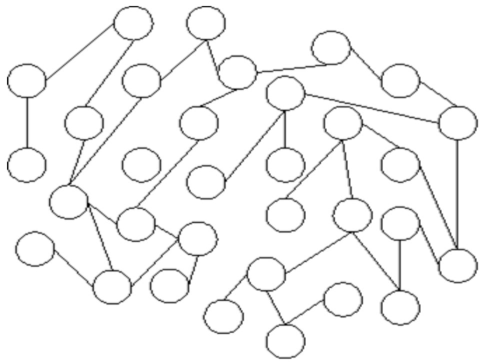
Cons

- Usually many false positive signals
- Different use of social networks in countries
- Sometimes too generic outcomes may be achieved in this way

Approaches for early warning systems

Social Network Analysis (SNA)

EXAMPLE



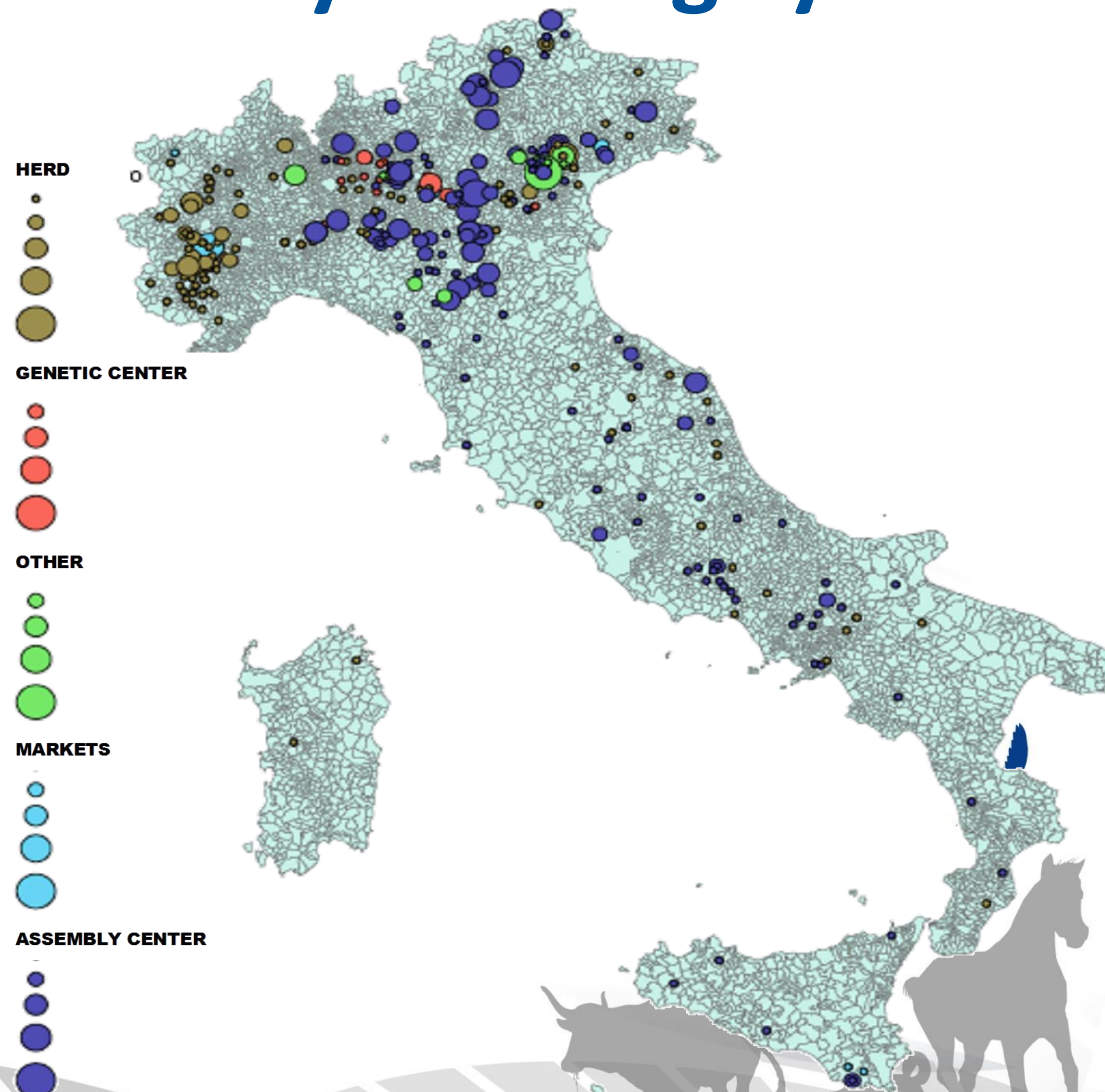
Centrality measures:

- “degree”: calculated counting the number of relations that the node has with its direct neighbours (“in-degree”, “out-degree”)
- “closeness”, which is a measure of the number of steps required to reach all others nodes along the shortest paths,
- “betweenness”, which is the measure of the number of times the node falls on the geodesic paths between other pairs of nodes in the network,
- “eigenvector”, which is a measure of centrality proportional to the sum of the centralities of the nodes to which a node is connected.

