VIRAL RESPIRATORY INFECTIONS IN CATTLE

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1. INTRODUCTION

Respiratory diseases in calves are responsible of major economic losses in both beef and dairy production (Smith, 2000; van der Fels-Klerx *et al.* 2001). Alone or in association with other pathogens, viral infections are probably the main causes of these diseases. Different viruses, such as bovine respiratory syncytial virus (BRSV), bovine herpes virus 1 (BHV1), bovine parainfluenza virus 3 (PIV-3), bovine coronavirus (BCoV), bovine adenoviruses or bovine viral diarrhea virus (BVDV) are detected in most clinical cases that are investigated early after the onset of clinical signs (Bryson *et al.* 1978a; Stott *et al.* 1980; Schelcher *et al.* 1990; Kapil & Basaraba, 1997). They sometimes occur in combination and they are frequently also associated with bacterial invasion of the lung (e.g. with *Mannheimia haemolytica, Pasteurella multocida, Haemophilus somnus, Salmonella dublin* and *Arcanobacterium pyogenes*) (Babiuk *et al.* 1988). Bacteria and viruses may also interact with *Mycoplasma* spp. (e.g. *M. bovis* and *M. dispar*) to induce chronic or more severe disease in a synergistic manner (Thomas *et al.* 2002). Bovine rhinovirus and bovine reovirus have probably low pathogenicity as single agents (Stott *et al.* 1980), whereas the respiratory clinical importance of bovine influenzavirus and bredavirus infections in cattle are unclear (Vanopdenbosch *et al.* 1991; Graham *et al.* 2002).

Frequent failure to reproduce clinical signs by infecting conventional animals with specific pathogens shows the complexity of respiratory disease, in which physiologic and anatomic characteristics together with environmental and production features favour the emergence of clinical signs during an infection. Controlling viral respiratory diseases in cattle requires a good understanding of factors that increase the susceptibility of animals to these viruses, as well as pathogen transmission characteristics within and between herds. Based on precise and complete knowledge of the epidemiology, virology and pathogenesis of each virus, control measures can be developed to decrease the cost of bovine respiratory diseases.

In this presentation we will describe:

- viruses involved in respiratory diseases in cattle,
- factors influencing the occurrence of clinical signs,

- the transmission characteristics of the viruses, and,
- control measures that may be applied to control these diseases.

2. VIRUS INVOLVEMENT IN RESPIRATORY DISEASES IN CATTLE

Bryson *et al.* (1978a) studied outbreaks of respiratory disease in housed calves in the Northern Ireland and found a large involvement of BRSV and PIV-3 in these outbreaks. Similarly, we have investigated the prevalence of several infectious pathogens in 78 beef calves less than three months of age on 20 farms located in central and South-western France (Valarcher & Schelcher, unpublished). Between three and five calves with acute respiratory signs of disease were sampled per herd in herds where ≥ 90% of the calves showed clinical signs of respiratory disease. On each animal, a bronchoalveolar lavage was performed during the acute phase of the disease for bacterial and virological analysis. Blood samples on the calves and the mothers of the calves were also performed on the day of the BAL and three weeks later.

High seroprevalence was detected on the day of the BAL for BRSV, PIV-3, BCoV, adenovirus type 3 (BAV-3) and BVDV, whereas the seroprevalence was lower for BHV1 and *Mycoplasma bovis* (Table I). Despite the presence of maternal antibodies in many animals a significant increase of specific antibodies were detected in some calves, mainly against BRSV, BAV-3 and BVDV. By direct detection of viral and bacterial pathogens, one or several micro-organisms were detected in 53.8% of the calves (n = 78) (Table II). Negative results were obtained by direct techniques of detection for PIV-3, BHV1, BAV-3, *Salmonella* spp., *Haemophilus somnus* and *Mycoplasma dispar*. Viruses and bacteria (*Mannhemia haemolytica, Pasteurella multocida* and *Mycoplasma bovis*) were detected in 41.0% and 16.2% of the calves, respectively. Both virus and bacteria were detected in 5.1% of the calves. By presuming that the origin of the acute respiratory diseases observed in the herds was the pathogen(s) detected in at least two calves (by serology and/or direct techniques), the causes were identified in 12 herds out of 20 (Table III). BRSV and BCoV were the two main pathogens detected in the calves. BRSV was identified in six herds, alone or in association with other viruses. In contrast, *Pasteurellaceae* were identified only in two herds and *Mycoplasma bovis* in one herd. This study demonstrates clearly the involvement of viruses in respiratory diseases in young calves and the major play by BRSV.

