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Rift Valley Fever

Vigilance needed in the coming months

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Rift Valley fever (RVF) is a zoonotic, viral, vector-borne disease that represents a threat to human health, animal health and livestock production in Africa, and potentially Europe, the Near East and the rest of the world. RVF virus belongs to the *Bunyaviridae* family, in the *Phlebovirus* genus, and is transmitted by a very large number of genera and species of arthropods, especially from the genus *Aedes* (which is considered the primary vector) and *Culex*, as well as *Anopheles*. The disease can affect cattle, sheep, goats, camels, buffaloes and many other mammalian species. Outbreaks of RVF are characterized by the onset of abortions in 80 to 100 percent of pregnant animals, and high neonatal mortality. The primary site of RVF-induced lesions is the liver, so hepatitis lesions should alert veterinarians or butchers. Humans are considered to be "dead-end hosts" and usually present with mild symptoms. However, in a small percentage of cases, the disease can also manifest in humans as one of the viral haemorrhagic fevers with high case fatality rates. Other clinical presentations are severe hepatitis, ocular lesions or meningoencephalitis. The main route of exposure to humans, leading to severe disease, is through contact with the blood or body fluids of infected animals.

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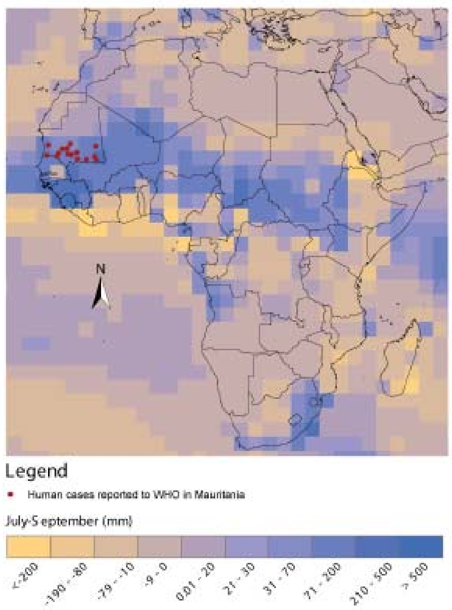
1. INTRODUCTION

In early September 2012, a human case of RVF was reported in Mauritania. By 30 October 2012, a total of six regions had been affected with 34 human cases of RVF, including 17 deaths. Only the southern regions of Mauritania, those closest to the usual enzootic areas along the Senegal River, seem to have been involved in this event. Although no active cases in animals have been reported to the World Organisation for Animal Health (OIE), analyses conducted by the National Veterinary Research Laboratory show serological evidence of ongoing virus circulation in several regions of the country, along with reports of abortions in sheep and camels.

From late July to late August 2012, above-normal precipitation (150 percent) was recorded in the sub-Saharan belt including southeastern Mauritania and adjacent areas in Mali, the middle and lower Niger River basin in Mali, the Lake Chad basin in the Niger, Chad, Nigeria and Cameroon. Flash and river floods, caused by excessive precipitation in and upstream of many locations in the Lake Chad and River Niger basin, were reported (ACMAD, 2012) (Figure 1). The current RVF event in Mauritania, which may be associated with the unusually high rainfall observed in the sub-Saharan belt this year, began just one year after OIE received the final report from Mauritania's 2011 RVF outbreak. This 2011 outbreak was situated in the northern desert region of Adrar, a very different ecological environment from the current outbreak area.

Figure 1: RVF human cases in Mauritania in 2012 and rainfall anomalies in Africa from July to September 2012



Sources: International Research Institute for Climate and Society (IRI) and Emergency Prevention System - Disease Information System (EMPRES-i).

