

Surveillance and monitoring of wildlife diseases

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Summary

It is now recognised that those countries which conduct disease surveillance of their wild animal populations are more likely to detect the presence of infectious and zoonotic diseases and to swiftly adopt counter measures. The surveillance and monitoring of disease outbreaks in wildlife populations are particularly relevant in these days of rapid human and animal translocation, when the contact between wild and domestic animals is close and the threat of a bioterrorist attack is very real.

The authors describe the problems inherent in wildlife disease surveillance and stress the importance of the establishment of national strategies for disease detection. The various sampling methods employed for monitoring outbreaks of disease and mortality in wildlife populations are discussed and their strengths and weaknesses described.

A major advantage of an efficient disease monitoring programme for wildlife is the early detection of new and 'emerging' diseases, some of which may have serious zoonotic and economic implications.

The authors conclude that wildlife disease monitoring programmes that are integrated within national animal health surveillance infrastructures should have the capacity to respond promptly to the detection of unusual wildlife mortality and to institute epizootiological research into new and emerging wildlife diseases.

Keywords

Diseases – Epizootiology – Monitoring – Sampling – Surveillance – Wildlife.

Introduction

It is now widely recognised that countries that conduct disease surveillance of their wild animal populations are more likely to understand the epizootiology of specific infectious diseases and zoonotic infections within their territorial borders and are therefore better prepared to protect wildlife, domestic animals and human populations. In the Office International des Epizooties (OIE: World organisation for animal health) Report of the Working Group on Wildlife Diseases presented at the 67th General Session of the International Committee, it was noted that 'the activity of translocations of wild animals is on

the increase, carrying with it economic, health and environmental risks in the event of concomitant introduction of diseases' (35). The Report also noted that wildlife health surveillance is proving to be a subject of growing importance and that the presence or absence of an infection in the wild cannot be declared by a country, or a local sub-national authority, unless sampling has been carried out and the results subjected to the appropriate statistical analyses. Clearly, the notion of 'absence of evidence' rather than the 'evidence of absence' is just as relevant to free-ranging animal populations as it is to domesticated animal populations. Regular monitoring programmes will therefore increasingly become part of proving national disease freedom and confirming the status of significant diseases in free-ranging animal populations.

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 ecologies. Whilst some diseases exist as symptomless, subclinical infections without any obvious ecological impact and of no consequence for domestic animals or humans, occasionally there are dramatic epizootic outbreaks characterised by high morbidity and mortality (44).

In addition, wild animals can be reservoirs of OIE List A or B diseases, as well as other important diseases that infect domestic animals or humans. Consequently, active surveillance for known diseases of economic or public health importance amongst wildlife is particularly beneficial to the national interest. Previously, there has been concern that the detection of a notifiable disease, such as an OIE-listed disease, in free-ranging animal populations, might potentially penalise an exporting country, particularly where a similar disease does not exist in domestic animal populations. The identification and reporting of List A or B diseases in wildlife populations should not necessarily have an impact on trade (principle of compartmentalisation). All countries should be encouraged to develop and maintain wildlife disease surveillance programmes which complement and support a national animal disease programme.

Invariably, the detection of such notifiable disease in the wild, in the absence of disease in farmed animals, becomes the catalyst for reactive investigation and research to define the nature of the host-pathogen interaction and to re-examine the potential risk of spill-over or cross-over infections to domestic animal populations. Differentiating between a newly established disease and a pre-existing, but formerly undiscovered, disease within wildlife populations will necessarily be part of that research effort.

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 are essential to the goal of determining the cause and significance of such outbreaks. Reports of this nature may be the first indication of the introduction of an exotic disease agent. Examples include the introduction of insect-borne viruses into new areas, such as the recent outbreak of West Nile virus infection in New York and other parts of the United States of America (USA) (25, 40) or movement of a disease into new areas due to unusual or exceptional climatic or ecological events, as was the case of the recent epizootic of kangaroo blindness (orbivirus) in southern Australia (39).

The discovery of a significant disease-causing agent in wildlife could also occur as a result of passive monitoring activities, such as the increased roe deer (*Capreolus capreolus*) mortality in Europe during the past decades (1, 23). There are many instances where significant disease-causing agents have been

discovered in free-ranging wildlife as a result of routine submissions of wildlife material 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 discovery of Australian bat lyssavirus infections in Australia and Nipah (morbillivirus) virus infections in Malaysia (12, 20, 21), or domestic animals, as in the case of the bat-associated Hendra and Menangle paramyxoviruses (36).

