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Management and control of outbreaks of vector borne disease

Workshop on: “Towards improved understanding & control of Vector-Borne Diseases in GCC and the Arabian Peninsula

29-30 July 2024 - UAE

Daria Di Sabatino – Paolo Calistri

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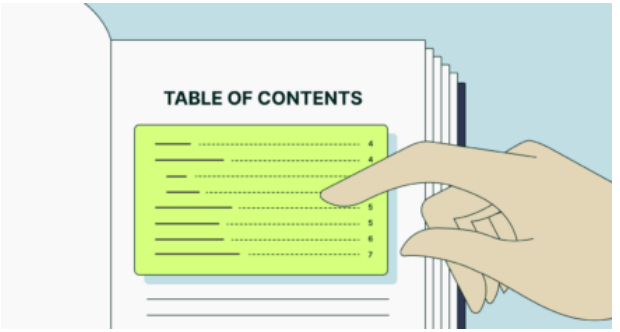
Contents

- Some differences between VBD and others disease
- Preparedness and response (example for RVF epidemic phases)
- Vector control
- Control measures for livestock
- Conclusions



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VBD – some differences

- **Measures against vectors alone** are ineffective for stopping the VBD spread
- **Rapid spread**, especially when flying vectors are implicated
- Need for a **territorial approach** (epi-regions, eco-regions) taking into consideration the spatial distribution of competent vectors and animal hosts
- Need for **early warning systems**

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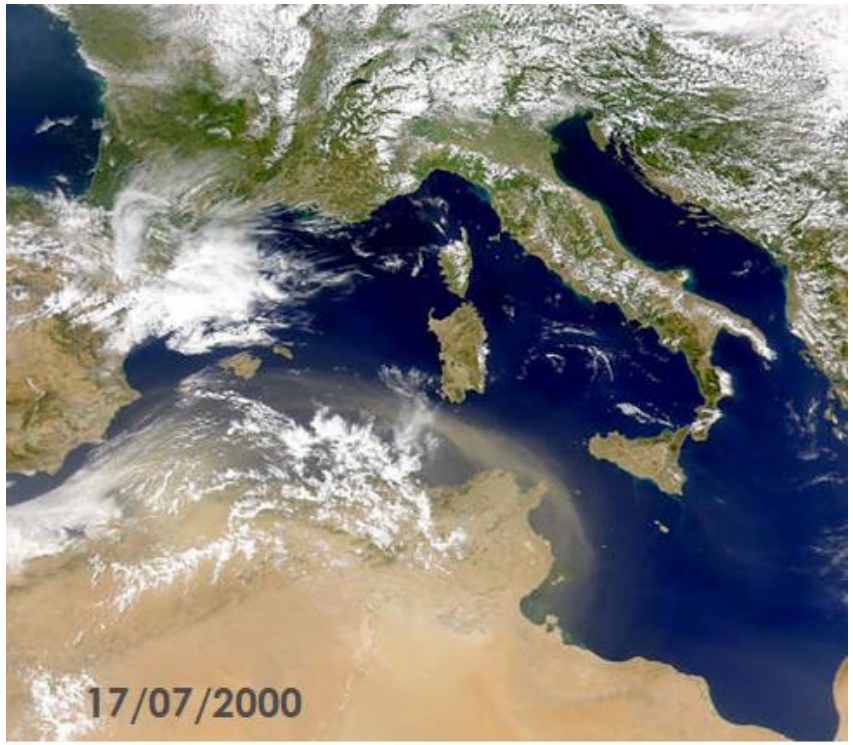
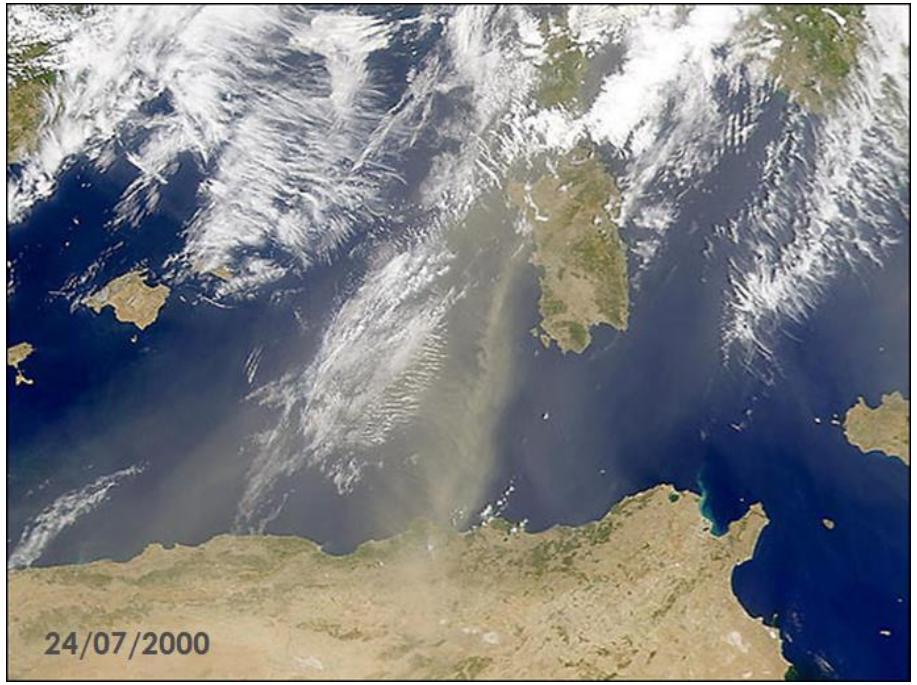
Rapid spread





Source:

- Images from “SeaWiFS Project”, NASA/Goddard Space Flight Center, and ORBIMAGE
- Satellite: OrbView-2
- Sensor: SeaWiFS

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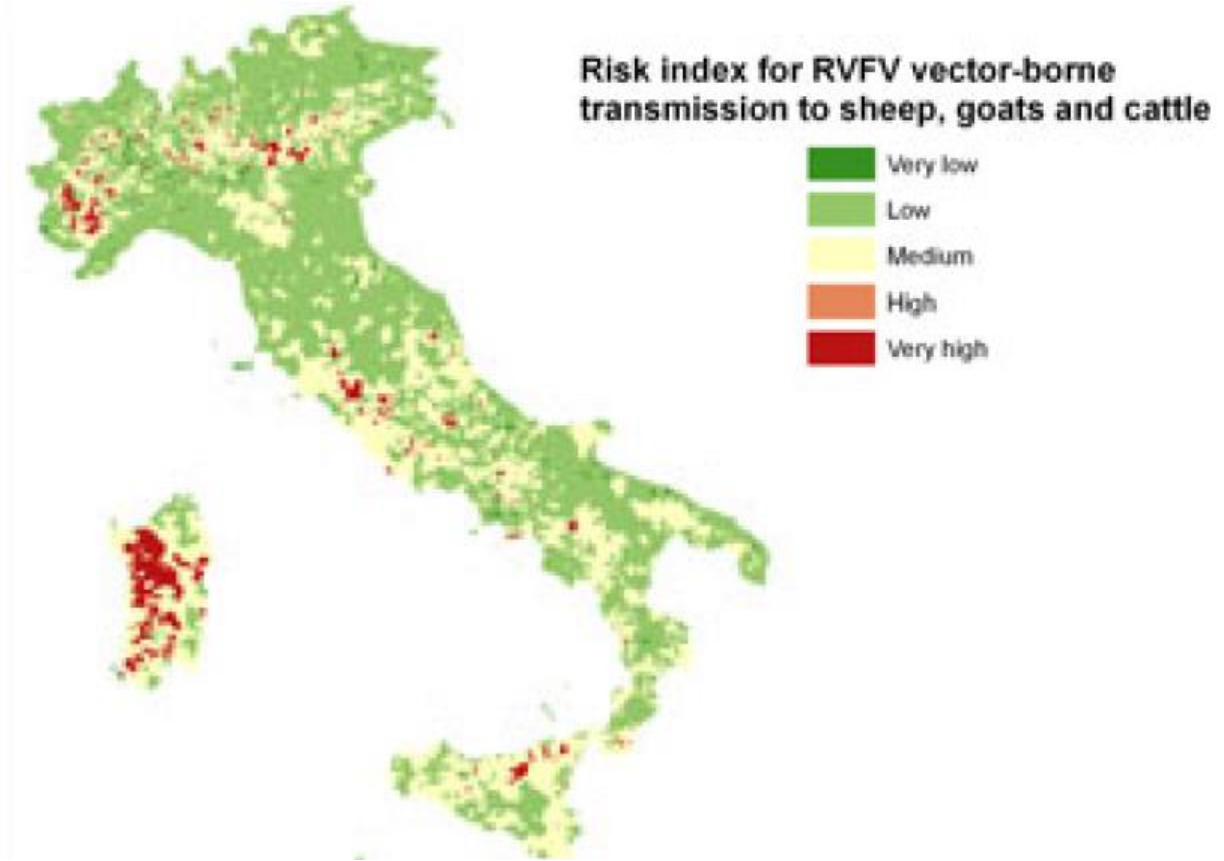
Territorial approach
Example of suitability maps



