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Transmissible spongiform encephalopathies in non-domestic animals: origin, transmission and risk factors

E.S. Williams [1] & M.W. Miller [2]

(1) Department of Veterinary Sciences, University of Wyoming, College of Agriculture, 1174 Snowy Range Road, Laramie, Wyoming 82070, United States of America
(2) Colorado Division of Wildlife, Fort Collins, Colorado 80523, United States of America

Summary
The transmissible spongiform encephalopathies (TSEs), scrapie and bovine spongiform encephalopathy (BSE), are serious diseases of domestic animals. Although not as significant in terms of numbers of animals affected or geographical distribution, TSEs also affect non-domestic animals. Transmissible mink encephalopathy (TME) was the first TSE to be identified in non-domestic animals. This disease of captive mink (*Mustela vison*) is very rare and is associated with exposure through feed contaminated by a TSE agent. The second TSE to be identified in non-domestic animals was chronic wasting disease (CWD) of deer and elk. This disease is not known to be associated with feedstuffs contaminated with the agent of CWD, but the natural route of exposure appears to be oral, possibly through direct interaction between animals or through environmental contamination. Over the last five years, the known distribution of CWD across North America has expanded, increasing concerns over the impact of this disease on populations of free-ranging cervids and the viability of game farming industries. Concurrent with the epidemic of BSE, a variety of non-domestic ruminants and felid species were also affected in the United Kingdom, presumably through exposure to the agent in contaminated feed. These examples illustrate that when non-domestic animals are held in captivity, they depend upon feeds supplied by their caretakers and may show degrees of susceptibility to infectious agents in feeds which vary from those of domestic species. Although humans have less influence over exposure of free-ranging species to infectious agents, monitoring these populations for diseases may be important for managing the health of these animals. It is important to institute or continue surveillance for an entire range of infectious diseases, including TSEs, in free-ranging and captive non-domestic species. Study of diseases in these species may provide important information about infectious agents of concern for domestic animals and humans.

Keywords
Animal disease – Bovine spongiform encephalopathy – Chronic wasting disease – Feline spongiform encephalopathy – Non-domestic animal – Scrapie – Transmissible spongiform encephalopathy – Wildlife disease.

Introduction

Most attention to the transmissible spongiform encephalopathies (TSEs) in animals has been directed at the domestic animal diseases scrapie and bovine spongiform encephalopathy (BSE). This is due to the economic value of the animals, and in the case of BSE, because of the causal relationship between BSE and the human disease, variant Creutzfeldt-Jakob disease (vCJD). Transmissible spongiform encephalopathies also occur in non-domestic animals; one of these, transmissible mink encephalopathy (TME), was the second animal TSE recognised following scrapie, the oldest known TSE. In each of these diseases, oral exposure to the agent, in various forms, constitutes the most significant route of infection.

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At the time of writing (November 2002), chronic wasting disease (CWD) of cervids (members of the deer family) is the TSE of greatest concern in non-domestic animals. The disease is found in farmed and free-ranging deer (*Odocoileus* spp.) and Rocky Mountain elk, also called wapiti (*Cervus elaphus nelsoni*), in portions of North America. Within the last decade, CWD has developed from being geographically isolated in a relatively small endemic focus in the western United States of America (USA), where it has been present for more than thirty years, to a disease identified in multiple jurisdictions in the USA, Canada and the Republic of Korea. Chronic wasting disease is not associated with contaminated feedstuffs, although the natural route of transmission appears to be by oral exposure.

Bovine spongiform encephalopathy was diagnosed in multiple non-domestic species in the families Bovidae and Felidae. These animals were thought to have been infected with the BSE agent via consumption of contaminated feeds, as were cattle. Mink (*Mustela vison*), which are carnivores in the family Mustelidae, developed TME following ingestion of feeds containing a TSE agent (scrapie or another agent) from sheep or possibly cattle.

In contrast to the exposure of non-domestic ruminants to BSE-contaminated processed feeds, the large non-domestic felids in zoological gardens in the United Kingdom (UK) that developed feline spongiform encephalopathy (FSE or BSE in felids), were probably exposed to the BSE agent in central nervous system tissues in the skulls and vertebrae provided to these animals as part of their diet (33).

