



Pestivirus and alphaherpesvirus infections in Swedish reindeer (*Rangifer tarandus tarandus* L.)

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ABSTRACT

Herding semi-domesticated reindeer has economic and social value for Sami people in the northern territories of Fennoscandia. However, with the intensification of reindeer husbandry, interspecies transmission of pathogens between reindeer and domestic animals may become a problem, especially for countries such as Sweden, Norway, and Finland where pestivirus and alphaherpesvirus have been eradicated in domestic ruminants. This study, which included 1158 Swedish reindeer, showed relatively high prevalence of antibodies against bovine viral diarrhoea virus (BVDV) (32%) and bovine herpesvirus-1 (BoHV-1) (53%). Adult animals were more often seropositive for BVDV and BoHV-1 (50% and 78%, respectively) than were calves (18 and 11%, respectively). While the seroprevalence of alphaherpesvirus was similar in different herding districts, pestivirus seropositivity was highest in the South and diminished towards the North of the Swedish reindeer herding area. High correlation of the seropositivity against both pathogens at both individual and herd levels may indicate possible mutual synergetic effects and may be explained by the immunosuppressive nature of the viruses. While alphaherpesvirus seroprevalence was probably related to putative cervid herpesvirus 2 (CvHV-2), the pestivirus infecting reindeer remains undefined. The virus neutralisation test of reindeer sera using different pestivirus strains, revealed higher titres against Border disease virus strains like 137/4 (BDV-1) and Reindeer-1 (BDV-2) than against BVDV-1. However, the virus was not identified by real time RT-PCR in any of the samples ($n=276$) from seronegative reindeers. The study showed that pestivirus and alphaherpesvirus infections are endemic in the Swedish reindeer population.

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1. Introduction

The species reindeer (*Rangifer tarandus tarandus* L.) belongs to the *Capreolinae* subfamily of cervids and comprises different subspecies such as the caribou of North America and reindeer from Eurasia. Reindeer herding in Sweden is maintained by Sami (or Sámpe) people in 51 often

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overlapping herding districts throughout the northern Swedish counties of Norrbotten, Västerbotten and Jämtland (Statistics Sweden, 2003). Reindeer pastures cover about the half of Sweden's area and overlap with domestic ruminant livestock, often grazing in the same fields, though very seldom at the same time. Although the chances of direct contact between reindeer and cattle or small ruminants are quite low because the density of cattle and sheep in North of Sweden does not exceed 70 and 20 animals per 100 km², respectively (Statistics Sweden, 2003), the possibility of transmission of pathogens between cattle and other domestic and wild ruminants including reindeer should not be dismissed. The mutual transmission of pestivirus and alphaherpesvirus between wild ruminant species and livestock was described as possible under experimental conditions (Deregt et al., 2010; Mollema et al., 2005; Ridpath et al., 2007; Uttenthal et al., 2006); however, such transmission has not been demonstrated so far in nature (Van Campen and Rhyan, 2010; Nettleton et al., 1988). Traces of bovine pestivirus specific antibodies (Krametter et al., 2004; Nielsen et al., 2000) as well as isolation of viruses specific to cattle (Fischer et al., 1998; Vilček et al., 2000) were described, while alphaherpesviruses seem to be more host limited. Modernisation and changes in reindeer management such as movement of animals by trucks and gathering animals in the slaughterhouses probably increase the risk of indirect cross-species transmission of different pathogens.

