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Monitoring for Diseases in Wildlife Populations

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Introduction

Diseases of wildlife occur in many different forms in a wide range of animal species and populations. Diseases, when expressed in free-ranging animals, can have a significant effect on wildlife ecology. Whilst some diseases exist as symptomless, subclinical infections without obvious ecological impact and of no consequence for domestic animals or humans, occasionally there are dramatic epizootic outbreaks characterised by high morbidity and mortality (Wobeser, 1994). In addition, wild animals can be reservoirs for highly contagious and severe diseases as listed by the World Organisation for Animal Health (OIE), including many that infect domestic animals or humans. Active surveillance for known diseases of economic or public importance amongst wildlife is an increasingly well recognized need at the national and international level. Reports of illnesses or deaths involving many animals from a free-living population may represent the initial alert to the likely presence of a new disease agent. Early intervention and investigation of such unusual or unexpected disease events is essential to the goal of determining the cause and significance of the outbreak. Such reports may be the first indication of the introduction of an exotic disease agent.

Many national disease monitoring programmes include free-ranging or farmed wildlife. These programmes are usually proactive measures aimed at generally supporting national domestic animal and wildlife health, international trade in animals and animal products and protecting public health. Part of any national or international strategy for monitoring wildlife disease should include the capability to investigate mass mortality or morbidity events, investigate new disease syndromes, identify and categorise new pathogens, and monitor the status of known diseases within wildlife populations.

A disease occurring in time between some constant limits, above and below an average, is called an endemic situation (enzootic is the specific word employed to specify that the population is composed of animals). Morbidity breaking out in a place where it was previously unnoticed is called an epidemic (or epizootic for animals). Finally, when events occur in an unpredictable manner, they are called sporadic.

Investigating and Sampling for Wildlife Diseases

For many reasons, it is more difficult to monitor diseases in wildlife than in domestic animals. Wild animals are not constrained by boundaries and can range over large distances. This is particularly so for migratory birds or mammals, which seasonally move across continents or vast oceans. Opportunities to sample them may occur only briefly, at selected feeding or breeding locations.

Wild animals inhabit natural environments in various ways. Apart from colonial and herding species, which may number in the tens of thousands, wild animals also exist as smaller groups such as family cohorts, or occupy territory as solitary animals and breeding pairs.

Among the earliest surveillance programmes for wildlife disease were those established in Denmark in the early 1930s (Christiansen, 1935) and in Sweden in the 1940s (Borg, 1975). These programs were based on examinations of dead animals submitted to national veterinary laboratories. In the early 1950s, the programme in Sweden revealed problems with mercury poisoning of wildlife (Borg, 1966), and it was after this discovery that a systematic health monitoring programme of the Swedish environment was established (Mörner, 1991). Similar health monitoring programmes of wildlife, based on examinations of dead wildlife, are today in action in some other European countries such as Norway, Finland, Austria and France (Leighton, 1994), but at the moment not in all European countries. Diseases in wildlife occur in most countries. In North America, there are several regional co-operative studies on wildlife diseases, e.g. the Southeastern Cooperative Wildlife Disease Study in Athens, Georgia, USA, the USGS National Wildlife Health Center in Madison, Wisconsin, USA, and the Canadian Cooperative Wildlife Health Centre in Saskatchewan, Saskatoon, Canada. Other wildlife disease surveillance programmes exist worldwide, but the majority of these programmes are designed primarily to protect domestic animal health and trade, and only part of the work deals with wildlife health *per se*. Australia is in the preliminary stages of developing a national wildlife health network designed to report, investigate and discuss unusual mortality or disease incidents as they occur.

Morbidity (Number of Animals with a Disease)

In contrast to humans and domestic animals, in wild animals the expression of clinical signs is extremely difficult to observe and quantify. Practical difficulties can exist in determining the morbidity and mortality rates as a proportion of the population at risk. Nearly identical clinical manifestations or lesions may be caused by many different types of pathogens and their occurrence in wildlife can be extremely difficult to detect. Furthermore, wild animals normally do not show any clinical signs when observed, and thus apparently healthy individuals may be carriers of various pathogens. Therefore, disease surveillance for pathogens and morbidity studies for a particular disease cannot be based on the collection of clinical data. In order to determine the morbidity for a certain disease, many animals or specimens from a large number of animals need to be evaluated. The migration or host range movement of some wild animals that occurs before a disease outbreak is discovered sometimes makes assessment of the rates of morbidity or mortality over time almost meaningless (Artois et al., 2001).