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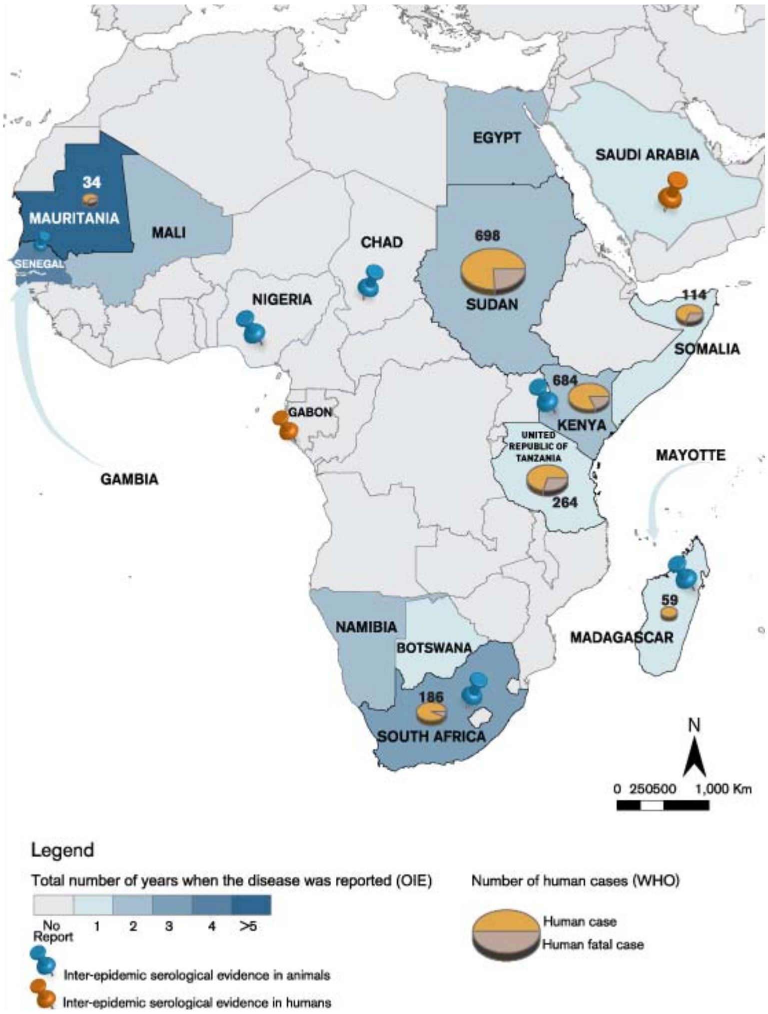
Figure 2: RVF distribution in animals and humans from 2002 to 2012



Sources: OIE; World Health Organization (WHO); Ringot *et al.*, 2004; Evans *et al.*, 2008; Pourrut *et al.*, 2010; Chevalier *et al.*, 2011; LaBeaud *et al.*, 2011; Al-Azraqi, El Mekki and Mahfouz, 2012; Cetre-Sossah *et al.*, 2012; Heinrich *et al.*, 2012.

Retrospective reviews from eastern Africa show that previous RVF epidemics have occurred in cycles of 5 to 15 years and have been linked with periods of unusually heavy rainfall associated with El Niño Southern Oscillation[1] (ENSO) warm events. Since July 2012, after a period of neutral conditions, climate indicators are showing anomalies, which are suggestive of borderline ENSO warm events. Areas at risk of an RVF epizootic will benefit from strengthened local surveillance and preparedness for outbreaks during the next two to six months.