Table I. **Detection of specific antibodies against bovine respiratory syncytial virus (BRSV), bovine parainfluenza virus 3 (PIV-3), bovine coronavirus (BCoV), bovine herpesvirus type 1 (BHV1), bovine adenovirus type 3 (BAV-3), bovine viral diarrhoea virus (BVDV) and *Mycoplasma bovis* in 78 beef calves and their mothers, in 20 herds located in central and South-western France**

Commercial ELISAs and hemagglutination tests were used.

Pathogen	Seroprevalence[a] % (n = 78)		Seroconversion or significant increase of specific antibodies[b] % (calves n = 75; cows n = 78)	
	Calves	Cows	Calves	Cows
BRSV	89.7	93.6	13.7	5.3
PIV-3	97.5	100	1.3	0
BCoV	100	100	1.3	1.3
BHV1	16.6	16.6	1.3	0
BAV-3	75.6	66.5	14.6	7.8
BVDV	61.5	66.7	3.9	0
Mycoplasma bovis	10.3	7.7	0	0

[a] An animal in which specific antibodies were detected was considered seropositive

[b] Seroconversion or significant increase of specific antibodies: blood samples were collected at three weeks interval from calves showing acute respiratory signs and from their mothers. Animals were considered positive if specific antibodies appeared between the first and the second samples or if antibodies increased significantly (2 units or two dilutions).

Table II. **Direct detection of infectious pathogens in the BAL obtained from 78 calves with acute respiratory diseases from 20 herds located in central and South-western France**

Indirect immunofluorescence was used to detect BRSV, PIV-3, BCoV, BHV1, BAV-3 and BVDV in BAL cells and bacteria were cultured.

Pathogen(s)	Number of calves	% (n = 78)
BRSV	17	21.8
BCoV	5	6.4
BVDV	1	1.2
Mannhemia haemolytica	4	9.5
Pasteurella multocida	4	9.5
Mycoplasma bovis	1	1.2
BRSV + BCoV	5	6.4
BRSV+ *Mannhemia haemolytica*	1	1.2
BCoV + BVDV	1	1.2
BVDV + *Mannhemia haemolytica*	1	1.2
BVDV + *Pasteurella multocida*	1	1.2
Mycoplasma bovis + *Pasteurella multocida*	1	1.2

Table III. **Pathogens associated with respiratory disease of calves less than three months of age in 20 herds located in central and South-western France**

A herd was considered positive for a pathogen if it was detected in at least two calves by direct and/or indirect diagnosis.

Pathogen(s) detected in at least two calves within the herd	Number of herd(s) positive
BRSV	2
BCoV	2
BVDV	1
Mannhemia haemolytica	1
Pasteuralla multocida	1
BRSV and BAV-3	1
BRSV and BCoV	3
Mycoplasma bovis	1

Viral infections are very frequent in most cattle-rearing systems. Annual BRSV and PIV-3 infections were detected in Dutch dairy herds (Verhoeff & van Nieuwstadt, 1984; Van der Poel *et al.* 1993) and 70 and 85% of animals in British beef-rearing units were infected with BRSV and PIV-3, respectively, by the age of nine months (Stott *et al.* 1980). In contrast, calves at a Swedish bull testing station operating an ‘all in-all out’ management system contracted BRSV only three years out of six, whereas both PIV-3 and BCoV were present annually and BVDV not at all (Hägglund *et al.* Submitted). Also reflecting the frequency of infections, seroprevaleces of viral infections were investigated in 5-11 month-old calves in 118 dairy herds in one area of Sweden (Hägglund *et al.* 2006). In total, 30% of these animals were seropositive against BRSV, 48% against PIV-3, 34% against BCoV and 8% against BVDV (n = 354). A significant association was found between seronegativity to these four viruses in a herd and absence of respiratory disease in calves from birth to sampling.

