

Differential diagnosis of neurologically expressed disorders in Western European cattle

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Summary

A classification of neurological or neurologically expressed disorders that occur in Western European cattle aged 12 months and over has been established on the basis of aetiology, frequency and conditions of appearance, age and type of animals concerned and the main clinical signs observed. Neurologically expressed disorders have been classified according to different groups of causes: biological, non-biological and non-specific or unknown. Differential diagnosis of neurologically expressed disorders is an essential element in the clinical epidemiological surveillance of bovine spongiform encephalopathy. A growing number of aetiologies are described in the scientific literature. The identification and centralised management of neurological disorders will make it possible, on the one hand, to take account of the inherent variability in the clinical forms encountered and in the diagnostic approaches of the observers and, on the other hand, to identify new risk factors in order to control them.

Keywords

Biological cause – Bovine spongiform encephalopathy – Cattle – Europe – Neurological disorder – Non-biological cause – Non-specific cause.

Introduction

Population data on the incidence of neurological disorders in bovines are scarce, and available results hardly lend themselves to comparison. Such data however are of prime importance in epidemiological surveillance of the transmissible spongiform encephalopathies (TSEs) (123). One source sets the percentage

of neurological pathologies amongst all pathologies found in veterinary medicine at 0.82% (65). In Switzerland, the minimum annual incidence of neurological cases examined in the Universities of Zurich and Berne has been estimated at 89 bovines of all ages per million; this rate is rather low (73). In the United States of America, the National Animal Health Monitoring System (NAHMS) recorded a mortality rate for 1995 of one dairy cow per 1,000 due to 'lack of coordination

or severe depression' and, for 1996, a morbidity rate in beef herds of one breeding female with 'neurological problems' per 1,000 (29, 30). According to Heim *et. al.* (73), neurological pathologies have a preferential distribution in bovines under one year of age (29.3%) and in those aged four to five years (18.9%).

The distinction between diseases of the nervous system and syndromes with a neurological expression is not easy to draw. Indeed, a disease such as bovine babesiosis may lead to anoxia or hepatic coma, resulting in the appearance of neurologically expressed clinical signs. Tsuji *et. al.* reproduced this phenomenon in a mouse model (139). The expression 'neurologically expressed disorder' (NED) has been used, and defined as: 'any neurological case in which either the anamnesis and/or clinical examination include nervous signs, or where necropsy and/or complementary testing results identify a cause capable of inducing a neurological symptomatology, or, in the absence of one or more of the preceding, specific tests of the central nervous system are carried out' (123).

There are several criteria for the classification of NEDs, depending on the objective. Various approaches have been considered. The choice may involve clinical signs and duration of their development (6, 11, 17, 111, 122, 127, 132, 135, 153), histopathological examination of the brain (73, 133), ante mortem (11, 57, 58, 140) or post mortem (62, 111) complementary testing, or, lastly, the results of treatment (11, 111, 143). The aetiological diagnosis of neurological disorders is also necessary to identify herd problems or errors in livestock management (6).

Specialised decision-support tools have been developed in recent years. The clinical signs observed during the clinical examination of an animal may be entered into a software program that provides a list of possible diagnoses in alphabetical order (154). More recently, pattern-matching models have been proposed, taking account of 55 neurologically expressed pathologies present in the United Kingdom (33). These are based on the presence or absence of 14 easily recognisable clinical signs. Thus, apprehension and/or nervousness, hyperaesthesia and ataxia are the most frequently observed signs over a period of 15 days in cases of bovine spongiform encephalopathy (BSE). This clinical profile corresponds to that described in other European countries (14, 36, 85, 124, 125, 130, 148, 149, 152, 155).

The purpose of this article is to establish, in bovines aged twelve months or more, a classification of NEDs that may be found in Western Europe based on aetiology, age, frequency, circumstances of onset, and the main clinical signs observed. For the sake of clarity, the aetiologies have been grouped in categories. The biological causes are sub-divided into parasitic, mycotic, bacterial, viral, and non-conventional transmissible agents. The non-biological causes are sub-divided into mechanical, physical, chemical, metabolic and nutritional,

genetic, and immune. A final category has been added: non-specific or unknown causes. The differential diagnosis of neurologically expressed disorders is an essential part of clinical epidemiological surveillance of BSE (78).

Biological causes

Parasitic diseases

Parasitic NEDs (128) are seldom or occasionally found in Western European bovines (Table I). They are most often caused by an inappropriate treatment (hypodermosis), specific regional conditions (babesiosis), management errors in overpopulation conditions (coccidiosis), or the transmission of an infectious agent to an intermediate host (toxoplasmosis) (46). To a lesser extent, nematodes (128), cestodes (56) and protozoa (15) may provoke NEDs.

Mycotic diseases

Certain fungi may colonise plants and produce tremorgenic mycotoxins (127). When fed to bovines, these plants may cause NEDs (34, 90, 116, 142, 158). Ergotism is a well-known example (see 'Chemical causes' under chapter on non-biological causes).

Bacterial diseases

Bacteria are the most frequent biological causes of NEDs, after viruses in countries where rabies has been enzootic (123). The principal bacterial diseases (Table II) are: listeriosis (73, 79, 92, 99, 135); thrombotic meningo-encephalitis, which affects mainly young bovines (133, 135); parahypophyseal abscess (133, 135, 143); tetanus (92, 135); and botulism (32, 68, 133, 135). Meningitis and/or purulent encephalitis are often the consequence of bacteremia; they are characterised by a succession of clinical signs corresponding to an initial period of excitation, followed by clinical signs resulting from cessation of function (11, 93). Sinusitis (consequent to dehorning, horn or tooth breakage) or otitis may induce NEDs as a result of tissue contiguity (70, 109). Enterotoxemia, less frequent in adult bovines, may also cause subacute forms of NEDs (6, 11, 100). Acquired hydrocephalus, which may be inflammatory, is exceptional in ruminants and is characterised by permanent immobility, occasionally interrupted by episodes of excitation (11, 93).