Many national disease monitoring programmes include free-ranging or farmed wildlife. These are usually proactive programmes aimed at supporting national domestic animal health, international trade in animals and animal products and protecting public health. Part of the national strategy for monitoring wildlife disease includes the capability to investigate events of mass mortality or morbidity and new disease syndromes (rabbit haemorrhagic disease and European brown hare syndrome – the lagomorph caliciviruses) (13, 34), identify and categorise new pathogens, and monitor the status of known diseases within wildlife populations (27, 30).

Apart from the direct economic, public health and trade implications of the presence of diseases in wildlife, overt disease outbreaks and mass mortality in wildlife may be important indicators of ecological disturbance, introduction of new animal species, introduction of new diseases, climatic or habitat change, or local pollution.

Monitoring mortality events in wildlife

Mass mortality events involving wildlife may often occur unpredictably. Opportunities to investigate such events may be short-lived. Examples include the recovery of dead marine mammals, fish or seabirds from beaches or coastal waterways, the 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 from landowners, hunters or the public. Such passive collections may provide a more 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 findings, 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 as, for example, studies on hare mortality in Europe (22, 32).

Much of the preliminary investigations of natural mortality events in wildlife can be derived from somewhat non-statistical

and non-random sampling. They represent a collection of different diseases, causes of death, perhaps associated with some distributional information. Such investigations tend to provide only limited insight into the epizootiology. The reason or motivation for submitting wildlife samples also needs to be considered, as increased efforts 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 submitted samples.

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 or try to assess 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 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 been useful in a study on epizootic hemorrhagic disease in deer (5) and in rabies in skunks (*Mephitis mephitis*) (18).

For significant diseases in wildlife, an active surveillance programme may be a 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 an infection within selected free-ranging populations.

Investigating mortality or morbidity events involving wildlife

The ability to prepare for and respond to unusual mortality or morbidity events can only be based on prior knowledge and understanding of such incidents. Infectious disease must always be discounted as a potential cause. Sampling during index outbreaks may be minimal, opportunistic and selective. However, after the preliminary evaluation of laboratory findings, it is likely that should there be a recurrence, subsequent sampling can be more comprehensive. In remote areas, it is likely that a layperson or a field biologist will discover 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 on 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.

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 all sick or dead animals may not be available for investigation, attempts should be made to estimate or count their numbers and relate this information 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 time-line).

Investigating and sampling for wildlife diseases

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

Wild animals inhabit natural environments in various ways. For animals that congregate in large numbers in the open, unusual outbreaks of mortality or disease may be quite visible and easily detected (e.g. at feeding sites, such as savannah grasslands or wetlands, and within communal breeding colonies). In the case of cryptic or more secretive species of wildlife, or those located in remote areas (such as polar regions, deserts or other sparsely inhabited areas), in mountainous terrain or in dense forests and jungles, the presence of disease may only come to light as a result of other biological collections of wildlife or from targeted surveillance efforts. Free-living species that are small and/or difficult to find in their natural habitats may experience a disease with high mortality and yet remain undetected for several years or decades. The declines and disappearances of frogs in Australia, Central and North America, New Zealand and parts of Europe have been linked to a new species of skin fungus (*Batrachochytrium*) and may be the

primary cause of these die-offs (4, 29). The only obvious indication that a pathogen is killing wildlife may be local declines (or extinctions) in certain species of wildlife. It may be only through systematic trapping programmes and disease sampling that the cause of such wildlife declines is precisely determined.

Apart from gregarious 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. Similarly, the area occupancy may vary from a limited home range of a few hectares, to vast nomadic ranges covering hundreds or thousands of square kilometres. Some wildlife species undergo extensive seasonal migrations and can be variously exposed to nutritional and climatic stress. Seasonal exposure to biting arthropods causes wildlife to host a broad range of blood-borne parasitic diseases, and arboviral and bacterial diseases.

Significant mass mortality and morbidity events involving wildlife usually represent a challenge for wildlife disease investigators. Outbreaks of unusual mortality or morbidity represent opportunities to methodically collect a range of data and to test the adequacy of wildlife disease protocols to diagnose the principle cause, its significance and epizootiology.

