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Review

Rift Valley fever outbreaks: Possible implication of *Hyalomma truncatum* (Acari: Ixodidae)

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Rift Valley fever (RVF) is a viral zoonosis that primarily affects livestock. However, the virus can also infect humans and may even cause human fatalities. Although the vast majority of human infections result from direct or indirect contact with the blood or organs of infected animals, human infections have also resulted from the bites of infected *Aedes* mosquitoes. Due to the increasing importance of zoonotic diseases including RFV to global health, there is need for in-depth knowledge on the transmission of RFV viruses. We postulate that some hard ticks might be involved in the transmission of Rift Valley fever virus between animals in nature. This can partially be explained by the biology of ticks. Firstly, ticks spend long periods feeding on the host. Secondly, disease-bearing ticks may survive long periods of desiccation and an infected fully fed female tick continue to harbour RVF virus post-oviposition. Current geographical distribution of *Hyalomm truncatum* (Acari: Ixodidae) appears to show correlation with incidence of RVF. Future interdisciplinary research focusing on Rift Valley fever molecular epidemiology and tick chemical ecology, will certainly establish the role that *H. truncatum* and other ticks play in the spread of the virus in nature, and consequently contributing to the development of effective Rift Valley fever management strategies.

Key words: *Hyalomma truncatum*, Ixodid ticks, Rift Valley fever virus, zoonosis, vectors, disease transmission.

INTRODUCTION

Rift Valley fever is an arthropod-borne viral disease that affects ruminants and humans. The disease is caused by a Phlebovirus genus (Bunyaviridae). It causes high morbidity and mortality in young ruminants and high abortions in pregnant animals especially in goats and sheep (Pépin et al., 2010). In humans, it induces haemorrhagic fever syndromes (FAO, 2005). The vast majority of human infections result from direct or indirect contact with the blood or organs of infected animals. Exposure to the virus in body fluids of livestock or carcasses and organs during necropsy, slaughtering, and butchering can lead to infection (Pépin et al., 2010). Human infections have also resulted from the bites of infected mosquitoes, most commonly the Culex and Aedes mosquitoes (Gear et al., 1953; WHO, 2012). The disease is widespread across the African continent; it is endemic in parts of southern and eastern Africa and sporadic cases have been reported in central and western regions of Africa. Many human fatalities caused by the virus have been reported in Africa (Meegan et al., 1979; Jouan et al., 1988; WHO, 2007; Sissoko et al., 2009).

Since it is widely believed that mosquitoes are mostly

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responsible for the transmission of Rift Valley fever (RVF), not much attention has been paid to other arthropods such as ticks, which are also capable of transmitting many zoonotic diseases. It appears the epidemiological process leading to RVF epidemics looks much more complex. Optimum climatic conditions (temperature and rainfall) and presence of mosquitoes have not completely explained the RVF outbreaks. For example, predictive model developed for East African region could not be applied in West Africa because abundant rainfall, which normally correlates with increased number of mosquitoes, was not often associated with RVF outbreaks (Pépin et al., 2010). Also, there could be other vectors including ticks that might be involved in the spread of RVF. The life histories of some Ixodid ticks such as *Hyalomma truncatum, Hyalomma rufipes* and *Amblyomma variegatum* (Acari: Ixodidae) suggest these ticks could be involved in the spread RVF virus in nature. Following an investigation carried by Gear et al. (1953) to explain the occurrence of RVF virus infections on cattle in parts of South Africa, the authors concluded that in 1953, Rift Valley fever virus still persisted in the Union of South Africa, however, they could not determine how and where the infection is maintained and they suggested that this presents an interesting problem for future study. In this review we comment on the possible involvement of ticks in the spread and maintenance of RVF virus in Africa.