To understand the risks of TSEs in non-domestic species, the feeding strategies of the species of interest and the way these animals are managed must be understood. Domestic animals are those that live and breed under the direct control of humans (12). Selection by humans has been carried out over many generations, such that the morphology and production characteristics of the species have been altered from those of the ancestral stock. Domestic animals usually have reduced capacity to survive under natural conditions and are dependent upon humans for sustenance. In this aspect, errors in the formulation of feeds may result in subsequent infectious, toxic or deficiency diseases.

Non-domestic species may be managed by humans in some aspects, particularly with respect to animal numbers and distribution, but they are capable of living and reproducing with minimal assistance or intervention from humans. Selection for human-preferred morphologic traits or production characteristics is not common with non-domestic species, although translocation and introduction of individuals with valued characteristics into populations sometimes take place. Animals living in a wild state are designated 'free-ranging' or 'free-living' to differentiate them from non-domestic animals living in captivity. Free-ranging non-domestic animals have evolved to take advantage of natural habitats to meet their nutritional requirements. When free-ranging animals are concentrated artificially by feeding or by other means, transmission of contagious disease is facilitated. This effect has been demonstrated in infectious disease problems of wildlife such as brucellosis in elk (67) and bovine tuberculosis in white-tailed deer (*Odocoileus virginianus*) (61). A similar phenomenon may occur with CWD when non-domestic cervids, either free-ranging or in captivity, are artificially concentrated (80, 83).

Use of the term 'wild' animal can be confusing and in common usage, suggests a free-ranging existence, but is often used synonymously with non-domestic. Non-domestic animals being reared in an agricultural context include many species of cervids (12). The emergence of cervid game farming in North America has generated considerable controversy over jurisdictional authority among agencies responsible for animal health, agriculture and wildlife management because of the lack of consensus about the domesticated status of these animals and the possible consequences of game farming on populations of free-ranging cervids. Although lines of authority are now becoming clarified through legislation, in the past, this confusion has contributed to lack of, ineffectual, or delayed response to diseases in non-domestic species.

There are many challenges associated with the study and management of diseases of non-domestic wildlife in comparison to domestic livestock. The difficulties are amplified when the animals of concern are free-ranging. The following discussion will address each of the TSEs of non-domestic animals and what is known about their origin, transmission and risk factors.

Chronic wasting disease

The 1992 issue of the Office International des Epizooties (OIE: World organisation for animal health) *Scientific and Technical Review* on TSEs included a general review of CWD (77). Since then, considerable progress has been made in understanding many features of this disease and several recently published review articles (79, 80) summarise what is currently known about CWD. These reviews provide details on the clinical signs, lesions and the epidemiology of CWD, which will not be repeated in this paper.

Origin

Unfortunately, the origin of CWD cannot be definitively established with currently available techniques. Historical evaluation of the occurrence of CWD in the captive wildlife facilities where it was first identified and the factors surrounding the emergence of the disease were hampered by lack of complete records of animal husbandry. This can be explained by the fact that the disease was diagnosed as a spongiform encephalopathy (75, 76) at least ten years, and possibly much longer, after adequate numbers of cases had been observed among captive mule deer (*Odocoileus hemionus*),

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so that the syndrome of chronic weight loss was recognised as the signature of a specific disease entity.

Based on analysis of the known distribution of CWD and prevalence data collected prior to 2000 (42), the disease probably first arose in free-ranging deer and elk somewhere within the historical CWD-endemic area in north-central Colorado or south-eastern Wyoming (Fig. 1). Surveillance data and epidemic modelling (42) suggest that CWD may have been present in some of the deer populations of these areas for at least twenty years before being detected in the wild in 1981 (64). Deer and, later, elk held in captive research facilities in Colorado and Wyoming mostly originated from these free-ranging populations (77). Although the proximity of research facilities with CWD-infected animals and affected free-ranging deer and elk populations suggests a common origin, discerning retrospectively whether CWD arose first in captive or free-ranging populations is impossible.