Outbreaks of respiratory diseases are responsible of direct and indirect losses. Indirect losses are caused by impact of the diseases on the work load, the growth rate of animals, the age at first calving (Wittum *et al.* 1996; Ames, 1997), premature culling and the milk production (Elvander, 1996). The direct losses derive from increased mortality and treatment costs. Even if the frequency and the economic importance of viruses in bovine respiratory diseases is clearly demonstrated in different studies, the lack of identification of pathogens highlights the necessity to develop more sensitive diagnostic tools and to screen for other viruses and bacteria to have a better knowledge of the causes of respiratory diseases in young calves.

3. THE VIRUSES

As shown by field and experimental studies, viruses such as BRSV and BHV1 are clearly pathogenic in the respiratory tract of cattle (Stott *et al.* 1980; Yates, 1982; Verhoeff & van Nieuwstadt, 1984; Tjornehoj *et al.* 2003). BRSV has been reported to be responsible of 14 to 71% of the respiratory diseases (Ames, 1997). The role of PIV-3 remains ambiguous as it seems, in some cases, responsible of respiratory signs but in other it is clinically unapparent or causes only mild disease (Bryson *et al.* 1978a; Verhoeff & van Nieuwstadt, 1984; Graham *et al.* 1999). Recent studies suggest that BCoV is a direct cause of respiratory disease (Lathrop *et al.* 2000; Storz *et al.* 2000; Plummer *et al.* 2004), however, it is most of the time associated with digestive clinical signs (Reynolds *et al.* 1985; Saif, 1990). The direct pathogenic power for the respiratory tract of other viruses, e.g. BVDV, adenoviruses, rhinovirus, reovirus and influenzavirus are not so well defined. These viruses are detected in cattle with respiratory disease but frequently in association with other pathogens.

BRSV is an enveloped RNA virus classified as a *Pneumovirus* in the *Paramyxoviridae* family, order *Mononegavirales*. Its genomic RNA is single-stranded, non-segmented, negative sense and is incorporated in helical nucleocapsides. By its cytolytic action on epithelial cells in the upper and lower respiratory tract BRSV induces a stong inflammatory response. Respiratory signs of moderate to marked intensity might be observed with polypnea, dyspnea, and cough. In some severe cases subcutaneous emphysema might appear. BRSV infections might also induce pathological immune responses that may explain some exacerbated clinical forms. Clinical disease caused by BRSV is mainly diagnosed in autumn and winter in temperate climate zones (Stott *et al.* 1980). This virus is responsible of a high morbidity (60 to 80%) and a mortality that can reach 20%. Maternally derived antibodies provide at least partial protection against clinical signs after natural and experimental BRSV infection (Kimman *et al.* 1987; Kimman *et al.* 1988; Belknap *et al.* 1991). Although virus shedding occasionally has been detected upon experimental BRSV re-infection, clinical disease is seldom observed in animals that have encountered the infection before (Kimman *et al.* 1987; Tjornehoj, 2000; Taylor *et al.* 2005). In agreement with this, i) natural disease is most often seen in calves younger than six months in areas where the infection is endemic, probably because older animals are immune (Van der Poel *et al.* 1993) and ii) in areas where BRSV is not endemic and where adult cattle remain seronegative to BRSV, severe disease may be observed in animals of all ages when the infections are introduced (Inaba *et al.* 1972; Elvander, 1996).