Sometimes an initial wildlife disease incident may take place within little or no apparent context. The epizootiology of the infection may only become apparent after multi-disciplinary discussions and extensive sampling. In some cases, it may be difficult to observe and follow the full sequence of a disease outbreak in the index outbreaks. The clinical expression of disease and the course of illness in the field may be incomplete. In addition, a new infectious disease introduced to a susceptible wildlife population is likely to spread from the index mortality or morbidity event. Plotting the rate of spread, seasonality and interactions with geography or climate may be useful. Experimental transmission and susceptibility studies are invariably necessary to understand the pathogenesis of such diseases.

Significant mass mortality can occur at places where wildlife congregate, such as seasonal breeding or feeding locations. Mass mortalities frequently occur amongst migrating waterfowl and seabirds in North America. Such outbreaks are variously attributed to bacterial infections such as avian cholera and botulism or viral infections such as Newcastle disease and avian influenza. The United States National Wildlife Health Centre reports quarterly on significant wildlife mortalities by location, date, principal species, mortality count and principal cause. The Wildlife Disease Association publishes these listings in their quarterly newsletter.

Investigating and sampling for diseases in wildlife should be performed so that as much information as possible is collected from the limited number of carcasses obtained for investigation.

Adequate sampling of both live and dead animals involves the collection of quantitative and qualitative data (biological data about the animals, behaviour, clinical findings, pathology observations, etc.) (15). The collection of blood, as well as frozen and preserved tissues, and appropriately prepared microbiological samples from a number of animals, will assist in the ongoing investigations to confirm the presence or absence of disease-causing agents.

The identification of a specific pathogen from a mortality event is likely to also suggest the method of transmission.

Practical difficulties can exist in determining the mortality rates as a proportion of the 'at risk' population (38). Wild animals may have dispersed after a disease outbreak is discovered, and therefore assessments of the rates of morbidity or mortality over time may be impossible.

It can also be difficult, for many different reasons, to find and count both sick and dead wild animals. Stutzenbacher *et al.* reported that only 6% of marked duck carcasses were detected by searchers in a Texas marsh (41). Similarly, less than 27% of the deer carcasses present in an area in Montana after a disease outbreak were detected by hunters (42). A way of improving the ability to find sick and/or dead animals is to use trained dogs. In one study, dogs found 92% of passerine birds carcasses placed on plots, compared to 45% for human searchers (19).

Ecological patterns of disease

Understanding the biology of the species of wildlife under investigation is crucial to any investigation of a disease outbreak. The occurrence and localisation of disease are determined by a variety of factors, including some that relate to the host, some that relate to the causative agent and some that are considered as environmental factors (44). Included among the environmental factors are climate, topography, soil, water and biotic features including other fauna and flora. Characterisation of the environmental conditions associated with disease and disease outbreaks is an important part of every investigation and is relevant to understanding the epidemiology of disease in wildlife. Many factors should be taken into consideration during a disease investigation, but it is impossible to prepare a comprehensive list of all factors that should be investigated (44). Cooperrider *et al.* (14) and Wobeser (44) provide excellent information about various environmental factors in relation to wild animals.

The host-parasite relationship also differs substantially between different infectious diseases, i.e. some disease agents are thought to only infect one or a small number of animal species, like calicivirus infections of lagomorphs (28) or myxomatosis (45), while other viral diseases, like rabies (37), bacterial diseases, like anthrax (16), tularemia (31, 33) or parasitic

diseases like sarcoptic mange (9) are found in a large number of different species.

The density of animal populations is of course of great importance when investigating the occurrence of diseases. Species that congregate or herd may be prone to contagious infections. The transmission of highly contagious and virulent viruses, such as avian influenza, Newcastle disease, and phocine morbilliviruses, provides good examples of diseases that are enhanced when hosts concentrate.

Surveillance programmes for wildlife diseases

The need for surveillance programmes of diseases among wildlife is becoming more and more obvious in the world today. There are several reasons for this. In Europe, fox rabies is an historic example of an attempt to routinely collect specimens for diagnosis and to obtain further information for health and agriculture administrations (6). As fox rabies spread across continental Europe, it became clear that international co-operation and a surveillance programme were necessary to keep rabies-free countries informed of the proximity of the threat at their borders.

In Europe, the World Health Organization (WHO) created a collaborating centre to monitor rabies cases on the scale of the continent and countries were informed each quarter of the rabies situation. This WHO collaborating centre for rabies surveillance and research has published a quarterly bulletin since 1977 (<http://www.who-rabies.bulletin.org>). This was the first attempt to circulate information on wildlife disease surveillance in Europe.