Transboundary and Emerging Diseases

Transboundary and Emerging Diseases

ORIGINAL ARTICLE

A Geographical Information System-Based Multicriteria Evaluation to Map Areas at Risk for Rift Valley Fever Vector-Borne Transmission in Italy

A. Tran[1,2], C. Ippoliti[3], T. Balenghien[4], A. Conte[3], M. Gely[1], P. Calistri[3], M. Goffredo[3], T. Baldet[4] and V. Chevalier[1]

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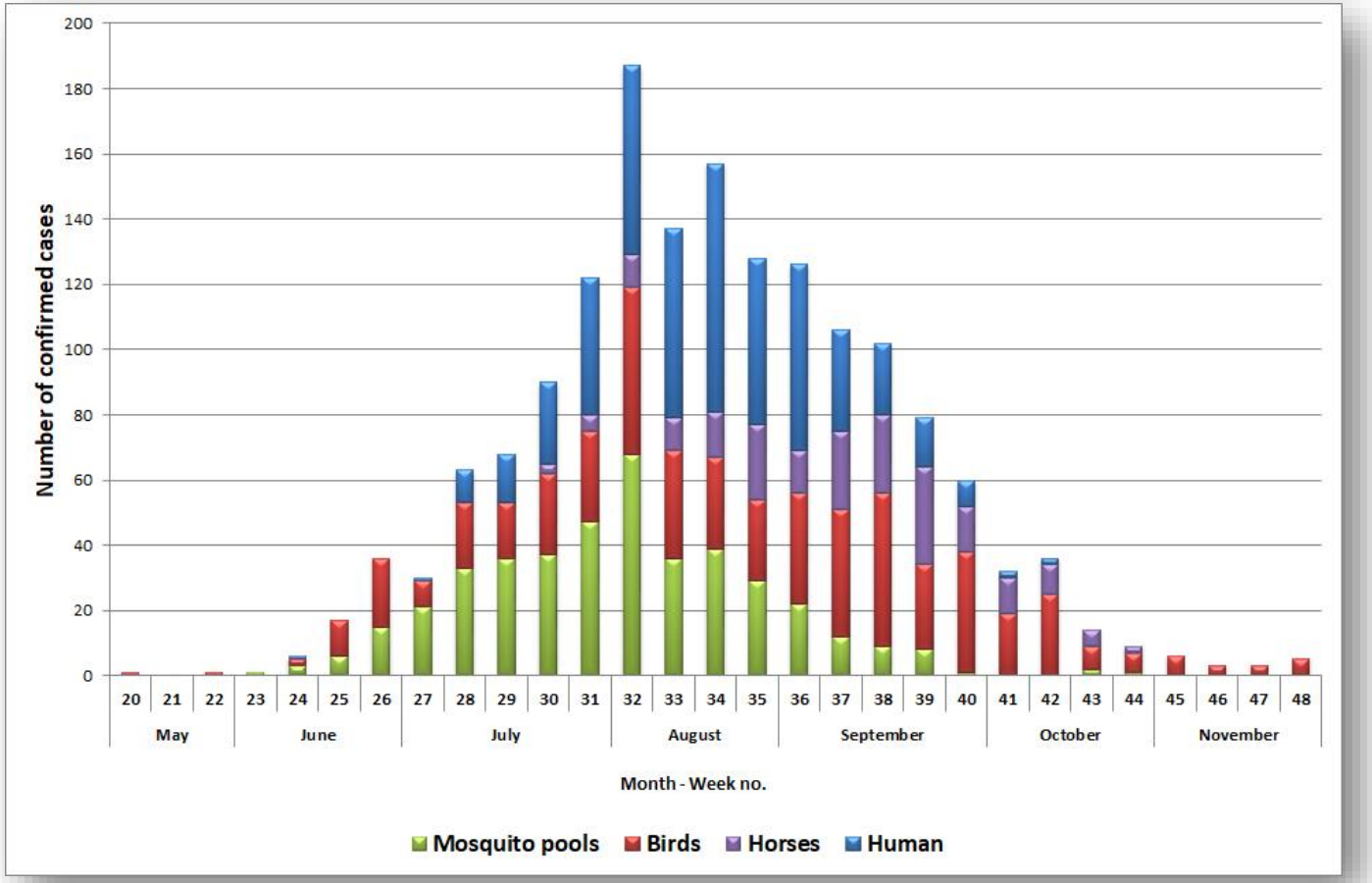
Need for early warning systems



West Nile Disease 2008-2018 in Italy

Seasonal distribution of humans, veterinary cases and entomological results

Elapsed time between events in 2006-2007 RVF outbreak in Kenya

Event	Average elapsed days since previous event
Onset of heavy rains	0
Mosquito swarms	23.6
First case in livestock	16.8
First case in human	17.5

On average, the onset of the first cases in livestock was only 17 days after mosquito swarms and approximately 40 days after heavy rains. Human cases were observed around 18 days after the first livestock cases (Jost et al., 2010).

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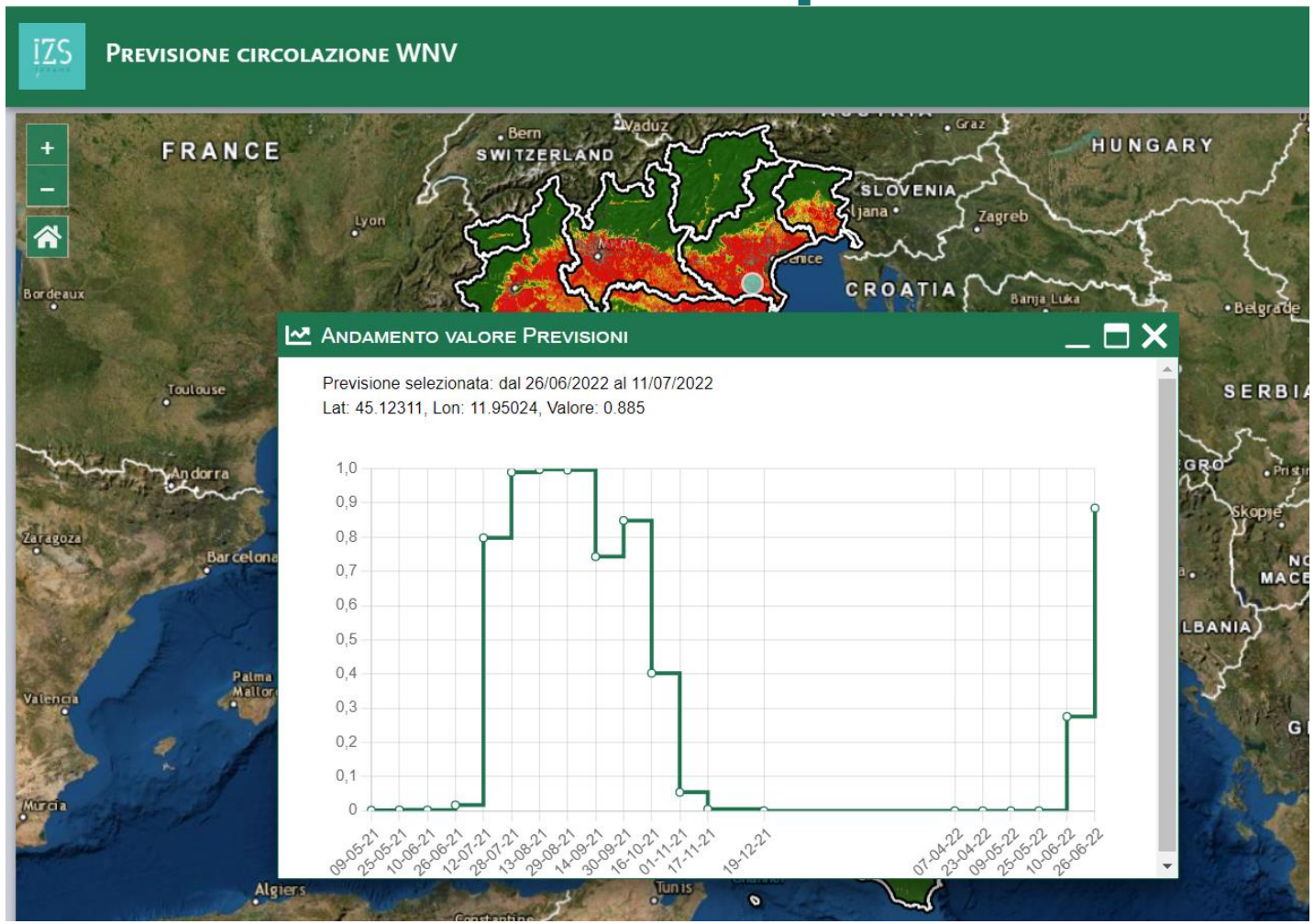
Need for early warning systems: WND predictive tool



remote sensing MDPI

Article

Predicting WNV Circulation in Italy Using Earth Observation Data and Extreme Gradient Boosting Model

Luca Candeloro [1,*], Carla Ippoliti [1], Federica Iapaolo [1], Federica Monaco [1], Daniela Morelli [1], Roberto Cuccu [2], Pietro Fronte [2], Simone Calderara [3], Stefano Vincenzi [3], Angelo Porrello [3], Nicola D'Alterio [1], Paolo Calistri [1] and Annamaria Conte [1]

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National contingency / control plan

A National contingency / control plan is a fundamental tools for effective preparation. The plan must include at least:

- Description of the command chain
- Roles and responsibilities
- Components of Crisis Units at the different levels (central / local)
  - In case of VBD, need for a multidisciplinary approach (involvement of entomologists, experts on wildlife, etc.)