The genus *Pestivirus*, which belongs to the family *Flaviviridae*, includes the four official virus species *Bovine viral diarrhoea virus-1* (BVDV-1), BVDV-2; *Classical swine fever virus* (CSFV), and *Border disease virus* (BDV). This division reflects phylogenetic relationships and is supported by differences in reaction with monoclonal antibodies and in cross-neutralisation reactions with polyclonal sera (Becher et al., 2003). Several additional putative pestivirus species were detected in giraffe, cattle, and buffalo (HoBi-like viruses) and pronghorn antelope (Arnal et al., 2004; Becher et al., 1999, 2003; Frölich et al., 2005; Kampa et al., 2009). Pestiviruses have been described in several free-ranging and captive wild cervid species (Becher et al., 1997; Vilček and Nettleton, 2006). The prevalence varied greatly depending on the species, geographic region, and proximity to domestic animals, especially cattle. Usually, the pestivirus antibody prevalence was very low and reported at levels of 0.7% and 6% of red deer in Austria and Italy (Krametter et al., 2004; Riekerink et al., 2005), 1% of free-living deer in Denmark (Nielsen et al., 2000) and 4% of European bison in Poland (Borchers et al., 2002). Higher seroprevalence of BVDV was found in free-ranging mule deer in Idaho (29%) and in wapiti in Alberta (52%) (Van Campen and Rhyan, 2010). Few studies on pestivirus infections in reindeer revealed considerable differences in the percentages of seropositive animals ranging from 0% to 70% in Canadian caribou (Elazhary et al., 1981; Van Campen and Rhyan, 2010) and from 4.2% to 33% in Norwegian reindeer (Lillehaug et al., 2003; Tryland et al., 2005). The single pestivirus strain (V60-Krefeld, Reindeer-1) isolated from a reindeer was obtained from an animal kept in the Duisburg Zoo in Germany (Becher et al., 1999). In the same place an almost identical

pestivirus (V65-Krefeld, Bison-1) was isolated from a wisent (*Bison bonasus*) (Becher et al., 1999). Further genetic studies revealed that V60 and V65 strains were most closely related to border disease virus type 2 (BDV-2) strains isolated from German sheep (Becher et al., 1999, 2003). Under experimental conditions, reindeer were shown to be susceptible to infection with BVDV-1, developing signs of laminitis and loose stool containing blood and mucus (Morton et al., 1990).

The alphaherpesviruses form a group of pathogens infecting all varieties of domestic ruminants, with the most common bovine herpesvirus type 1 (BoHV-1) responsible for infectious bovine rhinotracheitis and infectious pustular vulvovaginitis (IBR-IPV), as well as various wild ruminant species such as elk (elk herpesvirus [ElkHV-1]) (Deregt et al., 2000), red deer (cervid herpesvirus 1 [CvHV-1]) (Inglis et al., 1983), and reindeer (cervid herpesvirus 2 [CvHV-2]) (Ek-Kommonen et al., 1986; Rockborn et al., 1990). CvHV-2 is probably the only alphaherpesvirus infecting reindeer in nature (das Neves et al., 2009b, 2010), but reindeer infection with BoHV-1 is also possible (Thiry et al., 2001). The knowledge of alphaherpesvirus infections in reindeer was reviewed recently by das Neves et al. (2010). Virus specific antibodies were found in reindeer in Sweden (Rehlander et al., 1991), Norway, and Finland, as well as in reindeer's close relative, caribou (*R. tarandus granti*, *R. t. caribou* and *R. t. groenlandicus*) in Alaska (Evans et al., 2008), Canada (Elazhary et al., 1979), and Greenland. CvHV-2 was described as linked to lesions of the nose and upper alimentary tract (Rockborn et al., 1990), keratoconjunctivitis (Evans et al., 2008; Tryland et al., 2009), and abortions in reindeer (das Neves et al., 2009a).

Pestiviruses and alphaherpesviruses are well known to cause significant economic losses in domestic ruminants. Pestivirus infections have different consequences, including fertility problems, decreased milk yield (described especially in cattle), immunosuppression, mucosal disease with signs of diarrhoea, or an unapparent course. Infection with BoHV-1 shows high similarities to BVDV infection with clinical signs associated with the upper respiratory tract, conjunctivitis, fever, and abortions in cows. Both viruses can persist in the herd after the acute phase of disease. BVDV, when infecting fetuses *in utero* before the development of the immune system, produces life-long persistently infected (PI) carriers and constant shedders of the virus that are seronegative. As yet, no information on persistent pestivirus infections in reindeer is available. BoHV-1 produces latent infection, during which the virus DNA persists in the trigeminal and sacral ganglia of cattle and is reactivated and shed when the animal is stressed or immunosuppressed pharmacologically. Latent infection of reindeer with CvHV-2, similar to latent infection of BoHV-1 in cattle, has been described (das Neves et al., 2009a, 2010).

BVDV eradication programs introduced in cattle in 1993 in Sweden, Norway, and Finland were successful, leaving most of the areas free or almost free from the pathogen. Similarly, the strategy based on excluding BoHV-1 infected animals without the use of vaccine was successful in eliminating this virus from those countries. However, wild ruminants such as reindeer were not

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