VII. BATS AND DISEASE

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This section gives a brief introduction to diseases related to bats in Colorado. We present this information in two parts. The first part addresses bat-related diseases of public health importance, focusing on rabies. The second part addresses diseases that can or do affect bat populations, and may be of concern to biologists and managers with interests in bat populations. The discussion of bats and disease in Colorado presented here is not intended to be a comprehensive treatment of the subject, but rather strives to provide enough information so that interested readers will have a sense for where to look for more information. Information about diseases of bats that affect humans can be found at the Centers for Disease Control and Prevention (CDC) website (www.cdc.gov/rabies/index.html). A review of the ecology of infectious diseases of bats can be found in Hayman et al. (2013), and a review of bats as important reservoirs of viruses can be found in Calisher et al. (2006) and Moratelli and Calisher (2015).

BAT RELATED DISEASES OF PUBLIC HEALTH IMPORTANCE

There are two main categories of bat-related diseases relevant to public health: diseases carried by bats; and diseases that may be of concern to researchers and residents who work in or near bat roosts, or have bats roosting in buildings, but which are not primarily transmitted by bats. Worldwide, bats are known or suspected to be associated with a variety of human diseases. Noteworthy among these diseases are Marburg hemorrhagic fevers, Hendra virus disease, and Nipah virus encephalitis (Calisher et al. 2006), none of which are endemic to the United States. Bats in Colorado have been documented with coronaviruses (Dominguez et al. 2007). A general overview of public health concerns and bat researchers is provided in Kunz and Parsons (2009).

In Colorado, rabies is considered to be the key bat-related disease with a risk of direct bat-human transmission (O'Shea et al. 2011), with bats and skunks as the main sources in the state (see Colorado Department of Public Health & Environment (CDPHE) for information; www.colorado.gov/pacific/cdphe/rabies). Rabies is a viral disease that infects the central nervous system of mammals and is almost always fatal to humans once symptoms occur. Rabies virus can be transmitted via saliva from the bites of infected animals, and when infected saliva contacts blood via wounds or mucous membranes. Bats with rabies may appear normal or they may behave abnormally. For example, they may be observed roosting in unusual places, such as on the outsides of buildings during daytime; they may be seen flying in daylight, they may not appear to have a fear of people or predators; and they may behave very aggressively or appear very lethargic. Human exposure

Swabbing a bat for detection of rabies virus. Photo by D. Neubaum.

to rabies can be reduced by minimizing contact with bats, particularly those that appear sick or that are behaving abnormally (Kunz and Parsons 2009). Information on annual testing for rabies in Colorado is available at the CDPHE website.

PROPHYLAXIS AND PREVENTATIVE MEASURES

Bat researchers and wildlife professionals have an increased risk of exposure to rabies, but this risk can be reduced by taking precautions such as wearing leather gloves while handling bats, undergoing pre-exposure vaccination, and regularly having antibody titer checks. Prior to working with bats, wildlife professionals and students should consult their doctor about pre-exposure rabies vaccination. Basic information on the rabies vaccine is available through the CDC (https://www.cdc.gov/rabies/resources/acip_recommendations.html). It is generally recommended that anyone who will have direct contact with bats complete the full pre-exposure vaccination series. Following vaccination, titer checks (via serology testing) are recommended annually for those in frequent contact with bats, or at least every other year to ensure that antibody levels remain high enough to protect from infection. The CDC recommends the use of an end-point titer, rather than a coarser "greater than or less than" titer, as the former allows tracking of titer levels over time. Such information will provide guidance on the need for annual titer testing. One recommended test is the Rapid Fluorescent Focus Inhibition Test, available through the College of Veterinary Medicine at Kansas State University. We strongly recommend wearing leather gloves on both hands covered by nitrile gloves when capturing and handling bats. Consideration of nitrile gloves for other assistants handling field equipment during capture surveys is encouraged. Information on the types of gloves to consider can be found in Freeman and Lemen (2009). When potentially exposed to the saliva of a rabid bat, the CDC recommends irrigating the wound as soon as possible with soap and water followed with a providine-iodine solution, and seeking medical advice immediately. If this is unavailable in the field, an antiseptic concentration of ethanol may be used until further treatment is available. Following exposure, the bat should be retained and submitted for testing to determine if vaccinated individuals will require post-exposure prophylaxis. Unvaccinated individuals require post-exposure vaccination and immunoglobulin. For updated post-exposure treatment recommendations, visit the CDC's rabies page: www.cdc.gov/rabies/medical_care/. Such rigorous response measures emphasize the need for personnel to wear appropriate protection (leather gloves) at all times when handling bats, as the ramifications to the person and bat can be severe. See additional information and recommendations on this matter at Colorado Parks and Wildlife's (CPW) website, including information for obtaining a Scientific Collection Permit, which is required for anyone who will be handling wildlife, including bats (http://cpw.state.co.us/learn/Pages/WildlifeHealthWNS.aspx).