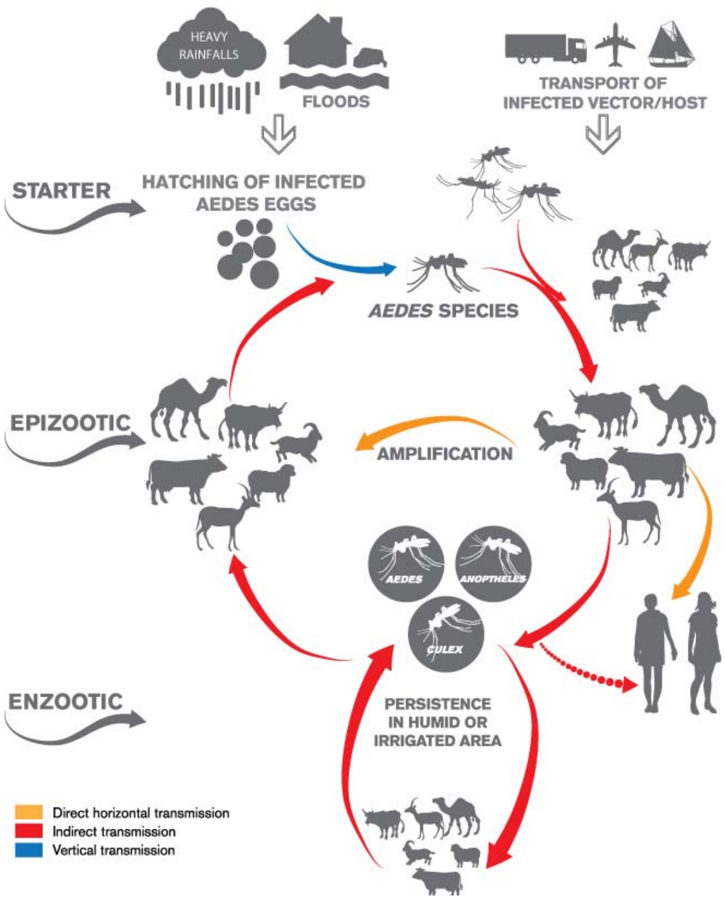
2. RIFT VALLEY FEVER ECOLOGY IN AFRICA AND THE NEAR EAST

Since the first observation in 1931, RVF has been detected in most of the countries of East, West and Southern Africa, and was reported outside Africa for the first time in 2000, when it spread to the Arabian Peninsula.

The great genetic diversity of RVF virus in eastern Africa, the ancestral virus origin of the disease, indicates that various lineages are maintained continuously in the region through enzootic circulation among domestic and/or wild mammalian reservoirs by local mosquito species. In contrast, when epidemics have taken place in areas such as Egypt, Madagascar and West African countries, where RVF had not historically been observed, the isolated viruses have been closely related to a central African strain with very limited genetic diversity, which suggests that each novel outbreak in these countries resulted from the introduction of a single virus strain from central Africa, followed by mosquito-borne spread among susceptible animals and humans (Ikegami, 2012). Sero-surveillance efforts have found significant prevalence levels of RVF antibodies in domestic and/or wild ruminants in many African countries throughout various agro-climatic zones. Many countries are

[1] El Niño is a disruption of the ocean-atmosphere system in the tropical Pacific and has important consequences for weather and climate around the globe. El Niño can be seen in measurements of the sea surface temperature (STT).

Figure 3: RVF transmission cycle



Source: FAO.

not aware of the circulation of the virus in their territories because systematic surveillance activities for the presence of RVF are lacking (Figure 2).

The combination of transovarial transmission of the RVF virus in *Aedes* species and the ability of the infective *Aedes vexans* mosquito eggs to remain viable through long periods of drought provides the opportunity for epizootics to start once the soil where these eggs are located is flooded for long enough to allow hatching of the infective larvae, and when susceptible ruminant species for amplification of the virus are present. This explains why large epizootics in eastern Africa are correlated with ENSO warm events (Linthicum *et al.*, 1999). Although no relationship between epizootics and heavy rainfall could be demonstrated in western Africa, transovarial transmission and the presence of drought-tolerant infective eggs waiting for water to hatch are thought to be part of the maintenance mechanism of the virus in these dry grassland and semi-arid endemic areas (Chevalier, Thiongane and Lancelot, 2009). The start of an epizootic can also be attributed to the dispersal of the infective vectors, including certain *Aedes*, *Culex* and *Anopheles* species, or to the introduction of infectious animals – wild or domestic – to areas conducive to increased vector activity, such as wet ecosystems and areas with irrigation schemes.

