Policy implications of an expanded chronic wasting disease universe

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Abstract

1. International policy for the management of wildlife disease(s) plays an important role for concerted action, and changes to policy should be evidence-based and updated as new evidence accumulates. Management of chronic wasting disease (CWD), the prion disease affecting cervids, is based on its highly contagious nature relative to most other prion diseases. These management actions are particularly invasive, with considerable biological and economic consequences.

2. A novel type of CWD has been discovered in moose (*Alces alces*) and red deer (*Cervus elaphus*), with prions restricted to the central nervous system (CNS). Prions in tissue outside the CNS are an indication of the contagiousness of a prion disease. As such, for this novel type of CWD, there is a lower likelihood of horizontal transmission under natural conditions. Furthermore, infected individuals were older (mean 15 years), and cases appeared with limited clustering in space and time; hence, with no indication of an epidemic outbreak.

3. *Policy implications.* The annual harvest of approximately 4 million cervids in Europe each year generates considerable cultural and economic value. 'Stamping out' policies would be inefficient and inappropriate to control diseases with no horizontal transmission among live animals, and banning the export of meat from a region after detection of a positively tested animal would make little sense in the case of sporadic disease. The novel type of chronic wasting disease (CWD) with epidemiological characteristics clearly different from 'classical' and contagious CWD calls for differentiated management strategies to avoid unnecessarily invasive actions.

Keywords

cervids, chronic wasting disease, disease management, EU-policy, moose, red deer, sporadic prion disease, TSE-regulation

1 INTRODUCTION

Wildlife diseases are emerging in many areas due to climate change (Jones et al. 2008), and globalisation increases the risk of pathogen introduction (Daszak, Cunningham & Hyatt 2000). The toolbox of tactics to combat infectious wildlife diseases includes invasive actions, such as culling (Wasserberg et al. 2009) or even ‘stamping out’, i.e., the targeted removal of entire infected herds or populations (Delahay, Smith & Hutchings 2009). The containment of pathogens may also involve fencing to limit host movements (Mysterud & Rolandsen 2019) and zonation, with restrictions on the export of animal products (Grear et al. 2014). Therefore, the management of wildlife diseases typically involves trade-offs between the impacts on human health and financial aspects (Joseph et al. 2013; Bolzoni et al. 2014), ecological side-effects (Vicente et al. 2019), conservation (McCallum 2012), and ethical considerations (Crozier & Schulte-Hostedde 2014).

There is a sound scientific basis for when to use culling to combat many wildlife diseases (Bolzoni et al. 2014; Tanner et al. 2019). Monitoring of how management actions influence development of disease incidence appear crucial to establish their efficacy. Nevertheless, once implemented, some drastic practices continue despite accumulating evidence of limited efficacy. Host culling continued even when it failed to control rabies (Morters et al. 2013). Culling targets of badgers (*Meles meles*) was found not to limit transmission of bovine tuberculosis (Donnelly & Woodroffe 2015), and the effects of culling badgers on the incidence of bovine tuberculosis are context dependent (Prentice et al. 2019). Facing African swine fever, Poland massively increased culling of wild boar with the aim of depopulating on a broad scale to limit the risk for spill-over to domestic pigs, even when the efficacy of such a measure was questioned by experts (Vicente et al. 2019). Whether management actions, in general, are effective in combating wildlife diseases depends on several factors related to the number and density of hosts, ecological interactions, as well as specific characteristics of the pathogen in question (Wasserberg et al. 2009; Joseph et al. 2013; Bolzoni et al. 2014). International policies play important roles for effective management of wildlife diseases (Voyles et al. 2015). It is essential that policies for management tactics follow scientifically updated knowledge of epidemiology and host ecology to be effective in combating disease, and also in limiting the adverse impact of actions, if they are unlikely to be effective. We advocate for differentiation of the European Union (EU) policy for the management of prion diseases in wildlife following recent discoveries of prion types with novel epidemiological characteristics.

2 PRION DISEASES

Prion diseases, otherwise known as transmissible spongiform encephalopathies (TSEs), are among the most feared group of diseases (Prusiner 1998). There is no effective vaccine or treatment for these fatal diseases, and infected individuals do not exhibit any overt immunological reactions. The cellular prion protein (PrP^{C}), which is highly abundant in the central nervous system (CNS) of all mammals, undergoes misfolding into an infectious form known as prions, which aggregate and cause neurodegeneration. Avoiding exposure to infectious prions, therefore, is key. Prompted by the tragic ‘mad cow’ disease epidemic, ‘TSE regulation’ of the EU was developed to protect the food chain from prions (European Parliament and Council 2001). Prions are restricted to the CNS for bovine spongiform encephalopathy (BSE) in cattle and sporadic Creutzfeldt-Jakob disease (sCJD) in humans, and the likelihood of horizontal transmission from an infected individual is considered to be low under natural conditions. In contrast, the presence of detectable prions outside the CNS is an indication of increased contagiousness because the infected animal is shedding prions in excreta, thus contributing to a higher risk of exposure (EFSA Panel-on Biological Hazards (BIOHAZ) et al. 2019).