The States in the United States of America and Provinces in Canada shaded in dark grey have reported chronic wasting disease (CWD) in farmed elk or white-tailed deer (most affected herds have been depopulated). The irregular red area in Wyoming, Colorado and Nebraska delineates the historical CWD-endemic area. Red dots represent foci of CWD in free-ranging mule deer, elk and/or white-tailed deer

Fig. 1
Reported distribution of chronic wasting disease in North America, 1981-2002

The husbandry of cervids within captive research facilities has been reviewed (77). Over the years, neonatal deer and elk were hand-raised on a variety of diets primarily composed of cow milk (fresh or evaporated) (26, 73). Prepared, commercial lamb or kid milk replacement formulas were not used in the facilities until the 1980s (77), many years after CWD was established in the facilities. Diets fed to growing and adult deer and elk have varied over the years and have been primarily based on high quality alfalfa hay and various grain mixtures and pellets. No evidence could be found that any of these animals were fed rendered ruminant proteins, although use of bone meal (4), calf manna, which is a prepared grain mixture (72), and special protein supplement (56) for neonates was advocated in early rearing protocols. Whether free-ranging cervids were historically exposed to livestock feeds containing rendered ruminant proteins is even more difficult to ascertain, although historical occurrence of such exposure in many locations throughout North America and Eurasia seems plausible. Rendered ruminant proteins have been banned from ruminant feeds in the USA since 1997, and deer and elk carcasses are not supposed to be accepted by establishments that render animal carcasses for use in ruminant feeds (70). Although no evidence can be found that the CWD agent was first transmitted to deer via contaminated feedstuffs, that possibility cannot be totally excluded. However, even if such was the origin of CWD, transmission among animals now maintains the disease in the absence of exposure to contaminated feedstuffs, both in captive and in free-ranging deer and elk.

The relationship of CWD to scrapie is unclear and the possibility the scrapie agent may have become adapted to cervids and manifest as CWD is one of the hypotheses for the origin of the disease. Although it has been suggested that sheep with scrapie could have been present in the captive wildlife facilities where CWD was first recognised and that CWD could have originated from scrapie (64), scrapie was not diagnosed in these facilities (R. Jensen, personal communication; C. Hibler, personal communication). However, lack of diagnosis of scrapie does not eliminate the possibility that scrapie may have been present in the small number of sheep and goats kept in these facilities. Strain-typing studies of CWD (8) in genetically characterised mice suggest that the CWD agent is different from the scrapie strains defined in this system. Similarly, differences in susceptibility of raccoons (*Procyon lotor*) to scrapie and CWD suggest the two diseases are caused by different agents (23).

Nevertheless, studies of *in vitro* conversion of ovine cellular prion protein (PrP^{C}) by cervid protease-resistant prion protein (PrP^{Res}) (55) and glycoform pattern analysis (54) suggest that considerable similarities exist between the two agents. Domestic sheep and goats are susceptible to CWD by intracerebral inoculation (77) (A. Hamir, personal communication), albeit with extremely long incubation in the case of the goat. Additional strain-typing studies may clarify the relationship between CWD and scrapie. Given the widespread overlap on the range of cervids and domestic sheep, some of which harbour scrapie, surveillance of cervids in many parts of the world for evidence of TSE seems warranted.

Another possible origin of CWD is spontaneous disease occurring as a rare event, as has been suggested for humans with sporadic Creutzfeldt-Jakob disease (CJD) (17). Proving such an origin would be extremely difficult. Chronic wasting disease may also have originated from an as yet unidentified prion agent with adaptation and subsequent lateral transmission among cervids. The precise origin of CWD will probably never be determined.

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Occurrence and genetics

Chronic wasting disease can reach remarkably high prevalence in captive cervid populations. In one infected research facility, more than 90% of mule deer resident for over two years died or were euthanised due to clinical CWD (75). Recently, high prevalence of CWD (>50%) has been demonstrated via immunohistochemistry (IHC) in white-tailed deer confined on a farm with CWD-affected elk (44). Chronic wasting disease prevalences ranging from less than 1% to 71% have been found among captive elk (42, 51, 80) (E.S. Williams, W.E. Cook and T.J. Kreeger, unpublished data). Although the vast majority of captive deer and elk residing in endemic research facilities eventually contract CWD (75) (M.W. Miller, unpublished data; E.S. Williams and T.J. Kreeger, unpublished data), individuals occasionally survive a lifetime in these facilities without succumbing to the disease. The nature of this apparent resistance is not known.

