Spongiform encephalopathies in Cervidae

E.S. WILLIAMS * and S. YOUNG **

Summary: The known host range of naturally-occurring transmissible spongiform encephalopathies has expanded in recent years to include wild ruminants. Chronic wasting disease (CWD) occurs in mule deer (Odocoileus hemionus hemionus) and Rocky Mountain elk (Cervus elaphus nelsoni) in Colorado and Wyoming, United States of America. These species belong to the family Cervidae. Cases have occurred primarily in captive animals but a few affected free-ranging animals have been identified. Clinical disease in both species is characterised by progressive weight loss, behavioural alterations and excessive salivation. In deer polydipsia and polyuria also commonly occur. Significant lesions are confined to the central nervous system and consist of spongiform change in grey matter, intraneuronal vacuolation, astrocytosis and amyloid plaques. Inflammatory reaction is absent.

The origin of this disease is not known. In contrast to the cases of spongiform encephalopathy recognised in five species of antelope (family Bovidae) in British zoological parks, which are an extension of the current bovine spongiform encephalopathy epizootic, CWD is not the result of food-borne exposure to the infectious agent.

CWD appears to be maintained within captive populations by lateral and, possibly, maternal transmission.

Spongiform encephalopathies in wild ruminants are currently geographically isolated and involve relatively small numbers of animals. However, these potentially transmissible diseases could be of greater importance in the future and should be viewed with concern in the light of international movements of wild ruminants and the current expansion of the game farming and ranching industry in many parts of the world.

KEYWORDS: Cervidae - Cervus elaphus nelsoni - Chronic wasting disease - Deer - Epidemiology - Mule deer - Odocoileus hemionus hemionus - Pathology - Rocky Mountain elk - Spongiform encephalopathy.

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INTRODUCTION

While scrapie has been known as a disease of domestic sheep and goats for over two hundred years, and has widespread occurrence in those species, no comparable disease was observed in non-domestic ruminants in any region of the world until two decades ago. Since that time a scrapie-like spongiform encephalopathy (chronic wasting disease or CWD) has been identified in wild ruminant species of the family Cervidae held captive in North America.

More recently, spongiform encephalopathy has occurred in five species of antelope of the family Bovidae in zoological collections or wildlife parks in southern England. However, the cases in antelope are clearly associated with the epidemic of bovine spongiform encephalopathy (BSE), in that most of the animals were fed the same type of ruminant-derived protein supplements that caused BSE in the United Kingdom (10). The species affected by CWD, the circumstances of capture and management of deer, the clinical characteristics of the diseases and their geographical occurrence, justify a separate description of CWD. It is important to note that while scrapie exists in domestic sheep in both North America and the United Kingdom, BSE has yet to be identified in domestic cattle in North America.

CWD is a spongiform encephalopathy of deer (family Cervidae) reported only from Colorado and Wyoming, United States of America (16, 17; unpublished data) or in zoological parks which received animals from these locations. The disease was first recognised as a distinct clinical syndrome by biologists studying captive mule deer (Odocoileus hemionus hemionus) in Colorado in 1967. To date, the only species affected have been mule deer, black-tailed deer (O. hemionus columbianus), mule deer x white-tailed deer (O. virginianus) hybrids, and Rocky Mountain elk (Cervus elaphus nelsoni). The majority of affected animals were captive, although recently, cases have been diagnosed in free-ranging animals in both Colorado and Wyoming (Miller and Spraker, personal communication; unpublished data).

CWD occurs only in adult animals. Females, males and castrated males are affected. The clinical course is long, usually months, and as suggested by the name, this disease is characterised by wasting in body condition leading to death or euthanasia. Various other behavioural alterations are also prominent at the clinical stage of disease. Significant microscopic lesions of CWD are confined to the central nervous system and are similar to the transmissible spongiform encephalopathies in other species. Histopathological features of the disease include spongiform change of the grey matter neuropil, intraneuronal vacuolation, astrocytic hypertrophy and hyperplasia, presence of amyloid plaques, and lack of an inflammatory response (18).

CWD has been experimentally transmitted by intracerebral inoculation of brain tissue from affected animals into a variety of species. Lateral and probably maternal transmission occur with CWD. The relatively high prevalence of clinical disease in captive deer of affected herds suggests that they are highly susceptible and/or CWD is efficiently transmitted among deer. However, natural transmission has not occurred to other captive wild ruminant species living in close proximity to affected deer and elk.

