UPDATE ON BOVINE SPONGIFORM ENcephalopathy, SCRAPIE AND CHRONIC WASTING DISEASE

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Summary: Transmissible spongiform encephalopathies (TSE) are a group of transmissible diseases, of which the earliest described was scrapie in sheep more than 250 years ago. Since then, TSE has been described in a large variety of species. Bovine spongiform encephalopathy (BSE) was first described in the United Kingdom (UK) in November 1986. Based on current knowledge, the infection is transmitted by the ingestion of insufficiently rendered meat-and-bone meal containing infectious organs of infected animals.

The most important action to prevent new BSE cases is the ban of feeding meat and bone meal. Further measures to be considered are the process parameters for rendering, the exclusion of specified risk material and cadavers, and the prevention of cross contamination.

Experiments have demonstrated that infectivity has been found only in the central nervous system (brain, spinal cord and eyes), the dorsal root and trigeminal ganglia and in the distal ileum. Until now infectivity has never been detected in muscle or milk. The most important measure to protect the consumer is the ban on mechanically recovered meat and specified risk material (SRM) such as brain and spinal cord, which may contain particularly high concentrations of BSE.

Countries other than the UK have reported indigenous BSE cases. Although it has been increasingly shown, that it is not a purely British problem, and more and more European countries have discovered BSE over the years, the absence of reported cases had been equated, by some countries, with the status of freedom from BSE. On the assumption that a country was free from BSE, its export activities continued and other countries became infected.

The lack of laboratory tests for live animals makes the estimation of the true prevalence of BSE very difficult. Therefore, a combination of effectively functioning passive and active surveillance strategies is recommended to reliably assess the BSE situation in a given country. Before claiming freedom from BSE, a risk assessment on the risk of introduction and amplification of the BSE agent is required by the OIE International Animal Health Code.

The reporting of cases of a variant of Creutzfeldt-Jakob disease (vCJD) showed that a correlation between BSE and vCJD has to be assumed.
Scrapie, a TSE in sheep and goats, has been reported in most countries throughout the world with a few notable exceptions. Infectivity has been found in a wide range of organs. There is no scientific evidence that scrapie poses a risk to human health.

However, concern was expressed that BSE could have been introduced into sheep and goats. Currently it is only possible to distinguish between scrapie and BSE in small ruminants by a comparative assessment of incubation time and pathological lesion profiles in the brains of mice inoculated with the isolate.

Chronic wasting disease (CWD) was first reported in the late 1960s in captive deer and later in free-ranging cervids in the USA and Canada. There is currently no evidence that humans are susceptible to CWD.

1. INTRODUCTION

The transmissible spongiform encephalopathies (TSEs) are a group of diseases encompassing a wide variety of disorders in humans and animals. The exact nature of the infective agent responsible for TSEs is not known. Although most evidence points towards the prion-theory (21), alternative hypotheses have not all been refuted (9, 12).

Of this group, the animal disease with the longest history is scrapie, which was first reported in the mid-18th century (14). TSEs also include chronic wasting disease (CWD), which was first identified relatively recently among deer in North America. For some decades, diseases in this group have also been reported in humans; the best known are classical Creutzfeld-Jakob Disease (CJD) and Kuru. Until 1996, no zoonotic potential of the animal TSEs was established.

This changed with the appearance of bovine spongiform encephalopathy (BSE), which was first reported in the United Kingdom (UK) in 1986. Case reports of a variant of Creutzfeld-Jakob disease (vCJD) in humans, which were reported in UK in 1996, showed that a correlation between BSE and vCJD has to be assumed (31).

Moreover, concern was expressed that BSE could have been introduced into sheep and goats because it has been experimentally demonstrated that BSE can be orally transmitted to small ruminants (11). At present it is not possible to distinguish between scrapie and BSE in sheep by clinical or pathological means (6). To make this differentiation, the only method currently available is a comparative assessment of incubation time and pathological lesion profiles in the brains of mice inoculated with the isolate (8).