Among the earliest surveillance programmes for wildlife diseases were the programmes established in the early 1930s in Denmark (11) and in Sweden in the 1940s (8). These programmes are based on the examination of dead animals submitted to national veterinary laboratories. This programme in Sweden revealed the problems of mercury poisoning of wildlife in the early 1950s (7), and it was after this discovery that a well-established health-monitoring programme for wildlife was established in Sweden (30). This programme is mostly supported by one laboratory that centralises samples from across the country; similar programmes are operating today in the other Nordic countries (Denmark, Norway and Finland).

Other health monitoring programmes of wildlife based on examining wildlife are in action today in other countries of Europe (10, 27). Some are based on the collection of ad hoc sampling and routine diagnostics carried out in various institutions and laboratories, collected on a voluntary basis on

a country scale (United Kingdom and Austria). In France the SAGIR Network (*Réseau national de surveillance de l'état sanitaire de la faune sauvage*: National network for the surveillance of the health status of wildlife) is an example of an official organisation (supported by the Agriculture and Environment Ministries) that collects data from wildlife autopsies performed at different laboratories across the country (24). Similar organisations exist on a regional or provincial scale in Italy, Spain and Switzerland. Progressively, such programmes are developed and are expanded in an increasing number of countries in Europe.

In North America, several regional co-operative studies on wildlife diseases are operating, i.e. the Southeastern Cooperative Wildlife Disease Study in Athens, Georgia, the Wildlife Health Research Centre in Madison, Wisconsin, and the Canadian Cooperative Wildlife Health Centre in Saskatoon, Saskatchewan. Other wildlife disease surveillance programmes exist world-wide, but the majority of these programmes are designed primarily to protect domestic animal health and trade in livestock produce with only part of the work dealing with wildlife health *per se*. Australia is in the preparatory stages of developing a national wildlife health network designed to report, investigate and discuss unusual mortality or disease incidents as they occur.

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

Historically, the investigation of wildlife diseases has in some countries, for example in Europe and North America, been a natural part of wildlife management, while many other countries of the world only perform such investigations to safeguard the economic viability of domestic animal production systems. With diminishing wild habitats and increasing numbers of threatened species world-wide, the capability to investigate wildlife disease is now an essential component in the management of free-ranging wildlife. Individual diseases or suites of diseases are now recognised as important threatening processes that locally are driving some wildlife to critically low numbers and even to extinction. Defining the diseases which have an impact on threatened wildlife is now considered integral to rehabilitation programmes for remnant wildlife populations and in captive breeding programmes designed to restore healthy animals to the wild. Such captive breeding programmes conducted within conventional zoological collections, unless strict quarantine and isolation from other disease-carrying species can be maintained, risk the likelihood

of inadvertently introducing disease agents into wild places. Awareness of these risks is leading to improved funding and careful preparation for endangered species recovery programmes.

The reasons for studying wildlife diseases have therefore broadened. Once significant diseases in specific wildlife species are identified, free-ranging populations can be monitored, using benign testing procedures without resorting to sacrificing animals.

Information on the occurrence of infectious, parasitic and toxic diseases in wildlife is essential to both the local and global understanding of free-living animal populations. Too often, only a small part of this research is published in technical or scientific journals. Most, if not all, the annual records of diagnostic laboratories are never published and consequently remain unseen by those concerned about the occurrence of a given disease in another part of the world (2). The establishment of national and regional monitoring programmes for wildlife disease surveillance is therefore essential to ensure a minimum level of reporting and circulation of this information.

The infrastructures to support the investigation of wildlife disease outbreaks and wildlife health programmes are comparable to those for domestic animal species. Indeed, all the scientific disciplines and technologies available in veterinary diagnostic laboratories would support such programmes. Developing local networks would necessarily also include epidemiological and zoological inputs to support these disease monitoring and surveillance studies. Universities, government facilities, zoological institutions, non-government and private organisations could all have a co-operative role in the delivery of this surveillance capability.

The international reporting system for wildlife diseases, as designed by the OIE, will be of vital importance (3). A further step would be to progressively expand the existing awareness to a larger range of diseases and to a larger range of species, according to what is perceived as important at the regional and national level and in accordance with standard diagnostic capabilities.