A significant increase in the number of cases of listeriosis was observed in Switzerland because of its clinical picture and age distribution similar to those in BSE (74). The prevalence of listeriosis in dairy cattle was estimated at 11.7% in England (confidence interval 95%: 9.6%-14.6%) (51). In several countries, the first cases of BSE were diagnosed following suspicion of listeriosis (23). Based on the results of histopathological examinations, a significant increase in the frequency of listeriosis was observed in winter and spring

Table I
Main parasitic causes of neurologically expressed disorders in Western European cattle over the age of 12 months

Disease and causal agent	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Hypodermosis <i>Hypoderma bovis</i>	+	Animals of all ages	Systemic insecticide administered at the time of larval migration in the spinal canal (after mid-December) Stiff, unstable gait followed by paralysis	11
Neurological form of coccidiosis <i>Eimeria</i> sp.	++	Young animals	More frequent in rainy summers Housed or confined animals Neurological form seldom encountered Fetid, mucoid, bloody diarrhoea Muscle tremors Nystagmus Hyperaesthesia Decubitus with convulsions Opisthotonus	6, 11
Furious form of babesiosis <i>Babesia divergens</i>	++	Adult animals	Linked to certain regions due to: – presence of ticks – particular plant communities (hedges, shrubs) – vertical transmission to tick offspring Linked to warm seasons (increased tick activity) The following three symptoms are characteristic: – high fever, up to 42°C – hemolytic icterus (pale yellow mucosae) – hemoglobinuria ('chocolate brown'-coloured urine) Severe depression (prostration) Sharp drop in milk production Anaemia Occasional neurological disorders due to anoxia and, when chronic, due to hepatic coma – teeth grinding – motor incoordination, ataxia – frenzy – convulsions and coma	1
Neurological form of toxoplasmosis <i>Toxoplasma gondii</i>	+	Cattle seem rather resistant	Encephalitis and pneumonia: – raised temperature – dyspnea – ataxia – hyperexcitation followed by lethargy	1, 11, 46

+ rare

++ occasionally encountered

(125). This observation is reported several times in scientific literature (51, 54, 73, 105, 122, 153). The explanation given is foodborne, specifically, the consumption of poorly preserved silage or over-consumption of silage (11, 64, 105, 122). Listeriosis may produce cases of collective foodborne infection (129).

Viral diseases

Owing to a rabies enzootic that occurred in several Western European countries, viral causes (Table III) were for a long time the most frequent causes of neurological diseases (123). In at least two countries, the first case of BSE was diagnosed following suspicion of rabies (74, 149). Rabies must be considered in the differential diagnosis of BSE (59), although

the course of disease is usually shorter, less than one week (150). In Belgium, all invalidated rabies suspected cases are also analysed for BSE (124, 125, 149).

Since most Western Europe countries are now recognised as rabies-free (113, 160), one might think that viral diseases play a lesser role in NEDs. Nonetheless, several diagnoses of viral aetiology have recently been made in bovines over 12 months presenting non-purulent meningo-encephalitis: bovine viral diarrhoea virus in a 26-month-old bovine (125); bovine herpesvirus 1, responsible for infectious bovine rhinotracheitis, in a 44-month-old animal (121, 125); and ovine herpesvirus 2, responsible for bovine malignant catarrhal fever, in three animals aged 12-18 months, of which two had been in contact with sheep (43). Epidemics of bovine herpesvirus 5

Table II
Main bacterial causes of neurologically expressed disorders in Western European cattle over the age of 12 months

Disease and causal agent	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Listeriosis <i>Listeria monocytogenes</i>	+++	Adult animals	<p>Mostly in winter and spring</p> <p>Abortion, mastitis, septicaemia in calves</p> <p>Temperature over 40°C</p> <p>Clinical signs are usually unilateral</p> <p>Paralysis of the facial nerve (VII):</p> <ul style="list-style-type: none"> – ptosis of the ear, upper eyelid and lower lip – presence of feed on one side of the mouth – unilateral ptyalism <p>Paralysis of the trigeminal nerve (V):</p> <ul style="list-style-type: none"> – facial hypoalgesia (poor or no response to stimuli) <p>Paralysis of the vestibular nerve (inferior root of the auditory nerve VIII):</p> <ul style="list-style-type: none"> – head bent to one side – rotational gait (always the same direction) <p>Hemiparesis</p> <p>Terminal phase: sternal decubitus with persistent rotational movement (circular arrangement of bedding)</p> <p>Good response to early therapy with antibiotics, especially in young animals (penicillins or tetracyclines)</p>	51, 54, 73, 74, 79, 92, 99, 105 122, 124, 135
Tetanus <i>Clostridium tetani</i>	++	Animals of all ages	<p>Soil-borne</p> <p>Anamnesis: wound, dehorning, surgery, retained placenta</p> <p>Causal organisms multiply in erosions of the mucosae or in deep or covered wounds (anaerobic conditions)</p> <p>Incubation period: 1 to 3 weeks, but sometimes longer</p> <p>Generalised muscle stiffness (bilateral spastic paralysis):</p> <ul style="list-style-type: none"> – impaired prehension of food and water – trismus – prolapse of the third eyelid – stiff, backward-drawn ears – extension of the head and neck (deer-like appearance) – raising of the tail (constant) – persistent tympany (not constant) – absence of any tendency to lie down (saw-horse stance) <p>Hyperaesthesia to noise, light and touch</p> <p>Lateral decubitus in the final stage:</p> <ul style="list-style-type: none"> – limbs in spastic extension – all hopes for cure disappear 	92, 135
Botulism <i>Clostridium botulinum</i>	++	Animals of all ages	<p>Causal organisms multiply in rotting animal matter (cadavers and their remains)</p> <p>The multiplication of <i>Cl. botulinum</i> is also possible in grass silage, especially if the pH is alkaline and in anaerobic conditions</p> <p>Flaccid, progressive and bilateral muscle paralysis:</p> <p>a) in the classical (anterior) form:</p> <ul style="list-style-type: none"> – ears and upper eyelids sag – the mouth opens easily and the tongue hangs – dysphagia (water, food) – myosis <p>b) In the non-classical (ascending) form:</p> <ul style="list-style-type: none"> – the tail hangs (like a 'swing') – no anal contraction upon rectal touch – unsteady, stumbling gait – hindlegs paresis, evolving subsequently forward – followed by decubitus (chin on the ground, tail stretched backward) <p>Abdominal respiration in terminal phase</p> <p>Death in a few days due to respiratory paralysis</p>	32, 68, 133, 135
Infectious thrombo-embolic meningoencephalitis <i>Haemophilus somnus</i>	+++	Fattening cattle	<p>One to four week incubation period</p> <p>10% morbidity and 90% mortality</p> <p>Respiratory disorders previous to neurological disorders: coughing, nasal discharge, salivation (not necessarily in the same animals)</p> <p>High fever (septicaemic phase), followed by normal temperature</p> <p>After a few hours: ataxia, locomotor incoordination followed by decubitus</p>	133, 135

Table II (contd)