2. BOVINE SPONGIFORM ENCEPHALOPATHY

2.1. Course of the disease

a) United Kingdom

• Measures

The first cases of BSE were reported in the UK in 1986 (28). Extensive epidemiological studies traced the cause of BSE back to animal feed containing inadequately treated ruminant MBM1 (29, 30).

The most important action to prevent new BSE infections in cattle was the ban on ruminant MBM for use in ruminants that came into force in the UK in July 1988. The use of mammalian MBM in ruminant feed was banned in November 1994. This eliminated the problem of distinguishing between feed of bovine origin and feed of mammalian origin, which in turn made it easier to monitor the feeding ban. Although these measures proved effective, they were not enough to bring the rate of new infections among cattle down to zero. Gradually, the measures were made increasingly stringent until in March 1996 the feeding of mammalian MBM to all farm animals was banned (1).

1 MBM: meat and bone meal

Update on bovine spongiform encephalopathy, scrapie and chronic wasting disease
The most important measure to protect consumers was the ban on the use of SRM\(^2\) for human consumption. At the end of 1989, the UK banned the use of SRM for human consumption – namely brain, spinal cord, tonsils, thymus, spleen and intestines from cattle older than six months. This ban was based on scrapie experiments on infectivity of the different tissues. At the time this ban was put in place there were no available data on BSE; subsequent experiments with BSE have shown that the pathogenesis, and hence the tissue distribution of infectivity in cattle with BSE and sheep with scrapie is different (10).

In mouse tests on tissues from field cases of BSE in cattle, infectivity has not been recorded outside the central nervous system (brain spinal cord and eyes). In experimental orally induced BSE, infectivity has been found in the distal ileum starting six months after exposure (26). Furthermore, central nervous tissues and dorsal root and trigeminal ganglia were found to be infective shortly before the onset of clinical signs. In one study, sternal bone marrow collected during the clinical phase of disease was infective; however, one of the possible explanations given by Wells et al. (27) is that this could have been due to cross contamination.

- **Course of the epidemic in the UK**

One of the problems with controlling BSE is that the effect of the measures taken cannot be evaluated until about 5 years have elapsed, which is the average incubation period for BSE. So the effect of the ban on feeding MBM to ruminants did not become clear until 1993. After a peak of 36,000 cases had been reached in 1992, the annual incidence fell. Following more than 177,000 cases in the UK, it would seem that the measures taken, in particular the ban on feeding MBM to all farm animals, implemented in 1996, have been effective. There has been only two cases of BSE in an animal born after these radical measures were implemented in August 1996.

**b) Bovine spongiform encephalopathy cases outside the United Kingdom**

In 1989, the first cases outside the UK occurred in cattle imported from the UK. Not until the end of 1989 were the first indigenous cases reported in Ireland and the European Continent (France, Portugal and Switzerland). In the mid-90s, other countries reported cases of BSE (the Netherlands, Luxembourg, Belgium and Liechtenstein).

In 2000 and 2001 cases of BSE were first diagnosed in four more countries: Denmark, Spain, Germany and Italy (Figure 1) (18).

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<tr>
<th>Year of first case</th>
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<th>Portugal</th>
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**Fig. 1. First occurrence of indigenous BSE cases.**

**2.2. Reactions of countries without reported BSE**

Initially BSE was seen as a purely British problem. Greater attention was paid to the problem after the initial reports of imported BSE cases; since 1989, a number of countries have imposed import restrictions to combat BSE.

The suspicion that BSE may be transmissible to humans in 1996 (31) led to increased calls for consumer safety, to which the regulatory authorities of the different countries responded in different ways. In many cases, import restrictions were introduced, but the restrictions were only against countries where BSE had been reported.
Most countries did not introduce regulations to combat BSE until cases had been reported in their
country. Only in very rare cases were imported cattle and MBM evaluated with regard to import risk and
the recycling process of potentially BSE-infected material in the country concerned subjected to any
serious review before the occurrence of BSE in the country. As the label 'no BSE cases detected' was
equated with 'BSE-free', the prophylactic measure of removing SRM was not contemplated and was
generally considered to be exaggerated.

2.3. OIE recommendations

The OIE International Committee was first informed of BSE in 1988 (16). A special expert meeting on
BSE was held in September 1990 (17). The minutes of this meeting contain the first references to the
prevention of BSE and to measures intended to prevent transmission of the disease through trade.