Mortality (Number of Animals Dying from a Disease)

Most wildlife disease monitoring programmes worldwide are based on examining dead animals found in the field. These monitoring programmes provide information about the kinds of diseases that occur within a certain region and the diseases that are of greatest importance. Such programmes often detect unexplained mortalities through the collection and analysis of dead wild animals. The carcasses of animals that have died from a trauma injury or other external factors can also be used to screen for toxic, infectious or parasitic agents, even where the carcass presents no macroscopically visible lesions.

The spatial and longitudinal analysis of wildlife mortality statistics and the results of the associated systematic screening provide a reliable source for analysing health risks posed by/to wildlife. In order to determine the mortality of a certain disease, carcases of animals that died in the field must be discovered. However, for many different reasons it can be difficult to find and count sick and dead wild animals. Stutzenbacher et al. (1986) reported that only 6% of marked duck carcasses were detected by searchers in a Texas marsh. Similarly, less than 27% of the deer carcasses present on an area in Montana after a disease outbreak were detected by hunters (Swenson, 1979). A way to improve the ability to find sick and/or dead animals is to use trained dogs. In one study, dogs found 92% of passerine bird carcasses placed on plots, compared with 45% for human searchers (Homan et al., 2001).

Passive Surveillance

Disease and mortality in wildlife can appear in many different ways, depending on the morbidity and mortality rate. In many programmes worldwide, passive surveillance is mainly based on investigations of dead animals submitted for necropsy and laboratory examinations.

Mass mortality events involving wildlife may often occur unpredictably, and opportunities to investigate such events may be short-lived. Examples of this include recovery of dead marine mammals, fish or seabirds from beaches or coastal waterways, discovery of dead birds or mammals in forests, agricultural or urban areas, and mass mortality events within national parks or nature conservation reserves. More commonly, dead wildlife are submitted as single accessions to animal health laboratories by landowners, hunters or the public. Such passive collection may represent the most frequent opportunity to identify various pathologies in association with disease-causing agents. In isolation, such wildlife accessions may merely represent a disease record to include in the laboratory database. Depending on the accompanying history and the consistency of diagnostic finding, such passively acquired accessions may give insight into the occurrence of important disease processes in wild animal populations. The significance of these accessions may only become apparent over time. To diagnose a wide variety of diseases occurring in wildlife, the necropsy of a wild animal must be carried out by a pathologist with certified specialist training. Also, the examination must be conducted exhaustively in accordance with a standardised procedure, regardless of the size and state of preservation of the carcass (Woodford et al., 2000).

Active Surveillance

For significant diseases in wildlife, an active surveillance programme may be the preferred approach. Such programmes aim to collect a certain number of samples from a target population (either live and/or dead animals) to determine the point prevalence of certain pathogens using antigen or specific antibody techniques. Once an infectious pathogen has been identified, serological surveys supported by accurate species-specific tests are the most commonly used means to actively assess the extent of previous infections within selected free-ranging populations.

Meat Inspection

Abattoir inspection of game meat can be another way to monitor for some important infections, e.g. tuberculosis. The status of this mycobacterial infection can be extremely difficult to monitor purely by field observations of clinical disease. Moose (*Alce alces*) and deer in the Nordic countries and wild boars (*Sus scrofa*) and deer in central and southern Europe are currently the species more frequently examined in this way. National legislation also requires inspection of game meat in many other parts of the world and this procedure should be part of the national monitoring programme for wildlife diseases.

New Diseases

One of the major functions of monitoring programmes is to detect new diseases. For different reasons, detection of new diseases is a difficult task. First, a concept definition of 'new' disease is needed. This would include alterations caused by known disease agents in new (different than known) host species, and also completely new causes of disease, including both single agents and multifactorial causes. Once again, detection probability will depend on disease prevalence, disease transmission and disease-caused mortality, and even on disease relevance. For example, disease agents that are likely to spill over to humans are likely to be more surveyed than others.

Detection of new diseases requires sound knowledge of the current disease status of a given list of host species in a given area, and the systematic investigation of those clinical cases where the aetiology is unclear or possibly new. This in turn is linked with a proper monitoring scheme (including population monitoring, active disease surveillance), and particularly careful passive or scanning surveillance.

