EXOTIC

White-nose syndrome

Fact Sheet

March 2025

Key points

- White-nose syndrome (WNS) is a fungal disease that affects cave-dwelling bats during hibernation.
- It has caused substantial declines in insectivorous bat populations in North America.
- WNS has **not** been identified in Australia, however it poses a significant threat and is on the Australian Government's *National Priority List of Exotic Environmental Pests, Weeds and Diseases*.
- The fungus causing WNS can be spread by humans on contaminated clothing, footwear or equipment.
- Cavers perform a vital role in protecting Australia from WNS. It is important that cavers returning or entering Australia from overseas are aware of the risk of carrying the fungus into Australia.
- White-nose syndrome is a nationally notifiable disease; you must notify animal health authorities if you suspect an animal has WNS (see *Surveillance and management* below).

Aetiology

The causative agent of WNS is the fungus *Pseudogymnoascus destructans.* It is the only known animal pathogen in the class of Leotiomycetes, which mainly consists of plant pathogens [1]. Three clades of *P. destructans* have been identified in Far-East Asia, Central Asia and Europe [2]. The fungal genome sequence is available in Genbank (Accession KV441386).

One Health implications

Wildlife and the environment: Millions of hibernating bats have died due to WNS since its arrival in North America, with populations in some hibernacula decreasing by 90 to 100%, and declines as high as 90% in three bat species in less than 10 years [3]. The tricolored bat (*Perimyotis subflavus*) was proposed for listing as federally endangered by the U.S. Fish and Wildlife Service in 2022 due to the widespread impact of WNS. This disease can thus have a substantial impact on susceptible bat populations.

Domestic animals: No direct impacts on domestic animals have been identified.

Humans: No direct human health risk from WNS has been identified. There is no information indicating that people or other animals have been affected after exposure to the fungus. However, people handling bats should use safe work practices and personal protective equipment (PPE) as there is a risk of exposure to other diseases such as Australian bat lyssavirus (ABLV). Bats are insectivorous and help to control pest insects. Indirect impacts of WNS on human health have been reported in North America, whereby the loss of bats has resulted in an increased use of pesticide, with an associated increase in human infant mortality levels [4]. The cost of WNS to US agriculture due to the loss of pest control services provided by bats has been estimated up to $495 million per year [5].

Natural hosts

By the end of 2024, twelve cave dwelling bat species (*Myotis*, *Perimyotis* and *Eptesicus* spp.) have been impacted by WNS in North America, including two endangered and one threatened species, with the fungus found on a further ten (*Corynorhinus*, *Myotis*, *Lasionycteris, Lasiurus, Tadarida, Parastrellus* spp.) with no clinical signs [6].

The WNS fungus has been found in 41 species across Europe and Asia [7], but without the mass mortalities observed in North America [8, 9]. This includes European species of *Myotis*, *Eptesicus, Barbastella, Miniopterus, Plecotus* and *Rhinolophus* [10], and in China, species of *Myotis*, *Murina* and *Rhinolophus* [11].

World distribution

The disease was first recognised in New York State in 2006 and since then has spread across most of North America. It was first identified in Canada in March 2010 in Ontario and is now present in 40 states and nine Canadian provinces. The fungus, but not the disease, has been recorded in an additional five US states and one Canadian province [12]. In March 2016, it appeared in Washington State, an apparent 2,000 km jump from the previous westernmost detection of *P. destructans.* A disease spread model has predicted that WNS is likely to have spread throughout the entire continental US by 2030 [13].

Evidence indicates that *P. destructans* has likely existed in Eurasia for millions of years, and was introduced into North America from Europe, most likely through human-mediated spread e.g. on contaminated equipment [2, 14]. Current surveys have found the fungus on bats in over 25 countries throughout Europe and Asia with no gross evidence of infection. In some cases, pathological lesions and a small number of deaths due to WNS have been recorded, but without mass mortality or population impact [7, 8, 15-20]. A survey conducted in north-eastern China in 2014 and 2015 found *P. destructans* on six species of bats, and on nine of 12 cave surfaces sampled [11].

Occurrences in Australia

There have been **no** reports of *P. destructans* in Australia.

While white-nose syndrome (WNS) has **not** been identified in Australia, a risk assessment concluded that there is a high likelihood that the causative agent, *Pseudogymnoascus destructans,* will enter Australia in the future. Although the scale of mortalities is not expected to be as severe as in America, significant impacts may still occur, particularly for already threatened populations. The loss of bats would also have a broader impact on the ecosystem and agricultural industries.

From 2015 to 2017, 325 live southern (*Miniopterus orianae bassanii*) and eastern bent-winged bats (*M. orianae oceanensis*) and 30 environmental samples from South Australia and Victoria were tested by PCR for *P. destructans*. All samples were negative [21].