To detect BSE in its early stages, it was suggested that information be provided on the clinical signs of
BSE, that pathologists be trained to diagnose BSE, and that it be classified as a notifiable disease. It was
further recommended that the risk factors for BSE be determined in the various countries and MBM be
excluded from ruminant feed. Import conditions for cattle, bovine products and animal feed were to be
laid down on the basis of the OIE recommendations.

At the General Session of the International Committee in 1992, the OIE issued detailed recommendations
on BSE in the International Animal Health Code (the Code), based on the recommendations of the group
of experts that was established in 1990. At that time, there was limited knowledge but recommendations
were established and these recommendations have since been modified several times as more information
was learned about the disease. The current version of the Code (19) recommends compulsory notification
of BSE cases and that the examination of brain tissue from suspect cases should be a precondition for
trading in cattle and bovine products. Animals affected with BSE must be culled and incinerated, and the
ban on feeding MBM to ruminants must be enforced. A precondition for determination of the BSE status
of a country is the outcome of a risk assessment. Additionally, an efficient surveillance system must also
be set up. The Code includes sanitary requirements recommended for the importation of live cattle and
bovine products according to the BSE status of the exporting country or zone.

a) Risk assessment

An important component of a BSE risk assessment is to evaluate whether potentially infected material
was imported and, if so, whether the conditions in the country were/are sufficient to cope with this
material, i.e. to prevent the disease being propagated. On the basis of the OIE criteria, the Scientific
Steering Committee of the European Union (EU) has carried out a BSE risk assessment in a number
of countries (5). As a result of Resolution No.XII adopted by the OIE International Committee in May
1998, an OIE Specialist Commission has developed a draft questionnaire that Member Countries will
have to complete if they want to be recognised by the OIE as free of BSE.

• Risk of introduction of the BSE agent into a country

On the assumption that BSE was first spread by the export of live cattle or MBM from the UK,
imports must be scrutinised first. As cattle born in the mid-1970s were affected in the UK, imports
dating back to this period should ideally be included in the risk assessment investigation. Also, since
1990 other countries in addition to the UK have been affected by BSE, therefore imports from these
countries also must be considered as ‘risky’, unless adequate safeguards had been implemented. The
risk of introduction of the BSE agent into a country should be evaluated with reference not only to a
country’s own import statistics but also to the export statistics of the UK and other at-risk countries.
This procedure allows an initial analysis to be performed to determine whether any potentially
infectious material (‘challenge’) might have entered a country at any time.

A glance at the export statistics of the UK (2) shows that by the end of the 1980s, MBM exports were
on the increase. This can be explained by the ban on feeding of MBM in the UK, so that new markets
had to be found for the MBM produced. The EU export ban imposed on the UK in 1990 did not affect
MBM, but only live cattle other than veal (less than 6 months old); it did restrict export of some
bovine organs and meat from animals on farms where BSE had been diagnosed. In 1994, the feeding
of MBM to ruminants was banned in all EU countries. As a result of this ban, and especially since the beginning of the 1990s, MBM was exported to other countries including countries outside Europe (Figure 2) (3). All these countries must be seen in turn as possible exporters of potential risk material to other countries, even though they have not been identified as countries affected with BSE. The amount of exported risk material may be requested from the exporting countries.

![Fig. 2. UK exports of flours, meals and pellets of meat or meat offal, unfit for human consumption (greaves), 1979–1995.](image)

Source: HM Customs and Excise

**Fig. 2. UK exports of flours, meals and pellets of meat or meat offal, unfit for human consumption (greaves), 1979–1995.**

- *Risk of propagating the BSE agent in a country*

When ‘risky’ imports are found to have occurred, it is of utmost importance to investigate what has become of the imports. This will elucidate the capacity of the systems in place in the country to prevent the introduction of the BSE agent into the feed chain and to reduce the spread of the pathogen. The outcome of the investigation should show whether or not the country is capable of preventing the contamination of bovine feed, and thus the infection of cattle, with BSE.