After some years, a monitoring programme based on regular investigations of diseases and post-mortem examination of dead animals will achieve basic knowledge about the kinds of diseases occurring within certain geographical regions or in certain animal species and populations (Williams, 2002). Archiving of laboratory cases associated with stored serum and tissue samples is invaluable for retrospective investigations of new or recently emerged diseases. If new diseases occur, they are probably most often discovered through passive programmes based on laboratory accessions and post-mortem examinations. An example of this is European brown hare syndrome (EBHS), which was first observed in European brown hares (*Lepus europaeus*) in Scandinavia in the early 1980s (Gavier-Widén and Mörner, 1991). This disease syndrome was characterised as a primary liver pathology and the etiological agent was assumed to be either an infectious agent, most likely a virus, or a toxic chemical, such as a pesticide. It was not until 1987, when colleagues from Northern Europe met to discuss the epidemiology of EBHS, that it became clear that an infectious agent was most probably causing this syndrome. The etiological agent, a calicivirus, was later described by Lavazza and Vecci (1989) and serological retrospective studies demonstrated that the virus had been present in Europe and other countries since as early as 1971 (Moussa et al., 1992).

There are other instances where significant disease-causing agents have been discovered in free-ranging wildlife as a result of routine submissions of wildlife to animal diagnostic laboratories. In addition, the search for a potential wildlife host may result from the diagnosis of infectious diseases affecting humans, as in the case of Lyssavirus and Nipah viruses (Hooper et al., 1997; Chua et al., 2000; Johara et al., 2001) or domestic animals, as with Hendra and Menangle viruses (McColl et al., 2000).

The Impact of Wildlife Diseases on Wildlife Populations

Many of the preliminary investigations of natural mortality events in wildlife comprised somewhat non-statistical and non-random sampling. They represent a collection of different diseases and causes of death, perhaps associated with some distributional information. Such investigations tend to provide only limited insight into the relevant epizootiology. The reason or motivation for submitting wildlife samples also needs to be considered, as increased effort to recover specimens may follow from increased public awareness. If the public or media perceives a disease outbreak in wildlife as new and important, the public response increases, and with it the number of samples submitted.

To assess the significance of a mortality event caused by a disease in a wild animal population, it may be necessary to attempt to measure the death rate. This can be a difficult task. Recording all dead animals and estimating even the local population at risk may be fraught with error. In the case of some investigations of wildlife diseases, clinically affected or diseased animals have been marked and monitored over time. By their nature, such studies tend to be restricted to defined host ranges and populations and conducted over limited durations. Another way to overcome this problem is to use radio-telemetry and satellite-tracking techniques to monitor the survival or otherwise of tagged animals. This has proved useful in a study on epizootic haemorrhagic disease in deer (Beringer et al., 2000) and in rabies in skunks (*Mephitis mephitis*) (Greenwood et al., 1997).

The ability to prepare for, and respond to, unusual mortality or morbidity events can only be based on previous knowledge and awareness. Access to and awareness of infectious disease must be diagnostic expertise and should be provided to the public and to persons with responsibility for wildlife and environmental stewardship. Sampling during index outbreaks may be minimal, opportunistic and selective, but after the preliminary evaluation of laboratory findings, it is likely that where there is a recurrence, subsequent sampling can be more comprehensive. In remote areas, it is likely that a layperson or a field biologist will make the discovery of an unusual morbidity, mortality or clinical disease event in wildlife.

Where non-specialist personnel are asked to conduct initial investigations, contact with specialists and the relaying of instructions about appropriate sampling and storage of specimens will be necessary. In the long term, the preparation of specific contingency plans and procedure manuals, supported by training, will improve the capability of field biologists and wildlife researchers to respond to such incidents. The development of national wildlife disease networks and training modules for wildlife investigators will also be useful.

Monitoring for the presence of diseases and conducting wildlife health evaluations are normally based on the premise that any pathological or microbiological data collected from individual animals that make up a population will be informative of the host-agent relationship within a given population and environment.

The host-parasite relationship differs widely among different infectious diseases. Some disease agents only infect one or few animal species, such as calicivirus infections of lagomorphs (Lenghaus et al., 2000) or myxomatosis (Woods, 2000). By contrast, viral diseases such as rabies (Rupprecht et al., 2001), bacterial diseases such as anthrax (Gates et al., 2000) and tularaemia (Mörner and Addison, 2000) or parasitic diseases such as sarcoptic mange (Bornstein et al., 2000) are found in a large number of different species.

