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Letter to the editor

La transmisión del virus del Ébola en el medio silvestre

Transmission of the Ebola virus in the wild

Introduction

The virus of Ebola is found in several non-human and unrelated mammalian species, but in some organisms this illness is manifested but in others not. This fact does difficult to determine transmission routes in which the infection occur. The bats are a vector in the transmission of diseases to wild mammals and humans. However hypothesis about the routes of diseases transmissions that connect wildlife species and humans are generally inconclusive. Ebola transmission via body fluids of infected animals is one of the possibilities. This review is oriented to propose a "rain" of fruit-saliva as a primary pathway for Ebola transmission. Fruit bats during their process of feeding ingesting the juices of fruits and ejecting the fibrous pulp. Therefore they are urinating and defecating during foraging bouts. During the night, this process produces a constant "rain" of fluids with the virus that come from the bats, and nutriments such as glycoproteins from the fruits. Close contact with an infected individual in a social group would likely spread the virus from infected to not-infected individuals rapidly. This "fruit rain" hypothesis, Ebola transmission to humans can occur by direct human consumption of infected food affected by this rain of fluids with virus and particles of biochemical components of the fruits, without dismiss the fact that the infection also can occur through the consume of contaminated animals.

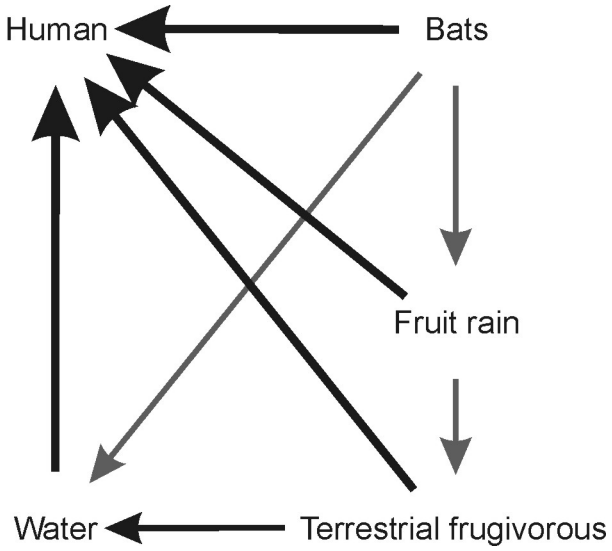
Currently is not a clear understanding of how the Ebola virus is transmitted among wild reservoirs and from them to humans. The virus has been found in several non-human and unrelated mammalian species. This fact made even harder to determine Ebola transmission routes. Current evidence suggests that this disease is transmitted to humans either directly or through an intermediate host (Jarman 1974). Several different mammalian species is known to host the virus. Among them are including frugivorous bats of the Old World family Pteropodidae; non-human primates such as the chimpanzee and gorillas; duikers, which are small forest antelopes, and forest pigs (Sanchez *et al*. 1993; Newing 2000; Daszak 2010). The bats are apparently unaffected by the virus but serve as a vector in the transmission pathway (Leroy *et al*. 2004) while other mammals such as gorillas and chimpanzees succumb to the disease (Leroy *et al*. 2009). Members of the Ebola group of viruses have been found in Asia and Africa, but to date only in Africa is where wild mammals and humans have been infected (WHO 2014). Mortality rates in non-bat species are exceedingly high, being above 90% in humans (Wong *et al*. 2012). HIV/AIDS, SARS, and AH1N1 are other viruses that were originated in wild mammals and became in diseases highly infectious in humans (Kühl *et al*. 2011).

Hypotheses connecting bats, other non-human mammals, and humans in the transmission pathway of Ebola are inconclusive. However, all non-human species that have been recorded to host the virus, either causing nonpathogenic or pathogenic symptoms, share two common traits: they are frugivorous and highly social. Moreover, human Ebola outbreaks tend to be preceded by wildlife deaths due to infection (Sanchez *et al*. 1993). A route of Ebola transmission is throughout via bodily