BHV1, which belongs to the *Herpesviridae* family and the *Alphaherpesvirinae* subfamily, is an enveloped DNA virus. Some strains of BHV1 have a tropism that is more marked for the respiratory tract and others more to the genital tract. This virus is spread worldwide; however, some countries have set up eradication programmes and are actually free (e.g. Scandinavia). Serous to mucopurulent nasal discharge, abnormal breathing sounds, and high respiratory frequency might be observed (Verhoeff & van Nieuwstadt, 1984). Humoral and cellular immunities protect against clinical signs. BHV1 infections spread through a herd within a few weeks if the animals are seronegative. The entry of the virus occurs mainly by nasal route after contact with infected

secretions or by inhalation and the virus spread in the animal by viremia and neuronal invasion (Lemaire *et al.* 1994). Conjunctivitis with an ocular discharge is frequently observed in the first phase of the disease. The infection induces a necrosis of the epithelium of the muzzle, nose, nasopharynx, trachea and the first bronchi. In addition, by impairing the macrophage, polynuclear neutrophil and lymphocyte functions, BHV1 favours bacterial colonisation of the respiratory tract. After infection the virus migrates to sites such as the trigeminal and sacral ganglia where it can become latent for life. The morbidity and the severity of the clinical signs vary according to the percentage of seropositive of exposed animals and the strain of virus. The mortality might reach 10% in some severe cases (Kapil *et al.* 1997).

PIV-3 is an enveloped, negative sense, non-segmented, single-stranded RNA virus that belongs to the genus *Respirovirus* in the *Paramyxoviridae* family, order *Mononegavirales*. Its major site of replication is epithelial cells in the respiratory tract (Tsai & Thomson, 1975), but viremia may occur with replication in monocytes (Adair *et al.* 2000). Bovine PIV-3 has a worldwide distribution and a high serum antibody prevalences in adult animals (Bryson, 1990). PIV-3 infections cause less serious disease than BRSV (Verhoeff & van Nieuwstadt, 1984), but are nevertheless significantly correlated with respiratory diseases in cattle (Stott *et al.* 1980). Mild clinical signs such as slight fever, coughing and nasal discharge are observed after pure PIV-3 infections in young animals (Bryson *et al.* 1978a; Bryson *et al.* 1979; Verhoeff & van Nieuwstadt, 1984). The virus is thought to have a predisposing role in shipping fever and enzootic pneumonia; it may be isolated from severe or fatal cases together with bacteria and *Mycoplasma* spp. (Bryson *et al.* 1978b; Storz *et al.* 2000). The predisposing role of PIV-3 in bovine respiratory diseases is probably correlated to its immunosuppressive effects on leucocytes (e.g. decreased phagocytosis by alveolar macrophages and decreased lymphocyte proliferation) and destruction of the mucociliary system (Hesse & Toth, 1983; Babiuk *et al.* 1988; Basaraba *et al.* 1994; Adair *et al.* 2000).

BCoV belongs to the *Coronavirus* genus in the *Coronaviridae* family, order *Nidovirales*. This virus contains a non-segmented, positive-sense and single stranded RNA genome. BCoV causes pneumoenteritic and enteric disease in young and adult cattle, contributing to important production losses worldwide. It is involved in shipping fever and has been significantly associated with treatments against respiratory disease in feedlots and in beef and dairy calves, as well as in adults (Thomas *et al.* 1982; Storz *et al.* 2000). The primary sites of BCoV replication are epithelial cells in the respiratory tract, enterocytes in the distal small intestine and in colon. In the respiratory tract, infected nasal cells form syncytia and in animals with respiratory signs interstitial pneumonia and lung emphysema may be observed (Saif *et al.* 1986; Kapil *et al.* 1991). Clinically, upper respiratory disease with nasal and lachrymal discharge, as well as lower respiratory disease with signs of bronchopneumonia, is observed that may be combined with enteric signs of disease. Lung lesions associated with BCoV replication and/or clinical signs from the lower respiratory tract have been reproduced in some animal experiments (Saif *et al.* 1986; Kapil *et al.* 1991; Tråvén *et al.* 2001), whereas others generated mainly enteric clinical signs (Reynolds *et al.* 1985; Cho *et al.* 2001).