There have been significant impacts on wildlife facilities harbouring infected animals, including direct loss of valuable animals and adverse effects on the research conducted at these facilities. The occurrence of disease has reduced options for handling surplus animals raised at these locations. Eradication attempts have failed.
CWD appears to be geographically restricted to two states at this time. However, the difficulty in diagnosing CWD, the growth of game farming and game ranching as alternatives to traditional domestic animal agriculture, indicate that CWD should be of concern in interstate and international trade in captive cervids.

**GEOGRAPHICAL DISTRIBUTION**

CWD has been recognised in four captive wildlife research facilities in Colorado (two in Fort Collins, one at Kremmling and one at Meeker) and one in Wyoming (Wheatland). There has been considerable exchange of deer and elk among these facilities since they were established in the 1950s and 1960s. In addition, this disease has been recognised in one zoological park in Canada (Barker, personal communication) and one in Wyoming. Animals with suggestive clinical signs have also been observed in a zoological collection in Colorado (Cambre, personal communication). All of these zoological parks had received mule deer or elk from facilities with confirmed or suspected CWD.

Cases of CWD have been confirmed histologically in free-ranging deer and elk at several locations within approximately 50 km of the main Fort Collins facility (henceforth referred to as the Fort Collins facility) (Miller and Spraker, personal communications). Similarly, two affected elk, but no deer, have been found in two locations within approximately 50 km of the Wheatland wildlife facility.

To the knowledge of the authors, CWD has not been recognised among either captive or free-ranging cervids anywhere else in the world. Because clinical signs are subtle and brains are frequently not examined at necropsy when emaciation is the predominant finding, CWD is most likely to be diagnosed where biologists and veterinary pathologists are familiar with the disease. However, the high prevalence and mortality associated with CWD makes it likely that responsible facilities holding susceptible species for research, display, or agricultural purposes, would eventually diagnose the disease if it was present, even though it might take years to be recognised. Diagnosis at necropsy is not difficult provided that brain is examined microscopically.

Conversely, recognising CWD in the wild would be much more difficult due to problems associated with:

a) observing clinical neurological disease in widely distributed free-ranging animals;

b) confusion of clinical signs with seasonal malnutrition which occurs commonly in free-ranging deer and elk on western North American ranges;

c) difficulties in regard to adequate diagnostic evaluation in a timely manner;

d) presence of large predators and scavengers which would kill and/or consume deer or elk showing clinical signs of CWD.

**ECONOMIC IMPLICATIONS**

To date, the economic impact of CWD has been negligible except to institutions which have experienced the disease on their facilities. Losses have been significant
in such cases. As many affected animals were hand-raised for research purposes, there was substantial monetary investment in each animal. Indirect costs include adverse effects on the types of research possible and limitations on the options available for animal exchanges and management of surplus cervids.

The economic impact of the introduction of CWD into the game farming industry could be very great. Problems associated with the control of a disease for which there are no ante-mortem diagnostic tests and with prolonged incubation periods would be undoubtedly similar to those of scrapie. Should CWD become established in the captive cervid industry, transmission of this disease from game farm animals into free-ranging conspecifics would also be a concern.

AETIOLOGY

CWD is clearly a transmissible disease belonging to the same group of diseases as scrapie, BSE and transmissible mink encephalopathy. The similarities of the clinical disease, the neuropathology, the presence of scrapie-associated fibrils in spleen and/or brain of both affected deer and elk (Merz, personal communication), and the presence of plaques in the brain which react with anti-Protease resistant Protein (PrP) serum (5, 6), all indicate the similarities to scrapie.

The fact that CWD is caused by an infectious agent has been demonstrated by its transmission via intracerebral inoculation of brain from affected deer into mink (Mustela vison), domestic ferrets (M. putorius furo), squirrel monkeys (Saimiri sciureus) (Marsh, personal communication), mule deer, and a domestic goat (unpublished data). Incubation periods following intracerebral inoculation were 17 and 21.5 months for mule deer and approximately 6 years for the domestic goat (unpublished data). Several attempts to transmit the agent to mice and hamsters through two passages have been unsuccessful (unpublished data); however, new trials are currently underway in mice (Fraser, personal communication). Transmission studies have not yet been conducted using CWD-affected elk inocula. There is no reason to doubt that the causative agent of CWD is similar in nature to the scrapie agent. Attributes of the scrapie agent have been reviewed elsewhere in this issue (3, 10).

