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Summary of the ESA Symposium: "What role do insects play in the Ebola virus transmission?
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Can Insects Transmit Ebola Virus?

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An outbreak of Ebola virus in West Africa that started in March 2014 has become the deadliest occurrence of this disease since the initial discovery of the virus in 1976[1]. Between March 2014 and February 2015, nearly 23,000 cases of Ebola virus were recorded with over 9,200 deaths occurring primarily in the African countries of Liberia, Guinea, and Sierrra Leone[2]. While these figures probably underestimate true morbidity and mortality, it does not appear that the number of infections is likely to reach the much higher end of year estimates the EbolaResponse model generated in September of 2014[3].

During the past year, many entomologists have been asked whether arthropods might be capable of transmitting Ebola virus. In fact, this question was asked of our entomological community so many times that the Medical, Urban, and Veterinary Entomology (MUVE) section of the Entomological Society of America (ESA) organized a symposium on the topic at the annual ESA meeting in Portland, OR, in November 2014. This article is a summary of that symposium discussion.

Ebola virus is one of only two viruses in the virus family Filoviridae; the other related virus is Marburg virus. Ebola virus is capable of causing severe hemorrhagic fever in humans and other primates, with human mortality during outbreaks often exceeding 30-40%[4] and near 70% for the current outbreak[5]. Clinical manifestations of Ebola include fever, fatigue, diarrhea and vomiting, with unexplained bleeding or hemorrhagic lesions occurring with reduced incidence[5]. At time of death, Ebola virus is common in macrophages and endothelial cells[6]. Transmission of Ebola virus among humans is typically associated with direct contact with the skin or blood of infected humans or cadavers[6]. The Ebola virus is thought to gain entry to the new human host through exposure to mucosal surfaces or injured skin.

Notwithstanding the mechanism by which Ebola first enters the human population during each new outbreak, human infections with Ebola can usually be traced to an intimate contact with an infected person or the cadaver of a recently infected person[5]. However, given that clinical symptoms include diarrhea, vomiting, and in some cases bleeding or hemorrhagic lesions, *it would be prudent to question whether Ebola virus might be capable of persisting in the environment long enough to be transmitted via fomites or insects that might contact the infected person*. While there are few studies examining the Ebola inactivation rate following exposure to environmental conditions, it appears that the rate of Ebola virus inactivation is similar to that of other highly virulent RNA viruses with 90% virus inactivation by 36 hours post deposition onto glass slides held in the dark under laboratory conditions[7]. Ebola virus is expected to reach a similar level of inactivation in only a few hours under outdoor daytime conditions[8].

During the ESA symposium to discuss the risk of insect involvement in Ebola transmission, **there was general consensus that "filth flies" which commonly feed on human body excretions and secretions, such as the bazaar fly (*Musca sorbens*) and the house fly (*Musca domestica*), or flies that are attracted to the recently deceased, such as blow flies in the Family Calliphoridae, are likely to pose the greatest risk for transmission of Ebola virus.** These flies will visit and feed on human vomit, feces, and excreted blood; all hallmarks of Ebola infection in humans. Following exposure to virus from infected hosts, these flies may visit the uninfected to feed on sweat, tears, wounds, exudate from wounds, or other body secretions perhaps passing the virus on to the new host following virus deposition onto mucosal surfaces or into damaged skin. In this way, flies might serve as simple mechanical vectors of viruses rather than as necessary components of the transmission process. Mechanical vectors can move a pathogen among human hosts, without the pathogen replication or development that occurs within a biological vector such as a mosquito or tick. Therefore, flies may serve the same role in virus transmission as a medical instrument used on an infected patient and

not properly cleaned and sterilized before use on a subsequent person. The evidence for flies serving as mechanical vectors of viral pathogens is increasing. These fly species are capable of acquiring viruses under natural field conditions, with deposition of virus subsequently onto human foods or substrates upon which they land. A list of references supporting the evidence of flies as mechanical vectors of human pathogens has been compiled and is available as a result of the ESA symposium[9]. To our knowledge, there is no reported evidence as to whether these flies can or cannot transmit Ebola virus.

With Ebola virus common in the blood of infected humans, particularly near end of life, ESA members also wondered whether blood-feeding insects might pose a risk for transmission of the virus. Blood-feeding insects like mosquitoes or sand flies that feed on a single host and then seek refuge away from the host to develop eggs were thought unlikely to transmit this virus given the rapid inactivation rate of Ebola virus outside the human host. There is **no evidence** that these blood-feeding insects can support replication or persistence of Ebola virus, or serve as mechanical vectors of Ebola virus following an infected bloodmeal; in fact, evidence to date suggests that these blood-feeding insects cannot transmit Ebola virus[10,11,12]. However, symposium members questioned whether blood feeding insects that remained in the vicinity of a host might be involved in transmission. It was suggested that bed bugs, lice, fleas or other blood feeding insects that had recently fed on an infected human could have virus in their undigested bloodmeal and that *handling* of these insects by family members or others in close contact with the infected human *might* result in transmission. In many cultures, it is not uncommon for people to remove blood-feeding insects from a debilitated family member and squish the offending insect between the thumb and finger. This could certainly result in direct contact with the blood of the infected family member.

Symposium participants concluded that it would be prudent to assume some risk of Ebola transmission by any insect species that will feed on an infected person or their excretions/secretions and which may be expected to have some contact with other persons within the subsequent few hours that Ebola virus is likely to remain active outside the infected human host. While the role of insects in Ebola transmission among humans, if any role at all, is likely to be minor relative to Ebola transmission by direct contact with infected humans or cadavers, management of filth flies and blood-feeding insects should be considered along with other sanitation and protective measures when managing Ebola infections.

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