A central issue is what happens with SRM after slaughter. Some material, such as brain and spinal cord, may contain particularly high concentrations of the BSE agent (26). If these SRMs – both from imported and from domestic cattle – are removed at slaughter and then incinerated, the risk of recycling the pathogen is markedly reduced. If these materials are used for further processing to animal feed, there is a high risk of amplification of the BSE agent. If an SRM ban, including cadavers, is put in place at an early stage, this increases the stability of the system.

Another central point in evaluating the risk of BSE agent propagation is what happens with animal waste and cadavers. The agent is extremely resistant to most physical and chemical inactivation methods (22, 24). It is scientifically proven that even treatment of infected material at 133°C and 3 bars of pressure for 20 minutes does not completely inactivate the agent if the initial infective load was high. Recent experiments have shown that residual infectivity can be present also when very high temperatures were used (7). Nevertheless, if the raw material is processed to MBM in a batch process at 133°C and 3 bars of pressure for 20 minutes (25), the risk is decreased. The risk of recycling is low if there is no rendering industry in a given country, and the animal waste and cadavers are buried or incinerated.

A further important point is the feeding of MBM to ruminants. In many countries, animals have traditionally never been fed MBM. But assumptions on this subject have to be looked at with circumspection. In the meantime, BSE cases have been diagnosed in many countries where it was not a customary practice to feed cattle with MBM. It has to be borne in mind that, even when no MBM has been fed to ruminants, a high risk still remains because of cross-contamination and cross-feeding.
If MBM was allowed in feed rations for pigs and poultry, and these were manufactured in the same mills, and transported by the same vehicles, and if inappropriate feeding practices cannot be ruled out on farms, the risk remains high. It is lower than in countries that have not prohibited feeding MBM to ruminants, but it is still a significant risk. This is demonstrated by the large numbers of BAB³ cases, which have occurred despite feeding bans and other measures.

- **Surveillance**

An important clue to the real BSE situation can be provided by the surveillance system.

In most countries, BSE is listed as a notifiable disease, which is a basic requirement for a functioning surveillance system. Until a few years ago, BSE monitoring was confined to the notification of clinically suspected cases. It was assumed that this would allow early detecting of an outbreak and would be more effective than random sampling of all slaughter animals. However, a system of this kind is dependent on many factors such as disease awareness, compensation practices and motivation to notify.

In recent times, it has become increasingly obvious that a passive surveillance⁴ system alone, based on the notification of suspected cases, is not sufficient to provide evidence of freedom from BSE.

The availability of rapid BSE tests (15), allowed the fast and uncomplicated testing of brain tissue for BSE on a large scale and to identify infected animals in the last stage of the incubation period. This made it possible to implement active surveillance⁵ programmes in populations at risk. Unfortunately these tests are not sensitive enough to identify animals that are infected but that do not yet have a high concentration of the BSE agent in the brain. A negative result is thus no guarantee that the tested animal is not infected. Nevertheless, through the use of these tests, it is possible to get closer to the true incidence of BSE and they have proven to be a useful screening technique. However the confirmatory test for BSE remains histopathology and immunohistochemistry as described in the OIE Manual of Standards for Diagnostic Tests and Vaccines (19).

![Fig. 3. BSE infection and testing.](image)

2.4. **Current situation**

In the past few years, there have been repeated allegations that some countries have not reported BSE cases because their surveillance is not efficiently conducted.

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³ BAB: Born After the date of the Ban
⁴ Passive surveillance: surveillance of notified suspects, i.e. cattle that are notified because of clinical signs compatible with BSE
⁵ Active surveillance: testing of cattle that are not notified as BSE suspects but belong to risk populations
Since BSE was first described in the UK in 1986, the detection of BSE cases is based on the notification of clinically suspect cases. Although since 1990 it has been increasingly shown that it is not a purely British problem, and more and more European countries have detected BSE in their herds over the years, the absence of reported cases has to date always been automatically equated with freedom from BSE. And this is the problem: a country has BSE but it has not been detected or reported, and so export activities continue on the assumption that the country is free from BSE – then other countries become infected.