Virus amplification may also be driven by viral transmission among animals via oral and respiratory routes and exposure to infective abortive tissues and fluids. The relative importance of each mode of transmission is still somewhat controversial (Pepin *et al.*, 2010). In enzootic areas, the virus may subsequently continue to spread indirectly from viraemic animals to susceptible ruminants via bites from competent RVF vectors. Because of the transovarial transmission of the virus by *Aedes vexans*, and the subsequent deposit of infective eggs in the soil, once countries have experienced an RVF outbreak in areas with suitable environments for vector populations, these areas may be considered endemic for the disease, and represent potential future disease foci (Figure 3).

3. SOCIO-ECONOMIC IMPACTS OF RIFT VALLEY FEVER

As well as animal and public health repercussions, RVF epizootics also have a severe negative socio-economic impact on people's livelihoods. The disease has caused serious impacts on rural food security and household nutrition, as well as direct and indirect losses to livestock producers in affected countries.

A socio-economic study implemented after the 2006–2007 RVF outbreaks in Kenya demonstrated financial losses incurred by surveyed representatives of the livestock production and marketing chain. The highest losses were, for livestock producers, loss of milk production caused by abortion, worth up to K sh 758 000 (US$8 900) per camel producer; for livestock traders, lost sales because of animal deaths, worth up to K sh 180 000 (US$2 100) per trader; for slaughterhouses, closures resulting in fewer animals being killed, worth K sh 132 000 to 1.44 million (US$1 500 to 16 000) per slaughterhouse; and for butchers, closure of business or reduced numbers of animals killed, worth up to K sh 125 000 (US$1 500) per butcher (Rich and Wanyoike, 2010).

In addition, because of the decreasing demand for red meat during an RVF outbreak, drastic decreases in livestock prices and shrinkage of internal and external markets are observed. For example, during the 2007 RVF outbreak in the United Republic of Tanzania, the average price of bulls for slaughter dropped by 33 percent, the internal flow of marketed cattle decreased by 40 percent, and at least 75 percent of exports were not allowed to leave the country. Decreased activities in these industries can lead to food security problems for larger cities, depending on the sources of their animal products.

At the macroeconomic level, the RVF outbreaks that occurred in Kenya in 2007 induced estimated losses to the economy of more than K sh 2.1 billion (US$24.5 million), based on the outbreaks' negative impacts on both agriculture and other sectors (transport, services, etc.) (Rich and Wanyoike, 2010). The cost of outbreaks also includes the cost of surveillance programmes. During the Tanzanian 2007 RVF outbreak, the government spent more than T Sh 4 798 billion (US$3 million) on surveillance and control of the disease, including sample collection from all over the country to identify affected areas, vaccination of livestock, training of personnel, and public awareness raising. In most countries, adequate funding is among the major constraints to the implementation of RVF control measures.