EPIDEMIOLOGY

Mule deer

CWD was first recognised in 1967 as a clinical syndrome in captive mule deer at the Fort Collins facility. These deer were maintained primarily for nutritional studies. Initially, the wasting syndrome observed was believed to be due to the circumstances of captivity and related to nutritional deficiencies, encounters with toxic agents in the facilities, or the stresses of confinement (Baker and Neil, personal communication). The clinical syndrome was not recognised in Wyoming until 1978. In the same year, CWD was first identified as a spongiform encephalopathy on the basis of characteristic histological lesions (16).

The annual incidence of CWD has been variable and dependent upon the number of deer which had been held in the facilities for two or more years. This in turn has been related to the types of research being conducted (long-term or short-term). During
the peak occurrence of CWD at the Fort Collins facility from 1970 to 1981, approximately 60 deer (90%) resident for two years or longer eventually developed CWD and died or were euthanised. Numbers of cases in other facilities in Colorado and Wyoming were lower because they had fewer deer and due to aggregation of captive deer in Colorado in the Fort Collins facility. However, morbidity and mortality were similar.

The disease occurred sporadically, and usually only one animal showed clinical signs at a time. Onset occurred during all seasons, but deaths due to terminal CWD tended to occur with greatest frequency in the winter months due presumably to stressful climatic conditions.

The youngest age at which deer became clinically affected by naturally-transmitted CWD was eighteen months, suggesting this as a minimum incubation period. The oldest was approximately nine years old. Most cases occurred at three to four years of age. There was no apparent association with breeding season or pregnancy. CWD occurred in deer from a variety of sources including:

**Born in captivity:**

a) deer born to resident does and raised by their dams in these facilities;

b) deer born to resident does, taken from their dams when about two days old, and hand-raised in the facilities;

c) deer born to wild does captured and held in these facilities only long enough to fawn, the fawns were then taken from the dams at about two days of age, and hand-raised;

**Born in the wild:**

d) deer captured in the wild as healthy neonates and hand-raised in the facilities;

e) deer captured in the wild and thought to be orphaned, raised for various lengths of time elsewhere (days to months), before being turned over to the wildlife facilities to complete hand-raising;

f) deer captured in the wild as adults before becoming residents in the facilities. These animals originated from throughout Wyoming and Colorado and, in the case of the black-tailed deer, from Oregon. Considering the diverse geographical sources of animals which subsequently developed CWD, there is no evidence that CWD has a familial or genetic association.

Management of animals has varied considerably over the years and among the different facilities. Little information is available on management of captive cervids at Fort Collins prior to about 1974. Fawns have been raised using a number of techniques; all include feeding cow’s milk in some form (raw or pasteurised whole milk, canned evaporated milk, or buttermilk). Commercial lamb milk replacer has been used occasionally during the last five years (Dawson, personal communication). Other feedstuffs have included fresh hay, grass, or other vegetation; dried high protein alfalfa hay; and grain mixtures. Multivitamins, salt and mineral blocks, and soil are available to the fawns. The authors are not aware that any animal protein, other than milk, has been fed to the animals. Most fawns have had access to inside shelter as well as to outside pens. Enteric diseases have been relatively common in hand-raised cervids and many, but not all, fawns received antibiotics, particularly prior to 1985.
In both Fort Collins and Wyoming, white-tailed deer fawns have been raised using the same techniques, and often together with mule deer fawns. It is interesting that white-tailed deer, close relatives of mule deer, have not developed CWD. This may be due to the small numbers of white-tailed deer maintained in these facilities over the years or possibly to some species-specific resistance to CWD. Similarly, bighorn sheep (*Ovis canadensis*) lambs and pronghorn (*Antilocapra americana*) fawns have been raised in these premises and have not become affected.

Weaned fawns and adult deer were fed high quality alfalfa hay, grain mixtures sometimes containing minerals, salt or mineral blocks, and water *ad libitum*. Some animals had access to pasture, but others were maintained in dry lots. Sources of hay and grain mixtures were different in Colorado and Wyoming. There is no evidence that CWD, as it has occurred since 1974, was associated with feed. Circumstances before 1974 are not known precisely, though the management was probably similar.