3 CONTAGIOUS PRION DISEASES REQUIRE MANAGEMENT ACTIONS

Chronic wasting disease (CWD) among cervids and classical scrapie in sheep are the most contagious prion diseases. Most CWD animals accumulate prions in their lymphoreticular tissues, and transmission among animals occurs through shedding of prions in body fluids and excreta, involving either exposure through direct contact from animal to animal, or through environmental contamination in soil or plants (Haley & Hoover 2015). The spreading of CWD among cervids is slowly, but steadily, sweeping across the North American continent since its discovery in the late 1960s. Cultural and economic repercussions are massive and increasing (Bishop 2004; Rivera et al. 2019). A tremendous challenge presented by CWD is that, once established, there is virtually no possibility of eradication due to environmental reservoirs of the infectious prions. Therefore, the persistent nature of CWD calls for immediate management action involving increased harvest and surveillance around positive cases, active containment efforts including zonation, prohibition of export of deer products, and individual testing of affected populations.

4 NOVEL TYPE OF CWD: LIKELY A SPORADIC DISEASE

The emergence of CWD among reindeer (*Rangifer tarandus*) in Norway in 2016 was the first in Europe (Benestad et al. 2016), and led to the eradication of the entire infected population of > 2000 wild reindeer (Mysterud & Rolandsen 2018). The 19 positive cases were clustered in a single population (Fig. 1) and exhibited similar diagnostic and molecular characteristics as those found in mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus canadensis*), and moose (*Alces alces*) in the United States and Canada. Alongside the outbreak of this ’classical’ contagious CWD among reindeer, we discovered a novel type of CWD in Norway with unusual characteristics in moose (Pirisinu et al. 2018), and later, we found a similar type in a red deer (*Cervus elaphus*) (Vikøren et al. 2019), most notably with detection of prions only in the CNS. Efficient monitoring of both diseases simultaneously are done by sampling both retropharyngeal lymph nodes and brain tissue from each individual (Viljugrein et al. 2019). Each sample is analyzed by rapid test (ELISA) the day they arrive at the laboratory and any positive diagnosis is confirmed by another method (Western Blot), generally within 2 to 4 days. These new CWD discoveries add to the considerable TSE strain variation documented for scrapie in sheep, BSE in cattle, and CJD in humans. Cases of classical scrapie and CWD, as known from North America, are of clustered occurrences in populations over time, thus reflecting their contagiousness. Other prion diseases with no prions detectable outside the CNS, such as human sCJD, sheep Nor98/atypical scrapie or cattle atypical BSE, occur sporadically in older individuals, generally at low global prevalence, and with no spatial clustering or increase in temporal incidence.

5 NOVEL TYPE OF CWD: A CALL FOR DIFFERENTIATED MANAGEMENT

Based on advice from the European Food Safety Authority after the discovery of CWD in Norway (EFSA Panel on Biological Hazards (BIOHAZ) et al. 2016), a specific regulation of CWD surveillance was also implemented in the EU. The Commission Regulation (EU) 2017/1972 of 30 October, 2017 (The European Commission 2017b), and updated 21 November, 2017 (The European Commission 2017a), led to the initiation of a 3-year surveillance program for CWD in the 6 EU member states with moose and/or reindeer populations from 2018. This led to discoveries of CWD in moose in Sweden and Finland (Fig. 1), with atypical characteristics similar to those in Norwegian moose. All these Nordic cases of “atypical”/”sporadic” CWD involve individuals of older age for cervids (mean, 15 years) and well beyond reproductive senescence of both moose and red deer (Ericsson et al. 2001; Langvatn et al. 2004). Disease affecting older individuals would have no measurable impact on population dynamics, which is in contrast to the situation in North American CWD, where decreasing survival rates of prime-age adults cause population declines in heavily affected areas (Edmunds et al. 2016; DeVivo et al. 2017). Representing experts on prions, epidemiology, and involvement in testing and surveillance of CWD in Norway, we emphasize that the novel prion strain with unusual characteristics calls for a differentiated understanding of CWD. The discovered diversification of CWD is currently causing confusion, even in scientific communities, assuming that all CWD is ‘epidemic’ in nature when discussing management implications (Escobar et al. 2020).