fluids of infected animals. Bausch *et al*. (2007) conclude that virus of Ebola during the acute period of illness is present in a wide variety of bodily fluids, but when those fluids are isolated, the risk of transmission is low. Therefore, we (Alvarez-Castañeda, pers. Communication) propose a fruit-saliva connection as a major pathway from wild mammals to humans (Figure 1). This hypothesis is supported by the observation that Ebola outbreaks in humans correspond temporally at the beginning of the tropical dry season (Sanchez *et al*. 1993), which correspond at the end of the fruiting season of the most tropical trees. Bats of different species tend to arrive at the same trees, and interspecies virus transmission (or simple antigenic stimulation) could occur via infected saliva deposited on fruits (Pourrut *et al*. 2009). The transmission of diseases caused by virus such as Hendra and Nipah, the first associated with respiratory and neurologic diseases in horses and humans, and the second to an outbreak of encephalitis and respiratory illness in pigs and humans (Hooper *et al*. 2001), has been suggested to occur in this way. The explanatory route of the transmission of those diseases is through the saliva of infected Bats belonging to Asian *Pteropus* species (Williamson *et al*. 1998; Pourrut *et al*. 2009) on fruit that is consumed by humans (Pourrut *et al*. 2009). For ebolavirus, outbreaks in nonhuman primates have been associated with a decrease of their immunologic system after a period in which their food is scarce (Leroy *et al*. 2009). The infection of these primates could initiate through consumption of contaminated fruit with blood and placentas during parturition of infected bats (Towner *et al*. 2009). Ebola entry into host cells mediated by glycoproteins (Jarman 1974), proteins associated with oligosaccharides that include fructose.

Pteropodid bats are both strictly frugivorous and most species roost and feed in groups of large size in the same or adjacent trees. Fruiting trees are like magnets for large numbers of bats and other fruit predators, especially terrestrial species such as duikers and bush pigs. Considerable fruit falls to the ground as a result of natural ripening or dislodging during foraging bat movement among the branches. Furthermore, bats do not eat large fruits whole, but crush the pulp, ingesting the juices and ejecting the fibrous pulp; they also urinate and defecate during foraging bouts. Ebola virus has found in frugivorous bats feces (Swanepoel *et al*. 1996). Thus, there is a near constant nightly "rain" of falling whole fruit, partially eaten fruit, and ejected fruit pulp onto the forest floor, all potentially coated with saliva and urine/feces. Any bat infected with Ebola that arrive at a social group would add that virus to the fruit "rain," providing the opportunity for transmission to other fruit predators foraging on the ground. Also, the close physical contact between bats

Figure 1. Via of transmission of the Ebola virus in the wild and to the humans. Terrestrial frugivorous are considered those species that feed on fruits very low or without climbing to the trees as chimpanzee, gorilla, duiker, and wild pigs)



in a social group and the exchange of sweat or saliva during affiliative behaviors, stimulate the virus spreading from infected to non-infected individuals, increasing the incidence of the virus in the fruit "rain." Ebola is an RNA virus (Vogel 2014) with a limited infectious lifespan, and it cannot replicate in fruit. But the high water content of fruits coupled with the high humidity typical of a tropical forest floor may extend the survival period of the virus and thus the time available to infect a new host. Experiments could be carefully constructed to test both the validity of the "fruit rain" hypothesis and determine the lifespan of the virus under the conditions we propose.

Under our "fruit rain" hypothesis, Ebola transmission to humans can occur in at least two different ways. The first is by direct human consumption of fruit of food covered by virus-containing bat saliva or urine/feces. A second means is through handling contaminated animals during transportation or preparation for consumption, as emphasized in two recent articles in public sources (Maughan 2014, Flynnand and Scutti 2014). Duikers, bush pigs, and non-human primates are major elements of the bushmeat trade, and are thus a major protein source for many African forest communities. This taking in account, that all is needed to stop the spread of several diseases is associated to clean habits and remembering the critical role of the bats as pollinators and predators of agricultural pests (Daszak 2010).

Literature

Bausch, D. G., J. S. Towner, S. F. Dowell, F. Kaducu, M. Lukwiya, A. Sanchez, N. T. Stuart, T. G. Ksiazek, and P. E. Rollin. 2007. Assessment of the risk of Ebola virus transmission from bodily fluids and fomites. Journal of Infectious Diseases 196:S142–S147.