Elk

Detection of CWD in elk at both the Fort Collins and Wyoming facilities followed the appearance of CWD in deer by at least two years. The average age of affected elk at the onset of disease was only slightly greater than affected deer (unpublished data). If the incubation period of the disease in the two species can be assumed to be similar, these data suggest that the disease was transmitted to elk from affected deer. Management of elk was similar to that of deer, with the exception that many more elk than deer were caught in the wild in Wyoming. Origins of elk which developed CWD included:

- **Born in captivity:**
  - a) born to cows resident in the facilities and raised by the dams;
  - b) born in a zoological park and hand-raised in Fort Collins;

- **Born in the wild:**
  - c) being caught in the wild as adults;
  - d) caught in the wild as healthy neonates or as presumed orphans and hand-raised in the facilities.

Most affected elk were females or castrated males, reflecting the fact that few adult males were kept in captivity.

General considerations

Deer and elk were moved between facilities where CWD has occurred. There was extensive movement of deer between two Colorado facilities. One small Colorado research station first detected CWD in exposed deer approximately eighteen months following importation of a deer from another Colorado facility which had experienced cases of CWD. The imported deer subsequently developed the disease.

Movement of animals from Wyoming to Fort Collins was considerable, but only a few animals have moved in the other direction. Histologically-confirmed CWD at a zoological park in Canada (Barker, personal communication) occurred in deer originating from a Colorado zoological park (Cambre, personal communication). The Fort Collins facility had provided deer to the Colorado zoological park and clinical signs suggestive of CWD have been observed at this zoo. However, CWD has never
been histologically confirmed at this location. CWD was confirmed in a single elk in a small zoological park in Wyoming; that animal had been hand-raised in the Wheatland facility prior to being donated to the park.

The mode of transmission of CWD is not known. A strong argument for lateral transmission can be made, based on the occurrence of CWD in deer in a Colorado facility previously free of the disease following introduction of a deer which subsequently died of histologically-confirmed CWD. Also, the occurrence of CWD in two unrelated cervid species (mule deer and elk) in the same facility suggests that deer, which were observed with CWD prior to all cases in elk, may have transmitted the disease to elk. However, it is possible that there is widespread infection in free-ranging deer and elk populations in Colorado and Wyoming although this is considered to be very unlikely.

Most affected animals were not related. There were some cases of CWD in offspring of dams which developed the disease but it has been impossible to determine if the transmission was maternal or horizontal. Maternal and horizontal transmission of CWD must be considered possible in view of their occurrence in scrapie of domestic sheep.

A variety of ruminant species have been resident over time in these different wildlife facilities and none, other than deer and elk, have developed CWD. Other ruminants which have been in direct or indirect contact with affected deer or elk for at least two years include bighorn sheep, moufflon (*O. musimon*), bighorn × moufflon hybrids, pronghorn, moose (*Alces alces shirasi*), white-tailed deer, black-buck antelope (*Antilope cervicapra*), mountain goat (*Oreamnos americana*), and domestic cattle, sheep and goats. Of these species, domestic cattle, sheep, goats and moufflon (19) have developed spongiform encephalopathy (BSE/scrapie) under natural conditions elsewhere.

A major question concerns the origin of CWD. There is no evidence to suggest a source of infection in feeds for either fawns or adults. Domestic sheep and goats were housed occasionally and used for nutrition and disease research and antibody production in Wyoming and in at least one of the Colorado facilities, especially prior to 1974. None was noticed to have neurological disease, but it is unlikely that scrapie would have been recognised in these animals. Prior to the late 1980s, scrapie of domestic sheep was only reported once in Colorado (1966) and twice in Wyoming (1959 or earlier), and these cases were from locations distant from the captive wildlife facilities (9). However, recognition and reports of scrapie during the 1950s and 1960s in Colorado and Wyoming were probably incomplete.

One domestic cow has been resident in the Fort Collins facility for approximately twelve years and is clinically normal (Miller, personal communication), but the degree of contact with the deer/elk was limited. Cattle were held in the Wheatland facility on occasion for several years; however, this was before recognition of CWD. Cattle have grazed the outside fence lines of some of the facilities and there were opportunities for nose-to-nose contact with animals inside the facility. There has been no evidence of transmission to cattle, though management of range cattle in this area would make spongiform encephalopathies hard to detect. Neither is there evidence that cattle were a source of infection and it is emphasised that BSE has not been reported anywhere in the United States and there is a current BSE surveillance programme in place.
The possibility must be considered that CWD was brought into the facilities from the wild by a single or a few infected individuals, which then transmitted the agent to other cervids under the close confines of captivity.