A number of bats have been submitted for exclusion testing for WNS, both individuals and as part of mass mortality events. All tested negative.

See below under Epidemiology for a discussion of the potential impact of WNS on Australian bats.

Epidemiology

P. destructans is psychrophilic, meaning it grows best at low ambient temperatures. *In vitro* studies have found that optimal temperatures for growth are between 12.5 and 15.8 °C, with cessation of growth above 20°C [22]. While the fungus grows best at humidity levels above 90% it is able to survive prolonged periods of low humidity, and is capable of growth on a range of environmental substrates [23].

Transmission is through bat-to-bat contact and contact between bats and the cave substrate. The pathogen can be spread by bats to new areas during the autumn swarm period [7]. A US study detected *P. destructans* in sediment from two mines that had been closed to bats for one to two years, indicating that the organism can persist in the environment in the absence of bats for several years [24]. Ectoparasites have been considered as possible mechanical vectors of *P. destructans* and the fungus has been found on bat mites [25]. Airborne transmission has not been demonstrated [26]. Humans have also been implicated in the spread of the disease.

WNS is a seasonal disease. Hibernating bats have a reduced metabolic rate and immune capability rendering them susceptible to infection and disease. Bats in North America are mostly infected in late autumn and early winter, with mortalities starting in the middle of winter and peaking at the end of the winter, along with infection prevalence and fungal loads [7]. Bats that survive the hibernation period are able to clear the infection after emergence when their immune system is no longer suppressed [27], although there are impacts on the energy balance due to the costs of healing and reduced foraging efficiency in early recovery [28]. In highly susceptible bat species, immunopathology can occur after emergence due to an intense inflammatory response [29, 30].

In North American bats, infection with *P. destructans* results in increased arousal frequency, which consumes additional energy reserves and affected bats have little or no fat stores. Wing damage results in increased evaporative water loss leading to electrolyte depletion and dehydration [23, 31-35].

Significant differences in species and population susceptibility to white-nose syndrome have been observed in bats in North America. A number of host and ecological factors have been identified that contribute to this difference. These include species differences in host immune response to the pathogen and hibernation behaviour. As *P. destructans* growth is strongly impacted by temperature and humidity, bats that choose to hibernate in warmer areas with higher humidity are more susceptible to infection and severe disease [36]. Species that hibernate in clusters and larger groups are also more susceptible by increasing transmission between bats [31]. The natural frequency of arousal during hibernation of a species or population may also impact susceptibility [37].

Females exhibit higher infection rates and lower survival than males in North America, which is believed to be due to the shorter hibernation period of males, and increased activity during the autumn mating season, which assists them in clearing the fungus [38]. Impacts of WNS on reproductive fitness have been observed, as well as a decrease in reproductive females in WNS affected populations [39, 40].

Evidence based on genetic comparisons between American and European isolates and the initial appearance of the disease at a single site followed by radial spread, indicates that *P. destructans* was imported into North America from Europe, possibly on shoes or equipment used in caves [41, 42]. Unlike in North America, WNS in European bats is not associated with any increases in mortality [8]. This is likely due to a combination of factors, such as lower fungal loads carried by infected European bats [10], a tendency to hibernate in small clusters rather than in large aggregations [43] and an indication that European bats can respond to the infection without arousing from hibernation [9].

The impact of WNS on Australian bats were it to be introduced is not known, however risk assessments have concluded that it poses a significant threat, particularly to threatened species due to the additive effect of existing threatening processes [44-46]. The critically endangered southern bent-wing bat (*Miniopterus orianae bassanii*) is considered at particular risk, as the entire population lives within the preferred temperature zone of *P. destructans*. While Australia's temperate climate could moderate the impact of WNS such that large-scale mortalities may be less likely to occur, recent experience in the USA seems to be indicating that bat populations in the warmer southern states may be more susceptible than previously thought [47]. WNS is on the *National Priority List of Exotic Environmental Pests, Weeds and Diseases* [48].

Clinical signs

Many, but not all, affected bats have a grossly visible white or grey fungal growth on muzzles, ears and wing membranes, which can lead to scarring and necrosis. Bats may have reduced fat stores and be clinically dehydrated. Affected wings may become thinner, discoloured, have a flaky appearance and develop erosions and ulcers. Folded surfaces of severely affected wing membranes adhere to each other, tear easily, and appear to lose tone, tensile strength and elasticity [31]. If bats survive the infection they are capable of healing their wing membranes, which retain a variable amount of post-WNS scarring [49].