To assess whether a mortality or morbidity event is due to a disease-causing agent, it is important to collect as much relevant data relating to the incident as possible. Although not all sick or dead animals may be available for investigation, attempts should be made to estimate or count their number and relate those affected or dead to the total population that is potentially exposed or at risk. It is also important to relate the occurrence of a disease to other factors in the environment, which may predispose to the expression of overt disease, and to prepare a time sequence (or timeline).

Conclusions

Surveillance and monitoring programmes are the first steps toward providing an appropriate awareness of the health status of wildlife populations. Justification for developing and maintaining such a capability includes the need for knowledge to: i) manage wildlife populations and their habitats, ii) limit risks related to animal export trade and translocation of animals, and iii) protect natural biodiversity values and safeguard public health. Wildlife disease monitoring programmes integrated within existing national animal health surveillance infrastructures are essential to adequately respond to unusual wildlife mortality events and to efficiently investigate the epizootiology of new diseases found in wildlife.

Chapter 22

Artois M., Bengis, R.G., Cheeran, J., Fischer, J., Leighton, F.A., Mörner, T., Woodford, M.H. and Pearson, J.E. 2001. Surveillance of wildlife diseases on the global scale. In: *Abstracts International Joint Conference of the Society for Tropical Veterinary Medicine/Wildlife Disease Association (STVM/WDA), Wildlife and livestock disease and sustainability: what makes sense?*, 22-27 July, Pilansberg National Park, South Africa. STVM/WDA, Lawrence, Kansas, 36.

Berringer, J., Hansen, L.P. and Stallknecht, D.E. 2000. An epizootic of hemorrhagic disease in white-tailed deer in Missouri. In: *J. Wildl. Dis*., 36, 588-591.

Borg, K. 1966. Mercury poisoning in Swedish Wildlife. In: *J. appl. Ecol*., 3, 171.

Borg, K. 1975. *Viltsjukdomar*. LTs förlag (in Swedish). 191 pp.

Bornstein, S., Samuel, W. and Mörner, T. 2001. Sarcoptes scabiei and sarcoptic mange. In: Samuel, W.M., Pybus, M.J. and Kocan, A.A. (eds). *Parasitic diseases of wild mammals*, 2nd Ed. Iowa State University Press, Iowa, 107-121.

Christiansen, M. 1935. *De vigtigste smittsamme Sykdomme hos vilt*. Meddelelser fra Statens Veterinære Serumlaboratorium (in Danish). 157. State Veterinary Laboratory, Denmark, 92 pp.

Chua, K.B., Bellini, W.J., Rota, P.A., Harcourt, B.H., Tamin, A., Lam, S., Ksiazek, T., Rollin, P., Zaki, S., Shiel, W.-J., Goldsmith, C., Gubler, D., Roehrig, J., Eaton, B., Gould, A., Olsson, J., Field, H., Danels, P., Ling, A., Peters, C., Anderson, L. and Mahy, B. 2000. Nipah virus: a recently emergent deadly paramyxovirus. In: *Science*, 288, 1432-1435.

Gates, C.C., Elkin, B. and Dragon, D. 2000. Anthrax. In: Williams, E.S. and Barker, I.K. (eds). *Infectious diseases of wild mammals*, 3rd Ed. Iowa State University Press, Iowa, 396-413.

Gavier-Widén, D. and Mörner, T. 1991. Epidemiology and diagnosis of the European brown hare syndrome in Scandinavian countries: a review. In: *Rev. sci. tech. Off. Int. Epiz*., 10 (2), 435-451.

Greenwood, R.J., Newton, W.E., Pearson, G.L. and Schamber, G.J. 1997. Population and movement characteristics of radio-collared skunks in North Dakota during an epizootic of rabies. In: *J. Wildl. Dis*., 33, 226-241.

Homan H.J., Linz, G. and Peer, B.D. 2001. Dogs increase recovery of passerine carcasses in dense vegetation. In: *Wildl. Soc. Bull*., 29, 292-296.

Hooper, P., Lunt, R., Gould, A., Samaratunga, H., Hyatt, A., Gleeson, L., Rodwell, B., Rupprecht, C., Smith, S. and Murray, P. 1997. A new lyssavirus – the first endemic rabies-like virus recognised in Australia. In: *Bull. Inst. Pasteur*, 95, 209-218.

Johara, M., Field, H., Rashdi, A., Morrissy, C., van der Heide, B., Rota, P., Adzhar, A., White, J., Daniels, P., Jamaluddin, A. and Ksiazek, T. 2001. Nipah virus infection in bats (Order Chiroptera) in peninsular Malaysia. In: *Emerg. infect. Dis*., 7, 439-441.