The occurrence of CWD in free-ranging wildlife was not recognised in either deer or elk prior to discovery of CWD in captive populations in Colorado and Wyoming. All documented cases in free-ranging cervids have occurred within approximately 50 km of two affected wildlife facilities and most were within 5 km (Miller and Spraker, personal communication; unpublished data). Fence-line contact between captive and wild deer and elk is possible. Escapes of animals from affected herds into the wild have not been documented. However, clinical recognition of a spongiform encephalopathy in free-ranging ruminants is extremely difficult and cases elsewhere could have passed undetected.

CLINICAL SIGNS

Deer

Clinical signs of CWD in deer (Table I) are referable to central nervous system lesions and/or secondary complications. Chronic wasting disease in deer (including mule deer, black-tailed deer, and mule deer × white-tailed deer hybrids) is characterised by slowly progressive weight loss which may occur over a period of weeks to months (Figs. 1 and 2). Hair coats are often poor and affected animals may not shed normally. Affected animals continue to eat grain but may show decreased interest in hay. Many animals show polydipsia and often spend much time near water. Polyuria is apparently a result of the elevated water consumption. Swallowing may be difficult for some deer since they frequently submerge the muzzle more deeply into water than do normal animals when drinking. The oesophagus of some deer is flaccid and may be dilated and filled with water and rumen contents. Excessive salivation and grinding of the teeth are present in the majority of affected deer. The apparent difficulty in swallowing and maintaining oesophageal tone is responsible for secondary aspiration pneumonia which may occur in the terminal stages of disease.

### Table I

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Deer (%)</th>
<th>Elk (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss/emaciation</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Behavioural changes</td>
<td>100</td>
<td>83</td>
</tr>
<tr>
<td>Polydipsia/polyuria</td>
<td>77</td>
<td>10</td>
</tr>
<tr>
<td>Teeth grinding</td>
<td>58</td>
<td>67</td>
</tr>
<tr>
<td>Excessive salivation</td>
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<td>50</td>
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<tr>
<td>Regurgitation of rumen contents</td>
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<td>0</td>
</tr>
<tr>
<td>Oesophageal dilatation</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Ataxia</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

Subtle behavioural alterations are frequently the first clinical sign observed by animal attendants who are familiar with the normal behaviour of individual deer. Behavioural changes eventually occur in all affected deer, but vary from case to case.
FIG. 1

Mule deer with chronic wasting disease showing emaciated condition and lowering of the head

FIG. 2

Mule deer with chronic wasting disease showing emaciated body condition
These include decreased interactions with other animals in the pen, changes in response to the attendants, listlessness, drooping of the ears, lowering of the head (Fig. 1), a "blank" facial expression, periods of somnolence from which the animals are easily roused, and repetitive walking in set patterns within the pens. Hypereexcitability and hind limb ataxia have been observed in only a few deer. There are no obvious auditory or visual deficits. Pruritus has not been observed in any case of CWD.

Clinical pathological studies on deer with CWD have been conducted (16). Haematological and serum chemistry values were considered to be within normal ranges for deer or to reflect emaciation or secondary disease. Cerebrospinal fluid analyses showed no abnormalities in cell counts, protein content, specific gravity, or pH. The urine, however, was extremely dilute (urine specific gravity less than 1.006 in many deer). The apparent inability to concentrate urine may reflect damage to hypothalamic nuclei that produce antidiuretic hormone, resulting in a diabetes insipidus syndrome of polydipsia and polyuria.

The clinical disease is progressive and invariably fatal. If allowed to run its course, animals become more depressed and somnolent, finally recumbent, and die from aspiration pneumonia, dehydration or hypothermia associated with cold weather. Most affected animals are euthanised once a clinical diagnosis is made.

Elk

The primary clinical sign in elk is gradual loss of body condition which sometimes appears as a failure to gain weight after natural seasonal losses (Table I) (Miller, personal communication). Behavioural alterations are similar to those observed in deer, however, they are more variable and may include nervousness, hypereexcitability and hyperaesthesia. Excessive salivation and grinding of the teeth are observed in many affected elk. Polydipsia and polyuria are not as pronounced in elk as in deer although low urine specific gravity was found in some affected animals. Slight hind limb ataxia and/or abnormal head postures have been observed in affected elk, but they are subtle and relatively uncommon. Pruritus has not been identified in any elk with CWD. Serum chemistry, haematological values, and cerebrospinal analyses from a few animals have been considered normal for elk (17). Ante-mortem diagnosis of CWD may be more difficult in elk compared to deer. No elk has been known to recover from CWD.