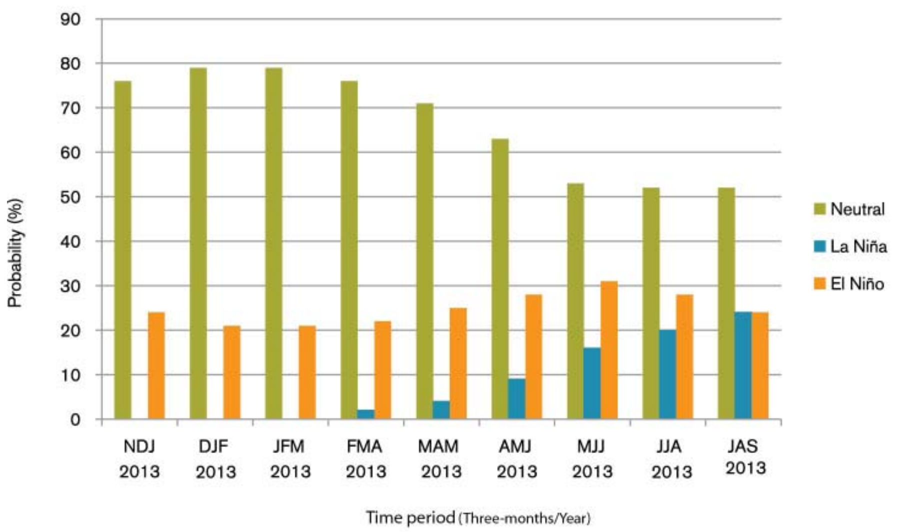
4. RIFT VALLEY FEVER EARLY WARNING SYSTEMS FOR PREVENTION AND CONTROL

Because both the geographical and seasonal distributions of many infectious diseases are linked to climate, the possibility of using climate-related environmental factors as predictive indicators, in association with regular disease surveillance activities, has proved to be relevant when establishing early warning systems for these diseases. RVF is one of the diseases for which early warning systems have been developed efficiently in the past. These systems have shown potential and relevance in anticipating major vector-borne epidemics and mitigating the associated public health and economic impacts.

The objective of establishing an RVF early warning system (RVF-EWS) is to assess the risk of occurrence of a major RVF epidemic before it arrives and to enable national veterinary services to anticipate the risk and react promptly and effectively to prevent the disease's devastating impact on animal and human health. RVF-EWS are based on a combination of local surveillance activities associated with the monitoring of different types of climate data, including three-month seasonal weather forecasts, near-real-time rainfall and Normalized Difference Vegetation Index (NDVI)[2] estimates, and ENSO indicators. Ultimately, risk assessment and alerts generated by RVF-EWS are translated into visual decision-support tools, such as risk maps, which decision-makers can use to plan targeted interventions and develop communication and sensitization campaigns in the face of an epidemic.

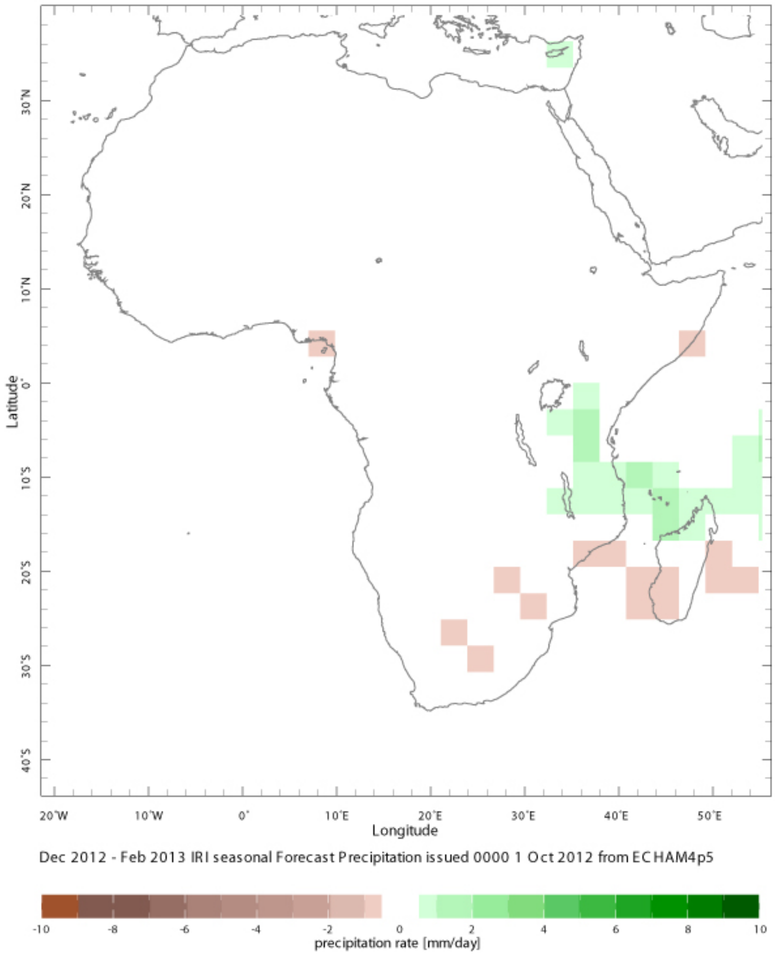
A body of knowledge on RVF-EWS and modelling techniques for monitoring environmental predictors to forecast potential epidemics of the disease in time and space has emerged over the last ten years, and is considered a growing field. The RVF modelling approach developed by the National Aeronautics and Space Administration's (NASA's) Goddard Space Flight

