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## First Detection of Chronic Wasting Disease in Moose (*Alces alces*) in Sweden

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**ABSTRACT:** We report the first detection of chronic wasting disease (CWD) in Sweden, in three old female moose (*Alces alces*). Prions (PrP<sup>CWD</sup>) were detected in brain but not in lymph nodes. The findings are similar to previously described CWD cases in old moose in Norway, where a spontaneous origin is hypothesized.

Chronic wasting disease (CWD) is a transmissible spongiform encephalopathy affecting cervids, first described in captive deer in Colorado, US in 1967 (Williams 2005). In North America, CWD has spread over large geographic areas, and prevalence in several affected populations is increasing (Carlson et al. 2017). The disease is lethal and difficult to control, partly due to environmental persistence of infectious prions (PrP<sup>CWD</sup>). Studies indicate that CWD can negatively impact cervid populations (e.g., Edmunds et al. 2016).

In Europe, CWD was first detected in Norway: in wild reindeer (*Rangifer tarandus*) in 2016 (Benestad et al. 2016), moose (*Alces alces*) in 2016 (Pirisinu et al. 2018), and a red deer (*Cervus elaphus*) in 2017 (Vikøren et al. 2019). One CWD-positive wild moose was found in Finland in 2018 (Evisa 2019). In Norway, the findings in wild reindeer differ from the findings in moose and red deer, and the hypothesis has been raised that the cases in moose might be of spontaneous origin (Pirisinu et al. 2018).

Following the detection of CWD in Norway, surveillance for CWD became mandatory in European Union-member states with populations of moose or reindeer: Sweden, Finland, Estonia, Latvia, Lithuania, and Poland (Commission Regulation [European Union] 2017/1972). The surveillance also includes roe deer (*Capreolus capreolus*) and

red deer, and primarily targets animals showing clinical signs compatible with CWD, animals euthanized due to disease, and fallen stock, including road- and predator-killed animals. A minimum of 6,000 wild, farmed, or semidomesticated cervids per member state were to be tested from 2018 to 2020.

Swedish cervid populations are managed by hunting, with an annual hunting bag of about 100,000 moose, approximately 100,000 roe deer, and 11,000 red deer (Viltdata 2020). In the southern half of Sweden, moose, red deer, and roe deer cohabit in varying densities, whereas in the northern half, about 250,000 free-grazing semidomesticated reindeer cohabit with moose, and less commonly with red deer or roe deer. There are approximately 120 deer farms farming red deer.

In March 2019, the first CWD case in Sweden was detected in the municipality of Arjeplog (66°6'37"N, 17°27'42"E). It was a female moose that had been euthanized and sampled after being observed emaciated and apparently blind, walking in circles on a frozen lake. The moose was 16 yr old based on examination of dental cementum annuli of molar tooth M1 (Hamlin et al. 2000). In May 2019, the second case was detected in the neighboring municipality of Arvidsjaur, only 70 km from the first case (Fig. 1). This was also a female, euthanized after showing behavioral changes, and was also aged by dental cementum annulation as 16 yr old.

After these two cases of CWD were detected, intensified surveillance was implemented in the region, targeting all adult moose shot during the hunting season starting in September 2019. In total, 661 moose were sampled. During the first week of hunting, the third case was detected, in an apparently



FIGURE 1. Map showing the sites at which the first three chronic wasting disease (CWD)-positive moose (*Alces alces*) were found in Sweden in 2019 (black arrowheads). All three were found within the county of Norrbotten. The first two cases were found in the general national screening for CWD in Sweden, and the third case was found within the active intensified surveillance initiated due to the first two findings, during the annual moose hunt in this region.

healthy female moose in normal body condition shot in the municipality of Arjeplog. The moose was aged by dental cementum annuli counting as at least 10 yr old.

The TeSeE SAP ELISA CWD protocol (Bio-Rad, Hercules, California, USA) was used as a rapid screening test of both the medulla oblongata at the level of the obex and the retropharyngeal lymph nodes. All three moose were positive in obex samples but negative in lymph node samples. The diagnosis was confirmed by TeSeE Western Blot (Bio-Rad). In formalin-fixed tissues, using immunohistochemistry as described by Benestad et al. (2016), PrP<sup>CWD</sup> was detected in the brain but not in the retropharyngeal lymph nodes. The Western Blot glycoprofile and the prion deposition pattern were similar to the

CWD cases in Norwegian moose (Pirisinu et al. 2018).

Further characterization of the cases in moose in Sweden, including biochemical analyses and transmission studies in different transgenic mice, is ongoing. The results, coupled with additional surveillance and epidemiological analysis, will add clarity regarding the type of CWD prion involved. Similarities with the cases in moose in Norway include old age, low molecular weight of the PrP<sup>CWD</sup>, and presence of prions in the brain but not in lymph nodes. These characteristics differ from previously described CWD cases in cervids, including the few described CWD cases in moose (*Alces alces shirasi*) from North America and CWD in wild reindeer in Norway (Baeten et al. 2007; Benestad et al. 2016; Pirisinu et al. 2018; Nonno et al. 2020).

The age structure of the Swedish moose population is skewed due to hunting, with few animals reaching a high age. Old moose are mostly females, because hunters often avoid harvesting reproductive females; males rarely reach ages above 10 yr. No CWD case has been detected in younger moose among the more than 24,000 moose tested in Norway and Sweden (National Veterinary Institute 2020; Norwegian Veterinary Institute 2020).

The three cases in Sweden were geographically clustered. However, clustering by itself is not evidence of contagiousness, because increased awareness and sampling in the area where the first case was detected might have contributed to the detection of cases two and three. Geographically clustered cases have also been reported from Norway (Våge et al. 2020); further analysis of Swedish and Norwegian surveillance data focusing on this aspect is ongoing.

When developing strategies to control or limit prion disease, strain diversity related to epidemiology is highly relevant. Other ruminant transmissible spongiform encephalopathies (bovine spongiform encephalopathy and scrapie) have different control strategies according to their classification as atypical or classical strains as the atypical strains are believed to be spontaneously occurring in older animals and not contagious between

living animals (Anonymous 2001). The recently reported diversity of CWD strains in Europe, with the report of atypical forms in old moose and a red deer (Koutsoumanis et al. 2019; Pirisinu et al. 2018; Vikøren et al. 2019), needs to be considered in planning management strategies. Characterization of the phenotype of this prion disease and the prion strain involved, and epidemiological studies, will be fundamental to understand the nature of this disease in moose.

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