EVIDENCE OF RVF VIRUS TRANSMISSION BY TICKS

Aedes mosquitoes are known to be the primary vectors of RVF; *Aedes mcintosh* are thought to be reservoir of the virus and has the ability to transmit the pathogen transovarially (Omuse, 1994). However, laboratory investigations on vector competence suggest ticks and sand fly could also transmit the virus (Omuse, 1994). Ticks are known to transmit many pathogens of viral, bacterial and parasitic origins to humans, livestock and wildlife. Besides vectoring of important disease-causing pathogens, ticks cause direct loss through sucking blood. Overwhelming evidences of tick involvement in transmission and spread of deadly zoonotic viruses are available in literature (Sambri et al., 2004; Parola et al., 2005). As research on vectors competences in the transmission of important viral diseases intensify, ticks are increasingly being recognized as one of the most important group of vectors. In a pioneer study, it was demonstrated that *H. truncatum* can transmit Rift Valley fever virus to hamsters and the virus can replicate in the ticks (Linthicum et al., 1989). The study also revealed that RVF can be transmitted transtadially and horizontally. Thus, ticks might be contributing to the increasing incidences of the virus. Rift Valley fever is a viral zoonosis that primarily affects animals but can also infect humans. Immature stages of some ticks including *H. Truncatum* readily attaches on humans, however, the frequency of contact with humans would be relatively low compared to contact between mosquitoes and humans, thus its roles as vector would most likely involved transmission of the pathogen between ruminants. *H. truncatum* might play an important role in the transmission of RVF virus between animals in nature. Despite the strong evidence suggesting that *H. truncatum* could be involved in the transmission of the virus, however, the geographical range of dissemination of the virus by the tick is expected to be quite small since immature stages of *H. truncatum* prefer feeding on hares and rodents (Walker et al., 2003).

TICK BIOLOGY AND DISEASE TRANSMISSION

Hyalomma truncatum has both two-host and three-host life cycles depending on the hosts species (Magano et al., 2000). The tick prefers domestic and wild herbivores. Immature stages prefer feeding on hares and rodents, meaning a single tick would feed on 2 or 3 different hosts. This would increase the chances of contact between the tick and a pathogen. Adults are abundant in the late wet summer and immature stages in dry Autumn to Spring month (Walker et al., 2003). Typically, mosquito populations peak during warmer and wet months, which coincide with availability of pastures for domestic animals and abundance of adult *H. Truncatum*. Infected mosquito can transmit the disease to herbivores during feeding and the pathogens can then contaminate ticks that attach to the infected herbivore. Ticks spend long periods feeding on the host, disease-bearing ticks may survive long periods of desiccation and an infected fully fed female *H. Truncatum* tick can continue to harbour RVF virus post-oviposition (Linthicum et al., 1989).

Depending on the tick species, some immature stages prefer birds. Migratory birds can transmit diseases and immature ticks across large geographical areas (Owen et al., 2006; Paulauskas et al., 2009). In the case of RVF virus, infected immature tick can easily be transferred by birds from one geographical area to another. Immature stages of *H. rufipes* and *A. variegatum* are known to parasitize ground frequenting birds. Compared to mosquitoes, ticks might be playing a more important role in the long range outbreaks of RVF. Although there is no evidence to support this claim, investigations on vector competence of these species could throw more light on the dissemination and incidences of outbreaks of the virus. Results from various studies have implicated *Hyalomma* spp. in the transmission of the Crimean Congo Haemorrhagic fever virus (Shepherd et al., 1991; Sang et al. 2011).

ROLE OF SMALL MAMMALS

In an earlier study, it was observed that mice that were experimentally infected intravenously with RVF virus were more susceptible to RVF infections compared to those that were infected subcutaneously (Mims, 1956). According to a study that was conducted in Senegal by Gora et al. (2000), 3.8% of 214 wild rodents belonging to 14 species