Approaches for early warning systems

EXAMPLE

Geographic distribution of herds with highest values of "degree" (connections, movements) according to the type of premise



Calistri P., Conte a., Natale F., Possenti L., Savini L., Danzetta M.L., Iannetti S., Giovannini A. (2013). Systems for prevention and control of epidemic emergencies. Veterinaria Italiana, 49 (3), 255-261. doi: 10.12834/VetIt.1206.06

SNA approach

Pros

- To concentrate control activities on specific hubs and super-spreaders
- To better evaluate options in preparation of contingency plans

Cons

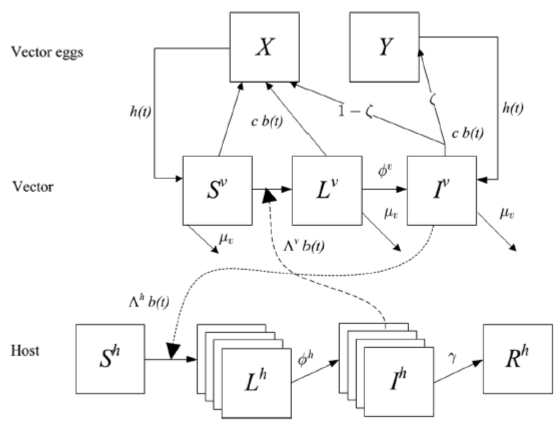
- Need very detailed and exhaustive data
- Useful mainly for direct contact transmissions

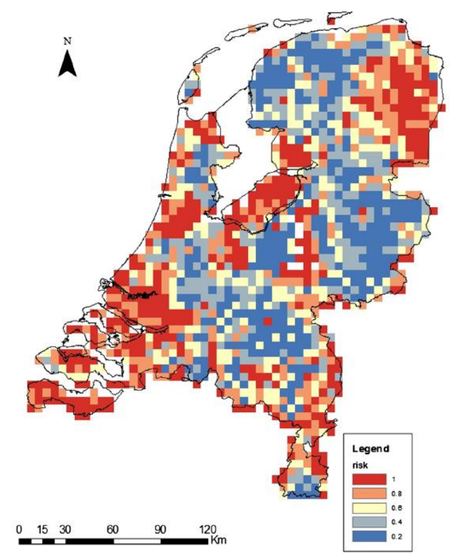
Approaches for early warning systems

Disease modeling

EXAMPLE

- Used for identifying territories or periods of time where conditions are more favorable for the transmission of infection
- Often the calculation of the basic reproductive ratio (R_0) is used as risk estimation





Fischer et al. 2013. The transmission potential of Rift Valley fever virus among livestock in the Netherlands: a modelling study. Veterinary Research 2013, 44:58

Disease modeling

Pros

- Efficacy of control methods could be assessed
- The contribution of biotic and abiotic factors to the final risk can be evaluated

Cons

- Need very detailed and exhaustive data
- Large uncertainty due to the limited knowledge on vectors biology, infections drivers and host’s parameters
- Significant computational resources can be necessary

Conclusions

- Complexity of the interrelationship between animal movements, hosts densities, environmental and climate conditions and vector distribution
- Multiple methods can be followed for the surveillance of vectorborne diseases, but:
  - multidisciplinary and supranational (international) approaches are indispensable to properly face the new challenges

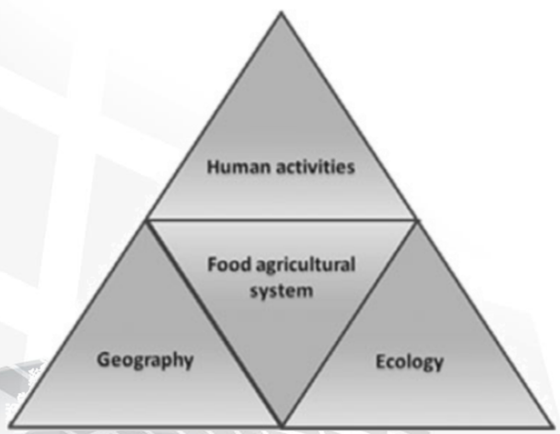


Fig. 1. Components of the interaction between men, animals and pathogens.