Figure 4: Series of Three-months at a time Probabilistic ENSO forecasts



Source: IRI Probabilistic ENSO Prediction for NINO3.4

Figure 5: Forecasts of rainfall anomalies from December 2012 to February 2013



Source: IRI.

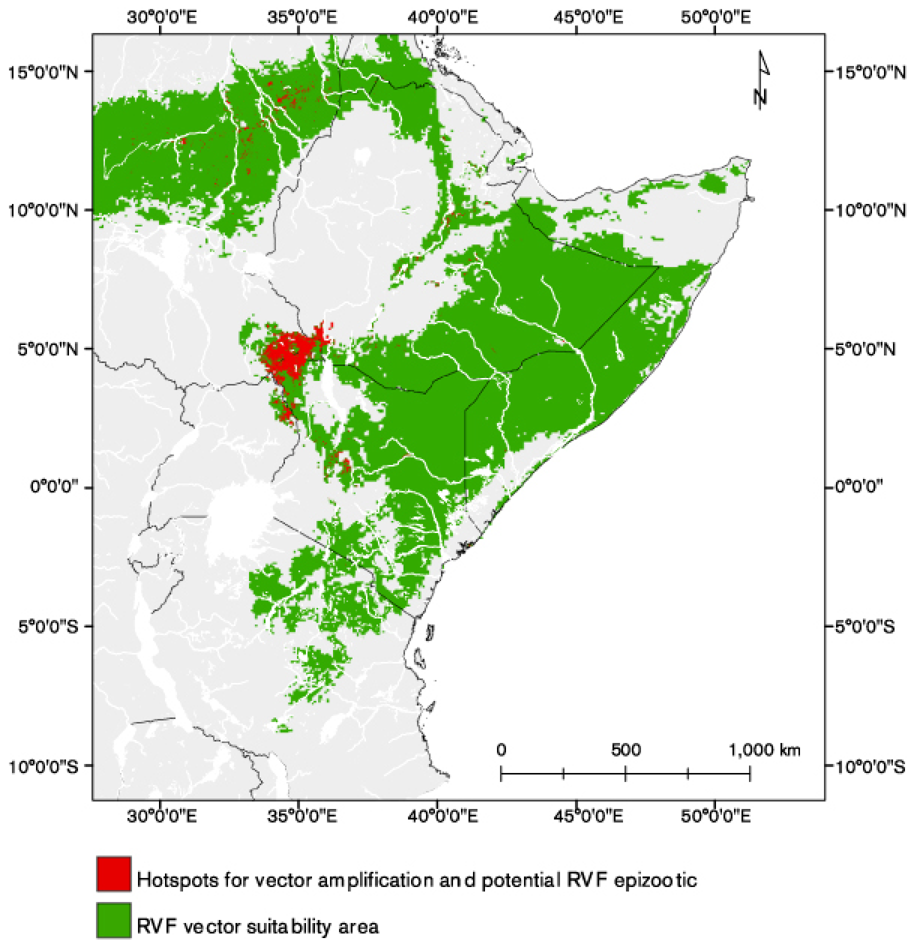
Center (GSFC) identifies areas with positive NDVI and rainfall anomalies (above the long-term average NDVI and rainfall). Areas with persistent positive anomalies represent suitable habitats for RVF vectors. These predictions were successfully used in the Horn of Africa in 2006 to implement enhanced surveillance activities for animals and humans two to six weeks before the first RVF human and animal cases were identified. More generally, retrospective studies have demonstrated the ability of such models to provide reliable indications of RVF occurrence in savannah agro-ecosystems, mainly in eastern Africa, although they are found to have a poor predictive performance for RVF outbreaks in tropical or temperate areas (Madagascar), western Africa and southern Africa. Improvements are still needed, especially related to the NDVI threshold and the validation system through incorporating epidemiological data from actual livestock and human cases (Anyamba *et al.*, 2009).