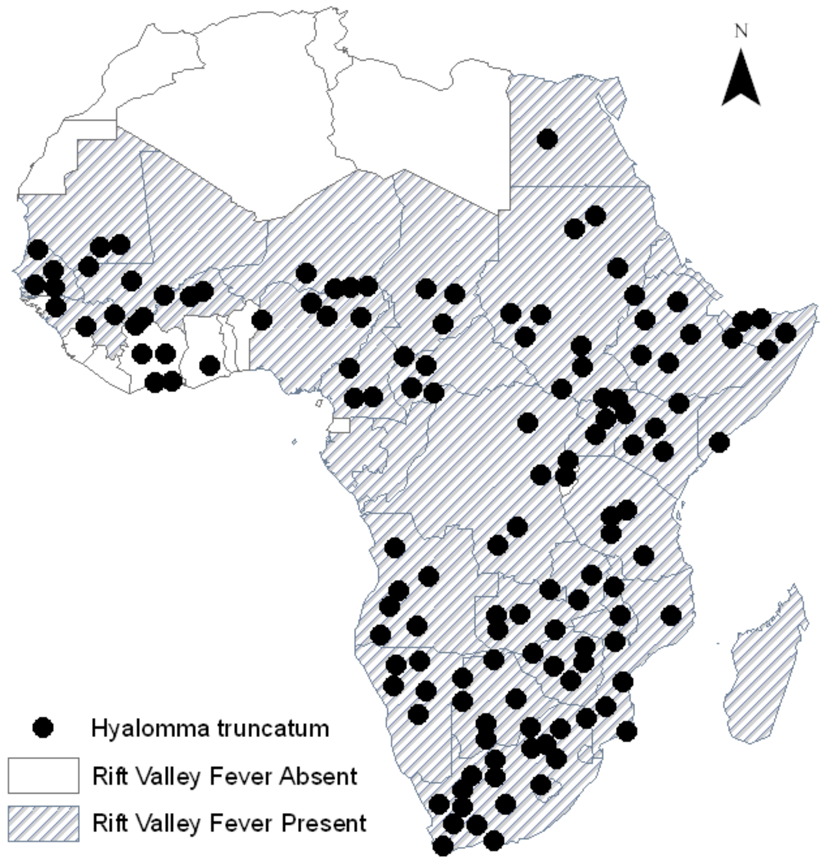

Figure 1. Yellow fever and Rift Valley fever distributions adapted from CDC (2003) (http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/rvfmap.htm) and Walker et al. (2003), respectively.

tested positive for anti-RVF virus antibody, and *Arvicanthis niloticus* and *Mastomys erythroleucus* were found to be susceptible to RVF virus following experimental infections. The researchers postulated that limited resistance to RVF infections could potentially allow for replication of this virus, making these mammals possible candidates as hosts in the maintenance cycle RVF virus in nature. Despite the fact that these evidences suggest there could be a link between rodents and RVF virus in nature, both hares and rodents generally have a small home range (Peinke and Brown, 2004; Schradin and Pillay, 2006) and it is unlikely these hosts are involved in the spread of RVF over long distances. Interestingly, immature stages of *H. truncatum* prefer feeding on hares and rodents (Walker et al., 2003), and blood-feeding sources of mosquitoes include rodents (Gear et al., 1953; Alencar et al., 2012). It is probable that rodents act as bridge mammal in the transmission of RVF virus between *H. truncatum* and mosquitoes.

GEOGRAPHICAL DISTRIBUTION OF *H. TRUNCATUM* AND RIFT VALLEY FEVER VIRUS IN AFRICA

Although the original records of tick distribution presented in Figure 1 may not be entirely accurate and precise, geographical distribution of *H. truncatum* appears to show correlation with incidence of RVF (Walker et al., 2003; CDC, 2003). Entomological research have produced predictive model for outbreaks and high risks sites in East Africa. However, these models have mixed successes and could not be applied in West Africa because abundant rainfall and mosquito populations cannot fully explain RVF outbreaks (Pépin et al., 2010).

CONCLUSION

In addition to mosquitoes and international trade of livestock and animal products, ticks could be implicated in the spread of RVF. Ticks, especially *H. truncatum* might be contributing to the increasing outbreaks of Rift Valley fever in Africa. Knowledge regarding how Rift Valley fever virus is transmitted among vectors (ticks or mosquitoes) and the role of vertebrates in propagating the virus could result in a more accurate prediction and control of future outbreaks of RVF. The best strategy to protect Europe and the rest of the world against RVF is to develop more efficient surveillance and control tools and to implement coordinated regional monitoring and control programmes

(Pépin et al., 2010). Members of the genera *Hyalomma* and *Amblyomma* are hunter ticks that actively seek their hosts and this behaviour can be exploited for tick surveillance purposes (Nchu et al., 2009). For example, members of the genus *Amblyomma* actively respond to the attraction-aggregation-attachment-pheromones (AAAP), which is secreted by feeding male ticks and to carbon dioxide (Kairomone) exhale by their host (Bryson et al., 2000). Further research, which combines molecular epidemiology and tick chemical ecology investigations, will certainly establish the role that *H. truncatum* and other ticks play in the spread of the virus in nature, consequently contributing to the development of effective RFV management strategies.

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