DISEASE RISKS OF RESEARCH AT BAT COLONIES

Bat roosts can also present additional risks for wildlife professionals. While bats do not carry Hantavirus, it is sometimes associated with rodent urine and feces, which may occur in buildings, caves, and mines, and can cause the acute and often fatal Hantavirus Pulmonary Syndrome. A fungus sometimes present in cave soils, and other areas with significant bird and bat guano, can cause histoplasmosis, which is a

lung infection that may be life threatening to immunocompromised individuals. Typical disinfection practices and the use of gloves can reduce the risk of exposure to these diseases, as can the use of respiratory protection. The CDC has published guidelines on prevention of histoplasmosis in at-risk workers, which includes bat researchers (Lenhart et al. 2004). Because Colorado's climate is generally dry enough to inhibit growth of this fungus, histoplasmosis is not a reportable event in Colorado (Baddley et al. 2011). Only outbreaks are considered reportable, and to date, no outbreaks of this fungus have been reported in Colorado (Benedict and Mody 2016). However, caution should be taken when working in humid or moist areas, and large concentrations of bat guano are present.

DISEASES THAT AFFECT BATS AND THEIR POPULATIONS

Based on currently available information the only disease known to have large impacts on bat populations in North America, and which is likely to impact future bat populations in Colorado, is white-nose syndrome (WNS). Currently WNS is restricted to eastern North America and the eastern edge of some central plains states, the Texas panhandle, and Washington state, but has not been detected in Colorado (https://www.whitenosesyndrome.org/about/where-is-it-now). Although other diseases, such as rabies, West Nile Virus, and coronaviruses, affect bats in the western United States, none of these diseases are known to result in large die-offs of bat colonies or populations in Colorado.


Bat with White-Nose Syndrome. Photo by S. Taylor.

WNS is a disease that affects hibernating bats that was first documented in February 2006 in eastern North America. Castle and Cryan (2010) provide an overview of this disease designed for natural resource managers. During the initial 2-year period after the disease emerged, some bat populations in eastern North America may have experienced more than a 75% decline, and over 5.5 million bats of several species are estimated to have died in the period from 2006–2011, leading to a regional population collapse and may result in the extinction of some of these species (USFWS 2012). WNS has had a particularly destructive impact on species that hibernate in large aggregations in the eastern United States and Canada (Castle and Cryan 2010).

The fungal spcecies *Pseudogymnoascus destructans* (*Pd;* formerly *Geomyces*) is now considered to be the causal agent of WNS (Minnis and Lindner 2013), and is transmitted by bat-to-bat and human (recreational/caving, research) modes of transmission. This fungus may be an invasive species recently introduced into bat hibernation habitats in North America, or it may be a virulent strain of a fungus with global distribution. At the time of this writing, WNS has not been documented in Colorado (www.whitenosesyndrome.org), however it was confirmed in the panhandle of Texas in 2017. There exists an almost continuous distribution of cave/karst habitat from areas with confirmed WNS, the

southwestern tablelands in the southern section of the Great Plains, and southeastern Colorado (Culver et al. 1999; Veni 2002). It is possible that the southwestern tablelands could provide a bridge for this disease to spread into western North America, including Colorado, and it is yet to be determined how the WNS presence further west in Washington arrived.