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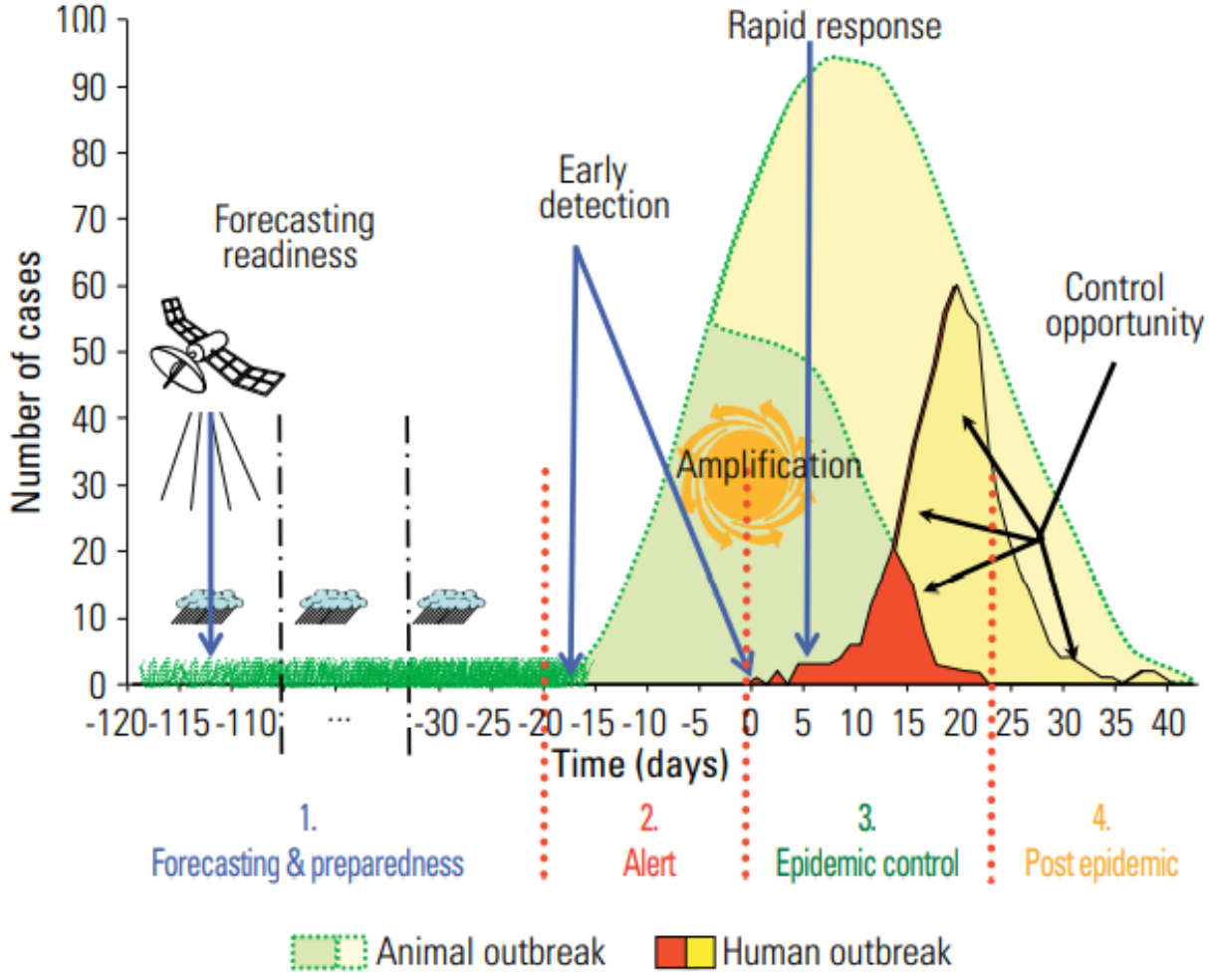
National contingency / control plan

- Procedures for:
  - Suspicions / confirmation and case definition
  - Notification
  - Application of control / eradication measures
  - Zoning
  - Surveillance activities in response of confirmed cases

- Definition of training programmes for veterinary services and professionals
- Simulation exercises

RVF epidemic phases



It can be applied to the other VBD too…

S. de La Rocque & P. Formenty, 2014. Applying the One Health principles: a trans-sectoral coordination framework for preventing and responding to Rift Valley fever outbreaksRev. sci. tech. Off. int. Epiz., 2014, 33 (2), 555-567

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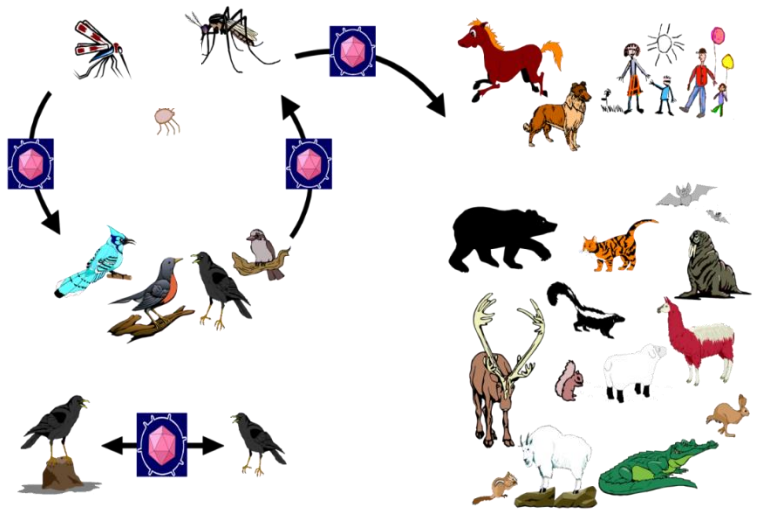
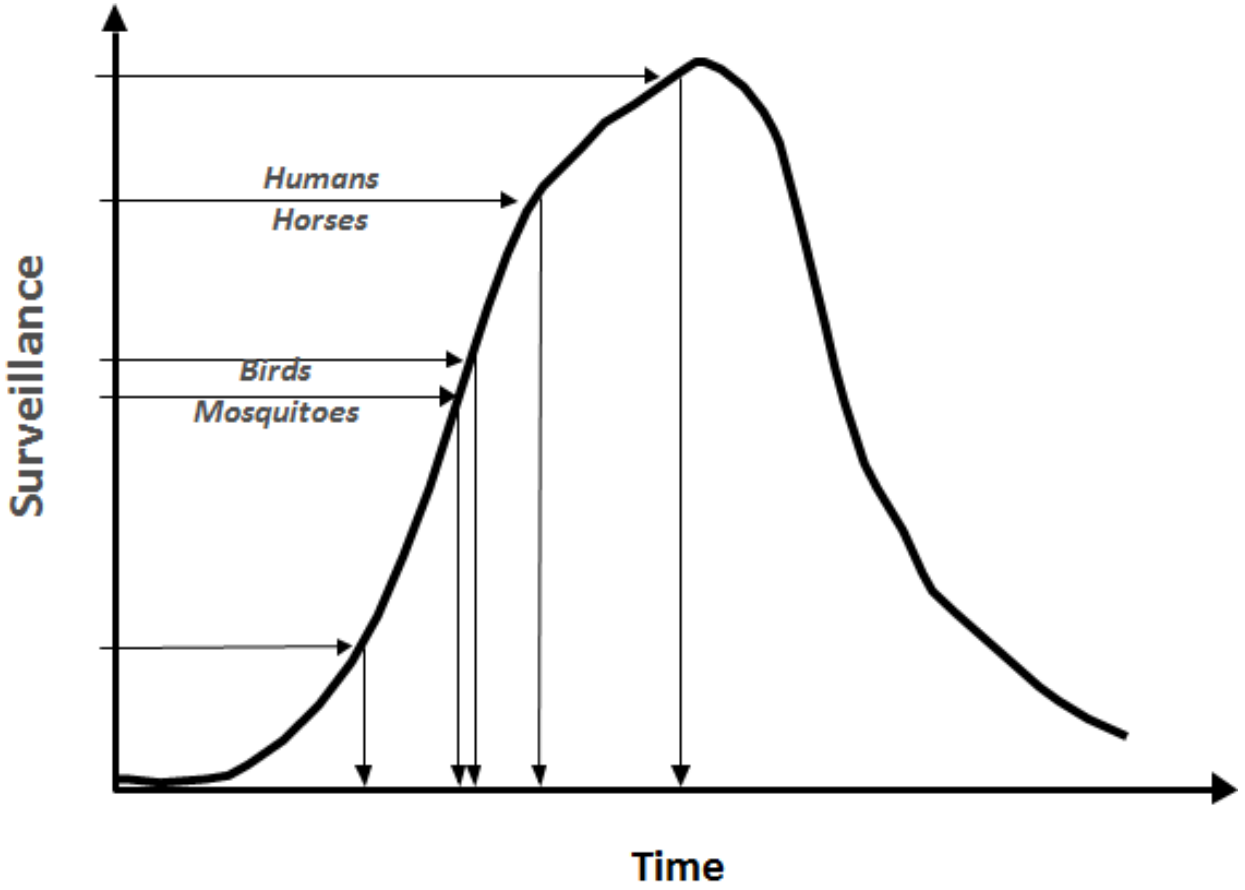
Epidemic phases of West Nile Disease





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INTER-EPIDEMIC PERIOD

The inter-epidemic period is the critical period for building the capacity to respond to new outbreaks.