In many countries in Europe, an active surveillance system has now been implemented; tests for BSE have been carried out in populations at risk since 1999/2000 in some countries and 2001 in others; the animals tested include cows that have died or were emergency culled or emergency slaughtered. The probability of detecting BSE-infected animals is greatest in these high-risk groups, as it may have been BSE that led to the death, cull or slaughter of the animals. As it takes an average of four to six years before BSE can be diagnosed, testing can concentrate on animals that are older than three years.

First results indicate clearly that active surveillance is a more objective approach and can help to assess the real BSE situation in a country. Consequently, some countries in Europe that for years have been considered BSE free are now shown to have BSE.

In 1986, BSE was believed to be only a British problem, and later to be a problem confined to a small number of countries. The prevailing view today is that it is a European problem. The question is whether or not BSE is really confined to Europe.

Perhaps it is time to learn from earlier mistakes and to seriously evaluate whether a problem might exist in one’s own country – including countries outside Europe.

Although it is known that MBM and cattle have been exported all over the world, unfortunately, it is not yet possible to detect infection in these imported cattle or MBM. It will be some years before a country can determine whether or not the problem has been imported. Imported MBM is eaten by domestic animals and the SRM will be recycled and find its way into animal feed. This feed will in turn be eaten by domestic cattle – and the animals will not fall sick until an average of 5 years later, which could lead to a steady amplification of the BSE agent. If prophylactic measures are not taken in good time, and the surveillance is not efficient, it may take decades before an epidemic is seen.

2.5. Measures to safeguard the consumer

Until today infectivity has never been detected in muscle (4) or milk (23). Besides the SRM, mechanically recovered meat (MRM) originating in particular from vertebral columns with dorsal root ganglia or residues of spinal cord is regarded as a risk factor. Therefore, the systematic ban on SRM and MRM from the food chain is and will remain crucial for the protection of the consumer. To monitor compliance with the SRM-ban in meat products, a test has now been developed in which brain and spinal cord tissue can be detected in meat products being provided to consumers (13).

A further policy for consumer protection is to incinerate all animals proven or suspected of being infected.

BSE is a disease with a mean incubation period of 4 to 6 years. All the diagnostic tests available today only pick up animals in the end-stage of the disease (Figure 3).

In the meantime some European countries have started to conduct blanket testing of all cattle over 30 months old, with the aim of restoring consumer confidence. However, it is questionable, whether this action offers a measurable increase in safety for the consumer as infectivity is only demonstrated in certain organs, and this SRM is efficiently removed.

There are also concerns about BSE in sheep, as BSE was experimentally transmitted to sheep through the oral route. This fact and the distribution of the agent in different organs in sheep together with the impossibility to discriminate clinically between scrapie and BSE in sheep may constitute an additional risk of introducing BSE-infected material into the human food chain. These considerations should be taken into account, in particular in countries where scrapie occurs.
2.6. Conclusions

- To estimate the extent of the BSE problem in Member Countries, a serious risk assessment must be carried out. Active surveillance in populations at risk plus passive surveillance can help to reveal a better estimate of the incidence.

- In the event of uncertainty as to the BSE status of a country, the most important preventive measures for the protection of cattle are the implementation of an effective MBM feed ban to ruminants and the prevention of cross-contamination in feed.

- The most important measure for protection of the consumer is a ban on SRM and MRM.

- The utmost attention should be paid to enforcing the implementation of all the stipulated measures. The slightest gaps in the system of disease control can undermine all the efforts to combat BSE.

- The long period of denial and hesitation to take action has led to consumer panic in many countries and to import bans, especially by countries outside Europe. A transparent, proactive information policy will not only help consumer confidence, but is also important for credible trading relations.

Although the discovery of BSE can be seen in the short term as a grave problem, the failure to detect the disease even though it is present would have more grave consequences – and prove far more costly – both in the medium and in the long term.

In the event of uncertainty, prophylactic measures are cheaper than late action – which may ultimately prove to be too late.

