Bluetongue and Rift Valley fever in livestock: a climate change perspective with a special reference to Europe, the Middle-East and Africa

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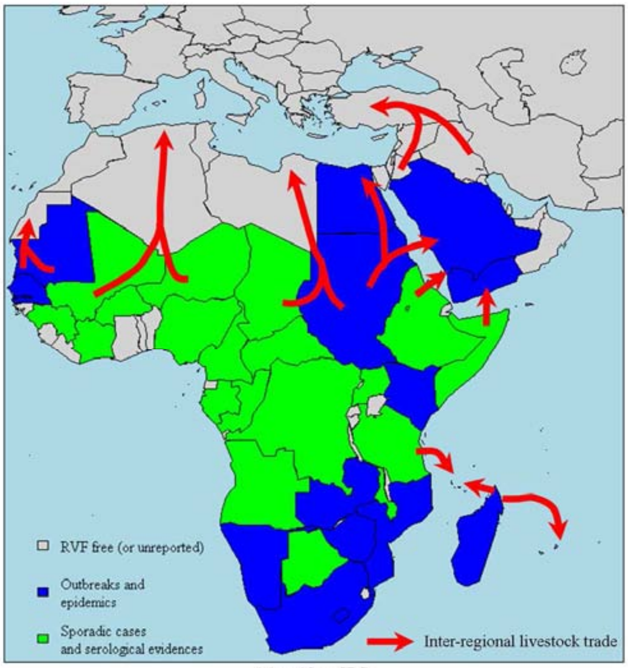
1. Present situation

1.1. Rift Valley fever (RVF)

RVF is a viral mosquito-borne disease affecting humans and domestic ruminants in which it causes abortions and neo-natal mortality (Lefèvre et al., 2003). In humans, infection is often unapparent or mild (flu-like syndrome). More severe forms can be observed, such as retinitis, encephalitis or hemorrhagic fever. In large epidemics, several hundreds of human deaths were often reported (Gubler, 2002).



Adapted from CDC,
http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/rvf/rvfmap.htm

Fig. 1. RVF status of African and Middle-East countries and inter-regional livestock trade

Many mosquitoes (and other arthropods) are possible RVF vectors, including *Aedes* spp. with possible transovarian transmission and a bio-ecology well adapted to long-term dry periods, and *Culex* spp. found in rice fields, irrigation canals, sewers, etc. Humans and ruminants can be infected either through mosquito bites or a direct contact with body fluids of viremic animals, including inhalation of infected aerosols released during abortions or slaughtering. Moreover, viremia duration is long enough to allow long-distance dissemination through cattle movements (transhumance, trade). This is the rationale for international trade bans of live animals where RVF occurs. These bans had severe economic consequences for countries like Somalia and Ethiopia after the 2000 RVF epidemic in Yemen and Saoudi Arabia or more recently Sudan just before the Hadj festival. Epidemics occur during the rainy season but temperature also plays an important role: transmission probably stops during the winter, even in irrigated-crops areas where surface water is continuously available.

1.2. Bluetongue (BT)

BT is a viral disease of ruminants which does not affect humans (Lefèvre et al., 2003). There are 24 serotypes of the BT virus (BTV). They are all transmitted by biting midges of the *Culicoides* genus (Ceratopogonidae). There is no trans-ovarian transmission in *Culicoides*. Long-distance dissemination of infected *Culicoides* midges by the wind is possible and was incriminated, for example, in the recent introduction of BTV-8 (BTV, serotype n°8) from Belgium to UK (Hendrickx et al., 2008).

BT is present on all the continents. Until recently, it was mostly confined between 40°N and 35°. Different *Culicoides* species are involved in BTV transmission. In SE Asia, Africa and the Mediterranean basin, *C. imicola* – a species complex **-** is considered as the most important vector. As any other *Culicoides* species, it is sensitive to climatic conditions, particularly water and temperature. Its extension northward was probably a consequence of global warming and was accompanied by BT dissemination in northern Africa and southern Europe. This dissemination, associated with a longer seasonal vector activity, resulted in increased virus persistence during winter, and higher transmission risk by indigenous European *Culicoides* species. Therefore, BTV transmission risk was expanded over larger geographical regions (Purse et al., 2005). An evidence of this process was the wide dissemination of BTV-8 in 2006 and 2007 in northern and western Europe after an initial outbreak (of unknown origin) in the Maastricht region: *C. imicola* was not involved in this BT epidemic, the largest ever recorded by the European veterinary services (Saegerman et al., 2008). This BTV-8 epidemic still causes major restrictions in ruminant trade in Europe, still worsened by outbreaks related to other BT serotypes (Fig. 2). Direct and indirect economic losses amount to hundreds of millions €. For example, besides national contributions, the European commission dedicated 130 millions € for BT control measures in 2008.