To estimate disease prevalence in infected free-ranging populations, brains and lymphoid tissues from deer and elk harvested by hunters in CWD-endemic areas of Colorado and Wyoming were examined (41). Within these areas, prevalence of preclinical CWD, based on IHC for the disease-associated prion protein (PrP), was estimated at less than 1% to approximately 17% in mule and white-tailed deer and less than 1% in elk (42) (E.S. Williams and T.J. Kreeger, unpublished data). Modelled CWD epidemics failed to achieve a steady-state equilibrium in infected deer populations, suggesting that the disease may lead to local extinctions of infected deer populations if left unmanaged (20).

There is no known explanation for the high prevalences of CWD documented in captive and free-ranging deer and elk, although several possibilities exist. Studies of the influence of PrP genotype on susceptibility in cervids are still in the preliminary stages (10, 47) but O'Rourke *et al.* found that elk, homozygous for methionine at codon 132, were over-represented among elk with CWD, although animals heterozygous for methionine/leucine were also susceptible. The leucine/leucine genotype is especially rare in free-ranging elk (47) and whether these animals are susceptible to CWD is unknown. Multiple PrP polymorphisms have been described in deer (45, 55), but based on apparent almost universal susceptibility of deer in captive facilities, it appears that even if resistant genotypes are identified, they are not common in populations of deer. This is in clear contrast to the situation in scrapie where susceptibility of sheep to scrapie is directly related to PrP genotype (28, 29, 30, 46). Lack of resistant genotypes in deer may contribute significantly to the high prevalences observed in deer in comparison to sheep. A very high prevalence of disease was recorded (16) in a flock of sheep with endemic scrapie bred for susceptible genotypes. An alternative explanation for the high prevalence of CWD in herds of deer and elk is that transmission among cervids may be highly efficient in contrast to the transmission of scrapie.

Transmission

Data from CWD epidemics in captive deer and elk provide strong evidence that the disease is contagious and laterally transmitted (41, 42, 77) (M.W. Miller, unpublished data) and thus, the epidemiology of CWD more closely resembles scrapie in sheep (27) than BSE (74). Contaminated pastures and paddocks appear to have served as sources of infection in some CWD epidemics (41, 77) (E.S. Williams, W.E. Cook and T.J. Kreeger, unpublished data; M.W. Miller, unpublished data), although these observations are anecdotal and have not yet been corroborated by controlled studies. Similar phenomena have been suspected in some outbreaks of sheep scrapie (1, 19, 48). Experimental and epidemic modelling data support these observations for CWD (20, 42) (M.W. Miller, unpublished data). Unfortunately, the exact mechanisms of CWD transmission are not known. Thus, speculation on some possible routes to explain direct lateral and indirect transmission through the environment is provided below. Understanding transmission is clearly vitally important to management and possibly control of CWD.

Excreta constitute probable vehicles for dissemination of the CWD agent in the environment. Susceptible animals may accidentally ingest the agent when foraging, which is typical for diseases transmitted by the faecal-oral route. Excretion of the agent in faeces is a plausible exit route from the body due to deposition of disease-associated PrP along the alimentary tract in the tonsils, oropharyngeal and intestinal lymphoid tissues in CWD-affected animals (63, 66). A similar route of excretion is suspected in natural and experimental scrapie (1, 34). The flushing action of saliva could result in the agent moving from the oral cavity down the digestive tract (65). Most saliva produced in ruminants is swallowed and finally excreted via the faeces, providing a potential source of contamination.

