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*Forum*

# To Cull, or Not To Cull, Bat is the Question

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Whether it is justified or effective to cull populations of bats, as a means for mitigating human–animal conflict or controlling disease, is an issue that has recently resurfaced with moves by the Mauritius government to cull a population of endangered Mauritius flying foxes (*Pteropus niger*) (IUCN 2015). Similar calls for fruit bat culls by the Australian government in response to crop damage and outbreaks of Hendra virus (Walker and Nadin 2011) underscore the urgent need for a more robust, science-based approach to guide wildlife management. Here, I review the evidence and argue that culling of bat populations is not an effective means to mitigate conflict with fruit growers, nor to reduce the likelihood of zoonotic disease risk.

## Invaluable and Industrious

Bats are too often vilified and grouped by policy makers into a single biological unit. The reality is, bats are an extremely diverse group of mammals with over 1300 species, second in diversity only to rodents within the Mammalia. Furthermore, each species has ecological, evolutionary, and life history traits that make it a unique and integral component of the ecosystem in which it is found. There are bats species that weigh less than a US penny, bats weighing over two pounds with 4-foot wingspans, bats that live alone in trees, and bats that roost with millions of others in caves. There are bats that eat fish, frogs, and blood (only 3 species globally are vampires), but the vast majority of bat species feed on insects—and in doing so provide a crucial "ecosystem service" that translates into billions of dollars of value for US agricultural systems alone each year (Boyles et al. 2011). About a quarter of all bat species feed on fruit and nectar, and these fascinating creatures are critical for dispersing seeds, pollinating crops and trees, and otherwise maintaining healthy forests and the genetic diversity of agricultural systems on which we depend. Silent and often unnoticed, bats work the graveyard shift and help keep our world pest-free and biodiverse.

Calls to cull bats to alleviate crop damage are often based on limited or incorrect information on the actual damage they do, and with poor consideration for the role that other fruit pests (e.g., birds and rodents) play in orchard damage (IUCN 2015; Aziz et al. in press). Commonly proposed methods for culling fruit bats include shooting them, i.e., 'taking Arms against' them, a serious animal welfare issue as many animals escape immediate death only to be mortally or permanently wounded. Further, there is no scientific evidence to show that reduction of a bat population results in a proportional reduction in fruit damage. Humane and conservation-friendly solutions to mitigate conflict with fruit growers exist, including the use of exclusion nets, tree pruning to reduce height, planting decoy crops, picking fruit before peak ripeness, and other deterrents like noise and light (Aziz et al. in press).

One third of all bat species around the world are considered threatened or have so little data available that we have no idea how endangered they are (IUCN 2015). Bats are threatened because we are destroying their habitat

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(acres per second) and we are eating them in vast numbers. These are hard things to control, but a dedicated team of bat scientists and conservationists are working on them. The last thing we need to do is knowingly reduce their populations through misguided policies based on poor information and vested interests.

## Misconstrued Fears of Plague

Bats do harbor a diversity of viruses including several known zoonotic diseases (those that jump from animals to humans), but so do all other wildlife species, including primates, rodents, ungulates, carnivores, other mammals, and birds (Olival et al. 2015). These diseases include the age-old scourge rabies; however, at least >1000 times more cases of rabies arise each year from domestic dogs than bats (De Serres et al. 2008; Nandi and Kumar 2011). New zoonotic diseases such as Nipah, Hendra, Marburg, and Ebola viruses have been linked to bats as 'natural reservoir hosts', and should be taken seriously, but the solution is not in destroying bat populations. To put this in perspective, the chimpanzee (*Pan troglodytes*), our closest evolutionary relative, has been definitively shown to be the species from which HIV-1 first emerged—arguably the most significant pandemic of our era that has killed more than 39 million people and currently infects another 37 million (WHO 2015). Yet, calls to cull chimpanzee populations as a means of controlling the next zoonotic disease seem ridiculous, and such a policy would rightfully be met with massive protest from conservation organizations and the public at large.

Efforts to cull bats as a way of mitigating disease risk can backfire and may well *amplify* the risk of a zoonotic disease spilling over to human populations. This is true for several reasons. First, the act of killing wildlife itself puts people in close contact with animals and increases the likelihood of an individual being exposed to a disease. Bats exist in complex, natural systems and when we disrupt them—through hunting, deforestation, habitat encroachment for development or mineral extraction—we may also disrupt the dynamics of diseases they carry and put ourselves at greater risk. Research has shown that human-driven ecological change is the primary cause of zoonotic disease emergence globally (Morse et al. 2012; Murray and Daszak 2013). Second, culling can result in increased disease spread by forcing populations of bats to migrate and establish in new areas. For example, the Nipah virus reservoir, the large flying fox (*Pteropus vampyrus*), migrates far more widely in Peninsular Malaysia than in other countries largely due to hunting pressure and habitat modification (Epstein et al. 2009). Third, a more nuanced effect is that fragmentation, habitat reduction and physiological stress imposed on bat populations may actually increase the likelihood of viral shedding—as has been shown with Hendra virus in Australia (Plowright et al. 2008; Plowright et al. 2011). Similarly, mobile bats can easily recolonize previously culled sites and may have higher rates of disease infection, due to a change in age structure in re-established populations. Culling programs have failed to reduce rabies prevalence in Latin American vampire bats (Streicker et al. 2012); and failed attempts to cull *Rousettus aegyptiacus* in Uganda resulted in a subsequent rise in the prevalence of Marburg virus (Amman et al. 2014). Fourth, culling of insectivorous bats could potentially result in an increased incidence of vectors and vector-borne diseases.

In summary, culling bats is an inhumane and ineffective way to mitigate conflict with fruit growers, and is more likely to increase, not decrease, the risk of disease emergence in the human population. If that were not enough, without bats we would live in a culinarily depauperate world without durian or petai (both acquired tastes, but delicacies in Southeast Asia), and without agave from which we make tequila and mescal (think about this next time you are enjoying a margarita)—crops for which bats are essential pollinators. Lastly, bats are cool. Do we really want to jeopardize losing such a fascinating group of animals that inspire and amuse us with their enigmatic behavior and mythology? If I had a dollar for each child I spotted in my neighborhood wearing a batman shirt, cape, or pair of rain boots, I would put it towards bat conservation and our Chiropteran friends would be in a much better place. Let's go forth and reflect on the real animals behind that comic silhouette in the sky, and make informed, science-based decisions to protect the bats and the ecosystems they call home.

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