In North America, white-nose syndrome is often associated with abnormal behaviour such as increased arousal from hibernation, increased grooming behaviour and flying during the day, and mass mortalities [23].

Diagnosis

Although the appearance of white fungal material on the muzzle, ears and wings is suggestive of WNS, bats in the UK displayed similar lesions that were caused by *Rhizopus* and *Paeciliomyces* [50]. Histopathology is considered to be the "gold standard" to confirm a diagnosis [51]. Fungal culture may also be used to confirm the presence of *P. destructans* (See Gargas et al. 2009 [52] for full description). PCR tests are available to detect fungus on bat wing tissue or a swab of the affected area [53-55]. *P. destructans* must be distinguished from other fungal species in the same or closely related genera, which may occur in cave environments.

Ultraviolet light has been used to screen bats for WNS and to optimise biopsy placement but is not recommended for confirmation or exclusion of WNS. See Alger and White Nose Syndrome National Response Team Diagnostic Working Group 2023 [56] and Wildlife Health Australia 2024 [57] for more detailed information on sample collection and testing for WNS in Australia. .

Laboratory diagnostic specimens and procedures

To submit samples for exclusion testing please contact your state/territory WHA Coordinator to discuss arrangements for processing samples.

NOTE: Members of the public should not handle bats. If you find an injured or sick bat, contact a wildlife care organisation or your local veterinarian. People trained in the handling of bats should have current rabies immunity (vaccination) and always use appropriate protection when interacting with bats [58]. National guidelines on pre-exposure prophylaxis for lyssavirus are published by the Communicable Diseases Network Australia [59]. Biosecurity measures for working in caves are outlined in WHA's Biosecurity Guidelines for Bat Research in Caves in Australia.

National guidelines for veterinarians on sample submission for WNS exclusion testing are available on the Wildlife Health Australia website, including advice on decontamination in the event of a suspect case.

Pathology

See Isidoro-Ayza et al. 2024 [1] for a detailed summary of the skin pathology associated with white-nose syndrome.

Grossly, apart from the presence of white fungal material on the face and wings, affected bats may have patches of rough skin, pinpoint white foci on the muzzle, contraction of the wing membrane and a loss of pigmentation. Microscopically, non-pigmented, branching, septate fungal hyphae with distinctive asymmetrically curved conidia cover the epidermis leading to characteristic cup-like erosions, ulceration and wing membrane infarction with minimal evidence of inflammation [31, 51, 60]. There may be minimal inflammatory response in affected hibernating bats.

Differential diagnoses

Other superficial fungal diseases may present with similar clinical signs. In Australia, diagnoses in bats that have been investigated for WNS include overgrowth of saprophytic fungi, mite infestation, and infection with bacteria or other fungi [61-63].

Treatment

There is currently no available treatment for WNS, although there are some promising results from ongoing research, some of which are summarised below. Some focus on treatment of bats, some on environmental control of the fungus, and others on management activities to support bats through hibernation.

Bats may recover from the disease and clear the fungus if supported through the winter period by bringing them into captivity, raising their body temperature and providing food [64]. When affected little brown bats were warmed to between 18.3 °C and 23.9 °C, administered lactated Ringer's solution subcutaneously and fed mealworms, 25 out of 26 individuals recovered from the disease and were PCR negative for the fungus 70 days after being brought into captivity [27].

Certain volatile organic compounds, produced by bacteria, have fungistatic activity, potentially giving them a role as chemical control agents. A number of these compounds have been shown to inhibit the growth of *P. destructans* [65-67]. Probiotic bacteria are also being developed for application to bats to help inhibit fungal growth [68-70]. Polyethylene glycol 8000 is another chemical that is being investigated as an environmental treatment [70].

UV light has been shown to kill *P. destructans* in a laboratory setting [14]. The use of UV light, similar to the existing practice of whole-room UV sanitisation used commercially, has been considered for treating environmental reservoirs of *P. destructans* [71], however its effectiveness in the natural setting of a hibernaculum is yet to be confirmed.

Antifungal testing showed that *P. destructans* was susceptible to amphotericin B, ketoconazole, itraconazole, posaconazole and voriconazole. It was resistant to flucytosine, caspofungin, anidulafungin and micafungin and had dose dependent sensitivity to fluconazole [72].

A vaccine using racoonpox as a vector has shown good initial field results in reducing the level of fungal infection in bats vaccinated once in summer or autumn. Delivery methods under consideration include oral administration to individual bats, and methods for vaccinating multiple bats such as an aerosol spray [73, 74].

Environmental modification has been used to manipulate the microclimate in which bats are hibernating in caves and mines, to provide colder areas where fungal growth is inhibited [75].