Lavazza, A. and Vecci, G. 1989. Osservazioni zu alcuni episodi di mortalitá nelle lepre: Evidenziazione al microscopio elettronico di una particella virale – Nota preliminare. In: *Selez. vet*., 30, 461-468.

Leighton, F.A. 1994. *Surveillance of wild animal diseases in Europe: a survey of sources of information on wildlife diseases.* Agence française de sécurité sanitaire des aliments (AFFSA), Nancy (France) & Canadian Cooperative Wildlife Health Centre (CCWHC), Saskatoon, 87 pp.

Lenghaus, C., Studdert, M.J. and Gavier-Widén, D. 2000. Calicivirus infections. In: Williams, E.S. and Barker, I.K. (eds). *Infectious diseases of wild mammals*, 3rd Ed. Iowa State University Press, Iowa, 280-292.

McColl, K.A., Tordo, N. and Aguilar Setién, A. 2000. Bat lyssavirus infections. In: *Revue Scientifique et Technique 19*, 177–198.

Mörner, T. 1991. *Liv och död bland vilda djur* (in Swedish). Sellin & Partner, Stockholm, 169 pp.

Mörner, T. and Addison, E. 2000. Tularemia. In: Williams, E.S.and Barker, I.K. (eds). *Infectious diseases of wild mammals*, 3rd Ed. Iowa State University Press, Iowa, 303-313.

Moussa, A., Chasey, D., Lavazza, A., Cappuchi, L., Smid, B., Meyers, G., Rossi, C., Thiel, H.-J., Vlasak, R., Rønsholt, L., Novotny, N., McCullough, K.C. and Gavier-Widén, D. 1992. Haemorrhagic disease of lagomorphs: evidence for a Calicivirus. In: *Vet. Microbiol*., 33, 375-381.

Rupprecht, C.E., Stöhr, K. and Meredith, C. 2001. Rabies. In: Williams, E.S. and Barker, I.K. (eds). *Infectious diseases of wild mammals*, 3rd Ed. Iowa State University Press, Iowa, 3-37.

Stutzenbacher, C.D., Brown, K. and Lobpries, D. 1986. Special report: an assessment of the accuracy of documenting waterfowl die-offs in a Texas coastal marsh. In: Feierabend, J.S. and Russell, A.B. (eds) *Lead poisoning in wild waterfowl*. National Wildlife Federation, Washington, 88-95.

Swenson, J.E. 1979. Effects of a hemorrhagic disease epizootic on a white-tailed deer population in eastern Montana. In: *Proc. Mont. Acad. Sci*., 38, 25-32.

Williams, E.S., Yuill, T., Artois, M., Fischer, J. and Haigh, S.A. 2002. Emerging infectious diseases in wildlife. In: Rev. sci. tech. Off. Int. Epiz., 21 (1), 139-157

Wobeser, G.A. 1994. *Investigation and management of diseases in wild animals*. Plenum Press, New York, 265 pp.

Woodford, M.H., Keet, D.F. and Bengis, R.G.;Woodford, M.H. (ed.) 2000. *Post-mortem procedures for wildlife veterinarians and field biologists*. , Office International des Epizooties, 200012, rue de Prony, 75017 Paris, France, 47 pp.

Woods, L.W. 2000. Adenoviral diseases. In: Williams, E.S. and Barker, I.K. (eds). *Infectious diseases of wild mammals*, 3rd Ed. Iowa State University Press, Iowa, 202-213.

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Bjoersdorff, A., Bergstrom, S., Massung, R.F. and Haemig, P.D. 2001. Ehrlichia-Infected ticks on migrating birds. In: *Emerg. Infect. Dis*. 5: 877-879.

Bodker, R., Msangeni, H.A., Kisinza, W. and Lindsay, S.W. 2006. Relationship between the intensity of exposure to malaria parasites and infection in the Usambara mountains, Tanzania. In: *Am J Trop Med Hyg*. 74: 716 - 723.

Brouqui, P., Bacellar, F., Baranton, G., Birtles, R.J., Bjoersdorff, A., Blanco, J.R., Caruso, G., Cinco, M., Fournier, P.E., Francavilla, E., Jensenius, M., Kazar, J., Laferl, H., Lakos, A., Lotric Furlan, S., Maurin, M., Oteo, J.A., Parola, P., Perez-Eid, C., Peter, O.,