By late July 2012, the SST anomalies had increased, and such conditions continued through the first half of September. However, the expected warm event weakened and was in the warm half of the ENSO-neutral range, and this situation generally continued through October and into mid-November. Currently, slightly less than one-quarter of the dynamical and statistical models predict El Niño SST conditions for the December 2012 to February 2013 season, and some of these show a brief continuation of El Niño into very early 2013[3] (Figure 4).

However, rainfall forecasts are still predicting above-normal precipitations in southern Africa, but not the Horn of Africa, through February 2013 (Figure 5). Countries located in the geographical areas where above-average rainfall anomalies are expected must stay on alert. Near-real-time satellite precipitation estimates (running rainfall totals and anomalies) and short-term forecasts for Africa can be checked on the National Oceanic and Atmospheric Administration (NOAA) Web site.[4] Online maps highlight at-risk areas of heavy rainfall (Figure 5).

[2] NDVI has been successfully used to monitor vegetation dynamics and to explain the distribution of wildlife, including arthropod pests and vectors of disease.
[3] http://portal.iri.columbia.edu/
[4] www.cpc.ncep.noaa.gov/products/african_desk/cpc_intl/africa/africa.shtml

Figure 6: The RVF vector suitability area (in green) and hotspots for vector amplification and potential RVF epizootic (in red) for October 2012 in Horn of Africa using satellite derived NDVI and rainfall data



See Anyamba *et al.* (2009) for a detailed description of methods.

In the Horn of Africa, a potential suitable area for RVF vectors has been defined using rainfall and NDVI data from satellite images (Anyamba *et al*., 2009). Within this suitable area, hotspots for vector amplification and RVF epizootic for a given month can be identified from persistent NDVI anomalies over three previous consecutive months. Figure 6 shows an example of this model for October 2012.

Given the low probability of heavy rainfall and an ENSO warm event, the risk of outbreak occurrence during the winter of 2012/2013 may be considered low to medium.

5. RECOMMENDATIONS

Based on this information, despite the medium-to-low risk of observing major RVF epidemics in the next six months, and considering the predictions of above-average rainfall – especially in countries with a history of RVF outbreaks – at-risk countries should: i) heighten their level of surveillance in RVF hotspots; ii) increase their level of preparedness, and implement targeted vaccination if necessary; and iii) raise awareness and communicate with communities at risk of emergence of the disease.

1) Surveillance in at-risk areas

RVF at-risk areas are defined as geographical locations with environmental conditions that may represent ideal mosquito habitats. The areas where mosquito breeding activity is likely to be greatest, such as near rivers, swamps and dams, should be selected. Such mosquito breeding sites are typically shallow depressions, which become flooded during prolonged periods of rainfall, and areas along irrigation channels. It is important for countries to be aware of the potential increased risk of RVF outbreaks following the creation of irrigation zones and water management areas:

- Surveillance of sentinel herds: Sentinel herds are small herds of susceptible ruminants located in geographically representative areas of the country. Use of sentinel herds is an important means of obtaining baseline epidemiological information on RVF exposure. Surveillance should be carried out by regular field visits and contacts with livestock farmers and communities. Activities should include periodic, geographically representative serological surveys and participatory epidemiological techniques. They

Mosquitoes in a net cage at a lab at the International Centre of Insect Physiology and Ecology in Nariobi, Kenya. © FAO/Simon Maina

should focus on active disease surveillance, to enhance the possibility for early detection of increased virus activity or of build-up in competent vector mosquito populations, and to establish baseline information on inter-epidemic virus transmission patterns.