4. FACTORS INFLUENCING THE ANIMAL SUSCEPTIBILITY TO RESPIRATORY VIRUSES

The susceptibility of cattle to viral or bacterial respiratory diseases is exacerbated by characteristics that are specific for this species and that might be modulated by factors considered as environmental.

4.1 Host factors

Lung anatomic characteristics of cattle appear to be a weak point of this species. The absence of interalveolar and interbronchiolar collateral ventilation, the high ventilation rate and strong

resistance to the airflow within the respiratory conducts make cattle more susceptible to respiratory diseases and to infections of this organ (Lekeux, 1998). Some of these weaknesses are exacerbated in young and/or beef calves.

At birth, the immune system of calves is relatively immature. Calves reach an immune maturity at around 4-5 month of age. For this reason, the passive immunity acquired through the colostrum is essential to protect calves against diseases. Corbeil *et al.* (1984) showed that the peak onset of pneumonia occurred between 2 and 4 weeks of age when calves' serum IgG1, IgG2, and IgA concentrations were lowest. These observations can explain the high susceptibility of some young animals.

4.2 Environmental factors

Respiratory defences of cattle can be impaired by environmental conditions. Immunosuppressive stress is induced by factors such as poor nutrition, early weaning, dehydration, low or high temperatures, little rest and transportation. Ammonia and hydrogen sulphide gases from manure, as well as dust particles, may additionally serve as irritants and predispose for respiratory disease (Callan & Garry, 2002). Large group size, high stocking density and mixing of animals of different age and different sources also predispose for respiratory disease, possibly through stress in combination with high infection pressure (Waltner-Toews *et al.* 1986; Svensson & Liberg, 2006).

5. TRANSMISSION OF VIRAL RESPIRATORY DISEASE

Controlling viral respiratory diseases requires a good understanding of the epidemiology and the transmission of each virus between and within herds and factors that favour this passage. The origins of respiratory diseases in beef-rearing units or feedlots can easily be explained by the mixing of animals from different origins under stressful conditions. The sources of viruses in closed herds, on the other hand, might have either external or internal origins. The specific “epidemiological cycle” of many viruses is not known in detail, although some field and experimental studies have attempted to give us a better understanding of transmission characteristics of BRSV, BHV1 and BCoV. Not much is known of the epidemiology or transmission of PIV-3, but since this virus is distantly related to BRSV, one could speculate that their epidemiology and transmission are similar. The spread of PIV-3 within herds is efficient (Verhoeff & van Nieuwstadt, 1984).

Some data indicate that BRSV may persist in infected animals between high incidence seasons (De Jong *et al.* 1996; Valarcher *et al.* 2001), but transmission of virus from carriers to susceptible animals has not been proved (Van der Poel *et al.* 1993; Van der Poel *et al.* 1997). One speculation, which may explain that BRSV infections are common also in herds that do not buy animals (Hägglund *et al.* 2006), is the occurrence of indirect transmission between herds. To the authors’ knowledge, no studies exist on the possibility of BRSV spread by man or by wild animals (such as rodents or birds) or of its prevention; however, human RSV (closely related to BRSV) is spread by infected hands and by contaminated environment, in addition to directly by droplets (Hall *et al.* 1980; Hall & Douglas, 1981).