- One Health coordination
- National action plan
- Surveillance
- Forecasting and early warning systems
- Disease control strategies
- Capacity building

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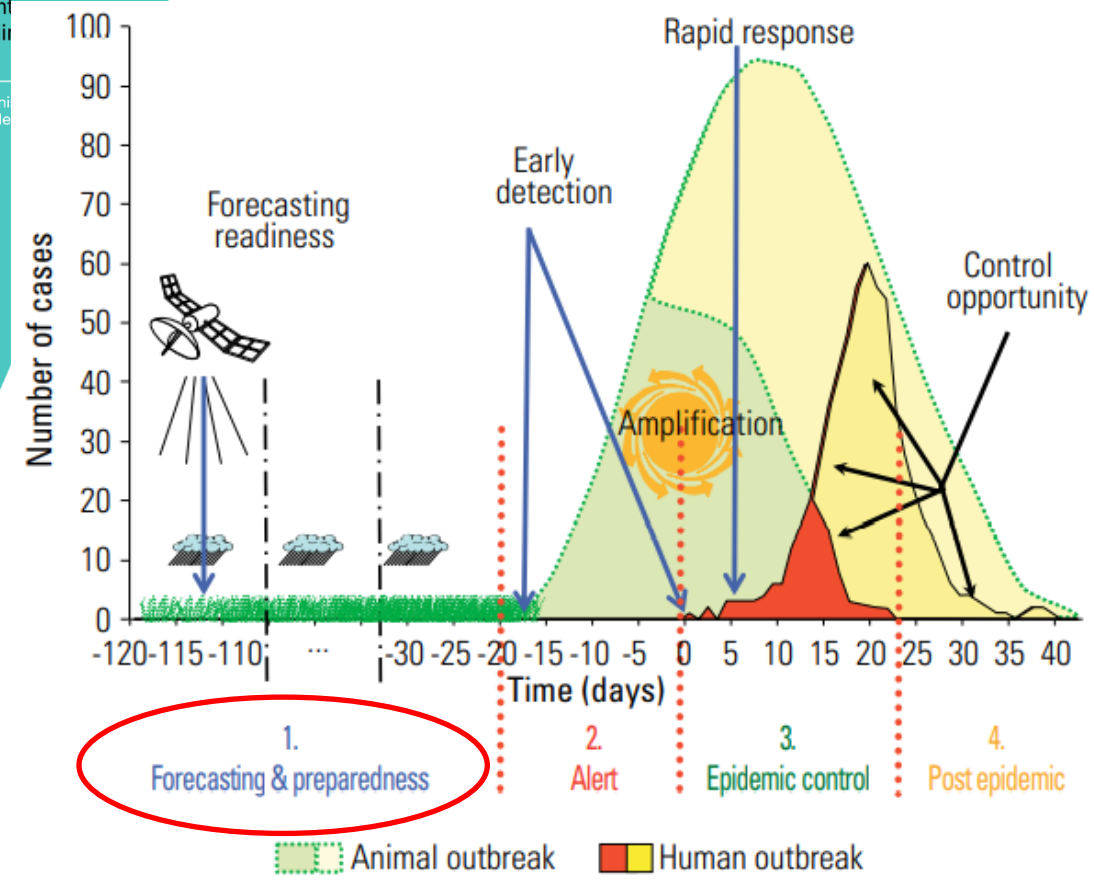
One Health coordination

- A Multisectoral Coordination Mechanism (MCM) should be created that includes human, animal and environmental (for vector control and weather forecasting) authorities, as well as representatives of communities and value chain stakeholders.
- During the inter-epidemic period, the MCM must develop detailed action plans.
- MCM should be empowered to:
  - implement contingency and preventive measures and capacity-building activities
  - issue national alerts
  - build coordination, collaboration, communication mechanisms, including responsibilities and command structures

Proper communication during phases



Phase1. **Communication strategy** and appropriate material for information and awareness-raising should be prepared, jointly or, if the information is sector-specific, by the sector concerned.
Targeted educational material should be prepared and disseminated to health care workers, veterinarians, slaughterhouse workers, laboratory personnel and other occupational groups that could be exposed to virulent material

S. de La Rocque & P. Formenty, 2014. Applying the One Health principles: a trans-sectoral coordination framework for preventing and responding to Rift Valley fever outbreaksRev. sci. tech. Off. int. Epiz., 2014, 33 (2), 555-567

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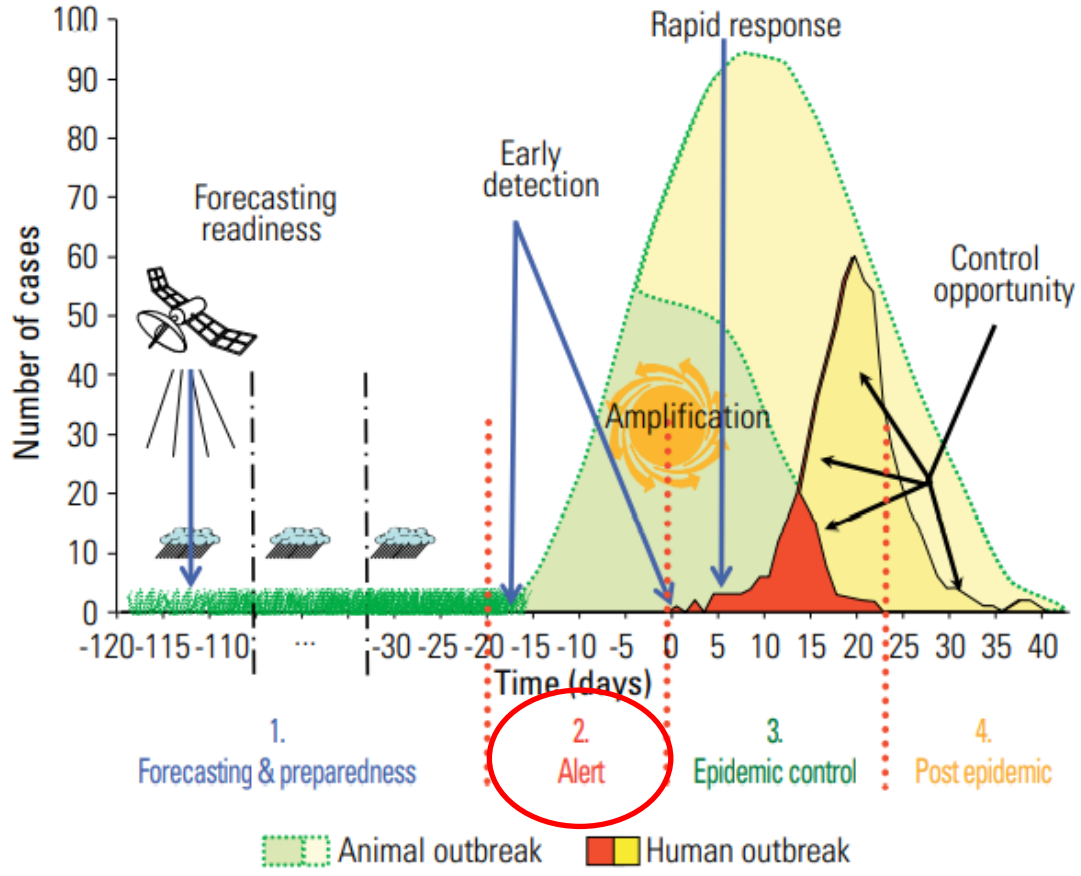
PRE-EPIDEMIC PERIOD

The pre-epidemic period starts when forecasts of future weather conditions or alerts are indicating the presence of conditions consistent with the possible occurrence of VBD

- Mobilization of resources
- Activation of logistics for sample collection
- Verification of laboratory and health system capacities
- Surveillance intensification
- Reinforcement of animal movement control and vaccination activities
- Risk communication

Proper communication during phases



Phase2. Suspected cases in animals or humans are notified. Multidisciplinary team must be sent to the site immediately to investigate the rumour, evaluate the risk of an outbreak, collect specimens and send them to a national or international reference laboratory, begin initial control measures pending the laboratory results. Communication with stakeholders is aimed at **promoting** and **communicating** recommended **interventions** to prevent and reduce animal/population and individual at risk.