Disease and causal agent	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
			Eyelid closure is characteristic, but the animal can still see Sometimes divergent unilateral strabismus Severe depression (apathy despite strong auditory or tactile stimulation) Persistent salivation and nasal discharge Paralysis of the tail, anus and bladder (detectable by rectal touch) Septicaemia induces polyarthritis (large joints) Course ends in death within a few hours to three days	
Meningitis and/or encephalitis	+++	Usually young animals	High temperature Acute meningitis is usually associated with encephalitis as a result of tissue contiguity Two phases are described, but they are often successive or simultaneous: – cortical inflammation (initial period of excitation) followed by – cortical destruction (arrest of vital functions) Initial period of excitation: – psychic disorders: hyperexcitability – sensory disorders: hypersensitivity to noise, light and touch – motor disorders: clonic convulsions, stiffness, nystagmus, trismus, myosis, rictus, teeth grinding, chewing, opisthotonus Arrest of vital functions: – psychic disorders: depression (immobility, indifference, somnolence) – sensory disorders: hyposensitivity to noise, light and touch – motor disorders: stumbling gait, paresis/paralysis – loss of neuro-vegetative functions (incontinence)	11, 93
Parapituitary abscess	++	Animals of all ages	Anatomic predisposition due to the large peripheral venous network Often results from an incorrect position of nose ring (necrosis of the septal cartilage) or a dehorning complication (sinusitis) Circumscribed metastatic abscess More or less clear paralysis of the lower jaw Trembling of the jaw and the muzzle Swallowing difficulties (dysphagia) Appetite and thirst are preserved, but: – some water flows out of mouth – some food balls up Interest in the environment is preserved or only slightly altered Treatment is ineffective	133, 135, 143
Sinusitis	+++	Animals of all ages	By tissue contiguity Following dehorning, horn or tooth breakage Fever Depression One or two eyelids are swollen and sagging One consequence may be a parapituitary abscess	70
Otitis	+++	Young animals	By tissue contiguity Fever and depression Head rotation downward and toward the affected side Tendency to move in a circle in the direction of the affected side Facial paralysis on the affected side may be observed	109
Enterotoxemia <i>Clostridium perfringens</i>	+++	Suckling calves Fattening cattle	Often peracute: death without clinical signs In the subacute form, the following clinical signs may be observed: – salivation, colic – constipation / diarrhoea – fleeting excitation/predominant depression – decubitus, pedalling movements – opisthotonus and coma Autopsy: haemorrhagic segmentary enteritis, often accompanied by a satellite adenitis	6, 11, 100
Acquired hydrocephaly *	+	Usually young animals	Retention and hypersecretion of cerebro-spinal fluid most often resulting from an ependymitis, meningitis or ventriculitis Considered internal when it affects the internal cavities Considered external when it affects the subarachnoid spaces Causes permanent immobility, rarely interspersed with excitation Often the result of an autopsy finding, while not necessarily the cause of death	11, 93

+ rare

++ occasionally encountered

+++ less frequently encountered

++++ frequently encountered

* often of inflammatory origin

Table III
Main viral causes of neurologically expressed disorders in Western European cattle over the age of 12 months

Disease and causal agent	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Rabies <i>Lyssavirus</i> , <i>Rhabdoviridae</i>	++	Animals of all ages	Most Western European countries are currently recognised as rabies-free Incubation period 20 to 150 days or more (average: 35-45 days) Disease course is generally two to six days Not all clinical signs are always present Prodromic phase (a few hours to a few days): – anorexia, slight hyperthermia and sudden reduced milk yield – salivation (clear and thready saliva), hoarse and biphasic bellowing – aggressiveness (rare in cattle), paresis or paralysis Furious phase: – alteration of behaviour with irritability, hyperexcitability, tenesmus and bellowing – does not refuse water or food, but swallowing is impossible Terminal phase: – paresis, paralysis, dehydration (rapid weight loss), prostration and opisthotonus	1, 138, 150
Aujeszky's disease Suid herpesvirus 1 <i>Herpesviridae</i>	+	Animals of all ages	Transmission by direct or indirect contact with pigs (slurry, material, personnel) Airborne transmission is possible, especially where pig density is high The incubation period is three to six days Outcome is always fatal (in a few hours, or 6 days at the most) The first clinical sign is nasal discharge Two to three days later, cattle present dyspnea, ptyalism and tympany The animals drink abundantly The neurological signs appear later: – muscle tremors and stamping of feet – cattle lie down and get up ceaselessly – they wag their tail, and have alternate episodes of excitation and bellowing with depression – there is no aggressiveness The predominant clinical sign is intractable pruritis: – located at certain places (muzzle, shoulders, limbs, belly) – infected animals try to relieve pruritis by all means: licking, scratching, rubbing, resulting in self-mutilation Concurrent mortality of one or more cats on the farm is an indicator	123, 138, 159
Malignant catarrhal fever ^(a) Ovine herpesvirus 2 <i>Herpesviridae</i>	++	Adult animals	The European bovine form is associated with sheep Sheep are asymptomatic carriers of the virus The lambing period is propitious to viral dissemination Horizontal transmission in cattle has not been described Incubation lasts a few weeks to a few months Marked febrile syndrome and prostration Muzzle covered by foetid necrotic fibrinous substance Blood vessel congestion is visible (brick-red mucosae) Ulceronecrotic lesions of the digestive and nasal mucosae Polyadenomegaly Cutaneous lesions appearing as raised crusts Acute ulcerative pericoronaritis Diarrhoea or dysentery Rare and inconstant neurological disorders: – muscle fasciculation – motor incoordination – nystagmus – general weakness and refusal to walk – teeth grinding	25, 35, 43, 92, 126, 138
Bovine viral diarrhoea Bovine pestivirus <i>Flaviviridae</i>	+	6-24-month-old cattle	Mucosal disease triggered by exogenous or endogenous superinfection (mutation) of the infected permanently immunotolerant (IPI) calf by a cytopathogenic strain of the bovine viral diarrhoea (BVD) virus, presenting moreover the same antigen characteristics as the non-cytopathogenic strain in the IPI There is no neurological form described in the mucosal disease However, isolations of the BVD virus on brains of cattle aged over one year with suspicion of BSE, subsequently disproved, were made	125, 138

Table III (contd)