3. SCRAPIE

3.1. Clinical signs

Signs of scrapie may vary widely among individual animals and breeds of sheep, but in most cases it is a slowly progressive neurological disease. Early signs include subtle changes in behaviour or temperament; these changes are followed by other signs, which may include tremor, especially of the head and neck, loss of coordination, scratching and rubbing against fixed objects, weight loss despite retention of appetite, biting of feet and limbs, lip smacking, and gait abnormalities, including high-stepping of the forelegs, hopping like a rabbit, and swaying of the back end. An infected animal may appear normal if left undisturbed. However, when stimulated by a sudden noise, excessive movement, or the stress of handling, the animal may tremble or fall down in a convulsive like state.

Sheep usually live 1 to 6 months or longer after the onset of clinical signs, but death is inevitable. While a progressive development of clinical signs seems to be the norm, there have been cases of confirmed scrapie of such short clinical courses that sheep were reported to be ‘found dead’ (37). Several other problems can cause clinical signs similar to scrapie in sheep, including ovine progressive pneumonia, listeriosis and rabies; the presence of external parasites (lice and mites); pregnancy toxaemia; and toxins.

3.2. Epidemiology

First recognised as a disease of sheep in Great Britain and other countries of Western Europe more than 250 years ago, scrapie has been reported in most sheep-raising countries throughout the world with few notable exceptions (63). The spread of scrapie to flocks and countries via the movement of affected sheep or sheep incubating the disease has been documented, but its prevalence and incidence remain obscure. With no validated diagnostic test to detect infections before clinical signs appear, the diagnosis of scrapie largely depends on disease recognition and willingness to report. It can be difficult to obtain the true incidence within a flock or within countries, especially when there are outside factors that influence reporting. Often the incidence is higher than the limited data indicate (41, 60, 71).

Scrapie occurs most frequently in male or female sheep between 2 and 5 years of age (41, 68) with the average onset of clinical signs being about 3.5 years (63, 71). As it is thought that most animals are infected at birth or shortly thereafter, age at onset of clinical signs and incubation period would be roughly the same. Flock mortality may range from 3 to 20% (64, 68, 72).
Most of the cases of natural scrapie in goats have involved close association with scrapie-infected sheep (33, 36, 69), although Hourrigan et al. (51) reported scrapie being spread from goat to goat with no sheep contact.

3.3. Transmission and pathogenesis

Over the years there has been much debate on the transmissibility of scrapie. Initially, arguments centered around a genetic versus infectious origin. Evidence of transmissibility was first recorded in the literature when Cuille and Chelle (39) were successful in transmitting the disease from affected sheep to healthy sheep via intraocular injection. Later, there was information to suggest that scrapie was a naturally occurring contagious disease caused by an infectious agent (33, 40, 51). At present it is generally accepted that scrapie is an infectious, contagious disease with genetics playing an influential role that is not completely understood. The means of natural transmission have also not been fully defined.

The detection of infectivity in the placenta (61, 65-67) in combination with a failure to detect infectivity in faeces, saliva, urine, colostrum or milk (48, 49, 51, 64) has led to a fairly wide acceptance that the placenta and fetal fluids play a significant role in the spread of scrapie. Hence transmission would most likely occur from an infected mother to her progeny and other lambs that are in close association around the time of parturition. Whether this spread would be from direct contact with the infected tissues/fluid or from a contaminated environment or possibly both is unknown. Scrapie has not been shown to be transmitted via semen. There are still unanswered questions surrounding the role that embryos may play in the spread of the disease (42, 43).

Once the agent enters the body, it replicates primarily in the lymphoreticular system. In the preclinical sheep and goat, infectivity has been found in numerous lymph nodes, tonsil, spleen, lymphoid tissue associated with the intestinal tract and placenta, and in the later preclinical phase, in the brain. (47-49, 67). Once the animal reaches the clinical phase of disease, infectivity is widely dispersed throughout the body. In addition to the lymphoreticular system and the central nervous system, infectivity has been detected in the pituitary and adrenal glands, bone marrow, pancreas, thymus, liver and peripheral nerves (46-49).