PATHOLOGY

Gross pathology

Gross lesions of CWD primarily reflect the clinical signs of wasting and polydipsia. Carcasses are usually emaciated, with lack of body fat and severe muscle atrophy in terminal cases. In deer, rumen contents are extremely liquid or frothy, reflecting excessive water consumption. Sand and gravel are frequently present in the rumen; however, this may be more obvious in affected animals due to the liquid nature of the rumen contents. Abnormalities in consistency of rumen contents are less apparent in elk. A few deer have a greatly dilated, fluid filled oesophagus. This lesion has never been observed in elk. Terminal aspiration pneumonia occurs in some deer and elk, and occasionally disease unrelated to CWD may be observed at necropsy, complicating both the clinical and pathological diagnosis. No gross lesions are found in the central nervous system.
Histopathology

The significant lesions of CWD occur in the central nervous system consistently and resemble those of other spongiform encephalopathies (18). Characteristic neuropathological features of CWD include spongiform change of the grey matter neuropil; intraneuronal vacuolation; astrocytic hypertrophy and hyperplasia demonstrated by histochemical and immunostaining (7) and electron microscopy (8); the presence of amyloid plaques (2, 5, 6) (although this lesion is usually absent in BSE and inconsistently present in natural scrapie), bilateral symmetry of the lesions, and absence of any inflammation.

The distribution and severity of lesions in brain and spinal cord of deer and elk have been compared (18). The most severe lesions in deer occur in the olfactory tubercle and cortex, hypothalamus and parasympathetic vagal nucleus. The lesions in the vagal nucleus and olfactory cortex are so marked and consistent that examination of these regions is probably adequate for diagnosis of CWD in deer. Changes in these areas also occur in elk but they are not as striking as in deer.

Other brain regions most affected with spongiform encephalopathy in deer and elk include thalamus, hypothalamus, midbrain, pons and medulla oblongata, with milder changes in the cerebellum, cerebral cortex, hippocampus, and basal nuclei. This distribution is similar to that observed in scrapie and BSE (13, 20). There was moderate variability among individual animals in distribution and severity of lesions. Duration of clinical disease did not appear to influence the topographic distribution or severity of lesions in animals killed in the terminal stages.

Minor differences in the patterns of central nervous system lesions of CWD in deer and elk include higher prevalence and relative ease of demonstration of amyloid plaques in deer as compared to elk (5, 6), occurrence of mild white matter lesions in elk but not in deer, and mild differences in the severity of lesions in various nuclei in the brain, and particularly of the thalamus.

Amyloid plaques observed in affected deer are relatively difficult to appreciate with haematoxylin and eosin staining, but they are congophilic, periodic acid-Schiff positive, alcianophilic, and argyrophilic (2, 5, 18). They immunoreact with anti-PrP serum (5). In the few elk which have been examined in detail, plaques were not observed by histochemical stains, but were demonstrable by immunostaining with anti-PrP serum (6).

Ultrastructural findings in a deer with CWD included membrane-bound vacuoles in neuronal processes, dystrophic neurites, astrocytic gliosis, amyloid plaques, neuronal autophagic vacuoles, and occasional spheroids containing dense fibrillar material (8). These changes are generally similar to those observed in other spongiform encephalopathies (11).

DIAGNOSIS

There are no definitive ante-mortem diagnostic tests for CWD. The most easily appreciated clinical sign, loss of body condition, is nonspecific and readily attributable to other causes, including malnutrition, which are more prevalent. Behavioural changes are often subtle and early detection usually requires knowledge of individual animals. Experienced observers may recognise the majority of deer with late clinical CWD,
but behavioural changes exhibited by affected elk are harder to appreciate. Clinical pathological studies are generally unrewarding. The disease usually only affects a single animal in a facility at one time; however, cumulative morbidity in mule deer resident in a facility for at least two years may reach 90%. It follows that ante-mortem clinical diagnosis of CWD in deer, and especially in elk, may be difficult.