Transboundary and Emerging Diseases

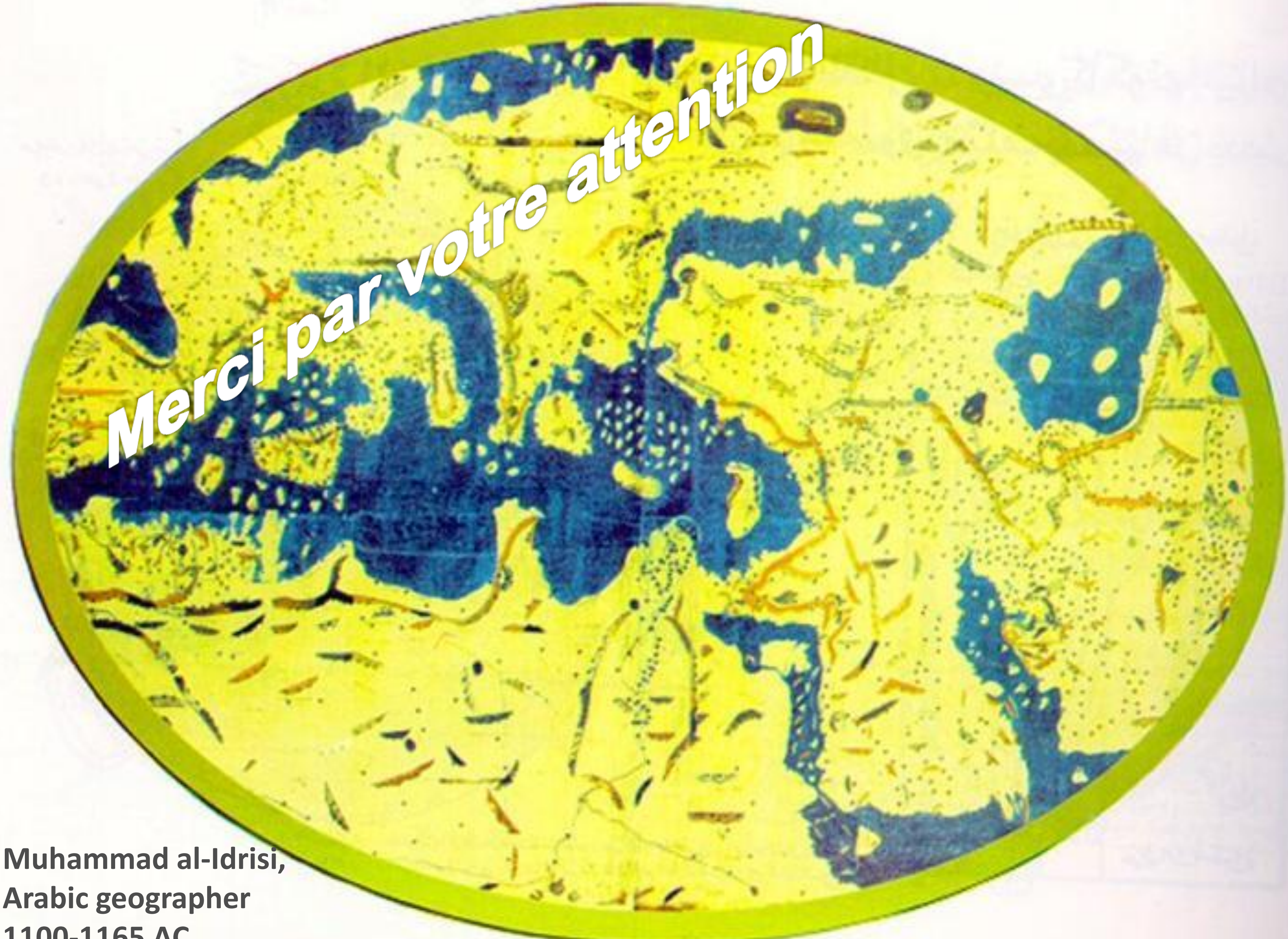
Transboundary and Emerging Diseases

REVIEW ARTICLE

The Components of 'One World – One Health' Approach

P. Calistri, S. Iannetti, M. L. Danzetta, V. Narcisi, F. Cito, D. Di Sabatino, R. Bruno, F. Sauro, M. Atzeni, A. Carvelli and A. Giovannini

Merci par votre attention



Muhammad al-Idrisi,
Arabic geographer
1100-1165 AC