Genetic variations among different breeds of sheep may play a role in whether sheep will become infected and how quickly clinical signs may appear. Researchers in Edinburgh, Scotland, UK, identified a gene, called Sip (scrapie incubation period) that controls the incubation period of scrapie in Cheviot and Swaledale sheep. Those sheep with ‘short’ incubation alleles usually develop signs between 2 and 5 years of age. Sheep with ‘long’ incubation alleles often die from what appear to be natural causes before the incubation period is complete. Because the incubation period can be longer than 5 years, it is not known to what extent or under what conditions infected sheep with the long incubation alleles might be able to transmit the disease to healthy sheep. It is likely that the prion protein (PrP) gene and the gene controlling scrapie incubation periods (Sip) are the same (35, 52, 54, 70). Further research involving additional breeds has suggested that genetic influence may extend beyond incubation length, and some degree of disease resistance may be conferred (32, 38, 53, 55, 56, 58, 59, 62, 70). The strain of the scrapie agent also appears to affect the development of clinical signs and the length of the incubation period (44, 45).

There is no scientific evidence to indicate that scrapie poses a risk to human health (50, 57). There is no epidemiological evidence that scrapie of sheep and goats is transmitted to humans through contact on the farm, at slaughter plants, or butcher shops (34).

3.4. Prevention and control

Routine methods of preventing a disease that is laterally transmitted are vaccination, quarantine, test and removal and/or prohibition of animal and animal product movements. As the scrapie agent elicits no detectable immune response in the host, vaccines and serological tests have not been possible. At present, there are still no practical validated diagnostic tests for live animals. This has prohibited the detection of animals, that are incubating the disease and may be shedding the agent, until the onset of clinical signs.

Until some of the new preclinical tests are validated, the ideal means for preventing the introduction of scrapie into a free flock is to restrict additions, especially ewes. Any replacement ewes or breeding rams should originate from flocks not known to be affected with scrapie for a period of years and that have management practices precluding the introduction of scrapie.
Control/eradication efforts vary widely among countries. These measures include total flock depopulations, partial flock depopulations (high risk animals, bloodline animals, etc.) or removal of only the scrapie-affected animals. Another approach being taken by countries or regions within countries is to breed the more ‘resistant’ genotypes. As with BSE the first step in control is enacting legislation that requires reporting.

The OIE International Animal Health Code Commission, with the help of an Ad Hoc Group of experts, is developing a new Chapter for the OIE International Animal Health Code. This Chapter will address scrapie health requirements for trade.

4. CHRONIC WASTING DISEASE

4.1. Clinical signs

Chronic wasting disease (CWD) naturally affects mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), and Rocky Mountain elk (Cervus elaphus nelsoni). Affected cervids (members of the deer family) are older than 17 months of age; the majority are 3-5 years of age. Sex does not appear to affect susceptibility to CWD. The earliest clinical signs are behavioural changes, which may include alterations in interaction with humans and members of the herd. These subtle changes are often only appreciated by caretakers familiar with the individual animal. With disease progression, behavioural alterations may include periods of stupor and depression. Captive animals may become difficult to handle in chutes. As the name suggests, progressive weight loss is characteristic of CWD and may occur over a long period of time. Duration of clinical signs varies from a few days in unusual cases to as long as a year, but is most often 2-3 months. At the terminal stages of disease, animals are emaciated. However, intercurrent disease, especially aspiration pneumonia, may cause an affected animal to die while still in good to fair body condition. In the later stages of disease, clinical signs may include increased drinking and urinating, excessive salivation, and incoordination and trembling. These clinical signs are nonspecific and could be caused by many other diseases affecting wild and captive deer and elk, thus laboratory examination is required for CWD diagnosis.

4.2. Epidemiology

CWD was recognised as a syndrome by biologists working with captive deer in the late 1960s. It occurs in deer and elk on a few wildlife research facilities that are now used to study CWD under controlled conditions. CWD occurs in contiguous herds of free-ranging cervids in southeastern Wyoming, north-central and north-eastern Colorado, and the extreme south-western portion of the panhandle of Nebraska, United States of America (USA). In 1996, CWD was diagnosed among privately owned elk on game farms in Saskatchewan, Canada, and in subsequent years it has been found in a small number of farms in South Dakota, Nebraska, Oklahoma, Colorado, and Montana, USA. The occurrence of CWD in epidemiologically linked herds in Saskatchewan has led to the slaughter of over 1500 elk in late 2000 and early 2001.