Daszak, P. 2010. Bats, in black and white. Science 329:634.

Flynnand, G., and S. Scutti. 2014. Smuggled bushmeat is Ebola's back door to America *Newsweek*, 29 Aug. 2014. http://www.newsweek.com/2014/08/29/smuggled-bushmeat-ebolas-back-door-america-265668.html.

Jarman, P. J. 1974. The social organization of antelope in relation to their ecology. Behaviour 48:215.

Hooper, P., S. Zaki, P. Daniels P. and D. Middleton. 2001. Comparative pathology of the diseases caused by Hendra and Nipah viruses. Microbes and Infection 3:315–322.

Kühl, A, M. Hoffmann, M. A. Müller, V. J. Munster, K. Gnirss, M. Kiene, T. S Tsegaye, G. Behrens, G. Herrler, H. Feldmann, C. Drosten and S. Pöhlmann. 2011. Comparative analysis of Ebola virus glycoprotein interactions with human and bats cell. Journal Infectious Diseases 204:s840–s849

Leroy, E. M., P. Rouquet, P. Formenty, S. Souquiere, A. Kilbourne, J. M. Froment, M. Bermejo, S. Smit, W. Karesh, R. S. Swanepoel, R. Zaki and P. E. Rollin. 2004. Multiple Ebola virus transmission events and rapid decline of central Africa Wildlife. Science 303:387–390.

Leroy, E. M., A. Epelboin, V. Mondonge, X. Pourrut, J. P. Gonzalez, J.J. Muyembe-Tamfum, and P. Formenty. 2009. Human Ebola outbreak resulting from direct exposure to fruit bats in Luebo, Democratic Republic of Congo, 2007. Vector-borne and Zoonotic Diseases 9:723–728.

Maughan, R. 2014. Ignorance and bush meat trade cause of Ebola epidemic *Wildlife Dis* http://www.thewildlifenews.com/2014/07/25/ignorance-and-bush-meat-trade-cause-of-ebola-epidemic.

Newing, H. 2000. Bushmeat hunting and management: implications of duiker ecology and interspecific competition. Biodiversity and Conservation 10:99–118.

Pourrut, X., Souris, M., Towner, J. S., Rollin, P. E., Nichol, S. T., Gonzalez, J. P. and E. Leroy. 2009. Large serological survey showing cocirculation of Ebola and Marburg viruses in Gabonese bat populations, and a high seroprevalence of both viruses in *Rousettus aegyptiacus*. BMC Infectious Diseases 9:159.

Sanchez. A, M. P. Kiley, B. P. Holloway, and D. D. Auperina. 1993. Sequence analysis of the Ebola virus genome: organization, genetic elements, and comparison with the genome of Marburg virus. Virus Reserch 29:215-240.

Swanepoel R, Leman PA, Burt FJ, Zachariades NA, Braack LE, Ksiazek TG, P. E. Rollin, S. R. Zaki, and C. J. Peters. 1996. Experimental inoculation of plants and animals with Ebola virus. Emerging Infectious Diseases 2:321–325

Towner, J. S., Amman, B. R., Sealy, T. K., Carroll, S. A., Comer, J. A., Kemp, A., et al., P. E. Rollin. 2009. Isolation of genetically diverse Marburg viruses from Egyptian fruit bats. PLoS Pathogens 5:e1000536.

Vogel, G. 2014. Are bats spreading Ebola across sub-Shaharan Africa? Science 344:140.

WHO. 2014. Ebola virus disease. http://www.who.int/mediacentre/factsheets/fs103/en/.

Williamson, M. M., P. T. Hooper, P. W. Selleck, L. J. Gleeson, P. W. Daniels, H. A. Westbury, and P. K. Murray. 1998. Transmission studies of Hendra virus (*Equine morbillivirus*) in fruit bats, horses and cats. Australian Veterinary Journal 76:813–818.

Wong G, J. S. Richardson, S. Pillet, A. Patel, X. Qiu, J. Alimonti, J. Hogan, Y. Zhang, A. Takada, H. Feldmann, and G. P. Kobinger. 2012. Immune parameters correlate with protection against Ebola virus infection in rodents and non human primates. Science Translational Medicine 158:158re146.

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