6 LESSONS LEARNED FROM SCRAPIE IN SHEEP

Classical scrapie in sheep has long been known as a highly contagious prion disease, and was historically endemic in some European countries. In cases of diagnosed classical scrapie, the primary management strategies involved stamping out the entire flock (together with contact flocks) and/or selective culling of susceptible genotypes, often accompanied by severe decontamination measures in the affected farms (EFSA Panel-on Biological Hazards (BIOHAZ) 2014). In 1998, at the Norwegian Veterinary Institute, we identified an unusual type of scrapie, Nor98, also known as atypical scrapie (Benestad et al. 2003), sporadically affecting older sheep, in which prions were confined to the CNS. In farms diagnosed with Nor98, it is generally rare to find > 1 affected sheep. The lack of evidence for horizontal transmission of Nor98 led to a differentiation in the management between classical scrapie and Nor98/atypical scrapie from 2007 onward in the EU/EFTA member states, with less stringent rules for Nor98/atypical scrapie. Similarly, the presence of different types of CWD elicited differentiation in disease surveillance and management in Scandinavia. The outbreak of contagious CWD in reindeer resulted in culling of the affected population (Mysterud & Rolandsen 2018) and ongoing fallowing, with subsequent massive sampling in adjacent populations (Mysterud et al. 2020). On identification of a sporadic CWD case, the most important measure implemented was to increase sampling in zones around it, aiming to determine prevalence and to understand its epidemiological nature. In the absence of horizontal spreading among animals, stamping out policies would be inefficient and inappropriate to control the disease. The first two cases of 'atypical' CWD in moose in 2016 appeared in the same geographical area of Norway (Fig. 1), and ordinary CWD zonation was also imposed at first (Landbruks- og matdepartementet 2017). Subsequent testing indicated the low prevalence and likeliness of a sporadic nature, and zonation was abandoned in Norway for such cases. Later, no zonation was implemented when Finland and Sweden discovered CWD with atypical characteristics in moose. The knowledge gained from Nor98/atypical scrapie in sheep (Benestad et al. 2008) demonstrated the importance of understanding the epidemiology of a disease when implementing management and control measures.

7 CONCLUSION

It is crucially important to consider the detailed epidemiology of a given disease when informing management, and equally to monitor the efficacy of implemented management actions to ensure they work as anticipated to avoid unnecessary costly actions. Contagious CWD appear clustered in space and time. As such, host culling, fencing to limit host movement, and zonation with restrictions on export of meat are likely to be effective in limiting transmission and spread. In contrast, the cases documented in moose and red deer in Fennoscandia appear to be sporadic, affecting older individuals, with limited clustering in space and time, and no invasive management currently seem warranted. Uncertainty regarding the characteristics of the newly detected CWD strains in Europe ought to elicit efforts to answer further important questions regarding strain variation, their zoonotic potential, capability of crossing species barriers, and other epidemiological traits, all to implement appropriate management for each disease. With approximately 2.4 million red deer, 9.6 million roe deer, 437,000 moose, and > 1 million semi-domestic and wild reindeer in Europe (Apollonio, Andersen & Putman 2010), and sustaining an annual harvest of approximately 4 million wild cervids (Linnell et al. 2020), the variation in CWD is an issue with potentially huge implications for culture, the economy, and cervid populations.

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AUTHORS' CONTRIBUTIONS

AM composed the figure and drafted the first version of the manuscript, which was significantly edited by SLB, CMR, and JV. All authors approved the final version for submission and publication.

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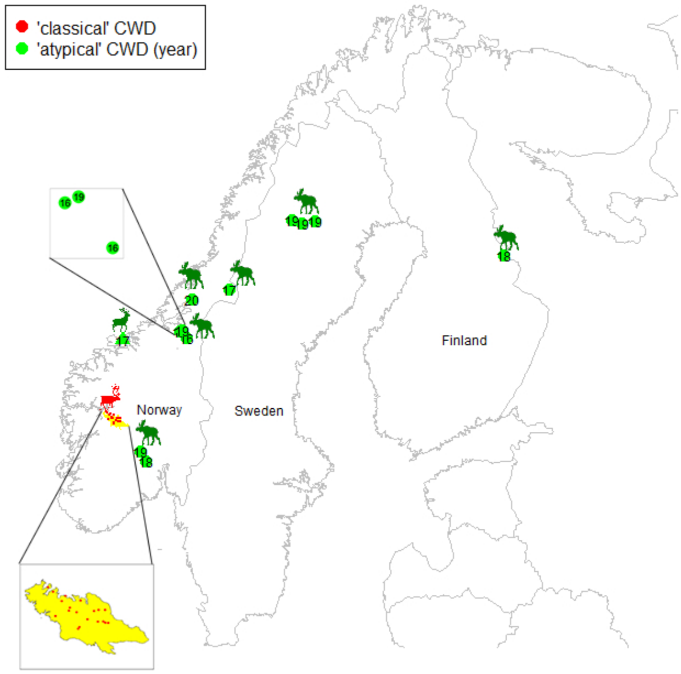

Figure 1. An overview of all detected cases of chronic wasting disease (CWD) in Europe, with 19 reindeer, 11 moose, and one red deer diagnosed with the disease. The contagious CWD detected in reindeer with lymphoid involvement (red) required immediate management actions and the population was culled. A different management strategy was applied to the sporadic detections in moose and red deer (green) under the assumption of different epidemiology. Sampling of cervids are implemented across Sweden (n > 3,700) and Finland (n > 2,500) following a surveillance program designed by the European Food Safety Authority (EFSA) securing adequate spatial coverage. Norway (n > 100,000) follow the surveillance program, but have massive additional monitoring.