Disease and causal agent	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Infectious bovine rhinotracheitis Bovine herpesvirus 5 (BoHV-5) Bovine herpesvirus 1 (BoHV-1) <i>Herpesviridae</i>	+	Usually young animals	BoHV-1 is capable of causing encephalitis in three to eight-day-old calves: – following a phase of excitation, without hyperthermia, the calf presents a period of depression accompanied by blindness – respiratory and general symptoms are associated – recovery is rare, and death occurs 3 to 4 days following the appearance of the first clinical signs – however, viral isolations of BoHV-1 on brains of cattle aged over one year with suspicion of BSE, subsequently disproved, were made The BHV-5 causes encephalitis in calves aged over 10 months – experimental infection of adult cattle is possible – BoHV-5 infection of cattle is rare in Western Europe	104, 121, 125, 138, 154
Borna disease Bornavirus <i>Bornaviridae</i>	+	Adult animals	Disease is more frequent in horses and sheep Infection is frequently non-apparent in cattle The clinical signs appear after a lengthy incubation period in the form of a progressive encephalopathy: – alternating phases of excitation and somnolence – ataxia, proprioception deficits, ocular disorders – death occurs three weeks after the beginning of the clinical phase	12, 38, 87, 96, 102, 110, 138, 163
Enzootic bovine leukosis Bovine leukosis virus <i>Retroviridae</i>	+	Usually adult animals	Many infections are subclinical A clinical diagnosis is only possible in the tumoral phase 0.1%-10% of infected cattle develop the tumoral phase, as opposed to sheep, in which all individuals develop tumours and die within five to seven years following inoculation In most cases, the tumours affect the lymph nodes (one or more), and may spread to all sorts of organs The symptoms, when visible, are the consequence of compression caused by tumours	138
Louping-ill Louping-ill virus <i>Flaviviridae</i>	+	Adult animals	Affect mainly sheep Transmitted by the <i>Ixodes ricinus</i> tick The infection is usually subclinical Amongst the infected animals, only some present central nervous system disorders characterised by ataxia, paralysis, coma and death	138
Bovine immunodeficiency Lentivirus <i>Retroviridae</i>	++++ ^(b)	Adult animals	The incubation period is long, from three to five years Leucocytosis Lymphadenopathy with follicular hyperplasia Cutaneous lesions resistant to treatment Meningoencephalitis	9, 18, 28, 81, 131, 134, 138

+ rare

++ occasionally encountered

+++ frequently encountered

a) malignant catarrhal fever associated with sheep

b) seropositive cattle exist in many of the countries under study, viral strains isolated in limited numbers

encephalitis have been described mainly in Australia, Argentina, Brazil and the United States of America. The virus has been identified in Hungary and Germany. However, many of the herpesvirus strains isolated in clinical cases of bovine encephalitis have not been characterised. It is likely that the distribution of bovine herpesvirus infections is wider than the isolation results indicate (104, 138).

The clinical signs of bovine malignant catarrhal fever are dominated by marked febrile syndrome, ocular keratoconjunctivitis and uveitis lesions, ulceronecrotic lesions of the digestive and nasal mucosae, and polyadenomegaly (25, 126). Acute ulcerative pericoronitis has also been observed (43). Clinical neurological signs in bovine malignant catarrhal fever are variable and infrequent (126), and often consist of

muscular fasciculations (25, 35, 126), motor incoordination (35) and nystagmus (25). General weakness with refusal to walk and grinding of teeth has also been described in bovines (43).

Borna disease is rare in bovines, as opposed to horses and sheep (96, 138). However, the Borna disease virus has been found in healthy cattle in Germany (87, 102, 163), Switzerland (27) and Japan (71). More recently, Borna disease was diagnosed in cattle with NEDs in several countries: Germany (12), Switzerland (26), France (38), and Japan (110). The clinical picture partly resembles that of BSE (96). Moreover, the detection of antibodies, antigens and/or the viral genome in nerve tissue of deceased humans having presented severe psychiatric disorders triggered a debate over the possible involvement of this virus in the aetiology of

neurological disorders and the possibility of viral transmission from animals to man (38, 96, 138).

The louping-ill virus is transmitted by the *Ixodes ricinus* tick. The infection is most often subclinical. Amongst infected animals, only a few present central nervous system disorders characterised by ataxia, paralysis, coma and death (138).

Enzootic bovine leukosis may induce NEDs. Several Western European countries are officially recognised as free of the disease by the European Commission (53). Animals imported from countries not yet officially recognised as disease-free should be monitored. Finally, cattle in contact with swine may contract Aujeszky's disease (118, 123, 138, 159). The risk has been decreasing over time as a result of swine herd qualification plans and a strict, and compulsory, separation of production units. However, sporadic cases may persist due to contact with wild boars, as has been demonstrated with hunting dogs in Germany (8).

The bovine immunodeficiency retrovirus (BIV) belongs to the genus *Lentivirus*; the incubation period is three to five years (138). Seropositive bovines have been found in all countries examined (28, 81, 117, 131). Leukocytosis, lymphadenopathy, meningo-encephalitis and lesions resistant to treatment have been found in naturally or experimentally infected bovines (9, 18, 134, 138, 151).

Non-conventional transmissible agents

The non-conventional transmissible agents have been provisionally classified with biological causes. Since its first clinical description in 1986 (152), BSE has affected many European countries (47, 67, 75, 114, 149, 155, 156). The disease occurs in adult bovines, with an age frequency peak in animals four to five years old (155). To date, the youngest bovine with BSE clinical signs was 20 months old and the oldest was 19 years and 9 months old (42). The duration of the clinical disease, from the earliest symptoms until death or slaughter, may be under two weeks (85, 98, 124, 153) or as long as one year (85). The average length is about one or two months (85). The frequency of clinical neurological signs observed in 164,771 bovines with BSE was determined by Wilesmith (155). In over 50% of the cases, the following disorders or anomalies are observed:

- a) psychic disorders: apprehension, temperament change, abnormal ear position, and abnormal behaviour
- b) sensitivity disorders: hypersensitivity, excessive licking
- c) postural and locomotory anomalies: ataxia and tremors.

A large majority of diseased animals present clinical signs falling into all three categories. Moreover, certain general signs may be associated with BSE: loss of physical condition, weight loss and reduced milk yield. Considerable individual variation has been reported in the presence and intensity of clinical signs. If

animals are kept in a calm and familiar environment, the intensity of clinical signs, in particular hyperaesthesia, is diminished. After a few weeks, the clinical signs lead gradually to repeated falls, then to permanent decubitus and eventually death (85).

Bovine spongiform encephalopathy detection depends on observation of the clinical signs (155) and/or requires active surveillance based on detection of the abnormal prion protein PrP^{Sc} through rapid immunological tests on samples from the central nervous system, either post-mortem or at the time of slaughter (107, 108, 114). Confirmatory diagnosis requires histological examination of the central nervous system demonstrating a spongiform appearance of the brain, extraction and examination of scrapie-associated fibrils (SAF test), immunohistochemistry, or a Western-blot test (85, 155).