Surveillance of free-ranging deer and elk for evidence of CWD has taken two forms. Wild cervids showing clinical signs compatible with the case definition are examined in veterinary diagnostic laboratories for spongiform encephalopathy by immunohistochemistry. No case of clinical CWD in free-ranging cervids has been diagnosed outside the known endemic areas of Wyoming, Colorado, and Nebraska. The second surveillance technique involves voluntary or mandatory submission of heads of hunter-harvested deer and elk so that brains can be examined for evidence of preclinical/subclinical CWD. Hunter-harvested cervid surveillance began in 1983 and thousands of animals have been tested across North America. In specific management units in the CWD endemic area, estimated prevalence is <1-15% in mule deer and white-tailed deer and <1% in elk. In surrounding wildlife management units, estimated prevalence in deer and elk is <1%.

The epidemiology and prevalence of CWD in privately owned elk are under investigation. Prevalence in affected private elk herds varies from <1% to > 30%. Surveillance for CWD in privately owned elk is tied to state and federal control programmes.
The mode of transmission of CWD is not known. Epidemiological evidence strongly suggests that lateral transmission occurs among deer and elk and probably from mule deer to elk and white-tailed deer. Maternal transmission may occur but does not explain many cases of CWD. Concentration of animals in captivity may facilitate transmission; however, CWD is maintained in populations of deer even at moderate to low population densities. There is no evidence that CWD is a food-borne disease associated with consumption of animal protein. The origin of CWD is not known and the source(s) of CWD in captivity and in the wild is uncertain. Based on strain typing in mice conducted at the Neuropathogenesis Unit in Scotland, UK (Dr M. Bruce), CWD is not the same as BSE or known scrapie strains.

The host range of CWD is currently only known to be mule deer and white-tailed deer and Rocky Mountain elk. Subspecies of elk, Cervus elaphus, are probably susceptible but it is not known if other cervids can develop CWD. There is currently no evidence that other wild species, domestic animals, or humans are naturally susceptible to CWD, though research to better characterise the host range is currently underway. Integrated studies of the experimental susceptibility of cattle to CWD are in progress. CWD was transmitted to 3 of 13 intracerebrally inoculated cattle with clinical signs observed 24-27 months post-inoculation; the remaining 10 inoculated cattle are clinically normal approximately 40 months post-inoculation. In addition, studies of orally inoculated and contact exposed cattle initiated at the same time as the intracerebrally inoculated animals are still healthy after approximately 40 months.

4.3. Prevention and control

To prevent extension of CWD outside the endemic area, free-ranging deer and elk have been restricted and are not to be transplanted or moved from the endemic areas of Wyoming, Colorado, and Nebraska. Surveillance to monitor distribution and prevalence of CWD in free-ranging deer and elk is being conducted so that changes over time can be detected. Because transmission of the disease may be facilitated by high densities of deer and elk, concentration of these species by artificial feeding is prohibited in CWD endemic areas.

Many state and provincial animal health agencies in western North America, in cooperation with wildlife management agencies and industry, have developed voluntary or mandatory programmes for management and control of CWD in privately owned elk. These programmes are based on individual animal identification, annual animal census, submission to accredited laboratories of brain samples from all elk over 12-16 months of age that die for CWD testing, and a certification scheme. Herds with CWD are quarantined or depopulated. Canada has implemented a federal CWD control programme. A federal control/certification programme is under development in the USA.

Education of the public, cervid owners, hunters, meat processors and taxidermists, wildlife biologists and game wardens, animal health officials, and veterinary diagnosticians and pathologists is being conducted through brochures, press releases, journal articles, public presentations, workshops, and a video. Because of the many unknowns surrounding CWD, much research is underway to better characterise the disease, determine host range, develop and validate diagnostic tests, and understand the epidemiology. Results of this work will assist in developing science-based methods for prevention and control of CWD.

REFERENCES

Bovine spongiform encephalopathy


**Scrapie**


**Chronic wasting disease (CWD): supporting literature**