S. de La Rocque & P. Formenty, 2014. Applying the One Health principles: a trans-sectoral coordination framework for preventing and responding to Rift Valley fever outbreaksRev. sci. tech. Off. int. Epiz., 2014, 33 (2), 555-567

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EPIDEMIC PERIOD

- Surveillance and notification system
- Disease control
- Palliative and supportive care
- Risk communication and social mobilization

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Outbreak control

- **Animal culling** is generally not a preventive measure (it can be considered only for animal welfare reasons)
- Control of **animal movements** is needed although it is not able to stop the spread due to the dissemination of infected vectors
- Identification of **infected area** by:
  - Clinical surveillance
  - Laboratory surveillance
  - Entomological surveillance

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Clinical surveillance

- The efficacy in identifying the infected area depends on the clinical features of the disease
- The incubation period must be considered
- Repeated clinical visits by veterinarians may be not feasible due to the number of heads under surveillance
- A syndromic approach may help (e.g. abortion monitoring)
- Good communication with farmers

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Laboratory surveillance

- ***Ad hoc* surveys**
  - Effective when target population is large or dispersed across a wide territory. It gives a picture. Need to be repeated regularly
  - Vector-borne diseases are not homogeneously distributed in the territory or during time and biotic/abiotic variables must be taken into account

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Laboratory surveillance

- **Sentinel animals**
  - It can give precise information about place and time of pathogen circulation
  - Sentinels may be tested for various pathogens / infections
  - Difficulties in selecting the right sites in lack of entomological information
  - Need for a individual animal identification system
  - Relevant load of field activities

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Entomological surveillance

- To map of the spatial distribution of vectors -> moving trapping device across the area under investigation
- To monitor vector population dynamics -> regular catches in selected sites along seasons
- To detect the virus circulation in vectors -> depending on the vector infection rate. In general difficult due to the pathogen dilution in vector population

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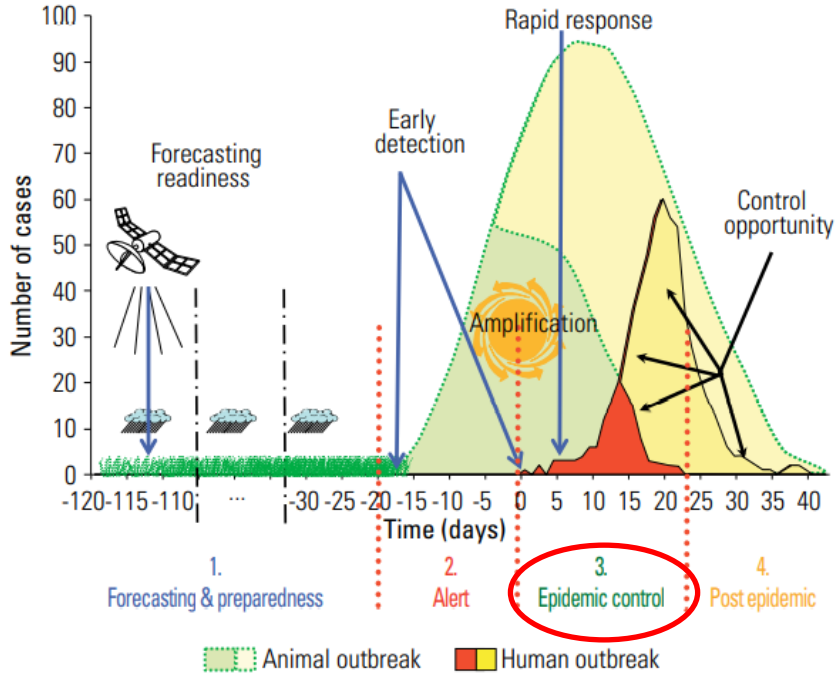
Proper communication during phases



Phase3. Promotion of a social and behavioural interventions programme aimed at informing the public and promoting the adoption of practices reducing community exposure.

S. de La Rocque & P. Formenty, 2014. Applying the One Health principles: a trans-sectoral coordination framework for preventing and responding to Rift Valley fever outbreaksRev. sci. tech. Off. int. Epiz., 2014, 33 (2), 555-567

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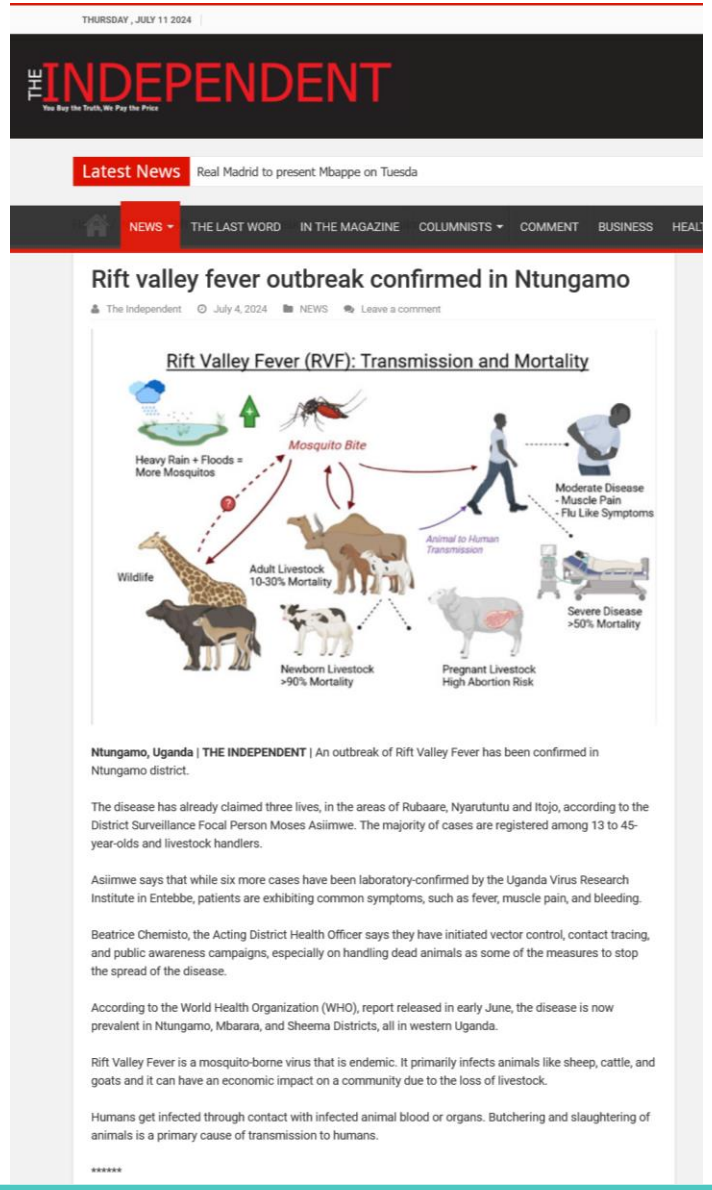
Proper communication during phases



THURSDAY , JULY 11 2024

THE INDEPENDENT

You Buy the Truth, We Pay the Price

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Rift valley fever outbreak confirmed in Ntungamo

The Independent July 4, 2024 NEWS Leave a comment

Ntungamo, Uganda | THE INDEPENDENT | An outbreak of Rift Valley Fever has been confirmed in Ntungamo district.

The disease has already claimed three lives, in the areas of Rubaare, Nyarutuntu and Itojo, according to the District Surveillance Focal Person Moses Asiimwe. The majority of cases are registered among 13 to 45-year-olds and livestock handlers.

Asiimwe says that while six more cases have been laboratory-confirmed by the Uganda Virus Research Institute in Entebbe, patients are exhibiting common symptoms, such as fever, muscle pain, and bleeding.

Beatrice Chemisto, the Acting District Health Officer says they have initiated vector control, contact tracing, and public awareness campaigns, especially on handling dead animals as some of the measures to stop the spread of the disease.

According to the World Health Organization (WHO), report released in early June, the disease is now prevalent in Ntungamo, Mbarara, and Sheema Districts, all in western Uganda.

Rift Valley Fever is a mosquito-borne virus that is endemic. It primarily infects animals like sheep, cattle, and goats and it can have an economic impact on a community due to the loss of livestock.

Humans get infected through contact with infected animal blood or organs. Butchering and slaughtering of animals is a primary cause of transmission to humans.