The new variant of the Creutzfeldt-Jakob disease (vCJD) was first identified in the United Kingdom in 1996 (157). It was subsequently shown that the pathogen strain responsible for vCJD is very similar to that of the BSE agent (19, 77). Several articles have been written on the subject (for example, 162).

Non-biological causes

Mechanical causes

The probability of the occurrence of mechanical causes increases with age. Traumatic pathologies of the nervous system are relatively rare in livestock (73), except in heavy animals which may suffer damage from riding and falls (44). Vascular disorders are seldom observed in animals (73). Fractures of the skull or spine, (sub)luxations and medullar compressions are most often characterised by hyperaesthesia of the segment located immediately before the localisation of the lesion, paresis or paralysis, and insensitivity behind the localisation of the lesion. Peripartum accidents are due either to overweight causing trauma in the lumbo-sacral vertebræ, lesions of the birth canal during parturition (paresis or paralysis), or more often ischaemia as a result of prolonged decubitus (postpartum paraplegia). Ossifying spondylosis may be observed in aged and heavy bulls (6). Intense pain induced by a foreign body may also cause a NED.

Neoplastic neurological pathologies are rare in cattle (55, 73, 99, 161). The shorter life span of cattle in present conditions may be an explanation. Based on abattoir surveys, their frequency in France has been estimated at 0.1 to 10 tumours per million animals (69). In Belgium, only one cerebellar neuroblastoma was identified in a total of 375 histopathological examinations performed in the BSE epidemiological surveillance network during 1998 and 1999 (124, 125).

Physical causes

Physical causes are rather rare. Sunstroke and heat stroke are included here because they frequently lead to cerebral oedema

(93). They affect young animals most often because of their high body surface to weight ratios. However, older, fatter animals confined during transport or insufficiently watered may also be affected by these conditions. Lightning strike or electrocution cause a shock to the nervous system that leads most often to instant death or, occasionally, to temporary unconsciousness with or without neurological sequelæ (11).

Chemical causes

Historically, chemical causes come in second place amongst the non-biological causes of NEDs in Western Europe (123). The range of potential toxins in the environment of adult ruminants is wide (31, 41). Cases of poisoning seem to be most frequent in spring and summer due to phytosanitary treatments and putting cattle out to pasture (41). Moreover, the innate curiosity of cattle, their fondness for licking, and their hearty and indiscriminate appetite make them prime targets (6, 20). The most common chemical intoxications that provoke NEDs include salt (in maritime regions), lead, organophosphates and carbamates, as well as certain plants. The relative importance of a certain number of toxics such as heavy metals and metalloids, as well as other industrial or non-industrial toxics (lead, arsenic, mercury, strychnine and cyanides) tends to decline due to improved information and prevention. Nonetheless, individual cases of poisoning by certain pollutants can never be ruled out, and may have serious economic, medical or social repercussions. Particular attention must be paid to this problem, in order to minimise the risk to livestock and thus to the consumer. Lead poisoning remains one of the most frequent types of poisoning (5, 41). Acute lead poisoning is characterised by amaurosis, pressing against objects and blindness which, in cattle, takes the form of a 'radar' ear position, wandering and motor incoordination, accompanied by depression or convulsions. Diarrhoea or constipation, cessation of rumination and tympany may also be observed. 'Empty-mouthed' mastication, along with frothing at the mouth, is a very suggestive sign, and is why lead poisoning is also known as the 'chewing disease'. Chronic poisoning is characterised by anorexia, cessation of rumination, tympany, inhibited growth, decline of general condition as well as mild to moderate anaemia accompanied by an increase in protoporphyrinemia (135). Abortions and nasal discharge may also be observed. Biocide poisoning has become less frequent in cattle due to more rational use (119, 136). However, certain breeds such as the Charolais seem more sensitive to organophosphate or carbamate poisoning (95). The clinical signs observed in this case are attributable to esterase inhibition. This inhibition leads to variable combinations of muscarinic signs (vomiting, diarrhoea, salivation, urinary incontinence, lachrymation, broncho-constriction, tympany, myosis, bradycardia), nicotinic signs (tremors, convulsions, paresis and paralysis) and central nervous system signs which are of later onset and less often observed (hyperexcitation, depression, prostration, coma). The medical use of organochlorines has been severely limited since the sale and use of products containing lindane as their sole active ingredient have been

prohibited. Some ear-treatment products for specific pet animals still contain lindane. Its continued use in agriculture may cause clinical poisoning through contact or ingestion. In this case, the clinical picture is characterised by agitation, muscular fasciculations, ataxia, convulsions and hyperthermia (22).

Poisoning by chlorates, nitrates, or chronic exposure to copper (especially in young calves) leads to a rise in methemoglobin level, bringing about a drop in cell oxygenation. Cyanosis, blackish, relatively uncoagulable blood, and a compensatory tachycardia are observed, and are accompanied by dyspnea and somnolence (11). Death occurs when the level of methemoglobinemia reaches or exceeds 80%. Chlorates constitute a total herbicide with low toxicity for bovines (22), but they are very attractive and thus may be consumed in large quantities (40). As for metaldehyde poisoning, a very common molluscicide, it is much less frequent in cattle (20) than in domestic carnivores, which often consume baits set unlawfully to poison them. Affected ruminants present digestive (salivation, diarrhoea) and neurological (muscle tremors, convulsions, ataxia) disorders. Blindness may also be observed (22).

Nitrates, transformed into more toxic nitrites in the rumen, may at times cause cases of poisoning following ingestion of plants, such as rape, cabbage, beetroot, turnips and rye-grass, that have become too nitrate-rich due to various unfavourable environmental or climatic conditions such as humidity or early frost (41, 80, 95). Excessive use of fertilisers and phenoxy acid herbicides, and water pollution may also be significant contributors to this form of poisoning. As with chlorates, nitrite toxicity is linked to its irritating effect on the mucosae and to its methemoglobinising action (62).

