UNUSUAL MORBIDITY/MORTALITY EVENTS IN WILDLIFE

AETIOLOGY

Classification of the causative agent

The term “unusual morbidity/mortality” is inherently difficult to define, especially as it pertains to wildlife species; for the purposes of this technical card, a morbidity or mortality event in wildlife is defined as a noteworthy occurrence of one or more sick or dead animals clustered in space and time. An event may be considered unusual if the aetiology is unknown or if the circumstances surrounding an identified disease occurrence differ from what is anticipated (e.g., changes in temporality or seasonality, geographic or spatial distribution and/or demographic composition; atypical clinical signs of disease; change in species affected; or morbidity/mortality beyond what is typically expected or observed).

Aetiologic agents of disease can be infectious (bacteria, viruses, protozoa, fungi, etc.) or noninfectious (toxins, prions, trauma, climatic events). Investigating causes of morbidity and mortality in wildlife species opens up the discovery of novel pathogens and previously unappreciated hosts for known pathogens. Additionally, seemingly unrelated mortalities may be connected by common contributing factors such as drought, severe weather events, et cetera.

EPIDEMIOLOGY

Affected Species

- Any animal species (avian, mammalian, reptilian, amphibian, invertebrate; terrestrial or aquatic) has the potential to be affected by an unusual morbidity or mortality event.
- Birds, fish, and marine invertebrates have experienced increased mortality events in recent years.
- From a conservation perspective, morbidity and mortality may be considered more significant in species or populations that are particularly vulnerable or endangered relative to more stable sympatric species.

Occurrence

- Unusual morbidity and mortality events can occur worldwide and at any time; detection requires vigilance and monitoring at the regional level.
- It is inherently difficult to determine mortality rate, incidence, prevalence, etc. in free-ranging wildlife populations.
- Wildlife species can be challenging to study due to their free-ranging nature, and effective investigations require a multidisciplinary approach between field biologists and diagnosticians.
    - It is critical to understand the ecology, behaviour, habitat use, and life history of species relevant to the geographic area, as well as their anatomy, physiology, and pathology.
    - Field biologists and diagnosticians should work together to determine the cause of morbidity and mortality in wildlife species.
- Mortalities may be part of a criminal investigation regarding malicious intent/action - response and legal course of action is beyond the scope of this card, but this is an aspect of investigation that should not be forgotten.

For more recent, detailed information on the occurrence of these diseases worldwide, see the OIE World Animal Health Information System - Wild (WAHIS-Wild) Interface [http://www.oie.int/wahis_2/public/wahidwild.php/Index].

DIAGNOSIS

The following considerations should be taken when investigating an unusual morbidity or mortality event in wildlife:

- Obtaining a field history
    - It is preferable that scientists who are familiar with the species and the environment gather relevant information; generally, they are most likely to appreciate any abnormalities or changes in habitat and behaviour.
    - Important information to collect includes:
        - Onset/duration of clinical signs and observed morbidity and mortality; photographs and/or video recordings of ill animals are particularly valuable
        - Affected species, sex, age
        - Species or groups not affected
        - Environmental changes, including abnormal weather and land use
    - It is important to consider factors such as vector control, seasonality, and congregation habits/animal density (breeding, feeding, overwintering, herd vs. solitary/breeding pair).
    - When reasonable to do so, consult landowners to obtain observations and other information pertaining to the event and local environment, including any similar events in recent history involving the site and species of interest.
- Sample collection
    - It is imperative that scientists and diagnosticians work together during investigations to ensure samples are collected safely and properly, and transported in a way that protects sample integrity.
    - Shipping samples and other materials across borders requires careful planning and forethought to remain compliant with regulations and to ensure sample integrity.
    - Because maintaining cold storage during fieldwork is a significant challenge, collecting temperature-stable samples such as formalin-fixed tissues, blood smears and collection tubes, or paper blood tabs is recommended.
    - Collecting multiple sets of samples is recommended for dissemination of material to diagnostic facilities and ensuring viable sample accessibility and back up samples.
    - Dogs have been used to find animals during large-scale morbidity or mortality events.
- Laboratory assays
    - Investigating the cause of an unusual event may require advanced diagnostic techniques, including laboratory assays and diagnostic pathology services.
    - There may be a need to identify and characterise a novel pathogen.
- Communicating investigation results
    - Avoid using technical jargon when communicating with officials in other disciplines or with the public; it often creates unnecessary obstacles to collaboration and implementation.
- For lists of laboratories and centers that perform diagnostic testing or disease surveillance, please refer to the following links:
    - OIE Collaborating Centers: https://www.oie.int/scientific-expertise/collaborating-centres/list-of-centres/
    - OIE Reference Laboratories: https://www.oie.int/scientific-expertise/reference-laboratories/list-of-laboratories/