New diseases

One of the major functions of these national, regional and international monitoring programmes will be to detect new and emerging diseases. A monitoring programme based on regular investigations of diseases and post-mortem examination will,

after some years, achieve a basic knowledge about what kinds of diseases occur within certain geographic regions or in which particular animal species and populations (43). Archiving of laboratory cases annexed to stored serum and tissue samples will be invaluable for retrospective investigations of new or recently emerged diseases. If new diseases (or mortality/morbidity events) occur, they will probably most often be discovered through passive programmes based on laboratory accessions and post-mortem examination. An example of this is the European brown hare syndrome (EBHS) that was first observed in European brown hares (*Lepus europaeus*) in Scandinavia in the early 1980s (17). This disease syndrome was characterised by a primary liver pathology and the aetiological 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 aetiological agent, a calicivirus, was later described by Lavazza and Vecchi (26) and serological retrospective studies demonstrated that the virus had been present in Europe and other countries since as early as 1971 (34).

Conclusion

Surveillance and monitoring programmes are the first steps towards providing an appropriate level of understanding of the health status of wildlife populations. The basis for developing and maintaining such a capability includes the management of wildlife populations and their habitats, the security of animal-based export trade and translocation of animals, the protection of natural biodiversity values and to safeguard public health. Wildlife disease monitoring programmes integrated within existing national animal health surveillance infrastructures have the opportunity to adequately respond to unusual wildlife mortality events and research the epizootiology of new diseases found in wildlife.

Suivi et surveillance des maladies de la faune sauvage

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Résumé

Il est désormais admis que l'existence de programmes de surveillance sanitaire de la faune sauvage permet aux pays de déceler plus vite la présence d'une maladie infectieuse ou d'une zoonose et de prendre rapidement les mesures appropriées. Le suivi et la surveillance épidémiologiques des animaux sauvages sont particulièrement importants à l'heure actuelle, du fait de la multiplication des déplacements, humains et animaux, du rapprochement entre espèces animales sauvages et domestiques, et de l'intensification du risque de terrorisme biologique.

Les auteurs décrivent les problèmes inhérents à la surveillance des maladies de la faune sauvage et insistent sur la nécessité de mettre en place des stratégies nationales de détection des maladies. Les diverses méthodes de prélèvements employées pour étudier les foyers et la mortalité affectant les animaux sauvages sont décrites et comparées.

Le principal atout d'un programme de suivi épidémiologique de la faune sauvage est de faciliter la détection précoce des maladies nouvelles et « émergentes », dont certaines peuvent avoir de graves conséquences pour la santé publique et l'économie.

En conclusion, les auteurs soutiennent que l'intégration de programmes de suivi des maladies de la faune sauvage dans les infrastructures nationales de surveillance zoonositaire devrait d'une part accélérer la capacité de réponse en cas de mortalité anormale frappant les animaux sauvages et, d'autre part, faciliter l'étude épidémiologique des maladies nouvelles et émergentes de la faune sauvage.

Mots-clés

Épizootiologie – Faune sauvage – Maladies – Prélèvements – Suivi – Surveillance.



Vigilancia y seguimiento de enfermedades de la fauna salvaje

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Resumen

Nadie pone en duda actualmente que los países que practican la vigilancia sanitaria de sus poblaciones de animales salvajes tienen más probabilidades de detectar la presencia de enfermedades infecciosas o zoonóticas y adoptar medidas de lucha con rapidez. La vigilancia y el seguimiento de brotes patógenos en poblaciones de animales salvajes revisten especial trascendencia en estos tiempos de rápido movimiento de personas y animales, estrecho contacto entre fauna salvaje y doméstica y peligro real de ataques bio-terroristas.

Tras describir los problemas inherentes a la vigilancia de enfermedades de los animales salvajes, los autores subrayan la importancia de instaurar estrategias nacionales de detección de enfermedades. También exponen los diversos métodos de muestreo utilizados para el seguimiento de brotes patógenos y de

episodios de mortandad entre esos animales, deteniéndose a describir las ventajas e inconvenientes de cada uno.

Uno de los grandes beneficios derivados de un programa eficaz de seguimiento sanitario de la fauna salvaje estriba en la detección precoz de enfermedades nuevas y "emergentes", algunas de las cuales pueden tener graves consecuencias zoonóticas y económicas.

Los autores concluyen que los programas de seguimiento de enfermedades de la fauna salvaje que estén integrados en las infraestructuras nacionales de vigilancia zoonosanitaria deberían permitir responder sin tardanza a la detección de mortandades inusuales de animales salvajes y emprender investigaciones epizootológicas sobre enfermedades nuevas y emergentes de esos animales.

Palabras clave

Enfermedades – Epizootiología – Fauna salvaje – Muestreo – Seguimiento – Vigilancia.



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