Some researchers and managers have shifted their focus from treatment of the disease to supporting the bats that survive WNS. Examples include enhancing foraging habitats by applying UV light near hibernacula to attract prey insects, building bat boxes for bats to use while recovering in the spring, and using general measures to promote bat conservation and protect habitat [76, 77].

Prevention and control

Cavers perform a vital role in protecting Australia from WNS. It is important that cavers returning or entering Australia from overseas are aware of the risk of carrying the fungus into Australia on their clothing, footwear and caving gear and take appropriate precautions to disinfect their equipment and clothing prior to entry into Australia[1]. People who come in contact with insectivorous bats in Australia should be aware of the disease and report any suspect cases.

[1] http://agriculture.gov.au/pests-diseases-weeds/animal/white-nose-syndrome

Wildlife Health Australia, in consultation with stakeholders, developed response guidelines to assist relevant agencies should the disease appear in Australia: a range of response options are outlined in the guidelines. The preferred options will depend on the situation but may include a combination of activities to prevent further WNS transmission by humans and bats, surveillance to detect the extent of the disease, communication and education to assist with early detection and prevention of spread, and support for infected bats and bat populations.

Detailed information is provided in the US National White-Nose Syndrome Decontamination Protocol, and in WHA's Biosecurity Guidelines for Bat Research in Caves in Australia.

Dedicated clothing and equipment should be used for infected caves, and ideally for all sites. Where decontamination is required, the items should first be cleaned of all mud and debris. Clothing and other suitable items should then be submersed in hot water maintained at a temperature of at least 55°C for a minimum of five continuous minutes. Equipment that cannot be immersed in water can be treated with a suitable disinfectant e.g. 50-70% isopropyl alcohol, 8.25% sodium hypochlorite or bleach, or Virkon® S [78].

Information on how to recognise and report a suspect case of WNS is available on the WHA website.

National guidelines are available for veterinarians for sample submissions for WNS exclusion testing. When sampling bats, appropriate PPE should be used and decontamination protocols followed. Any bat where WNS is suspected should be kept separately and isolated from all other bats and animals to reduce the risk of disease transmission.

The U.S. Fish and Wildlife Service has written "A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats", May 2011.

Research

Current overseas research focuses on surveying caves and mines to identify new WNS-affected sites and track known sites; predicting the potential for future WNS spread; investigating biological or chemical treatment and control strategies; determining if there is resistance to WNS among bat populations; and developing a better overall understanding of the disease.

Some surveys of at-risk bat groups have been conducted to determine if the fungus is present in Australia [21]. Risk assessments examining the possible introduction of WNS into Australia and its potential consequences have been undertaken [44-46].

Knowledge gaps in relation to WNS risk in Australia include: fungal species present in Australian caves; temperature and humidity in Australian caves; body temperature of Australian bats during torpor/hibernation; susceptibility of Australian microbats to WNS; population and ecology of at-risk bat species; and the economic importance of insectivorous bats to agriculture in Australia.

Surveillance and management

WNS is a nationally notifiable disease (see www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/notifiable). By law you must notify animal health authorities in your jurisdiction if you know or suspect that an animal has a notifiable pest or disease. Refer to advice in your jurisdiction (www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/state-notifiable) and on outbreak.gov.au on how to report.

Wildlife Health Australia administers Australia's general wildlife health surveillance system, in partnership with government and non-government agencies. Wildlife health data is collected into a national database, the electronic Wildlife Health Information System (eWHIS). Information is reported by a variety of sources including government agencies, zoo based wildlife hospitals, sentinel veterinary clinics, universities, wildlife rehabilitators, and a range of other organisations and individuals. Targeted surveillance data is also collected by WHA. See the WHA website for more information https://wildlifehealthaustralia.com.au/Our-Work/Surveillance and https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/eWHIS-Wildlife-Health-Information-System.

There have been no reports of WNS in any bats from Australia's States and Territories or in the National Wildlife Health Surveillance Database. We are interested in receiving reports of any testing or field observation of the health of bat colonies. Please contact us at admin@wildlifehealthaustralia.com.au.

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Wildlife Health Australia recognises the Traditional Custodians of Country throughout Australia. We respectfully acknowledge Aboriginal and Torres Strait Islander peoples' continuing connection to land, sea, wildlife and community. We pay our respects to them and their cultures, and to their Elders past and present.

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References and other information

Further information on WNS is available through the Australian Government Department of Agriculture and Water Resources website (www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/animal/white-nose-syndrome), the USGS National Wildlife Health Center website (www.usgs.gov/centers/nwhc/science/white-nose-syndrome) and the North American White-nose Syndrome Response Team website (www.whitenosesyndrome.org).

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