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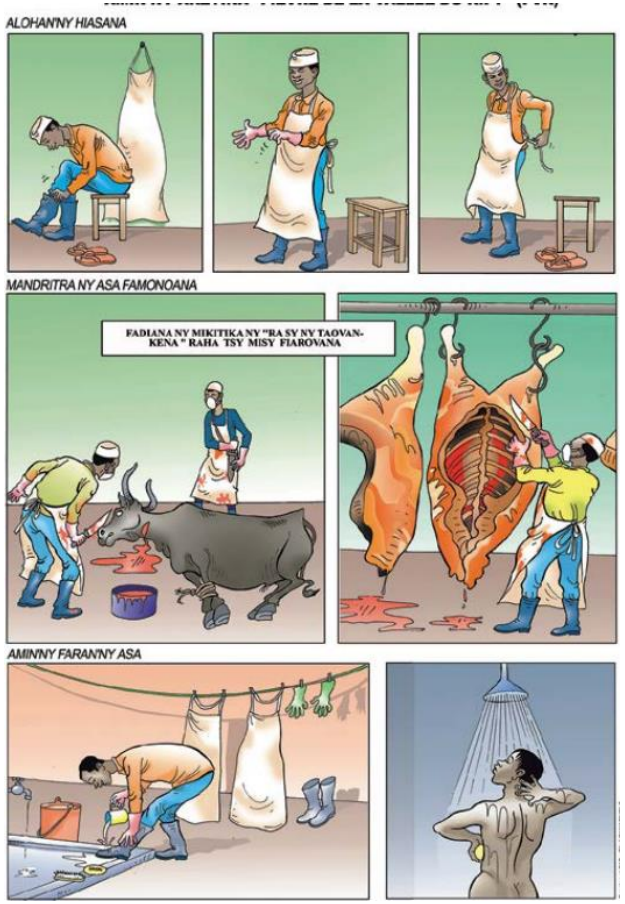

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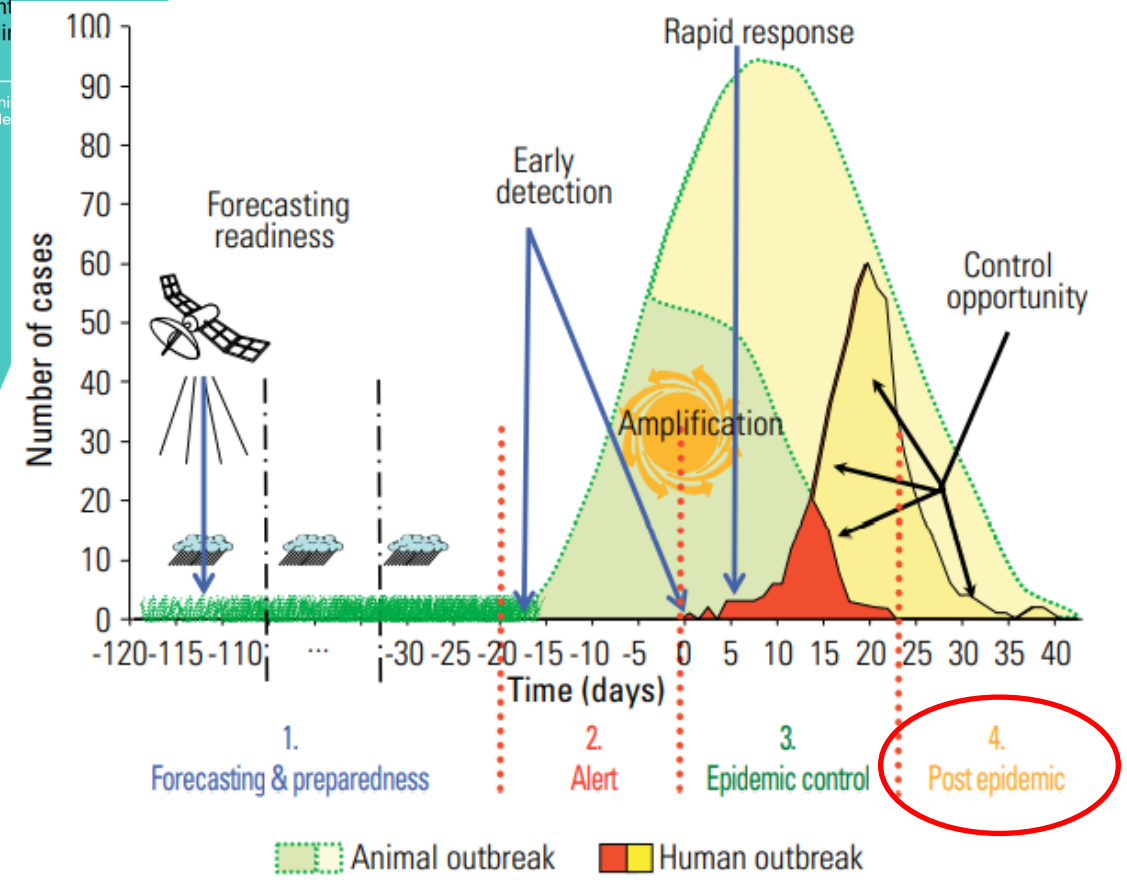
POST-EPIDEMIC PERIOD

- Surveillance
  - serosurvey to measure herd immunity
- Study and impact assessment
- Economic and social impact mitigation

Proper communication during phases



Phase4. Experience and data should be resumed and shared with the international community to improve preparedness and facilitate additional research on the disease. Communication should consider **lessons learned** and the assessment of social, economic and public health impact. Publicly **acknowledge** contributions of all communities and sectors and communicate the lessons learned; **incorporate** lessons learned into communications activities and planning for the next major public health crisis.

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Vector control

Any control strategy for vectors must be:

- Knowledge-based
- Surveillance-driven

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Knowledge-based

- Which/where breeding sites are
- Activity peaks (nocturnal, diurnal)
- Flight ranges, flight patterns, active host-seeking
- Flight ranges
- Wind dispersal
- Host preferences
- Temperature and humidity requirements for each stage
- ……

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Hyalomma tick – host seeking

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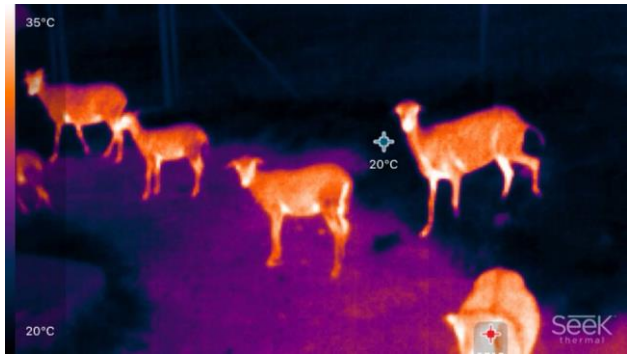
Knowledge-based

Need for research studies on the biology of vectors and their behaviour



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Surveillance-driven

- Needed for targeting control activities, to increase the efficacy, reduce the environmental impact and avoid to stimulate resistances
- It must govern the control activities, giving indications on:
  - Which actions
  - When
  - Where
  - How to monitor the efficacy

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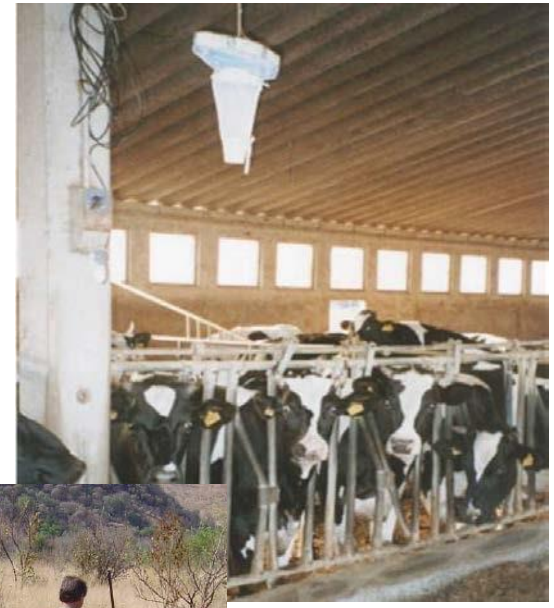
Surveillance-driven

Need to develop:

- Surveillance methods
- Surveillance protocols
- Entomology skills
- Laboratory capabilities
- ….