Many plants containing toxic substances can be found in nature (20, 39). The respective frequency of each depends on the biotope encountered. With some exceptions (e.g. *Atropa belladonna*) the only treatment for plant poisoning is symptomatic (22). If the animal dies, an autopsy and a determination of plant remains in the rumen or found on the ground may be useful to identify the risk and avoid new cases (41). In the event of a legal dispute, for example when hedge clippings are dumped on pasture land by a neighbour, botanical identification of the plants concerned may be considered insufficient, and a botanical and/or chemical identification of remains found in the animal may be necessary. Some of these toxic plants may be found in the countryside, and may cause NEDs. The following list is not exhaustive: yew (subacute poisoning by *Taxus baccata*) (22, 123), many cyanogenic plants (cherry-laurel, elder, flax, sorghum) (20, 22), oak acorns (95), rye-grass when colonised by *Neotyphodium* or *Acremonium* (10, 34), rye-grass when colonised by *Claviceps purpurea* (ergotism) (11, 62, 94), poison hemlock (6), box, thuja, black nightshade, deadly nightshade, yellow water dropwort, rhododendron, azalea and laburnum (20).

Due to heightened safety precautions, drug poisoning has become rarer. Drug poisoning may result from drug misuse or overdose, the use of unauthorised preparations, or a specific breed- or age-linked sensitivity. The main active ingredients that require special attention are: quinolones (147), nitrofurans whose use is prohibited (2, 52, 136), sulphonamides (62), lincomycin which may cause acetonemia (11, 120), aminosides (11, 37), as well as certain antiparasitics, antiprotozoals, or anthelmintics such as avermectin and milbemycin derivatives (e.g. moxidectin) (unpublished clinical observations), salicylanilids that may cause blindness (11, 146), amprolium (145), levamisole/tetramisole (45) and organophosphates.

Metabolic and nutritional causes

Metabolic diseases (88) are functional disorders, generally not accompanied by lesions in nervous tissue (6, 103). They constitute a major problem in cattle (73), and their relative frequency is the highest amongst the non-biological causes of NEDs (123). Since mortality is relatively low and, in many

cases, the cause and therapy are known, only 17% of cases are referred for further examination (73). Because of the early behavioural modifications involved, metabolic and nutritional pathologies (Table IV) intrude into the differential diagnosis of BSE (73, 83, 85, 130). An insidious course and relapse after treatment should prompt suspicion of BSE. Necrosis of the cerebral cortex is a metabolic disease that is sporadic in traditional livestock farming or enzootic in fattening cattle. It is caused by a disruption of vitamin B1 synthesis in the rumen, destruction of vitamin B1 by thiaminases, or excess sulphur in the feed. It most often affects animals older than 4 months (functional rumen) and younger than 24 months (73, 92). Cases have also been described in older animals (73). Blindness of central origin is observed. Due to a large rise in intracranial and intraspinal pressure, the animal stretches its head upwards. When it is still capable of walking, it adopts a parade step, goes in circles and hugs the walls. Ataxia and growing motor incoordination set in, followed shortly by decubitus (135).

Table IV

Main metabolic and nutritional causes of neurologically expressed disorders in Western European cattle over the age of 12 months

Disease	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Milk fever Puerperal hypocalcaemia Parturient paresis Puerperal paresis	++++	Mainly dairy cows	During the periparturient period (particularly the first post-partum weeks) Incidence estimated at 5 to 6 cows per 100 at risk per year Represents 70%- 80% of recumbent cows Cause: excess cations during drying-off period Three stages are conventionally described: Stage 1: the animal can stand up and remain standing – the udder is stretched in the absence of mastitis – an initial excitation and tetanic spasms may be observed Stage 2: sternal decubitus in self-auscultation most often (head in flank) – with anorexia, atony of the rumen and absence of defecation – followed by numbing (cold extremities) and reflex attenuation – eyes are fixed and sad, and pupils are dilated (mydriasis) Stage 3: decubitus becomes lateral with loss of consciousness, coma and death Response to calcium therapy is generally good (eructation is the first sign of improvement) Certain cases of milk fever require potassium and vitamin D	3, 6, 11, 61 66, 88, 89, 154
Grass tetany Hypomagnesaemia	+++	Heifers or cows	Especially in heifers or lactating cows Also in highly productive cows at the end of the dry period Or in cows after lengthy transport or stress More frequent in spring and autumn during consumption of young or second-cycle grass or grass to which a large quantity of fertiliser was applied (potash and nitrogen in the form of ammonium nitrate) Bulging eyes, teeth grinding Excitation, hyperaesthesia, backward ear movements Muscle fasciculation (shoulders, thighs), tetany Inconstant hyperthermia (observed especially during crises) Sudden death or convulsions Responsive to magnesium therapy, but failures are frequent Determination of urinary magnesium fraction is an early diagnostic method Magnesium determination may be performed in the aqueous humour until 48 hours after death (if outside temperature <23°C)	6, 11, 88 89, 97, 101, 154
Acetonaemia Pregnancy toxemia in meat cattle	++++	Dairy cows, meat cattle with protein and caloric malnutrition	From the beginning to the peak of lactation It is primary when the energy balance is negative (disequilibrium between intake and requirements) It is secondary when appetite decreases following another disease (lameness, mastitis, abomasal displacement)	50, 76, 88, 89, 154

Table IV (contd)