Because CWD is difficult to diagnose clinically, necropsy and microscopic examination of the brain are essential. This requires necropsy soon after death to prevent autolytic changes obscuring or confounding the interpretation of the spongiform lesions of CWD. It is important that brains of captive cervids suffering from wasting conditions and/or behavioural abnormalities be examined microscopically and that a gross diagnosis of malnutrition not be made in these cases without first ruling out CWD.

The microscopic lesions of CWD are characteristic and easily appreciated in brains fixed soon after death. In normal mule deer and elk, a few intraneuronal vacuoles have been observed in the red nucleus, but neither neuronal vacuolation nor spongiform change occur in other nuclei (18). Lesions in three areas of the brain are sufficiently consistent and severe to make a diagnosis of CWD in mule deer: the olfactory tubercle and cortex, hypothalamus and parasympathetic vagal nucleus. These areas are less severely damaged in elk, but an experienced veterinary neuropathologist would not have difficulty in identifying the lesions.

Diagnosis of CWD in cervids can be supplemented by immunostaining for the abnormal isoform of PrP (PrP\textsubscript{Sc}) (5) or made by demonstration of scrapie-associated fibrils; these tests can also be used on autolysed tissues.

**PREVENTION AND CONTROL**

Captive cervid facilities which have not had cases of CWD should prevent entry of any cervid that has had contact either directly or indirectly with affected animals (1). The presence of CWD in free-ranging animals from areas of Colorado and Wyoming also suggests it would be prudent not to bring animals from these areas into hitherto unexposed captive populations, or to translocate them into other wild populations. Although the origin of this disease is not known, the similarities to scrapie suggest that, in countries where scrapie is endemic, moufflon, domestic sheep and goats should not be housed with cervids. Based on the clear relationship of contaminated feed and BSE (14, 15), cervids should not be fed ruminant-derived protein (e.g. meat-or-bone meal) from countries with scrapie or BSE.

Control of CWD in Colorado and Wyoming facilities is currently based on maintaining relatively low cervid populations and recognising that CWD is an ongoing problem (Miller and Thorne, personal communication). In the past, a few surplus deer and elk were returned to the wild, or given or traded to other facilities; these practices have been stopped.

Eradication has been attempted (Thorne, personal communication) at the Wyoming facility by killing all elk and deer in the main portion of the facility where CWD had been recognised, but not in outlying areas where CWD had not occurred. Disinfection of the facility and turning the soil where affected animals had been housed was not attempted. Deer and elk were not reintroduced for approximately a year.
The new animals had no contact with affected deer or elk; however, contact had previously occurred between affected deer and elk, and other ruminants (pronghorn, bighorn sheep and moose) which still remained on the premises. Subsequently, CWD occurred in newly introduced deer and elk, the first case occurring approximately five years after the eradication attempt. The cause of the failed eradication attempt may be due to contaminated premises or shedding of the infectious agent by species which have never become clinically affected. The source of animals for restocking was wild deer and elk from a variety of locations where CWD had not been recognised.

In a second eradication attempt (Miller, personal communication), all resident deer and elk at Fort Collins, but no other ruminants, were killed, buried on site, the soil turned, the structures and pastures repeatedly sprayed with calcium hypochlorite, and the area kept free of cervids for a year. The following year, twelve elk calves collected from the wild were hand-raised in a new rearing area, with evaporated milk as their only source of animal protein. Two cases of CWD occurred in those elk at three to four and a half years of age. The cause of the failure of this eradication attempt is not known. Contaminated pastures may be sources of scrapie agent for domestic sheep (4, 12); however, the extensive disinfection procedures followed at the Fort Collins facility should have been adequate to greatly reduce exposure of cervids to the agent. Perhaps elk are so susceptible to CWD that adequate infectivity remained. Possibly the disease was reintroduced into the facility from a focus of CWD infection in the wild; replacement calves had been collected from an area subsequently recognised to have had several cases of CWD in free-ranging elk and mule deer (Miller and Spraker, personal communication).

Recognition of CWD in some free-ranging deer and elk in Colorado and Wyoming has prompted surveillance to determine the prevalence of the disease in the wild. To date, these limited surveys conducted at hunter check stations have not detected CWD in the wild. Obviously, there are considerable difficulties in surveying free-ranging wildlife for a disease of this type. Obtainable sample sizes are small for a disease suspected to be at a very low prevalence. However, responsible wildlife management agencies are continuing surveillance for CWD in these and other areas.