2. What can be expected from climate and global change?

2.1. Rift Valley fever

On the eastern coast of Africa, RVF epidemics are closely related to *El Niño* events which result in heavy rainfalls (Black, 2005), thus allowing massive proliferation of RVF vectors. This phenomenon has been recognised for a long time and predictive models have been developed using remotely-sensed surface sea temperature and normalized difference vegetation index (Linthicum et al., 1987). These models are now used in early warning systems (Anyamba et al., 2006). However, their geographical scope is limited and they cannot be used in other African regions (e.g., Sudan, Egypt, Mauritania) where no correlation between excessive rainfall and RVF outbreaks has been demonstrated.

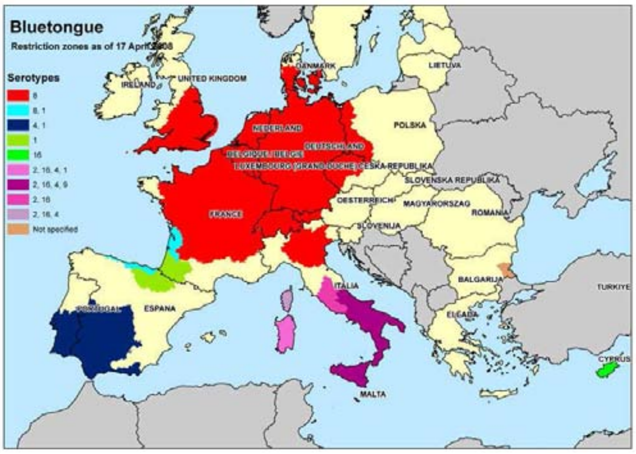


Fig. 2. Restriction zones for ruminant movements related to bluetongue infection in Europe as of 17th April 2008
http://ec.europa.eu/food/animal/diseases/controlmeasures/bluetongue_en.htm

Reports of the intergovernmental panel on climate changes (Boko et al., 2007) foresee that extreme climatic events such as *El Niño* will become more frequent. Moreover, deep changes in the African ecosystems are expected with consecutive (i) breaks in the unstable epidemiological equilibriums of many vector-borne diseases, and (ii) more intense livestock movements. These changes will probably result in more frequent RVF epidemics with a wider dissemination. Because of the inter-regional livestock trade movements (Fig. 1), northern Africa, Middle-East and, consecutively, Europe will be at higher risk for RVF.

Trade globalization and development of international travels will also favour the dissemination of some of the RVF vectors (see e.g., Reiter and Sprenger, 1987). Higher temperature might increase vector competence of mosquitoes for RVF (Turell, 1989). Climatic and other environmental changes will cause variations in their habitat suitability, both in space and time. Finally, there is an increased risk of RVF introduction in new ecosystems, followed by local virus amplification and installation with vectors of exotic or endemic origin.

2.2. Bluetongue

Bluetongue is endemic in sub-Saharan Africa with economic losses limited to countries using exotic sheep breeds (southern Africa). Climate and environmental changes might deeply alter the transmission pattern and disrupt the local epidemiological equilibrium, like this is expected for malaria (Boko et al., 2007).

The demographic growth of large cities and more generally, the increase of human populations in northern Africa and the Middle-East will result in more intense livestock aggregation around market areas, merging of populations from different origins and increased trade from sub-Saharan Africa to these regions. Regarding vector competence and habitat suitability, the same remarks as RVF applies to BT. In the end, the present European BTV-8 epidemic might only be the first of a series of *Culicoides*-transmitted outbreaks touching northern Africa, the Middle-East and Europe, involving different serotypes of BTV, as well as other viruses of major veterinary importance, such as African horse sickness.

3. How to deal with changes and uncertainties?

Bluetongue and Rift Valley fever are two examples of vector-borne emerging diseases of livestock with strong economic or public-health consequences. There are many other such diseases and their list is open, with the possible emergence of new pathogens, or existing pathogens crossing the species barrier (Mahi and Brown, 2000).

To address this issue, we need to understand and model the underlying epidemiological mechanisms at the agro-ecosystem level, and the impact of climate and environmental changes. An integrated approach must be adopted, combining field and laboratory studies on vector biology and ecology, collection of human and public-health information and of the associated risk factors (including economy and sociology), remote sensing of environmental features (landscape, land cover and land use), statistical and mathematical modelling. The EDEN project (Emerging diseases in a changing European environment) is funded by the European commission. It provides an example of what can be done in terms of scientific results, capacity building, networking and innovation potential (see e.g., Ponçon et al., 2007, Sumilo et al., 2007). Outputs of this research are disease-transmission models, risk maps and catalogues of agro-ecosystem at high disease risk, and guidelines to design disease monitoring and early warning systems implemented by public-health agencies.

Based on this knowledge, disease and vector surveillance networks must be implemented, including modern laboratory facilities to diagnose and characterise vectors and pathogens, investigate vector competence, etc. Capacity building and long-term maintenance are important issues which must be accounted for, especially in developing and emerging countries. Also, a regional and international coordination is very important to consider.

Finally, public-health policies must be designed or updated using these methods and tools, including integrated surveillance and control strategies, preparedness and general-audience information. Again, these policies must be designed and shared at a regional and international level, vector-borne diseases being excellent examples of transboundary diseases.

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