BHV1 is mainly transmitted directly by nose-to-nose or genital contact and by aerosol within a building (Mars *et al.* 1999; Mars *et al.* 2000). BHV1 might also spread indirectly by artificial insemination of infected semen and embryos and by unanimated vectors such as ropes, buckets, or clothes of human beings (Wentink *et al.* 1993). After infection, the virus stays latent in neural ganglions that innervate genital or respiratory mucosae and may be re-excreted upon immunosuppressive stimuli, such as corticosteroid injection or stress after shipment, calving etc. (Thiry *et al.* 1985). The immunity against BHV1 has no direct control of the latency state and the

reactivation, it just modulates the re-excretion of the virus (Pastoret & Thiry, 1985). Vertical transmission of BHV1 to the foetus can occur during the acute infection of seronegative cows and is followed by abortion.

Continuous BCoV infections in calves seem to occur in some herds, even in those that are closed with regard to animal introduction (Heckert *et al.* 1991). Some authors suspect an occurrence of chronically infected adult cows that constitutes a virus source for calves (Crouch *et al.* 1985; Collins *et al.* 1987). However, these results have been questioned and need to be confirmed (Saif, 1990). Other reports show self-clearance of virus in herds (Alenius *et al.* 1991) and termination of nasal and faecal virus shedding within 1-3 weeks after infection (Cho *et al.* 2001). Nevertheless, virus may be shed upon experimental re-infection of virus, indicating that in large herds it may circulate between animals with low immunity (El-Kanawati *et al.* 1996; Cho *et al.* 2001). Short distance to closest cattle rearing herd has been associated with higher risk of BCoV infection in dairy herds (Hägglund *et al.* 2006). The highest disease incidences of BCoV associated diarrhoea are seen during winter in temperate climate zones, possibly due to increased virus survival during low temperatures and low intensities of UV light (Pensaert & Callebaut, 1978). Crowding of animals during the winter season may also facilitate virus spread and generate higher virus loads to susceptible animals.

6. CONTROL

The control of viral respiratory diseases in cattle is based on specific and unspecific measures. Vaccination specifically targets a certain agent, whereas biosecurity measures and good management practice may unspecifically reduce the pathogen load of a range of agents.

6.1 Biosecurity and good management practice

Biosecurity measures and good management practice should be set up to limit the spread of diseases between and within herds. A common question is: why reducing the pathogen exposure to animals, when exposure is an efficient way of immunization? We still do not have enough knowledge to ultimately clarify why certain animals become sick and others not during exposure to respiratory pathogens. Some important factors, however, have been identified. One such determinant is the pathogen load, i.e. the number of different pathogens and the infection dose that the animals' immune system must simultaneously overcome in order to remain healthy (Yates, 1982; Barrington *et al.* 2002). Good management practice with adequate colostrum-intake for young animals, good nutrition and little physiological and psychological stress will promote the immune system. It is also clear that by reducing the pathogen load through:

- biosecurity,
- low stocking density,
- good ventilation and hygiene,
- individual housing or strict grouping of animals in small groups according to age ($n < 10$),
- transfer to group housing at a minimum age of two weeks, and,
- isolation of sick individuals, the number of sick animals is reduced (Wathes *et al.* 1983; Barrington *et al.* 2002; Callan & Garry, 2002; Svensson *et al.* 2003; Svensson & Liberg, 2006).

The herd-biosecurity may be improved by restrictive introduction of animals or animal introduction only from a limited number of sources. When the production system allows so a solution might be to bring animals together during summer when the virus infection incidences are lower and might stay outside during the quarantine. Quarantines for bought-in animals should not share airspace with the rest of the herd and should be taken care of with strict hygiene or by different personnel. In beef-rearing units, an "all in-all out" management system may be considered, at least in different sections of the herd. Inspection of animals before grouping them might also be advantageous. In all herds indirect modes of pathogen transmission should be prevented by providing protection wear and boots for visitors, and by encouraging hand hygiene and disinfection of material that is carried between herds.

A herd cannot rely only on biosecurity measures. Rapid detection of disease by measuring the rectal temperature of animals is one action that enables early isolation of sick individuals and early treatment. This favours animal welfare as well as reduces economic losses and spread of disease.