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ENCÉPHALOPATHIES SPONGIFORMES DES CERVIDÉS. — E.S. Williams et S. Young.

Résumé: L'éventail des hôtes dont on sait qu'ils peuvent héberger des encéphalopathies spongiformes transmissibles dans les conditions naturelles s'est étendu, dans les dernières années, aux ruminants sauvages. La cachexie chronique (chronic wasting disease: CWD) a été observée chez le cerf-mulet (Odocoileus
hemionus hemionus) et chez le cerf élaphe des Montagnes Rocheuses (Cervus elaphus nelsoni) dans le Colorado et le Wyoming aux États-Unis d'Amérique. Toutes ces espèces appartiennent à la famille des Cervidés. Des cas ont été observés essentiellement sur des animaux en captivité, mais aussi en quelques occasions sur des animaux vivant en liberté. Les signes cliniques consistent, dans les deux espèces, en des troubles du comportement, une perte de poids et une sialorrhée abondante. Chez le cerf, polydypsie et polyurie sont également fréquentes. Les lésions histopathologiques significatives sont limitées au système nerveux central ; on note des altérations spongiformes de la matière grise, la formation de vacuoles dans les neurones, une hypertrophie des astrocytes et des dépôts de substance amyloïde. On n’observe pas de réaction inflammatoire.

L’origine de cette maladie est inconnue. Contrairement aux cas d’encéphalopathie spongiforme reconnus dans cinq espèces d’antilopes (famille des Bovidés) de jardins zoologiques de Grande-Bretagne, qui se rattachent à l’épizootie d’encéphalopathie spongiforme bovine, qui sévit dans ce pays, la CWD n’a pas pour origine la contamination des aliments par l’agent responsable de la maladie.

La transmission horizontale et, probablement, la transmission verticale semblent être les modes de contagion de la CWD au sein des effectifs d’animaux en captivité.

Les encéphalopathies spongiformes des ruminants sauvages sont géographiquement isolées et concernent des effectifs relativement peu importants. Cependant, ces maladies potentiellement transmissibles peuvent prendre une grande importance dans l’avenir et doivent être considérées comme préoccupantes, compte tenu du trafic international de ruminants sauvages et de l’expansion que connaît actuellement l’élevage du gibier dans de nombreuses régions du monde.


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ENCEFALOPATÍAS ESPONGIFORMES DE LOS CÉRVIDOS. – E.S. Williams y S. Young.

Resumen: La lista de huéspedes conocidos de encefalopatías espongiformes transmisibles en condiciones naturales ha aumentado estos últimos años e incluye ahora también a los rumiantes salvajes. En los estados norteamericanos de Colorado y Wyoming se han observado casos de enfermedad crónica caquectizante (chronic wasting disease; CWD) en poblaciones de ciervos-mulas (Odocoileus hemionus hemionus) y de alces de las Montañas Rocosas (Cervus elaphus nelsoni). Estas dos especies pertenecen a la familia de los Cérvidos. La mayoría de los casos se han producido en poblaciones de animales criados en cautividad, pero se han observado también algunos casos en los animales en libertad. En ambas especies, los signos clínicos son la pérdida de peso, los trastornos comportamentales y una abundante salivación. En el ciervo, la polidipsia y la poliuria son también frecuentes. Las lesiones histopatológicas importantes se limitan al sistema nervioso central y consisten en alteraciones espongiformes de la materia gris, formación de vacuolas en las neuronas, astrocitosis y formación de placas amiloïdes. No se ha observado reacción inflamatoria.
Se desconoce el origen de esta enfermedad. Contrariamente a los casos de encefalopatía espongiforme observados en cinco especies de antílopes (familia de los Bóvidos) en parques zoológicos británicos y relacionados con la actual epizootia de encefalopatía espongiforme bovina, el origen de la CWD no es la contaminación de los alimentos por el agente infeccioso.

La transmisión horizontal y, probablemente, vertical parecen ser las formas de contagio de la CWD entre los animales en cautividad.

Las encefalopatías espongiformes de los rumiantes salvajes se encuentran, en la actualidad, geográficamente aisladas y afectan a un número de animales relativamente reducido. No obstante, estas enfermedades potencialmente transmisibles pueden adquirir un día mayor importancia y deben considerarse preocupantes dado el tráfico internacional de rumiantes salvajes y la actual expansión de la cría de animales de caza en numerosas regiones del mundo.