Disease	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
			<p>Reduced milk yield Appetite is capricious at first: concentrates and silages are ignored Followed by rapid and lasting weight loss No temperature Neurological symptoms are uneven, generally late and intermittent: – incessant licking, mastication and salivation – incoordination, circular movements, pressing against the wall – at times, tremors, tetany, passing delirium An odour of acetone may be detected in exhaled air, urine and milk Ketone bodies may be easily determined in urine, milk and blood Affected cows recover in 80% of the cases</p>	
Uraemia Renal insufficiency	++	Animals of all ages	<p>Terminal stage of renal insufficiency or acute or chronic renal inflammation Temperature is normal, or higher if of inflammatory origin Dehydration, anorexia, weakness Tachypnea and tachycardia Neurologically expressed disorders have been reported: – depression – muscle tremors, constant stamping of feet</p>	11, 88, 154
Excess non-protein nitrogen Alkalosis of the rumen Urea poisoning	++	Mainly dairy cows	<p>Often in the case of a clinical series The cause of poisoning is excess non-protein nitrogen (NPN) in the ration due to: – excess intake (dairy cows) or sudden shift to NPN intake – defective NPN distribution system (dairy cows) – accidental ingestion of nitrogenous fertiliser – an accumulation of NPN in grass when large quantities of fertiliser are used – or when the weather becomes suddenly cold (alteration of protein synthesis) Three to four weeks are necessary for the rumen microflora to adapt in order to be able to use gradually increased quantities of NPN. However, adaptation is rapidly lost (after 1 to 3 days) After ingestion, NPN is hydrolysed and absorbed if it is in excess with respect to the hydrocarbonated skeletons available in the rumen. It causes a hyperammonaemia if the liver can not fulfil its role in urea synthesis Most often peracute evolution (<4 hours) Anorexia, sudden reduced milk yield Constant stamping of (hind) feet, arched back (abdominal pain) Softened excrements (effect of NPN on the digestive mucosae) Some tremors and foamy salivation The cow lies down with difficulty, and no longer stands up Hyporeflexia, opisthotonus in the terminal phase Autopsy: myocardial petechiae, the small intestine is very congested with submucous suffusions Treatment: cold water to dilute and inhibit bacterial urease and vinegar to decrease pH</p>	11, 62, 106, 115, 154
Acute lactic acidosis of the rumen	+++	Animals of all ages	<p>Importance of anamnesis: free-roaming animal consuming large quantities of starch and soluble sugars without food transition (for example, fruit, cereals, beetroot, carrot roots, chicory, potatoes) or error in programming the automatic distribution of concentrates Anorexia, weakness, fatigue, depression Hyperpnea, tachycardia Atony of the rumen (tympany) with liquefaction of its content (milky appearance) Diarrhoea (yellowish foamy faecal matter), dehydration Tremors, inebriated gait Sternal decubitus</p>	88, 141, 154
Hepatic encephalopathy Hepatitis	+	Animals of all ages	<p>Neurological signs associated with hepatic disorders of toxic origin (mycotoxins, hepatotoxic plants, pyrrolizidine alkaloids of groundsel, copper) or chronic major hepatic parasitoses (distomatosis) Several factors responsible for neurological disorders may be involved (e.g. protein metabolic disorders with hyperammonaemia) Apathy, depression, lethargy Behavioural disorders: hallucination, furious attacks Convulsions and coma The SGOT and SGPT enzymes, alkaline phosphatase, SDH are greatly increased Total proteins drop</p>	11, 84, 88

Table IV (contd)

Disease	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Photosensitisation	++++	Animals of all ages with unpigmented skin and/or skin with light fur cover	<p>The least coloured and most exposed skins (back) are the most sensitive</p> <p>Ultraviolet light is always necessary to activate the photodynamic agents; daylight is sufficient, but the pathology most often occurs in sunny weather</p> <p>Activation of photodynamic agents produces energy and causes cutaneous lesions</p> <p>Photosensitisation is either primary when of exogenous origin:</p> <ul style="list-style-type: none"> – by food or contact – photodynamic agents may be plants (groundsel, buckwheat, certain varieties of clover and alfalfa) or drugs (phenothiazine, sulphonamides, tetracycline) <p>Photosensitisation is secondary when it is of hepatogenic origin: the phyloerythrin derived from anaerobic lysis of chlorophyll by rumen microorganisms. It is usually absorbed in blood circulation and subsequently eliminated by the hepatobiliary pathway. Any alteration in biliary excretion (extended fasciolosis, hepatic toxics) causes its accumulation in blood circulation and may then reach peripheral circulation in sufficient concentrations to induce photosensitisation</p> <p>The appearance of a single case should prompt suspicion of hepatic fasciolosis</p> <p>Hyperaesthesia of the affected depigmented areas</p> <p>Oedema, exsudate, necrosis and gangrene of exposed areas, according to the stage of development: especially the head (muzzle, eye contour), the teats, and the vulva (asymmetric oedema)</p> <p>When in pasture, the animal seeks shade (stabling is an integral part of treatment)</p> <p>Neurologically expressed signs accompany cutaneous disorders: state of intense prostration due to pain or hyperexcitability</p>	11, 94, 154
Salt or water poisoning	+	Animals of all ages	<p>Normal salt intake with insufficient or nil watering, followed by free watering (freezing of drinking troughs) or ingestion of seawater or overly salty food</p> <p>High-production dairy cows are physiologically more sensitive</p> <p>Induces a cerebral oedema</p> <p>Acute poisoning:</p> <ul style="list-style-type: none"> – mucous diarrhoea, polyuria – nystagmus, blindness, opisthotonus – tremors, paresis – decubitus after convulsions – death 24 to 48 hours following the first clinical signs <p>Chronic poisoning:</p> <ul style="list-style-type: none"> – inappetence, weight loss, dehydration – weakness, diarrhoea – collapse and tetanic convulsions under effort 	6, 11, 88
Necrosis of the cerebral cortex (NCC)	+++	Mainly animals aged 4-24 months	<p>Becoming rarer thanks to improved information</p> <p>Due to a vitamin B1 metabolic disorder:</p> <ul style="list-style-type: none"> – either due to insufficient production by the rumen flora – or to lack of resorption – or in the presence of thiaminases (food, piperazine derivatives) <p>Modifications of the rumen flora disrupt vitamin B1 production</p> <ul style="list-style-type: none"> – change in diet – temporary interruption of watering <p>No temperature increase</p> <p>Isolation from the rest of the herd</p> <p>Blindness of central origin:</p> <ul style="list-style-type: none"> – by day as well as by night – absence of palpebral reflex and presence of pupillary reflex (unlike the last stage of vitamin A deficiency) – the animal bumps into obstacles, goes around in circles hugging the walls (circular arrangement of bedding) <p>Dorsomedial strabismus</p> <p>Increased intracranial and intraspinal pressure (astronomer's disease) causes animal to stretch its head upward</p> <p>When still able to walk, adopts a parade step</p> <p>Loses interest in its surroundings</p> <p>Sternal or lateral decubitus with pedalling movements and opisthotonus</p> <p>Death occurs within three to ten days</p> <p>Good response to the administration of vitamin B1 in early treatment</p>	6, 73, 92, 127, 135

Table IV (contd)

Disease	Frequency	Age and type of animals	Condition of appearance and main clinical signs	References
Vitamin A deficiency	++	Mainly young animals	Vitamin-A-poor diet over a long period and without a vitamin-mineral complex complement (corn silage, dry pulps, cereals, linseed cake) Drop in crepuscular vision in the early stage Disappearance of palpebral and pupillary reflex, unlike with NCC Very frequent neurological disorders: convulsions followed by paralysis	6, 11, 88
Vitamin E/selenium deficiency	+++	Mainly young animals	Generally, myopathy-dyspnea occurs in young animals but may also be observed in older ones Spastic paresis	11, 144

+ rare
 ++ occasionally encountered
 +++ less frequently encountered
 ++++ frequently encountered

Genetic causes

Genetic diseases in cattle are many and varied (6, 62). Intensive breeding within a small pool of elite subjects serves to increase the diversity and frequency of such disorders (6, 137). In general, animals suffering from such anomalies die or are slaughtered before the age of 12 months (73, 91, 133). Progressive ataxia of Charolais cattle (6, 62) has been described in 8 to 24-month-old animals. Periodic spasticity affects bovines aged 3 to 7 years (6, 11) whereas idiopathic epilepsy generally affects bovines under the age of two years (11). Mannosidosis (7, 21, 49) and bovine progressive degenerative myeloencephalopathy, still known as Weaver syndrome, mainly affect cattle under the age of one year, but have also been observed in older animals (13, 48, 91, 112, 137). Blindness has been observed in a 14-month-old Devon cow presenting neurovisceral lipofuscinosis (11, 72).