- Surveillance in slaughterhouses/markets: Places of congregation can be used as sources of information on RVF viral circulation, especially when the origins of animals slaughtered and traded can be traced back. Although the information generated from this type of surveillance is not as geographically precise as that from sentinel herds, it may give some insights on the disease situation in areas of the country known to be at risk of RVF.

- Syndromic surveillance: Identification of the disease in humans often signals increased virus activity, because RVF virus circulation may remain unnoticed in animal populations in the early stages of an epidemic. To enhance the prevention of exposure to RVF virus in humans, and the subsequent chance of severe disease, it is critical to reinforce active surveillance activities, sensitize and train field veterinarians to report non-specific signals in animals (i.e., higher than expected numbers of abortions or neonatal mortalities), and be aware of particular climatic conditions or alterations in the environment that create a suitable environment for the development of competent vector populations.

2) Vaccination against RVF

Vaccination can be considered as a control strategy to limit virus circulation in enzootic areas and to prevent epidemics in free areas. Vaccination is most effective when used in conjunction with other control strategies. Currently, only a few countries have implemented a strategy of continuous annual vaccination (Egypt, South Africa and Saudi Arabia). Other countries have chosen to implement vaccination strategies as soon as an RVF outbreak has been identified (Kenya and the United Republic of Tanzania). There are no reports of West African countries using RVF vaccine.

Two types of vaccine have traditionally been used in RVF control strategies: live vaccine prepared from an attenuated strain of RVF virus (Smithburn strain), and a non-replicating inactivated vaccine (virulent field origin strain). Live attenuated vaccines have been shown to induce abortions and exhibit other signs of pathogenicity in naïve ruminants. Because of the losses caused by abortions, and the resulting decreased confidence in the potential benefit of a vaccine programme in the affected farming community, the application of live attenuated vaccines to animal populations has been limited (e.g., in South Africa and Kenya). In contrast, inactivated vaccines are safe in pregnant animals, but confer only short-term immunity and require multiple inoculations. This type of vaccine has been used for long-term vaccination strategies in some countries (e.g., South Africa and Egypt). More recently, a new generation of vaccines have been used, such as the avirulent natural mutant Clone 13, which exhibits a high level of protection while offering less virulence in the host (currently registered in South Africa). Other vaccine candidates are under development and seem promising, but further validation for safety and efficacy are needed.

Vaccination should be seen as only one of the tools for preventing RVF epidemics and should always be used in combination with enhanced surveillance, quarantine and movement controls, to minimize production losses until herds reach the end of their production cycles.

3) Vector control

Vector control can also be part of an overall strategy for reducing the risk of RVF, through the use of strategic larvicidal treatment of mosquito breeding habitats or the widespread use of insecticide. However, its efficacy in disease control for RVF has still to be assessed. Repellents used on animals and mosquito netting can decrease the risk of virus transmission.

6. PUBLIC HEALTH, COMMUNICATION AND AWARENESS

Communication regarding disease risk and awareness campaigns on risk mitigation are essential in protecting humans from RVF infections by limiting exposure to the RVF virus for populations at risk, such as farmers, veterinarians and slaughterhouse workers. A communication strategy, jointly prepared by the animal and human health authorities, will increase the chances of decreasing the population's risk of exposure to the RVF virus and subsequent disease, as well as increasing consumer confidence and avoiding miscommunication on food safety concerns.

For more information

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CONTACT

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