Sample collection

Depending on the clinical manifestations, it is recommended that the following samples are taken:

- Oropharyngeal swab
    - Include the choanal slit when swabbing birds
- Rectal/cloacal swab, faeces
- Serum or plasma (live animal)
- Centrifuged heart blood (dead animal)
- Fresh tissue

    - Heart, liver, kidney, lung, trachea, air sacs, spleen, pancreas, brain, stomach (including ventriculus, proventriculus, and various forestomach chambers, if applicable), duodenum, jejunum, ileum, colon, caeca, and any lesioned tissues
- Formalin-fixed tissue
    - Heart, liver, kidney, lung, trachea, air sacs, spleen, pancreas, brain, bursa of Fabricius/bone marrow, skin plus feather or hair follicles, stomach (including ventriculus, proventriculus, and various forestomach chambers, if applicable), duodenum, jejunum, ileum, colon, caeca, and any lesioned tissues
- Collecting live, moribund individuals for examination and euthanasia may be preferred to carcass collection for ensuring freshness of samples, especially for species that autolyse and decompose rapidly (such as fish).
- Sampling and submission - especially when involving the general public - is often passive, opportunistic, and sporadic; therefore, it is potentially not representative of the affected population(s).
    - Sampling efforts should be systematic and targeted
    - Opportunistic sampling often yields a poor history and inconsistent submission quality
    - Examples of opportunistic or biased sampling include:
        - Recovery of marine mammals and seabirds on beaches
        - Observation of morbidity and mortality within nationally protected lands
        - Findings by landowners and hunters
        - Morbidity and mortality in prominent, easily spotted, or frequently encountered species, especially when compared to species in remote locations, those with cryptic colouration, or those with elusive behaviours

Laboratory diagnosis

- Emphasis is on timely recognition and reporting; having a pre-established relationship with a diagnostic laboratory is critical for a quick turn-around time.
- Most diagnostic tests have been developed for use in domestic animals. The results from these tests for wildlife should be interpreted with caution.
- Indirect tests such as serology should be used to determine if animals have been previously exposed to a pathogen or if determining immune status in a herd.
- Direct tests such as PCR or bacterial culture may indicate that an animal is currently infected.
- Sample size should be considered when interpreting diagnostic tests at the population level. For example, if the pathogen prevalence is low in a population and the population is small, it may be missed.
- Some pathogens are intermittently shed; therefore, several samples should be taken to increase the chance of a positive test result if such a pathogen is suspected.
- For positive test results, it is recommended that samples undergo alternative diagnostic testing or be sent to a reference laboratory for confirmation.
- Novel agents
    - Diagnostics techniques commonly used to identify novel pathogens include whole genome sequencing (WGS), metagenomics, and electron microscopy (EM) from cultured isolates or infected tissues.
- Even if cause of death is not determined, ruling out causes of disease and appreciating any predisposing factors or commonalities between affected individuals may be attainable; this is still valuable information when investigating and formulating a response to an event.

PREVENTION AND CONTROL

- Initial outbreak management is critical to reduce the impact of infectious pathogens or disease agents from a common point-source (e.g., toxins).
- It is recommended to establish reporting mechanisms and surveillance frameworks that can be used to inform and facilitate investigation, response, and mitigation efforts.
    - Established surveillance is particularly beneficial for identifying unusual events in a timely fashion, thereby allowing a rapid response.
    - Existing frameworks and plans also aid in implementing investigation and management efforts, as strategies do not have to be created *de novo*.

    - Collaboration between non-governmental organizations, local and national governments, and international agencies is encouraged.
- Integration and cooperation between laboratory staff and field biologists is critical, especially regarding areas such as vaccination engineering and deployment.
    - For example, vaccines against *Yersinia pestis* in prairie dogs (Family *Sciuridae*) have been developed and disseminated within the western United States to prevent colony collapse and aid in the conservation of the endangered black-footed ferret (*Mustela nigripes*).
- Appropriate carcass management and disposal are necessary to minimise further infection or contamination in the affected population, other animal species, humans, and surrounding environment.
- Wildlife can be reservoirs of OIE-Listed diseases; therefore, active surveillance for diseases known to be important to public health and the economy of a country is important. There is concern that detecting an OIE-notifiable disease in wildlife populations might negatively impact exportation abilities, but identifying and reporting these diseases in wildlife populations does not necessarily affect trade. Countries should maintain wildlife disease surveillance programmes that are beneficial to a national animal disease programme.
- Use international policies to inform conservation efforts
    - Examples of these policies or organisations working to implement conservation policies include: International Union for Conservation of Nature (IUCN), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
    - The illicit wildlife trade is a particular source of concern regarding transboundary disease introduction, biodiversity and ecosystem health, and a nation’s economy. Reducing the volume and frequency of illegal wildlife trade is a goal shared by conservationists, animal health experts, and other government entities alike. Therefore, cooperation and communication between these groups is encouraged.

POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS

- Outbreaks can be a signal for emerging pathogens and an early warning for risk to public health (e.g., highly pathogenic avian influenza) and agriculture/environment (e.g., white-nose syndrome)
    - Countries that conduct general disease surveillance of wild animal populations are more aware of the epidemiology of infectious diseases within their territorial borders and are therefore better prepared to protect wildlife, domestic animals, and human populations.
    - Many wildlife monitoring programmes include free ranging and farmed wildlife with explicit goals to protect domestic animal health, international trade, and public health. Beyond the direct implications to these sectors, detection of unusual morbidity and mortality events in wildlife may serve as indicators of ecological disturbance, including new animal species or pathogen introductions, climate or habitat changes, and environmental contamination due to pollutants.
    - Wild animals are increasingly relocated and translocated for management purposes or illicit trade, which carries significant economic, health, and environmental risks regarding potential disease introduction.
- Outbreak responses in endangered species are typically of a higher profile and greater urgency. Information gleaned from these investigations and responses may reveal general susceptibility or risk factors that can be applied to other management and conservation decisions.
- Outbreak investigations may entail exposure to unique occupational hazards and indicate specialised training (e.g., SCUBA for cave investigations, boating for aquatic investigations).

Risks to public health

- Any zoonotic pathogens causing morbidity and mortality in wildlife should be approached with caution and appropriate pre-planning. Even if a cause of death or disease is unknown, investigations should be approached as if the pathogen has zoonotic potential.
- Appropriate personal protective equipment (PPE) should be used during investigations for both laboratory and field personnel. This may include eye protection, gloves, respirators, boots, and hazardous materials suits.

Risks to agriculture

- Some pathogens that infect wildlife also have the potential to infect livestock.
- Depending on the pathogen or vector, several methods can be used to prevent disease in livestock (e.g., vaccination, drenches, acaricides).
- Fences can be used in some circumstances to prevent interaction between wildlife and livestock.
- Livestock infected with wildlife diseases may cause financial hardship for farmers due to production loss, animal death, management requirements, and trade restrictions.
- There may be a risk to wildlife populations if the incorrect approach is taken towards the diagnosis or management of the disease in livestock.
    - Mass culling is sometimes suggested as a way to control a disease without knowing if it truly will control, reduce, or eradicate the disease. For example, wild badgers (*Meles meles*) can transmit bovine tuberculosis, and mass culling of this species in the United Kingdom has been utilised as an attempt to control this disease in cattle, though the practice does not seem to have been effective.

EXAMPLES OF UNUSUAL MORBIDITY AND MORTALITY EVENTS IN WILDLIFE

The following are examples of pertinent unusual morbidity and mortality events in wildlife.

Description of Events

- Large-scale die-off of Eared Grebes (*Podiceps nigricollis*) (North America, 1992)
    - Large-scale mortality events have decreased the population of Eared Grebes that frequent the coast of California. Most events are due to weather events or known disease, but in January-March 1992 an unusual mortality event close to the Salton Sea resulted in the death of approximately 150,000 of these birds. It is speculated that the cause was a weather event. This event was notable because it was the largest mortality event of any bird species.
    - Clinical signs of illness included spending increased time onshore preening and sunbathing, wet feathers, and excessive drinking. Birds also had low body mass and poor body condition.
- Laysan Ducks (*Anas laysanensis*) (Laysan Island, Hawaii-1993 and Midway Atoll-2008)
    - From August-October 1993, Laysan Ducks on Laysan Island were found emaciated due to *Echinuria uncinata* nematode. It caused the population of this endangered species to decrease by about 75%.
    - In 2008, nearly 200 Laysan Ducks died due to Type C botulism. Clinical signs included visible nictitating membranes and flaccid paralysis of the neck, legs, and wings.
- Highly pathogenic avian influenza (HPAI) (China, 2005)
    - An HPAI event in waterfowl in 2005 (Qinghai Lake, China) occurred during which 6,000 birds died over two months.
    - Clinical signs included head tilt and paralysis.
    - The predominant bird species affected included: Brown-headed Gulls (*Larus brunnicephalus*), Great Black-headed Gulls (*Larus ichthyaetus*), Bar-headed Geese (*Anser indicus*), and Great Cormorants (*Phalacrocorax carbo*).
- White-nose syndrome (WNS) in several bat species (2006-present)
    - WNS is caused by the fungus *Pseudogymnoascus destructans* and was first identified in a cave in New York, United States in 2006, where it has since spread throughout North America. It grows on the muzzle, ears, and wings of hibernating bats, causing a disturbance in hibernation and depletion of energy stores. It also exists in Europe but is typically subclinical.
    - WNS has caused a severe decline in several bat populations in North America, including the little brown bat (*Myotis lucifugus*).
- Harbour seals and porpoises (Denmark and Sweden, 2007)
    - Multiple mortality events involving harbour seals and porpoises were due to an unknown infectious agent. It is estimated to have killed 2300 harbour seals and 28 harbour porpoises.