Immune causes

Amongst the immune causes, drug allergies are the most frequent. They tend to have become rarer thanks to the production of vaccines in cell cultures instead of embryonated eggs. The incidents observed are acute, not very specific and the clinical expression is highly variable. Motor incoordination may be observed (4).

Non-specific or unknown causes

A considerable percentage of NEDs are of unknown origin because the high cost of an aetiological diagnosis is a disincentive. The figure has been estimated at 39% of animals with suspected rabies in Switzerland (54), and 40% of bovines for which neurological disorders were reported in a veterinary diagnostic laboratory in Belgium (123). Certain cases

presenting no pathological alteration were probably metabolico-toxic in nature, as proposed by McGill and Wells (99). Statistics from the Animal Neurology Institute of the University of Bern show that the percentage of undiagnosed cases has decreased over time, thanks to experience and the use of improved analysis techniques (73). Several entities of unknown origin have been described in the course of differential diagnosis of BSE: epileptiform convulsions in adult cattle (16, 93), a neuronal chromatolysis and necrosis of the brain stem nuclei with or without sclerosis of the hippocampus in bovines aged six to sixteen years (82).

Discussion and conclusions

A classification of NEDs that occur in Western European cattle aged 12 months and over has been established on the basis of aetiology, frequency, age and type of animals concerned, conditions of appearance and the principal clinical signs observed. Infrequent NEDs are more often described in scientific literature due to their novelty. Account has also been taken of the experience acquired by the veterinary profession. To create the classification, a preliminary table was distributed to a restricted circle of veterinary practitioners and diagnostic laboratories with a particular motivation for the subject. These were asked to use the table in their daily practice and offer critical suggestions. The classification is also useful to the practising veterinarian facing a clinical presentation whose differential diagnosis includes BSE. As many as 85 aetiologies for NEDs have been listed. Other classifications are available, according to the approach used; for example, there is one based on anatomo-pathological diagnoses (73).

The clinical expression of NEDs in an animal depends on several parameters: the nature of the causal agent (dose, virulence) (129), the location of induced lesions (63, 111), the host (resistance, general condition, immune status) and the

environment; certain clinical signs may be exacerbated when the environment of the animal is altered (85, 124). The quality of observation plays a prime role, and is proportional to the breeders' and veterinarians' level of information, awareness and training. The intensity of observation is also important, and seems to depend directly on herd size. According to NAHMS, the rate of neurological problems in breeding females in beef herds, expressed in affected bovines per thousand, doubles when herd size is less than 100 head, and is nil when herd size is over 300 (30). In addition to these parameters, there is a degree of variability that depends on the individual animal and the observer (clinical picture, pre-patent phase, course of disease).

To improve knowledge regarding NEDs, it is important:

- a) to improve awareness, training, and information available to breeders and veterinarians
- b) to use a uniform method for clinical examination
- c) to make more systematic use of diagnostic tests
- d) to create sentinel networks of highly-motivated breeders and veterinarians
- e) to transcribe the results of observations in a codified and standardised form, as regards both nature and course
- f) to compile existing information
- g) to enrich a relational database
- h) to discuss actual experience.

A typology or systematic classification of neurological disorders will then be established, and the risk factors highlighted. Two networks of this sort were initiated in 2000: one for bovines over the age of 12 months in Belgium (L. Xambeu, personal communication), and one for bovines over the age of 18 months in France (24). The viability of these networks will depend on the degree of voluntary participation by breeders and veterinarians, on the analysis of data obtained, and on the degree of positive feedback (dissemination of summary and specialised reports amongst the network players).

Neurological pathologies are rare in veterinary practice (65), and aetiological diagnoses are rarely made (58), as they are time-consuming and relatively costly (6). To gain greater knowledge on the subject, outside sources of funding should be provided to cover research in aetiological diagnosis. The knowledge to be gained is, and will remain, especially useful with regard to TSEs, as it will, on the one hand, help remove contaminated animals from the food chain and, on the other, provide a fuller picture of the polymorphic clinical expression of these diseases. Incidentally, incubation periods and clinical pictures may be modified or even attenuated in the eventuality of interspecies transmission of the TSEs (60). Likewise, it is known that wild ruminants in captivity with BSE present

clinical signs similar to those of farm animals, but the duration of illness is shorter, in the order of a few days (86). Consequently, advances in knowledge about neurological disorders and the enhancement of existing epidemiological surveillance and monitoring networks in the different countries are priorities.

Proper aetiological diagnosis require clinical examination using standardised methodologies, a complete anamnesis, and appropriate complementary tests. Although great progress has been made in veterinary neurology, the collection and systematic analysis of data can still be improved. It is unfortunate that the establishment of diagnoses and the conduct of epidemiological investigations are often hindered by difficulties in obtaining histories (6, 73). An aetiological diagnosis serves several purposes:

- a) to classify pathologies on the basis of frequency, and thus to give due consideration to those most frequently encountered and to the risk factors that allow their control
- b) to keep up-to-date on new pathologies and improve our understanding of them
- c) to assess the appropriateness of clinical diagnoses made, in order to improve the clinical methodology used.

Bovine spongiform encephalopathy is a neurodegenerative disease. The presence of clinical signs seems to be linked to the localisation and degree of vacuolisation of the neurones. The main warning signs are psychic disorders (apprehension, temperament change, abnormal ear position and abnormal behaviour); sensory disorders (exaggerated responses to stimuli, excessive licking) and postural and locomotory anomalies (ataxia and tremors). Their identification requires a clinical approach: a thorough examination of the animal when on a halter and when moving in an uncustomary environment. As no clinical sign is pathognomonic, it is risky to consider only one aetiology when one or more clinical neurological signs appear in an animal. Familiarity with the differential diagnosis of neurologically expressed disorders will contribute to the improved clinical epidemiological surveillance of BSE.

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