Preventive and control actions

- Preventive
  - Reduction/treatment of breeding sites
  - Reduction of animal exposure (physical/chemical barrier)

- Control
  - Treatments against larvae/adults in the environment, in the stables, over the animals

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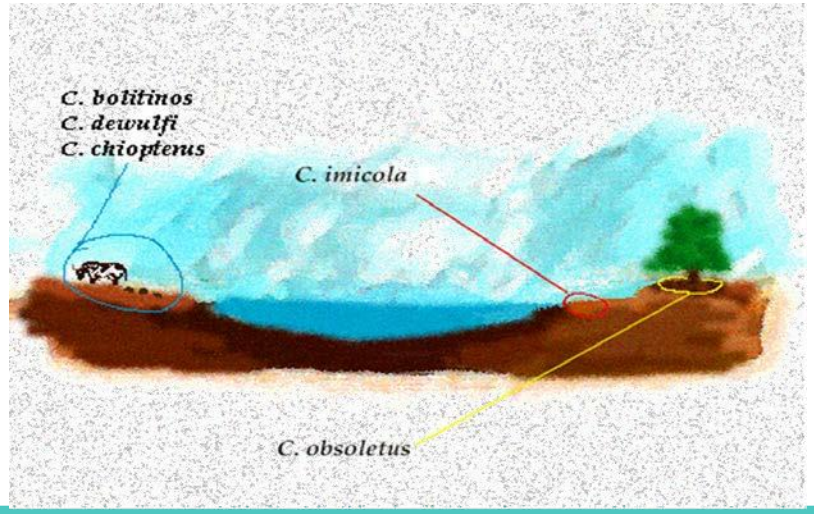
Preventive measures – breeding sites

- For some vectors (for example some *Culicoides* species) breeding sites are not well known
- Difficult to perform effective interventions (need for landscape modification!)
- In-farm hygienic measures could be more feasible



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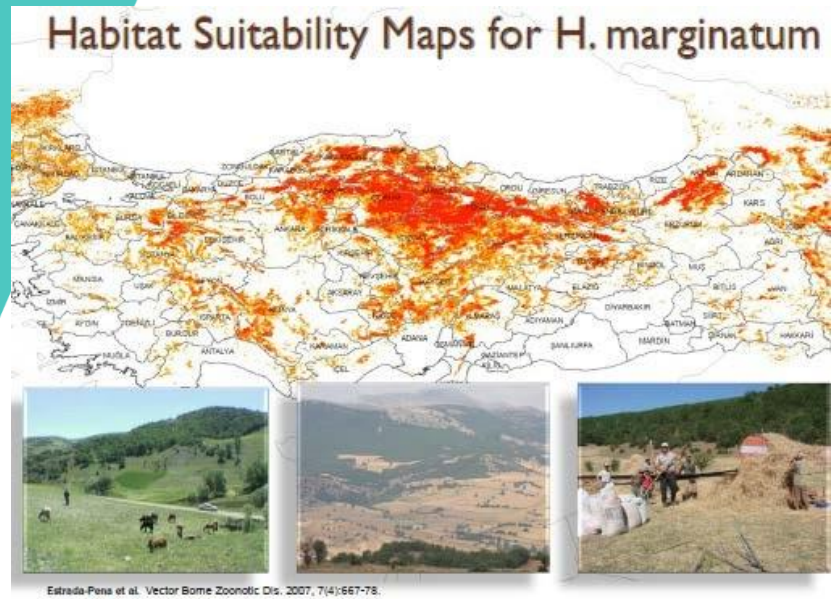
Preventive measures – breeding sites

- Some conditions are known to create a suitable larval habitat
- Effective measures need for community involvement



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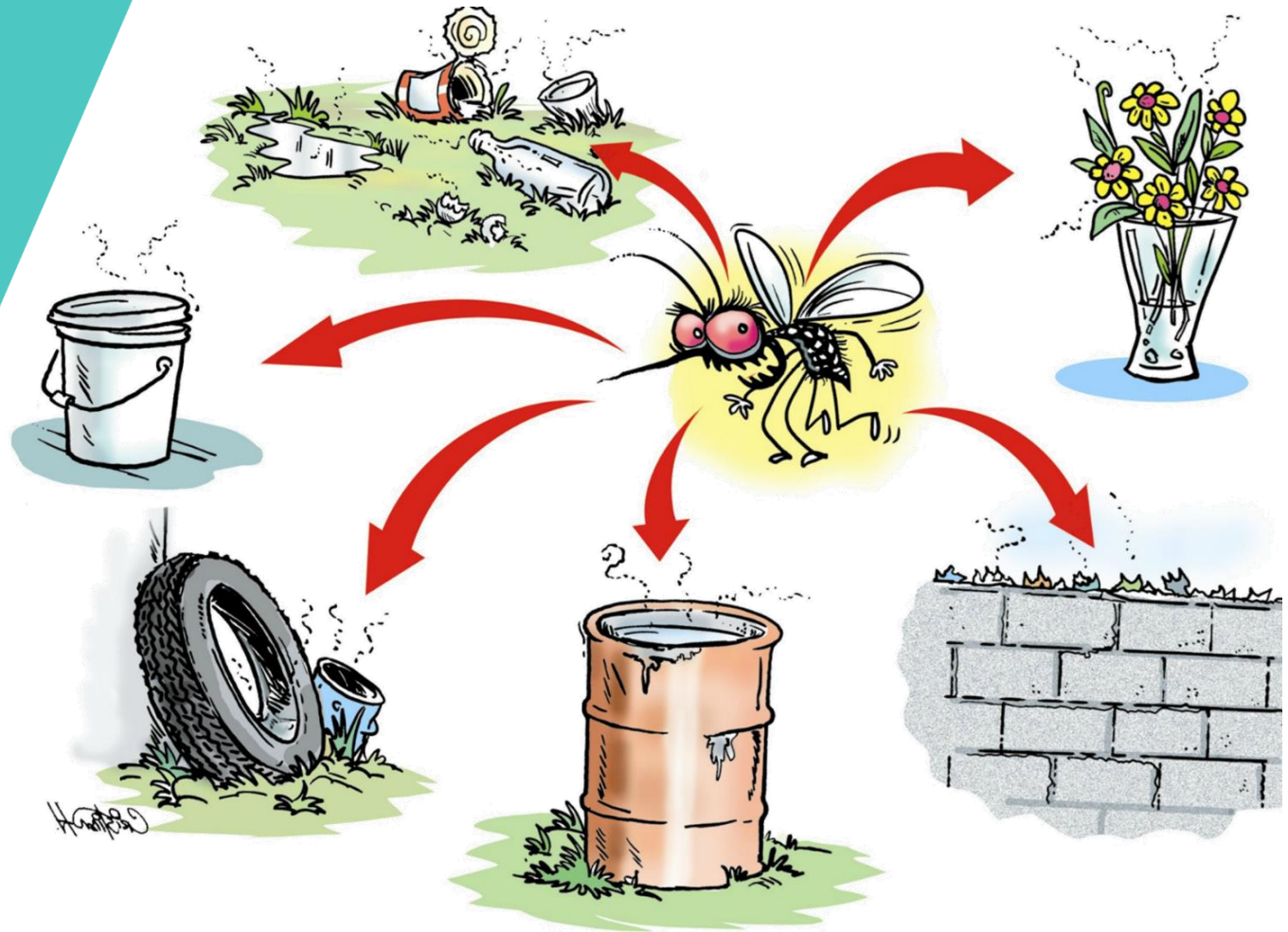
Preventive measures – breeding sites



Also at small scale…..

Examples of human activities influencing the presence and abundance of mosquitoes

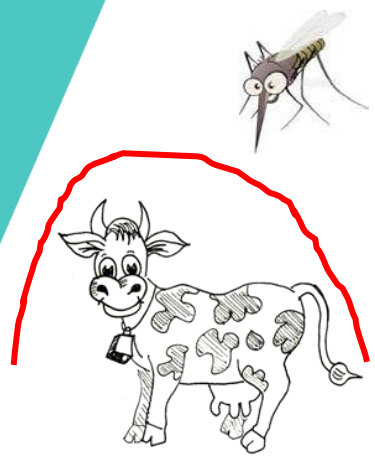
Preventive measures
Reduction of animal exposure

Physical barrier

- Use of nets is not feasible for livestock under field conditions
- To stable animals during night (effective only for nocturnal and not endophilic insects)

Chemical barrier

- Repellents
  - Correct application (reach all parts of the body, particularly the legs and belly)
  - Effects duration under field conditions (rain, animal licking, …)
  - Respect of waiting periods for milk and meat
  - Species-specific (some substances are not allowed in some species for toxicity, residue problems)
  - Costs !!



Control methods

Treatments against larval stages

- Biological:
  - *Bacillus thuringiensis israelensis*
  - *Bacillus sphaericus* (against *Anopheles* and *Culex* larvae. Ineffective on *Aedes*)
  - Predators: *Gambusia* fish

Control methods

Treatments against larval stages

- Chemical:
  - Insect growth regulator substances that interrupts the growth cycle of insect larvae
  - Careful and very targeted use to avoid accidental contamination of water bodies and effects on other insects

Control methods

Treatments against adults

- Biological:
  - Spinosad, compounds found in the bacterial species *Saccharopolyspora spinosa*
- Chemical:
  - Many compounds. Pyrethroids most commonly used

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Control methods

Chemical treatments against adults

- Environment: Ultra low volume spraying
- Animals: Dipping
- In the stables: fly traps and other solutions

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Anti-ticks vaccines

- Vaccines addressing tick antigens (midgut, salivary and others). They are able to reduce the number, weight and reproductive capacity of engorging female ticks, thus indirectly reducing the transmission rate of some tick-borne diseases.
- A commercially available anti-tick vaccine was produced in the early 1990's against *Rhipicephalus* (*Boophilus*) *microplus* and marketed in Australia and Latin America.
- Researches are ongoing for the production of a commercially suitable vaccine.