    - Harbour seals coughed up blood, had difficulty breathing due to emphysema, and developed a lump on the shoulder. Emphysema was found in necropsied harbour porpoises.
    - It was suspected that the animals had phocine distemper virus (PDV), as outbreaks of this virus occurred in 1988 and 2002.
- Multifocal necrotising myopathy (MNM) in northern elephant seals (*Mirounga angustirostris*) (San Miguel Island, California, United States, 2015)
    - A previously unappreciated disease of northern elephant seal pups was identified and named MNM. The observed pups displayed abnormal locomotion but maintained appropriate mentation.
    - MNM causes white streaking within muscles that is most apparent within the thoracic and abdominal body walls of affected pups. Histology revealed a multifocal necrotising granulomatous myopathy with or without mineralisation in various muscles.
    - The aetiology remains unclear but is believed to involve vitamin E and selenium deficiencies, among other factors.
- Pasteurellosis in saiga (*Saiga tatarica*) (Kazakhstan, 2015)
    - Approximately 200,000 of the critically endangered saiga died from haemorrhagic septicaemia caused by *Pasteurella multocida* B.
    - Pasteurellosis is thought to have caused other large-scale mortality events in saiga in 1981, 1984, 1988, 2008, and 2012.
- Pheasantshell mussel (*Actinonaias pectorosa*) die-offs (Clinch Watershed, Tennessee and Virginia, United States, 2016)
    - Pheasantshell mussels were found floating in the lower river starting in 2016; it is estimated that fifty to ninety percent of the pheasantshell population perished from 2016-2019.
    - These mass die-offs were due to possible densovirus infection.
- Wildfires (Australia, 2019-2020)
    - These wildfires have displaced or killed an estimated 3 billion animals of several vertebrate and invertebrate species; reptiles are believed to be the most severely impacted.
- African bush elephants (*Loxodonta africana*) (Botswana and Zimbabwe, 2020)
    - At least 350 African elephants were found dead in Botswana and Zimbabwe starting in March 2020 in the Okavango Delta. The cause of death was determined to be cyanobacterial toxins.
    - Clinical signs included disorientation, circling, and sudden death.
- Rabbit haemorrhagic disease virus-2 (RHDV-2) in lagomorphs (United States, 2020)
    - RHDV-2 infects both domestic and wild rabbits. In this outbreak, the virus was isolated from black-tailed jackrabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*).
    - This virus causes sudden death in infected lagomorphs. Epistaxis and possible respiratory or nervous system dysfunction are sometimes appreciated in moribund individuals.
- Shaggy Lame Fox Syndrome (SLFS) in arctic foxes (*Vulpes lagopus*) (Pribilof Islands, Alaska, several years)
    - This disease in arctic foxes is characterised by emaciation, winter coat retention, and lameness secondary to polyarthritis. Death typically occurs secondary to the effects of starvation. Histologically, polyarthritis, vasculitis, renal infarction, myocarditis, meningitis, and brain infarction are appreciable.
    - The aetiology of SLFS is still unclear; *Erysipelothrix rhusiopathiae* is hypothesised to be the causative agent. SLFS was first appreciated in Pribilof Island arctic foxes (*Alopex lagopus pribilofensis*) in 1986 and continues to contribute to fox mortality.
- Population decline of New Zealand sea lions (*Phocarctos hookeri*) (Auckland Island, New Zealand, several years)
    - Several theories for the decrease of the New Zealand sea lion population on Auckland Island have been postulated, including genetics, migration, predation, and disease, with the most likely cause being competition with fisheries for food.
- Several unusual morbidity and mortality events have occurred in a variety of wildlife species. Please refer to the following OIE technical disease cards for more information on these topics:
    - Algal toxicosis in sea otters (**Algal Toxicosis**)
    - CWD in cervids (**Chronic Wasting Disease**)
    - Lead toxicity in endangered species such as the California Condor (*Gymnogyps californicus*) (**Chemical Toxins - Heavy Metals**)

- ○ Morbillivirus in seals and dolphins (**Morbillivirus (Marine Mammals)**)

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The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Samantha Gieger and Erin Furmaga with assistance from the USGS National Wildlife Health Center.