In the terminal stages of CWD, affected cervids either produce excessive quantities of saliva or are unable to swallow the volume of saliva produced, which results in drooling (77). If the CWD agent is present in saliva, this could provide a means of transmission between animals during social interactions and even suggest mechanisms by which the disease could spread across fence-lines. The agent may be produced in the salivary gland as has been suggested in laboratory animals (21, 60), although a recent report found that this route of excretion is unlikely in sheep scrapie (25).

Protease-resistant PrP has been identified in the urine of humans with CJD, cattle with BSE and rodents with scrapie (32, 62). Although the exact mechanism of urinary shedding remains to be demonstrated, the observation that PrP^{Res} can be shed in urine provides another possible route by which the CWD agent could exit affected animals and contaminate the environment.

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Scrapie disease-specific PrP has been found in placenta (52, 68, 69) and transmission among sheep via contact with placenta is considered one of the most important modes of spread of scrapie, although this theory is not universally accepted (57). However, periparturient transmission of scrapie is apparently insufficient to sustain epidemics (40, 85, 86). Similarly, based on simulation modelling, CWD epidemics probably cannot be sustained by maternal transmission alone (20, 41, 42). In addition, many cases of CWD have developed in captive cervids that were never directly exposed to placentas. However, residual contamination of the environment with infective agent from placenta cannot be excluded as a mechanism of transmission in some of these herds.

Although excreta are probable sources of infection for susceptible animals, infectivity probably occurs at the highest concentrations in portions of the brain, spinal cord, spleen and lymph nodes of CWD-affected animals (43, 66) (E.S. Williams and M.W. Miller, unpublished data). On range, such as occurs in the wild, decomposing carcasses of CWD-infected animals could serve as an additional source of infection. Various combinations of scavenging and decomposition could play a role in releasing large quantities of the CWD agent into the environment after an infected animal dies. Susceptible animals foraging near such sites subsequently could be infected by ingesting contaminated forage, soil or water. Scavenging invertebrates actively exploit deer carcasses and could liberate the CWD agent from the central nervous system. Demonstration of infectivity in maggots fed on scrapie-infected hamster brain (52) lends plausibility to this potential mechanism. Moreover, local environmental contamination could be amplified if the PrP agent propagates in invertebrate hosts (9, 82).

When during the course of infection an animal becomes infectious is unknown, but CWD agent shedding is probably progressive through the disease course in deer. The presence of PrP in alimentary tract-associated lymphoid tissues early in the incubation period (63) suggests that shedding of the agent may begin at an early stage. Epidemic models suggest that shedding probably precedes onset of clinical disease in both deer and elk (M.W. Miller, unpublished data): for models of CWD in captive mule deer, the optimal estimate for latency is about 50% of the total incubation period (M.W. Miller, unpublished data). Similarly, models incorporating an assumed latency of twelve to eighteen months faithfully represented the dynamics of CWD observed in free-ranging mule deer (20).

Distribution

Concern about dissemination of CWD via movement of farmed cervids in commerce was expressed well before the problem was identified in the industry (77). Within the cervid industry, CWD was first diagnosed in 1996 in elk in Saskatchewan, Canada. Subsequent epidemiological investigations traced the source of that infection to South Dakota, USA. The recent identification of CWD in farmed elk in Alberta, a Canadian Province that has closed borders to movement of cervids, suggests that CWD has been present but unrecognised in the industry since at least the early 1990s. Although no documentation is available, the infection probably originated somewhere in the Colorado-Wyoming endemic area. Surveillance of CWD has been greatly increased in the last five years and many federal, state and provincial jurisdictions have concurrently implemented CWD control programmes. The apparent recent increase in distribution of CWD is probably due to a combination of true geographical spread via movement of deer and elk in commerce, local expansion by natural movements of deer and possibly elk from the CWD-endemic areas in Colorado, Wyoming and Nebraska, and to greatly increased surveillance efforts throughout North America. As CWD appears to be a disease found mainly in North America, surveillance elsewhere in the world has been almost nonexistent.