6.2 Therapy and vaccine

Due to high costs, no antiviral treatments are used to control viral respiratory diseases in cattle in the field. However, attempts have been made to use recombinant bovine Type I IFN to treat experimental BHV1 infection. Type I IFNα prevented BHV1 induced immunosuppression and decreased the morbidity and mortality of calves subsequently challenged with *Mannhemia haemolytica* (Babiuk *et al.* 1985; Czarniecki *et al.* 1985; Babiuk *et al.* 1987).

Antibiotic therapy is used to prevent and treat primary or secondary bacterial infections in bovine respiratory diseases. According to a survey performed by the World Organisation for Animal health (OIE), respiratory disease is the fourth largest cause of antibiotic use (after septicaemia & sepsis affections, digestive diseases and mastitis) for treatment of animal diseases around the world. Tetracyclines, macrolides and penicillins are the three major antibiotic families used to treat respiratory diseases in cattle (Manuscript in preparation).

Antibiotics are used for therapeutic, metaphylactic and prophylactic purposes. Antibiotic treatment should be initiated at an early stage of the infection and should be continued for a period of a minimum of 4-5 days. Administration of antibiotics must be pursued at least until 48 hours after the improvement of health status and the antimicrobial might be changed if no improvement is observed 48 hours after administration. The use of antibiotic needs to be rationalised by the practitioners according to the results obtained in a herd and also based on trials. We regret that more trials performed to obtain marketing authorisations for antibiotics are not made public or easily available.

It is important to notice that the use of antibiotics in veterinary medicine is questioned by human health authorities. WHO, OIE and FAO organisations have set up working groups to try to define a strategy in the use of antimicrobials in human and veterinary medicines. OIE is actually producing a Veterinary Critically Important Antimicrobial (VCIA) list after having consulted its member countries and stakeholder organisations. The use of antibiotic for prophylactic purposes and even metaphylactic treatments might be restricted and even banned in some countries. This emphasizes the necessity to decrease the use of antimicrobial and to increase the use of efficient vaccines.

Vaccines are widely used to prevent respiratory diseases, although their economical benefit is not always proven (Martin, 1983; Perino & Hunsaker, 1997). Indeed, the vaccine strategy faces a difficult challenge. Vaccination against all the pathogens that could be involved in respiratory diseases is not possible. The diagnosis should be confirmed, but one must be aware that several viruses are often involved in disease in the same herd. Accordingly, when we monitored BRSV,

PIV-3, BCoV and BVDV infections in dairy herds (n = 118) in one area of Sweden, at least 8% of calves had encountered ≥ 3 of the infections (and at least 32% had encountered ≥ 2 of the infections) at the age of ~7 months (Hägglund *et al.* 2006). In addition, the acquisition of an efficient immunity is not always fast enough after vaccination or is impeded by the existence of maternal antibodies. One way to protect young calves from viral disease might be to immunize the cows so as to enhance the antibody-levels in colostrum. Vaccines exist against BCoV infections that significantly do so, but the clinical effect on calf health is dependent on good management systems of calves (Waltner-Toews *et al.* 1985; Kohara *et al.* 1997). Continued feeding of colostrum from vaccinated cows during the first three days of life has been recommended (Crouch *et al.* 2000). However this vaccine strategy might fail for viruses such as BRSV. Numerous vaccines against the respiratory infections are available for immunization of 3-4 months old calves and older, but in the younger calf, immune responses is often hampered by the presence of maternal antibodies during vaccination (Crowe, 2001; Larsen *et al.* 2001). Current work is focusing on new formulations that may overcome this obstacle (Stott *et al.* 1986; Howard *et al.* 1987; Hägglund *et al.* 2004; Patel & Didlick, 2004).

It is the role of the veterinarian to advise in each individual case whether vaccination should be carried out, or not, and against which pathogen. It should hence be estimated if benefits exceed the costs of vaccination and if, according to the actual pathogen, the problem cannot be overcame with changes in management. Research must generate enough data about each pathogen and the vaccines to facilitate such estimations.