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Stimulating RNA Interference (RNAi) in infected vectors

- Arboviruses require vectors for transmission and there is evolutionary pressure on keeping the right balance between virus replication and vector survival
- Research on mosquito-arbovirus interactions indicates that innate immune responses such as RNA interference (RNAi) are key factors in reducing arbovirus replication
- RNAi has been shown to be an important antiviral response in mosquitoes
- This approach for controlling arboviruses is valid for biological vectors

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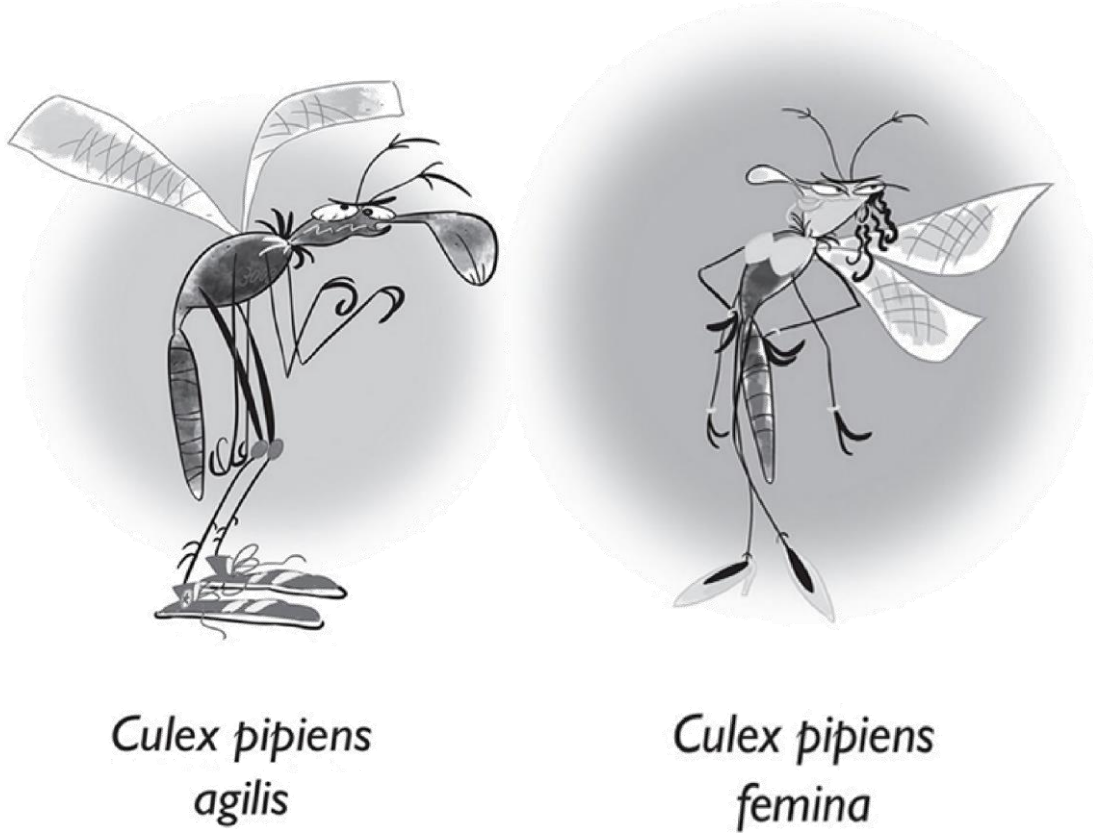
Effectiveness of vector control for reducing VBD spread

- It can reduce the VB-pathogen circulation and transmission
- It cannot stop an epidemic without the application of other control measures



Culex pipiens agilis

Culex pipiens femina

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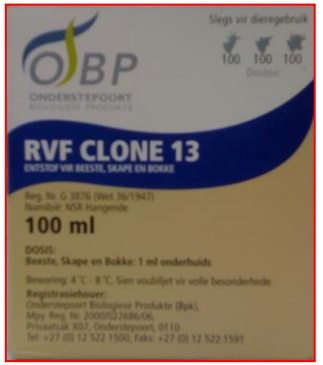
Disease control

- Livestock
  - Vaccination
  - Movement control

RVF vaccines

- Formalinised Rift Valley fever virus with aluminium hydroxide gel as adjuvant. Susceptible animals can be immunised at any age (> 6 months) irrespective of the stage of pregnancy and lactation. Annual vaccination is recommended.
- Freeze-dried, live attenuated Rift Valley fever virus (Smithburn strain). Animals can be vaccinated at any age (>6 months) but risks for pregnant animals. A single inoculation usually produces a life long immunity.
- Freeze-dried, live attenuated Rift Valley fever virus (Clone 13 strain). Young animals immunised >2 months; >6 months if from vaccinated mother. Annual vaccination.



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LSD vaccines

- Available vaccines: live-attenuated vaccines, homologous (Neethling strain) or using sheep pox virus vaccine (10x sheep dose)
- Vaccination must repeated annually

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Bluetongue vaccines

Immunity is serotype-specific:

- Live-attenuated vaccines for all serotypes
- Inactivated vaccines available only for some serotypes

Possible side-effects of live vaccines on animals and circulation of attenuated strains

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Movement control

- Very effective for direct contact disease, but not so effective for VBDs
- Impossible to maintain for long period or when movements are needed for grazing purposes
- Testing animal subjected to movement may be very expensive and risk cannot be reduced significantly when large numbers of animals are involved

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Conclusions

- Any action during “war” must be carefully planned during “peace” to be effective
- Rapid and efficient data / information exchange between actors and clear command chain are the cornerstones for the success of control measures
- Establishing a continuous and good communication with stakeholders is a pre-requisite for the early detection and control of VBDs

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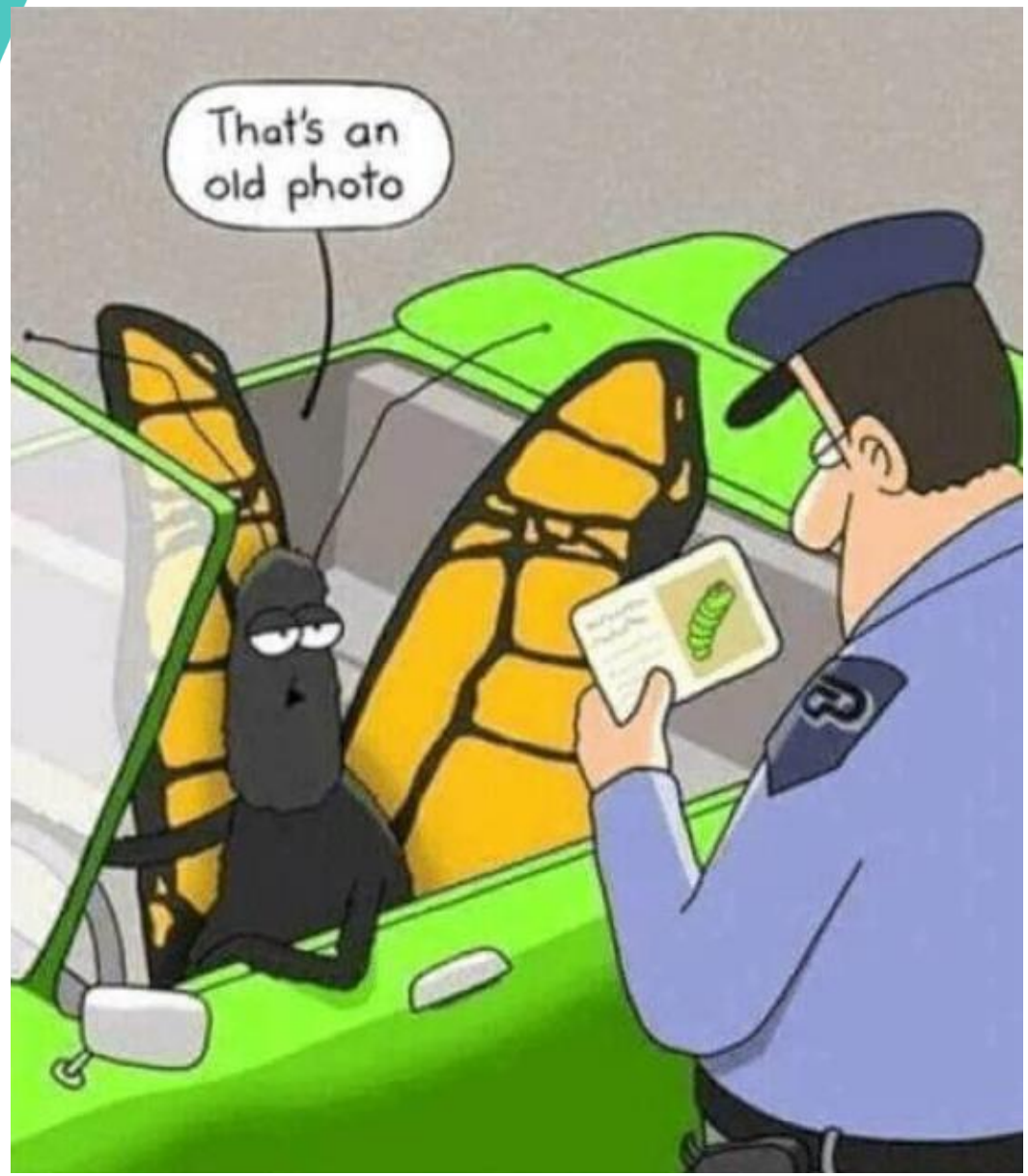

Thank you