As of late 2002, CWD was diagnosed in farmed elk from Colorado, Kansas, Minnesota, Montana, Nebraska, Oklahoma and South Dakota in the USA, and Alberta and Saskatchewan in Canada (Fig. 1). Infected elk were exported from Saskatchewan to the Republic of Korea, representing the first known extension of CWD distribution beyond North America. Most CWD-affected herds have been depopulated. Very recently (Autumn 2002), CWD was diagnosed in privately owned white-tailed deer on game farms in Wisconsin and Alberta. This is alarming because privately owned white-tailed deer have been moved in commerce with relatively little restriction, suggesting that the distribution of CWD among this farmed species could be much more extensive than is currently appreciated. In addition, white-tailed deer are more difficult to fence as compared to larger cervids such as elk and thus could serve as 'vectors' for movement of CWD from wild to captive cervids or vice-versa.

Chronic wasting disease was diagnosed in publicly owned white-tailed deer on game farms with resident CWD-affected elk prior to recognition of the disease in farmed deer. This caused concern because it suggested that the disease could be transmitted from CWD-affected elk to deer, but, alternatively, the disease in elk on these farms could have originated from free-ranging CWD-affected deer. Although the detection of CWD in these white-tailed deer generated concern, the animals were not allowed to be legally moved in commerce and thus the impact of the disease was primarily local.

The known geographical distribution of CWD in free-ranging cervids beyond the historical CWD-endemic areas in Colorado, Wyoming and Nebraska, has greatly expanded since the beginning of 2000 (Fig. 1). Cases of CWD in free-ranging mule deer were diagnosed in west-central Saskatchewan, north-west Nebraska, south-west South Dakota, southern New Mexico

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and south-central Wyoming. The disease was found in free-ranging mule deer and elk in north-western Colorado. Diagnosis of CWD in free-ranging white-tailed deer in south-central Wisconsin and in northern Illinois is of great concern to wildlife managers, politicians and the public. The origin of the disease in free-ranging deer in these states is unknown but is under intense study. Some jurisdictions are actively attempting to eradicate CWD in localised populations of free-ranging deer by population reduction or depopulation.

Host range

The natural host range of CWD is only known to include mule deer, white-tailed deer and elk. While cattle, domestic sheep and goats are susceptible to CWD by the artificial route of intracerebral inoculation (22, 77) (A. Hamir and colleagues, personal communication), there appears to be a moderate to substantial species barrier to the transmission of CWD to these livestock species (55) and ongoing studies of cattle susceptibility by oral and contact transmission have yielded negative results more than five years post-exposure (E.S. Williams and colleagues, unpublished data). Surveillance for TSEs in cattle living in the CWD-endemic areas of Colorado and Wyoming have been negative since 1991 (18) (E.S. Williams and colleagues, unpublished data).

Transmissible mink encephalopathy

Transmissible mink encephalopathy is a rare disease of ranch-raised mink first described by Hartsough and Burger in 1965 (24), which has never been reported in free-ranging mink. The disease has been reported in Canada, Finland, Germany, Russia and the USA (38). The last outbreak was reported in the USA in Wisconsin in 1985 (37). Transmissible mink encephalopathy appears to result from feeding mink either scrapie-infected sheep or cattle affected with an unidentified TSE (35, 36, 37, 59). Epidemiological investigations of an outbreak of TME in 1985 showed no evidence of an ovine feed source but revealed that cattle were incorporated into mink feed (37, 39), suggesting the possibility of an unidentified TSE of cattle being present in the USA. However, despite ongoing surveillance, no cases of BSE have been identified in the USA (71). Intracerebral inoculation studies of TME in cattle showed some similarities with BSE as regards incubation periods, clinical signs and neuropathologic lesions, but distribution of the lesions in the affected cattle was different from that observed with BSE (58). The lesions in the cattle were also found to be different from those in cattle with scrapie (11, 13, 14) and CWD (22). Mink were included in the feed ban enacted in 1997 (70). Thus TME presents little risk to cattle or other ruminants.

Although there is no evidence of TME occurring naturally in free-ranging animals, the disease has been transmitted by intracerebral inoculation to striped skunks (*Mephitis mephitis*) and raccoons (15).

