

7.9 Zoönoses (No Update)

“Zoönoses” is the classic term for an infectious disease that is shared between humans and animals. The roles that animals play in “sharing” zoönoses are varied. Animals can serve as the incubator from which bacteria or viruses emerge that can cause illness in humans. Measles, AIDS, and most recently COVID-19 are examples of diseases that originated in animals—cattle, non-human primates, and bats, respectively—but have evolved to be efficiently transmitted directly between humans (Düx et al., 2020; Furuse et al., 2010; Lytras et al., 2021; Sharp et al., 2011). Animals can also serve as a reservoir for microbial pathogens, maintaining infection but without suffering any ill health themselves. *Borrelia burgdorferi*, the bacterial agent of Lyme disease, and Sin Nombre virus, the cause of hantavirus pulmonary syndrome (HPS), are both maintained in wild mice. Infected mice do not develop disease but can transmit the pathogens to humans indirectly (via ticks for Lyme disease) or directly (through aerosolized urine or feces for HPS). Finally, some zoonotic pathogens cause disease in both human and animal hosts; for example, the bacterial agents of anthrax and plague can cause severe and often fatal disease in wild animals, domestic animals, and humans.

Transmission of disease agents between humans and animals is in part dependent on their respective populations’ distributions, densities, and proximity. For animals, these population dynamics are defined by the type of habitat in which the animal exists. Habitat—food, shelter, and water are largely determined by the prevailing climatic conditions. Significant changes to these conditions can alter the character of a geographic region to render it conducive to the species’ survival.

Animals may adapt to changing environments through the random mechanism of natural selection. However, the dramatic environmental transformations wrought by anthropogenic climate change outpace the ability of most species to evolve. The only other responses available to most animal species are to reduce their population to a size that the altered habitat can continue to support, or to adjust their geographic range to areas that remain hospitable. For California, these climatologic changes will likely favor those species that can endure higher temperatures and more arid conditions, or can relocate to regions that remain relatively cooler and wetter. Both responses could



change the frequency and intimacy with which some animals and humans interact, enhancing opportunities for zoonotic disease transmission (Heffernan, 2018; Hoberg and Brooks, 2015; Lorentzen et al., 2020; Morand and Walther, 2023).

Hotter, drier conditions can impact the size or density of zoonotic animal host and vector populations. Sustained elevated temperatures result in mosquitoes maturing more quickly and lead to larger populations (Mills et al., 2010). Protracted drought may reduce aquatic breeding habitat for some mosquito species but can benefit others by transforming previously free-flowing rivers and creeks into stagnant pools (Bartlow et al., 2019). Changes to local conditions that favor some generalist species but reduce or eliminate species with unique habitual needs can reduce local biodiversity, potentially to the benefit of zoonotic disease reservoirs. For example, reduced diversity of bat species can facilitate perpetuation of rabies virus, leading to greater incidence among viable host species and increased risk of transmission to non-hosts such as humans (Patil et al., 2017).

Species that are unable to adapt to hotter or drier conditions may adjust their ranges toward higher elevations or polar latitudes. These movements could alternatively introduce zoonotic diseases into previously unaffected human populations or dissociate disease agents from human contact. For example, the bacteria that cause plague (*Yersinia pestis*) and tick-borne relapsing fever (*Borrelia hermsii*) in California are maintained in wild rodents and transmitted via flea and tick bite, respectively; with incrementally hotter average temperatures, their current foci in mid- and upper elevations of the Sierra Nevada may shift to higher and constricted elevations, possibly farther displaced from areas where humans reside or visit. Approximately half of the 28 species surveyed in Yosemite National Park—including squirrel (*Spermophilus* spp.) and chipmunk (*Tamias* sp.), reservoir species for *Y. pestis*—had upslope shifts of range limits compared with similar surveys conducted approximately 100 years earlier, when minimum temperatures were 3°C lower (Moritz et al., 2008). This shift from temperate to alpine regions parallels a similar shift of hosts and vectors of zoonoses previously concentrated in tropical and subtropical latitudes to temperate regions. In the last decade, vampire bats (*Desmodus rotundus*) and mosquitoes (*Aedes aegypti*, *Ae. albopictus*) have encroached northward from Latin America, threatening local



transmission of rabies and arboviruses (e.g., Zika, Chikungunya, dengue), respectively, in North America (Hayes and Piaggio, 2018; Iwamura et al., 2020; Ryan et al., 2019).

Loss of natural food, water, or harborage may stimulate some animal species to seek these essentials from areas of human development and residence. Deforestation, including via climate-enhanced mega-wildfires, has been cited as possibly contributing to displacement of bats from natural roosting sites in favor of concentration around human habitations, leading to the emergence of bat-borne zoonotic viruses such as Nipah and Hendra (Halpin et al., 2000) and the SARS-type coronaviruses (Afelt et al., 2018). Water stored near human communities may attract wild mammals such as skunks, raccoons, and coyotes, increasing the peri-residential risk of zoonoses such as rabies and *Toxocara* and *Baylisascaris* larval migrans. Standing water in eaves, yards, and patios can provide habitat for mosquito breeding, increasing peri-residential risk of West Nile virus and other mosquito-borne arboviruses.

As hospitable habitat contracts, individual animals are drawn into more confined areas, resulting in more frequent competition and contact which enables transmission of zoonotic pathogens. In 2021, 29 cases of salmonellosis among human residents of eight states, including California, were traced to unusual concentrations of songbirds densely congregating at backyard feeders and bird baths (CDC, 2021), possibly as a result of reduced natural food and water sources. Avian influenza viruses have traditionally resided in and emerged from wild birds, particularly migratory waterfowl. As drought and development displace natural wetlands along avian flyways, this traditional breeding ground for avian influenza might diminish. If wild waterfowl seek alternative water and food resources near poultry operations, this proximity can enhance transmission of influenza viruses to domestic poultry and one step nearer to humans (Gilbert et al., 2008).

The impact of climate change on zoonotic disease epidemiology in California and the western U.S. has yet to be fully understood. Effective preparation will require an integrated collaboration of human health and animal health professionals and environmental scientists to identify and respond to climate-induced changes in zoonotic disease incidence and distribution in a timely, comprehensive, and effective manner.



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