The *Pd* fungi are common in cold environments, capable of thriving in low nutrient conditions, and are commonly dispersed by animals, humans, air currents, and water (Hayes 2012; Furbino et al. 2014). These qualities will continue to present substantial challenges to those charged with controlling the spread of WNS and its causative agent in western North America. However, the ecology of western bat species may be different than that of eastern bats which could influence how WNS spreads. Relative to population estimates, the number of bats using caves and mines tends to be lower in the West, and concentrations of bats using these features is often less than found in eastern situations. Bats in the West are known to hibernate in other features such as rock crevices. Use of these roost structures by bats, if in small aggregations, may inhibit the spread of WNS, but more research on the winter roosting ecology of most species in Colorado is still needed. Because we know so little and this disease could devastate our bat populations we strongly recommend implementing and following decontamination guidelines (see links below) and carefully considering the need to visit bat roosts or capture and handling of bats as humans can transfer the fungal spores. Current information on WNS can be found at www.whitenosesyndrome.org. This website provides access to key documents and resources, including decontamination protocols, maps of disease spread, the national response plan, information on research, and educational resources.

Researchers swabbing a bat for detection of White-Nose Syndrome. Photo by S. Taylor.

It is critical that all researchers and agency personnel follow the guidelines for decontamination of all equipment and gear to help prevent the spread of WNS. Information on decontamination protocols can be found at federal (https://www.whitenosesyndrome.org) and state (http://cpw.state.co.us/learn/Pages/WildlifeHealthWNS.aspx) websites.

We address two categories of issues relating to bats and disease in Colorado: Monitoring of WNS, and inadequate knowledge of bat diseases in Colorado.

MONITORING OF WNS IN COLORADO

GOAL

ENCOURAGE PROACTIVE MEASURES OF MONITORING THAT WILL ASSIST WITH MANAGEMENT OF BAT SPECIES IN COLORADO IF WNS REACHES THE STATE.

Objective 1: Reduce gaps in natural history of bats in Colorado, such as roosting ecology, and attain a better understanding of winter roost selection by bats in Colorado.

MANAGEMENT RECOMMENDATIONS

- Measure and describe microclimate conditions (e.g., temperature and relative humidity) inside known and potential hibernacula in Colorado.
- Determine what conditions facilitate the growth of the causal fungi and development of WNS, and identify hibernacula in Colorado that meet these conditions.
- Continue surveillance for the causal fungus and WNS in Colorado.
- Improve understanding of the roosting needs of bats that hibernate in Colorado.
- Improve understanding of how bats disperse among hibernacula and maternity sites in Colorado.
- Examine seasonal, regional and species-related differences in fungal diversity among bats in Colorado.

INADEQUATE KNOWLEDGE OF BATS AND DISEASE IN COLORADO

GOAL

IMPROVE THE UNDERSTANDING OF DISEASES THAT INFECT AND FUNCTION IN BAT SPECIES OF COLORADO AND THE POTENTIAL IMPACTS THEY CARRY TO LOCAL AND REGIONAL POPULATIONS.

Objective 1: Promote research to attain a better understanding of the prevalence of diseases in Colorado bat populations.

Objective 2: Investigate prevalence of coronavirus and fungal communities in wild bats across Colorado.

MANAGEMENT RECOMMENDATIONS

- Secure funding sources that support proactive inventory and monitoring efforts related to bat species and roosting requirements.
- Initiate policy decisions that facilitate disease monitoring on public and private lands.

- Identify important winter roosts used by bats in Colorado and protect these sites with seasonal closures if necessary. These sites may provide future treatment locations if proactive methods, such as exposure to ultraviolet light, are successfully developed (Palmer et al. 2018).
- Establish long-term and strategic monitoring sites in Colorado that are critical to early detection of WNS. Consider the implications of winter roost disturbance in WNS related activities, and minimize the risk of impacts to bat populations. Conduct such activities, when possible, during non-winter seasons, and/or limit the frequency of visits to hibernacula.

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