Bovine spongiform encephalopathy in non-domestic species

The epidemic of BSE in the UK and other countries has not only affected cattle, the disease having been diagnosed in a number of non-domestic species in zoological gardens and research colonies. The first recognition of a spongiform encephalopathy in a bovid was made by Jeffrey and Wells in a nyala (*Tragelaphus angasi*) from a zoological garden (31) and preceded recognition of the impending epidemic of BSE. Since then, BSE has been diagnosed in non-domestic bovids including *Oryx* spp. (gemsbok [*Oryx gazella*], Arabian oryx [*Oryx leucoryx*], scimitar-horned oryx [*Oryx dammah*]), eland (*Taurotragus oryx*), greater kudu (*Tragelaphus strepsiceros*) and North American bison (*Bison bison*) (78). The relationship of the TSE in non-domestic ruminants to BSE was confirmed through strain-typing studies (7). The non-domestic animals were presumed to have been exposed to the BSE agent in contaminated feedstuffs, as were cattle.

Although BSE has been known to be present in the UK since the mid-1980s and in other parts of the world more recently, systematic surveillance for TSEs in cervids and other non-domestic species has not been implemented. In light of the apparent susceptibility of cervids to one TSE agent (CWD), it seems prudent that where these animals could have been exposed to the BSE agent or even the scrapie agent, some form of surveillance should be instituted.

In addition to domestic cats (49), FSE was detected in large non-domestic felids in zoological gardens, concurrent with the BSE epidemic. Affected non-domestic cats included the cougar (*Felis concolor*), cheetah (*Acinonyx jubatus*), ocelot (*Felis pardalis*) and tiger (*Panthera tigris*) (78). Affected cheetahs were imported into Australia and France where they were diagnosed with spongiform encephalopathy (2, 50). The relationship of these feline TSEs to BSE was confirmed through strain-typing studies (7). The cats were presumed to have been exposed to the BSE agent via feline rations contaminated with rendered bovine proteins or bones containing infected central nervous system tissues (33).

Spongiform encephalopathy, presumably also associated with the BSE agent has also been reported in captive primates. Affected primates include rhesus macaques (*Macaca mulatta*) (5) and lemurs (*Eulemur* spp.) (6).

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Other transmissible spongiform encephalopathies in non-domestic species

Transmissible spongiform encephalopathies have occasionally been reported in other non-domestic species, but with the exception of presumed scrapie in mouflon (*Ovis musimon*) (84), these reports have not been convincing. A report of a possible link between a putative TSE in grey squirrels (*Sciurus carolinensis*) and CJD (3) resulted in extensive media attention, but this link, or even the occurrence of any TSE in non-domestic rodents, remains unconfirmed. The study of infectious diseases of wild species is still young. Surveillance for a wide variety of infectious diseases, including TSEs, in non-domestic species is important because disease in these species may emerge prior to recognition of the disease in domestic species and humans (81).

■

Les encéphalopathies subaiguës spongiformes transmissibles chez les animaux non domestiques : origine, transmission et facteurs de risque

E.S. Williams & M.W. Miller

Résumé

Les encéphalopathies subaiguës spongiformes transmissibles (ESST), la tremblante du mouton et l'encéphalopathie spongiforme bovine (ESB) sont des maladies graves pour les animaux domestiques. Toutefois, les ESST contaminent également des espèces animales non domestiques, même si leur importance est plus limitée en termes d'effectifs atteints et de distribution géographique. L'encéphalopathie transmissible du vison (TME) a été la première ESST identifiée chez des animaux non domestiques. Cette affection extrêmement rare du vison en captivité (*Mustela vison*) est associée à la consommation d'aliments pour animaux contaminés par un agent de l'ESST. La maladie du dépérissement chronique des cervidés a été la deuxième ESST diagnostiquée chez des animaux non domestiques. L'implication d'aliments contaminés par l'agent de la maladie du dépérissement chronique dans l'apparition de cette maladie n'a pas été établie. L'exposition semble se produire naturellement, par voie orale, probablement lors des contacts directs entre animaux, ou par contamination environnementale. L'extension, au cours des cinq dernières années, de l'aire connue de distribution de la maladie du dépérissement chronique en Amérique du Nord suscite de plus en plus d'inquiétude, notamment en raison de l'impact de la maladie sur les populations de cervidés vivant en liberté et sur la pérennité de la filière du gibier d'élevage. Différentes espèces de ruminants non domestiques et de félidés ont été infectées au Royaume-Uni, en marge de l'épizootie d'ESB, probablement à la suite d'une exposition à des aliments contaminés pour animaux. Ces exemples illustrent la dépendance des animaux non domestiques vivant en captivité à l'égard des aliments qui leur sont offerts. Or, par rapport aux espèces domestiques, ces animaux peuvent présenter une sensibilité différente aux agents infectieux présents dans les aliments. Bien que l'homme ait moins d'influence sur l'exposition aux agents infectieux des espèces vivant en liberté,