7. CONCLUSIONS

Not enough knowledge exists on the epidemiology and transmission of the endemic bovine viral infections for development of a strategic control. Indirect spread by human and the role of chronic/latent infections in the epidemiology of BRSV, PIV-3 and BCoV need to be studied further. Attempts to prevent virus entry into herds and to protect young animals from viral sources within herds should be combined with adequate colostrum-intake, good nutrition, clean environment and, when necessary, with effective vaccines. The effect of vaccination should be evaluated objectively in controlled field trials, according to good scientific practice (Perino & Hunsaker, 1997).

Practical advices for prevention of viral disease

- assure adequate colostrum-intake,
- avoid nutritional and psychological stress of animals,
- maintain hygiene and good ventilation in stables,
- avoid high stocking density,
- group calves in small groups (< 10) according to age and “all in-all out” in sectioned stables,
- house young calves separately from older calves. During shifting of pens, put the youngest animals in a pen where the oldest (immune) animals have been,
- avoid commingling of animals from many different sources,
- reduce new introduction of animals in herds; use a quarantine for new animals that is managed with separate staff, or at least with separate clothes and hand-hygiene,
- if possible, buy animals during summer and use a separate pasture as quarantine,
- control direct contacts between herds at pasture,
- provide protection-wear and boots for visitors at each farm and encourage hand-hygiene,
- use vaccines that are effective in the targeted age group.

8. SUMMARY

Viral infections play an important role in bovine respiratory diseases. Viruses such as bovine respiratory syncytial virus and bovine herpesvirus type 1 sometimes cause severe disease as single agents and several other viruses predispose for bacterial infections of the lung. This paper describes the major viruses involved in bovine respiratory disease, bovine susceptibility factors, transmission characteristics and possible control measures.

9. KEY WORDS

Respiratory, bovine, virus, aetiology, control.

10. RESUME

Les infections virales ont un rôle important dans les infections respiratoires bovines. Des virus comme le virus respiratoire syncytial bovin ou l'herpesvirus de type 1 sont directement responsables de troubles sévères, et plusieurs autres virus prédisposent aux infections bactériennes du poumon. Cet article décrit les virus majeurs impliqués dans les maladies respiratoires chez les bovins, les manifestations cliniques, les facteurs de sensibilité propres à l'espèce bovine, les caractéristiques de leur transmission et les mesures de contrôle qui peuvent être appliquées.

11. MOTS CLES

Respiratoire, bovin, virus, étiologie, contrôle.

12. ZUSAMMENFASSUNG

Viren spielen eine bedeutende Rolle in der Aetiologie von respiratorischen Erkrankungen des Rindes. Das bovine respiratorische Syncytial virus und das bovine Herpesvirus 1 resultieren in schweren Primärerkrankungen, während andere Viren nur als Kofaktoren und Wegbereiter für bakterielle Infektionen eine Rolle spielen. Hier werden die wesentlichen Viren des Respirationstraktes des Rindes diskutiert unter Berücksichtigung ihrer Übertragungseigenschaften, Predispositionsfaktoren und Interventionsmassnahmen.

13. SCHLÜSSELWÖRTER

Respiratorische, rindes, virus, ätiologie, kontroll.

14. RESÚMEN

Las infecciones virales desempeñan un papel importante en las enfermedades respiratorias bovinas. Los virus tales como el virus respiratorio sincitial bovino y el herpesvirus tipo 1 causan a veces enfermedad grave como agentes individuales mientras que otros virus predisponen para infecciones bacterianas en los pulmones. Este trabajo describe los principales virus implicados en la enfermedad respiratoria bovina, factores de susceptibilidad de los bóvidos, características de la transmisión y posibles medidas de control.

15. PALABRAS CLAVES

Respiratorias, bóvidos, virus, etiología, control.

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