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une surveillance épidémiologique de ces populations pourrait s'avérer importante dans le cadre de leur gestion sanitaire. Il convient d'entamer ou de poursuivre la surveillance d'un large éventail de maladies infectieuses, y compris les ESST, chez les espèces non domestiques vivant en liberté ou en captivité. L'étude des maladies chez ces espèces pourrait apporter de précieux renseignements sur les agents infectieux dangereux pour les animaux domestiques et l'homme.

Mots-clés
Animal non domestique – Encéphalopathie spongiforme bovine – Encéphalopathie spongiforme féline – Encéphalopathie subaiguë spongiforme transmissible – Maladie animale – Maladie des animaux sauvages – Maladie du dépérissement chronique – Tremblante.

Encefalopatías espongiformes transmisibles de animales no domésticos: origen, transmisión y factores de riesgo

E.S. Williams & M.W. Miller

Resumen
Las encefalopatías espongiformes transmisibles (EET), el prurigo lumbar y la encefalopatía espongiforme bovina (EEB) son enfermedades graves de los animales domésticos. También pueden declarase casos de EET entre los animales no domésticos, aunque por el número de animales afectados o por su distribución geográfica son menos importantes. La encefalopatía transmisible del visón fue la primera EET que se identificó en animales no domésticos. Esta enfermedad del visón criado en cautividad (*Mustela vison*) es muy poco frecuente y está asociada a la exposición a alimentos contaminados por un agente de EET. La segunda EET que se identificó en animales no domésticos fue la caquexia crónica de ciervos y venados. No consta que esta enfermedad esté asociada a alimentos contaminados por el agente de la misma, pero su vía de transmisión natural parece ser oral, posiblemente debida al contacto directo entre animales o a la contaminación medioambiental. La distribución de la caquexia crónica en Norteamérica se ha extendido estos cinco últimos años y ha acrecentado la inquietud sobre sus repercusiones en las poblaciones de cérvidos criados en libertad y sobre la viabilidad de la cría industrial de especies cinegéticas. En el Reino Unido, cuando se produjo la epidemia de EEB, se observaron también casos de la EET en rumiantes no domésticos y especies felinas, supuestamente debidos a la exposición a alimentos contaminados por el agente de la EEB. Estos ejemplos ilustran la dependencia de los animales no domésticos criados en cautividad con la alimentación que se les suministra. Su grado de susceptibilidad a los agentes infecciosos presentes en los alimentos puede ser distinto del que manifiestan las especies domésticas. Aunque la exposición de las especies criadas en libertad a agentes infecciosos esté menos determinada por la intervención humana, el seguimiento epidemiológico de estas poblaciones resulta fundamental para la gestión sanitaria de estos animales. Es importante instaurar o mantener la vigilancia de toda una serie de enfermedades

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infecciosas, incluidas las EET, en las poblaciones de especies no domésticas criadas en libertad como en cautividad. El estudio de las enfermedades de estas especies puede proporcionar datos importantes sobre agentes infecciosos que representan un peligro para los animales domésticos y los seres humanos.

Palabras-clave
Animal no doméstico – Caquexia crónica – Encefalopatía espongiforme bovina – Encefalopatía espongiforme felina – Encefalopatía espongiforme transmisible – Enfermedad animal – Enfermedad de los animales salvajes – Prurigo lumbar.

■

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